

## ADVANCES IN MAPPING IN INDONESIA

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### ABSTRACT

The Indonesian civil mapping community, represented by BAKOSURTANAL has embarked on an ambitious mapping programme. Considerable short term conventional production goals are combined with long term goals to incorporate digital techniques and to use radar and satellite imagery. The private sector is involved in the process to secure an adequate production capacity in the future.

### INTRODUCTION

The Indonesian civil mapping community is represented by BAKOSURTANAL (Badan Koordinasi Survey dan Pemetaan Nasional), the National Coordinating Agency for Surveying and Mapping. BAKOSURTANAL is responsible for the production of base maps, as well as the coordination of resource inventories and mapping activities, which are conducted by the sectoral resource mapping agencies. As such its competence comprises also the establishment of basic geodetic networks, synchronizing the acquisition of imagery, and cartographic finishing of thematic maps. The Agency was founded in 1969. In 1978 it had a staff volume of 50, by 1988 it increased to almost 600.

A look into an atlas makes it evident: Indonesia covers a vast territory, roughly 2 million sq.km. A review of Indonesia's mapping history [1] makes it clear: Systematic mapping is still fragmentary. A query to the the Five Year Development Plan of the Republic of Indonesia reveals it: There is an urgent need to provide up-to-date information for planing purposes. Indonesia's population of about 180 million is very unevenly distributed. Roughly 100 million live on the islands of Jawa, Madura and Bali with an area of only 10% of the national territory. The much larger islands -Sumatera, Kalimantan, Sulawesi, and Irian Jaya- are underpopulated, with vast uncultivated areas. The Government of Indonesia considers the uneven distribution of the population to constitute a serious fold for the country's development and economic growth.

Since the beginning of the century programmes have been carried out to transmigrate people within Indonesia. They have been aiming at

- improving the living standard of both the migrant and the non-migrant population, as well as that of the original inhabitants of the transmigration areas;

- decreasing population pressure, especially in areas that are vulnerable to environmental degradation;
- increasing food and tree crop production.

However, in former transmigration programmes disconnected geodetic control, lack or non-uniformity of maps and lack of other planning prerequisites contributed to occasionally selecting the wrong transmigration sites. This resulted in human suffering and ineffective use of funds. Provision of basic information was considered being of utmost importance in planning and implementing the current Transmigration V Programme (1984-1989). Therefore, the current programme includes both a resources evaluation and settlement planning part and a mapping component. The mapping component was defined with a much wider scope than satisfying the immediate needs within Transmigration V. BAKOSURTANAL was entrusted with base mapping and all related tasks.

Next to mapping, BAKOSURTANAL is also involved in a Land Resources Evaluation and Physical Planning Project (LREP). The overall concept of this project was outlined in [1]. LREP aims at supporting day to day planning of provincial authorities in areas that are already developed to some extent. For BAKOSURTANAL it means establishing the framework of a computerized geographic information systems network and building the topographic database component. The first phase network will link topography, hydrology, soil classification, and regional planning information - for the island of Sumatera only.

#### TRANSMIGRATION-V PROJECT

Given the incentives of the Transmigration V Programme, a four year project commenced at BAKOSURTANAL in 1986, financed by the International Bank for Reconstruction and Development (IBRD) and the Government of the Republic of Indonesia. Its three aspects are:

- (1) Start-up activities for Transmigration V (SUAT V)
- (2) Upgrading of geodetic control and topographic base mapping
- (3) Institutional strengthening of BAKOSURTANAL itself and of the Indonesian mapping community as a whole.

SUAT V represented the short term goals, which have already been achieved. They included the delivery of basic documents for delineated transmigration sites. Aerial photography was acquired and (semi-controlled) photomaps were produced. Areas persistently under cloud cover were scanned by radar (SAR) and radarmaps were produced digitally, conforming to the framework of 1:50.000 base mapping.

The mid term goals concerning bulk production are listed in Table 1. The challenge becomes obvious, if one considers the time constraints and the volume of work involved.

