GIS & REMOTE SENSING NEWS

FIJI USER GROUP, Number 9 (9407), December 1994

As 1994 draws to a close it is interesting to note how far Fiji and regional users have come since this newsletter was first produced in October 1993 and it is instructive to see what has been achieved. The first and most important benefit is exchange of information with the hopeful goal of informing users who has got what data, where that data is and in what format it is stored. This of course leads to users getting results faster and the reduced cost of the end product. Another benefit is the promotion of standards to facilitate ready exchange of data where the statement to sales “If this application of yours doesn’t export and import DXF then I don’t want it” is the current conventional wisdom as shown in Intergraph Opens Data Format article. However, new standards will evolve and we want to keep you informed. Another standard appears to be the selection of MapInfo as the midrange desktop GIS which will result in cost–effective training through an increased user base and more effective use of MapInfo’s features with rising skill levels.

We attempt to bring new applications and this issue looks at RADAR for remote sensing and the possibilities for forestry studies especially in the area where RADAR excels which is high percentage cloud cover or haze such as is found in Fiji.

Please be reminded again that we need articles from all sectors involved in GIS and Remote Sensing so we can keep you more fully informed in 1995 and finally, from all of us here at the news desk, a very merry Christmas and a happy new year.

NEWS UPDATE

The September and the October meetings have been used to give all participants the opportunity to report about the status and prospects of the Remote Sensing and GIS activities of their Departments.

• The **Bureau of Statistics** want to carry out a mapping project for the next census. The Bureau will establish a close link to FLIS in order to use their facilities.

• The **Department of Environment** is still in the planning stage. The department will buy a GIS system very soon. The Department of Environment will be the point of contact for the regional environmental network.

• **Fiji Pine** Ltd. is interested in installing a GIS and Remote Sensing unit to monitor the pine plantations. The mapping done with aerial photographs is expensive and relatively slow. There are plans to use the facilities of MSD-Forestry in order to map the extension pine plantations using satellite data.

• The **Fisheries Department** bought MapInfo to map fishing boundaries and fishing rights in Fiji.

• The **FLIS** (Fiji Land Information Support Centre) has important relational data such as cadastral boundaries, land title, land valuation information, register of all indigenous Fijians in Revelation Technologies Advanced Revelation Relational Database. A PC-based GIS is installed (Intergraph MGE sitting on top of Micro Station in an Oracle environment). FLIS has installed a data conversion to transfer data stored at NLTB to MicroStation from where it can be extracted in DXF file format in order to be useable for other departments. The support centre keeps an up-to-date catalogue of spatial data available in different departments in Fiji.

FLIS will establish a 1:50,000 topographical database using new aerial photography and the introduction of socio-economic data through the Bureau of Statistic's.A DTM at 1:25,000 scale will be produced.

• **Harrison Grierson Consulting** using SDR map 5.5 software to assist survey work. This company will move to GIS application soon.

• **Post and Telecom** is very interested in GIS applications because the planning of a cable network in Fiji needs the information about the topography, soil, land ownership and vegetation cover for the most suitable course. Similar information is needed to plan the location of relay stations for wireless telephone. Contacts with Intergraph in Australia are establised to purchase GIS facilities.

• The **Lands Department** is equipped with several systems to map at 1:10,000, 1:25,000 and 1:50,000 scale using aerial photographs. The Department archives all aerial photographs taken from Fiji since 1954. The Department has an aerial camera (Wild RC8) which can be installed in planes designed for it. Facilities for development of aerial photographs are available as well.

•The **Land Use Section of MAFF** moved to a complete new GIS system. The Soil Crop Evaluation Project of was already planned prior to the coup and has stayed in the planing stage since then. Now, two GIS systems are installed ARC-INFO (for vector data collection) and EPPL7 (raster data processing) and the Section starts to digitise the newly compiled soil map of Fiji.

•Kevin McConell from **Lukemine Enterprises** is the representative for MapInfo beside his responsibility for Trimble Navigation GPS systems.

• **MRD** (Mineral Resources Department) has a series of data bases on exploration and offshore data. An important project currently being carried out is the Suva Peninsula nearshore mapping. The software used is FoxPro and MapGraphics.

• The **MSD-Forestry** (Management Services Division) is equipped with ERDAS VGA for raster GIS application and ERDAS-Imagine and ERDAS-7.5 for digital satellite data analysis. ARC-INFO and Micro Station are available for vector GIS application. Data transfer can be done with ARC-INFO data conversion and Image Alchemy software. The division has relational data on forest and timber related information and forest area on (district level) Spatial data is available at 1:50,000 scale such as:

· digital terrain model
· soil map (11 soil types)
· forest types (4 types plus pine, coconut and hardwood plantation)
· forest functions (5 different functions)
· declared areas (declared reserves, protected water catchments etc.)
· erosion risk map (10 different classes related to soil, slope and rainfall)

and several others. A coverage with Landsat TM data recorded 1991 and 1992 is available as well as SPOT data taken 1994. The Division is also equipped with an analytical aerial photo analysis system (VISOPRET). This system creates a digital terrain models at 1:10,000 scale for logging planning using existing aerial photographs.

• **NLTB** (Native Land Trust Board) has a micro based (VAX) GIS called INFORMAP (Synercom, Australia). It was the first GIS existing in Fiji. Much data has been gathered, however, the system is not compatible to others. NLTB is now moving to Map Info. At NLTB important spatial data is stored such as:

· *mataqali* boundaries
· river system
· forest cover (LRD inventory 1969)
· road network

• The **PWD** (Public Works Department) has no GIS at present. A number of projects dealing with sewerage water could be planned faster and more correctly if GIS and GPS were be involved, there is high interest expressed by the Department.

• **Queensland Insurance** is still interested in a GIS application. The target is a hazard mapping to locate areas which are more in danger than other to forecast and plan potential damage. The insurance is concentrating on data bases which should later be transferred to a spatial data base.

• **SOPAC** (South Pacific Applied Geoscience Commission) is equipped with ARC-INFO and MapInfo. SOPAC is serving the GIS facilities of the other South Pacific countries. SOPAC is also equipped with digital image analysis systems ERDAS and OSIRIS. ERDAS Imagine NT is ordered as well. SOPAC has a Regional Data Centre with the Pacific Islands Resource and Environment Information Service which includes regional data catalogue, SPOT images, relational data base, GIS specialists, remote sensing specialists. SOPAC also holds the data catalogue of all spatial information and remote sensing data available in Fiji.

