START

NOTES ON REMOTE SENSING TECHNIQUES

By

A M COONEY and P G DAHLHAUS

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GENERAL DESCRIPTION

Remote Sensing is the collective term applied to the family of sophisticated mapping methods which have been developed over the last 20 to 30 years. All these methods use pre-determined ranges of precisely defined bands of the electromagnetic spectrum to map the earth's surface from a distant (or remote) platform such as an aircraft, space shuttle or satellite. Remote sensing has been intimately associated with the USA's space exploration for more than 20 years and is one of the commercially successful "spin-offs" of that program. Numerous anagrams have arisen in association with this new technology and brief explanations of their derivations are given when the terms are first used below.

COMMERCIALLY AVAILABLE PRODUCTS

The most widely known, commercially available products are those generated by the USA's Landsat series of satellites which commenced in 1972 with Erts (Earth Resource Technology Satellite, subsequently renamed Landsat 1); Landsat 5, launched in 1984 is the most recent addition. Landsats 1 to 3 are no longer functioning while Landsat 4 has some problems with its power supply. The French SPOT satellite was launched in 1986 and its products are now commercially available. Within the next few years the European Space Agency, India, Brazil, Canada and Japan will have launched satellites with remote sensing capabilities. In addition, the USA's NOAA satellites (National Oceanic and Atmospheric Administration), although specifically designed for meteorological observations, are sources of valuable data on the earth's surface. Recently, conventional high resolution photography has been put on the market by the USSR - these photographs were taken manually from their orbiting laboratories.

Table 1 is a summary of the current and planned satellite platforms carrying remote sensing instruments. It does not include aircraft borne sensors such as SLAR (side looking airborne radar) which is flown on a contract basis or SIR (shuttle imaging radar) which was recorded from the shuttles and is still in the experimental stage. Landsat was developed by NASA (National Aeronautics and Space Administration) and its products are now being sold by EOSAT (Earth Observation Satellite Company). Similarly, Spot products are sold by SPOT Image. Both Landsat and Spot products are available in Australia through ACRES (Australian Centre for Remote Sensing) - formerly ALS (Australian Landsat Station). As Acres does not currently have the capability of processing Landsat 5 raw data, products from that satellite must be bought through AMIRA (Australian Mineral Industries Research Association).

TABLE 1 **CURRENT AND PLANNED SATELLITE BASED REMOTE SENSING SYSTEMS**

SYSTEM	COUNTRY	PIXEL SIZE	DETAILS
Existing Systems			
LANDSAT 1-3, series originally named ERTS (LANDSATS 1-3 are no longer functioning)	USA	79 m	1 RBV: return-beam vidicon 2 MSS: 4 bands, multispectral scanner
LANDSAT 4, 5	USA	30 m (120 m for thermal emittance band - band 6)	1 MSS: as above 2 TM : 7 bands, thematic mapper - The thematic mapper has higher resolution than earlier MSS products and there are more bands some of which are specifically directed towards geology, e.g. band 7 is sensitive to hydrothermal alteration zones.

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SPOT (Satellite Pour l'Observation de la Terre)	France	10 m - panchromatic mode (P) 20 m - multispectral mode (XS)	MSS: 3 bands recorded on HRV (high resolution visible) instrument gives much better resolution than Landsat MSS and also allows for the production of stereo pairs.
IRIS	India	No details in available literature	
MOS-1 (Marine Observation Satellite)	Japan		MOS-1 is an experimental satellite to assist in the development of Japan's capabilities.
		50 m	1 MSS: 4 bands as with Landsat MSS: MOS-1 instrument is MESSR (multispectral electronic self scanning radiometer).

SYSTEM	COUNTRY	PIXEL SIZE	DETAILS
		0.9 km + 2.7 km	2 Also carries VTIR (visible and thermal infrared radiometer). - Compares to Landsat TM Band 6.
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Planned Systems			
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BRESSEX	Brazil	No details in available literature.	
ERS-1 (ESA Remote Sensing Satellite)	ESA -European Space Agency	?	1 AMI: active microwave instrument
		?	2 SAR: synthetic aperture radar
		30 m	3 SAR: image mode
			4 other instruments specifically to do with ocean features
LANDSAT 6 & 7 *	USA		1 ETM: enhanced thematic mapper
			2 EMSS: emulated MSS
			3 MLA: multi-spectral linear array (in Landsat 7 only)

SYSTEM	COUNTRY	PIXEL SIZE	DETAILS
OMNISTAR	USA		A new generation of platforms to succeed Landsat 5.
RADARSAT	Canada	100 m + 10 m	SAR: synthetic aperture radar

* Preparations for Landsats 8 and 9 are also underway.

