Integrated Digital Techniques for development of the Geographic Information System in Indonesia

by
M. Mustafa Radwan, ITC, The Netherlands
and
Paul Suharto, Bakosurtanal, Indonesia

ISPRS Commission IV

ABSTRACT

Digital techniques are recognised as the way to achieve high level of efficiency, cost effectiveness and improve responsiveness in the production of maps and related information. Lately, Bakosurtanal had purchased the computerized graphic system COMARC, computer controlled orthophoto system WILD OR1, automatic recording equipment for photogrammetric plotters, digital image processing system (DIPIX) for landsat data, program packages for aerial triangulation, DTM, contour generation, etc. Unfortunately, the lack of integration between these "individual" subsystems has reduced their effectiveness in achieving objectives. Further, attempting to interface the existing photogrammetric system with the COMARC system involves many problems due to the slow response of the existing computer. Under the ITC-Bakosurtanal/World Bank cooperation project, a specially designed system, tailored to the existing capabilities and priorities, is set up for the interaction between the data base subsystem and the various input, output and digital data manipulation systems. The supporting software package takes care of the formating and structuring of the output of the existing photogrammetric system, orthophoto system, the processed Landsat data, etc. Using the digital mono plotting concept for updating the existing natural resources data base is also included.

1. INVENTORY OF NATURAL RESOURCES IN INDONESIA

Completion of natural resource inventories and their continuing revisions are prerequisities for rational planning and decision making in any development having socio-economic goals and objectives.
The inventory of natural resources in Indonesia is channeled through the National Resource Inventory and Evaluation Programme, launched since 1976 [6]. With emphasis in the on-going Five Year Development Plan being given to the agricultural sector and the transmigration programme (where 500,000 families will be moved to areas outside densely populated islands), the objectives of this inventory programme are directed towards the acquisition of up-to-date and reliable information on environmental potentials and conditions, including information on land resources, water resources, vegetation and climate. For this purpose the inventory includes: topography, geology and geomorphology, soils, vegetation, forestry, landuse, hydrology, climate and meteorology.

With the multidisciplinary nature of the problem, the implementation of this programme is based on the functional participation of the various agencies which are in charge of the resource fields concerned, as outlined in figure (1). While each agency is doing only that part of the work for which it is best qualified, their activities are coordinated in order to achieve synchronization, prevent duplicity of work and enforce standardization of the map production, the map formats and the accuracy criteria.

The three main components of the inventory programme are:

1. Surveying and Mapping Programme
2. Resource Inventory Programme
3. Resource Potential and Environmental Evaluation Programme

It is the responsibility of Bakosurtanal, the National Coordination Agency of Surveying and Mapping, to provide:

a. Image coverage of the entire territory, ranging from high altitude aerial photography and satellite imageries for the purpose of reconnaissance and monitoring of natural resources up to detailed surveys for topographic mapping.
b. Systematic base mapping of the national territory.
c. Entry of resources data into a computerised Geographic Information System. The data is provided by and in cooperation with the various relevant information producing agencies.
d. Cartographic completion and printing of resource (thematic) maps
e. Presentation of composite regional information.

Resources agencies are responsible for the interpretation of images, the aggregation and the updating of resource data and for the compilation of thematic overlays for the base maps.

Ultimately, the completed analysis and evaluation of the resource data will come under the jurisdiction of the Committee on Natural Resources.

