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THE ASSOCIATION OF SURVEYORS OF PAPUA NEW GUINEA

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THE JOURNAL

of the

ASSOCIATION OF SURVEYORS OF PAPUA NEW GUINEA

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PRESIDENT MESSAGE

As this my very first time to be at the helm of an organisation of professional people, I would like to take the opportunity to thank those who have made it possible Like any other organisation, it is only a figure head. The welfare and running of an organisation depends so much on the support of its committee (Councillors) and its members.

The 1988 Congress in Lae was a successful one which was attended by 63 delegates. The theme of the Congress 'Resource Development" attracted varying papers from special expertise (G.P.S. Surveying) to how to run a small business. Of the 63 delegates 6 of whom came from Overseas and most of them presented papers while others participated very actively at technical sessions and the forum.

At this stage I would like to take this opportunity to all our overseas guest, especially our guests from Australia who have contineously been attending our Congress and therefore it is our responsibility to participate in their Congress.

During my brief speech as the incoming President, I stressed that, it is our responsibility to participate in the running of the Affairs of our organisation, and I would like to encourage the up and coming members to be actively involve in the Association.

It is always my intention to pursue the matter of having a permanent executive position created, although funding of such position is far beyound our expectation. If we want to be truely recognised, we need to have full time personell who in time will committ himself to all the affairs of the association of Surveyors of Papua and New Guinea. Although we have Councillors, their Committment is somewhat hampered by their own work committment which has led to the down fall of Constructive ideas that could not be implemented.

Should any of the members who may support or or against the idea, I would like to have your comments please.

As I will be proceeding on my recreation and furlough leave on the Eighteent of December 1988, my family and I would like to wish every member and their families a Merry Christmas and a Prosperous 1989.

ADELBERT M ALOIS

KEYNOTE ADDRESS TO ASPNG CONGRESS, 1988

RESOURCE DEVELOPMENT :
CHALLENGES AND OPPORTUNITIES FOR SURVEYORS.

When assessing the performance of an economy, the analyst tries to determine how well the factors of production have been used. "Factors of production" is a general term used by economists to describe the inputs or resources used in an economy or a productive process. These factors are classified under four broad headings: land, labour, capital and entrepreneurial (or organisational) skill. There are alternative ways of doing or making most things which means that we have many opportunities open to us, however, the real challenge is to find the most effective way of combining resources so that P.N.G. prospers.

Taking the economist's view, resources are seen to extend well beyond those grouped as "natural"; land, minerals, forestry and fish and so on. My remarks will be directed largely at land and labour; for you are aware that the others are frequently stressed in the media and there is little that I can add to what has been said there. It need merely be noted that the development of natural resources will require a good deal of ordinary, run-of-the-mill survey work on roads, bridges, wharves, power lines, structures, mines, mapping and so on. While some of the work will come to us by looking ahead and preparing for it, it is probable that most of us will just respond to initiatives by others.

However, opportunities to influence the course of events do exist for us, requiring only that we accept the challenges and use our knowledge and skills to arrive at solutions. The problem that will bring about these circumstances and pose the challenge is pressure on the land. It will be caused by two agents: population increase and a rising sea level, both seem almost insidious in that they are unnoticed until it is nearly too late, but are very real for all that.

Economists see population as the resource of labour and you will agree that it is an alternative to capital; exemplified in surveying by the use of manual or electronic methods of measuring distances. To return to the point, the scale of population increase is great. The last census for which I have data was taken in 1980 when the population totalled 2,978,057. The rate of growth from 1966 to 1980 had been a little over 2.2% per annum; applying that rate to the 1980 figure, the total comes to over 3,622,000 by 1989, just a few months away. The situation in the major urban areas is also of concern; Lae can serve as an example : its 1980 population was 61,682 and the rate of increase between 1971 and then had been 5%. If that rate remained constant, the population by 1989 would be 95,600; if it had fallen to 4% the number would be 87,700, assuming a middle figure, there will be an extra 30,000 people over the period. I have been unable to locate data for the 1986 Census so these estimates may need modification.

When analysing population trends a couple of years ago, the Institute of National Affairs looked at a range of likely growth rates and concluded that by the year 2,000 the population would be a little under 5,000,000 and would continue to grow after that. Providing housing and other facilities for these extra people would be enough of a problem on its own, but we live in a dynamic situation and other things do not remain constant, indeed, the amount of available land to accomodate and feed them will itself be reduced as the sea level rises due to the "greenhouse" effect.

We know that the earth is getting warmer and the increase in temperature alone will cause a rise in sea level, but it will eventually go higher for a number of other reasons, one being a partial melting of the polar ice caps. I have no more detailed knowledge of this field of study than is available to any interested person and the following information came from several recent papers on the topic. During the next 50 years sea level can be expected to rise by up to 1.4 metres (the maximum figure) and weather patterns to change substantially from the warming effect alone. It is expected that rainfall will increase in the humid tropical regions by between 5% and 20% at the same time as the temperatures will rise by up to four degrees Celsius. The temperature rise may be expected to result in tropical storms extending into areas where they do not now occur. This means that the area of land available for use will diminish as the sea intrudes and more land becomes saline or subject to storm surges. These effects will pose real problems for politicians and may well have international ramifications beside which the present problems experienced with land rights may pale into insignificance.

The international aspects are beyond our control, but we are still left with a picture of there being a reduced area of land available on which to accomodate and provide for an increased number of people. Keep in mind that it will happen in your lifetime and that this conjunction of circumstances may well make a politically volatile mixture.

In its budget for 1988, the government gave a high priority to lands, agriculture, minerals and energy and fisheries, in addition to other sectors of the economy. One part being emphasised is small-holder agriculture, as is obvious to us at Unitech, where we have had numerous requests to perform various types of surveys for persons and communities so that holdings may be developed.

In my opinion members of this Association have an opportunity to make a significant contribution to the development of land and labour resources by accepting the challenge to formulate a policy that combines the matters discussed above into a development programme for the small-holding sector of the economy. The rewards from the exploitation of minerals, timber and so on are such that they will be developed by entrepreneurs whatever we say or do, hence I argue that we should concentrate on the land resource, about which we have some knowledge.

I have a few recommendations:

1 We should initiate action in conjunction with other bodies to obtain reliable information on changes in the sea level and the climate.

2 We should try to assess the area of land in Papua New Guinea that will become unusable or unproductive for each half metre rise in the sea level.

3 We should approach our sister professional bodies with a view to developing guidelines for land use in coastal areas likely to be affected by these changes.

4 We should make politicians, decision makers and the people aware of the problem and the need to allocate funds to make the above assessments.

Thankyou for the opportunity to speak to you, I hope that the Congress is a resounding success.

SURVEYING, CARTOGRAPHY AND LAND MANAGEMENT EDUCATION AND TRAINING AT THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY - AN UPDATE

by T. M. Nacino BSc, MPhil, MIS(Aust)

INTRODUCTION

Over the years, the Department of Surveying and Land Studies has successfully maintained its role of being in the forefront of technological changes. It has provided educational leadership not only in the established fields, but more importantly, in the evaluation and application of new systems, equipment and techniques associated with Global Positioning System, Remote Sensing and Land/Geographical Information System. Equally important is the cooperation displayed by industry in providing much needed input and funding.

Students and staff members are extensively involved in research projects and other activities. It is expected that participation in these activities and projects will ultimately benefit the students and the nation. It is also anticipated that the students will develop a sense of intrinsic motivation to be more inquisitive than at present and to develop a more practical approach to various problems.

It is the intention of this paper to demonstrate to the surveying community that the Department is (1) implementing vigorously its aims and objectives on schedule and (2) improving/updating its teaching capabilites and expertise.

COURSE DEVELOPMENT

A review of the curriculum for the Bachelor of Technology in Surveying is currently in progress with a view to keeping abreast of changes of technology and changes in survey practice. The views of the various groups within the surveying profession are being sought in order to cater for their requirements.

The main feature of the new curriculum is the departure from the traditional emphasis in cadastral surveying and movement towards an increase in the engineering, mining, and to a lesser extent, the hydrographic content. It is anticipated that this will greatly contribute to a logical, consistent and systematic development of PNG's natural resources.

In 1990, the Bachelor of Technology in Land Management will be upgraded to include a period of industrial experience with a view to exposing the students to the work environment and to enable them to consolidate, via continuous practical experience, the knowledge and skills gained in three years of study. Starting in 1989, all degree courses will incorporate a major project that will develop the capacity of students to work independently.

The Bachelor of Technology in Cartography was first offered in 1985 to provide the survey drafting graduates comprehensive knowledge and skills in the art of map production, management and distribution.

The Diploma in Land Administration course which used to be offered by the University of Papua New Guinea, has been transferred to this Department. Despite a period of only one year, some changes have been necessary and have been introduced to render the course broader and more relevant.

The post graduate Diploma in Land Studies has attracted a number of qualified and experienced candidates and the impression is that the graduates have developed a much greater confidence to undertake overseas studies or to occupy middle level management positions.

REMOTE SENSING

The Department has placed an order for an applications oriented image processing system called the microBRIAN to augment, if not replace, the existing system.

This system, which is implemented on an IBM AT compatible microcomputer using high resolution graphics hardware, has a wide range of proven applications in remote sensing and image processing which include shallow water mapping, coastal zone inventory, water colour mapping, mangrove mapping, land erosion mapping, forest inventory and crop yield monitoring. The significant advantage of the microBRIAN is the fact that it allows image processing to move away from centralized main frame computer systems into the offices of the end user through its use as a standalone system or as an intelligent work station.

Three members of staff, assisted by students, are currently engaged on remote sensing projects.

COMPUTER ASSISTED MAP PREPARATION

The acquisition of the ARCAD Graphic Design System (GDS), has proved to be a significant step in introducing the students to the principles of computer assisted mapping. A number of staff members have acquired considerable proficiency in the use of the system. The system has also served as a model to demonstrate its capabilities to interested parties.

The introduction and development of low cost microcomputer peripherals, colour graphics monitors and digitizing tablets has created a market for computer graphics software. Recently, the Department purchased the Tektronix 4207 work station which communicates with the PRIME 550 via a standard RS 232 line. The necessary software is also available. The most important characteristics of this display colour system include pixel resolution, colour and quality, addressable coordinate space, processing speed, support for graphic segments and communications capabilities.

MICRO-BASED LAND INFORMATION SYSTEM (LIS)

In addition to the the LIS project previously carried out, the Department has embarked on a research programme to develop a model Geographic Information Management System (GIS). This GIS was to go beyond merely a cadastral information system, and was to incorporate all the other geographical land attributes necessary for planning and management of Papua New Guinea's environment, and more importantly, a system that would also cater for Papua New Guinea's unique customary land tenure. Its primary use was to be in teaching and research with future expansion into a Resource Information System suitable for Provincial Government departments. The result of this work has been the development of the Morobe Resource Information System (MORIS)

AUTOMATED SURVEYING

Today, the trend in mapping, engineering and mining operations is to acquire a rapid and systematic method of field data collection and plotting. The GEOCOMP software being marketed by WILD totally automates the computing and drafting side of the whole operation. It eliminates time consuming and tedious hand drafting. With a totally automated system, data collection becomes much more rapid and accurate. The tedious and error prone manual booking process is eliminated, moreover the results can be entered directly into a computer.

The demands for rapid and systematic techniques both in the field and office, has prompted the Department to acquire two completely automated "Total Stations", including the necessary software. The students are being put through the operation and use of these tools.

COMPUTING FACILITIES

The computing laboratory contains a network of BBC microcomputers and is being used extensively by the surveying students for word processing and to carry out lengthy and repetitive calculations in geodetic, engineering and plane surveying. In the network, there exist a number of surveying programs which deal with numerous facets of computation in land surveying.

Lately, it has become apparent that there is a drift towards IBM PCs (or compatibles) in the business world. In anticipation, the University has set up a network of IBM PC compatibles and the Department has already written a number of IBM surveying and engineering programs for students' use. More programs will be written in due course.

PHOTOGRAMMETRIC LABORATORY

The existing photogrammetric capability of the Department is limited in that the machines available are mainly for the introduction of the basic principles of orientation, plotting and semi-numerical operations.

The Department is seeking funds to upgrade the present equipment and techniques. This way, the Department could offer training in analytical and fully computerised orientation, aerial triangulation, data capture and plotting. The unit under consideration is an analytical affine plotter capable of accepting all types of photography taken from satellites (e.g. SPOT) and from conventional aircraft.

REASEARCH PROJECTS COMPLETED, IN PROGRESS AND UNDER INVESTIGATION

The research interests within the Department cover a wide range of subjects and several projects have attracted support from the Research Committee of this University. The list below includes projects completed recently and projects in progress or under investigation.

Remote Sensing Application:

- A significant project which was carried out by the Department is the visual and digital image interpretation for the Gogol-Naru timber rights purchase area, which was accomplished using two 1 : 250,000 LANDSAT false colour images generated for bands 4,5 and 7.

- The Department prepared a submission to AIDAB for funding to prepare a set of maps of the shallow water areas of Papua New Guinea using remote sensing techniques; it includes a significant research component. The proposal has the strong support of the Department of Environment and Conservation.

- A member of staff is currently involved in the reef and sea grass identification from LANDSAT digital analysis.

- Two members of staff and students are involved in (1) the delineation of traditional marine ownership by means of SPOT imagery and (2) mapping of small holder coffee growing areas using satellite remote sensing techniques.

- Also in progress is the study of urban development of Lae City using SPOT imagery.

Crustal Movement:

Staff from the University of New South Wales and the Joint Institute for Laboratory Astrophysics of the University of Colorado have invited the Department to join in a long term study of the movements of crustal plates in Papua New Guinea.

Sea Level Change:

The Department is preparing a project aimed at identifying the lands that will be inundated as the sea level rises due to the "green house" effect. Substantial funding will be required and it is probable that the Department will be part of an interdisciplinary group dealing with several related matters.

Miscellaneous Projects:

- Occasional map series and guide to maps of Papua New Guinea.
- Channel changes along the Bumbu River.
- Land use survey and planning re-development.
- Land tenure, land management and affordability factors in low cost housing schemes and self-help housing areas.

SHORT COURSES

There is a growing interest in continuing professional development among past graduates, but courses cannot be conducted as frequently as they would like. Their numbers are small and they are spread throughout the country, often in situations where it is difficult to bring them together. For this reason, the Department is looking at the prospects of offering some short courses by correspondence.

- A short course in Land Acquisition and Delineation was recently conducted for ELCOM officers.
- In January 1989, the Department, in conjunction with the Asian Institute of Technology, will conduct a short course for industry on the Introduction of Remote Sensing using SPOT imagery.

LIBRARY AND AUDIO VISUAL FACILITIES

The University library has a wide range of reading material in surveying, mining, cartography, land management and use, computing, the environment and other related fields. The audio visual section has acquired a good collection of slides, video tapes and 16 millimeter films dealing with plane and geodetic surveying, astronomy, photogrammetry, cartography, remote sensing, first aid and environmental control.

Students are encouraged to use the library frequently so as to improve their literary skills. The library facilities are available to practicing surveyors and the general public.

OTHER ACTIVITIES

- The Department gave technical assistance to Prof J. Chappel of the Research School of Pacific Studies in connection with further studies of the raised terraces near Sialum on the Houn Peninsula.
- The Department conducted a seminar in Rabaul for managers and loan officers of the Agricultural Bank in relation to rural valuation.
- In August 1988 staff and students participated in a gravity survey of the eastern Markham valley which was carried out by the Massachusetts Institute of Technology.
- In May 1988, the final year surveying students had hands-on experience with the Magnavox 1502 in connection with the establishment of a Doppler satellite station on campus.
- Recently, a national member of staff represented the Department at an FIG workshop on LIS/GIS held in Bali, Indonesia.

STAFF DEVELOPMENT AND OVERSEAS STUDIES

- A lecturer in surveying is at present attending a course in remote sensing at the Asian Institute of Technology in Thailand.
- Early in 1988, a lecturer in land management spent three months on industrial experience with Graeme Dunnage Real Estate of Port Moresby. Later, he took up a one year scholarship in the Netherlands that will lead to a post graduate diploma.
- In 1989, a lecturer in cartography will enrol for his masters degree program in the Netherlands.
- A lecturer in surveying is at present in Australia attending a three-year course leading to a post graduate diploma in Survey Practice.

- A lecturer in surveying was seconded to Bougainville Copper Limited for three months to bring up to date his knowledge of mine surveying.
- A senior technical officer was sponsored by AIDAB for a three months period of industrial experience with the Queensland Department of Geographic Information in the management of a carographic laboratory.

CONSULTANCY

The cartographic section has been active in this area and has been engaged to prepare a variety of maps by bodies such as the Coffee Development Agency and the Madang Visitors Bureau.

The land management section has advised the Bursary on the disposition of certain University properties.

OTHER FACILITIES AND EQUIPMENT AVAILABLE

Visitors to the Department, both from within and overseas, have been impressed by the wide range of up-to-date equipment and facilities available for teaching and research. In addition to traditional equipment, the Department has acquired a number of short and medium range EDMs, a WILD GAK1 gyro attachment and an astronomic theodolite with all accessories. However, much of it will become outdated as new instruments are introduced which incorporate electronic components and are compatible with computers. The new instruments are at present expensive - the costs are clearly prohibitive. However, as the market become more and more competitive, manufacturers will do their utmost to reduce the price.

Most notable of the facilities are : (1) the EDM calibration base, together with the necessary computer programs and (2) the geodetic suite of programs capable of handling the optimisation and adjustment of a sizeable control network and allows for computation on both the spheroid and projection.

CONCLUSION

The future direction and development of the Department will be guided by numerous factors which include (1) the demands imposed by industry (2) a close liaison with government departments and international agencies and (3) the availability of funds to upgrade equipment and techniques. The Department will continually strive to gradually improve the quality of graduates in order to meet the rapidly changing needs of this developing country.

It is reiterated that training, which is generally regarded as the process of gaining the necessary level of competence in specific areas so that execution of projects could be carried out with minimum supervision, is adequatly being provided by the Department. This is accomplished through the one-year practical training with industry and by active participation in survey camps and community projects. The diversified training that a graduate obtains from this Department allows him to seek employment in many fields other than in surveying (especially when there is a downturn in the country's economy).

The Department has always been characterised by an esprit de corps and by a level of industry of which the staff and students can be proud of.

STUDENT USING IBM PC MICROCOMPUTER

THE WILD "TOTAL STATION" IN USE

microBRIAN An Applications Oriented Image Processing System

microBRIAN is a powerful yet inexpensive package for the analysis of remotely sensed data. Developed jointly by Australia's Commonwealth Research Organisation, C.S.I.R.O., and Microprocessor Applications (MPA), microBRIAN has been specifically aimed at transferring remote sensing technology to the widest possible range of users.

Implemented on an IBM AT compatible computer using high resolution graphics hardware, microBRIAN is distributed and supported throughout the world by MPA.

Continuous development over many years in a practical scientific environment has resulted in a wide range of proven applications for microBRIAN in remote sensing and image processing. These include:

- remote sensing based shallow water mapping
- coastal zone inventory
- water colour mapping
- mangrove mapping and sediment load analysis
- baseline inventory of large wilderness areas
- monitoring successional change and fire effects
- land erosion mapping
- forest inventory using digital elevation data
- continental scale mapping using environmental satellite data
- crop yield monitoring

Geometric rectification of a variety of satellite images for oceanographic and continental scale mapping is included. Data from airborne scanners and digitized photography may be processed in a similar manner. A variety of data types including digital elevation and thematic data, processed GIS data and management or cadastral zones may be easily integrated with remotely sensed data as raster channels.

microBRIAN Software Overview

microBRIAN is organized into a structured series of menus, with the top levels arranged by analysis function. The levels are:

- the microBRIAN access menu
- the microBRIAN work areas
- the microBRIAN program set
- the microBRIAN utility libraries

The main Menu is accessed on entry to microBRIAN and lists a set of work areas which collect together the main types of image processing tasks. Each of these work areas has a menu of options comprising choices from the main level of the microBRIAN program. Help is available for each option at this level and communication between modules is maintained through a standard environment file. This file and a 'user' option provide the means for a user to easily link his or her software packages with the microBRIAN system. A brief description of the main work areas are:

IMAGE MANAGEMENT - for editing image menu, ground control point and transformation files, managing image subsets, and sending images to the display screen or colour ink jet plotter.

IMAGE PROCESSING - to compute statistics for images, perform selected image transformations, and digitize areas spectrally and spatially.

IMAGE ANALYSIS - for image feature classification using seeds and themes, statistical analysis and labelling, analysis of image labelling by sampling and cross tabulation, water depth analysis, colour and chromaticity, and eroded surfaces analysis using spatial modelling.

IMAGE INTEGRATION - includes image rectification and registration modelling routines, image resampling and blocking routines, and multi-temporal image analysis and processing routines.

Hardware

A standard microBRIAN system consists of an IBM AT compatible computer, colour inkjet plotter, RGB high resolution monitor, and the microBRIAN Software and User Manual, along with serial communications software and comprehensive after sales software and hardware support.

This system is expandable with options including high quality printers, a standard half-inch 1600 BPI tape drive, and a 70Mbyte hard disk. Planned enhancements include support for larger hard disks, 400Mbyte WORM optical disks, a joystick or mouse, and a high speed mainframe or mini communications interface.

Data input to the basic system is via floppy disks or serial data line. Those users choosing the optional tape drive have immediate access to the standard image tape products such as Landsat, NOAA, and SPOT.

A number of applications based manuals are planned as companions to the User Manual. The first is called **Applications Based Image Processing** with chapters assembled under the following headings:

Introduction to remote sensing
Introduction to image processing
Image classification
Image rectification and data integration

The second is a collection of separately issued Application Notes, covering the application of microBRIAN to specific subjects in remote sensing and image analysis. The initial set of titles include:

- Shallow water mapping
- Land cover mapping
- Land cover monitoring
- Crop condition mapping
- Land erosion mapping
- Landform mapping

A specific aim during microBRIAN development was to simplify the user interface, allowing users who may not be specialists in image processing to undertake meaningful analyses of remotely sensed data. To a new user, the microBRIAN system is interactive and menu-driven, with an extensive and simply accessed online HELP facility. However, the experienced user may bypass the menu structure and access the various modules with direct command calls for specific applications.

microBRIAN represents a significant move to distribute image processing away from large centralized computer systems into the offices of the end user through its use either as an intelligent work station or as a standalone system.

The microBRIAN software and hardware is fully supported by MPA, ensuring product quality and comprehensive after sales support. MPA will provide continuing liaison with users and encourage formation of a Users Group to ensure all have full access to future software and hardware improvements as well as new methods developed for image processing applications.

microBRIAN is a complete and powerful system - one that at last provides performance and flexibility for remote sensing analysis at an affordable price.

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PAPUA NEW GUINEA PARTNERSHIP - ??

by

E H L Young
LS, MIS (AUST), MASPNG

ABSTRACT

The paper discusses the Association of Surveyors Papua New Guinea's 1986 policy in relation to foreign surveyors, aid, new technology and its application to Land Information Systems in Australia and potential use in Papua New Guinea.

The paper concludes by offering some alternatives in order to open discussion on the subject among members.

1 INTRODUCTION

The title of this paper reflects my concern regarding the direction of the Association's policy in relation to foreign surveyors working Papua New Guinea. A letter dated 28 August 1986, which was published in the Association's Journal, stated:-

> "Recent Government initiatives or policies have opened the way for different forms of monetary aid to be accepted in papua New Guinea from a wide range of donor countries. While this move may benefit Papua New Guinea we are concerned about its impact on the surveying industry.
>
> If part of any aid package involves the supply of foreign surveyors, technicians or draftsmen, then it will have an immediate detrimental effect on surveyors in this country and many Papua New Guineans, who have received up to 5 years of training at Unitech, will be out of work".