<p>acquisition of additional aerial photography coverage, scale 1:25.000 and 1:50.000, 30.000 line km</p> <p>12.500 km of APR data capture and aerial triangulation of about 6.200 models (scale 1:100.000 and 1:50.000)</p> <p>production of 760 1:50.000 maps. Both line and annotated photo maps (by BAKOSURTANAL and private sector)</p> <p>establishment of second order levelling networks in Sumatera, Sulawesi and Kalimantan, with a total length of some 13.000 km (by BAKOSURTANAL and private sector)</p> <p>data capture and production of 600 radarmaps scale 1:50.000 and 50 at scale 1:250.000 over Sumatera</p> <p>covering the whole archipelago with SPOT imagery</p>
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**Table 1** Mid term goals

The long term goals take into account the future needs of Indonesia in terms of mapping and dissemination of other basic data for planning. Institutional strenghtening to reach the long term goals listed in Table 2 implies the transition from conventional methodologies to digital techniques, utilization of pertinent non-conventional data sources, such as radar and space imagery, introducing state-of-the-art techniques of geodesy, and last but not least, upgrading the mapping environment. The latter includes enhancing the capabilities in management, improving system maintenance, education and staff training, and promoting participation of the private sector in national production programmes.

<p>integration of geodetic networks</p> <p>implementation of digital mapping, automated cartography, and digital terrain modelling</p> <p>use of SPOT imagery for mapping and map revision</p> <p>use of SAR imagery for map revision and resources surveys</p>
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**Table 2** Long term goals

To assist BAKOSURTANAL in project management, solving scientific and technical problems and developing software related to the above mentioned items, a Technical Advisory Team (TAT) was installed. This consulting team is composed of experts from the International Institute for Aerospace Survey and Earth Sciences, the Netherlands (leading partner), the Forschungsinstitut fur Luftbildtechnik (FLT, now INPHO), Germany, and the Bandung Institute of Technology (ITB), Indonesia. TAT provides for more than 300 man-months of consultancy until 1990 (Table 3).

FUNCTION	MAN MONTHS
Project management/ Senior Project Advisor	48
SAR System Specialist	12
Digital Radar Image Processing Specialist	24
Dual Camera Aerial Photography Specialist	18
Digital Mapping Specialist	12
Automated Cartography Specialist	14
Digital Terrain Model Specialist	24
Senior Geodesist	27
Map production specialist - Photogrammetry	15
Map production specialist - Cartography	15
Aerial Triangulation Specialist	6
Motorized Levelling Specialist	6
Geographical Names Specialist	9
Map Reproduction Specialist	6
Remote Sensing Specialist	6
Computer System Engineer	6
Computer System Analyst	6
Scientific back up	<u>48</u>
Total	302

Table 3 TAT Consultancy

### PRESENT STATUS

In the following a brief overview is given of what has been achieved to date and the factors are indicated which influence further development.

**Geodetic control:** Several local networks exist, but not yet a unified datum. A first order levelling network has been completed for the islands of Jawa and Bali. Second order networks have been pre-reconnoitered on Sumatera, Sulawesi, and Kalimantan. Levelling itself has been tendered to the private sector. Currently local companies, some in cooperation with recognized foreign companies, are carrying out the works. On all major islands a sparse distribution of Doppler points has been established providing control for small scale mapping. Connections with other networks which are based on astronomic observations have not been made or have not been made rigorously. A dense gravity network only exists for Jawa; precise absolute gravity points have not been determined yet.

**Imagery:** Small scale super-wide angle B&W photography has been acquired through the years. Recently 1:50.000 panchromatic material, simultaneously with 1:30.000 false colour infrared photography, has been taken over large stretches of transmigration areas. A complete coverage of the target areas has not yet been achieved, but the contracts for gap closing have been awarded and security clearance has been obtained. Presently, flying is making good progress. Several regions where aerial photography never succeeded, because of persistent cloud cover, were flown with synthetic aperture radar; the derived map (strip mosaic, not geometrically corrected for relief displacement) has become an accepted intermediate product. SPOT imagery (mono, multispectral and panchromatic) has been ordered for the entire territory.

