ALCORSS

ACTIVITIES REPORT 1979-1990

FOREWORD

The Australian remote sensing community is diverse, covering users, consultants, researchers, hardware developers and educators in industry, government and academe. Various committees coordinate the communities broad range of activities.

The principal advisory body is the Australian Liaison Committee on Remote Sensing by Satellite (ALCORSS) which was established by the Australian Government in 1980, initially to advise on the operation of the Australian Landsat Station (ALS) - now known as the Australian Centre for Remote Sensing (ACRES).

The first interim meeting was held in March 1979. Prior to this meeting, satellite remote sensing matters were considered at the Commonwealth level by the Australian Committee for Earth Resources Technology Satellites (ACERTS). This committee, formed in 1971, was an informal gathering of representatives of interested Commonwealth Departments.

ACERTS has continued under the name of the Commonwealth User Committee on Remote Sensing (CUCRS).

ALCORSS now provides a forum for consultation, liaison, cooperation and exchange and to promote the efficient and effective use of remote sensing in Australia.

Earth resource monitoring from space began in earnest in 1972, with the American National Aeronautics and Space Administration (NASA) Earth Resource Series of satellites (LANDSAT).

The vast potential of satellite data was progressively realised and is now widely used, particularly in mineral exploration and in the monitoring of national resources. Australia has had its own satellite data receiving, processing and distribution facilities for earth resources data since 1979.

The recently completed upgrade of these facilities will further enhance the range of satellite data to be acquired.

With the continual evolution of technology resulting in new processing techniques, new satellites and sensors, the remote sensing community can look forward to an exciting future with ALCORSS providing an effective forum for the stimulation and nurture of remote sensing in Australia.

Grahame Lindsay
Chairman, ALCORSS

ROLE AND COMPOSITION OF ALCORSS

Advisory Role

The role of ALCORSS is to provide a forum in which all sectors of the Australian community with an involvement or interest in remote sensing can engage in consultation, coordination and liaison at a senior level with a view to :

> providing advice to Government on the development and implementation of a national remote sensing strategy and the provision of facilities and services to support that strategy;
>
> ensuring the effective utilisation of remote sensing technology in Australia for the benefit of the nation.

Membership

The membership of ALCORSS comprises representatives from each State, the Commonwealth, private industry and tertiary education.

The State representatives on ALCORSS are appointed by Ministers designated under a Prime Minister to Premiers' agreement. They initially coordinate remote sensing issues through local committees.

The Commonwealth user Departments are represented by a member of the Commonwealth User Committee on Remote Sensing (CUCRS).

The CSIRO is also represented on ALCORSS. Twelve Divisions of CSIRO are engaged in research involving remote sensing, and scientific advice is provided to the Committee through representation by the Head of the CSIRO Office of Space Science and Applications (COSSA).

Private industry is represented by the Chairman of INDUSAT, an association which draws its membership predominantly from mining and exploration interests, but which also maintains formal liaison arrangements with the Australian Association of Aerospace Industries (AAAI).

Universities and Colleges of Advanced Education/Institutes of Technology have separate representation on ALCORSS. The University representative is appointed by the Australian Vice Chancellors Committee (AVCC) and the Colleges/Institutes representative by the Australian Committee of Directors and Principals in Advanced Education (ACDP).

Specialist groups such as the various technical sub-committees of Standing Councils (e.g. the Agricultural Remote Sensing Committee of the Standing Council on Agriculture) are invited on a regular basis to present their views to the Technical Sessions of ALCORSS for consideration by the Committee in Plenary Session.

Effectiveness

Because ALCORSS provides representation from remote sensing data users, researchers, consultants, data processors and educators, it has been instrumental in propagating the use of the technology into practical areas of benefit, in defining the data requirements and products best suited to the users needs, and in establishing the training necessary to support the rapidly expanding remote sensing industry.

From the handful of users, principally engaged in research, which existed prior to the establishment of the Australian LANDSAT Station in 1980, there are now several hundred people employed full-time and several thousand employed part-time in the industry.

Applications have expanded from the few research projects in geology, agriculture and mapping to some hundreds of operational uses in geology, agriculture, mapping, environmental monitoring, disaster monitoring and mitigation, rangelands management, hydrology, shallow water studies in coastal zones and the Great Barrier Reef, engineering planning (e.g. road, railway, pipeline and power line location, location of building materials, dam site selection, etc.), and the detection of illicit crops.