I believe the Association's members should have a positive attitude to these new initiatives because they will generate work, introduce new appropriate technology and facilitate opportunities for ongoing training. A paper by P Done, in 1983, indicated some possible areas in which development may take place in the emerging nation of Papua New Guinea and to emphasise the important part to be played therein by the surveyor.

The Data Verification Project, started in 1986, under Australian Tied-Aid, is an introduction to a Land Information System (LIS) and is the start of one major program requiring skills and new technology not yet available in PNG.

Fuller's paper in the 1986 Journal recognises the problems of using consultants to introduce an integrated, computerised, LIS:

> "The extent of coverage, the standardisation of resource data classification system and standardisation in the map presentation of the data need to be addressed. This becomes more critical if experts from different countries are employed as consultants for different project." (Page 91).
>
> "However, consultants should be aware of the need to know the nature and workings of existing systems together with an appreciation of the aspirations of the indigenous people especially their feeling for their land. With this awareness, the consultant's advice could help to implement changes to systems that would allow the systems to work for the people rather than be reminders of their colonial past". (page 101).

Australian consultant surveyors are in a good position to asist, because of their ongoing involvement in PNG and their development work at the "frontiers of technology" in the surveying and mapping industry.

2 . THE USE OF NEW TECHNOLOGY IN PNG WHICH HAS PARTICULAR APPLICATIONS FOR A LAND INFORMATION SYSTEM (LIS)

It is now possible for overseas consultants to use technologies like Global Position Systems (GPS), Remote Sensing (RS), Lasers, ie Airborne Profile Recorders and Numerical Photogrammetry with limited ground control to provide most of data required in digital form for their computers usually based in their head offices. These computers can then provide a wide variety of products to clients like your Department of Finance and planning for their LIS program, or to mining companies work ing PNG. The consultants will be paid with funds supplied under aid schemes or future profits from private projects. Major benefits will be obtained for consultants, who realise local conditions should be considered, by they ground conditions or social effects. This is an important aspect for Association members to understand, because the success of the use of this technology, which is very costly to operate, will depend on sound planning and knowledge of local land conditions. In PNG, this will be essential when gathering the data and in most cases with follow up checking and finally with the ground survey which will be required. These consultants will use electronic distance meters and data recorders with special software and other similar equipment to complete their projects.

Association members should, through working with foreign consultants keep control over what new technology is to be used. They should define what is to be the consultants' responsibility on the contract and what should be the responsibility of the local member having regard to the need to implement a technology transfer environment, but avoiding the need to re-invent the "frontiers of technology".

The days of a Master Surveyor teaching a pupil have gone and the new technology has created a new professional with a higher level of training, who is skilled in a variety of specialist areas. It is this person Association members should be seeking out and forming partnerships with to keep up with the new developments, which will benefit PNG.

I believe these two quotes sum up new technology in our industry:-

> "For the industry to be effective and economically viable, it is essential to keep abreast of technological developments." (AKCLIS, 1986).

> "They should not be seen only as a means of improving the efficiency of existing practices, but as an opportunity for new activities, new initiatives as well as new sources of income." (Humphries, 1985).

3. DEVELOPMENT AID

3.1 THE SOURCE

Aid money in the Surveying and Mapping industry seems to come mainly from:-

- International agencies and regional development institutions.
- Bilaterial agencies, private/commercial banks and technical promotion schemes.

Co-financing operations with Australia appear to be having rapid growth, recently renegotating its programme with the World Bank. The main emphasis of Australian International Development Assistance Bureau (AIDAB) programmes is in PNG and the countries of SE Asia, Pacific and China.

3.2 TIED AID PROJECTS

Association members can expect to see the aid money tield. You will see project objectives set with an agreed development plan established and a percentage of the work to be undertaken is carried out by staff of the donor country.

In Thailand for example, at the start of the Land Titling Project, a number of objectives were set, directed towards the planning, management and development of the country. Some of these were:

- people issues
- planning and development issues
- land information issues.

The work done in Thailand is very relevant to PNG (see paper "Urban Mapping an LIS Developments: Thailand", Hostein Smith, 1985).

3.3 THE ADMINISTRATIVE NEED

> "To become fully aware of the complexity of the systems of land tenure in PNG, it must be remembered that alienated land for which written records of title are held, constitute only 3% of the total land mass. The remaining 97% of land is held under customary ownwership." (Puller 86 pg 72, Journal).

For aid to assist with this problem, the independent PNG Government is in a position to change the existing management system established by previous administrations.

3.4 THE MANPOWER AVAILABLE IN PAPUA NEW GUINEA

> "In October 1982 there were 77 registered surveyors (15 natinals), of whom 16 (3 natinals) were in Government service. The professional organisation, the Association of Surveyors of Papua New Guinea has a membership of 156; 85 of these reside in the country but of these only 43 are nationals" (Done 1983, pg L3-16).

> "The National Manpower Assessment (1979-1990), produced by the National Planning Office, quantities required outputs of University graduates by disciplines for the period. It assumes that "medium growth" will occur and that "all positions requiring degrees will be nationalised by 1990". A surprisingly specific figure of 153 B. Tech (Surveying) is quoted therein, implying an annual average output of 14. Historically the output for the years 1976-1981 has been 9." (Done 1983, pg L3-17).

This would indicate a potential shortage of professional surveyors in 1990, who would have difficulty coping with the present work load. The graduates from the University of Technology in Lae have certainly been trained to work with some of the new technologies that may be introduced. Future developments may create the right opportunities.

3.5 SUMMARY

The aid aimed at contributing to the social and economic advancement of a country like PNG has fringe benefits for those working in partnership achieve those goals in the form of increased trade, more development for both countries and stability for the region.

4. THE AUSTRALIAN EXPERIENCE IN THE INTRODUCTION OF LIS SYSTEMS

I think I could say that there has been endless talk over the last 10 years, a lot of time, effort and money spent on development and at last some results are new being achieved. We are now seeing the Government, Private and Academic sectors working together to get the system working. These groups are now keen to export their expertise, developed in this area. Lack of funds, duplication of effort, difficulty in setting code standards and competition between the major hardware suppliers all contributed to a difficulty in having a common system operating throughout Australia.

Years ago, individual organisations who could see the benefits of LIS did their own thing with limited funds and found the project was just too big for them. They then egan talking between themselves and with the Government, taking the best of each system, sharing costs and exchanging information, and with a little in-fighting getting and the system operational.

5. SYSTEMS THAT ARE BEING DEVELOPED TO INPUT TO LIS

I should start by commenting that I believe that all surveyors should now have become familiar with the "bits" and "bytes" of the hardware and the software of the new technology, because those who don't will have difficulty staying in practice during the next decade.

This is a large subject and for this paper I only propose to discuss some aspects that may ahve some relevance to the PNG situation, breaking the information up into three sections.

5.1 GROUND COLLECTION THROUGH TO PC PROCESSING

5.1.1 Total Stations and Data Recorder

There is a wide range of reliable total stations available in Australia, some I would believe require extensive testing in PNG before general introduction. Interfacing to different data recorders is a problem and in some cases not possible.

Data recorders are improving all the time. The early recorders just took information from the total stations and were very limited in their operation and ability to hold large amounts of data. Some were capable of working in any environment and some were originally designed for other specific purposes.

We are now seeing a greater variety of recorders that will hold larger amounts of data, some permitting the surveyor to work with that data on location before processing in a Personnel Computer (PC). Australian surveyors are developing software for these units to suit the specific project on hand. Some of these units may not stand up to the rigour of operating in PNG.

The next generation of recorders about to be released will be easier to program, ave greater storage and should operate in the harsh PNG environment.

Now, a word of warning about these systems. it has been my experience that some distributors may not know a great deal about their products. Software is a real problem. My advice is to field test the total station and data recorder that may suit your requirements in your working environment before purchase. If you are lucky enough to find software that suits your requirements, acquire it. The experience from people I have spoken to on the subject is that it takes about 12 months development to get a major piece of software operating properly in a work situation. Ongoing maintenance of that software is something programmers are working at now. (PLATE A)

The last link in this chain being the personal computer (PC) printer and plotter, will be controlled by the products required by the surveyor's clients and a surveyor's budget. Most PCs are bought with a DOS operating system and several standard software packages to get into operation. A decision is then required regarding the main language your PC will operate in. This seems to be a very trendy area, because programmers seem to jump from one language to another creating problems for survey staff who later have to work on the programs.

Good, general purpose, simple plotting packages aren't generally available yet. They seem only available as art of a much larger software design package.

It seems that most total stations and data recorders are easy to learn to operate, but to learn and operate all of the special attributes built into the operation of the intelligent recorder, like a HP71B, can take several months of regular use. (PLATE C)

5.1.2 The Personnel Computer (PC) and Peripherals

It is important to recognise that while this equipment's primary task is linkage with the data recorder and routine surveying tasks, it can be used for office tasks like word processing, spreead sheets and possible future direct entry into LIS when further developed. To give some idea of the software available the following table could be used as a guide to a surveyor who has chosen an IBM PC system.

SOFTWARE	COST *(A$)	USE
DOS (DISK OPERATING SYSTEM)	150	manages resource allocation, files, data access and other housekeeping.
FRAMEWORK	1300	Fully integrated and combined text processing, spreadsheets reports and documents.
FOCUS	2000	High level database and report package.
BASIC	-	Basic program language.
LOTUS 123 package	900	Spreadsheet.
BASE III	1300	Data base package.
SPF/PC EDITOR	300	Word processing.
QUICK BASIC	150	Compiled basic as a machine language

*NOTE: AUD (A$) 1 = PNK (K) 0.68

Some of the larger Australian utilities have developed PC base information systems that feed into large mainframe computers. These PC systems could be of interest to the architects of the new PNG LIS. (PLATE B)

Special PC Applications

CAD drafting packages worth around A$4000 can receive digital data via conversion software direct from some data recorders. I understand drafting officers generally allow around 3 months for staff to become proficient in the utilisation of this powerful drafting package, which has a lot of applications for site development works and architectural design.

Remote Sensing

Special PC software is now available to allow the successful interpretation and presentation of the remotely sensed data by an operator with training in the science of remote sensing.

5.1.3 GLOBAL POSITIONING SYSTEM (GPS)

The Concept

The US Dept of Defence has planned to place a constellation of 18 satellites in orbit linked to control stations with a variety of military applications in mind. It will be possible to measure by day or night in any weather, carry out relative positioning of two or more points without terrestrial line-of-site. Recording all data necessary to obtain three-dimensional Cartesian co-ordinates in the geocentric co-ordinate system of the satellite datum. Transformation will be required to allow results to be express in a country's co-ordinate system.

At present, the limited number of satellites available restricts the observation time available in Australia and PNG to about 5 hours. It is now hoped all Block I and Block II satellites will be in place by 1991.

Position Determination

Distinction is made between "dynamic" (Kinematic) used for navigation and "static" which is being used for surveying. Methods being developed for the static method are:

(a) Pseudo ranges

where measured distances to satellite are derived by comparing the code with a similar code generated in the receiver and this time interval is converted to a distance. Three satellites are used to create a resection.

(b) Carrier Pase Measurements

are made using codeless receivers and are more precise than pseudo ranges. This method involves measuring the phase shift on the carrier wave, where the phase of the satellite signal is compared with that of a reference signal generated in the receiver. A part of the distance is obtained as part of the wavelength measurement aken on two frequencies which is processed by software developed for that receiving system.

In the field a method of "double differencing" or "relative positioning" where the same satellites are observed with two receivers at two different locations has obtained results with a relative accuracy of 1-2 ppm. In distance less than 50km errors due to unmodelled tropospheric and ionosphoric refraction effects are reduced.

GPS heighting is still a problem and is an area under detailed investigation in Australia by a special study group formed in 1986. The position of tectonic plate in PNG will create special problems for GPS heighting in PNG.

Equipment

Recievers costing A$40000, weighing around 20 kg used in pairs or groups are powered by 12 colt heavy duty batteries and linked to an Antenna/Preamp set on tripod legs. These results will then be reduced on a A$3000 laptop computer with the following features:-

- 640K RAM
- 8087 maths coprocessor
- high density 3 1/2" floppy disk drive
- RS232C serial interface

Radio communication between each receiver is usually required.

Pre Survey Planning

Detailed planning for GPS surveys is more critical than conventional surveys because of expense of the equipment involved and the limited number of satellites available at present. Software called "SATPLAN" and "SATNET" for planning is amongst that available. A GPS survey usually breaks the job down into the following tasks:

1. Field Reconnaissance
2. Network Design
3. Schedule for Observation

Results

The first trial with the equipment by a utility organisation produced AMG co-ordinates to first order accuracy for 16 stations over 4 nights of observation along a 90 kilometre corridor. It is estimated that, using a 3 man party, the project would have taken about 3 months. An earlier Survey by the South Australian Government produced the following results:

	CONVENTIONAL	GPS
COST:	$4-10K/Point	$3K/Point
TIME:	6 months field 12 months office	6 weeks field 4 months office
ACCURACY:	1-2 ppm	2 ppm horizontal 4 ppm vertical

Summary

- The development of GPS has a long way to go with better software to be developed, the complete placement of all satellites and reduction in the cost of receivers. New applications like installation of receiver into planes or into boats put this equipment in the area of "frontier technology."

5.2.1 AERIAL COLLECTION THROUGH TO MICRO COMPUTER

I think we can say that much of the hardware required to acquire the aerial photos is well understood but a lot of Australian mapping groups are adding additional hardware to the aircraft like Kinematic GPS, Laser Airborne Profiling System (LAPS) over land, WRELADS over water and sometimes the "The FLIR" thermal image system.

The use of different flying heights special films and lens is opening a wide number of new applications for surveyors.

Low level photography is being investigated at present for application in the management of large mining operations, which is something that may have real implications for PNG gold mines. The work being carried out by the staff on "The Land Titling Project" in Thailand in their production of rectified photo maps in assisting with their urban LIS program is also relevant to PNG in land, whch is under 97% customary tenure.

5.2.2 ANALYTICAL PLOTTING

The use of analytical stereoplotter linked up to computers that can manipulate or transfer digital data collected, into CAD drafting systems, has opened the opportunity for a wide variety of LIS applications. New generation software has improved collection, adjustment and editing.

5.2.3 AERIAL MOUNTED SCANNERS

A partnership developed between Government and private industry to bring a most advanced aircraft scanner to Australia is something I believe we will be seeing more of when people understand the products these scanners produce.

The scanners carried were:

- Thematic Mapper Simulator Scanner (NS001)
- The Thermal Infrared Multispectral Scanner (TIMS)
- The Airborne Imaging Spectrometer (AIS)

5.3 SATELLITE TO MAINFRAME COMPUTER

5.3.1 REMOTE SENSING

Various remote sensing centres throughout Australia staffed with experts in computer sciences, image processing and interpretation now provide clients with valuable data for:

- Land Use
- Agriculture
- Forestry
- Geology
- Geophysics
- Hydrology
- Coastal Processes
- Rural and Urban Land Cover

Remote sensing is playing an important role for Australians in the resource management and mapping of the Continent and territorial waters. The Australian Centre for Remote Sensing (ACRES) is being upgraded to enable direct reception and processing of Landsat Thermatic Mapper (TM) sensors and SPOT satellite data, which will be available to be acquired on a commercial basis by PNG clients.

Since the first remote sensor was placed in orbit in the early 1960s by NASA, we have watched a very rapid development in this technology.

Landsat 1, launched in 1972, has been the most commonly used here with a pixel resolution of about 80 metres followed by Landsat 4 in July 1982 with a resolution of 30 metre pixel T M imagery.

A more recent satellite launched in February 1986 by the French carrying their SPOT system is producing scenes which are vertical multispectral (20 metre pixels recorded in three spectral bands) with a few vertical panchromatic (10 metre pixels) also being recorded. Stereo scopic imagery with strong internal geometry can also be produced. Spot images can be used in stereoplotters for map compilation and map revision. PNG is well palced to benefit from the increasing number of earch observatin satellites being launched with orbits crossing the country.

5.3.2. COMPUTER HARDWARE FOR LAND INFORMATION SYSTEMS

The hardware for any of these systems is expensive.

The following list of hardware in 1985 would have cost in excess of A$950000:-

- Intergraph interview 32C Graphic with digitised table
- Alphanumeric Screen.
- Printer
- Hewlett Packard Drum Plotter
- Intergraph Interpro 32C
- VAX 8650 32MB Memory
- 2-337 MB Disk Drive

6. CONCLUSION

In the last 10 years members would have seen foreign surveyors from a variety of countries working in PNG producing mixed results. I believe the Association should welcome these surveyors, provided that they are prepared to undertake long term commitment to training and provide value for money with results produced.

Having stated my concern at the direction of the Association's policy toward foreign surveyors and described a little of what is happening in the Australian surveying and mapping industry that may have some application in PNG, I hope to open active debate on the extent of the future partnerships between surveyors in PNG and Australia.

I. suggest that partnerships should be established through joint venture groups set up for specific projects, where fixed goals are set for involvement of personnel, use of technology, training and financila arrangements. A role model could be the Land Title Project in Thailand. I don't believe in the placing of PNG surveyors on the boards of overseas companies to share in the profits, but not the action as happens in some countries like Malaysia. this is not healthy because it leads to a "Cargo Cult" culture. Another alternative, to restrict access for foreign surveyors and go alone, will stifle the future development of the surveying profession in Papua New Guinea.

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Digital Electronic Total Station	SOKKISHA SET 3, 4, 10	GEODIMETER 410, 420, 440	WILD T1000, T2000 WILD TC 1600
Data Recorder (PNG Test 1st)	HP41CV & CX HP71B SDR2 EPSOM	HP41CV & CX EPSOM	
Data Recorder (Rugged Design)	SDRP MC II LINK	GEODAT 126 GEODAT 400 HUSKY HUNTER HUSKY SURVEYOR LINK	SDRP GRM 10 GRE 3 GRE 4 LINK
Software for Data Collection	EPROM SURVEY PACKAGE COGO POLES(Pole Line Design COMPS(Co-ord Base Package)	 VIEW 400	 PROFIS PLINE - INT
Personnel Computer	X Y Z RS 232 - c INTERFACE	Z Y Z RS 232 - c INTERFACE	X Y Z RS 232 - c INTERFACE
Software For Special Applications	CASE POLES AUTOCAD MICROSTATION GEOCOMP SDRMAP	SET-OUT 400 ECLIPSE AUTOCAD MICROSTATION GEOCOMP BLOOMFIELD (Eng Design) LANDMARK	MAP-MAGIC 11/BLIS AUTOCAD MICROSTATION GEOCOMP PALETTE

Some Special Applications	SURVEY PROCESSING TERRAIN MODELLING SPATIAL DATA EARTH WORKS PLOTTING POWER LINE DESIGN TITLE CALCS.	SURVEY PROCESSING DIGITAL TERRAIN MODEL SECTION CONTOURS ROAD DESIGN GRAPHICAL DATA BASE PLOTTING 3D VISUALISATION QUANTITIES	SURVEYING PROCESSING DIGITAL TERRAIN ROAD DESIGN SPATIAL DATA SYSTEM PLOTTING POWER LINE DESIGN
Mainframe Software	INTERGRAPH MOSS	INTERGRAPH MOSS WESCOM	INTERGRAPH MOSS

SOME POSSIBLE HARDWARE CONFIGURATIONS, SOFTWARE OPTIONS & APPLICATIONS
PLATE A

SHALLOW WATER MAPPING IN PAPUA NEW GUINEA BY SATELLITE REMOTE SENSING

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ABSTRACT

Much of the waters within the Papuan New Guinea Exclusive Economic Zone are both poorly charted and incomplete. This paper looks at the use of shallow water mapping from satellite remote sensing to provide much of the information needed for management within this area and as mapping revision tool.

INTRODUCTION

The nation of Papua New Guinea consists of the eastern half of the island of New guinea and a large number of smaller islands. The land area of the country is 461 700 square km while the total length of coastline is about 7000km. However due to many of the islands being fairly scattered PNG has a vast amount of ocean within its Exclusive Economic Zone (EEZ) which the government must control and regulate.

Due to the nature of the country, in both terrain of the mainland and scattered nature of the island areas, water transport plays an important part in communication within the country. However large areas of PNG waters are poorly charted (Young 1982, Done 1983, Quinn, Harvey, Keenan and Kershaw 1986), while many of the numerous coral reefs are inaccurately charted or not shown at all (Kojis and Quinn 1984; 1985).

COVERAGE OF PAPUA NEW GUINEA´S EEZ

SCALE	COVERAGE OF OCEAN AREA	% OF SURVEYED AREA OF COVERAGE	OCEAN AREA NOT COVERED BY CHARTS OF LARGER SCALE
1: 12 500 - 1: 75 000	1%	83%	1%
1: 100 00 - 1: 150 000	4%	69%	3%
1: 250 000 - 1: 300 000	25%	76%	21%
1: 750 000 - 1:1 000 000	80%	79%	55%
1: 1 700 000 and smaller	100%	N/A	20%

Source: after young 1983a

As can be seen from table 1 the charts covering the waters of PNG´s

EEZ vary from scales of 1:1 700 000 to 1:12 500, with the latter generally being used for harbours and channel approaches. Of the 2 339 900 square km of ocean area covering the EEZ only 701 970 square km is covered by a scale suitable for general navigation (scales larger than 1:300 000) of which only 528 580 square km is actually surveyed (Young).

Many of these charts are based on old, erroneous or often incomplete surveys carried out in the late 19th and early 20th centuries.(See appendix 1 and 2 for chart coverage of PNG waters) and need to be updated or verified. This process along with providing additional charts of selected areas is a monumental task outside the economic and technical resources of the country. However it has been suggested by some (Colvocoressess) that satellite remote sensing offers the only feasible and cost effective method for mapping much of the shallow water areas of PNG.

PENETRATION OF ELECTOMAGNETIC RADIATION IN WATER

The depth to which electromagnetic radiation will penetrate water is dependant on the wavelength, the shorter the wavelength the greater the depth penetrated. The multispectral scanner system on board LANDSAT 5 used for this study has four sensors detecting electromagnetic radiation in four bands. The wavelengths of these bands and the theoretical depth penetration at which reflected electromagnetic radiation for a particular band can be detected are given in table 2.

TABLE 2

WAVELENGTH (nm)	LANDSAT BAND	DEPTH PENETRATION (m)
500-600 (GREEN VISIBLE LIGHT)	1	15 - 20
600-700 (RED VISIBLE LIGHT)	2	4 - 5
700-800 (NEAR INFRARED)	3	0.5
800-1100 (NEAR INFRARED)	4	0

From Moore (1980) and Jupp and others (1982)

This maximum depth penetration however is affected by a number of factors such as atmospheric haze, type of seabed bottom, water clarity and turbidity. As these affects become more marked the actual penetration will be proportionately reduced.

PROCESSING TECHNIQUES

For the study raw LANDSAT digital data for a particular scene obtained from a computer compatible tape (CCT) was down loaded using a Prime 550 computer to a BBC microcomputer. The digital data was then analysed using a suite of programs developed by Mr. W Harvey and Mr P

Kirshaw. The CCT consists of the numerical reflectance values for each of the four bands for every pixel within the scanned scene.