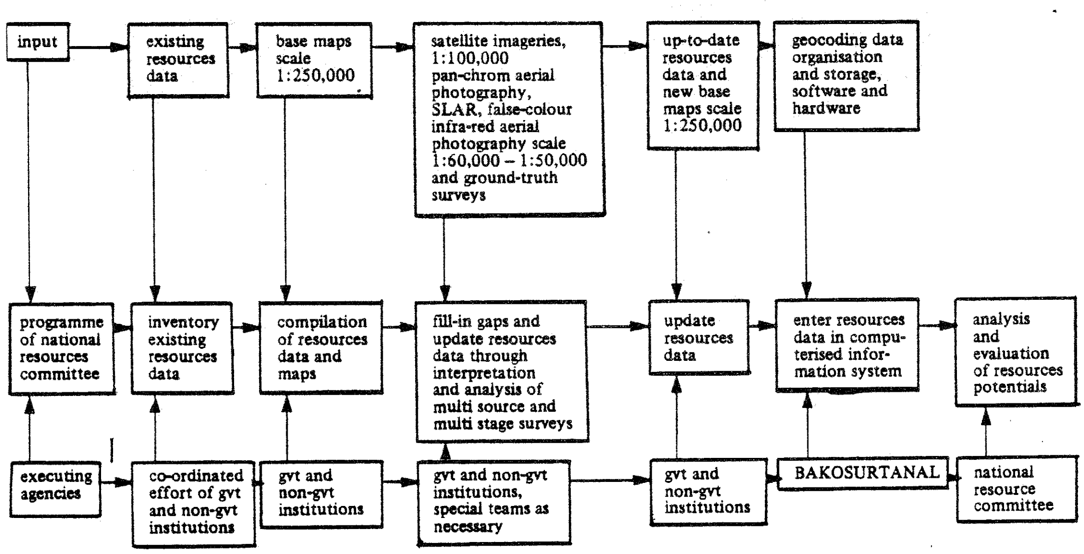
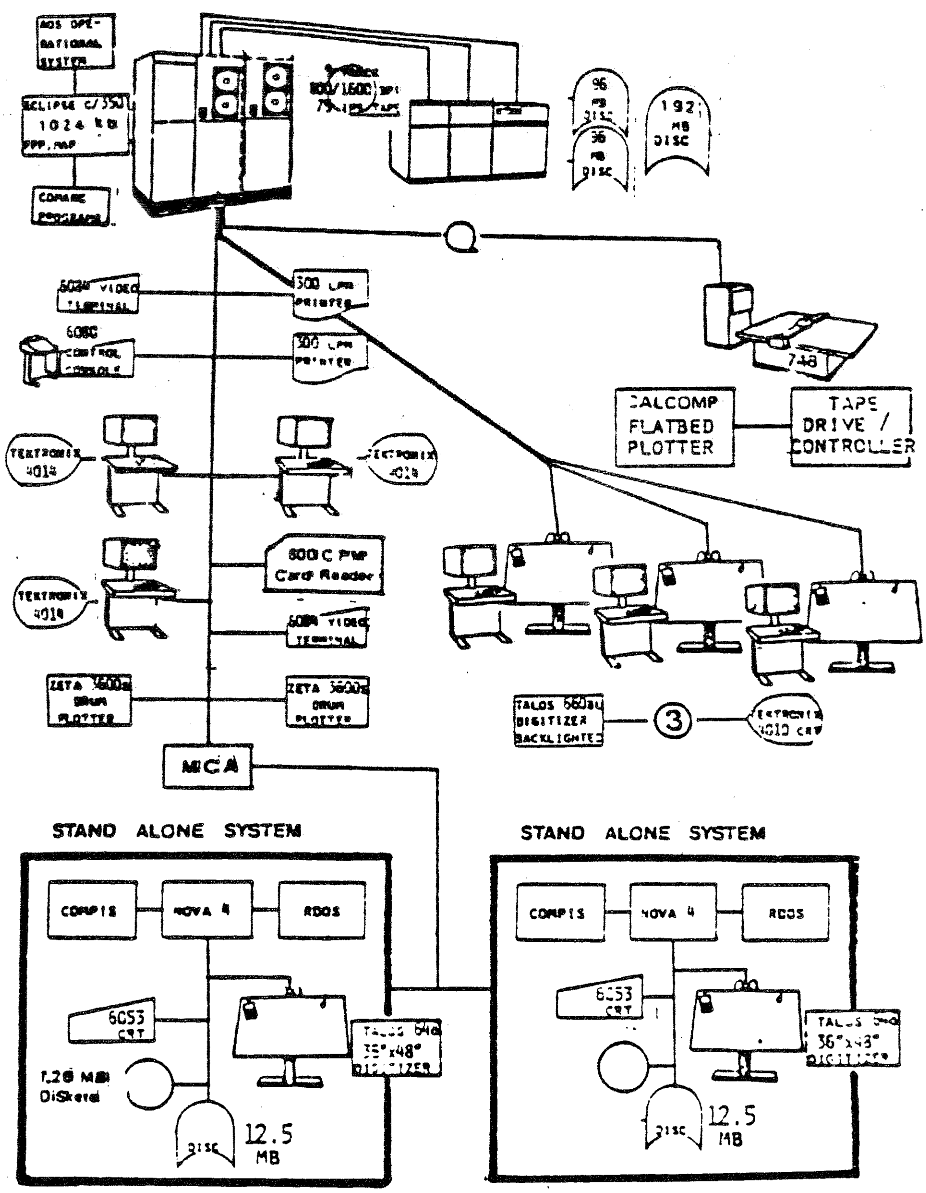


Figure 1
Functional approach to the inventory reconnaissance type information and the evaluation of resources
(Source (6))

2. RECENT DEVELOPMENTS AT BAKOSURTANAL

Recognizing the importance of a national base map series for standardization and coordination of resource survey work, the systematic mapping of the whole of Indonesia and its proper integration and synchronization with the Inventory Programme are tasks of primary concern at Bakosurtanal. Rational measures have recently been taken to introduce modern methods of surveying and to make optimum use of the advances made in the field of digital mapping [11], [12]. This with a view to improve the accuracy and to reduce the production time of base maps, in particular the photogrammetric, cartographic and reproduction phases. In the following, these developments are reviewed in brief.