Fifty-five tertiary institutions now offer training ranging from short courses, through inclusion in most earth based sciences degree courses, to masters and post-graduate diploma programmes and post-graduate research resulting in doctoral degrees.

Major Achievements

Through ALCORSS, a decentralised network of ACRES Remote Sensing Reference and Distribution Centres has been established in various universities and other centres of remote sensing expertise. These are self-supporting from the point of view of Commonwealth funding and provide a valuable source of advice, especially to newly emerging users, on the suitability of remote sensing to meet their particular needs.

The 1982 ALCORSS report Earth Resources Satellites - Current Australian Activities and Future User Requirements is still a benchmark publication in defining the extent of remote sensing activities in Australia and their benefits to the nation. It has been used as a model by a number of countries, including Brazil and New Zealand, to justify the establishment or upgrading of their remote sensing facilities.

ALCORSS has been active in promoting Australian expertise in remote sensing in the south east Asian and Pacific regions.

Through ALCORSS, Announcements of Opportunity to participate in the evaluation phases of remote sensing satellite programmes of other countries have been widely publicised and responses encouraged. The most notable success was the acceptance of seven Australian proposals by the French space agency, CNES, for evaluation of SPOT data. This was the greatest number accepted from any country other than France. Other initiatives are in hand for participation with the European, Japan and Indian programmes.

ALCORSS members provided a great deal of evidence to the Australian Academy of Technological Sciences inquiry on space science and technology for Australia which undoubtedly influenced the Academy to recommend in their report, A Space Policy for Australia, that :

> the major thrust of Australian space activities should be in the remote sensing sector; and
>
> the Government should ensure a continuing Australian capability to receive the latest types of earth-observation satellite data, and in particular, should allocate funds at the earliest opportunity for the upgrading of the Australian LANDSAT Station.

Modus Operandi

The Commonwealth Government, through the Australian Surveying and Land Information Group (AUSLIG), Department of Administrative Services, provides secretariat and support services for ALCORSS.

The Committee has endeavoured to meet twice yearly, however there have been circumstances occurring in some years which have prevented this from happening.
Since the first meeting held on the 4 June 1980, ALCORSS has met in plenary session on seventeen occasions. Members in all instances have met their own cost of participation. Meetings have been conducted in formal plenary sessions and occasionally in complementary Technical Sessions to consider developments in the remote sensing industry.

ALCORSS invites the views from other interested parties and, as a liaison body, welcomes matters of mutual interest for discussion and dissemination.

Conclusion

The comprehensive representation of the remote sensing user community on ALCORSS provides a mechanism which is particularly effective as demonstrated by its performance over the nine years of its existence.

ALCORSS provides an important source of advice to the Commonwealth on remote sensing needs and activities, assists in liaison and co-operation within the user community, and provides expert advice to other bodies where remote sensing can be an adjunct to their central objectives.

MEMBERS REPORTS

Introduction

The Commonwealth Government, State Governments, universities and research organisations have all developed remote sensing facilities. The government centres, although primarily established to service the public sector, also include substantial commercial components.

A number of airborne and ground reception developments have already been taken up by private industry. The developments have in turn spawned specialised image processing systems such as the fast delivery processor for ERS-1 data and the CSIDA system for NOAA data.

A number of image analysis systems, for example microBrian, DISIMP, ER Mapper and A-Image, are developed and marketed in Australia. Australia is also a leading supplier of ground-based remote recorders and data loggers.

The following sections summarise the remote sensing activities of the members of ALCORSS.

COMMONWEALTH

The Commonwealth Government's involvement in remote sensing includes directing research and funding for equipment and applications, the supply of data products and the utilisation of data in the following various Departments and agencies.

Department of Industry, Technology and Commerce

The Australian Space Office (ASO), under the guidance of the Australian Space Board (ASB), has the responsibility of implementing a national space policy and to focus space activities on the generation of significant economic benefits. The Board's Annual Report announced that :

> the major thrust of space activities should be in the remote sensing sector involving both hardware and software;
>
> Australia should build on its expertise in reception, image processing and analysis of remotely sensed data with the objectives of :
>
>> establishing remote sensing expertise
>>
>> developing Australia as a remote sensing regional centre.

A remote sensing Working Party of the ASB prepared a National Remote Sensing Industry Strategy and Action Plan in 1989 after an extensive consultative process with the various sector interests. This Plan made a number of recommendations aimed at the establishment and growth of a commercially viable industry while recognising that the principle benefits of remote sensing relate to the long term environmental and national estate issues.