The determination of water depths from reflected electromagnetic radiation can be accomplished as water penetration is highly dependant upon wavelength. It is then possible using a computer to take each band respectively to determine the minimum seabed reflectance value that corresponds to a particular depth zone. The first step in producing a shallow water map from digital data is to determine the land water interface. As there is almost total absorption of band 4 by water the land water interface can be easily determined and all land areas masked out from the study area.

The next stage is to determine the reflectance values associated with deep water in each band, this can be found by producing a histogram of the four bands over an area of known deep water. In theory all four bands should be totally absorbed by water over approximately 20 metres however due to atmospheric haze, water turbidity and sensor noise some returning signal is detected. Water depth zones for each band can then be determined by progressing from shallow water to deep water using each of the four bands in turn, bands 1, 2 , 3 and 4, to mask out areas having reflectance values greater than those associated with deep water.

Having produced the shallow water map the next stage is to determine the actual maximum depth that each masked area represents, which will depend on the atmospheric haze, water turbidity, water clarity and seabed bottom type. This can be determined from either existing hydrographic charts or a hyrographic survey of selected control areas. With accurate water depth information available for areas it is also possible to further break down each band into narrower water depth zones.

STUDY AREAS

Two study areas where chosen, Port Moresby and Madang. Data from the Port Morseby area came from a Multispectral scanner CCT acquired 2/06/86. The time of the overpass by LANDSAT 5 was approximately 10.30 am and the tide was 3.1m above low water. Using the method described above a shallow water map for the eastern end of Sinavi reef and the Basilisk Passage was produced (see appendix 3). The maximum and minimum depths for each zone were determined by comparison with the hydrographic chart AUS 505 for the area, (see appendix 4). It can be seen that the water depths for both bands 3 and 4 are greater than that those given by table 2. One explanation for the increased depth penetration of the bands could be attributed to the extremely clear waters and white sandy sea floor around Port Moresby.

The data from a CCT is raw data or data that has not been corrected for radiometric or geometric corrections. Looking at the bathymetric map for Sinavi reef (APPENDIX 3) a banding effect is quite noticeable, this is known as six line banding and is due to the drifting response levels of the six detectors per band and results in every sixth line being regularly either lighter or darker than average. Also scattered throughout the map are random singular pixels that may or may not be indicative of depths at that point. Both these affects can be eliminated by using a 9 point smoothing algorithm. This simply takes a block of 9 pixels and assigns the average reflectance to the middle pixel. The result of such a smoothing procedure can be seen in appendix 5. The resulting shallow water map is a clearer representation of information, however some accuracy has been lost. This averaging out of reflectance levels over 9 pixels can cause very small or narrow features that are evident in a raw shallow water map to diminish in size or totally disappear. Fortunately the features around Port Moresby are of such extent that this does not pose a significant problem.

The second study area (see appendix 6), Madang Harbour and surrounds, was chosen as the reefs tend to be either very narrow or small and the waters have a high content of suspended sedimentation due to the number of rivers flowing into the area. The depth zones for the area were developed as described above and assigned the same depth ranges as for Port Moresby. The minimum reflectance values for each zone differ slightly from those developed for the Moresby area and this is due to the different atmospheric conditions of the two areas at the time of acquisition.

Comparing the shallow water map to the chart of the area (appendix 7) it can be seen that some shallow water features due to their small size are not shown or are only partly shown. This is particularly evident with the small narrow reefs either side of Rasch Passage. In places there appear to be a number of deep water gaps through the reef that are not shown on the Hydrographic chart. This is one of the weaknesses of the Multispectral scanner in that the reflectance for a pixel is the average over an area 79m*57m. This means that in situations where deep water predominates over a small shallow water feature in a pixel, the resulting reflectance will tend to be that of deep water as in the cases above. Smoothing the data for this scene exasperates the problem even further as can be seen in the smoothed shallow water map shown in appendix 8. The gaps in the reef have become even larger and more pronounced.

The affects of sedimentation in the water can also adversely affect the accuracy of water depth over an area. Appendix 9 shows a shallow water map for the mouth of the Gum river and as can be seen from the map there appears to be a large area of shallow water. In fact this is not the case, as water depths in this area are over 50m in depth and what has actually been shown is the sedimentation plume for the Gum river.

LIMITATIONS AND USES

Satellite remote sensing will not replace the more conventional methods of shallow water mapping. One problem is that water depths obtained from this type of data under controlled conditions are only accurate to 10% root mean square error (Hammack) which does not meet the accuracy specifications for Hyrographic charts. Another problem is the resolution, with the Mutispectral scanner this is 79*57m, which means objects or features smaller than this will very often remain undetected. This sampling interval has been greatly improved with the The new generation of scanners now in orbit, namely the French SPOT and American Thermatic Mapper systems. Both have smaller sampling intervals than the Multispectral scanner, which means the ability to detect smaller objects has now been greatly increased.

With the French SPOT using the panchromatic mode the ground sampling interval is 10m*10m, which is becoming more acceptable for charting purposes. The French system also has the added advantage that full coverage over the whole of PNG can be obtained due to the satellite having onboard recorders. The American LANDSAT satellite on the other hand does not have this facility so all data acquired has to be transferred to a ground station as it is sensed. The nearest receiving station to PNG is the Australian Centre for Remote Sensing (ACRES) facilities located at Alice Springs which limits the available coverage over the country to the mainland and parts of Milne Bay.

One of the major uses that LANDSAT mutispectral scanner data has been used for in shallow water mapping is to update and add additional information to existing hydrographic charts. Although there are limitations of accuracy for water depths obtained, it is posssible to rectify an image to a map base and obtain accuacies of 50-60 metres root mean square error (Lyons and Guerin) for position.

As early as 1976 LANDSAT multispectral data was used to chart a major reef and shoal water area in the Bahamas (HAMMACK) where the Hyrographic charts of the area showed safe deep water. As a result of this study a notice to mariners #28, dated July 10 1986 was issued and the horizontal positions of the new reefs and banks derived from Multispectral imagery was added to the hydrographic chart of the area.

More recently in PNG waters the Australian navy has used LANDSAT multispectral scanner data as both a reconnaissance tool and a mapping tool. From multispectral imagery a channel through the Star reef in Milne Bay was found which was then surveyed using conventional Hydrographic survey methods. The resulting Hyrographic chart (AUS 519) drawn to a scale of 1:150 000 not only shows information derived from the Hyrographic survey within the channel, but shows the position of shoals and other dangers derived from satellite imagery or unconfirmed reports outside the survey area.

CONCLUSION

The Use of satellite remote sensing has the potential to provide information about much of PNG´s shallow water at a significant saving in both cost and time, as opposed to the more conventional methods of shallow water mapping. Although in certain areas, especially in water depth determination, accuracies using satellite remote sensing are not acceptable for use in Hydrographic charts it can still play a major role as a reconnaissance tool to locate areas within PNG waters where conventional surveys need to be carried out. Another important use of satellite remote sensing is in the area of verification and updating of existing Hyrdrographic charts and this is now quite feasible with the capability of SPOT to provide coverage over all of PNG.

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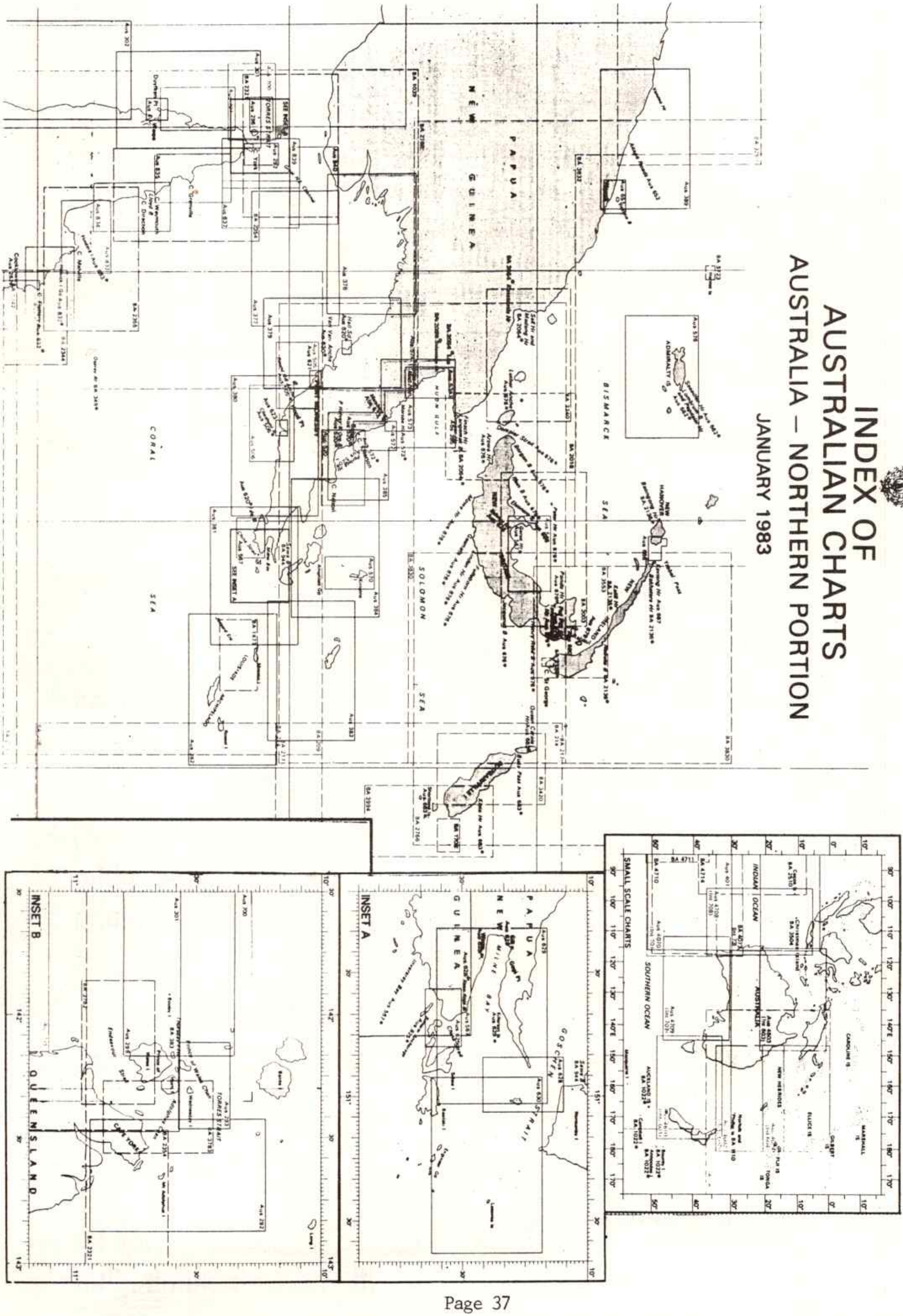
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AUSTRALIA – NORTHERN PORTION
JANUARY 1983
INSET A
INSET B
SMALL SCALE CHARTS

Chart No	Title	Scale	Current Edition
Aus 4m	Approaches to Weipa	1:75,000	Nov. 1981
	Port of Weipa (1:15,000)		
Aus 14m	Groote Eylandt – Approaches to Milner Bay	1:75,000	Aug 1970
	Milner Bay (1:7,500)		
Aus 16	Crocodile Islands – Approaches to Milingimbi Inlet	1:81,900	Sept. 1961
	Milingimbi Inlet (1:32,800)		
Aus 17	Entrance to Liverpool River	1:72,000	Mar 1883
Aus 18	Port Essington	1:72,800	May 1867
Aus 20m	Clarence Strait	1:50,000	Oct. 1975
Aus 27m	Approaches to Port Darwin	1:75,000	Aug. 1973
Aus 28m	Port Darwin	1:25,000	June 1973
	Darwin Wharves (1:7,500)		
Aus 32m	Cambridge Gulf	1:75,000	Feb. 1972
	Appr. to Wyndham (1:37,500) Wyndham Wharf (1:7,500)		
Aus 37	Approaches to Port Nelson	1:100,000	June 1950
	Port Nelson (1:37,500)		
Aus 40	Yampi Sound	1:25,000	June 1965
	Cockatoo I (1:5,000) Koolan I (1:5,000)		
Aus 43	Scott Reef	1:75,000	Dec. 1944
Aus 45	Approaches to Derby-King Sound	1:50,000	Aug. 1950
Aus 50m	Approaches to Broome	1:50,000	Mar 1969
	Broome Hr. (1:18,000)		
Aus 53mt	Approaches to Port Hedland	1:50,000	Sept. 1974
Aus 54m	Port Hedland	1:7,500	July 1974
Aus 55mt	Approaches to Port Walcott	1:50,000	Feb. 1979
Aus 56m	Port Walcott	1:12,500	April 1974
Aus 58mt	Port of Dampier and Approaches		Oct. 1972
	Appr. to Port Dampier (1:75,000) Port of Dampier (1:25,000) Dampier Wharves (1:10,000)		
Aus 72	Anchorages on the West Coast of Australia		April 1956
	Maud Landing (1:40,000) Norwegian Bay (1:24,800) Point Cloates Anch. (1:75,000)		
Aus 99	Cape Don to Cape Wessel	1:500,000	Jan. 1958
Aus 248	Port Clinton	1:24,140	Oct. 1974
Aus 249m	Hay Point to Penrith Island	1:75,000	Sept. 1971
	Hay Pt (1:12,000)		
Aus 250m	Plans of Mackay and Bowen		July 1972
	Port of Mackay (1:25,000) Mackay Outer Hr. (1:7,500)		
	Port of Bowen (1:25,000) Bowen (1:10,000)		
Aus 252	Cumberland Islands and Whitsunday Passage	1:100,000	Nov. 1966
Aus 253	Plans on the East Coast of Australia		Dec. 1937
	Port Newry, Kennedy Sound, Cid Hr. and Gloucester Pass (1:25,000) Molle Chan. and Long I. Sound (1:40,000)		
Aus 254	Sizorehaven Anchorage	1:12,500	Jan. 1932
Aus 256m	Cleveland Bay	1:50,000	July 1974
	Townsville Hr. (1:8,000)		
Aus 258	Approaches to Hinchinbrook Channel	1:75,000	July 1969
Aus 259m	Hinchinbrook Channel	1:50,000	Mar 1977
	Lucinda (1:18,750)		
Aus 262m	Plans of Cairns and Cooktown		May 1972
	Appr. to Port of Cairns (1:20,000) Port of Cairns (1:7,500) Port of Cooktown (1:10,000)		
Aus 292m	Adolphus Channel to Harvey Rocks	1:75,000	July 1978
Aus 293m	Prince of Wales Channel	1:37,500	Jan. 1974
Aus 296m	Goods Island to Proudfoot Shoal	1:75,000	June 1973
	Gannet Passage (1:25,000)		
Aus 301	Booby Island to Archer River	1:300,000	Aug 1969
Aus 302	Archer River to Nassau River	1:300,000	Oct. 1968
Aus 303	Nassau River to Wellesley Islands	1:300,000	Mar 1971
	Investigator Road (1:150,000) Appr. to Karumba (1:50,000) Karumba (1:18,000)		
Aus 304	Wellesley Islands to Vanderlin Island	1:300,000	Feb. 1969
Aus 305	Cape Vanderlin to Cape Grey	1:300,000	Nov. 1966
Aus 306	Cape Grey to Cape Wessel and Elcho Island	1:300,000	Sept. 1973
Aus 308	Goulburn Islands to Melville Island	1:300,000	May 1968
Aus 309	Darwin to Penguin Shoal (Eastern Sheet)	1:300,000	Nov. 1966
Aus 310	Cape Van Diemen to Messels	1:300,000	Sept. 1967
Aus 314	Sahul Banks	1:300,000	Feb. 1966
Aus 315	Darwin to Penguin Shoal (Western Sheet)	1:300,000	Mar 1966
Aus 316	Charles Point to Pelican Islet, including Victoria River	1:300,000	Feb. 1969
Aus 318	Lesueur Island to Troughton Island	1:300,000	July 1969
Aus 319	Penguin Shoal to Browse Island	1:300,000	Mar 1966
Aus 323	Adele Island to Lacepede Islands	1:300,000	Sept. 1967
Aus 324	Lacepede Islands to Bedout Islet (Eastern Sheet)	1:300,000	Jan. 1975
Aus 325	Lacepede Islands to Bedout Islet (Western Sheet)	1:300,000	Nov. 1966
Aus 326t	Bedout Islet to Port Walcott	1:300,000	Mar 1980
Aus 327t	Port Walcott to Monte Bello Islands	1:300,000	Aug. 1967
Aus 328	Monte Bello Islands to North West Cape	1:300,000	Oct. 1968
Aus 329	North West Cape to Point Cloates	1:300,000	May 1967
Aus 330	Point Cloates to Quobba Point	1:300,000	Feb. 1969
	Cape Cuvier (1:10,000)		
Aus 367m	North Reef to Pine Peak Island	1:300,000	Oct. 1977
Aus 377	Bligh Entrance to Eastern Fields	1:300,000	Mar 1973
Aus 378m	Daru Roads to Kerema Bay	1:300,000	Mar 1974
Aus 379m	Kerema Bay to Port Moresby	1:300,000	Feb. 1974
Aus 380	Port Moresby to Orangerie Bay	1:300,000	July 1968
Aus 381	Orangerie Bay to Jomard Entrance	1:300,000	Aug. 1971
Aus 382	Louisiade Archipelago	1:300,000	July 1971
Aus 383	Bonvouloir Islands to Woodlark Island	1:300,000	Aug. 1971

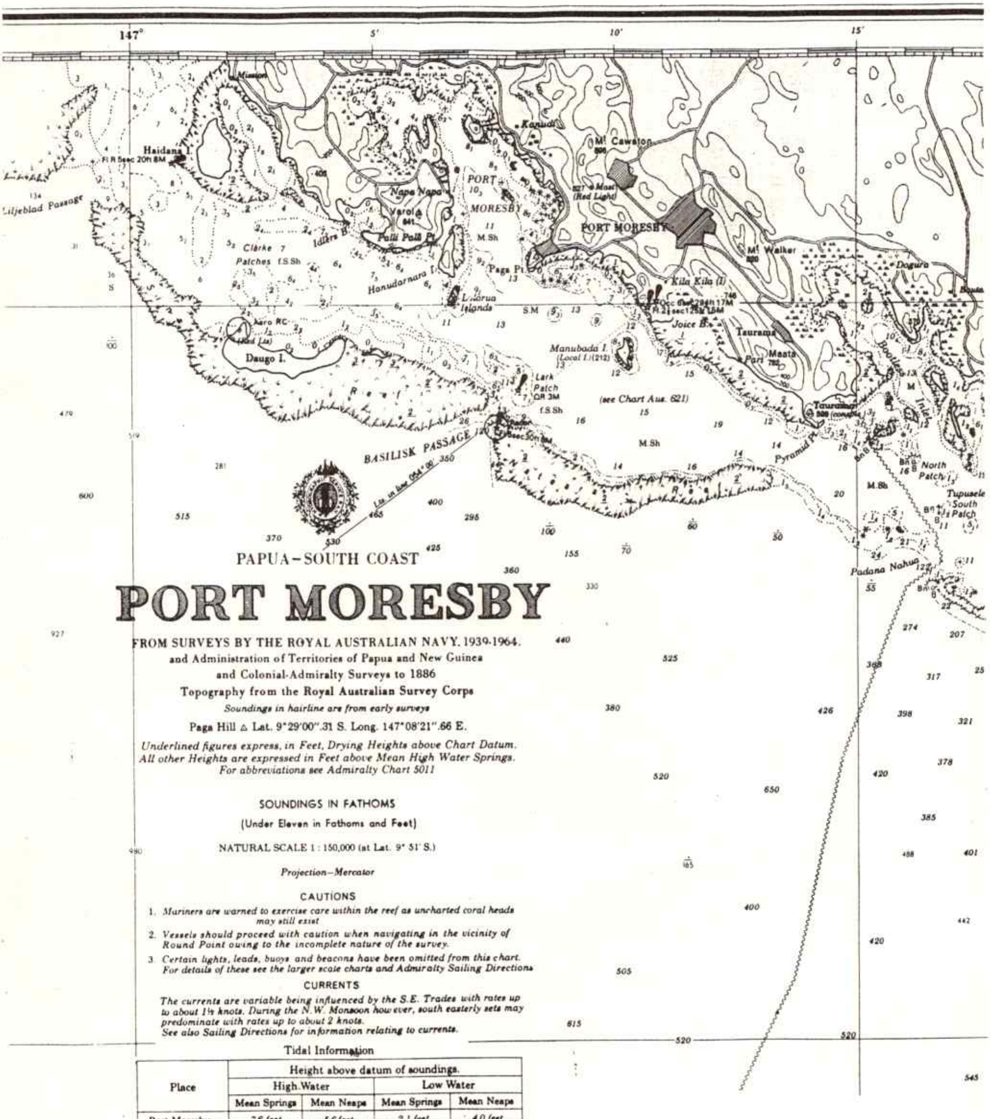
Chart No	Title	Scale	Current Edition
Aus 384	Cape Vogel to Cape Nelson with the D'Entrecasteaux Islands	1:300,000	Oct. 1975
Aus 385	Cape Nelson to Cape Ward Hunt	1:300,000	Feb. 1975
	Cape Ward Hunt to Cape Cretin (1:300,000)		
Aus 389	Karru Island to Vanimo Harbour	1:300,000	May 1968
	Vanimo Hr. (1:25,000)		
Aus 410	Booby Island to Cape Wessel including Gulf of Carpentaria	1:1,000,000	July 1971
Aus 414	Rowley Shoals to Lombok Strait	1:1,000,000	Aug. 1969
Aus 505	Port Moresby to Hood Point	1:150,000	July 1965
	Round Hill Anch. (1:50,000)		
Aus 506	Hood Point to Rothery Passage	1:150,000	Nov. 1965
	Cheshunt Bay (1:50,000)		
Aus 520	Cape Nelson to Cape Killerton	1:150,000	July 1975
	Oro Bay (1:18,000) Porlock Hr. (1:30,310) Appr. to Buna (1:50,000) Port Harvey (1:18,000)		
Aus 547	Lolobau Island to Willaumez Peninsula	1:150,000	Aug. 1967
	Garua Hr. (1:50,000)		
Aus 567	Mugula Island to China Strait	1:100,000	May 1945
	Inverary Bay (1:37,500)		
Aus 570	Amphlett Group to Kiriwina	1:120,000	July 1944
	Musao Bay (1:25,000) Boli Pt. Anch. (1:40,410)		
Aus 572	Buna to Mambare Bay	1:100,000	June 1975
	Appr. to Cape Killerton (1:25,000)		
Aus 573	Mitre Rock to Hosken Islands	1:100,000	Mar 1948
	Morobe Hr. and Appr. (1:37,500) Mambare Bay (1:66,666)		
Aus 574	Hosken Islands to Lae	1:100,000	Dec. 1956
	Mort Hr. (1:50,000) Nasser Bay (1:37,500)		
Aus 576	Admiralty Islands	1:250,000	Dec. 1962
	Kelaua Hr. (1:25,000) St. Andrew Anch. (1:37,500) Nares Hr. (1:75,000)		
Aus 613	Marion Reef	1:145,000	Nov. 1908
Aus 620	Half Sound (Bia Atai) and Van Van Anchorage	1:36,300	Oct. 1957
	Fife Bay (1:15,800)		
Aus 621	Approaches to Port Moresby	1:35,000	Dec. 1966
	Port Moresby (1:17,500) Basilisk Passage (1:25,000)		
Aus 623	Tovak Entrance to Marshall Lagoon	1:50,000	Jan. 1974
Aus 625	China Strait and Approaches	1:25,000	June 1963
	Samarai Anch. (1:10,000) Samarai Wharves (1:2,500)		
Aus 628	Goschen Strait	1:37,500	Oct. 1945
Aus 629	Milne Bay	1:75,000	Dec. 1970
	Gili Gili Anch. to Gobi Pt. (1:30,000) Killerton I. and Anch. (1:25,000) Discovery Bay (1:7,500) Kana Kopi Bay (1:7,500)		
Aus 630	Eastern Approaches to Milne Bay and Goschen Strait	1:75,000	May 1970
Aus 651	Approaches to Wewak	1:75,000	Jan. 1970
	Kairiru Strait (1:37,500) Wewak Hr. (1:37,500) Victoria Bay (1:25,000)		
Aus 652	Aitape Road	1:33,000	Jan. 1954
Aus 662	Seeadler Harbour	1:30,000	Sept. 1952
	Lombrum Bay (1:10,000) Papitalai Hr. (1:15,000)		
Aus 665m	Approaches to Eleonora Bay	1:25,000	May 1981
Aus 666	Passages between New Ireland and New Hanover	1:50,000	Mar 1955
Aus 667	Kavieng Harbour	1:12,500	May 1966
Aus 674m	Kulungi Roadstead	1:25,000	Jan. 1976
Aus 676	Plans in New Britain		Sept. 1979
	Luther Anch. (1:12,000) Put Put or Rugen Hr. (1:18,000) Henry Reid Bay (1:50,000) Jacquinot Bay-south west part (1:50,000) Linden Hr. (1:50,000) Gasmata (1:50,000) Fulleborn Hr. (1:36,000) Mowe Hr. (1:75,000) Arawe Hr. (1:36,000) Pondo Hr. (1:25,000) Iboki Anch. (1:50,000) Peter Haven (1:18,000) Tavanatangir Hr. (1:25,000) Borgen Bay and Appr. (1:75,000) Dampier Strait (1:150,000)		
Aus 679	Plans in the Bismarck Archipelago		Oct. 1956
	Duke of York Group (1:50,000) Mioko Hr. (1:18,000)		
Aus 680	Approaches to Simpson Harbour	1:30,000	July 1964
	Simpson and Matupi Hrs. (1:12,500) Kokopo (1:18,000)		
Aus 683	Plans in the Solomon Islands		May 1970
	Kieta Bay and Anewa Bay (1:50,000) Anewa Bay (1:15,000) Shortland Hr. (1:75,000) Buka Passage (1:50,000) Queen Carola Hr. (1:100,000)		
Aus 700m	Western Approaches to Torres Strait	1:150,000	July 1979
Aus 701	Vrilya Point to Duyfken Point	1:150,000	Nov. 1966
Aus 715m	Cape Arnhem to Cape Wessel	1:150,000	Mar 1971
	Gove Hr. (1:37,500)		
Aus 720	Port Essington to Cape Hotham	1:150,000	June 1967
Aus 722	Cape Hotham to Cape Fourcroy	1:150,000	Sept. 1945
Aus 726m	Approaches to Cambridge Gulf	1:150,000	June 1979
Aus 728m	Eclipse Islands to Cape Voltaire	1:150,000	July 1976
Aus 731	Yampi Sound to Champagny Island	1:150,000	May 1949
Aus 733	Buccaneer Archipelago and King Sound	1:150,000	Feb. 1965
	Port Usborne (1:37,500)		
Aus 739mt	Bedout Islet to Port Hedland	1:150,000	Jan. 1975
Aus 740mt	Port Hedland to Port Walcott	1:150,000	Aug. 1979
	Depuch I. Anch. (1:20,000)		
Aus 741mt	Approaches to Dampier Archipelago	1:150,000	Aug. 1974