• **UNDRO** (United Nations Department of Humanitarian Affairs) is equipped with several PCs donated by the Chinese Government. UNDRO wants to map critical areas for Hazard assessment. Necessary software will be bought during the next months.

• The **UN Water and Sanitation Project** which is based at SOPAC headquarters has no dedicated GIS system and will access SOPAC's Regional Data Centre. The project will use existing the spatial data.

• The **USP** (University of the South Pacific) is involved in GIS training. Newly installed PCs allow basic GIS training. Training courses have been provided for one year.

• **Regional Workshop on Remote Sensing and GIS in Suva February 1995.** A workshop will be held on GIS/Remote Sensing for Land and Marine Resource and Environment Management in the Pacific Subregion in Suva 13-17 February 1995.

• **ESCAP** will finance this workshop including the travel of 20-30 participants from other Pacific Island Countries while Fiji will provide the facilities. The first day will be reserved for country status reports and introduction to GIS and Remote Sensing. Then, applications in different areas will be presented. Site visits to USP, SOPAC, Forestry, MRD, NLTB and FLIS will leave room for discussion on applications. One day will be reserved to compile a report with the participants. At present, a committee including FLIS, SOPAC, MRD, USP and Forestry is planning the details.

• **New Adviser at FLIS**
Ansell Haanen a new adviser from New Zealand started a two year project at FLIS which will concentrate on data capture for the 1:50,000 topographic maps. These maps will be transferred to the digital data base. He also will install and extend the GIS facilities at FLIS.

• **Post Graduate Scholarship for Fijian Forester.** In April 1995, Osea Tuinivanua (MSD-Forestry) will begin a 18 month postgraduate study at the University of Freiburg (Germany). His study will concentrate on forest type mapping with satellite data. The supervisor for his study, Dr Barbara Koch, is involved in the MOMS-02 programme. With this link, MOMS data will be available for Fiji during the next year. The Fiji Government welcomes Osea´s study which is financed by the Hanns Seidel Foundation.

SATELLITE NEWS

• **SPOT** continued data recording without problems known to this newsletter. MSD-Forestry bought two SPOT scenes 436-386 from 30 June 1994 and 436-386 from 5 August 1994. Both scenes will be matched together to mask out the cloud cover as far as possible. Both scenes arrived on one CD-ROM which is the best data storage medium in tropical countries such as Fiji. MSD-Forestry has also acquired the following SPOT scenes:

- 435-385 31 July 1994
- 435-386 31 July 1994
- 437-383 30 June 1994
- 437-384 30 June 1994
- 438-383 5 September 1994

MSD-Forestry will ask for special acquisition for scenes:

- 436-385
- 437-385
- 439-383
- 439-384

• The United States Department of Defence signed an agreement with Image Corporation, the US subsidiary of SPOT Image for the direct reception of SPOT data by a transportable receiving station. This station has been based at the US Air Force base at Ramstein, Germany, where it is undergoing testing. (*SPOT Magazine June 1994*)

• EOSAT data can be shared between different government departments, if the Government is the owner of this data. We do not have such an agreement from SPOT Image. However, SPOT Image (Australia) announced that they will convince the main office in Toulouse (France) to allow the same data sharing between Government departments in Fiji as EOSAT is offering for Landsat Data. That would mean, that all departments can use the data without copying fee, once the Government of Fiji signed the ownership.

• **MOMS-02** will soon be in space on board of the Russian Space Station MIR. Dr. Barbara Koch from the University of Freiburg (Germany) is involved in the MOMS-02 Program. She will try to set Fiji on the priority list for data recording. This has been assisted by the postgraduate study which will be undertaken by Osea Tuinivanua from MSD-Forestry at Dr Koch's Institute.

• **EOSAT** is a private company and will stay that way. The rumour of switching over to a government company was not based on facts (fax from EOSAT).

GPS DIFFERENTIAL CORRECTIONS NOW AVAILABLE IN FIJI

Management Services Division, Department of Forestry at Colo-I-Suva, have installed a 12 channel Trimble Pathfinder Community Base Station (PFCBS). Funding was provided by AIDAB. The base station is now operational, and data collected will be available to the general public for a minimal cost.

The base station is sited on the roof of the Forestry garage and has been surveyed by Department of Lands Control Branch.

Details of the Base Station are as follows:

UTC offset (Local-UTC)	12 hours
Elevation Angle Mask	10 degrees
Station Co-ordinates	18 deg 03 min 25.2162 sec SOUTH 178 deg 27 min 34.2811 sec EAST 282.91m Height Above Ellipsoid (HAE) Co-ordinates are in terms of WGS-84
Data Collection Rate	5 second intervals
Data collection	By arrangement - Phone Mike Poidevin 320814 or Osea Tuinivanua 322644. Collection during working hours, but could be arranged for any time period
Data access	By modem 322635 between 5-6pm or down loaded to floppy disk.
Fee Structure	$2.20 per hourly file (this does not include floppy disk) on monthly account basis.

The PFCBS will provide a seamless differential (DGPS) post processing solution for the Trimble Pathfinder family of GPS mapping receivers, with accuracies in the sub-metre to 5m range. Receivers from other manufacturers which are capable of processing data in the RINEX format can also utilise the service, although Trimble makes no representation about the achievable accuracy.

Any number of rover receivers within 500km radius can be serviced, with the best accuracy near the base station. Accuracy will be degraded at around 1m for each 100km from the base.

Figures 1 and 2 show a walk-around survey of a rugby field at Albert Park, Suva, carried out with a hand-held Trimble GeoExplorer. Total time from arrival to departure was about 6 minutes, of which initialisation to 6 satellites occupied the first 2 minutes. By pre-arrangement the PFCBS was in operation.

The raw data file distortion, shown in Fig-

• Now, EOSAT is marketing the **Japanese JERS satellite data** in addition to Landsat and the **Indian satellite IRS data**. However, as stated in the previous newsletters, there are no onboard tape facilities and the IRS data can be received only in the range of the ground antennas in India and the station in Norma (USA). JERS-1 data is available in photographic and digital formats. The satellite has an onboard recorder. (*EOSAT Notes 3/194*).

• The EOSAT Online Network **EON** now is available. 24 hours a customer can download by electronic male information about products and services, technical services etc. Through the Browse Image Management System the customer can view Landsat subsampled imagery before buying. (*EOSAT Notes 2/1994*)

• The **Portable Ground Station** (PGS) is operational in Kenya (Africa) now. This ground station is managed by a newly founded company "Teleos" formed by EOSAT and Telespazio. This PGS will collect and process data from Landsat, SPOT, ERS-1, IRS and other remote sensing satellites (fax from EOSAT and GIS-World August 1994). Political steps are necessary to place such a Portable Ground Station for a time in the South Pacific Island Countries. SPOT will support such a step for a station in Fiji (phone talk with SPOT Australia).

