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OBSERVATIONS ON INTERPRETATION OF DATA FROM THE EARTH RESOURCES TECHNOLOGY SATELLITE - ERTS 1

Report on overseas visit to the U.S.A.,
Canada and U.K. 27 September-5 December, 1972

by

C.J. Simpson

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ILLUSTRATION

SUMMARY

The U.S.A., Canada and U.K. were visited to gain experience in the interpretation of data from the first Earth Resources Technology Satellite (ERTS-1) which was launched 23 July, 1972.

Despite the initial slow dissemination of imagery some investigators have demonstrated that the satellite data can provide new information to some disciplines.

Only the U.S.A. and Canada have the capability of directly receiving data from the satellite. Other nations receive data via the U.S.A. The potential benefits to Australia of ERTS-1 data should be evaluated within the next 12 months and this information will be used by the authorities in deciding whether the installation of special satellite tracking/receiving facilities in this country is warranted.

The Skylab EREP Principal Investigators' Conference at Houston was attended on behalf of Dr N.H. Fisher, the Principal Investigator for Australian EREP proposals, and as a result recommendations for modifications to the original proposals were made.

INTRODUCTION

The primary purposes of the visit were to gain experience in the interpretation of data from the Earth Resources Technology Satellite (ERTS) and to compare the satellite data acquisition and remote sensing systems of the U.S.A., Canada, and U.K.

Whilst in the U.S.A. the Skylab Earth Resources Experiment Package (EREP) Principal Investigators' Conference was attended on behalf of Dr N.H. Fisher, Principal Investigator for the Australian Skylab EREP proposals.

The following centres were visited:

NASA Goddard Space Flight Centre - Maryland, USA - Conference 'Preliminary Findings from analysis of ERTS observations'.

NASA Manned Spacecraft Centre (now Lyndon B. Johnson Space Centre), - Houston, Texas, USA - 'Skylab EREP Principal Investigators' Conference'.

Ann Arbor - Michigan, USA - Conference 'Eighth International Symposium on Remote Sensing of the Environment'.

United States Geological Survey - Offices in Denver, Colorado, and Washington, DC

Earth Resources Observation Satellite Program - Offices in Washington, DC, and Sioux Falls, South Dakota, USA.

Colorado School of Mines - Golden, Colorado, USA.

Canada Centre for Remote Sensing - Facilities at Ottawa and Prince Albert, Canada.

Geological Survey of Canada - Ottawa, Canada.

Space Engineering Division Systems Ltd - Saskatoon, Canada.

Institute of Geological Sciences - London, England.

Bedford College, London University - London, England.

Natural Environment Research Council - London, England.

Department of Geology, Imperial College of Science and Technology - London, England.

EARTH RESOURCES TECHNOLOGY SATELLITE

The first experimental ERTS (ERTS 1) was placed in orbit 915 km above the earth by the US National Aeronautics and Space Administration (NASA) on 23rd July, 1972. On-board instrumentation has the capability of creating electronic images of any part of the earth's surface between latitudes 81°N and 81°S (imagery types are given in the Appendix). In clear weather the entire earth could be completely imaged every 18 days. Image data are telemetered to ground-based receiving stations and recorded on magnetic tape for processing to photographic products. When the satellite is out of range of USA or Canadian-based receiving stations image data are stored on on-board magnetic tape which is read out when the satellite is in range of the ground stations. The ERTS 1 has a designed life of 12 months.

Nationally approved researchers (Principal Investigators) are currently evaluating the ERTS 1 imagery to assist NASA in deciding whether subsequent experimental or operational earth resources satellites can be justified.

Systems Problems

The main operational problem to date has been a tape recorder malfunction, resulting in the Return Beam Vidicon (RBV) cameras being switched off. NASA has embarked on a program which is aimed at obtaining a complete world coverage of imagery from the 4-channel Multispectral Scanner (MSS). When this program is completed, or nearing completion, attempts may be made to turn the RBV system on again.

Both the USA and Canadian satellite centres are having instrument problems in converting the tape-recorded image data into photographic products. This has resulted in slow supply of imagery to investigators. Present operational problems are expected to be resolved within the next few months. Despite problems, some imagery has been produced to pre-flight prediction standards.

Some of the effects of NASA instrument problems are: dark blooming around black elements of the grey scale; MSS band 7 has a slightly smaller format than other bands; the 70 mm negatives of bright scenes are generally too dark to allow rapid reproduction; 'Newtonian' type banding on some negatives.