Chart No	Title	Scale	Current Edition
Aus 742mt	Rosemary Island to Barrow Island	1:150,000	Aug. 1980
Aus 743m	Barrow Island to Onslow	1:150,000	Nov. 1979
	Fortescue Road (1:75,000) Appr. to Onslow (1:75,000)		
Aus 744	Exmouth Gulf with Approaches	1:150,000	Aug. 1955
	Learmonth Anch. (1:50,000) Pt. Murat Wharf (1:25,000)		
Aus 820m	North Reef to Port Clinton	1:150,000	July 1975
Aus 822m	Port Clinton to Percy Isles	1:150,000	Aug. 1976
Aus 823	Percy Isles to Mackay	1:150,000	Feb. 1963
Aus 824	Bailey Islet to Whitsunday Island	1:150,000	June 1964
Aus 825	Whitsunday Island to Bowen	1:150,000	Dec. 1982
Aus 826	Bowen to Cape Bowling Green	1:150,000	June 1964
Aus 827	Cape Bowling Green to Palm Isles	1:150,000	June 1964
Aus 828m	Palm Isles to Brook Islands and Palm Passage	1:150,000	Feb. 1979
Aus 829m	Brook Islands to Russell Island	1:150,000	Aug. 1979
	Dunk I. Anch. (1:50,000) Gladys Inlet (1:15,000) Mourilyan Hr. (1:7,500)		
Aus 830m	Russell Island to Low Isles	1:150,000	Feb. 1978
	Port Douglas (1:10,000)		
Aus 831m	Low Islets to Cape Flattery	1:150,000	Mar 1979
Aus 832m	Cape Flattery to Barrow Point	1:150,000	April 1971
	Howick Group (1:75,000) Cape Flattery (1:45,000)		
Aus 833m	Barrow Point to Claremont Isles	1:150,000	July 1976
	Flinders Group (1:75,000) C. Melville and Pipon Is (1:75,000)		
Aus 834m	Claremont Isles to Cape Weymouth	1:150,000	Nov. 1978
	Appr. to Haath Reef (1:50,000)		
Aus 835m	Cape Weymouth to Cairncross Islets	1:150,000	Jan. 1975
Aus 837m	Olinda Entrance to Mer Island	1:150,000	Oct. 1982
Aus 839m	Cairncross Islets to Arden Island	1:150,000	Feb. 1978
Aus 840m	Arden Island to Bramble Cay	1:150,000	Nov. 1974
Aus 4070m Int. 701	Indian Ocean – Southern Portion	1:10,000,000	Dec. 1978
Aus 4602m Int. 6021	South Pacific Ocean – Tasman and Coral Seas Australia to Northern New Zealand and Fiji	1:3,500,000	Feb. 1982
Aus 4603m Int. 6031	Indian Ocean, Australia – North Coast and Adjacent Waters	1:3,500,000	Mar 1982
Aus 4604m Int. 6041	South Pacific Ocean – Coral and Solomon Seas and Adjacent Seas	1:3,500,000	Mar 1982
Aus 4708m Int. 708	Indian Ocean – Australia, West Coast	1:3,500,000	Mar 1982

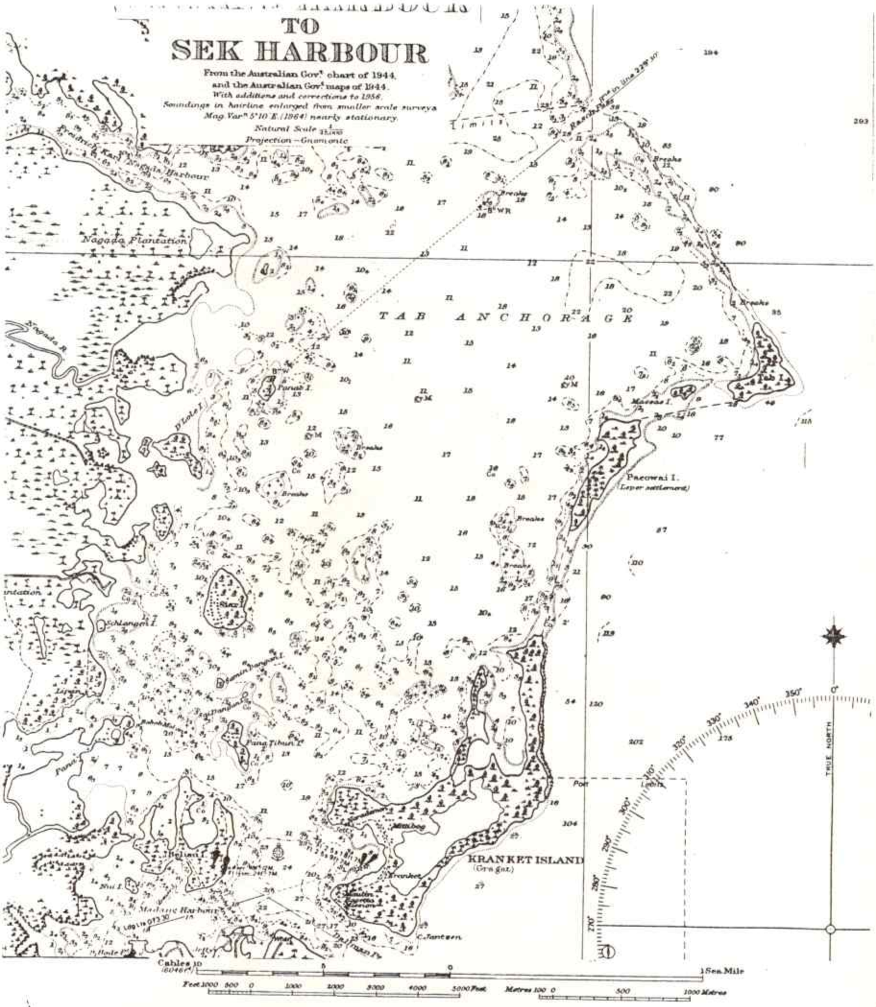
SELECTED BRITISH ADMIRALTY CHARTS

Chart No	Title	Scale	Current Edition
BA 208	Solomon Islands – Southern Portion	1:1,000,000	Aug. 1969
*BA 209	Port Moresby to Cape Deliverance	1:1,000,000	Sept. 1975
*BA 214	Solomon Islands – Northern Portion	1:1,000,000	Aug. 1974
*BA 217	Ward Hunt Strait to St. Georges Channel	1:1,000,000	Sept. 1975
*BA 347	Percy Isles to Whitsunday Passage	1:300,000	Mar 1965
*BA 348	Whitsunday Passage to Palm Isles	1:300,000	Aug. 1965
BA 349	Reef Anchorage in the Australian Coral Sea		Dec. 1961
	Cato I Reef and Bank, and Kenn and Frederick Reefs (1:72,600) Wreck Reef – West and Bird Islet Anchs (1:72,600) Saumarez Reefs (1:145,300) South Bellona Reefs (1:72,600) Middle Bellona Reefs (1:72,600) Chesterfield Group – Southern Anchs (1:145,300) Long I. Anch. (1:40,000) Mellish Reef (1:72,600) Mellish Reef Anch. (1:24,200) Osprey Reef (1:145,300) Willis Islets (1:72,600)		
*BA 383	Thursday Island Harbour	1:12,500	Sept. 1952
BA 780(I)	Pacific Ocean – South West Sheet	1:6,900,000	June 1977
BA 864	Islets and Reefs in the Coral Sea		July 1887
	Coringa Islets (1:72,600) Holmes Reefs, and Flinders and adjacent Reefs (1:145,000)		
BA 942A	Eastern Archipelago – Sheet 3 – Eastern Portion including the Flores, Banda and Arafura Seas, and the Eastern passages to China	1:1,550,000	Nov. 1959
BA 942B	Eastern Archipelago – Sheet 4 – Eastern Portion including the Flores, Banda and Arafura Seas, and the Eastern passages to China	1:1,550,000	Nov. 1959
BA 944	Sewa Bay	1:12,500	Sept. 1957
*BA 1024	Fraser Island to Cumberland Islands	1:1,000,000	Feb. 1976
*BA 1039	Cooktown to Booby Island and Port Moresby	1:1,000,000	July 1970
*BA 1042	Cumberland Islands to Cooktown	1:1,000,000	Jan. 1973
*BA 1044	Cape Arnhem to Cape Fourcroy	1:1,000,000	Oct. 1959
*BA 1047	Cape Fourcroy to Cape Leveque	1:1,000,000	Oct. 1959
BA 1048	Buccaneer Archipelago to Bedout Island	1:691,000	Nov. 1922
	Beagle Bay (1:72,600) Lagrange Bay (1:145,000)		
BA 1055	Bedout Island to Cape Cuvier	1:680,000	Feb. 1960
BA 1206	Approaches to King Sound	1:300,000	July 1954
BA 1242	Cape Voltaire to Adele Island	1:300,000	May 1954
BA 1477	Jomard Entrance to Yana Island, including Misima, Deboyne and Renard Islands	1:131,000	Dec. 1950
BA 1708	Bougainville Strait	1:75,000	Mar 1977
BA 2003	Vitu Islands to Watom Island	1:300,000	Sept. 1960
*BA 2018	Vitiaz and Dampier Straits	1:300,000	June 1979
*BA 2054	Plans in New Guinea		Sept. 1960
	Salamaua Harbour (1:50,000) Lae (1:25,000) Dreger and Schneider Harbours (1:12,000), Langemak Bay and Finsch Harbour (1:10,000) Konstantin Harbour (1:10,000), Madang Harbour to Sek Harbour (1:25,000)		
BA 2136	Plans in New Ireland		Jan. 1958
	Passages between New Ireland and New Hanover (1:100,000) Cape St. George to Sperber Pt. (1:75,000) Nabuto Bay (1:30,000) Kalili Hr. (1:12,000) Bakhaven Hr. (1:12,000) Kavieng Hr. and Nusa Channel (1:30,000) Beongung Hr. (1:12,000) Ysabel Pass (1:100,000)		
BA 2240	Vitiaz Strait to Isumrud Strait	1:300,000	Mar 1958
*BA 2321	Torres Strait and Approaches	1:300,000	Aug. 1958
*BA 2344	Franklin Islands to Lizard Island	1:300,000	Feb. 1960
*BA 2349	Palm Isles to Franklin Islands	1:300,000	Nov. 1959
*BA 2354	Cape Sidmouth to Cape York	1:300,000	July 1956
*BA 2355	Lizard Island to Cape Sidmouth	1:300,000	Sept. 1959
BA 2510	Approaches to Cocos or Keeling Islands	1:250,000	May 1962
	South Keeling (1:37,500) North Keeling I. (1:37,500)		
BA 2766	North-East Coast of New Guinea, with Bougainville, New Britain, New Ireland, Admiralty Islands and off-lying reefs	1:1,700,000	Feb. 1938
BA 3250	Cape D'Urville to Wuvulu Island	1:500,000	Feb. 1943
*BA 3420	Bougainville Island	1:250,000	July 1978
BA 3504	Christmas Island	1:60,000	Sept. 1963
	Flying Fish Cove (1:3,000)		
BA 3553	Gazelle Peninsula and St. Georges Channel	1:263,000	May 1967
BA 3723	Hermit Islands	1:50,400	Feb. 1913
	Endeavour Strait –		
BA 3782	Western Sheet	1:50,000	Aug. 1953
BA 3783	Eastern Sheet	1:50,000	Dec. 1953
	Bismarck Archipelago –		
BA 3830	Sheet 1 – Bougainville Island to North Cape New Ireland	1:750,000	Oct. 1954
BA 3832	Sheet 3 – North Cape New Ireland to Wuvulu Island	1:750,000	Jan. 1953
*BA 3994	Bougainville Island to Ghiro Island	1:300,000	July 1980
BA 4073 Int. 73	Indian Ocean, Eastern Portion	1:10,000,000	June 1979
*BA 4710m(I)	Indian Ocean: Cape Leeuwin to South East Indian Rise	1:3,500,000	Nov. 1978
BA 4711m(I)	Indian Ocean: Ile Amsterdam to Iles de Kerguelen	1:3,500,000	Nov. 1978
BA 4714m(I)	Cocos or Keeling Islands to Ile Saint-Paul	1:3,500,000	Feb. 1978

* BA charts printed in Australia



Place	Height above datum of soundings			
	High Water		Low Water	
	Mean Springs	Mean Neaps	Mean Springs	Mean Neaps
Port Moresby	7.6 feet	5.6 feet	2.1 feet	4.0 feet



TO
SEK HARBOUR
From the Australian Govt. chart of 1944, and the Australian Govt. maps of 1944.
With additions and corrections to 1956.
Soundings in hairline enlarged from smaller scale surveys.
Projection – Gnomonic
Nagada Plantation
TAB ANCHORAGE
Breaks
Paeowai I.
Schlangen I.
Siar I.
Panab I.
Pana Tibun I.
Madang Harbour
Mitibog
Kranket
KRANKET ISLAND
C. Jantzen
Cables 10
1 Sea Mile
Feet
Metres
1000 Metres
TRUE NORTH

STARTING A SMALL BUSINESS IN PAPUA NEW GUINEA

INTRODUCTION:

The importance of Small Business to Papua New Guinea economy is a well advocated fact by many of our leaders and the Business Community. The importance of Small Business Development is further amplified by the establishment of policy guidelines and institutions aimed at promoting Small Businesses. Whether such policies and institutions are meeting their objectives remains to be answered:-

WHY IS SMALL BUSINESS IMPORTANT TO ANY ECONOMY?

The contribution of Small Business to an economy can be measured in a variety of ways.

What follows is a typical analysis of contributions which applies to both the so called 'Developed Nations and Developing Countries'

a) Employment:- small Business provide major avenues for formal employment and exposes family members to business activity. In many countries 50% of total employment in private sector is provided by Small Business. You would only need to call into a couple of Trade Stores in town and see this taking place.

b) Consumer Service - Small Business provide a range of products and services direct to the consuming public. They contribute towards improving the standard of living of the Community.

c) Distribution outlets for Big Business:

- Small Businesses can prevent a monopoly situation - Small Business create competition by entering any market where business business opportunity exists. They can compete with large business and amongst themselves.

e) Avenue for Independence, innovation and Entrepreneurial talent. In a free Enterprise Economy such as the ne we have in Papua New Guinea; high value is placed on independence of individual. The Small Scale Business offer a means of achieving that goal. Small Businessman are innovative people - providing new products, new services and new approaches to satisfying customer needs. The Entreprenurial talents enable businessman will drive, energy, foresight and imagination to establish new businesses by combing resources for an effective result.

There are many other ways the contribution of Small Businesses can be measured but the above mentioned will suffice for our purpose. So you can see that Small Enterprises cannot only make the individual entrepreneur gain in terms of profit and personal development but also influence the entire economy of a country. Now that we have had a look at the importance of Small Businesses to any economy, I will present to you the necessary procedures or activities that should be followed and done before actually starting a business.

Going into Business or starting a small Business does not just happen. It must be well thought out, properly planned and a lot of ground work must be done.

Often most businesses that fail are those that come into being just over night without proper planning. A proper approach to Business will leave us with less room for failure.

WHAT DO YOU NEED TO BE IN BUSINESS?

To start your own Business you need a number of things; you just don't jump onto the first idea that comes into mind and get going with it. There are a number of things that you need if you are to be successful as a Business person:-

The following are necessary before starting a business:-

a) A Product to sell

b) A service to provide

c) Some knowledge of the type of business you want to start.

d) A Business plan in corporating the different stages in which you will develop your business and the manner resources are to be combined to achieve effective results.

e) Money - Probably more than you have.

f) Some knowledge of yourself.

WHAT ARE SOME OF THE CHARACTERISTICS OF A GOOD BUSINESSMAN?

Is a good entrepreneur born or made?

What characteristics must a person possess to be a successful businessman?

To answer these two questions. There is, unfortunately, no check list, that if properly filled out, will rule out the possibility of failure. However, there are certain personality traits that a person must possess to be a successful businessman.

Here are just a few:-

a) desire for achievement
b) motivation
c) technical competence
d) good judgement
e) courage
f) initiative
g) self-confidence
h) energy
i) honesty
j) emotinal stability
k) risk taker

Not everybody have all of these characteristics but you should possess some of them, if you are to be successful.

If you do not have all of the above qualities, do not worry. A man is more than his personality traits, in the same way that beautiful colours, by themselves, do not make a beautiful painting.

This means that starting and running a successful business is not reserved for a exclusive group or to an elite.

You can be one of them if you are prepared to work hard (perhaps 12 to 16 hours a day!) and assume some risks.

WHY GO INTO BUSINESS?

Almost everyone at sometimes in their lives has thought about starting a bùsiness. There are varied reasons for persons to become entrepreneurs. No one sees a doctor for nothing!

Entrepreneurs usually start a business cconcern for profit. Through capital gains they hope to live a better standard of living or htey will pay themselves a good salary.

Another reason for people going into business is the though of being your own boss. A businessman/women you a void the so-called routine supervisor checks, none to tell you what to do, how to do and when to do it.

The third reasons why people become businessman is that they want to make their own decisions. They do not have to wait for big "boss" to to say "yes, you cango ahead and do it!.

The fourth reasons why people become entrepreneur is freedom from routine. Have you every caught up with a situation where you have to do the same thing day upon day, week upon week, month upon month. When you are your own boss you avoid this experience.

There are other reasons why people become businessman. Can you think of your own reasons for wishing to be a businessman or for being a businessman?

NOW YOUR OWN BUSINESS

After completion a favourable self-evaluation of yourself and having completed a feasibility studies, it is now time to own your business. There are actually three (3) ways by which you can be in business.

1. Starting from scratch

   Most people when they talk about owning a business, they tend to think of a business they have started themselves. Perhaps, this better suits their drams. It would then be something they have created themselves.

   You can start a business from scratch if the following conditions exists:

2. Where the customer needs are not being taken care of becuase of poor inefficient service, lack of selection, etc.

3. Where a new product or service is being comtemplated for which no present business exists.

If this conditions do not exist you will have a more difficult, but not impossible! - Job of meeting the well established competition.

2. Buying a existing Business

   The second way of owning a business of your own is by buying a existing business. A lot of consideration should be given to looking for a business that is already in operation, something in which the start up problems have already been resolved.

   Business owners may sell their business for many reasons including retirement health, or even because its growing too fast for their particular requirements, an excellent reason for you to buy a existing business.

The following are some of the disadvantages of buying a existing business.

a) Location, facilities, image and policies are difficult to change.

b) Business may have operated entirely on past owners rapport with customers and his departure could result in significant loss of business.

WHAT KINDS OF RISKS ARE FACED BY A BUSINESSMAN?

One of the characteristics of a businessman is that of a risk taker. There are basically four major types of risks that are faced by a businessman.

a) The risk of psychological failure. This is rarely discussed but it is very important. Business failure may mean loss of personal confidence or feelings of inadequacy, leading to an inability to work effectively or to retain a normal personal life.

b) The Risk of Interrupting your Career

Whatever you are doing now, you probably have some sort of job security. If you fail in as a entrepreneur, you may have difficulties in finding another job or at least you willhave lost your senority.

c) The Risk of Straining Family Relationships

Starting and owning a business is very demanding in terms of energies, emotions and time. Whatever is devoted to the business will not be devoted to the family.

d) The Risk of Financial Difficulties or Even Failure

Most new entrepreneurs (businessman) who come into the business field willhave their entire life savings invested in the venture, or you might have to allow mortgage over your property if you have one.

At the very least, you and your family have to accept a low standard of living until the business gets onto its feet.

So it is very necessary for your to discuss these risks with someone who is close to you and those who will be affected by your future decisions.

SELF-EVALUATION

Having a look at both the advantages and disadvantages of being a business man or women, you must now decide if you are the type of person who will assume these risks and responsibilities. Remember you will be your most important employee, so be completely honest in your evaluation of yourself.

To assist you with your self evaluation, here are some questions you should ask yourself before lmaking any commitments.