Topographic base mapping: Control network densification by aerial triangulation has been completed for West and East Jawa, parts of Kalimantan and of Sulawesi. APR flights and aerial triangulation for the remaining parts are under contract, due to be performed this year. Sumatera is entirely covered by 1:50.000 line maps, not older than 15 years; because of the rapid development going on in several parts of the island, map revision is already desirable. Considering the size of Kalimantan, only a small portion has been mapped, by SAR and conventional line maps. Mapping of the remaining portion of Kalimantan and of the principal island of Sulawesi is about to commence. Local companies together with foreign ones will carry out the work within 2 years, following traditional methodology. Also a SAR contract for Sumatera is under cover. Moreover, a pilot project for original topographic mapping from SPOT has been defined for an area in Irian Jaya. Local investigations for using SPOT for map revision were conducted recently [2].

The local private companies operating in the field of surveying and mapping have mainly been engaged in large scale work, rather than in small scale national mapping. In forming consortia with experienced foreign companies, strong emphasis is given to transfer of knowledge. BAKOSURTANAL is performing the necessary preparatory, coordinating and supervisory tasks. Under the given premisses it is expedient to employ predominantly conventional techniques in achieving the set out mid term goals. Annotated photomaps and line maps from aerial photographs, supplemented by radar maps of almost permanently cloud cover areas, can be produced within an acceptable period. These hardcopy products satisfy the present needs of the concerned planning authorities, as well as those of the sectoral mapping agencies which require a common basis for mapping various physical parameters. They do not yet have available the capabilities to utilize digital products.

However, while complying with the task to provide basic geodetic control, adequate imagery and base maps, BAKOSURTANAL is preparing itself for the future. Physical planners, government administrators, and other bodies, which currently rely on traditional maps and documents, will increasingly use digital databases and geo-information systems in solving their problems. This implies the steadily growing need to also provide topographic data in digital form. Each mapping organization has to react to evolution and technological innovation in its own way. Decisive are not only present and anticipated responsibilities but also given constraints emerging from the environment, financial resources and available expertise in a wide context. Time is perhaps the most crucial factor for a mapping organization in a developing country. Since introducing new technology is not simply a matter of purchasing hardware and software, difficult management decisions have to be taken.

BAKOSURTANAL has already embarked on digital technology in mapping in the early eighties [3]. All analogue stereoplotters were equipped with digital components. Digitally controlled orthophoto equipment and a computerized graphics system were installed; a digital image processing system was acquired. First experiences in going digital have been gained. They can be used now in a rather rapid transition to fully utilize advanced techniques.

#### FUTURE STATUS

A first step in implementing digital mapping for base map production was the recent compilation of 16 map sheets of 3 islands of Sulawesi. Contouring was done digitally, planimetry plotted with the aid of the RAP system and scribed manually. The present configuration suffers from the lack of on-line editing facilities. Photogrammetric data compilation will be strengthened by an analytical plotter and editing facilities directly accessible to the photogrammetric operator.

BAKOSURTANAL's main thrust in applying computer technology, however, will be LREP for the coming two years. The hardware configuration as installed this year is shown in Figure 1. The topographic database corresponding to a map scale of 1:250.000 will be created and maintained at BAKOSURTANAL, supported by ARC/INFO. The other subsystems of the network will be located at the respective resource agencies and at the provincial planning authorities. Data collection will be done predominantly through manual digitizing of the available maps. Successful utilization of the data made available by the LREP project, for the actual physical planning, will lead to extensions. They include other components of geography and eventually coverage of all major outer islands.

