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Medium Scale Digital Mapping Project in Indonesia

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1. INTRODUCTION

The present general mapping situation in Indonesia is characterised by a poor availability of updated analogue base maps in medium and large scales which therefore makes available only limited facilities for the management of infrastructure and resources. The use of a Geographical Information System (GIS) is at a preliminary stage, and ad hoc thematic maps are therefore produced by various user organisations as a result of the limited availability of common base maps. An ongoing project "Large Scale Maps of 100 Cities and Towns in Indonesia", will, to a certain extent, meet some of these basic requirements for large scale maps.

The need for general and co-ordinated base mapping in Indonesia is emphasised by the country's high population density, particularly in Jawa, intensive land utilisation and Indonesia's general economic growth. The country is experiencing considerable development of its infrastructure and has put increased emphasise on sound planning of operations and maintenance of existing infrastructure. Furthermore, there is a growing awareness of the need for monitoring, conservation and improvement of the environment.

The project "MEDIUM SCALE DIGITAL MAPPING OF JAWA, BALI AND NUSA TENGGARA" has been defined to meet the above requirements by producing digital basemaps of scale 1:25,000.

The basic skills and expertise required for the implementation of this project is present within Indonesia's mapping authority, BAKOSURTANAL, and within the private sector in Indonesia. However, to satisfactory implement the project, and in particular in consideration of the size, duration and technology involved, the need for specific expertise and resources was recognised, and is today provided by Blom A/S of Norway together with P.T. NARCON in Indonesia. Part of the objective of the project is to establish expertise and capacity within BAKOSURTANAL to fully supervise the implementation of the project and to establish both a production environment for digital base mapping, and to transfer skills, know-how and to develop and build up the capacity in the private sector to ensure a successful continuation of the project.

2. DESCRIPTION

The signing of the contract for Medium Scale Digital Mapping of Jawa, Bali and Nusa Tenggara was done on November 23, 1992.

The Project Budget is approximately US$ 50 Million. The Norwegian part is financed as a soft loan with some interest subsidies from the Norwegian Government.

Included in the project budget is purchase of hardware and software that will be used during production and for training and technology transfer.

The work to be performed covers 215.000 km2 which equals 9,950 map sheets at scale 1:25,000. Aerial photos will be taken at picture scale 1:50.000 and, for the urban areas, 1:30.000. Approximately 39.000 line km will be flown. Airborne kinematic GPS is used during execution of all aerial photography, thus reducing the need for ground control points drastically.

The mapping area is divided into 40 photo blocks. Each individual photo block represents the unit for aerial triangulation. One ground control point is required in each corner of any photo block. Extra cross-lines must also be flown at the start and at the end of each block to strengthen the aerial triangulation. Approximately 170 ground control points will be premarked and measured by GPS.

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All flight lines within a block are to be documented by delivery of approved photos with corresponding kinematic GPS. Optimal photo conditions are difficult to achieve. Clouds are frequent most of the time. The use of GPS adds further constraints to the accomplishment of the flight operation. Additionally, the terrain height vary from 0 to 3.000 meters with peaks up to 5.000 which frequently makes it necessary to rapidly change flight levels. This may cause gaps both in the flight lines and in the GPS measurements.
Few of the islands east of Lombok have an established levelling system. Mean Sea Level will therefore be established for each island. Height measurements by means of GPS would not give the necessary accuracy since the current geoide model is too weak for this area.
Approximately 9,950 models will be established for aerial triangulation and mapping.
Digital production techniques will be used throughout the project. Data will be acquired digitally by means of analytical stereo plotters and transferred to the Geographical Database, which will be updated with field edited information. All information necessary for cartographic presentation (editing and generalisation etc.) will be kept in a Cartographic Database. Testplots will be produced on colour raster plotters showing approximate colour presentation.
Each of the 9,950 map sheets will be printed in a varying number of copies (minimum 500, maximum 2000).
The stereo plotting is planned to last 4 years which means that 45 models or 8 map sheets must be finished every week.
The cartographic editing is planned to last 5 years, i.e. 6 map sheets must be finished every week.

2.1 Analogue and Digital Production Methods.

This mapping project will utilise both analogue and digital production methods, although the bulk of the production will be performed with fully digital methods.