1. Have yu had enough experience in this type of business?
2. have you every been a Manager?
3. Are you will to gamble your savings in this venture?
4. Have you the full backing of your spouse?
5. Do you have a secondary source of income in your family?
6. Do you have a strong desire to make money?

7. In legal terms do you fully understand:-

- Personal Guarantees
- Partnership
- Sole Traders
- Limited Company.

ADVANTAGES AND DISADVANTAGES OF STARTING FROM SCRATCH AND BUYING A EXISTING BUSINESS

There are a numbe of advantages and disadvantages that should be seriously considered before deciding on how to get into business. Both need equal attention to commence a successful business.

We will now look at the advantage and disadvantages of starting a new business.

1. ADVANTAGES

   a) Freedom of choice in all aspects of business
   b) If available capital is limited, entrepreneur can start at any scale desired.
   c) There may be no established business of type desired.
   d) Often less expensive; you don't have to buy "GOODWILL".

2. DISADVANTAGES

   1. Slow start up, requires times, effort patience and hardwork.

      - To establish customers
      - To develop lines of credit and supply
      - To build up experienced staff.

   2. High risk of types discussed as above and uncertainty.

The buying of an established one has a number of distinct advantages which include the following:-

a) Immediate income from sales to existing customers

b) Relationships already established with banks, suppliers, accountants, trade association, etc.

c) Employees can provide invaluable assistance, vendor can provide benefit of his experience and sometimes assist with secondary financing.

d) Proven operation reduces uncertainty and makes it easier to obtain financing from third parties.

e) You can often buy at bargain prices....When?

FEASIBILITY STUDY (SUCCESS FACTOR)

Having a product or service to provide and completion a fourable self evaluation are not the only requirements to go into business. A proper feasibility study which requires a wide range of areas must be carried out.

Without a proper feasibility study the risk of business failure is not impossible:-

1. MANAGEMENT

Management implies more than giving orders. It involves the best use of money, people and other resources to meet the required result. It also involves keeping and interpreting records to evaluate changes, trends and weakness.

As a owner of a Business, it success or failure will depend on your management skills. Those skills will be tested even before the business starts.

The money you make in business (return) should e more than what you can earn working for someone else.

Therefore, if you don't possess the required management skills, you should look for someone who has before going into business.

2. EXPERIENCE

Experience is the greatest of all teachers. It will assist you to avoid mistakes, see in advance how things will turn out if a certain action is taken.

The experience you have in the type of business you want to start will help your plan alternatives courses of action and use your resources.

If you do not have the required experience in the types of business you want to start, you should work for someone else who has a established business for sometime.

3. CONFIDENCE

You must have confidence in yourself. Confident people take the initiative. People are decision makers and decision are the most important action called for in Business.

4. PLANNING

As we have seen already, going into business involves some risk. You reduce the risk factor by careful planning. Your chance of success will depend to a very large extent on how well you have examined all aspects of the operation you are proposing to start.

To help you do this in a systematic way, I have compiled a check :
which will assist yu in planning your new business.

Specific areas covered included are Market Analysis, Choosing a Location, Labour and Equipment.

MARKET ANALYSIS

a) Your customers-

- Who are they? Age, Sex, Income bracket.
- Where do they live, play, shop?
- What motivates them to buy yur products?
- How often do they buy? Seasonal?
- Cash or credit?
- Can you afford to carry accounts receivable?

b) Your competition-

- How big, how old, how strong?
- What percentage of the market do they have?
- How far away?
- What advantages do you have?
- What advantages do they have?
- What percentage of the market will you get?

c) Your Products-

- Are they unique, eye appealing?
- Better designed, higher quality?
- What sizes, any special packaging?
- Is there a need for your products?
- Must you offer guarantee?
- What will be your return policy?
- Must you stock parts for service?

d) Pricing

- Do you know what to charge to cover your costs?
- Are your percentage competitive?
- How important is low price?
- Is service more important?
- Must you give discounts for cash, volume, distributors, salesm
- What will discounts do to your mark-up?
- Must you stock parts for service?

e) Advertising

- How much is normal for your products?
- What media, how often? Seasonal?
- Do you have a logo or trademark? Is it registered?
- Is any free publicity available?
- Will you need an advertising agency?

f) Buying-

- How much of each will you buy? From whom?
- Are you getting the best deal?
- Can you return unsold merchandise?
- have you a stock control plan to avoid overstocks, understock and out of stocks?
- Have you established a line of credit with each supplier?
- How much you pay - COD, 30 days, 60 days

g) Distribution

- If you are a manufacturer how ill you will...through dealers, distributors, sales agents or direct to the consumer?
- What is common in the Industry?
- Do transportation costs dictate the best method of distribution?

6. CHOOSING A LOCATION

A) Zoning

- Present zoning and future zoning?
- If it must be rezoned what time span is involved and at what cost?

B) Building

- Outside and inside appearance?
- Layout, lighting, heating, floors, accoustics, comfort, waste disposal, parking, landscape, snow removal?
- Outside storage.... Is it permitted?

C) Lease

- Has it been checked by your lawyer?
- Is it short or too long?
- Any options available?
- Who pays to have the lease drawn?
- What are you responsible for?
- What is the landlord responsible for?

D) Approvals

- Be sure all government regulatory bodies will approve your use of the building.
- Zoning, health, Firemarshall, Transportation, Environment, labour.

E) Transportation

- Shipping doors? Truck access?
- Any truck-road restrictions?
- Is there a truck terminal nearby?
- Is rall or air important?
- Is it on a bus route for your staff?

F) Utilities

- Check your power supply, water, sewer, gas.
- What does each cost?
- Are they adequate?
- How much to upgrade them to your requirements?

G) Taxes

- present and future assessment for property taxes and business taxes

H) Protection

- Are there regular police patrols?
- What kind of fire protection?
- Hydrants nearby?
- Sprinkler system/
- Night watchman?
- any history of vandalism?

I) Neighbourhood

- How stable is it? Getting better or getting worse?
- Are you compatible with theneighbours?
- Will you enjoy living nearby?

J) Restrictions

- Are there protective covenants that will limit your sales?
- Any legal easements on your property?
- Can you grow physically in size?

K) Insurance

- Fire, theft, publicliability, staff liabiity, business Interruption.

L) Suppliers

- Are you near them? Is it important?
- Can you get quick service when something breaks down?

7. <u>LABOUR</u>

- How many employees - males and female?
- Skilled or unskilled - are they available?
- What wages will you offer?
- What are competitive wage rates in area?
- What fringe benefits? What hours?
- Will you train your staff?
- Can you train your staff?
- Who is in charge of who?

Pilferage
- controls over cash, Inventory?
- do you need a safe?
- who has keys?
- bonding of employees?

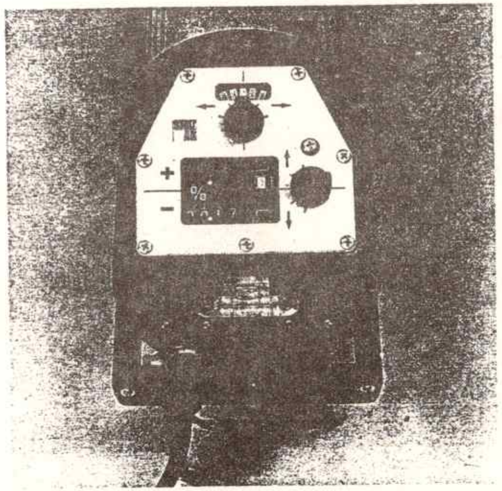
8. <u>EQUIPMENT</u>

- List all equipment, fixtures, furniture required.
- New versus used?
- Installation costs, how low?
- Terms of sale, guarantees
- Any duties or sales tax extras?
- Can you make any of your own equipment
- Maintenance costs?
- Work flow chart or plant layout?

045 AUTOMATIC

The small fully-automatic alignment laser with wide automatic range in two axes ...

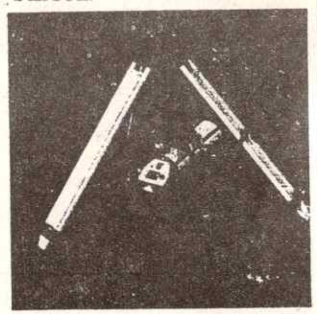
... a sure-fire return on investment for your pipelaying operations.



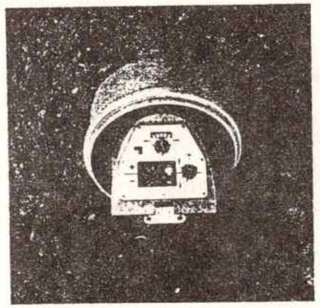
Extremely simple to operate:
- Power slope adjustment, two speeds.
- Power left/right movement, two speeds.
- Transverse spirit level for fast setting up.
- Remote control connection.

Absolute Reliability
- Separate indication for positive and negative slopes.
- Pilot lamp for both servo systems.
- Pilot lamps for the automatic ranges of both servo systems.
- Pilot lamp for battery voltage.
- Direction indicator for left/right movement.

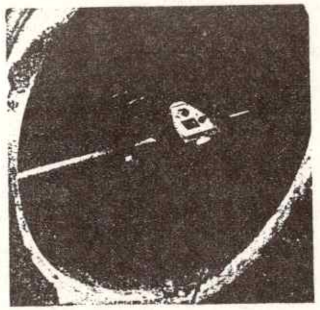
Convincing Advantages
- Handy to use.
- Quickly mounted.
- Simple operation.
- Optimum reliability.
- An investment which pays off.



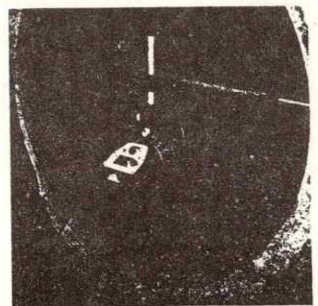
The 045 automatic mounted on a tripod in wet trenches and on unstable subsoil.



The 045 automatic in pipes or channels from 15 cm diameter.



The 045 automatic on horizontal bracing strut for mounting in shuttered trenches, shafts and large-diameter pipes.



The 045 automatic on vertical bracing strut for large-diameter pipes and in shafts.

STOLZ AG

MODERN TECHNOLOGY IN THE MILITARY ENVIRONMENT - SOME APPLICATIONS IN MAPPIING, CHARTING AND GEODESY

by Colonel A.W. Laing, RASvy

INTRODUCTION

History is littered with examples of developments in technology whcih were generated by military requirements. Developments in the shipping and aircraft industry, i the space programme and indeed in theprocesses and techniques which have continually evolved in the multi-disciplined engineering field provide but some of the evidence of a Defence community at the forefront of technology. Moreover, Defence is an industry within itself and until we reach a Utopian existence where defence is no longer required, it makes eminent sense to be cognisant of technological developments in the Defence arena and their applicaion to the broader civilian community.

This prominence of Defence as a user and generator of new technology, in the Australian context, is no more evident than in the field of mapping, charting and geodesy. the Royal Australian Survey Corps (RASvy) which has responsibility for mapping, charting and geodesy within the Australian Defence Force, has over the years, successfully exploited the advantages offered by the latest technology. Recent examples, on which this paper will focus, include the operational development of the latest inertial survey system and satellite positioning system user equipment, the installation and development of the AUTOMAP 2 computer assisted cartography system, through which our digital topographic data base is generated, and an increasing emphasis on the design and production of terrain an malysis products to meet the anticipated need of the Australian Defence Forece.

This paper also points to areas where RASvy experience has been and can continue to be of value to the civilian mappoing community, particularly in an age which is witnessing an increasing deman for geographic information and one in which the mutually beneficial exhange of such information will facilitate cost-effective operations.

SURVEY EQUIPMENTS AND PROCEDUR

As the end of this decade approaches, the postioning and surveying community has access to technology of ever incereasing accuracy and productivity. The traditional surveying techniques of measuring directions, distances and differential heights are enhanced by electronic theodolites, electromagnetic distance measuring equipment, total stations and electronic fieldbooks. However all of these instruments and technologies require line of sight between survey stations. The terrain and vegetation types typical of areas being developed for their resources, usually necessitates survey stations being close together, and their
establishment and preparation for observation is labour intensive.

Airborne distance measurement systems of the 1960s and early 1970s allowed trilateration networks of non-intervisible stations. For this technique to be utilised economically, at least four survey parties had to be deployed at any one time, and reliable and rapid movement between stations was essential. Normally fine weather for aircraft operations was also required.

Rapid Heighing and Profiling

Airborne laser terrain profiling is a technique that has ben used for two decades to determine heights of specific points or vertical profiles. Various techniques have bbn used to determine the position of the profile. These include photography from cameras aligned with the laser direction,and inertial survey systems. The latter is normally used on projects where high precision is required, however the procedures to monitor the inertial survey system errors must be adhered to.

Three-Dimensional Positioning

Until the early 1970s, the most effective method of establishing accurate position without reference to adjacent stations was geodetic astronomy, which was time consuming and obviously required clear skies for observations. The use of the United States TRANSIT Doppler system since the mid-1970s has allowed for rapid, all weather, all terrain, manpower effective precise absolute and relative three dimensional positioning. This system has been widely used for many applications to provide absolute three dimensional positions accurate to 1-2m and relative accuracies of 20-30 cm. TRANSIT is to be supported by the United states Nave (US Navy) until at least 1994 to overlap the introduction of the operational Global Positioning System)GPS). The current status of TRANSIT is seven satellites with broadcast ephemerides and five satellites being tracked for precise emphmerides. The US Navy plan to launch another five transit satellites before the end of 1989 (Sentman et al., 1986). This will ensure three plane coverage for the remainder of the life of the system. To exploit the system to its full potential and achieve the absolute and relative accurancies mentioned above, the required observation period is about 48 hours.

The two technologies which will probably have the greatest impact in the next decade on the science of postioning and surveying are inertial surveying and GPS.

Inertial Survey Systems (ISS) have now been used for varied applications for more than 10 years. One of the major reasons that the technology has not been used more widely is the high purchase or lease cost of current equipment. Survey systems currently available rely on mechanical gyroscopes which are costly to manufacture and maintain. Ring Laser Gyroscopes (RLG) are now used in inertial navigation systems. This technology is not only reducing the size of the equipment but also the purchase and maintenance costs while increasing the reliability. RLG technology should flow on to ISS. ISS mounted in helicopters or vehicles have the potential for rapidly densifying survey control networks. ISS operate independently, but are relative survey instruments in that existing survey points must be occupied during each traverse to determine ISS errors and smooth instrument determined co-ordinates. ISS determine distances travelled with respect to three axes by double integrations of the outputs of three mutually orthogonal acelerometers on a platform which is oriented in space by three gyroscopes. System errors are reduced by the so-called zero velocity updates (ZUPTs) where the ISS comes to rest and the known velocity (zero0 is compared with the system determined velocity. For 3rd Order surveys the recommended 'interval between ZUPTs for most ISS is about 4 mintues. this ma obviously be restrictive for projects in remote areas of steep terrain and dense vegetation. RASVy experience with the Ferranti Inertial Land Surveyor Mark III (FILS 3) has shown that helicopter mounted traverses with ZUPTs at 4 minute intervals may be observed at the rate of 1 kilometre (km) per minute. If double traverses are observed to provide redundancies to identify unmodelled system or large random errors, a reasonable acquisition rate is 100 km per day. If survey stations are required every 2 km, up to 50 stations may be co-ordinated in a day.

Assuming that helicopter charter rates are less than $8000 per day (including all operational costs) and the lease charges for the ISS are $1500 per day, the fifty stations could be co-ordinated by ISS at a cost of $190 per station. Additional overheads for station clearing and marking are about the same for coventional surveys, although the clearing costs may be less for ISS as observation lanes are not required. The RASvy FILS 3 produces results better than 3rd Order (30 ppm0 on 6 hour traverses with control 70 km apart and using survey design criteria and observation procedures drafted for the Australian National Mapping Council. The FILS 3 data is procesed on a portable IBM PC in the field, and adjusted results are available within 45 minutes of completion of each traverse. FILS 3 on board mission adjustment software provides near-real time co-ordinates accurate to 3m if at least two existing stations are connected to on a traverse.

GPS is an outgrowth of the TRANSIT Doppler system. In the early 1970s it was recognised that TRANSIT would not provide the naviagion accuracies required by Military Forces in the 1990s and beyond. The real time GPS Precise Positioning Service (PPS) availble to United States Military Forces and its allies, will provide navigation accuracies of 16 m spherical error probable. the Standard Positioning Service (SPS) will be available to civilian users and will provide real time navigation accuracies of 100 m shperical error 95% probability. The first of the operational Block II satellites is to be launched by expendable launch vehicle in October 1988. By the end of 1989 the By the end of 1989 the Block II constellation should comprise 12 satellites providing 24 hr, worldwide, all weather, two dimensional vavigation coverage. For three dimensional coverage, the constellation should be complete by the end of 1990.
As with the TRANSIT system, the military and civilian geodetic community have exploited the GPS satellite signals to achieve high precision survey quality accuracies. Relative accuracies of lppm between receivers observing the same satellites simultaneously are now routinely achievable using the carrier phase observable.

RASvy experience with Texas Instruments T14100 receivers supports results reported worldwide. Processing of 30 minutes of observations using the proprietary Texas instruments GEOMARK TM software and the broadcast ephemerides, produces results of 1-5 ppm on baselines up to 30 km in length. Observation spans of 15 minutes have also produced similar results, however this may not be the case if the satellites - station geometry is poor. GEOMARK TM processing on lines longer than 30 km normally produces results accurate to 3-7 ppm. RASvy observations from light weight towers up to 22m high have produced similar results to tripod mounted surveys. In areas of dense vegetation this technique reduces clearing costs. It should be noted that when GPS is fully operational, use of the broadcast ephemerides may not produce relative accuracies greater than 5 ppm. Field processing of data by GEOMARK TM on a TI Portable Professional Computer takes 15-45 minutes for each 30 minute baseline. RASvy network design and observation procedures are based on standards and specifications produced for the Australian National Mapping Council.

GPs receiver costs are related to the respective capabilities. For projects in areas of a few hundered kilometres square, where stations are about 50km or less apart, single frequency coarse/acquisition (C/A) code receivers costing about $50,000 should be suitable for accuracies up to and including 1st Order. Costs are expected to reduce as receiver numbers increase.

GPS point positioning at the 1-2m level is achievable from 1-3 hours of observation. This is in contrast to observing periods of 48 hours for similar accuracies with the TRANSIT system. Obviously GPS relative positioning is more precise and more productive than point positioning, assuming that more than one receiver is available for observations.

Image/Sensor Positioning

To reduce the cost of providing three dimensional ground control for photogrammetric mapping, RASvy is now actively pursuing a GPS T14100 based Total Camera Station, where the required control is effectively moved from the ground to the aircraft. The camera exposure station co-ordinates are determined by kinematic relative positioning with respect to at least one station on the ground. RASvy proposes to trial a system (position only and not orientation) in late 1988 using technology developed by the United States National Geodetic Survey (NGS). NGS [Mader et al., 1987] has demonstrated accuracies of greater than 15 cm on airborne tasks in the United States. RASvy trials of vehicles mounted GPS kinematic relative positioning in Sydney NSW, produced precisions of 2cm [Hein, 1987].

RASvy has successfully trialled a stateoscope integrated with a WILD RC10 aerial camera, to provide differential heights between exposure stations. In photogrammetric blocks, this effectively eliminates the requirement for internal vertical control. Accuracies in differential height of 1-2 m have been achieved.

Remotely Sensed Imagery

The other major component of mapping source data which, with survey control provides the baiss for mapping, is the photographic imagery from which maps are produced. The use of aerial photography in a military context is recorded as early as the battle of Solferino in Northern Italy just prior to which Emperor Napolean III ordered the sports balloonist Tournachon to provide reconnaissance photography (Thompson, 1980). Since then, remotely sensed imagery has been used extensively through the science of photogrammetry and it is this medium, more than any other, whch has been able to satisfy the unique military requirement to observe enemy actions from a safe distance. The on-going developments in remote sensing in the military environment has resulted in the continued application of its use in the broader civilian community.

Today, in relatively more peaceful times, remote sensing remains a powerful tactical and strategic weapon. It guides aircraft, ships, vehicles and missiles of modern armies to their targets with accuracy hitherto unimaginable and, through its ability to provide surveillance of international developments, it has become a key factor in the course of international politics, particularly between the super powers.

Due to the enormous research effort of the Cold War and the 'race to space' between the US and USSR, unclassified sensor are now available that provide the civilan community with high resolution imagery well suited to resource detection, development and monitoring.

Continuing research into the military uses of aerial sensors produces absolenscene in older models and there is a subsequent de-classification and release to the civilian community of equipment which can meet the needs of the resource manager, who now more than ever, prefers the synoptic, rather than the narrow perspective of the environment. By way of example, the Manual of Photogrammetry lists 98 aerial cameras known to be in use as at 1978. Fifteen manufacturers world wide take the credit for this array, but of particular interest is the fact that 59 of these cameras are reconnaissance instruments. the Fairchild company manufactured 35 of the 98. In 1917 Fairchild became the first American firm to begin manufacturing cameras exclusively for military use (Thompson, 1980).

Another example of civilian spinoffs from Defence initiatives is the meteorological imagery from the US Defence Meteorological Satellite Program (DMSP) administered by the Air Force. This imagery of 3km resolution has been available and de-classified since 1973 and senses in the 0.4 to 1.1 micron band plus a thermal Infrared (IR) band. Auroral displays, volcanoes, oil and gas fields, forest fires and snow cover extent have been mapped using the DMSP imagery (Lillesand, 1979).

Aerial photography of exceptional quality has recently become available to the civilian community from an unexpected military source. The USSR is now offering multispectral photography of Australia acquired during the Cosmos, Soyuz and Salyut space programmes. Cameras known to have been used include the KATE 140 and 200 models, the KFA 1000 and the Zeise Jena MKF-6. Imagery from the KATE 200 is as recent at 1986. Three spectral bands are used; 500-600 nanometers, 600-700 nanometers and 700-800 nanometers.

These bands correspond closely to the spectral bands used by all of the LANDSAT series of earth sensing satellites as well as by the recently operational SPOT satellite. KATE 200 photography is available in stereo-scopic format with 60% forward overlap and one 18 cm square frame covers a ground area of 46,600 Km square. Focal length is 200 mm and with a spatial resolution of about 15 metres, the imagery supplied at the nominal scale of 1:1,200 000 will stand substantial enlargement (Technical and Field Surveys, 1988). The Manual of Remote Sensing (1983) claims that the KATE 200 has a lens resolution of 160 line pairs/mm, about 2 1/2 times the power of a normal mapping camera . The system resolution would be less than that extraordinary figure.

The KFA 1000 photography offers even finer spatial resolution of 5 metres in two spectral bands in the visible portion of the spectrum. Forward overlap of 60% is also available. Whilst the improved resolution makes this imagery comparable with the US Large Format Camera (LFC) imagery flown in 1984, Newton (1987) has calculated that the poorer base-height ratio of the larger 30 cm x 30 cm frames reduces the KFA 1000 heighting ability to around + 15 m. Technical and Field Surveys (1988) report tht 85% of Australia is covered by the Russian photography. If this is true and if the geometric fidelity is similar to that of the LFC, extension of ground control for special resource mapping in more remote areas of Australia may be possible at far less cost than with the traditional photogrammetric solution using standard 9" x 9" photographs. Rapid control extension from LFC imagery was shown to be a feasible technique by Captain Laurie Newton, RASvy in 1986.

Presumably Russian photography exists over other countries of the South West Pacific region and it would appear to be an opportune time for us to take advantage of Glasnost to find out what is available to assist us in our resource inventories.