Complimentary to the LREP topographic database, a DTM is currently created. First applications of the digital terrain relief data will be the provision of elevation and slope information for land resources evaluation, geometric rectification of SPOT imagery of the mountainous regions of Sumatera, and terrain correction of gravity measurements. Data capture is already in progress; although exclusively by map digitizing, as far as Sumatera is concerned, the system is designed flexible enough to also accommodate other data sources such as aerial photography, radar, etc. The longer term target is a nation-wide coverage, satisfying a potentially wide spectrum of users. While data administration and maintenance will be conducted at BOKOSURTANAL, data collection will be decentralized.

The plans for introducing aspects of automated cartography are still comparatively vague, because of limited resources and because LREP does not provide for base map production. Under the assumption that the topographic database will carry the most up-to-date and complete data available, it is near at hand to

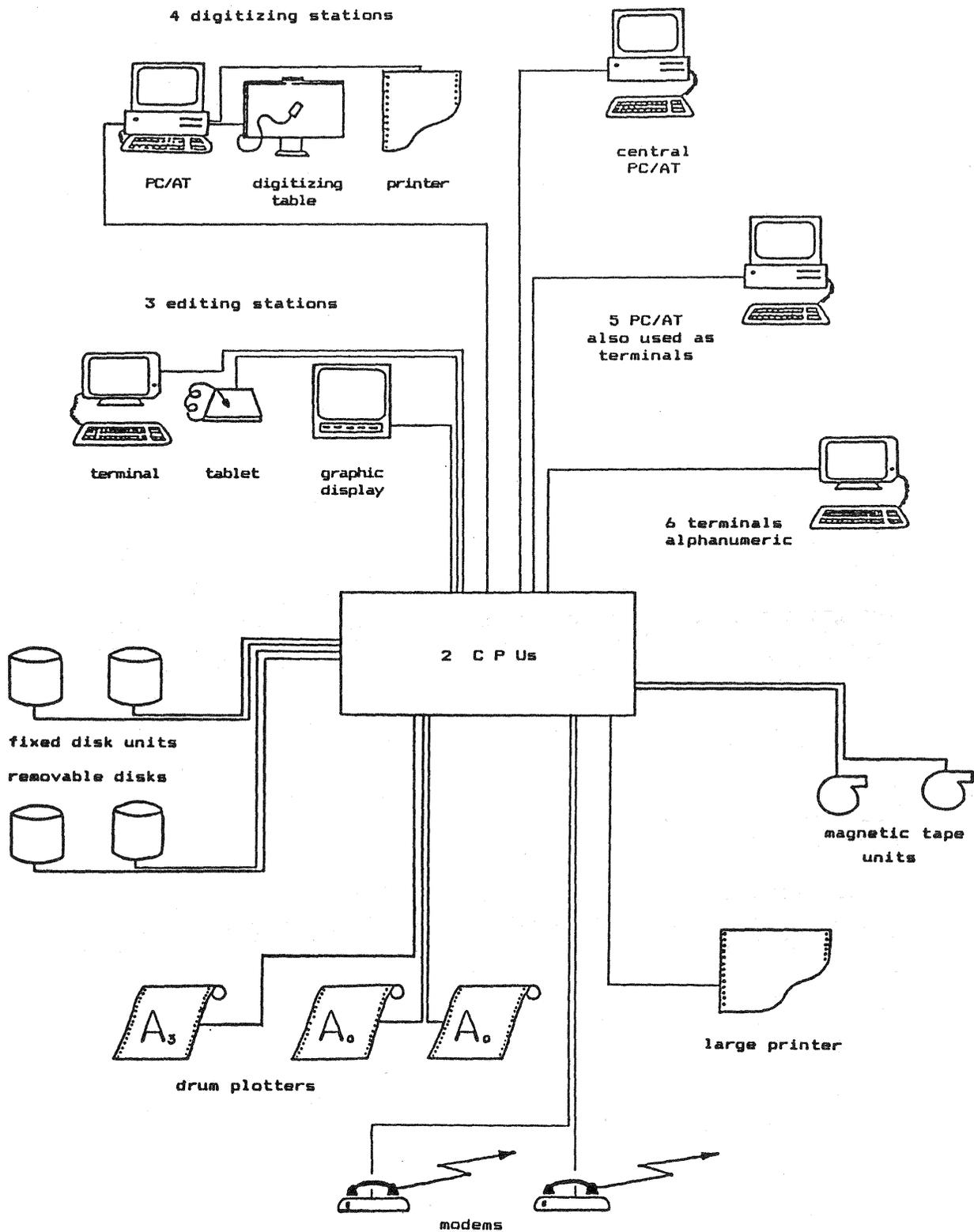


Figure 1 LREP, 1 : 250.000 database hardware configuration

consider the 1:250.000 topographic map production by standard printing procedures from the database. However, the creation of an automated gazetteer has already been provided for in preparing the directives for collecting names for the conventional mapping project.

Beside developing interface software between various systems to finally attain a functional integrated system, development will be continued of an adequate SAR processing package. Development of radar mapping is pursued in two directions. One is to build up in-house capabilities of processing SAR, and the other is to establish sufficient height control to enable stereoradar mapping. SPOT will be used for various resource surveys and also for revision of topographic maps. BAKOSURTANAL is about to launch a programme for the 1:250.000 series.

Collecting all existing geodetic data is continued, to arrive at a unified Indonesian datum. The availability of the GPS satellites allows for precise, uniform measurements over the entire archipelago. However, for connecting the older networks gravity values must be known first. A first GPS campaign will start in the second half of this year. Proposals for further GPS campaigns and first order and absolute gravity measurements have already been formulated. Financial and logistic problems are currently being solved. Depending on the success of the latter actions, more advanced studies in geodynamics and of volcanic phenomena will be initiated. Moreover, geoid determination for the island of Jawa has commenced. The intention is to gradually accomplish this for the entire archipelago.