• EOSAT agreed with the Indonesian National Aeronautics and Space Institute (**LANPAN**) to establish distribution rights to the Landsat data collected at the ground station at Pare-Pare on the island of Sulawesi. The antenna covers all of Indonesia, the Philippines, Malaysia, the southern half of Vietnam and Cambodia, and the northwestern Australia. EOSAT has the exclusive right to market the data to users outside the station's coverage area, and LAPAN has the exclusive right to distribute the data within Indonesian national boundaries. (*EOSAT Notes 2/1994*) This Indonesian ground station cannot cover data captured over Fiji.

• **RADARSAT**, scheduled for launch in 1995, will be a commercial Synthetic Aperture Radar (SAR) spacecraft. It will produce images with up to 10-meter resolution and collect data up to 500 kilometres wide, showing objects the size of buildings. Using a sun-synchronous orbit, RADARSAT will circle Earth 14 times a day and acquire data day and night, regardless of weather conditions, smoke or dust. (*GIS World, September 1994*)

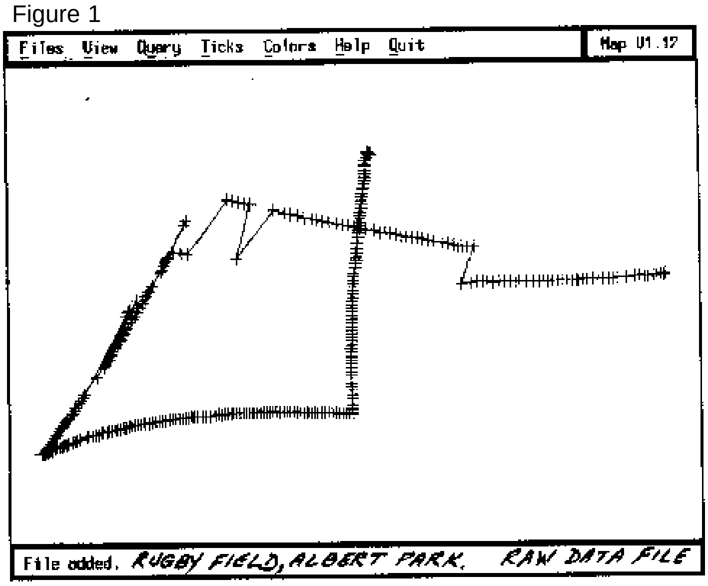
• The Indian satellite **IRS-1C** is scheduled to be launched in mid 1995. This satellite will carry three sensors: Linear Self Scanning Sensor-III, with 20 resolution in green, red, near-infrared and short wave infrared bands, a panchromatic camera with 10 m resolution, and a Wide Field Sensor with approximately 188 m resolution.

• **JERS-1** was launched on 11 February 1992 in Japan for designed life of two years. The satellite has a sun synchronous orbit with an inclination of 98° similar to Landsat (overflight approx. 10:30 - 11:00). It has a Synthetic Aperture Radar (SAR) and Optical Sensors (OPS). The SAR has a 75 km swath width, a resolution of 18 x 18 m, an off nadir angle of 35°, a frequency of 1275 GHz (L-band) and polarisation HH. The OPS has 8 bands. However, the infrared-bands gave up to work only achieved data are available. The ground resolution is 18 m x 24 m. The visible bands cover following wavelength:

Band 1: 0.52 - 0.60 um
Band 2: 0.63 - 0.69 um
Band 3: 0.76 - 0.86 um

Band 4 has the same characteristic as band 3 but the sensor is looking forward. The combination of band 3 and 4 creates a stereo image pair. (Fax from Remote Sensing Technology Center of Japan).⊕

Figure 1



ure 1, clearly demonstrates the possible degradation of positional accuracies which pertain to all GPS receivers. Differential correction through GEO-PC software took a matter of minutes, the results of which are shown in Figure 2

For comparison purposes two dimensions of the field were measured. The northern side measures 101.0m, calculates 103.6, the western measures 69.9m, and calclates 66.8m. These results confirm the claimed accuracy (2 to 5m) of the GeoExplorer.

There are no immediate plans to provide realtime DGPS, although a Suva based company has been asked to investigate costs to provide the necessary radio links.⊕

POTENTIAL OF IMAGE ALCHEMY SOFTWARE

Background

The Management Services Division of the Forestry Department (MSD) printed the first coverage of the GIS information layer "Potential Forest Function" beginning of 1994. However, this was only possible with the help of SOPAC, because there was no printer available. Further these print outs were printed in six parts for one map sheet. In May the MSD was equipped with a own A3 ink Jet printer. However, this printer only was able to print A4 size in the right scale probably due to the Corel Draw software used map editing. In July the A0 plotter of Micro Station map editing section printed the first maps. But, raster data from in ERDAS or TIFF file format showed a striping and the colour was poor. This was due to the transformation to the plotter needed format.

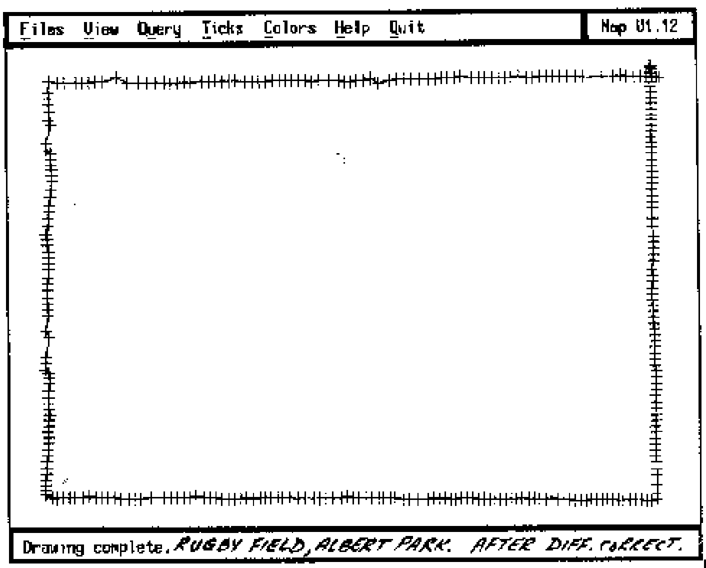
New Software

The dealer of the company as well as the dealer selling ERDAS software advised to use IMAGE ALCHEMY to overcome the problem. This software was provided to the MSD and tested. The ERDAS as well as the TIFF file formats were printed sucessfully. The software is user friendly and strait forward. Several tests were carried out to identify the best Colour enhancement, the results are shown.