Figure (2) **BAKOSURTANAL FACILITY**



(Source: (8))

- In addition to conventional ground survey methods, the introduction of Doppler and Aerodist surveys for horizontal control, APR surveys for vertical control and the capability to process in house large aerial triangulation blocks using the Stuttgart PATM computer package, have accelerated the provision of control required for map production considerably. These control data are then entered into the computerized Geodetic Information System (SINDESI) for later use [11].

- All photogrammetric equipments are equipped with automatic recording units and magnetic tape output units, for the digitization of aerial triangulation measurements, of the digital elevation models DEM (parallel profiles, contours, characteristic lines, etc.), and of planimetric details. No attempt has been made so far to interface any of these equipment with a digital computer for the purpose of direct data transfer and on-line processing.

- In consideration of the volume of work involved in the entire coverage of the country and the manpower problems, the production of topographic base maps in the form of photo maps instead of the conventional line maps, as a provisional solution, provides an efficient way to improve responsiveness in providing base maps and related information [6]. while the final stage of the National Base Mapping Programme is the publication of line maps, the map users with urgent needs will have earlier access to these 'provisional' maps for their resource completion work.
  The published photo maps (rectified- or orthophotos) at 1:50,000 scale have graudally gained acceptance as the preferred medium for the display of results of resource inventories. they display the recorded scene without any generalization and offer more wealthy information, (although climate and seasonal dependent), about the ground scene than line maps and thus broaden the range of their potential application particularly in areas with little or no cultural features.

  For this reason, Bakosurtanal and the Army Topographic Service (which takes part in the National Mapping Programme), have been equipped with the Wild OR-1 orthophoto equipment system and the necessary computer package SORA (Software for Off-line Rectification with Avioplan) [4]. This off-line approach allows much flexibility in designig the processes for the production of orthophotos together (but not simultaneously) with the production of contours and spot heights. further, it initiates the establsihment of DEM (Digital Elevation Model) Data Bank which can be used for future updating of orthophotos, generating slope maps, etc.

- To speed up the process of producing line maps and optimize the compilation work, Bakosurtanal purchased the COMARC computer assisted cartographic system in 1979 [8]. The system configuration is shown in figure (2). Its central processing unit is a Data General Computer Eclipse C/350 system with a 1024 k byte memory, 3 removable disc subsystems (384 million byte storage capacity), and 2 magnetic tape units. It supports 5 interactive digitizing tables (although two of them can be operated as stand alone systems and each is supported by a Data General Nova microcomputer), 2 Data General Video terminals, 6 Tektronix graphic CRT interactive terminals, a line printer and 2 Drum plotters. The Calcomp 7000 Flatbed Plotter system has also been purchased.

This system supports the various phases of map production, mainly digitizing, editing, storage, retrieval and presentation (digitally as well as graphically) of map data. further, the system will store the information while compiling the 1:50,000 scale base maps for later compilation of the smaller scale maps. Thus a digital cartographic data base is create as a direct output of the map making process.

This reflects the gradual transition taking place at Bakosurtanal from the use of the automatic cartographic system as a production tool only for the verification of digitized data, for the elimination of manual drafting and scribing, and benefiting from the advances in computer graphics (a badly needed development due to the substantial shortage of cartographers and the urgent need for base maps), towards the establishment of a computerized cartographic (/resource) data base.

The Bakosurtanal is establishing its computerized Geographic Information System in order to:

1. Improve the responsiveness to users' expanding demands for topographic information (map details, elevations, slopes, etc.) to be supplied in digital form with the specified format.
2. Organize, manipulate and overlay various resource surveys into a composite presentation.
3. Facilitate exchange of data between geo-information producers, according to a standardized digital data structure and geographic reference system.
4. Offer enough flexibility to allow continuous updating of resource data being provided by several data collection subsystems with various formats and to serve several users requiring a variety of outputs.

The system is basically a geographic grid cell reference system, based on the National 1:250,000 Topographic Mapping System. Each map sheet is divided into grid cells, each of 1/2 minute x 1/2 minute size and is given an unique reference number, [6].
All phenomena, existing or occurring in a given area are recorded (or digitized) directly in the individual cell to which they belong. Once converted into a digital data and stored in the computer, they can be retrieved as a single or composite entities and produced cell by cell.

The COMARC software package COMPIS (COMARC Planning Information System) was purchased in 1980 for storage, retrieval, manipulation and presentation of thematic data [8].