ERTS DATA INTERPRETATION TECHNIQUES

Because of the initial slow supply of imagery only a few of the investigators interviewed had received imagery, and none were really familiar with the practical problems of ERTS imagery interpretation.

Several items of equipment are being manufactured commercially to assist with interpretation of ERTS imagery. At this stage it appears that most investigators will be employing conventional photo-interpretation techniques. Whether they purchase equipment to assist their interpretation will depend on the results of their preliminary examinations.

The US investigators can be divided into two groups: those evaluating ERTS data directly from computer-compatible tape (CCT) and those evaluating NASA-processed imagery. The former are university or commercial research groups. Computer programs to convert CCT data to television display can be obtained from Dr D. Landgrebe, Laboratory for Applications of Remote Sensing, Purdue University, West Lafayette, INDIANA, 47907, USA.

Most investigators will be evaluating NASA-produced imagery. Techniques being employed to assist evaluation are mainly aimed at producing good quality enlargements of the 70 mm format positive images with pre-existing projection equipment such as: conventional 70 mm projector, Multiplex photogrammetric plotter, microfiche viewer (e.g. the 3M 'Model 400' will accept 70 mm chips), and military interpretation aids such as 'Richards VF 550 M' back projection table. Overhead projection equipment can be used for enlargement of 240 mm format transparencies.

For rapid photographic enlargements/printing of ERTS imagery Quick Copy Cameras (manufactured by Mitchell Camera Corp.) are widely used. These polaroid, fixed focus cameras can be obtained for a variety of enlargements e.g. 1:1, 1:3.16, 1:4, 1:7.

The technique of multiple projection and colour reconstitution of the various ERTS image bands may provide useful data for the interpreter. Colour reconstitution can be obtained by using three projectors, but it is best achieved by using a commercially manufactured colour additive viewer. True colour reconstitution cannot be achieved with the MSS imagery because of the absence of the blue part of the spectrum but false colour displays simulating false colour infrared photography can be produced, and these are very useful in vegetation studies.

In general, colour additive viewers are not of great value for basic regional interpretation but may assist the interpreter in making decisions on specific problems.

ERTS colour reproductions, either prints or transparencies, have less detail than the separate waveband products they are generated from.

Interpretation Results

It appears that for many disciplines, examination and comparison of two of the four bands of imagery will provide most of the useful data that can be extracted from the imagery. In some cases one particular band may suffice. Selection of the optimum band or bands will generally have to be determined by trial. Some investigators claim that projection of a single band through a colour filter will produce enhancement of particular features. Some of the findings to date are discussed below.

Geology

Results to date are demonstrating that the satellite regional overview does allow identification of previously unrecognized geological features. In both the USA and Canada several previously unidentified major faults and fractures have been recognized on ERTS imagery. Large linear and circular features are normally the easiest to identify. Some investigators have been able to identify more geological information on ERTS images than is shown on published maps. Previously unidentified palaeodrainage and glacial features have been discovered.

Cartography

For cartographic purposes the RBV imagery has better geometric fidelity than that produced by the MSS. Of the three RBV cameras RBV Band 2 has the highest geometric fidelity.

The MSS has better resolution than the RBV and after scene correction (precision processing) has an internal accuracy ground scale of approximately 50 m. Scene correction does degrade the resolution.

Experimental orthophoto image maps at 1:1 000 000 scale have been produced directly from the imagery and comply with USA National Map Accuracy Standards.

Imagery can be readily enlarged and at 1:250 000 scale it is suitable for updating of line maps. The amount of useful updating that can be carried out depends on the resolution, which is very difficult to define for scanners. In maximum contrast conditions, linear features (such as roads) of 10 m width have been identified.

Forestry and Agriculture

In Canadian natural forests some different tree species and logging patterns are being recognized. Colour composites of RBV Bands 2 and 3 or MSS Bands 5 and 6 are the most useful for this. Fireburn areas are readily identifiable and areal damage can therefore be rapidly assessed.

Research into computerized interpretation techniques is being concentrated on identification and areal measurement of certain vegetation species. The techniques are normally based on pattern recognition by textural and spatial variations. Promising results have been obtained on MSS imagery (the RBV data are not suitable for analyses involving brightness evaluation). Fields as small as 8 ha (20 acres) have been identified. Colour additive viewing techniques are proving very useful for differentiation of some plant species.