Beside the transformation of ERDAS *.GIS, ERDAS.LAN and *TIFF files The softwar can translate vice versa more than 60 raster file formats.

During the data transformation process several image enhance-

Figure 2



ments and image treatsments can be perforemed such as

• colour enhancement,
• scaling, enlargement or reduction
• location on the output paper (shifting directions)
• mirror or turning of image

For further information see User's Manual "Image Alchemy PS", Version 1.7. Or contact Mike or Wolf at the Management Services Division, Forestry.

INTERGRAPH OPENS DATA FORMAT

Intergraph software is used in Fiji by FLIS and MSD-Forestry. GIS-World August 1994 advised that Intergraph will provide *file format information* to all users. Intergraph will also promote an open system architecture for its GIS products.

The GIS/RS Newsletter welcomes such a step which allows an easy data exchange in future. Data exchange avoids duplication of work and better planning and charring of work potential. Fiji is one of the few countries which have a regular meeting on a technical level where technical problems can be brought up which mostly lead into discussions at decision maker level. A good example is the agreement on a common GIS file format "DXF". However, there are still problems to be faced. Synercom from Australia provided the first GIS in Fiji to NLTB and it is still impossible to communicate with this data, although a lot of effort have been done by FLIS during the last three years to overcome this. The consequence is that other user repeat data capture of information, already stored in the NLTB GIS.

A further step in the direction of data sharing is a documentation showing the data available in each department, the data origin and scale and the *physical file format*. The same article stated that Intergraph's main competitor ESRI (ARC-INFO) had mixed reactions. Today's buyers of GIS software should be aware of the compatibility of the available software. If software is capable to producing good results, much time and effort can be again lost if the file structure is not compatible. A open and well documented file format is an important step!

■ *Barbara Koch, University of Freiburg, Department of Remote Sensing and Land Information Systems*

MOMS–02 A HIGH-RESOLUTION SATELLITE SYSTEMWITH STEREO CAPABILITY

With the fast advance of the application of GIS-Systems in different regions of the world the request for high resolution geocoded satellite data which can be integrated more easily in georeferenced data bases increases. Most existing satellite systems cannot meet these requirements because they neither offer high spatial resolution nor stereo capability. That means that for geocoding of the data the basic digital elevation models have to be retrieved from different sources, which can be time and cost consuming. It has to be admitted that SPOT generally meets the above requirements but the system is not able to register along track stereo data, causing problems in gathering a stereo data set. Photographic products which can provide quite good spatial resolution, miss the spectral resolution and require long time for data delivery to earth.

The Modular Optoelectronic Scanner (MOMS) has the capability to register high resolution along track stereo data as well as high resolution multispectral data. The MOMS-02 camera has 5 objectives three for stereoscopic data recording and two for multispectral data recording. The stereo triplet has one nadir looking objective and two tilted objectives with 20.1° forward and 20.1° backward in flight direction. The focal length of the lenses is 237 mm. From a flight height of 300 km there is a ground resolution of 4.5 m x 4.5 m in nadir and 13.5 m x 13.5 m for the tilted objectives. The two multispectral objectives with a focal length of 270 mm reach from 300 km distance has a ground resolution of 13.5 m x 13.5 m. In the focal plane of the cameras there is a line array sensor with different filter which allows data recording in 4 different spectral channels. In Table 1 the most important technical parameters are listed.

Table 1. Most technical parameters for MOMS-02 (in : Zeitschrift fur Photogrammetrie and Fernerkundung 1993).

Channel	Mode	Orientation	Band Width	Pixel Size	Focal Length	Swath Width1
M/S	Nadir	440-505nm	13.5mx13.5m	220 mm	78/43 km	
2	M/S	Nadir	530-575nm	13.5mx13.5m	220 mm	78/43 km
3	M/S	Nadir	645-680nm	13.5mx13.5m	220 mm	78/43 km
4	M/S	Nadir	770-810nm	13.5mx13.5m	220 mm	78/43 km
5	HR	Nadir	520-760nm	4.5mx 4.5m	660 mm	37/27 km
6	Stereo	+21.4°	520-760nm	13.5mx13.5m	237 mm	78/43 km
7	Stereo	- 21.4°	520-760nm	13.5mx13.5m	237 mm	78/43 km

HR = high resolution
MS = multispectral

The MOMS-02 sensor offer six different modes for data recording:

Mode	(I)	channels 5, 6, 7 (HR + 2 Stereo)
Mode	(II)	channels 1-4 (MS)
Mode	(III)	channels 3, 4, 6, 7 (2MS + 2 St)
Mode	(IV)	channels 1, 3, 4, 6 (3MS + 1 St)
Mode	(V)	channels 1, 3, 4, 7 (3MS + 1 St)
Mode	(VI)	channels 2, 3, 4, 5 (3MS +HR)

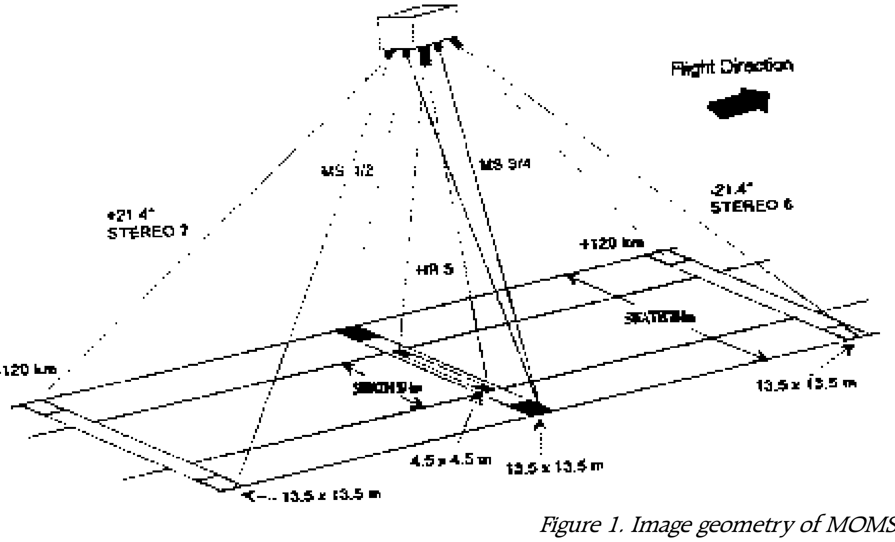


Figure 1. Image geometry of MOMS-02.