In 1990, the ASO published an Australian Space Industry Development and Strategy and actions outlined in the Remote Sensing sub-programme are now being implemented. The Working Party has been succeeded by a Remote Sensing Committee which provides advice to the ASB.

Department of Administrative Services

The Australian Surveying and Land Information Group (AUSLIG) is the Federal Government's primary agency for surveying, geodesy and mapping. Its mandate covers the collection and distribution of land information including remotely sensed data. As part of these responsibilities, AUSLIG manages the Australian Centre for Remote Sensing (ACRES), the national receiving and distribution facility for earth resources data sensed by satellite, and also provides the Chairman and Secretariat for ALCORSS. ACRES services are provided by contract with Australian industry.

ACRES also provides an application bureau service to Commonwealth and other clients on a fee-for-service basis, specialising in applied use of earth resources satellite data.

Data are received at the ACRES antennae at Alice Springs from the following satellites and processed at Canberra :

LANDSAT (United States)

System Probatoire d'Observation de la Terre (SPOT - France)

National Oceanic and Atmospheric Research Administration (NOAA - United States)

Marine Observation Satellite (MOS - Japan)

A major upgrade being undertaken by British Aerospace, Australia, under contract to DITAC, will enable the reception and processing of data from the European Space Agency (ERS) satellite due for launch in 1991.

About $23 million of Commonwealth Government funding has been provided over the last several years to ensure that ACRES is equipped to provide high quality data to Australian users.

ACRES participates and has hosted international meetings of ground station operators and satellite owners, which exchange information and develop standards for data exchange and product specifications. AUSLIG provides Australian representation for the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) Regional Remote Sensing Programme which facilitates the transfer of this technology to the Asia and South Pacific region.

Department of Primary Industries and Energy

Remotely sensed data are utilised in the following areas :

> the Bureau of Mineral Resources (BMR) maintains its own digital image processing centre and applies satellite data in support of onshore and offshore geoscience research

> the Bureau of Rural Resources (BRR) has image processing facilities and uses satellite data in resource assessment and land degradation investigations

> the National Resource Information Centre (NRIC) maintains an image processing capability for processing of satellite data during analysis of natural resources databases.

> Department of the Arts, Sport, the Environment, Tourism and Territories

> The Australian National Parks and Wildlife Service applies remote sensing in the management of national parks.

> The Antarctic Division uses remotely sensed maps for operations and planning.

> The Bureau of Meteorology maintains meteorological satellite (NOAA and GMS) tracking and data reception facilities at several sites around Australia. It also uses digital image processing equipment in support of research and development and applications programmes.

Department of Defence

The Department of Defence utilises remote sensing for shallow water mapping and hydrographic surveying, image analysis for planning and exercises, and for facilities planning and management.

The Defence Science and Technology Organisation (DSTO) maintains a digital image processing capability and carries out research for development of operational remote sensing technology for defence purposes.

The Australian Defence Force Academy (ADFA) conducts remote sensing research and training under the auspices of the University of New South Wales.

CSIRO

The Commonwealth Scientific and Industrial Research Organisation of Australia (CSIRO) has long been both a user and a developer of remote sensing techniques, technology and related research. Many of the results of CSIRO remote sensing operations have been successfully developed as commercial activities, under licensing, or joint ventures, or other

arrangements, with the private sector. CSIRO regional laboratories work in close cooperation with State government organisations, universities and local industry, to develop local applications, education, and technology- development centres working on scientific opportunities and problems of common interest. CSIRO's charter encompasses international scientific cooperation and this aspect is particularly evident in the inherently international earth observation area.
The following report highlights significant achievements in remote sensing during the past decade.

Satellite data Reception

Accessing LANDSAT TM data

In 1990, CSIRO combined with the then Department of Resources and Energy to provide an experimental modification of the Australian LANDSAT Station, now Australian Centre for Remote Sensing, ACRES), facility at Alice Springs so that it could receive LANDSAT Thematic Mapper (TM) data for a group of experimenters, including representatives of Australian extractive industries. These data were distributed successfully by the Australian Mining Industry Research Association (AMIRA).

The experiment has yielded a set of inexpensive, flexible systems for the processing and storing of large digital images, and has provided significant experience in the design of resources satellite ground stations and in the utilisation of advanced remotely sensed data. Features of the experimental system included :

- a LANDSAT TM data decoder
- a real-time moving window display for TM data
- a quick-look product generator for TM data
- an intelligent file server for image processing background
- an interactive, digital image display system.