Whilst the military has in may cases generated the demand for sophisticated sensors and imagery, it is also possible to adapt civilian generated imagery to Defence requirements. Multispectral imagery from the LANDSAT and SPOT satellites has been examined for military uses and in the United States the Defence Mapping Agency is the single point of contact-for all Department of Defence users wanting special map products for strategic purposes using LANDSAT and SPOT. The US Air Force uses Landsat imagery 'draped' over Digital Terrain Models for pilot training and mission simulation (Wright, 1988).

It is the enormous information potential of this type of merged data and imagery that has attracted military and civilian Geographic Information Systems researchers alike. The added value of multispectral imagery such as the 20 metre resolution SPOT data now freely available world-wide, when combined with elevation, vegetation, hydrographic and cultural data is the current focus of some research within the ADF RASvy is well placed to take advantage of this technology to provide AUTOMAP base terrain analysis of the areas of Australia that are of prime interest to Defence. We will have a decided advantage in the task of geocoding imagery to precise ground co-ordinates in these areas. We have been using state of the art ISS and GPS equipment now for 2 yeas. RASvy is contributing to the formulation of standards and techniques to be sed by the civilian community in years to come when GPS will be the byword of the resource surveyor. it is in this area that the great challenges are yet to be met in the use of multi-spectral remotely sensed imagery.

Radar Imagery

This form of processed imagery most certainly had its operational debut in an exclusively military environment between 1934 and 1941, even though radar principles were well known before that time. The increased use of aircraft for military purposes in WWII saw tha rapid development of radar both as an offensive device, assisting bombadiers onto their targets, and as a defensive device, locating enemy ships and aircraft. The radars of this area were principally confined to supplying range and bearing data or to detection oof cultural detail which, when compared to the plotted position on a map, enabled course corrections to be made.

Further development through the 1950s and 1960s resulted in radars capable of being used for ampping. The Side Looking Airborne Radar or SLAR commenced operation as a military reconnaissance tol, obviating the need for the sensor platform to overfly hostile terrain. The same type of radar was researched by earth scientists in the 1960s and has become an important remote sensing tool. (Moore, 1983). In conjunction with other remote sensing devices such as LANDSAT or even conventional aerial photographic cameras, radar imagery offers great promise for resource detection, monitoring and development, particularly in remote and heavily forested areas such as Papua New Guinea.

It is now well known that one of the principal advantage of radar imagery is that is may be acquired through rain, mst and cloud and in the hours of darkness; the natural enemies of the aerial photographer. Off more importance to the resource scientist is radar's ability to penetrate the soil beneath the groud cover to reveal the geological structure. The L-Band Shuttle Imaging Radar-A (SIR-A) flown onboard the space shuttle Columbia in 1981 obtained imagery which reveal ed ancient hydrologic features buried 20 feet beneath the libyan desert (CANBY, 1983).

For some developing countries in the equatorial belt, side looking radar may be the only means of obtaining cloud free imagery of the topography. Ali (1987) cites the RAMP Project in Panama, the PRORADAM and RADAM Projects in South American and the NIRAD Project in Nigeria as successful mapping tasks carried out for primary coverage using radar. it is currently being used in Indonesia.

SEASAT, launched in 1978 was designed to measure ocean dynamics and carried a synthetic aperture imaging radar or SAR (Townshend, 1981). The success of this mision provided the impetus for the SIR-A and SIR-B missions. Consequently the utility of data from SIR-A and B for geological resource mapping, and oceanographic survey has spurred European countries, with Canada, to include synthetic aperature radar in the instrument package for ERS-A, the first European conditions and latitudes, however if imagery becomes available in our region the Defence community will be eager to exploit its advantages on a regular basis.

In the case of Papua New Guinea, radar imagery acquired digitally over remote areas may be transformed to fit the existing 1:100 000 Topographic Map Series provided by RASvy. This together with selected imagery from some of the sensors previously mentioned would contribute towards an effective geocoded planning tool for the challenges of Resource Development that are yet to come.

DIGITAL TOPOGRAPIC PRODUCT GENERATION

Exploitation of Technology for Computer Assisted Cartography in RASvy

The impact of computers is as evident in the mapping community as it is in any other technological field. Advances in digital cartography have paralleled those in the survey control and remote sensing areas, and, by incorporating the latest technology across the broad spectrum of its production process, RASvy has been able to maintain a balanced production environment.

RASvy utilizes the latest technology with its AUTOMAP 2 system at the Army Survey Regiment in Bendigo, Victoria. The system makes extensive use of computer assisted techniques in the generation of digital topographic data, and through it, RASvy produces 170 new 1:50, 000 scale maps and associated digital elevation models per year. These products subsequently provide a substantial amount of the source data from which smaller scale products are derived. Add to this the increasing use of AUTOMAP 2 for the production of RAAF aeronautical charts and it is readily apparent that AUTOMAP 2 plays the major role in the production of the 360 new maps and charts published annually by RASvy - an output which makes it by far the largest producer of topographic products in Australia.

Advanced technology is applied at virtually every step of map production, from aerotriangulation to stereoplotting, map editing and cartographic completion. Aerotriangulation adjustments are performed using a modern block adjustment program, PATM, which performs gross error detection and saves considerable effort in the identification of errors. Map compilation is done on the AUTOMAP 2 Input Sub System (ISS) using Wild B8 stereoplotters which have been modified for digital data collection and graphic superimposition. The graphic superimposition gives the operator immediate feedback as to the quality of his plotting, which reduces both the time required to plot a model and the chance of making an error. Superimposition graphics also allows a supervisor to verify the accuracy and completeness of all the plotted detail while it is still set up in the stereo model.

As data is collected digitally it can be manipulated, merged, and edited in digital form on high resolution graphics workstations. Digital elevation models are created from the digital contour data. The digital elevation data is produced now as a standard product and is also used by the AUTOMAP 2 system to create analytic hill shading for the Joint Operations Graphics. As each map is produced, the digital data is added to a rapidly growing data base which will ultimately cover the entire north of Australia.

Manual map compilations can also be input to the system and added to the data base. Topographic manuscripts are scanned on an Optronix raster scanner, following which the scanned detail is converted from the raw raster format to vector format, where it can be edited and manipulated on the system, and then finally added to the data base. When a map file is completed it is output via the Optronics raster plotter onto lith film. This step requires a conversion from vector data to raster data. This conversion includes the automatic generation of screens and stipples within the system (Gilbert 87), resulting in a manuscript which is immediately ready for plate making and subsequent printing.

Future Trends in Digital Cartography

Decreasing costs accompanied by higher performance of hardware will result in much more powere being available for extensive processing (Dangermond 87). Sophisticated software, to include expert systems and other artificial intelligence techniques will take advantage of the increased processing ability of the new hardware. Ther have also been great advances in the ability to store and manage large data bases. Optical disk technology offers the potential to maintain a huge cartographic database very economically (Light 86). New source materials such as multi-spectral, radar and digital imagery are being used successfully in research to supplement traditional aerial photographs, 'and in some cases to replace them. Potential cartographic applications of these new soruce materials are for generation of Digital Elevation Models (Elers 87, Leberl 87), feature extraction (Wang 87), and map compilation (Konecny 87).

An important new trend is the integrationof digital topographic data with other geographic data into computerized Geog raphic Information Systems (GIS). The GIS provides decision makers and managers with the opportunity to manipulate and view geographic data in many new ways. there have been many applications in the ilitary and civilian sectors, particularly to support resource management (Johnston 87, Wilkening 87). Whatever the purpose of a GIS, an important primary data layer will be the accurate topographic data provided by the mapping agencies. the digital topographic data will provide the geographic reference for all the other data layers from other sources.

There will be increasing use of digital geographic data in a host of military systems to support command and control, performance modelling and navigation. Another trend is the shift in tasking of the mapping agencies from first cover mapping (paper maps) to revision mapping and to provision of a wider range of digital and hard copy topographic products. These products would not be possible without the use of digital technology.

Future Implications for RASvy

Advances in technology and changes in tasking will require a philosophical cahnge in the objectives set by mapping agencies. In the past all effort has been directed towards producing the paper map. Although we used digital technology, the digital data base was only a by-product in the production of the paper map. Now and in the future our objective must be to create and maintain a comprehensive digital data base from which a range of products can be produced. Products will include paper maps at different scales as well as a number of different digital data products. The data base, not the product, will be of primary importance. To be most useful the database must include the topological relationships between cartographic objects. The topology is required to support applicaitons in GIS and other decision support systems. The data base will be huge and will require considerable resources to manage and maintain.

There will also be a need to establish standards for data formats, data content, data quality, and for the exchange of digital topographic data bases and duplicationof effort in collecting data. International standards will allow data collected by different agencies and different countries to be exchanged and combined into large data bases. These standards must support the topological relationships required by GIS and other decision support systems.

There must be a capability to produce a wide range of products from he data base. It is hoped that much or all of this task can be automated through the use of rule-base expert systems. Based on the product to be produced, the system must interrogate the data base, select features to be shown and format them according to the product specification either digitally or symbolically (for a paper map). There will also be a greater requirement for education of the users of this data. Paper maps are graphic and easy to use and understand. Digital topographic data use with other remote sensed imagery, while offering increased flexibility and wider application, can be easily misused ina digital system (Gallent 87), Berry 87). An example is the user who wishes to 'zoom in' to see more detail and unknowingly goes well beyond the resolution of the data.

TERRAIN ANALYSIS FOR MILITARY APPLICATIONS

The graphical portrayal of terrain, whether in 'hard-copy' as a map or chart, or as a 'soft-copy' on a computer screen provides the user with an excellent aid to navigation, or a product on which he can plan a range of activities appropriate to his role. Developing this product one step further, by providing an analysis of the terrain, completes the provision of the terrain information cycle and thereby provides the military commander with a comprehensive knowledge of the battlefield and a significant advantage in the conduct of battle. Terrain evaluation techniques therefore, have a very important role in warfare.

Terrain evaluation can be applied for many purposes ranging from agricultural to recreational use of land. In the military context the term terrain analysis is preferred. Townshend (1981) believes that evaluation involves 'placing a value or worth in qualitative terms on a piece of land', whereas analysis is 'the set of activities which leads to the compilation of terrain characteristics or qualities'. NATO defines terrain analysis as 'the process of interpretation of natural and man-made features of a geographic area to determine effects on military operations. This includes the influence of weather and climate on these features.' The process of analysis often leads to evaluaton, however the two are so intimately entwined as to be virtually inseparable. The total process of analysis and evaluation will therefore be referred to a Terrain Analysis.

Military Requirements for Terrain Information

The military commander needs to assess terrain information from two points of view. Firstly he must deploy his own troops and resources to maximize the errect of the terrain on his objectives but simultaneously he must consider how an enemy might make best use of the terrain and act to conteract this. A summary of the major terrain elements which have considerable military significance is given at Figure 1.

TERRAIN ELEMENT	MILITARY SIGNIFICANCE
Slope	Cross Country Movement (CCM) Weapon Emplacement Drop Zones Troop Positioning Airfield/Landing Zone Sites
Soils	CCM Minefield Emplacement Construction of roads, airfields, etc. Weapon Effects (Artillery, Mortars) Digability (Trenches, Command Posts, etc)
Geology	Construction Materials (stone, sand, gravel) Potential Construction Sites Sub surface structure (CCM, underground water)
Landforms	Key Terrain Avenue of Approach Major Obstacles Lines of Sight (Visibility, Radio/Radar Sites) Weapon Sites/Fields of Fire
Vegetation	Cover and Concealment Visibility CCM Construction Materials
Water Features	CCM Water Supplies Obstacles (require bridging) Flood Prediction
Coastal Features	Amphibious Operations Beach Landing Sites Potential Harbours

FIGURE 1 : Terrain Effects on Military Operations

A useful approach to a more detailed consideration of the terrain's effect on military operations is to consider terrain analysis with respect to four important military applications:

- Cross Country Mobility,
- Key Terrain and Avenue of Approach,
- Natural Resources, and
- Potential Weapon and Communication Sites.

Cross Country Mobility

The ability to move troops and weapon systems around the battlefield is vital in land warfare. Troops in trucks or armoured troop carrers need to be able to move quickly, tanks must be mobile to be effective, guns and guided weapon systems must be able to redeploy quickly and the logistic supply system needs to be able to resupply troops, evacuate casualties and maintain vehicles and weapons without being restricted to existing roads which deteriorate rapidly during hostilities.

- Terrain factors which influence Cross Country Mobility include:-

Slope:	Vehicles can operate less effectively on steep or unstable slopes and may be prevented from moving at all on certain slopes.
Vegetation:	Tree trunk diameter and spacing effect all vehicular movement. Visibility through vegetation also restricts the speed of movement.
Natural Obstacles:	Rivers, streams, canals and lakes all restrict vehicle movement. The surface roughness in an area also slows or prevents movement. ditches or steep embankments are also considerable obstacles to movement.
Soils:	Certain soil types have greater load bearing capacity than others. Some can support considerable vehicular traffic, others wil stop a single truck or tank. Some soils when dry will support vehicles but not when wet. Sub surface soil profiles are also important as they effect load bearing capacity and water table levels.

Key Terrain and Avenues of Approach

Terrain which dominates a locality because of its position, height and view over the surrounding area is of prime military concern. Similarly natural features which tend to channel the movement of troops or vehicles in certain ways are also very important to the tactician. Factors which effect the location of key terrain and avenues of approach include:

Landforms or Surface Configuration:	The relative position of mountains, ridges, valleys, water courses, floodplains and other landforms are instrumental in selecting key terrain.
Slope:	Steep or unstable slopes prevent access to a defended position whilst providing good visibility down the slope.
Drainage Pattern:	Watercourses and low water-logged areas are natural obstacles to movement and tend to channel troops or vehicles into certain areas.
Soil/Geology:	Soft soils or very rough surfaces also tend to channel movement.

Natural Resources

The more natural materials and supplies that can be obtained in an area the less is the logistic burden on a military force. Natural resources of considerable importance include:

Water	One of the major problems in military operations is an adequate supply of potable water. It is even more critical in arid or semi-arid regions. Both surface water and subterranean water are of of vital importance to the military commander.
Rock, Sand and Gravel:	Any major conflict involves either construction or rapair of roads, railways, ports and airfields. The close proximity of suitable stone and sand to construction sites can have considerable effect on logistic resupply to a force and its operational deployment capabilities.
Timber:	Suitable timber for construction tasks and possibly as fuel can be important.

Potential Weapon and Communication Sites

Guided weapons, guns and missile systems generally need to be sited with maximum visibility over the surrounding terrain. Similarly, radio transmitters and receivers need to be sited to serve the battlefield effectively and radar antenna sites need to be carefully selected with respect to the surrounding terrain. Landform heights and relative heights have the maximum impact on these considerations, however vegetation can effect visibility and weapon characteristics of artillery shells.

The military terrain analyst is not only concerned with natural features of the terrain but is also concerned with man's modification of the terrain. Existing road and rail networks, bridges and other stream crossings, buildings of all types and utility services such as electricity are most important.

The prime source of terrain information for the military commander has traditionally been the topographic map, coupled with personal observation of the ground (reconnaissance in military terms) either on foot, by vehicle or from the air. Terrain analysis is chiefly concerned with reducing the reconnaissance requirement as well as providing additional information not immediately obvious from the map or even by observation of the ground. The information is generally best provided in the form of fairly simple map overlays or special graphic products.

The major sources of information, apart from the topographic map include:

- Geology maps.
- Soil maps.
- Vegetation maps.
- Land Use maps,
- Aerial Photography, and
- Satellite Imagery.

New Approaches to Terrain Analysis

The traditional method of deriving map overlay products is very manpower intensive and complex. The application of computers to this process has changed may of the basic techniques used, speeded up the process and opened up the possibility of generating new and different products. Three developments of considerable significance are:

- The application of Digital Terrain Models (DTM's),
- The grid cell approach to data storage and manipulation, and
- The application of expert systems and artificial intelligence.

Digital Terrain Models

Regular arrays of height data allow computer analysis of several problems of military significance. Software that has been developed and is now fully operational allows the automatic generation of slope maps, the easy assessment of intervisibility from point to point and the generation of visibility diagrams from selected vantage points.

Grid Cell Appraoch

The storage of land attributes such as soil types, vegetation types and geology in rctangular grid cells allows efficient and speedy processing, and analysis of these attributes to generate derived products. Again much software has already been developed to carry out this analysis for both military and non-military applications.

Expert Systems and Artificial Intelligence

Coupled with DTM's and grid cell storage of attribute data, rule-based computer analysis can remove most of the human interpretation of terrain data. By human experts defining rules to the computer it can very quickly analyse vast amounts of data and even derive graphic products based on that analysis. For example if a rule is given to the computer that, in a particular grid cell, the slope is > 10 , the soil is a clay/sand mix and the vegetation is tropical rainforest, then a land-rover will not be able to travel across that grid cell at a speed faster than 4 kph. Developing such expert systems requires the definition of a large number of rules and can involve experts from several fields. However, one they allow speed and accurate assessment of vast amounts of data.

Civilian Applications of Military Techniques

Although Terrain Analysis has been described as applied to military situations, it is not difficult to extrapolate the techniques to analyse many non-military problems. Cross country movement analysis may equally apply to the assessment of access to forestry areas for harvesting. The siting of communications facilities, especially in rugged terrain, is as important to the civil community as it is to the military and the application of new technology and techniques is not restricted to the military.

Conclusion

Defence will continue to have a strong impact on technology both as a user and an initiatior of new developments. This is no more so than in the field of mapping, charting and geodesy as evidenced by the preceding discussion. As new technology is incorporated in one facet of this descipline it becomes important to review the whole process so that the system remains balanced. RASvy has been able to complement the technology utilized in its product generation facility with the latest technology in the area of survey data acquisition. By keeping abreast of technology advances, Defence mapping, charting and geodesy has been able to make significant contributions to the civil mapping community, contributions which in themselves have resulted in other developments from which we can benefit.

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FINDING THE BEST FIT

I.J.BILLOWS B.SURV. LS.

Some 5 or 6 years ago I remember reading an article describing how to fit a circular curve through a given number of points using the method of least squares. I do not remember the author but I do recall that a HP41 program was also supplied and that despite a sophisticated approach the calculator program was rather cumbersome. Having then spent some time trying to fit mathematical curves to an existing road alignment I thought development of this idea may be worth some effort. What follows here are the results which have been in mothballs for four or five years and I hope they are of interest to some as I have had little occasion to use the programs.

Briefly, there are two programs, one for fitting a curve through a number of fixed points, Program "RD" and another for using this program's results to calculate a road's centreline parameters, Program "TN". I have employed the example of a road as it lends itself to the theory but clearly any group of points approximating a circular curve could be processed using the program. In the road example the approach is the opposite to that normally employed where straights are fitted to an existing alignment and the curves juggled to fit. In this case the curves are produced and the straights are left to fit to the curves.

Both programs will run on a HP41 series calculator but as to whether they have any practical use I leave it for the reader to pursue.

PROGRAM "RD"

SIZE	25+3*no. of C.P.s
Printer	No
Bytes	662
Local labels	A - adjustment
	B - weights
	C - radius

Program determines the M.P.V. of the radius of a circular curve through any number of points about its circumference. Eastings and northings of at least three such points (now called C.P.s) are required. The program iterates towards solution employing the first three entered points ordinates to calculate an approximation to the radius (R) and (EO,NO), being the co-ords of the centre of the circle. Later, using program "TN", tangents and I.P. co-ords may be calculated.

See Appendix 1 for definition of terms and theory
See Appendix 11 for an example
See Appendix 111 for program listing
See Appendix 1V for storage and flag usage

Notes on Input/Output

1. Before running program either of the following two methods of co-ordinate input are possible.

   (a) Easting & Northing (E,N) of all C.P.s — MANual input
   OR
   (b) An Easting & Northing of a control station (EC,NC) and radiations (BRG,DIST) from this station to each C.P. — AUTOmatic input

   In either case other (detail) points may be included with a zero (0) weight which will delete them from the adjustment whilst showing an offset from the final curve centreline.

2. A facility for relative weighting of all points is provided. A zero weight will delete the point from the adjustment whilst the larger the relative weight of a point the smaller the resulting residual between the final curve centreline and this station.

3. As the program uses an iterative solution and employs the ordinates of the first three C.P.s input, care should the taken that these stations are not colinear nor likely to produce an approximate curve which arcs in the wrong sense. This possibility is most likely if one or more of the first three points are only detail points (to be given zero weight) and to avoid such a case these should be entered after all C.P.s. During execution an interim total of the absolute corrections to EO,NO & R is displayed. If this is not reducing after each iteration convergence to a solution will not result and the first three ordinates should be re-examined and then possibly all ordinates re-entered in a different order.

4. The program will cease iteration when a term displayed as Σ=-.--- is less than 0.0005. This term "Σ" is made up of $|\delta E|+|\delta N|+|\delta R|$ and its display will be preceded by a TONE 9 during execution. To halt iteration before the given criteria of 0.0005 key R/S at the TONE 9 and clear the display with the backarrow key (←), then proceed with R/S, the current values of EO,NO & R etc. will follow.

5. All resultant values will display to 3 decimal places where EO,NO & R are previously defined whilst the residuals of all points (C.P.s and detail points) are displayed in the order they were entered, where

$$RES = ((E_i - (EO + \Sigma\delta E))^2 + (N_i - (NO + \Sigma\delta N))^2)^{\frac{1}{2}} - (R_a + \Sigma\delta R)$$

ie a positive residual shows a C.P. is outside the M.P. circle &.
a negative " " " inside " " " " .

6. Note that despite careful selection of C.P.s, weighting and choice of radius the program may still not produce the desired results and conventional methods of curve selection may often be warranted.

To run program XEQ "RD"

(R/S after each entry or program stop)

DISPLAY:

POINT CORDS	pause	(circumference points)
MAN O, AUTO 1	enter 0 for manual input enter 1 " auto " of C.P. cords	
	if 0 entered	
E	Easting of first C.P.	
N	Northing of first C.P.	
E	Easting of second C.P	
N	and so on	
.	.	
.	.	
N	Northing of final C.P.	
E	key R/S only	
	if 1 entered	
CONTROL	pause	
EC	Easting of control station	
NC	Northing of control station	
BRG	bearing in Deg.MinSec from control station to first C.P.	
DIST	distance from control station to first C.P.	
BRG	to second C.P.	
DIST	and so on	
.	.	
.	.	
DIST	distance to final C.P.	
BRG	key R/S only	

program now prompts for the relative weights of each (detail and) C.P. in the same order as each was initially input. The final WT PT n prompt may be used as a check on the total number of points entered. This weighting section of program is under LBL B and may be later re-executed by keying the 1/x key.

WT PT 1.	weight of first point
WT PT 2.	weight of second point
.	.
.	.
WT PT n	weight of n^{th} point to give a station a weight of 1 (one), key R/S only. (default value is 1)

Cont.......

After the final weight is entered key R/S and execution begins. This execution section section of program is under LBL A and may be later re-executed by keying the Σ+ key.