Each mode is a certain combination of channels and is selectable before the data recording. The swath width differs according to channels included in the mode between 37 km and 78 km. The distance between the ground elements of the forward looking and backward looking objectives in flight direction is from edge to edge 240 km (Figure 1).

The MOMS-02 was first flown during the D-2 Mission in April 1993 within the geographic latitude of plus/minus 28 degree. The first data take yielded, besides some minor technical problems during the Mission, high quality images. (Figure 2).

The MOMS-02 instrument is scheduled to fly in April 1995 on the Russian space station MIR. This longterm activity allows data recording from 350 to 400 km altitude with a 51.7° inclined orbit. This will cover the earth surface between the 52 latitude plus/minus. It is expected, that a mapping with high accuracy in a scale 1:50,000 can be provided by this data set. The transmission of the data to the data center Neustrelitz in Mecklenburg/ Germany is provided by an X-Band data line with a data rate of 120 Mega Bits per second.

According to the data structure an improved application for landuse and forest inventory tasks can be expected.

Acknowledgement

The MOMS scientific program and the investigation are funded by the Ministry of Research and Technology (BMFT).

The image, Figure 2, is provided by Dr. H. Kaufmann and Dipl.-Ing. Michael Berger, GFZ Potsdam.

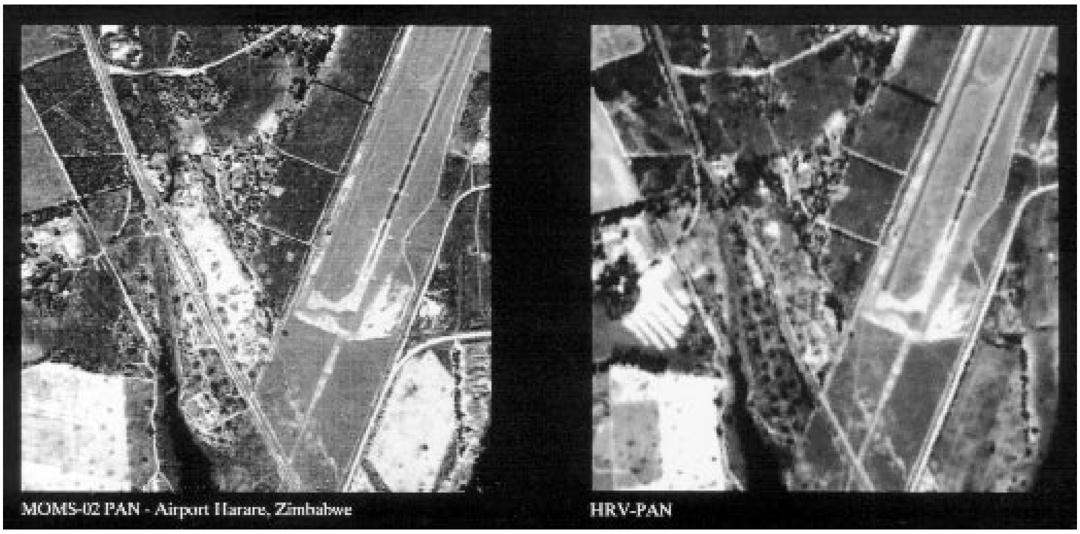


Figure 2. MOMS-02 PAN and HRV PAN (SPOT) Images, Harare Zimbabwe (Producer GFZ Potsdam).

Literature

KOCH, B., SCHNEIDER, TH.; AMMER, U. (1993): Expected Radiometric and Spectral Significance of MOMS-02 Data for Vegetation Mapping; Calculations Based on System Parameters Applied on Spectral Field Measurements. Remote Sending of Environment 1993. Vol 46 p. 73-88.

BODECHTEL, J., KAUFMANN, H.; KOCH, B.; BERGER, M., LEI, U. AND LÖRCHER, G., (1994): MOMS-02/ D2; First Results and Future Applications. In: International Journal of Remote Sensing. In print.

SEIGE, P., LEHNER, M.; REINARTZ, P.: Erste MOMS-02 Daten zeigen vielversprechende Ergebnisse. In: Zeitschrift fur Photogrammetry und Fernerkundung 1993. Heft 6 S. 238-239 ISSN 0937-9800.

DESKTOP GIS SALES INCREASE

The falling costs of high performance personal computers has made Desktop GISs (Geographic Information Systems) available to a wider audience of business and scientific users. Traditionally, GISs, with their large datasets and heavy graphic requirements, were only available for workstation, minicomputer and mainframe based systems and required specialists to handle the operation and analysis.

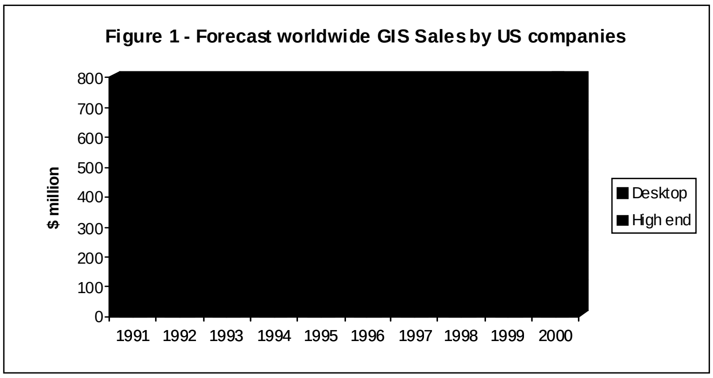
Three players in the Desktop GIS field are MapInfo with MapInfo for Windows 3.0, Strategic Mapping with Atlas GIS 2.0 and Munro Garrett International with Argus Professional 3.0. These products while not offering the full functionality of a true GIS are often adequate for most tasks and all fall within the under $2,000 range. GISs which are perceived as fully functional and which may only be available for workstations and minicomputers will often cost ten or more times the above.

But the game is changing rapidly with Strategic Mapping cutting the price of Altas from $1,595 to $495 with expected cuts from MapInfo whose current price is $1,295 and Argus at $995.

The cut in prices can be attributed to increases in sales as the industry research firm Duraptech (Cambridge, MA) has forecast approximately $615 million worth of GIS products will be purchased in 1995 and that the percentage of GIS products for the desktop will grow. The available figures up to 1994 are shown in Table 1 with growth forecast growth until the end of the century while Figure 1 shows desktop sales overtaking the high end platforms by the end of the century.