In addition to the Base Mapping Program (which provides the geographic base for the presentation of the resource surveys), the entry of resource data into this computerized system, the completion of thematic maps at 1:250,000 scale and including all relevant information about soils, vegetation, landuse patterns, etc., and the creation of digital data base for resources information, are taks of high priority in Bakosurtanal today.
This resource data is continuously fed in by and in cooperation with various relevant information producing agencies and presented in a standardized format using the topographic map of the National Base Mapping system as vehicle for information presentation.

At this moment, direct data entry and uses of resource data in the Geographic Information System are only possible via the facilities available at Bakosurtanal offices. The system will be further developed for the establishment of a national network, directly linking together the information producing agencies and the information using agencies (planning offices), [12].

- Bakosurtanal is also responsible for utilizing satellite remote sensing imageries as an aid for the Resource Inventory Programme. With the advances made in computer assisted image data processing, remote sensing images are increasingly important in the analysis of broad regional patterns of geomorphology, geology, soil and vegetation surveys, landuse, etc.
  A Remote Sensing Analysis Center has been established at Bakosurtanal and is equipped with analog and digital analysis systems and a hard copy reproduction system. The analog system consists of multi-spectral viewers, projectors and image to map as well as map to image transfer systems. The digital analysis system, DIPIX Image Analysis system (Canada) was purchased in order to process Landsat CCT's.

3. PROBLEMS AND POSSIBLE SOLUTIONS

In addition to problems arising from the large extent of the national territory, the continuously changing nature of the natural resources data and the increasing pressure imposed by the growing rate of regional developments in Indonesia, the problems in systematic mapping evolve around the time available for completion of the various mapping stages and other factors such as the techniques and methodology to be utilized, the number and qualifications of personnel required, the existing capacities and the possible extension, etc. [7].

Under the bilateral arrangement made between Bakosurtanal / World Bank and the ITC, Enschede, for technical cooperation, [11], the first author of this report was assigned to assist in solving problems involved in the digital aspects of the Geographic Information System at Bakosurtanal. With the cooperation of the second author, the major influencing problems were identified and solutions, adapted to the existing human skills and equipments were set and implemented as is briefly reviewed below.

1. With the present system configuration, as outlined in figure (2), manual digitization (via digitizing tables) of the existing maps, photogrammetric manuscripts, annotated photos, etc., is the only means of data entry to the system. Considering the volume of work involved, this method is too slow and needs considerable time, due to the significant density of details. Further its accuracy is limited by the plotting accuracy and cartographic enhancement and it is subject to unpredictable human errors during digitization although graphical displays and editing capabilities are available in the system.
   It has been realised that this method cannot be economically justified for the sole purpose of producing graphics by computer drafting. With no other alternative available, this system will however continue due to the shortage of cartographers for the production of line maps, the need to create a digital topographic database as a direct output of the Base Mapping Programme and to compile and update resource data.
   In parallel, other solutions can be developed:
   - conversion of the existing photogrammetric system into a digital system, as direct input to the existing computer-assisted cartographic system

- conversion of the digital output of the existing orthophoto system for compatability with the existing computer-assisted cartographic system

Interfacing photogrammetric plotters with a digital computer and direct digitization (of planimetric as well as height information) on a stereomodel will improve the operational characteristics. Further the on-line interactive display and editing capabilities will give the operators control over the recorded information, the verification of data and the edge enhancement between adjacent models [1].
The on-line editing on the other hand will add an extensive load to the 'traditional' photogrammetric operators and with the present computer capacity at Bakosurtanal it will slow the computer responsiveness considerably. This is particularly the case when several subsystems (i.e. photogrammetric ploters, digitizing tables, editing stations, etc.) are supported by the same computer.
The future development at Bakosurtanal will go towards the development of multiple sub-systems in a distributive computer network as outlined in [2], but the start will be on a simplified approach as implemented in [3]. Each subsystem is provided with a microcomputer (personnal computer type) which is capable to support digitization and assignment of attributes, data compression and formatting, graphical display, coordinate transformations, etc., and to support data transfer to the central computer and the master database. Compatibility must be ensured between these various sub-systems. Extensive and time consuming editing functions can be performed separately on the COMARC editing stations.
Due to financial and technical reasons and the necessary training required for the photogrammetric operators, however, it might take long time before such a system can be implemented and can become beneficial. Therefore, a decision was made to develop, as an intermediate solution, a software package for (off-line) reformatting and structuring the recorded output (on magnetic tapes) of the photogrammetric instruments such that it is compatibel with the COMARC computer graphic system and its data management package COMPIS. Details are given in chapter 4.