DATA AQUISITION AND PROCESSING

In order to understand the cost of remote sensing products, it is important to appreciate the nature of the complex processes involved. Most remote sensing systems use either satellite or aircraft mounted instruments to systematically scan the earth's surface and collect sets of electromagnetic radiation data from discrete, small, sampling areas along the scan traverse; each sampling area becomes a pixel (picture element) on the final image. The standard Landsat scene covers an area of 185 km square on the earth's surface. Pixels on the earlier Landsat images - the MSS or multispectral scanner series - represent sample areas of 79 m square while those from Landsat 5 - the TM or thematic mapper series - represent sample areas of 30 m square; however, the pixel size for the thermal infrared band on Landsat 5 is 120 m. Thus each Landsat MSS image contains 7.6 million pixels and each Landsat TM (apart from the Thermal IR band image) contains 38 million pixels. The panchromatic mode (black and white) French Spot images are compiled from a hugh number of pixels representing sample areas 10 m square (pixels for Spot's multispectral mode represents 20 m square sample areas). Several readings - one for each electromagnetic band width being sampled - are taken at each sampling area - 4 for the Landsat MSS and 7 (or 6 + 1) for the Landsat TM. Thus the amount of information collected for each standard scene is vast.

The "raw" readings are transmitted to receiving stations on earth where they are first of all processed so that they can be stored in a digital form on CCTs (computer compatible tapes). Because of the vast amount of data generated by remote sensing satellites - particularly by the more recent ones - very powerful main frame computers are required to carry out this conversion. The CCTs are then processed through relatively conventional dedicated computer hardware and software to produce images on computer monitors. Hardcopies of selected images can be reproduced, as required, on transparent or opaque photographic materials. The CCTs and hardcopy images are sold as commercial products.

COMPARISON BETWEEN CCTs AND HARDCOPY PRODUCTS

The CCTs are the much more useful products as they contain all the digital information and this can be mathematically manipulated using well established procedures to highlight-or enhance-phenomena such as geological structure. The required dedicated hardware and software can be used to repeatedly analyse the data and generate a wide range of images. They can also be used to process any other digital information stored on magnetic tapes - for example geophysical data.

On the other hand, most commercially available hardcopy products comprise a standardized image for each band width plus a standardized composite image derived from the combination of three selected band widths. Some commercial laboratories carry out the mathematical manipulation of the CCT's in the presence of the customer who can then specify the scenes to be reproduced as hardcopy. However, this operation (and cost) must be repeated each time a different scene is required.

USE OF REMOTE SENSING IN AUSTRALIA

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INDUSAT, an association of users, commissioned Technical and Field Survey Pty Ltd to provide quantitative information on the use of remotely-sensed data in Australia and the following is extracted from the executive summary of the report (May 1986).

Responses to the survey were :- industry (55%), government departments (33%) and universities (12%). Ranges of annual expenditure within these groups is shown in Table 2.

TABLE 2 **DIRECT ANNUAL EXPENDITURE ON REMOTE SENSING**

	TOTAL $	AVERAGE/USER $
Industry	5 342 000 - 6 255 000	45 650
Government	4 814 000 - 4 980 000	63 597
Academic	689 000 - 700 000	25 722
All users	$10 845 000 - 11 935 000	$49 307

The survey estimated the full flow-on to the economy (including use by non respondents) to be between $35 380 000 and $49 330 000.

USE OF REMOTE SENSING BY VICTORIAN GOVERNMENT DEPARTMENTS

The first government organizations to use remote sensing products in Victoria appear to have been the Geological Survey of Victoria (GSV) and the State Rivers and Water Supply Commission (SRWSC). In the early 1970's the GSV was provided with what would now be considered very poor quality hardcopy, black and white Erts imagery to determine its application to the mapping of the State's structural geology. This work was carried out by Bruce Thompson in association with CSIRO scientists. In the early 1980's the GSV purchased the much more sophisticated MSS colour composite coverage of the State - again the hardcopy product. This has been used as an aid to regional mapping as well as being made available to other government bodies, consultants and small mining companies. The most active and original "user" of the technique, however, was the late Don Currey, supervising geologist with the SRWSC, who used hardcopy colour composite images as an aid to geomorphological and hydrological studies. Thus there was recognition of the value of the technique within some Victorian departments for a very long time.