Table 1. Forecast worldwide sales by US companies in $ million.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Desktop	67	83	119	149	199	263	347	459	606	799
High end	251	295	321	365	413	467	527	595	672	758
Total	317	378	440	514	612	730	874	1,053	1,277	1,558



It is not valid to forecast sales growth against increasingly powerful desktops with workstations, minicomputers and mainframes over a long period such as 5 years but what is clear is that Desktop GIS or Desktop Mapping is gaining significant popularity and an increasing share of the market against the traditional platforms.

Notwithstanding all the forecasts, the important point is that Desktop GIS is here to stay and within the near future users will have access to tools for analysis of spatial and tabular data that were only possible in the supercomputer labs of the late 80's.

For further information, contact Les Allinson, Computer Systems Manager, at SOPAC, Suva, which is a site using MapInfo as a Desktop GIS.

■ *Osea Tuinivanua, MSD, Forestry Department, Fiji*

RAINTREE AS A NEW FOREST TYPE

Summary
The forest type, Raintree *(Samanea saman)* has been identified in the field to be consisting of mainly raintree species. With digital image classification, using the digital Landsat TM data, it was possible to separate raintree from other forest cover types. Raintree has a unique forest canopy and structural appearance and covering a wide ground area to be classified as a forest type.

Introduction
The forest cover of Fiji has evolved quite significantly in the last century. For example, the continuous ground clearing for various farming activities, indiscriminant burning and the gradual population movement into rural areas. It became obvious that in the drier areas, the continuous disturbance inflicted to native forest has made it impossible for its quick recovery. Consequently, introduced fast growing tree species have beeen able to thrive in such sites.

The dominance of raintree in the low-lying alluvial sites and river valleys was related to little competition from other tree species and its greater shady effect to animals. Its adaptability has resulted in its widespread to covering the upper natural forest sites in the drier zones of the Vanua Levu and Viti Levu.

Stratification of this forest type with remote sensing data is necessary for a number of reasons. The change detection and the extent of exotic forest movement into natural forest region has never been considered. Apparently, the natural forest will continue to shrink while the migration and expansion of other fast growing tree species continue.

Raintree Distribution and Role
The exotic tree species was introduced from Hawaii and has naturalised itself in Fiji (Berry and Howard 1973). The extent of distribution is influenced by human and the grazing cattle with redistribution of seeds. It has a signifant environmental role not only as soil erosion control but as habitat for bird and animal life. The timber has been widely used for carving. Further literature review of its historical introduction and growth is continuing.

Raintree Growth Characteristics
Raintree is characterised by its fluffy husky green widespreading (domed) type crown with short bole. It has an irregular branching pattern with buttressed boled stem form. It is often a single storey forest with other shrubby species forming the lower and fringe cover. *(Figure 1).*

Raintree crown and leave colours change with age and seasonal effect. Young raintrees have fresh green leaves with no seasonal effect while the older stands shed its leaves during the year (September – November) for newer leaves after the rainy season (December – February). The leaf arrangement is opposite with petiolate insertion and bipinnate leaf composition. The leaf shape is ovate with entire leaf margin. Leaf size falls within microphylls (25 – 225 mm²) on Raunkiaer's leaf size class.

The single storey growing characteristic of raintree has many advantages. It's generally has little ground fire risk. Its thick tessellated and scaly bark is quite fire resistant plus the ability to rejuvenate its leaves after shedding. Further information will be provided from the permanent sample plots established in this forest type.

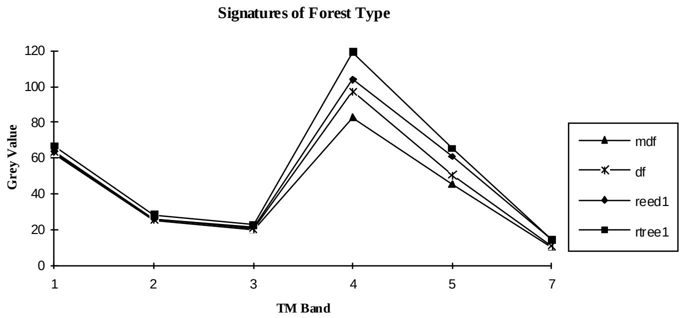


Figure 2. The graph shows the mean grey value of different training areas in different spectral bands of the TM data set. mdf = medium dense natural forest, df = dense natural forest, reed1 = reed forest, rtree1 = raintrees

Digital Image Processing

Image Enhancement
The Landsat TM data (25/12/1991) has been used in the MSD as the most appropriate digital image for forest stratifications.

The best contrast for visual interpretation and detection of raintree was provided with band combination 5,4,3 for R:G:B respectively. The extent of raintree forest cover was clearly visible from the other forest type. This was further stretched with the linear contrast stretch for every band separately. The mid-infrared band 5, near infrared band 4 and the visible band 3 were able to show better discrimination in the enhanced image of the study area, e.g. the discrimination between the major forest types. The spectral signatures of the selected training areas showed that the clear differentiation between this forest cover *(Figure 2).*

With the exception of bands 4 and 5 no clear dicrimination between the test areas can be made. Near infrared band 4 showed the best discrimination between raintree(rtree), dense forest (df) and medium dense forest and followed by band 5. However, the standard deviation of the near infrared band 4 was in all cases was greater than mid infrared band 5. It was able to higlight the subtle difference in the forest cover for raintree, native forest, reed and non-forest area.

The non-forest area was masked out leaving only the forest and reed areas for further classification. The uniformity of its crown structure, leaf arrangement and formation, growing sites and distribution were able to provide a visual distinction from the general shadowy outlook of the native forest on the same area.

Digital Image Classification
The discrimination between the forest types showed a marked distinction in dense forest, medium forest, reed area and the raintree area. This was shown clearly in the classification contingency matrix. *(Table 1)*

The field check proved the classification was quite accurate. Further detail classification continues.

Figure 1. Cross Section view of a raintree showing the single column of leaves on the outer covering of crown.

Conclusion
It was possible to classify raintree as a separate forest

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REMOTE SENSING WITH IMAGING RADAR SYSTEMS

1. Introduction
The acronym RADAR stands for *Radio Detection and Ranging*. Actively emitted microwave radiation can be used for various purposes, e.g. as a navigation device to determine the speed and distance of moving objects or in meteorology as weather radar and, last but not least, as a tool for geoscientific remote sensing of the earth's surface.