2. In addition to this problem of data entry, the processing of elevation information for the purposes of creating a DEM coverage and producing orthophotos suffers from another shortcoming due to the limitation imposed by the present version of the SORA package, as also pointed out in [4]. This version performs a "flight oriented" processing, where height information from a single or two neighbouring models can be processed to produce one orthophoto. Difficulties will arise when height information is extracted from an existing data bank or from a flight other than that used for the production of the orthophotos and when more models from neighbouring flight strips might be needed.
It is required to design a flexible system (and the necessary software) which allows a separation between the establishment of DEM coverage and the orthophoto production. Basically, the processing of height information for the DEM coverage should be based on the map sheet lay-out of one of the National Base Map series, while the extraction of the necessary heights from the DEM Data Bank for the orthophoto production should then be the next step to follow as one of the many possible applications of this DEM.

3. In view of the afore mentioned problems, and with the current rate of map production (for line maps as well as photo maps) the national base mapping programme will continue to face the challenge of having to keep up with the resource inventory activities, where the various resource agencies urgently require a 'geographic base' for the presentation of their resource surveys.
   As a substitute, the use of aerial photogaphs in areas lacking base map coverage, could be a solution and thus the inventory need not wait until the completion of photogrammetric manuscripts or orthophotos. The entire coverage of the country with aerial photography will soon be completed [7], and the users will have easy access to them via the developed Information and Documentation System for Aerial Photos and Maps, INDOFOTO [11].
   The usefulness of this substitute, however, will ultimately depend on the ability to transfer the interpreted data onto these images and to the geographic reference system in order to allow their integration with other resource data in the Geographic Information System.
   The use of simple graphical or analogue means for image to map transfer will violate the accuracy standards of the Inventory Programme [6]. For this reason, the 'mono-technique' has been applied so far for rectified or orthophotos in order to facilitate the transfer of interpreted data to the geographic base.
   When the DEM-coverage is available in an area, the use of the digital mono-plotting concept provides on the other hand an effective means as an updating process that reflects the dynamics in the resources data, particularly renewable resources, [5]. In this approach, resource data is extracted from the photographs and is then digitized. The digitized data is transformed in an iterative fashion into the map geometry, using the photo exterior orientation elements and the ground relief of the DEM [9].
   When such a technique can be implemented, then the production of orthophotos if done solely for thematic mapping is not justifiable. Once the aerial photography mission has been completed, natural resources specialists can start to interprete these 'original' photographs, extract, mark and code relevant information, digitize and store on the computer for later processing by the digital mono-plotting package. The last step is the responsibility of the Geographic Information System Manager (Bakosurtanal) and will be performed when the topographic information is complete.

4. SOFTWARE DEVELOPMENTS

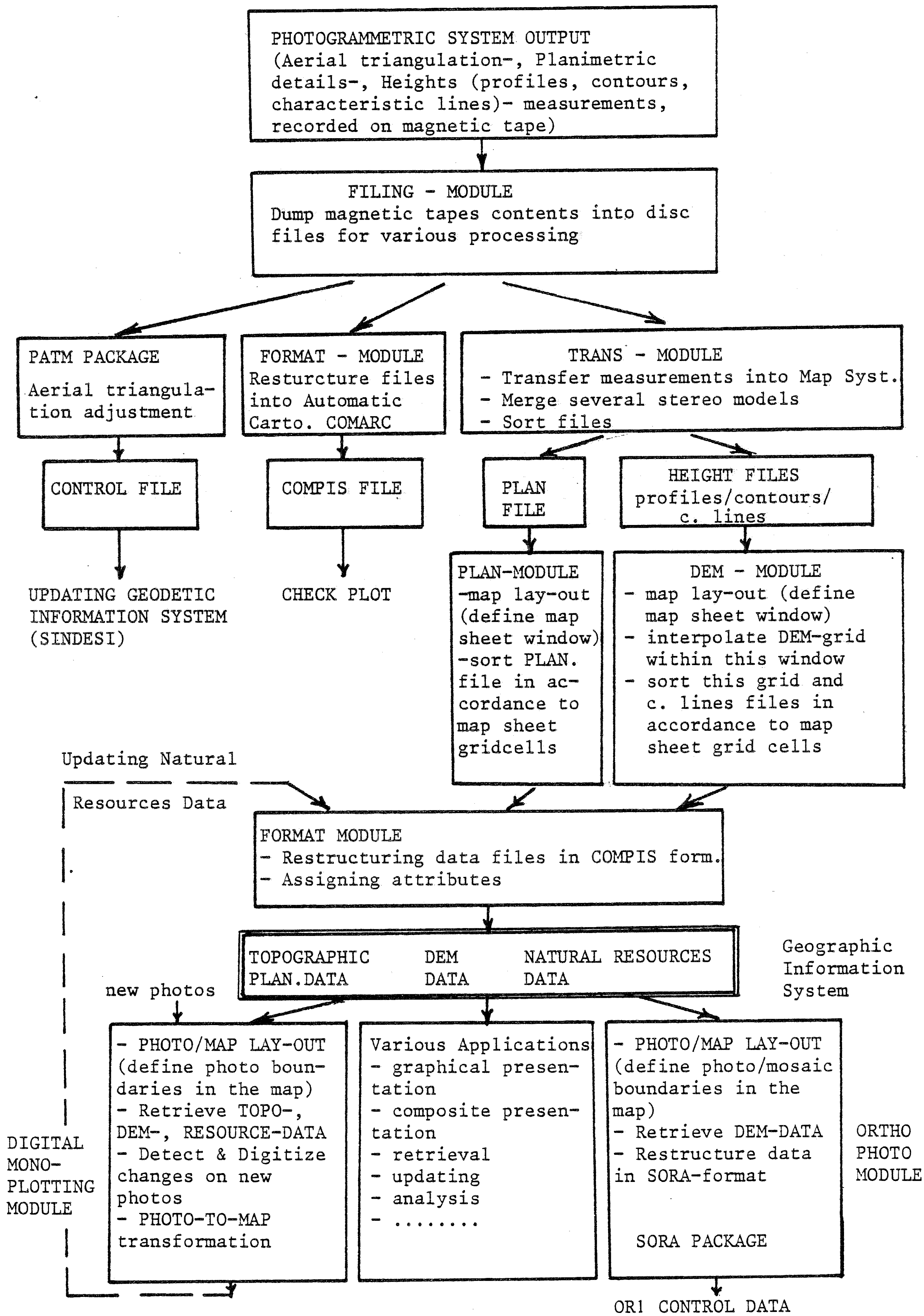
In view of the afore mentioned problems and assigned solutions, a special software package (RAD-PACKAGE) has been designed as outlined in figure (3), in order to support the following tasks:

Task (A): reformatting and structuring of the output of the photogrammetric and orthophoto systems to be compatible with the COMARC computer assisted cartographic system.

Task (B): management of digital terrain height information

Task (C): supporting of the off-line orthophoto production

Figure (3): Integrated Digital Processing at Bakosurtanal (RAD)



Task (D): transfer the resource data, as interpreted on aerial photographs, into the geographic reference system (the digital monoplotting concept).

The basic requirement of this package is modularity for easy use, modification of input/output and file handling operations and extension of tasks. This package is also compatible with the existing software packages at Bakosurtanal, namely SORA-OP, PATM and COMARC packages for Grid Interpolation (DEM), Contour generation (CONTOUR) and data management (COMPIS). This allows easy data transfer between the various modules of the RAD package and other packages.
Further the RAD-package can call many of the modules included in the Data Management package (COMPIS) for the purpose of data retrieval, updating, plotting and composite presentations.

The RAD-package consists of four basic modules, namely FORMAT-, DEM-, ORTHO- and DMP-Modules, in correspondence with the above mentioned four tasks. The user can in a dialogue mode via the main module RAD, run these four modules either individually or in combination. A detailed description of these modules is given later.

In order to perform the specific tasks involved in these basic modules, a set of supporting modules have been developed, such as:

- <u>FILING MODULE:</u> It dumps the magnetic tape output from the photogrammetric equipment (WILD EK 22, WILD RAP, etc.), to disc files of suitable structure for the other modules such as PATM, SORA-OP, TRANS, FORMAT, ORTHO, DMP, etc. Further it includes all necessary instructions for handling input/output files on various media (discs, magnetic tape, etc.)
- <u>TRANS-MODULE:</u> It performs coordinate transformations (plane-, space-, and polynomial- transformation) of the stereo-model data (planimetric coordinates, profiles, contour lines, characteristic lines, etc.) into the map system. The transformed data are then sorted out into various disc files according to data attributes or specific locations (windowing). Data from various stereo-models from the same- and /or from the neighbouring strips, after being transformed to map system, can be merged into a single data file.
- <u>SPACE RESECTION-MODULE:</u> It provides the exterior orientation elements of single photographs.
- <u>PHOTO-TO-MAP-MODULE:</u> It transforms the photo-coordinates of the mono images into the map system, using height information from the DEM files, and the exterior oreintation elements of the photographs (Digital Mono-Plotting concept).)
- <u>MAP-TO-PHOTO-MODULE:</u> It locates the map feature points (map x,y coordinates) in the photo system, using height information from the DEM files (for interpolating heights) and the exterior orientation elements of the photographs.
- <u>MAP-LAY-OUT-MODULE:</u> It provides the map sheet lay-out and the boundaries of its grid-cells in the geographic reference system. This information is used to access the Geographic Information System which is a grid-cell system [6].
- <u>PHOTO-LAY-OUT-MODULE:</u> Using the PHOTO-TO-MAP-MODULE, it provides the photo boundaries in the map system.
- <u>PHOTO-MAP-LAY-OUT-MODULE:</u> Using the MAP-LAY-OUT and the PHOTO-LAY-OUT Modules, it provides the grid cells within the photo coverage on the map.