In introducing new systems and techniques much effort is devoted to enhance the support capabilities. At the end of the Project, reliable power supply, efficient hardware and software maintenance, an operational mechanism to monitor user needs, and an organizational structure attuned to the new technologies should be materialized. Regular maintenance and preventive upkeep is aimed at, to assure optimal exploiting of productive resources, and to prevent emergency repair and replacement outlays. Respective training extends beyond short, dedicated courses, which are offered by suppliers. Broad, general education in maintenance issues is pursued.

Man-power development is, anyhow, an essential part of the Project and is provided for by formal institutional training, both within and outside of Indonesia. Local training continues in the form of day to day contacts with experts and through seminars and workshops. Overseas education is offered at different levels: short courses, often tailor made to BAKOSURTANAL's needs and staff capabilities; postgraduate courses, and MSc and Phd studies related to advanced techniques as mentioned above. Since BAKOSURTANAL can also use regular fellowships for such advanced studies, it is sometimes difficult to decide whether Transmigration-V funds should be spent. In fact almost every staff member holding an MSc, BSc or an equivalent degree is affected by the Transmigration-V or the LREP project, and will be trained or will study overseas.

## EPILOGUE

An ambitious programme like this has of course some inherent pitfalls. Project planning always tends to be optimistic. In the execution various unforeseen obstacles are encountered.

- Administrative problems, often beyond control of an executing agency, give considerable delays.
- Inflexibility in budget procedures prevent money to be spent in an optimal way, satisfying the expected needs during budget preparations, rather than the current needs.
- Infrastructural problems like insufficient maintenance, lack of reliable power supply, funds for spareparts, etc. are other causes of delays.
- The need for formal training and education conflicts frequently with the need for "hands on experience".
- Delays in the progress of the project ask for considerable flexibility from the consultant agencies in mobilizing their experts at times when they are needed most.

The current Transmigration V Programme aims at keeping a balance between ambition and realizable goals. The involvement of the private sector provides for a vast future potential in mapping capacity. Although on the short term the firms have to master the challenges of achieving both the enhancing of proficiency and materializing of competitive production. The transition from conventional to digital and other advanced techniques within BAKOSURTANAL - although causing similar short term problems - is another long term prospect.

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