LANDSAT operations and continuity

At the time of a threatened LANDSAT shutdown in early 1989, CSIRO prepared a media release and voiced concern at the vulnerability of the Australian remote sensing marker to arbitrary decisions made overseas. Ultimately, only Australian participation in the earth observation space segment will reduce this vulnerability. CSIRO has continued informal discussion with Hughes Aircraft and NASA in relation to our R & D based interest in the development operation of the SeaWIFS (Sea Wide Field of View Sensor) instrument tentatively proposed for later LANDSATs.

Satellite Ground Stations

Three Divisions of CSIRO established reception and processing systems to satisfy their research needs for data from environmental/meteorological satellites. These systems are used primarily to receive data from the Advanced Very High Resolution Radiometer (AVHRR) on the US NOAA satellites, but they can also access information from the Japanese GMS meteorological spacecraft, and one was used to receive data from the Coastal Zone Colour Scanner (CZCS) on Nimbus.

One of the satellite data acquisition systems developed by the CSIRO is now being manufactured and marketed under the name SAT-TRAC by Melbourne company PCM Electronics Pty Ltd following a development period involving close collaboration between the company, CSIRO and the Bureau of Meteorology.

SAT-TRAC systems have been sold to the Bureau of Meteorology to form the hardware basis for the operational AVHRR and TIROS Operational Vertical Sounder (TOVS) system utilised for the Bureau's weather forecasting and climate monitoring responsibilities. Regional consortia in Townsville (the North east Australian Satellite Imagery System) and in Perth (the Western Australian Satellite Technology and Applications Consortium) also exploit CSIRO-derived PCM hardware to meet their NOAA reception needs. CSIRO is a member of both regional consortia. The SAT-TRAC system is marketed internationally.
MOS-1

In June 1987, CSIRO signed an agreement with Japan's Science and Technology Agency (STA) and National Space Agency (NASDA) under which Australian and Japanese scientists will use data from Japan's Marine Observation Satellite (MOS-1), launched in February of that year. This important space research and development agreement has boosted Australia's expertise in remote sensing and other space technologies. Outside of Japan, MOS-1 data is being directly received in only Thailand, Australia, Antarctica, and by the European Space Agency. The Australian Centre for Remote Sensing's satellite ground station at Alice Springs was modified to receive MOS-l data. This work was successfully conducted by Australian industry, tertiary education institutions and CSIRO, with partial financial support from the Department of Industry, Technology and Commerce and with the cooperation of the Department of Administrative Services.

On 5 March 1989, CSIRO and NASDA signed agreements for an extension of data reception, and for sales of data (probably through ACRES) to non-investigators.
ERS-1, TERSS and JERS-1

Informal discussions have been conducted with NASDA on the possibility of reception in Australia of experimental data from the Japanese ERS-l, while Australian investigators in the European ERS-l project discussed their data requirements with ESA, ACRES and the Australian Space Office through the Australian ERS-1 Science Committee chaired by CSIRO. Australian researchers have been extremely successful in obtaining ESA recognition as official investigators for the ERS-l mission, and in fact Australian researchers comprise some 10% of the total accepted worldwide by ESA.

Examination of the prospects of establishing an X-band receiving facility in Hobart (the Tasmanian Earth Resources Satellite Station, TERSS) has been assessed by an Australian Space Office (ASO) consultant. Australian Space Board will soon announce a decision about funding support for TERSS, which will be a Joint CSIRO/University of Tasmania/ Industry/State and Commonwealth Government technology development project by PCM and by Clough Engineering Ltd.

TERSS is regarded as a preliminary step in establishing a network of new-generation, lower-cost, Australian developed X-band satellite data reception stations in Australia and its

Territories. The COSSA Steering Committee (see below) has called upon COSSA to prepare, in consultation with the Department of Administrative Services, a paper on the development of such a network within the timeframe of the Earth Observation System (EOS).

An obvious basis for a national, interactive X-band network would be the current AVHRR network, which currently has limited electronic data switching capability. CSIRO will host the first Australian AVHRR Station Operators Workshop in Canberra on 4 June 1990. The Workshop will allow for exchange of information and discussion on standards, the operational status of each of the 8 known AVHRR stations, prospects for fast data package switching, and other issues.

Antarctic Reception Study

During 1986, CSIRO conducted a technical feasibility study for the reception of LANDSAT, SPOT, and ERS-1 data in Antarctica. The reception footprint of Casey, or Davis, together with the existing reception from Alice Spring, and from the station being established in New Zealand, would provide an excellent ability to study atmospheric, oceanographic, and ice conditions at high southern latitudes.