All corresponding topographic resource data can then be retrieved from the Geographic Information System.

In the following, the four basic modules are outlined in detail.

4.1 FORMAT-MODULE

this module reformats and structures the various data files produced by other modules, DEM, FILE, TRANS, DMP, etc., into the five file structures in the COMPIS package, namely ARCS, LINES, POLYGON, TOPO and GRID files. It also assings various atrributes, up to 16 attributes, which provide links between data items in these files and the resource data base.
This module allows the conversion of the existing photogrammetric system into a digital system, as direct input into the COMARC computer-assisted cartographic system. All facilities in this system can then be applied such as computer-supported editing, automatic drafting, compilation of various map series, composite presentation of resource data, creation-/updating of topographic data bases, etc.

4.2 DEM-MODULE

This module generates a DEM coverage from the height information available as output from the Base Mapping Programme, mainly from the orthophoto production phase. This DEM coverage will be in the form of a regular DEM grid and characteristic lines. Although these two forms are stored separately on disc files (one file/mapsheet) they are nevertheless interrelated via attributes which provide entry to each others files.
The main features of this module are:

- input: TRANS-Module output
- regular DEM-grid is interpolated through the GRID-INTERPOLATION-Module in the COMPIS-package [8].
- using the MAP-LAY-OUT-Module, and the EXTRACT-Module (COMPIS package), a TOPO file is created from the DEM grid data covering one map sheet lay out. DEM grid data covering one grid-cell forms one record in this file.
- the same procedure is repeated with the characteristic line data and sorts them map sheet wise.
- correspondance between the DEM grid file and the characteristic line file, covering the same map-sheet, is establsihed through attributes. Such an attribute defines whether a particular grid-cell has characteristic line data and the record in the characteristic line file.

4.3 ORTHO-MODULE

This module extracts the necessary height information from the DEM coverage data base in order to support the production of orthophotos. This information, in addition to other data, is then structured in the form as required by the SORA-OP package. No special reference is made to the source of the height information or to the flight configuration from which they have been extracted. This module can handle two cases:

4.3.1 ORTHO SINGLE:

It handles the case where a single orthophoto is produced.

4.3.2 ORTHO-MOSAIC

It handles the case where a group of orthophotos is produced to form a single mosaic. The exact portions of the original photographs will be processed thus reducing a large amount of manual mosaicing, [10]. As a result, many 'sub files' of height information and additional data, will be produced for each of the original photographs. Each of these sub-files belongs to one of the neighbouring mosaics which have that photo in common. Although these sub-files will be processed separately their processing is done sequentially in order to reduce the time required for loading and unloading of the photo transparency in the orthophoto projector. More results will be published later about the efficiency of this module, [10].

In the ORTHO-SINGLE-MODULE the steps involved are:

- using the PHOTO-MAP-LAY-OUT Module and the EXTRACT-Module (COMPIS package), all necessary height information is extracted from the DEM coverage data base.
- using the photo boundaries, derived from the PHOTO-MAP-LAY-OUT Module, then orientation of the flight line with respect to the DEM coverage (which is map system oriented) is established.
- all this derived information is then reformatted and structured in the form required by the SORA-OP package, which will in turn provide all control data for the WILD OR-1 orthophoto equipment.

In the ORTHO-MOSAIC-MODULE the steps involved are:

- using the PHOTO-MAP-LAY-OUT-Module, the boundaries of the photographs, forming a single mosaic, are derived
- from the coordinates of the boundary points of the neighbouring photographs, the mid-lines in the overlap areas are derived. When the flight direction coincides with the geographic reference system, i.e. east-west or north-south, which is the normal practice when mosaicing is a primary product, these mid-lines will coincide with the map-grid lines. These mid-lines are then used as the photo boundaries of the individual photos.
- for each photo, the ORTHO-SINGLE-Module proceeds with these new boundaries and produces a sub-file with all necessary information for the SORA-OP package.

4.4. Digital Mono-Plotting DMP-MODULE

The process of updating resource data involves two basic tasks:

- interpretation of the new photographs and detection of changes
- updating the resources data base with the extracted changes.