Σ=-.---	display after each iteration and a TONE 9. When this term is less than 0.0005, BEEP will execute.
EO=---.---	Easting of M.P. circle centre
NO=---.---	Northing of M.P. circle centre
R=---.---	Radius of M.P. circle

RESIDUALS	pause
RES 1=-.---	residual relating to first C.P. (or detail)
RES 2=-.---	" " " second " "
.	.
.	.
RES n=-.---	" " " final " "

program now reverts to the WT PT 1 section (LBL B)

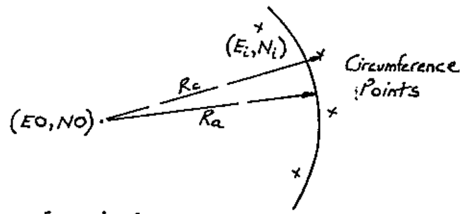
OR

LBL's A,B or C (Σ+, 1/x, $\sqrt{x}$) may be executed

where	LBL A	will readjust using the same weights
	LBL B	will allow the weights to be re-entered with different values
	LBL C	displays the current radius and sets flag 01 after the next R/S. Whilst R=-.--- is displayed a new radius may be entered, rounded to the nearest 10 units, say or the present value may remain. Now keying R/S will store, display and fix this radius. With the radius fixed a readjustment is now possible for new EO,NO values and residuals. R may be altered again at any time but to have it reincluded in an adjustment flag 01 must be manually cleared.

APPENDIX 1

THEORY



Let (EO,NO) be assumed Easting & Northing of a circle centre
(E_i,N_i) be Eastings & Northings of co-ordinated circumference points (C.Ps.)

R_a be the assumed radius of a circle
R_c be the calculated radius of the circle

where $R^2{}_c = \Delta E^2 + \Delta N^2$

and $\Delta E = E_i - EO$ & $\Delta N = N_i - NO$

δE, δN, δR are corrections to the assumed values EO,NO,R_a respectively

n is the number of C.P.s

i is the i^{th} C.P.

Then $(R_a + \delta R)^2 = (\Delta E - \delta E)^2 + (\Delta N - \delta N)^2$

note $\Delta E - \delta E = E_i - (EO + \delta E)$ etc.

or $R^2{}_a - (\Delta E^2 + \Delta N^2) \doteqdot -2\,\Delta E\,\delta E - 2\,\Delta N\,\delta N - 2R_a\,\delta R$

$$\Rightarrow \quad \frac{R^2{}_c - R^2{}_a}{2} = \Delta E\,\delta E + \Delta N\,\delta N + R_a\,\delta R \qquad \text{----- obs. eqn.}$$

in matrix form ....

$$\begin{bmatrix} (R^2{}_{c_1} - R^2{}_a)/2 \\ (R^2{}_{c_2} - R^2{}_a)/2 \\ '' \\ (R^2{}_{c_n} - R^2{}_a)/2 \end{bmatrix} = \begin{bmatrix} \Delta E_1 & \Delta N_1 & R_a \\ \Delta E_2 & \Delta N_2 & R_a \\ '' & '' & '' \\ \Delta E_n & \Delta N_n & R_a \end{bmatrix} \cdot \begin{bmatrix} \delta E \\ \delta N \\ \delta R \end{bmatrix}$$

$$\underset{\sim}{x} = A \cdot \underset{\sim}{y}$$

appendix 1 cont.......

and $A'W\,\underset{\sim}{x} = A'\,W\,A\,\underset{\sim}{y}$,

$$\text{where } W = \begin{bmatrix} w_1 & 0 & 0 & 0 & . & . \\ 0 & w_2 & 0 & 0 & . & . \\ 0 & 0 & w_3 & 0 & . & . \\ . & . & . & . & . & 0 \\ . & . & . & . & . & w_n \end{bmatrix}$$

Note: w_i is the relative weight of the i^{th} C.P.

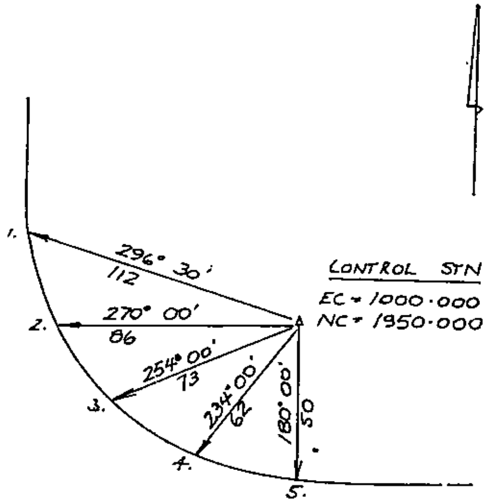
so

$$\begin{bmatrix} \Sigma w_i\,\Delta E_i(R^2_{c_i} - R^2_a)/2 \\ \Sigma w_i\,\Delta N_i(R^2_{c_i} - R^2_a)/2 \\ \Sigma w_i R_a(R^2_{c_i} - R^2_a)/2 \end{bmatrix} = \begin{bmatrix} \Sigma w_i\,\Delta E^2_i & \Sigma w_i\,\Delta E_i\,\Delta N_i & \Sigma w_i R_a\,\Delta E_i \\ \Sigma w_i\,\Delta E_i\,\Delta N_i & \Sigma w_i\,\Delta N^2_i & \Sigma w_i R_a\,\Delta N_i \\ \Sigma w_i R_a\,\Delta E_i & \Sigma w_i R_a\,\Delta N_i & \Sigma w_i R^2_a \end{bmatrix} \cdot \begin{bmatrix} \delta E \\ \delta N \\ \delta R \end{bmatrix}$$

where δE, δN, δR are solved by elimination.

APPENDIX II

Example



	Residuals	Weights	Stn	Weights	Residuals	
	0.074	1	1	1	0.420	
EO= 1001.561	- 0.088	1	2	1	- 0.236	EO = 1000.187
NO= 2001.619	- 0.281	1	3	1	- 0.491	NO = 2000.246
R = 101.732	.0.395	1	4	1	0.248	R_{new} = 100
	- 0.101	1	5	1	0.246	
	0.008	10	1	10	0.109	
EO= 1001.449	- 0.116	1	2	1	- 0.583	EO = 999.877
NO= 2001.666	- 0.282	1	3	1	- 0.821	NO = 2000.090
R = 101.687	0.423	1	4	1	- 0.043	R_{new} = 100
	- 0.011	10	5	10	0.090	

```
01•LBL "RD"
02 CF 00
03 CF 01
04 SF 27
05 25
06 STO 00
07 "POINT C
    ORDS"
08 AVIEW
09 PSE
10 "MAN 0,
   AUTO 1"
11 PROMPT
12 X=0?
13 GTO 00
14 SF 00
15 "CONTROL
          "
16 AVIEW
17 PSE
18 "EC"
19 PROMPT
20 STO 17
21 "NC"
22 PROMPT
23 STO 18

24•LBL 10
25 CF 22
26 "BRG"
27 PROMPT
28 FC? 22
29 GTO 09
30 HR
31 "DIST"
32 PROMPT
33 P-R
34 X<>Y
35 RCL 17
36 +
37 STO IND
         00
38 ISG 00
39 CLX
40 X<>Y
41 RCL 18
42 +
43 STO IND
         00
44 ISG 00
45 CLX
46 GTO 10

47•LBL 00
48 CF 22
49 "E"
50 PROMPT
51 FC? 22
52 GTO 09
53 STO IND
         00
54 ISG 00
55 CLX
56 "N"
57 PROMPT
58 STO IND
         00
59 ISG 00
60 CLX
61 GTO 00

62•LBL 09
63 RCL 25
64 RCL 29
65 -
66 STO 05
67 RCL 26
68 RCL 30
69 -
70 STO 06
71 RCL 25
72 RCL 27
73 -
74 STO 07
75 RCL 26
76 RCL 28
77 -
78 STO 08
79 RCL 25
80 X↑2
81 RCL 26
82 X↑2
83 +
84 STO 10
85 RCL 29
86 X↑2
87 RCL 30
88 X↑2
89 +
90 -
91 STO 09
92 RCL 27
93 X↑2
94 RCL 28
95 X↑2
96 +
97 ST- 10
98 2
99 ST/ 09
100 ST/ 10
101 RCL 08
102 RCL 09
103 *
104 RCL 06
105 RCL 10
106 *
107 -
108 RCL 05
109 RCL 08
110 *
111 RCL 06
112 RCL 07
113 *
114 -
115 STO 08
116 /
117 STO 02
118 RCL 05
119 RCL 10
120 *
121 RCL 07
122 RCL 09
123 *
124 -
125 RCL 08
126 /
127 STO 03
128 RCL 25
129 RCL 02
130 -
131 X↑2
132 RCL 26
133 RCL 03
134 -
135 X↑2
136 +
137 SQRT
138 STO 04

139•LBL B
140 RCL 00
141 STO 01

142•LBL 14
143 RCL 01
144 RCL 00
145 -
146 1
147 +
148 FIX 0
149 1
150 "WT PT "
151 ARCL Y
152 PROMPT
153 STO IND
         01
154 ISG 01
155 CLX
156 RCL 00
157 25
158 -
159 2
160 /
161 RCL 01
162 RCL 00
163 -
164 X≠Y?
165 GTO 14

166•LBL A
167 FIX 3
168 25
169 STO 01
170 ΣREG 05
171 CLΣ
172 ΣREG 11
173 CLΣ

174•LBL 02
175 RCL IND
         01
176 RCL 02
177 -
178 STO 08
179 ISG 01
180 CLX
181 RCL IND
         01
182 RCL 03
183 -
184 STO 09
185 ISG 01
186 CLX
187 RCL 08
188 X↑2
189 RCL 09
190 X↑2
191 +
192 RCL 04
193 X↑2
194 -
195 2
196 /
197 STO 10
198 RCL 00
199 1
200 -
201 RCL 01
202 25
203 -
204 2
205 /
206 +
207 RCL IND
          X
208 ST* 10
209 RCL 10
210 RCL 08
211 *
212 ST+ 05
213 RCL 09
214 RCL 10
215 *
216 ST+ 06
217 RCL 04
218 RCL 10
219 *
220 ST+ 07
221 ΣREG 19
222 CLΣ
223 RCL 08
224 RCL 09
225 Σ+
226 RCL 00
227 1
228 -
229 RCL 01
230 25
231 -
232 2
233 /
234 +
235 RCL IND
          X
236 11.016
237 19.024
238 RCL Z

239•LBL 08
240 ST* IND
          Y
241 RCL IND
          Y
242 ST+ IND
          T
243 ISG Z
244 RDN
245 ISG Z
246 GTO 08
247 ΣREG 11
248 RCL 01
249 RCL 00
250 X≠Y?
251 GTO 03
252 GTO 02

253•LBL 04
254 RCL 14
255 RCL 12
256 *
257 RCL 15
258 X↑2
259 -
260 RTN

261•LBL 05
262 RCL 14
263 RCL 06
264 *
265 RCL 15
266 RCL 05
267 *
268 -
269 RTN

270•LBL 06
271 RCL 14
272 RCL 11
273 *
274 RCL 13
275 RCL 15
276 *
277 -
278 RTN

279•LBL 03
280 RCL 04
281 ST* 11
282 ST* 13
283 X↑2
284 ST* 16
285 RCL 14
286 RCL 07
287 *
288 RCL 13
289 RCL 05
290 *
291 -
292 XEQ 04
293 *
294 STO 10
295 XEQ 05
296 XEQ 06
```

appendix III cont......

```
297 *
298 ST- 10
299 RCL 14
300 RCL 16
301 *
302 RCL 13
303 X↑2
304 -
305 XEQ 04
306 *
307 XEQ 06
308 X↑2
309 -
310 ST/ 10
311 .
312 FS? 01
313 ST* 10
314 XEQ 05
315 STO 09
316 XEQ 06
317 RCL 10
318 *
319 ST- 09
320 XEQ 04
321 ST/ 09
322 RCL 05
323 RCL 15
324 RCL 09
325 *
326 -
327 RCL 13
328 RCL 10
329 *
330 -
331 RCL 14
332 /
333 STO 08
334 ST+ 02
335 RCL 09
336 ST+ 03
337 RCL 10
338 ST+ 04
339 RCL 08
340 ABS
341 RCL 09
342 ABS
343 +
344 RCL 10
345 ABS
346 +
347 TONE 9
348 "Σ="
349 ARCL X
350 AVIEW
351 5 E-4
352 X<Y?
353 GTO A
354 BEEP
355 "E0="
356 ARCL 02
357 PROMPT
358 "N0="
359 ARCL 03
360 PROMPT
361 "R="
362 ARCL 04
363 PROMPT
364 "RESIDUALS"
365 AVIEW
366 PSE
367 25
368 STO 01
369 XEQ 07
370 GTO B

371*LBL C
372 FIX 3
373 CF 22
374 "R="
375 ARCL 04
376 PROMPT
377 FS? 22
378 STO 04
379 SF 01
380 GTO C

381*LBL 07
382 RCL IND 01
383 RCL 02
384 -
385 ISG 01
386 CLX
387 RCL IND 01
388 RCL 03
389 -
390 ISG 01
391 CLX
392 R-P
393 RCL 04
394 -
395 5 E-4
396 X<>Y
397 ABS
398 X>Y?
399 GTO 07
400 .
401 *

402*LBL 07
403 LASTX
404 RCL 01
405 25
406 -
407 2
408 /
409 FIX 0
410 "RES "
411 ARCL X
412 "⊢="
413 FIX 3
414 ARCL Y
415 PROMPT
416 RCL 00
417 RCL 01
418 X=Y?
419 GTO 07
420 RTN
421 END
```

APPENDIX IV

Storage

00	1st weight reg. (25+2n)	21	$w_i \Delta E_i$
01	counter	22	$w_i \Delta E_i^2$
02	EO	23	$w_i \Delta E_i \Delta N_i$
03	NO	24	w_i
04	R	25	E_1
05	$\Sigma w_i \Delta E_i \ (R^2_c - R^2_a)/2$	26	N_1
06	$\Sigma w_i \Delta N_i \ (R^2_c - R^2_a)/2$	27	E_2
07	$\Sigma w_i R_a \ (R^2_c - R^2_a)/2$	28	N_2
08	ΔE_i / Σ E	29	.
09	ΔN_i / Σ N	30	.
10	$(R^2_c - R^2_a)/2$ / Σ R	31	.
11	$R_a \Sigma w_i \Delta N_i$	32	.
12	$\Sigma w_i \Delta N_i^2$	33	w_1
13	$R_a \Sigma w_i \Delta E_i$	34	w_2
14	$\Sigma w_i \Delta E^2_i$	35	.
15	$\Sigma w_i \Delta E_i \Delta N_i$	36	.
16	$R^2_a \Sigma w_i$	37	
17	E_c		
18	N_c		
19	$w_i \Delta N_i$		
20	$w_i \Delta N^2_i$		

Flags

	Clear	Set
00	No control stn.	Control stn.
01	radius incl. in adj.	radius input under LBL C and fixed.

PROGRAM "TN"

SIZE 011
Printer NO
Bytes 205

Program uses data produced by "RD" to calculate tangent bearings and I.P. co-ordinates along a route centreline. A series of co-ordinates for the centre of each circular curve and its radius are required ie EO, NO, R. The program fits tangents to successive curves and calculates corresponding I.P. co-ordinates.

See Appendix 1 for definition of terms and example
See Appendix 11 for program listing
See Appendix 111 for storage

Notes on Input/Output

1. All information is input/output sequentially in a forward direction of either increasing or decreasing chainage. In this sense curves bending to the right are considered to have a positive radius (R) whilst those bending left are considered to have a negative radius and are thus input with a preceding minus sign (-R).

2. All eastings, northings and radii (+R) may be input with any number of decimal places whilst output is in Deg.MinSec to 1" for bearings and 3 decimal places for I.P. co-ordinates (E, N).

3. To begin or complete a sequence soley on a line, a co-ordinate on such a line (an I.P. say) should be selected for the EO, NO prompts and a value of zero (O) should be entered for the radius (R) prompt.
(see appendix 1).

4. To fix a tangent on a particular bearing or through a set station some precalculation via selection of suitable curve radii and centres etc. is required before using "TN".

5. As more "NEXT CURVE" prompts are satisfied the present "NEXT CURVE" becomes the "AT CURVE" which in turn becomes the "FROM CURVE" and so on whilst all ensuing tangent bearings continue to be produced only once (and in a forward sense).

6. I.P. co-ordinates produced should be considered as relating to the "AT CURVE" with all tangent bearings (b) produced relating to the "AT CURVE"/"NEXT CURVE" combination except the very first tangent bearing (b) displayed which connects the "FROM CURVE" and "AT CURVE".
(see appendix 1).

To run program XEQ "TN"

(R/S after each entry or program stop)

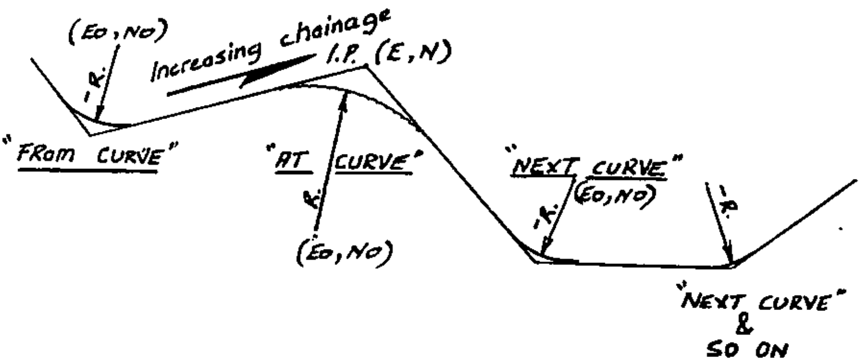
DISPLAY:

	FROM CURVE	pause
	EO	Easting of centre of "FROM CURVE"
	NO	Northing of centre of "FROM CURVE"
	R	Radius (+R -L) of "FROM CURVE"
	AT CURVE	pause
	EO	Easting of centre of "AT CURVE"
	NO	Northing of centre of "AT CURVE"
	R	Radius (+R -L)
	b--.----	bearing of tangent to "FROM" and "AT" curves
****	NEXT CURVE	pause
	EO	Easting of centre of "NEXT CURVE"
	NO	Northing of centre of "NEXT CURVE"
	R	Radius (+R -L) " " "
	b --.----	bearing of tangent to "AT" and "NEXT"curves
	IP CORDS	pause
	E ------.---	Easting of I.P. at "AT CURVE"
	N ------.---	Northing of I.P. at "AT CURVE"

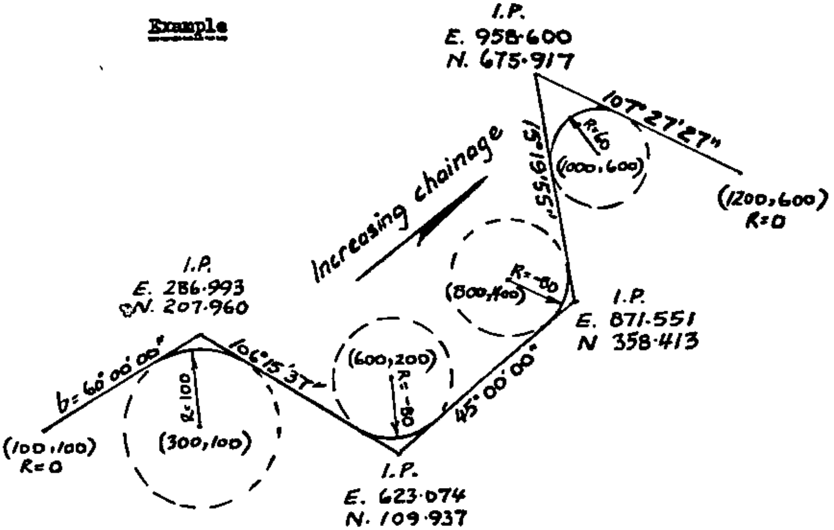
Program now returns to step **** above and loops in this section.

APPENDIX 1

At any IP



Example



APPENDIX 11

```
01♦LBL "TN"
02 "FROM CU
      RVE"
03 AVIEW
04 PSE
05 "E0"
06 PROMPT
07 "N0"
08 PROMPT
09 "R"
10 PROMPT
11 "AT CURV
         E"
12 AVIEW
13 PSE
14 "E0"
15 PROMPT
16 STO 00
17 ST- T
18 RDN
19 "N0"
20 PROMPT
21 STO 01
22 ST- Z
23 RDN
24 "R"
25 XEQ 01
26 STO 09
27 XEQ 02

28♦LBL 00
29 RCL 00
30 STO 03
31 RCL 01
32 STO 04
33 RCL 02
34 STO 05
35 "NEXT CU
      RVE"
36 AVIEW
37 PSE
38 "E0"
39 PROMPT
40 STO 00
41 ST- T
42 RDN
43 "N0"
44 PROMPT
45 STO 01
46 ST- Z
47 RDN
48 "R"
49 XEQ 01
50 STO 10
51 XEQ 02
52 RCL 09
53 180
54 +
55 RCL 10
56 STO Z
57 -
58 1
59 P-R
60 R-P
61 RDN
62 2
63 /
64 STO 07
65 +
66 180
67 +
68 RCL 05
69 RCL 07
70 SIN
71 /
72 ABS
73 P-R
74 RCL 04
75 +
76 X<>Y
77 RCL 03
78 +
79 "IP CORD
         S"
80 AVIEW
81 PSE
82 FIX 3
83 "E "
84 ARCL X
85 PROMPT
86 "N "
87 ARCL Y
88 PROMPT
89 RCL 10
90 STO 09
91 GTO 00

92♦LBL 01
93 PROMPT
94 STO 02
95 -
96 RDN
97 R-P
98 R↑
99 X<>Y
100 /
101 ASIN
102 +
103 180
104 +
105 RTN

106♦LBL 02
107 360
108 MOD
109 FIX 4
110 HMS
111 "b "
112 ARCL X
113 PROMPT
114 END
```

APPENDIX III

Storage — Size 011

00	EO	AT CURVE/NEXT CURVE
01	NO	
02	R	
03	EO	AT CURVE
04	NO	
05	R	
06	Spare	
07	$\pm \phi / 2$ (ϕ = supplement of defl. angle)	
08	spare	
09	Entry tangent bearing	
10	Exit tangent bearing	

Flags

Nil.