Oceanography

Some bottom features down to 20 m depth have been identified and suspended sediment has been recognized. The ability to detect suspended silt can be enhanced by projecting MSS Band 4 through a single filter. Circulation features in water appear more clearly in colour reconstitutions of Bands 4, 5, and 6 than in the separate bands. Band 7 appears to have no water penetration and with the increased penetration capabilities of Bands 6, 5, and 4 (in that order) some idea of the depth of suspended sediment, reefs and shallow bottom features can be obtained.

Fisheries

Regions of clear and silty water have been differentiated, and this difference has significance because of the association of certain fish schools with clear water. The 18 day satellite cycle does not permit continual tracking of water features, but monitoring over a period of time is expected to provide more accurate current circulation data than are now available to fisheries.

Surface Hydrology

Water bodies as small as 100 m across have been identified. Changes in surface area of larger water bodies can be monitored with sequential coverage. Snow areas can be identified, and comparison of MSS Band 5 with 7 gives a good assessment of snow and snow melt conditions. Band 7 is superior for interpretation of ice flow conditions. The identification of meltwater conditions on ice is made easier by studying the colour reconstitution of Bands 5 and 7.

INTERPRETER TRAINING

The successful launch of ERTS 1 has stimulated considerable interest in remote sensing within the USA. Many Federal and State Government agencies are taking advantage of this to conduct extensive public relations campaigns to encourage the use of remotely sensed data in all relevant sectors of industry and the community.

A major problem facing the USA and Canada is the lack of skilled photo-interpreters for both efficient interpretation of imagery and instruction of users in interpretation techniques. In both these countries government agencies are conducting training programs in the use of remotely sensed data. Training is not restricted to the interpretation of satellite imagery but includes all aspects of aerial photography and remote sensor imagery. This is because in most disciplines aircraft-acquired imagery (principally aerial photographs) will remain as the main interface between the satellite imagery and ground investigation.

With the predictable increase in the use of remotely sensed data (from both aircraft and spacecraft) in Australia, a similar problem can be expected to develop, though to a lesser extent than in the USA and Canada.

ERTS DATA RECEIVING FACILITIES

The acquisition of imagery and its quality over regions outside the USA and Canada is dependent on the performance of the tape recorders in the satellite. Any country with the necessary receiving facilities has the potential to receive ERTS data by direct readout irrespective of the condition of the tape recorders. (Future operational satellites may be direct readout and may not have on-board tape recorders.)