Accordingly, the software package for the DMP-Module as presented in [9], has been modified to include further tasks and to insure compatibility with the COMPIS package and the DIPIX Digital Image Analysis System, as follows:

4.4.1 DMP-A MODULE

It provides tools to the natural resource specialists in order to assist them in detecting relevant changes on the new photographs when compared with the resource data presented on National Base Maps. The contents of the base map are geometrically transferred into the projection system of the aerial photographs to allow superposition of these two information carriers. The steps involved are:

- using the PHOTO-TO-MAP-Module, the DEM data TOPO-files for the area under consideration, and the exterior orientation elements of the new photos, the photo boundaries are located in the map system.
- using the EXTRACT Module (COMPIS package), these boundaries are used as a window to retrieve the planimetric coordinates of the aera points (POLYGONS) which correspond to the chosen label i.e. resource data

type, from the POLYGON-file in the resources data base. A new data file is created, say FILE(A).

- using the MAP-TO-PHOTO Module, the DEM data files and the exterior orientation elements, the feature points in FILE(A) are transformed to the photo system and a new data file with the same file structure as COMPIS files, is created, say FILE (B).
- Depending on the method used for photo-interpretation, this module provides two alternatives:
  a. for conventional interpretation, the co-ordinates in FILE(B) are plotted via PLOT-Module (COMPIS package), on a transparant sheet. These transparancies are then superimposed on the new photographs and the natural resources specialists can start to identify and mark the changes in the items of interest.
  b) when the DIPIX Image Analysis System is used, the coordinate FILE (B) is transferred to raster format via the VECTOR-TO-RASTER MODULE available in the DIPIX package and stored on disc file. This file can be displayed and superimposed on the image file of the new photographs to form a composite image. The image file is obtained by digitizing the new photographic film with the DIPIX image digitizer. The natural resources specialist can make use of the various capabilities of the DIPIX system in order to identify the changes on the composite image and produce hard copies with these changes being annotated.

4.4.2 DMP-B MODULE

This is the geometric phase where the interpreted information is transferred to the geographic reference system and merged in the existing data base. The steps involved are:

- Digitize the annotated changes on the photographs via the COMARC system and give the required labels which specifies the data type and provides the necessary instructions for addition and/or deletion of data items. A new POLYGON file is created, say FILE (C).
- Using the PHOTO-MAP-Module, the DEM files and the exterior orientation elements, the photo coordinates on FILE (C) are transformed to and replaced by the map coordinates.
- Using the REPLACEMENT and MERGE-Modules in the COMPIS package, data on FILE (C) are used to update the original resource data base files.

5. CONCLUSION

The RAD-package is a modest development which allows the various data collection subsystems (photogrammetric-, orthophoto-systems, etc.) to be compatible with the available graphic system and its data management system. It provides the possibility to overcome the bottlenecks resulting from the shortage of cartographers, the possibility to develop a topographic data bank as direct output of the photogrammetric output and flexibility in the orthophoto producation as one of the many possible applications of the DEM data bank. Introducing the concept of the digital mono plotting system allows the resource surveys activities to go in parallel with the base mapping production.

Further development is still going on in order to optimize the various modules of this package and evaluate its contribution in the Base Mapping Programme.

6. ACKNOWLEDGEMENT

The authors acknowledge the support offered by Ir. Pranoto Asmoro, Chairman of Bakosurtanal, staff of the Data Processing Depaartment at Bakosurtanal and the Directorate of the ITC, Enschede. Special thanks to Mr. Sri Kusmo Gularso for his contribution in the implementation of the RAD-package.

REFERENCES

[1] Allam, M.M., Interfacing analog photogrammetric instruments with digital information system, ASP Annual meeting, March 1979.

[2] Allam, M.M., Acquisition of digital topographic data and the need for a standardized digital data base, ISPRS Commission IV Sympisium, Canada, 1982

[3] Brunnthaler, F., Hansa Luftbild, Multi cartogrphy and computing system.

[4] Haitzmann H, Kraus K., Loitsch J., A data base towards the digitally controlled production of orthophotos, ISPRS Commission IV, Hamburg 1980.

[5] Makarovic, B., Data base updating by ditial mono-plotting, ITC Journal 1982-4

[6] Pranoto Asmoro, Technological and Institutional support systems for resource management programming, Integrated Surveys in resource management Symposium, Manila, 1978.

[7] ------------, Developments in Mapping in Indonesia, ITC Journal 1982-2.

[8] Paul Suharto, Terrain information analysis based on DTM, Symposium on DEM and orthophoto technology, Australia, 1981.

[9] Radwan, M., Makarovic, B., Digital mono plotting system - improvements and tests, ITC Journal 1980-3.

[10] Radwan M., Computer controlled mosaicing, (under preparation).

[11] United Nations Regional Cartographic Conferende for Asia and the Pacific, Cartographic Activities in Indonesia, New Zealand, 1980

[12] -------- ,Bangkok, 1983