In the late 1970's the Victorian Remote Sensing Committee undertook the task of defining a strategy for the acquisition of a central government facility to analyse CCTs. Such a strategy was formulated in the early 1980's but government funds were not made available and there is little likelihood that such a central facility will now be established. What has happened, however, over the last few years is that the cost of the dedicated hardware and software needed to process the CCTs has dropped markedly and is now within the realm of departmental budgets. For example, the Department of Conservation Forests and Lands (DCFL) has two micro-Brians, one for mapping vegetation types and fire damage, the other for carrying out work for the Land Protection Division while the Melbourne and Metropolitan Board of Works (MMBW) also has a micro-Brian. In addition, the Department of Land Information at RMIT has one of the systems as does the Melbourne University's Department of Surveying. The Country Fire Authority (CFA) has a link with the CSIRO's SLIP DISIMP system at Aspindale.

DIRECT COSTS INVOLVED IN USE OF CCTs

Table 3 shows there are two types of costs involved in the use of CCTs - that of the tapes themselves and that of the processing.

The latter can either be done under contract commercially or "in house" using purchased dedicated hardware and software. Table 3 shows there are 3 levels of such hardware and software. The AMIGA system is by far the cheapest but is considered by some to be more of an educational facility than a truly analytical one. The available medium cost facilities includes the CSIRO's micro-BRIAN (the BRIAN being an anagram for Barrier Reef Image Analysis) and two commercially available forms of another CSIRO development the SLIP DISIMP (Satellite Image Processing; Device Independent Software for Image Processing). Micro-BRIAN is apparently more "use friendly" than SLIP DISIMP but the latter has the much more powerful hardware and software. It also can accommodate 3 or so work stations at the same time whereas micro-BRIAN has only the one work station capability. The I^2S (Imaging Information System) is an expensive but highly capable system and is the one used by BHP at Camberwell.

Little information is to hand at the moment with regard to outside processing. The NSCA (National Safety Council of Australia) has facilities at Traralgon.

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	Outside Processing	
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	In House Processing	
$ 90 540	1 AMIGA 2 000 Microcomputer + CSIRO software $4 900 + Vax facility to read CCTs	$ 95 440 for all bands

Cost of CCTs	Costs of Processing Options	Total Costs
$90 540	2 Micro-Brian SLIP DISIMP (sold as:- ARLUNYA or QUENTRON) $80 000 to $100 000	$170 540 to $190 540 **for all bands**
$90 540	3 I^2S $500 000	$590 540 **for all bands**

Additional costs would be incurred in having photographic quality hardcopy images produced, if required. Staff training would also be advisable; the Department of Land Information, RMIT is running a two semester course in 1988 - cost approximately $670, this could be an efficient way of gaining knowledge on the processing of remote sensing data.

CONCLUSIONS AND RECOMMENDATIONS

Remote Sensing is a highly developed technique which uses various parts of the electromagnetic radiation spectrum as a means of mapping an area's geology. Over the years, it has developed and is now capable of much higher resolution (down to 10 m compared to the earlier 80 m) while the available electromagnetic bands are now more valuable in revealing certain aspects - or themes - of the geology, eg hydrothermal alteration zones. This development is ongoing and it can be anticipated that the capabilities of the technique will be enhanced. To get the full benefit of the technique it is necessary to manipulate data on the CCTs using dedicated Computer hardware and software. This facility also allows processing of other forms of digital data.

The process has value in conjunction with the more traditional geological, geophysical and geochemical methods. It is, however, of particular value in areas where access is prevented or severely limited either because of logistics or, and this is now the more common, because of planning restrictions. With regard to this latter point it should be noted that some 10% of the State is now classified as national or State park, flora and fauna reserve, wilderness area etc and as such unavailable for, or severely restricted from, exploration.

It is recommended therefore, the DITR avail itself of the technique, as a number of other government organizations have, and purchase a system or at least carry out evaluation tests on a selected area. With this in mind, it is recommended that the Mallee and adjacent areas be used for a test study.

CONTACTS

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Peter Woodgate, DCFL, 6511 049: for information on local groups. (Melb.)

Others not consulted but with relevant information are:-

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