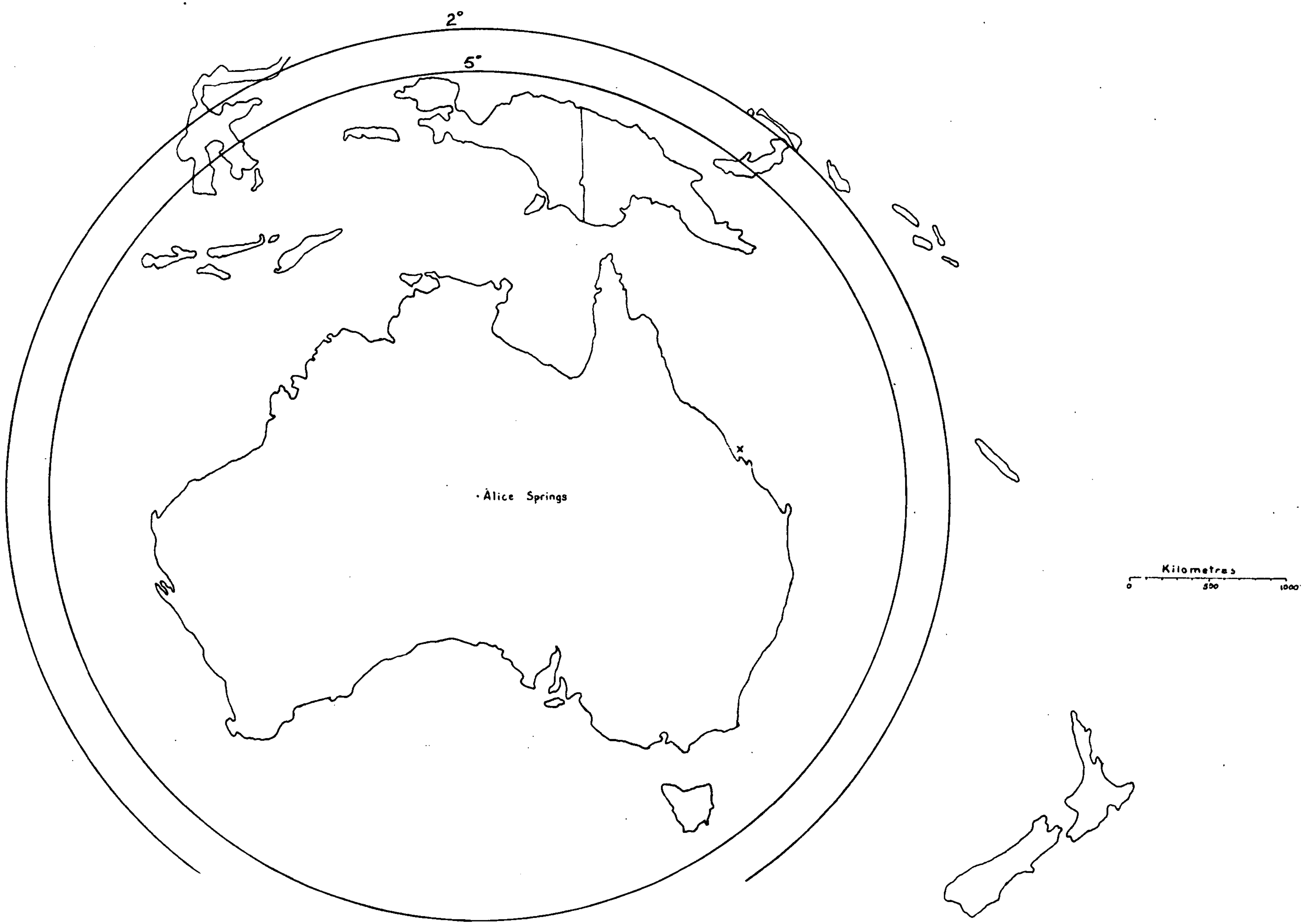
The potential value of ERTS data to Australia should be evaluated within the next 12 months. The evaluation for particular disciplines would probably be best undertaken by ACERTS. If the findings are considered to justify the installation of Australian ERTS data receiving facilities, action should be taken to ensure such facilities are available if an operational ERTS type satellite (rather than the present experimental type) is launched.

Justification for installation of Australian receiving facilities will be mainly dependent on the value of ERTS to those disciplines that can take advantage of repetitive imagery e.g. forestry, agriculture, environmental management, etc.

The time necessary to install new tracking facilities is in the order of 12 months. In addition it may be necessary to allow extra time for calling of overseas tenders.

NASA will attempt to give early notification of their intention to launch an operational ERTS type satellite.

To accompany Record 1973/90



GROUND RECEIVING STATION COVERAGE

Fig. 1

AUS 2/239

Existing space tracking stations in Australia could (subject to approval) be modified to receive ERTS data but because of their locations it would probably be necessary to modify two stations to receive complete Australian coverage. It would cost about as much to install one new well positioned station as to modify two existing ones.

Some idea of the potential receiving range of a tracking facility located at Alice Springs is shown in Figure 1. This shows possible receiving ranges for elevations of 2^{o} and 5^{o}. Range/elevation plots are after Grant & Barrington (1972)*. A conservative estimate would limit the coverage to elevation angles greater than 5^{o}. The Canadian ERTS receiving facility at Prince Albert, Saskatchewan, is receiving satellite data signals of acceptable quality to 0^{o} elevation. A station located at Bourke, NSW and operating to 0^{o} elevation would probably give total coverage of Australia, New Zealand, and Papua New Guinea. The map of Figure 1, taken from a Zenithal Equidistant projection, is based on Broad Sound, Qld, and distances from any other point are not precise.

Another factor in favour of establishing a new receiving facility (if justified) rather than modification of existing stations is that the downlink transmission of all data from ERTS 1 (and planned ERTS 'B') uses the 'S' radio band. The downlink is currently transmitting at a data rate which is near the limit of the 'S' band capability and which will be too low for the transmission band of an operational earth resources satellite. NASA is currently investigating the selection of a new transmission band, and the results of its findings should be available in mid-1973. If an operational satellite is launched then most existing ERTS tracking facilities will have to be modified to receive the new transmission band. This modification expense would not apply to a new station build specifically for an operational earth resources satellite.

The Canada Centre for Remote Sensing established an ERTS tracking station by converting an existing radar research laboratory. The 1972 cost of modification was A$650,000. At that time the cost of building a new receiving facility was estimated at A$1,000,000. The cost to Canada of equipment to convert received ERTS data to image products was in the order of A$4,000,000.