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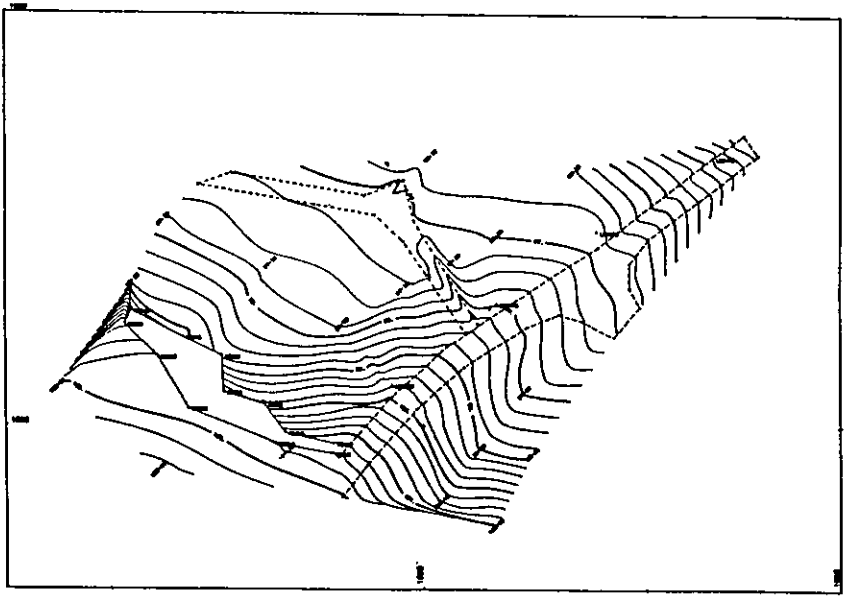
CIVILCAD

Software Overview		GRAPHICS GEOMETRY
Data Entry	—	Data may be entered by manual screen input, digitizing or electronic field books: Topcon FC1 Sokkisha SDR1 Topcon FC2 Sokkisha SDR2 Wild GLE1 Nikon Wild GRE3 Aga HP41
	—	Data can be entered in co-ordinate form, stadia, EDM measurement or from a simple ASCII file.
Digitizer	—	Digitizing program for contours, features, existing cross sections.
	—	Points are displayed graphically as they are digitized.
Feature Coding	—	All data whether it be from electronic field book, manual data entry or digitized can be coded. This code is interpreted by the software and the points can be:- — automatically joined — defined as contourable/non-contourable — detailed as a breakline — plotted with a given pen type — plotted showing point number/height/code — separated into layers



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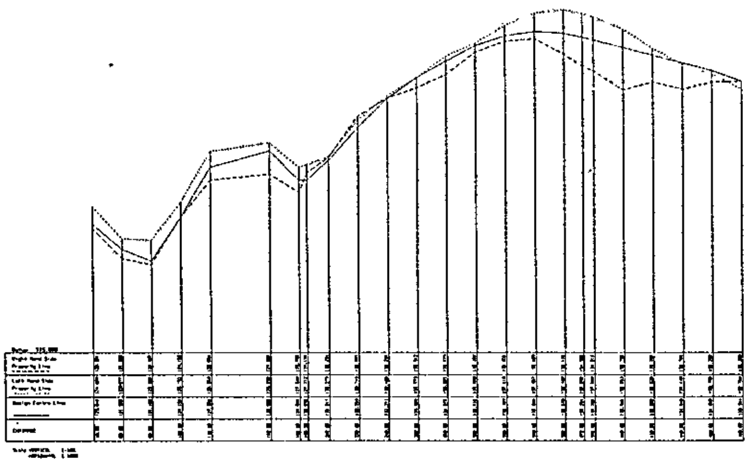
CIVILCAD

Software Overview	ROADWORKS DESIGN AND PLOTTING
Data Entry	— all data entry is through a flexible full screen format. This allows rapid entry, editing and listing
Graphics	— a full range of graphics options are provided for long and cross sections and plot previews
Plotting	— Several different formats for long and cross section plotting to a finished standard
Features	— Data entry by field book, chainage offset and level or terrain model data
	— Long and cross section plotting on screen
	— Specification of up to 32 typical road sections
	— Easy modelling of varying road widths, and superelevation
	— Design of cross sections or string lines
	— Full design facilities for VC's, table drains, batters and boxing
	— Software for shifted centre line from pegged line
	— Extensive facilities for road reconstruction, kerb and gutter etc.
	— Finished plotting on A1 or A0 sheets
	— Unique screen plot preview for checking prior to plotting
	— Suitable for rural roads, multi lane highways, subdivisions and urban design
	— Roadworks volumes
	— Construction Tables



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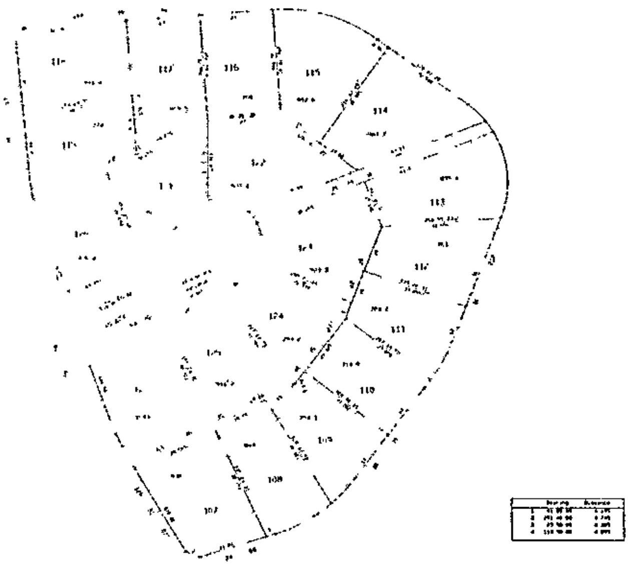
SURVEYING

GRAPHICS GEOMETRY (Continued)

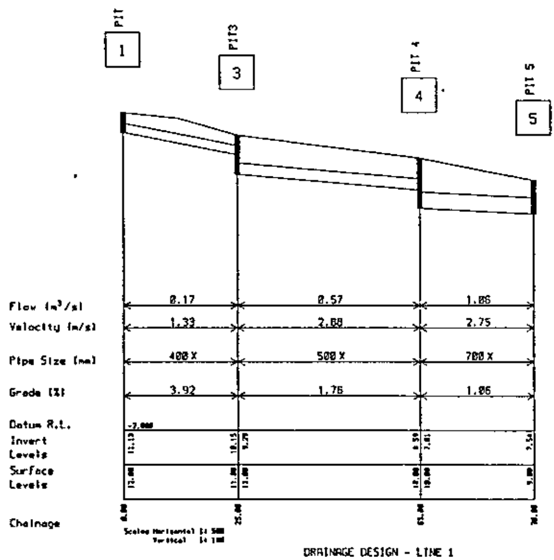
Contouring

- The formulation of the surface model is now rated at approximately 500 points per minute for an AT machine and 750 per minute for a 32 bit 80386 machine.
- Editing of triangles and breaklines achieved interactively with mouse driven cursor.
- Layer control. Up to 255 layers may be used to separate data/information.
- Geometric calculations with results shown "on the spot"
- Calculation of curves, filleting of curves to other curves and lines, spirals.
- ZOOM and PAN
- Volume calculations, Resection Transformation and Traverse calculation
- Calculation of cross and long sections
- Text input for plan annotation.
  Automatic annotation of line with bearing and distance
- Setting out calculations



CIVILCAD

Software Overview		DRAINAGE DESIGN
Data Entry	—	Full screen format
Graphics	—	Screenplots of long section design
Plotting	—	Long section plotting, showing HGL, 2 ground surfaces, services, intermediate levels, with optional velocity, grades, sizes etc. Plotting from downstream up or upstream down
Features	—	Computes time of concentration
	—	Computes gutter and pipe flows (all AR & R tables incorporated)
	—	Computes HGL and pipe sizes with formatted reports
	—	Plots long sections
	—	Checks services
	—	Full computation of flow widths and depths for arbitrary gutter profiles
	—	Checking of existing systems
	—	Calculation of flows for several return periods
	—	Hydraulic grade line checking
	—	Large capacity
	—	Extensively used throughout Australia



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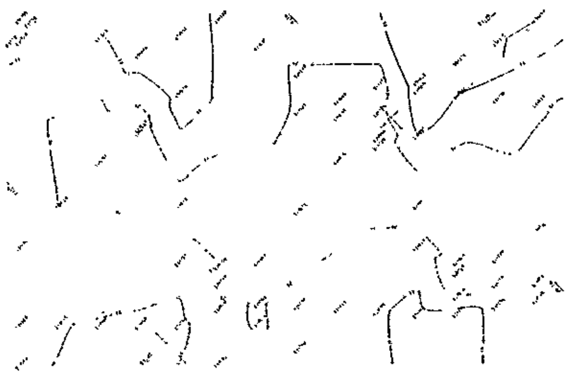
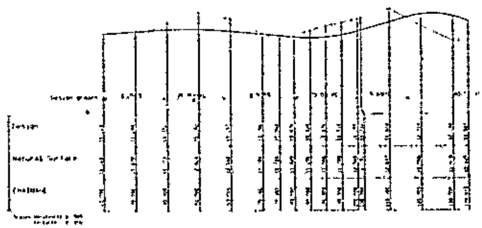
CIVILCAD

Software Overview	DRAWING EDITOR
Data Input	— Interactive input of text, lines and curves
	— Drawings from Contour and Roads programs
Title Blocks	— Creation and storage of title blocks including text
Symbols	— Draw and store of symbols and user definable line types
Merging drawings	— Drawings can be merged together with title block
	— Text editor
	— "Move Window" option allows user to adjust position of large blocks of data e.g. long section within title block
	— Up to 10,000 lines capacity
	— Up to 255 layers





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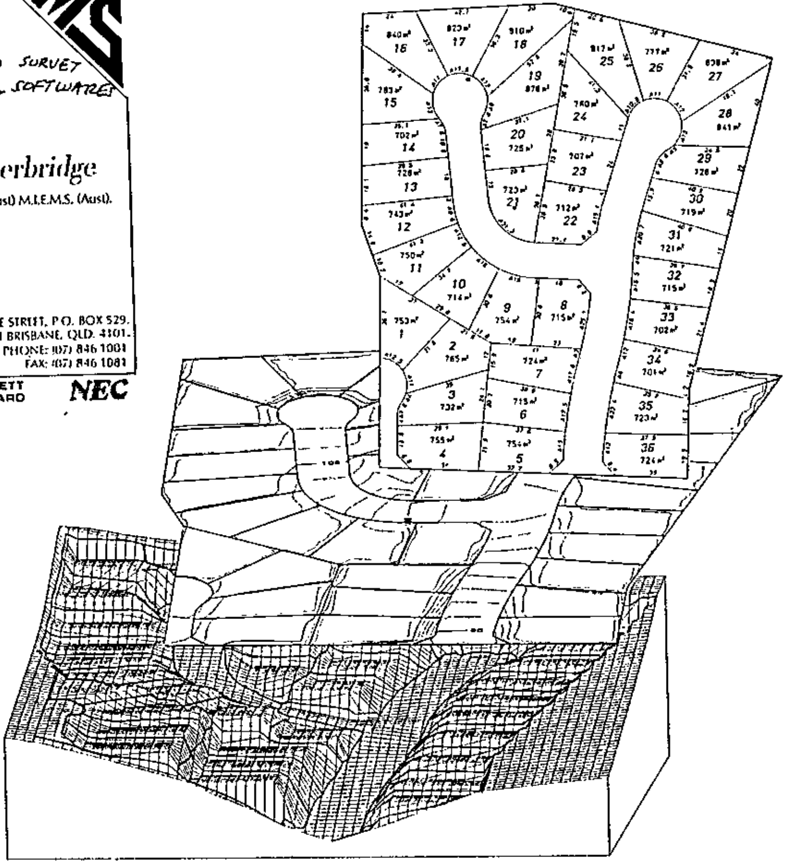
HEWLETT PACKARD NEC



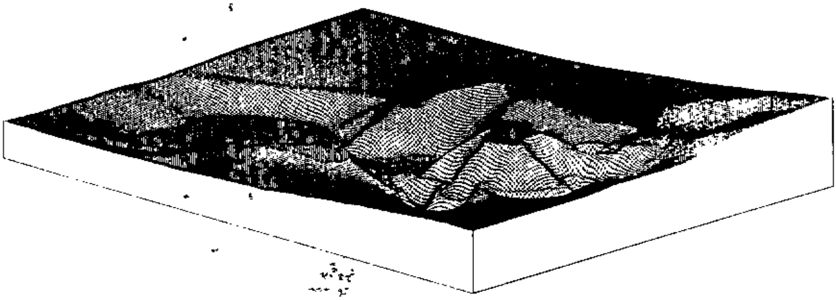
APPLICATION SOFTWARE for the CIVIL ENGINEERING, SURVEYING, & MAPPING INDUSTRIES

WESCOM

WESCOM is a group of computer and engineering professionals which has provided practical applications software to the civil engineering, surveying, and mapping industries since 1969.

WESCOM software is designed to be user oriented with an emphasis on the practical approach. All software is proven in our own service bureau operations prior to release.

The company has built its reputation on service and support for each of its products and is committed to the professionalism expected within the industry today.



SOFTWARE ARCHITECTURE

A menu driven applications manager is provided to setup and run batch files. The application manager contains a mask facility which creates ready-to-run batch files for the infrequent user.

All plotting programs create device independent plot files. A graphics manager is used to preview plot files on your graphics screen before sending them to any **WESCOM** supported plotter. The graphics manager can also window, rotate, scale, move, and mirror image plot files, or use combinations of these to compose a final plan from several plot files.

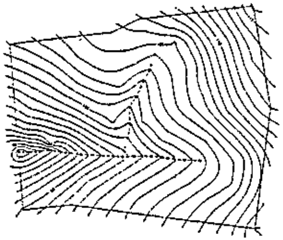
All software modules utilise a **WESCOM** database. This is the common denominator which integrates the engineering, surveying, and mapping functions. The database is designed to be quickly and easily created and managed. Data only needs to be input once during the life of a project.

As the software is modular the user may select individual modules to meet specific applications, or utilise the total package for a complete solution to land development projects.

PRIMARY APPLICATIONS

- Subdivision Calculation and Mapping
- Traverse and Network Adjustment
- Site Evaluation
- Detail Surveys
- Digital Terrain Modelling
- Contour Mapping
- Volume Calculation Between Surfaces
- Road and Railway Design and Mapping
- Volume Calculation from Cross-sections
- Presentation Graphics

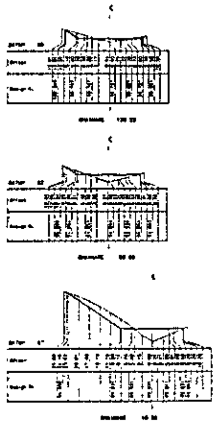
ENGINEERING PACKAGE



MODULES

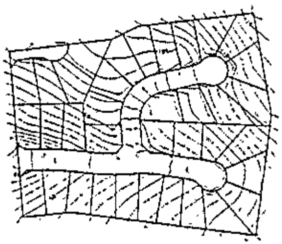
- Contouring
- Earthworks
- Roads
- Site Grading

These Engineering Modules integrate with WESCOM's Primary, Data Management, and Surveying Modules.



KEY FEATURES

- Accepts data from virtually any source
- Innovative digital terrain modelling techniques
- Geometrical design surface modelling
- Statistical data checking
- Volume calculation between any combination of natural and/or design surfaces
- Automatic interpolation of natural surface cross-sections from a digital terrain model
- Powerful design cross-section templates with:
  - Variable dimensions
  - Multiple vertical alignments
  - Decision making intelligence
- Output includes:
  - Contours
  - Profiles
  - Plan Views
  - Perspective Views
  - Detailed Listings
  - Cross-sections
  - Anaglyphs
  - Mass Haul Diagrams
  - Axonometric Views
  - Check Plots



BENEFITS

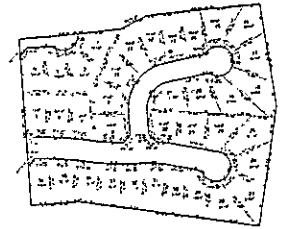
- Fast and simple redesign processing
- Quality graphics for presentations
- Improved algorithms for better accuracy
- Powerful tools for optimisation of engineering design
- Easy definition of complex design surfaces
- Eliminates tedium of routine tasks

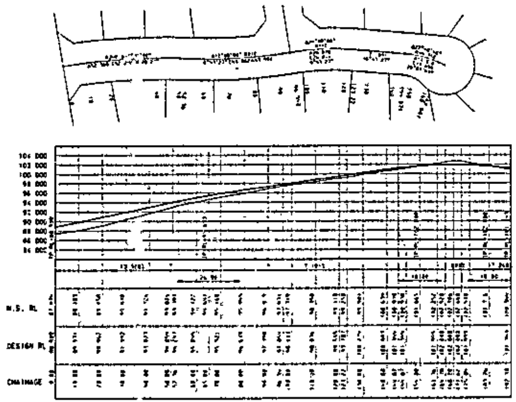
SURVEYING PACKAGE

MODULES

- Field Input
- Adjustments
- Coordinate Geometry
- Subdivision Mapping

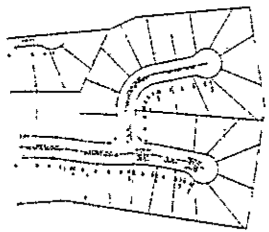
These Surveying Modules integrate with WESCOM's Primary, Data Management, and Engineering Modules.





KEY FEATURES

- Accepts data from virtually any source
- Rigorous adjustments of traverses and networks
- Powerful coordinate geometry routines
- User-definable coordinate geometry routines
- Database files include points, traverses, lots, & descriptors
- Specific routines for subdivision calculation & mapping
- Comprehensive quality assurance routines for all survey computations
- Unattended automatic generation of annotated survey plans
- Table driven automatic mapping to accepted drafting standards
- Customizable plans and listings for field set-out



BENEFITS

- 100% confidence in the integrity of all computations & mapping
- Easy memorization of a few powerful coordinate geometry routines
- Early detection of field and transcription errors
- Fast and simple redesign processing
- Elimination of labor intensive plan generation
- Ability to produce a unique output style for individual projects

WESCOM SOFTWARE FEATURES

- Interactive Applications Manager:
  - Help in Using All Applications Programs
  - Mask Facility for the Infrequent User
  - Input Validation Prior to Program Execution
- Accepts Input from Standard Sources:
  - Electronic Data Recorders
  - Manually Recorded Field Books
  - Digitizers
  - Stereoplotters
  - Data Listings or Files
- Project Database
  - Stores All Project Data
  - Eliminates Repeated Entry of Data
  - Accessed by All Programs
- Interactive Graphics Manager:
  - Preview of Plans
  - Multiple Overlay Facility
  - Optional Manual Override
  - Output Device Selection
- True Hands-off Automated Mapping
- Design Modifications Quickly and Easily Processed
- Results Checked Using Independent Routines at Each Stage of a Project
- Software Architecture Minimizes Possibility of Data Loss in the Event of System Failure
- Modular Programs Adapt to a Wide Range of Applications
- Professional Development of Rigorous Mathematical Solutions
- Central Error Reporting
- Programmer's tools for users who want to write programs to interface with WESCOM software
- Comprehensive User Manuals with Examples

HARDWARE REQUIREMENTS

- IBM PC XT, IBM PC AT, Compaq 386 or compatibles (AT or 386 recommended)
- 640 Kbyte RAM memory
- Floppy disk drive (1.2 Mbyte recommended)
- Graphics screen (EGA recommended)
- Plotter dependent upon application
- A text editor is recommended
- 20 Mbyte hard disk
- 8087, 80287, or 80387 math coprocessor
- 132 column printer
- MS-DOS 3.0 or later

SUPPORTED PERIPHERAL DEVICES

- Digitizers
  - Calcomp
  - Hitachi
  - GTCO Digi-Pad
  - Graphtec
- Electronic Data Recorders
  - Geodimeter Geodat 126
  - Nikon DR-1
  - Sokkisha SDR2
  - Topcon FC-1
  - Wild GLE-1 & GRE-3
  - HP41 & HP71
- Plotters
  - Hewlett-Packard
  - Houston Instruments
  - Calcomp
  - Roland
  - Graphtec

Further devices are added to meet user requirements.

AUSTRALASIAN SALES & SUPPORT CENTERS

WESCOM offers sales and support through the above dealer network. Staff from each dealer have attended comprehensive training at WESCOM facilities and are qualified to provide full technical support and advice on our products.

WESCOM software with PC hardware is the optimum in price and performance.

If you demand :

- The most from your field data
- Efficient use of available resources
- Highest quality output
- Reduced project turnaround time
- Continuing software development

then a WESCOM software package is your solution.

For further information contact WESCOM or an authorized dealer.

WESCOM
38 Rowland Street
P. O. Box 506
Subiaco
Western Australia 6008
Telephone: (09) 382-2811
Facsimile: (09) 382-4740

AMS APPLIED MICRO SYSTEMS
145 MELBOURNE STREET,
SOUTH BRISBANE. QLD. 4101
PHONE:- 846 1001

Introducing

LANDMARK

Interactive Surveying & Engineering Software

— Not like any other Surveying & Engineering Software you may have seen or used!

LANDMARK is owned by PHM Australia Pty Ltd and was written several years ago by a surveyor, who in consultation with civil engineers provided an interactive system which was powerful in all aspects of subdivision design. Since that time the software has undergone certain changes to meet the requirements of local councils, government departments and private practices throughout Australasia and now encompasses rural road design and even mining.

The software is designed to run on personal computers employing DOS and is currently being modified for the UNIX system. The package comprises 4 main modules which may be totally integrated or operated individually. Data may be input manually or transferred through the use of electronic data recording equipment with final ouput being provided through a printer and/or as a plotted drawing.

DESCRIPTION

STADIA : Reduction of field data, contouring and volumes.

SURSUB : Surveying and subdivisional calculations and design of layouts.

ROAD 3 : Road design and quantities.

PIPE : Analysis and design of stormwater drainage systems.

Plotting routines are incorporated in each module which will produce final working drawings. Plot files may be transferred to most of the popular CAD packages currently available.

Queensland Laser and Survey Supplies

BRISBANE: 145 MELBOURNE STREET, (P.O. BOX 223,) SOUTH BRISBANE, QLD. 4101. PHONE: (07) 846 3385, FACS: 8461081
GOLD COAST: 46 KORTUM DRIVE, BURLEIGH HEADS, QLD. 4220. PHONE (075) 35 6644

HEWLETT PACKARD

SOKKISHA Survey Instruments

WARRANTY

All Sokkisha equipment is covered by a two year warranty against electronic defects and a lifetime warranty against optical and mechanical defects.

SERVICE FACILITIES

Queensland Laser & Survey Supplies has a fully equipped workshop in Brisbane manned by factory-trained technicians.

SUPPORT

In the event of breakdown:-

1) During the warranty period a replacement unit will be supplied within 24 hours of notification of breakdown free of charge.

2) At the completion of the warranty period a replacement unit will be provided within 24 hours of notification of breakdown at a cost of half the hire rate. The hire rate of the SET 3 is $300 per week. This hire is charged for a maximum of two weeks only. If the unit is not fixed within two weeks the unit may be kept on loan at no charge.

QUOTATION

Total Stations

		SALES TAX
SOKKISHA SDM3F Total Station	$ 9,900	$1,683
SOKKISHA SDM3FR Total Station (LED)	$10,990	$1,868
SOKKISHA SDM3FR Total Station (LCD)	$11,990	$2,038
SOKKISHA SET 4 Total Station	$13,750	$2,337
SOKKISHA SET 3 Total Station	$15,375	$2,613
SOKKISHA SET 2 Total Station	$18,700	$3,179
SOKKISHA DT2/RED MINI2 Combination	$15,700	$2,669

Prices include: 2 x BDC18 Batteries, 1 x CDC11D Charger Instruction Manuals, Tool Kit, Plumbob, Carry Case.

Data Recorders

SOKKISHA SDR2 Data Recorder 32K
including
- 11 built-in programs
- cable to total station
- cable to computer/printer/plotter
- carry case
- instruction manuals — $ 4,750 — {$760}

SOKKISHA SDR22 Data Recorder 64K

including - as per SDR2 — $ 4,995 — {$799}

SOKKISHA SDRP Data Recorder

including
- RS232 interface
- DB25 adaptor
- Sokkisha SET series program pack
- Sokkisha instrument cable
- 2 x 32K data packs
- tripod clip
- carry bag
- instruction manual
- quick reference card
- formatter
- mains adaptor — $3,065 — $490

Special Packages

SOKKISHA SET 2 & SDR2 32K	$22,745	$3,939
SOKKISHA SET 2 & SDR22	$23,025	$3,978
SOKKISHA SET 2 & SDRP	$21,050	$3,669
SOKKISHA SET 3 & SDR2 32K	$19,500	$3,373
SOKKISHA SET 3 & SDR22	$19,775	$3,412
SOKKISHA SET 3 & SDRP	$17,800	$3,103
SOKKISHA SET 4 & SDR2 32K	$17,900	$3,097
SOKKISHA SET 4 & SDR22	$18,200	$3,136
SOKKISHA SET 4 & SDRP	$16,225	$2,827