2.2 Data Acquisition

The Survey of Ground Control Points will be done by the use of GPS in the horizontal plane. Precise height information is difficult to obtain with GPS because the geoide model in this area is still too inaccurate. Trigonometric height measurements or levelling will be used in the areas where a basic height network exists. Otherwise the Mean Sea Level will be established by tide measurements and modelling.
Aerial Photography is carried out with continuous GPS measurements at each photo centre, thus reducing the need for ground control points drastically.
Photogrammetric Plotting will be carried out using analytical stereo plotters. The information in the photos is digitized in 3 dimensions with appropriate feature codes.
Field Editing will be based on manuscript maps. Corrections and additions will be digitized on digitizing tables with combined interactive editing of the Geographic Database. Field editing will also include selection of names, administrative boundaries, road classification etc.
Data acquired during photogrammetric compilation will be stored in the Geographic Database as 3-dimensional data with an accompanying feature code. Field editing data will be stored as 2-dimensional data. All data will be assigned a quality code, a date of origin code (in addition to x, y, z) and a feature code. The Geographic Database will be built up as a general storage of photogrammetric and field edited data, independent of the map sheet layout.
The Cartographic Database will contain cartographic modifications for each map sheet. These modifications will be assigned during manual editing.
The Geographic Database and the Cartographic Database kept physically will be in one database. Data may be transferred to other databases (GIS) by means of standard interchange formats.

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The Cartographic Design work is done digitally by means of graphic editing and raster plotting. Preliminary plots are drawn by a colour raster plotter showing approximate colour presentation. The final plots will be drawn in black and white, one for each printing plate.
Colour Offset Printing will be carried out in 5 colours.

3. COMMENTS

Through the execution of this project, and with the establishment of up-to-date, high quality database for digital base maps at a scale of 1:25,000 for such a large part of the country, Indonesia has made a considerable step ahead in its continuing development.
These base maps will give authorities and planners an indespensable tool for making decisions and to achieve high yield for their investments as high quality maps will always form the basis for all significant planning purposes.
By employing modern technology and through a sound and integrated co-operation between the executing company, BAKOSURTANAL and the Indonesian private mapping industry, the results of this project will be of considerable benefit to the country and its people in the foreseeable future.

3.1 Experiences so far

The project was mobilized May 1993. The total project period is 91 months (7 years and 7 months). By end of May 1995 after 25 months, the following work has been performed (total workload enclosed in parenthesis):

Premarking	170	(170)	Points
Natural Passpoints	47	(64)	Points
Horizontal Ground Control	160	(182)	Points
Verticalal Ground Control	172	(246)	Points
Aerial Photography	37,300	(40,733)	Line km
Kinematic GPS	9,200	(10,300)	Photo Frames
Aerial Triangulation	3,000	(9,950)	Models
Stereo Plotting	100	(1,678)	Sheets
Field Editing	57	(1,678)	Sheets
Geographic Database Establishment	57	(1,678)	Sheets
Cartographic Database Establishment	17	(1,678)	Sheets
Printing	0	(1,678)	Sheets

The project area covers 215,000 kmý. This is approximately 60% of the total area of Germany. The project area has a population figure of 120 million people, approximately 150% of Germany's population.
The project staff consists of 127 members in Indonesia including 13 Norwegian expatriates. Local staff has been given education and on the job training as follows:

Surveying and Field Editing	21	
Aerial Triangulation and Stereo Plotting	25	
Terrain Modelling	2	
Database Establishment, Editing and Cartography	18	
Office Management		2
Administrative Tasks (office personnel)	19	
Computer System Operation	5	

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The actual number of participants in the education programs have been more than the double. Operators have, among other, been recruited from the technical university in Bandung. After screening, the final number has been reduced with more than 50%.
In addition, the Client have been given training. A small capacity production line is installed in the Client premisses. 28 employees have been given basic training and 5 of these are now working as Counterparts to the Project Assistance Group (refer below) on a full time basis.
The project language is defined to be English. However, it was initially recognised that the local operators were not able to use English as their work language. Instead, the expatriates working in the production had to learn Indonesian. All documentation, programs menus etc. to be used at operator level are now written in "Bahasa Indonesia". By now Indonesian supervisors are undertaking training of new expatriates. All reports etc. are still written in English.
The expatriates are devided into two teams. The Technical Advisory Team of 8 members supports the production taking place in Bandung. The Project Assistance Group is working in the Client's premisses in Cibinong nearby Bogor and is supervising the Client and undertaking quality control. The latter team is also responsible for building up and maintain of the Project Quality System.
The following experiences may be of general interest:

- To ensure correct positioning of the premarks within the crossing of a transversal strip and a cross strip building up a block; the field teams used handheld GPS receivers since no topographic maps at a scale larger than 1:250,000 were available in most of the project area.
- The signalizion material of the premarks were often removed by local people. It is thus important to measure not only the premarked location but, in addition, some natural details visible in the picture to be used as backup if the premarking is removed prior the flight operation.
- Horizontal Ground Control by means of GPS has been undertaken with good results. It is of great importance t instruct the field team to male extensive documentation of measurements and point locations (sketches) etc.
- Additional Natural Passpoints had to be measured. The total number of Ground Control Points had to be exceeded to secure good geometry in the photo blocks.
- The aerial photography operation is undertaken by a local company operation the Client's aeroplanes. Certain areas of Indonesia are almost constantly covered by clouds and this, in addition to the demand for good KGPS results, complicates the flight operation.
  Ideally, the areas should be flown on a block per block bases. However, this demand is difficult to fulfil due to the extent of the project area (2,750 km in East-West directions) and considerable transport distances to the different blocks. These transport distances are, if conditions are satisfactory, combined with photography operation.
  It is very demanding to keep track of all photos, the KGPS results and their quality. The Contractor has developed a computerized monitoring system for visualization of photos and KGPS results in comparison to the flight plan.
- Aerial Triangulation results are very good. Since the photo blocks seldom have the theoretical rectangular shape, additional passpoints are needed. Refer to comment above.
  It has also been obvious that breaks in the KGPS data within a block have to be accepted based on certain criteria, e.g. the neighbouring strips are unbroken.
- Stereo Plotting tasks more time than originally expected.
  A feasibility study was carried out in 1990 concluding that the data acquisition should bed undertaken by digital methods. However, it was recommended to undertake cartography by way of both digital and manual methods (some digital and manual scribing and typesetting and masking techniques for screens). During contract negotiations this was changed to a full digital production line. The ratio between man hours used for Stereo Plotting verses Cartography was in the feasibility study described to be 1 to 2. After introduction of a full production line, the ratio is 4 to 1, limiting the cartographic work to batch processing and very little manual editing.

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Originally it was also planned to plot contour lines during the stereo compilation phase. This procedure has been terminated and replaced by measurement of a 100 by 100 meter grid and breaklines because:

- It is much easier to train an operator to acquire grid points and break lines than contour lines.
- The accurancy of contour lines generated by means of a terrain model gives a much more uniform representation of the terrain and the accurancy is well within the half of the contour interval, which is the quality criteria. (The contour interval is 12.5 meters).
- It gives a better representation of the terrain in forested areas.
- It gives better completeness and speeds up the stereo plotting in mountainous areas.
- It is possible to undertake preliminary aerial triangulation and stereo plotting prior to final approval of tidal measurement in areas where basic height network do not exist. When the final height network is established, all data is transformed from preliminary height network to final height network and contour lines in correct level are generated.

• Aerial Triangulation and Stereo Plotting are now undertaken by 7 instruments 7 days a week at 3 shifts. Administration of data is a major task. VAX/VMS based Phocus with its central database has been suitable for handling parallel work in different blocks and by several operators per block.
• All data are collected map sheet vice before entered into a seamless database where all polygons and lines are linked together. Sysdeco (former SysScan) MAPMAN and GINIS software are used for the database system (Geographic and Cartographic Database).

- Cartography
- Printing

The production line will reduce the field activity to only one visit on each island during the full project time.
• The following equipment is used:

GPS measurement
Trimble 4000 SSE and Trimble Plus and Trimble GPS Survey SW

Aerial Photography
Leica RC20 and Topas Turbo SW for processing of KGPS. In addition a special programme developed by the Norwegian Agricultural University is used for processing of data from certain areas where the TOPAS SW is unable to cope.

Aerial Triangulation
Zeiss P3 with Phocus, PATB-RS/GPS and SKIP SW

Stereo Plotting
Zeiss P3 with Phocus SW

Terrain Modelling
MOSS SW

Database Establishment, Graphic Editing and Cartography
Sysdeco (former SysScan) GINIS, GINPLO and MAPMAN SW and Blom developed routines

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All SW is based on either MS-DOS/Windows operating system (GPS or KGPS processing) or VAX computers utilizing Open VMS operating system.