Brazil has recently let a contract (based on the Canadian system) for the construction of ERTS data receiving and processing facilities. The cost to Brazil for the receiving facilities (including wages and installation expenses) will be less than A$850,000. Data processing facilities will cost less than A$4,000,000.

Current indications are that existing ERTS data processing facilities in both Canada and the USA would be available to process Australian acquired data if processing facilities were not initially installed at the same time as receiving facilities.

* GRANT, H.A., & BARRINGTON, R.E., 1972 - Low cost ERTS receiving station. Paper presented at XIA RASSEGNA INTERNAZIONALE ELETTRONICA NUCLEARE ED AEROSPAZIALE - Rome.

FUTURE EARTH RESOURCES SATELLITES

ERTS 'B', another experimental satellite identical with ERTS 1, is scheduled for launch in November, 1973, but if the data signal quality from ERTS 1 remains satisfactory the launch date will be delayed. The present NASA processing facilities could not handle the quantity of data generated by two satellites.

Current NASA plans are that ERTS 'B' will be followed by ERTS 'C' and possibly 'D'. These satellites may have different on-board instrumentation from the ERTS 1 and will still be classified as experimental.

A total assessment of the value of earth resources satellites will be made by NASA. If it is decided that the USA should launch an operational earth resources satellite it will be administered by the US Department of Interior rather than NASA. Generally speaking both USA and Canadian ERTS data users are very enthusiastic at the results obtained to date; and most are optimistic that an operational earth resources satellite will be in orbit in the late 1970s.

SKYLAB EREP PRINCIPAL INVESTIGATORS' CONFERENCE

'Skylab', the first orbiting manned laboratory, is scheduled for launch in May 1973.

The first Skylab EREP Principal Investigators' Conference at Houston, Texas (10-13 October, 1972) was attended on behalf of Dr N.H. Fisher, Principal Investigator for the Australian Skylab EREP proposals.

Attendance at the conference proved very worthwhile since it provided a better understanding of NASA's requirements for EREP investigators. As a result of discussions with NASA representatives recommendations were made for alteration to the original Australian proposals.

The Australian proposal as it now stands requests S190A and S190B photographic coverage of Mt Isa test area - first priority, Kalgoorlie, Alice Springs, and Canberra test areas - second priority. Continuous photographic coverage along that part of orbit 41 which extends from Cobourg Peninsula (NT) to Taree (NSW) has been requested.

Original requests for data from S191 (IR spectrometer) and S192 (Multispectral scanner) have been withdrawn.

BRITISH APPROACH TO REMOTE SENSING

Earth resources satellite research

Britain is a member of the European Space Research Organization (ESRO), an international body composed mainly of Common Market countries. ESRO is attempting to maintain a European space program independent of the USA. The long-term aim of the program is to launch an earth resources satellite specifically designed for European national requirements and environmental conditions. British Principal Investigators will be evaluating ERTS imagery but because of the climatic problems (e.g., high incidence of cloud cover over parts of Europe) the present ERTS is not expected to be of such value to Britain and Europe as it is to countries in drier climatic regions. In 1974 ESRO is initiating a three year program of aircraft remote sensing to test and develop instrumentation suitable for their Europe oriented satellite.

Remote sensing research

The British Department of Trade and Industry is attempting to maintain a current listing of all UK groups and individuals engaged in remote sensing activities. It also provides some funds for research into remote sensing techniques and it was through such funding that the project of geobotanical remote sensing by Bedford College (London University) commenced during 1971 in the Mount Isa-Cloncurry area Qld. The results of this three year research program are due for public release in 1973.

Other government departments have some involvement in remote sensing. Various component establishments of the Natural Environment Research Council conduct investigations into remote sensing techniques for specific disciplines.

APPENDIX :- ERTS Imagery

The spectral bands sensed by the satellite instruments are as follows:

Instrument	Band code	Wavelength (micrometres)	Spectral colour
RBV	1	.475 - .575	blue/green
RBV	2	.580 - .680	red
RBV	3	.690 - .830	infrared
MSS	4	.5 - .6	green
MSS	5	.6 - .7	red
MSS	6	.7 - .8	infrared
MSS	7	.8 - 1.1	infrared

Image scenes are available on a 70 mm format (positive or negative) at 1:3 369 000 scale or 240 mm format (positive or negative) at 1:1 000 000 scale.