The main advantage of this active sensor technology is its independence from natural illumination sources and weather conditions, so that data acquisition can be performed at night time as well as through cloudy skies.

2. Historical overview
The history of radar has begun at the end of the 19th century when HEINRICH HERTZ came to the conclusion that solid objects were interfering with and reflecting radio waves.

During the second world war radar technology was developed to an operational stage and was mainly used for detecting military objects such as ships and aircrafts.

The first imaging radar system for remote sensing was built in 1953. It followed the concept of a side looking radar and was mounted on an aircraft, therefore it was called side looking airborne radar, or short SLAR.

In the sixties and seventies the mapping projects RAMP (Radar Mapping Panama), RADAM (Radar of the Amazon) and PRORADAM (Project Radar Amazon Columbien) were initiated to map great parts of middle and south America with the help of SLAR.

The first earth orbiting radar satellite (SEASAT) was launched in 1978 and collected a great amount of image data all over the world during the short operation time of only 106 days.

Since 1978 several radar imaging missions have been flown on aircraft, space shuttle or satellite with different radar systems on board. The most recent ones are the European ERS-1 satellite mission (1991), the Japanese JERS-1 satellite (1992) mission and the SIR-C/XSAR mission on the space shuttle (1993/1994). The Canadian RADARSAT satellite is scheduled for launch in 1995.

3. Basic principle of side looking radar
In a side looking radar system, short SLR, high frequency pulses of microwave radiation are emitted from an antenna sidewards rectangular (range direction) to the flight direction (azimuth direction) and downwards to the earth's surface. The reflections of the illuminated areas and objects are received by the same antenna and are transferred to videosignals for storage on a photographic image film or they are processed digitally and stored on a magnetic tape (Figure 1).

Figure 1. Basic principle of side looking radar from: LILLESAND & KIEFER, 1987, p. 479.

The most often used wavelength for imaging radar are the so called X-, C-, L- and P- bands (Table 1). In comparison with the commonly used passive optical sensors on board of LANDSAT and SPOT, which are only able to detect reflections in the visible, near and mid infrared parts of the spectrum, the radar bands bands are situated at the long wave part of the spectrum.

Table 1. Wavelengths and frequencies for imaging radar bands.

Band	Wavelength [cm]	Frequency [GHz]
X	2.4-3.8	12.5-8.0
C	3.8-7.5	8.0-4.0
L	15.0-30.0	2.0-1.0
P	30.0-100.0	1.0-0.3

Furthermore the emitted microwave radiation is linear-polarized, as a result there are four combinations of polarization (Table 2).

Table 2. Combination of polarization for radar waves.

	Polarization of transmitted signal	Polarization of received signal
like polarized	Horizontal H	Horizontal H
	Vertical V	Vertical V
cross polarized	Vertical V	Horizontal H
	Horizontal H	Vertical V

As a consequence the detected radar signal is caused by different scattering and reflection processes and the information inherent in this signal has another quality than the information inherent in optical data.

For example microwave radiation has the ability to penetrate into surface layers of objects in dependence of the used wavelength and of the target composition. The resulting reflection is not only caused by scattering at the target's surface (surface scattering) but also by scattering in the volume beneath the surface (volume scattering) which is determined by the

Table 1. The table shows a clear discrimination in dense and medium dense native forest and non-forest areas including the reed areas. However, a raintree test area has a 2.4% misclassification into reed which is insignificant.

CONTINGENCY MATRIX

	rtree1	rtree2	reed1	reed2	df	mdf	nonforest
rtree1	86	25.3	0	0	0	0	0
rtree2	14	72.3	0	0	0	0	0
reed1	0	0.1	87.8	11.9	0	0	0
reed2	0	2.3	12.2	88.1	0	0	0
df	0	0	0	0	100	0	0
mdf	0	0	0	0	0	100	0
nonforest	0	0	0	0	0	0	100

type with the use of Landsat TM data. The less light diffusion resulting in the high reflectance from the raintree forest is related to the domed canopy with the compact leaf structure.

The current status and the gradual increase in raintree forest area in the drier sides of the Fiji main islands necessitate to need to consider raintree as a separate forest type.

physical and chemical properties of the object.

Besides the chemical and physical properties, the shape and the geometric orientation of the target towards the sensor are of great importance for the reflected signal. Surfaces orthogonal to the incident radar beam will cause a more intensive return signal than surfaces that are bend away from the incident beam. Buildings, bridges or other man-made objects such as ships often show a very bright reflection pattern at that side which is oriented towards the sensor. This is caused by multiple reflections at the corners of these objects ('corner reflectors').

Figure 2 summarises the most important parameters and processes that influence the radar image formation.

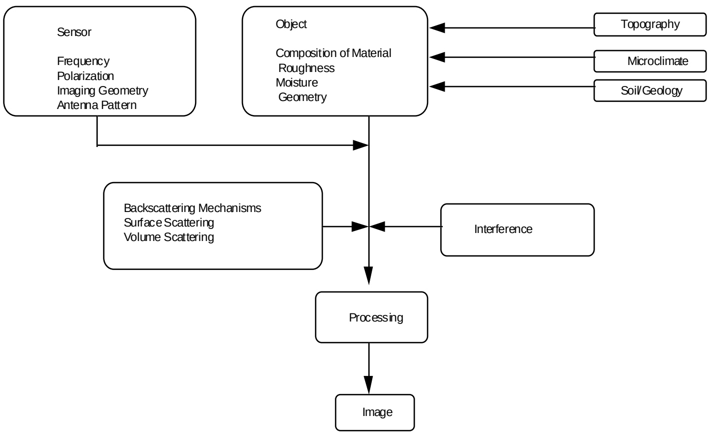

Figure 2. Important parameters and processes in radar image formation from HOLECZ/MEIER/NUESCH 1993, p. 300.

4. Radar remote sensing for forestry applications

Numerous studies have been carried out to determine the potential of radar remote sensing for forestry applications. They can be grouped into the following fields of main interest:

- assessment and modelling of microwave backscatter from forestry targets;
- discrimination of forest cover types;
- forest clearcut and regeneration assessment;
- forest biomass and canopy structure assessment.

The research up to the end of 1989 was reviewed in a literature study by WERLE (1989). He summarized the results of different research projects (Table 3) and showed that the longer wavelength bands, here the C- and L-band, have a greater potential for several forestry application than the shorter wavelength bands.

Table 3. Interpretation results of different forestry related radar studies from WERLE 1989, p. 17.

	X-Band				**C-Band**				**L-Band**			
Interpretation Element	HH	HV	W	VH	HH	HV	W	VH	HH	HV	W	VH
Forest-non forest boundary	p	p			+		p	+		p		p
Coniferous vs deciduous forest	+	p					p	-	p	-	p	-
Coniferous forest identification	p						p	p	+	+		
Deciduous forest identification	p						+	p	p	p		
Clearcut identification	p	+			+		p	+	p	p	p	p
Regenaration identification	p				p	p	+	p	p			
Stand structure	p						p		+	+		
Biomass estimate	p										+	+
Tree height estimate	p								p	p	-	-
Age estimate									p		p	p
Moisture Conditions									p	+	+	

Interpretation key :

+	=	identification generally possible
p	=	identification possible under certain conditions
-	=	identification very vague or impossible

Nevertheless the above shown table has to be evaluated very carefully. It might suggest that radar remote sensing with imaging radar nowadays is an operational tool for forestry. Especially for forest monitoring in the tropical regions imaging radar systems seem to appear ideal because of their independence of weather and illumination conditions.

But although a lot of research work has been done since 1989, especially after the launch of ERS-1, radar remote sensing has not yet reached this operational status for forestry applications. Only a little number of forestry institutes and administrations have the trained personnel and the necessary 'high-technology' (hard-and software) to utilize imaging radar data for their needs. So the broad transfer of know-how and results from the research stage to the operational application is often very difficult.

5. Summary

The all-weather capabilities and the active sensor technology of imaging radar systems in general bear a great potential for several geoscientific applications, in particular as supplementary information source to optical data. But especially for forestry applications there is a need for more low-cost operational image processing and analysis strategies as well as for more skilled image interpreters who are used to the different appearance and properties of radar images in comparison with optical data.

6. References

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LILLESAND, Th. M. & Kiefer, R.W. (1987): Remote Sensing and Image Interpretation - 3rd ed., New York, Chickester, Brisbane, Toronto, Singapore.

WERLE, D. (1989): Radar Remote Sensing for Application in Forestry - A Literature Review for Investigators and Potential Users of SAR Data in Canada - Ottawa.

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MAP MOSAIKING WITH RASTER DATA

Introduction

The forest cover maps and the forest functions maps have been completed. Because the new Lands Department map series was not available when the project started, all maps used were based on the old topographic map series. During our field work it was noted that the road system shown

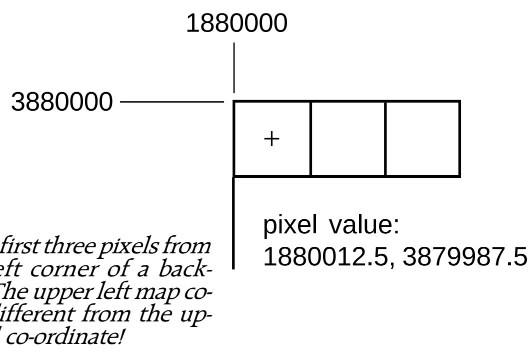

Figure 1. The first three pixels from the upper left corner of a background file. The upper left map co-ordinate is different from the upper left pixel co-ordinate!

in the old maps series was not of practical use. A shift to the new map series was necessary.

Creating empty background files

A dBASE program was written to create files containing a matrix of pixels related to the FMG values of every map sheet. The program got from the typed name of the particular map sheet the starting point of the upper left corner. The number of rows and columns are the same for all maps in the new series, 1600 columns and 1200 rows (one pixel covers 25 x 25 m on the ground, 0.5 x 0.5 mm on the map). The program also takes into account that ERDAS is referring to the centre of the pixel. That means to the upper left corner of the map, the program adds 12.5 m in x-direction and subtracts 12.5 m in y-direction (see Figure 1).

Mosaiking

A special map was produced by Microstation software. This map shows the outline of the island, the old map sheet coverage and the new map sheet coverage (Figure 2). The operator knows which map sheets from the old series falls into the map sheet of the new series.

An ERDAS GISMO program cuts out of the old map sheet files, the parts which fall into the area covered by the new map sheet. The program cuts out of the file containing the map of the old map series all pixels which have a corresponding pixel in the background file of the new map series. A corresponding pixel is a pixel which has a similar FMG value. The program is looking to the value stored for the pixel centre. Because they

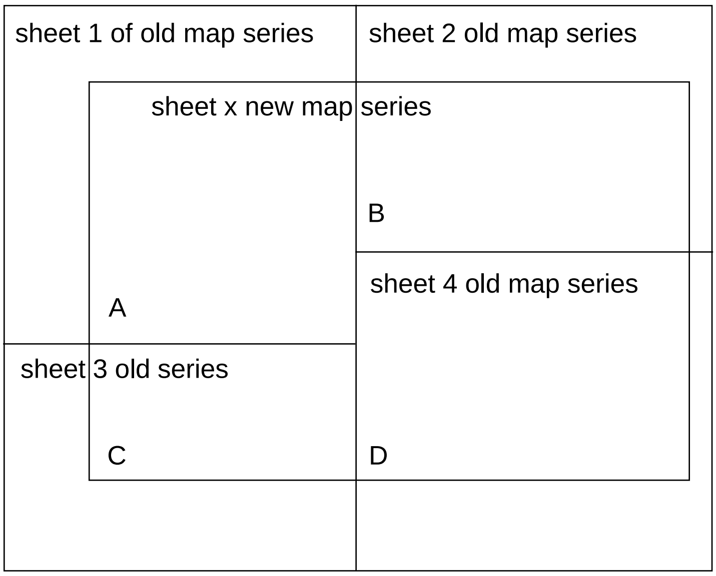

Figure 2. Overlap of map sheets from the old and from the new series. The GISMO program of ERDAS cuts out of the sheets 1, 2, 3 and 4 the parts A, B, C and D which cover the map sheet x of the new map series.

are not absolutely identical the program is looking to the nearest neighbour. The operator has to run GISMO four times and creates four files containing the overlapping parts A, B, C and D. Using the program sub set, the operator copies all these parts into another empty background file.

Some times there is a gap between the files of one or two pixels due to inaccuracy of the co-ordinate transformation program converting geographical co-ordinates to FMG co-ordinates. This was eliminated manually by using the ERDAS program GIS EDIT.

Conclusion

All important information is stored now in files relative to the new map series. The road network was digitised and will be included. The map output is now compatible with the new Lands Department map series. Orientation in the field is easier and the grid is now applicable to all parts of the forest. It is easy to join maps together now because the grid lines are parallel to the map edges.

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