CSIRO's satellite data reception facility in Hobart has already assisted re-supply operations for Australia's Antarctic bases by providing satellite pictures of the location and evolution of sea ice.

Applications Development

Agricultural Applications

Superphosphate fertiliser costs Australia's grazing industry over $300M per year. CSlRO is developing ways of using data from satellites such as LANDSAT and SPOT to find which areas of improved pasture are in most need of fertiliser application.

By relating the satellite data from pastures with known histories of fertiliser treatment, it has been possible to calibrate the satellite measurements and use them to predict and map the likely responsiveness in particular areas of improved pastures.

This research, which is supported by the Australian Wool Corporation, will make it possible for agricultural extension offers to be provided with colour-coded images giving the fertiliser status of farms.

Fisheries Applications of NOAA Data

CSIRO has pioneered the use of NOAA sea-surface temperature imagery by the fishing industry of Australia as a cost-effective tool for locating fishable stocks. CSIRO participated with university partners in Western Australia in the development of a system for sending processed NOAA imagery to the fishing fleet base via the telephone system, to assist boats in locating the catch. In the east, CSIRO has a contract with the Trawler Owners Distribution Organisation to provide daily NOAA satellite imagery of south-eastern Australian waters. CSIRO researchers use NOAA sea-surface temperature data to study the relationships between the distribution of pelagic fish and ocean temperature. In a collaborative project with Tasmanian fishermen, satellite data are used to direct the fishing fleet to likely areas for catching jack mackerel. The cost effectiveness of the fishing operation has improved as a direct result of the use of such images.

CSlRO has close links with the Australian tuna industry and supplies NOAA satellite images to a number of fishing co-operatives in south-eastern Australia. The southern bluefin tuna industry is an important national and international fisher; the Australian industry is worth approximately $17M, while the Japanese catch in the Tasmanian sector of the 200 mile exclusive economic tone is worth between $50M and $100 annually.

CSIRO has developed a low-cost PC-based image display system to allow the transmission of NOAA images to fishing co-operatives around Australia.

Advanced Mineral Exploration Techniques
Australia's first digital LANDSAT imagery was processed by CSIRO in l975 and the lessons learned were used in defining the specifications for the Australian LANDSAT Station, which became fully operational at the end of l979.

Since then, CSIRO has undertaken a detailed study of the spectral properties of Australia's terrain, using LANDSAT and aircraft multi-spectral scanner data.

Image Processing and Data Acquisition Systems
Several CSIRO Divisions, working in collaboration with industry, have developed advanced suites of software and software/hardware packages to meet the image processing requirements of the remote sensing user community. MicroBrian, DISIMP, and A-Image have become well known and successful image processing systems within Australian universities, research institutions, and operational agencies, and have gained significant recognition and use overseas via direct sale and through the international development programs of the Australian International Development Assistance Bureau (AIDAB).

DISIMP provides comprehensive facilities for processing digital images from many different sources. These facilities include image restoration and enhancement, geometric and intensity transformations, statistical analysis and image classification, and interactive colour image display. DISIMP is readily ported to a variety of well-known hardware systems, and can operate in a UNIX environment.

At the beginning of 1986, CSIRO signed an agreement with Microprocessor Applications Pty Ltd (MPA) of Melbourne for that company to market microBrian, a micro-computer-based version of the Brian system for image analysis developed by CSIRO to assist in mapping in the Great Barrier Reef, a task in which it saved an estimated $20M and l0 years of survey effort.

MPA has encountered strong interest in microBrian in Australia, Southeast Asia and, most recently, China.

The PC-based (Commodore compatible) A-Image system developed by CSIRO offers sophisticated sampling and statistical analysis software and is attractively priced, especially for school, college and university use.

Remote Data Platforms

CSIRO has developed robust remote data acquisition platforms that use the French ARGOS system on-board the NOAA satellites to retrieve the data. The platforms provide high mechanical and electronic reliability at minimum cost. A number of these systems are in use in remote locations throughout Australia, operating reliably under extreme climatic conditions. They can function unattended for more than 8 months in both marine and terrestrial environments, have low power requirements, can be solar-powered and are suitable for adaption to a wide range of both analogue and digital sensor systems.

Instrument Development

Airborne Scanner for mineral exploration

An airborne multi-spectral scanner, initially developed by CSIRO for research on soil salinity, has been commercialised in collaboration with the mining company Carr Boyd Minerals and is in widespread use for mineral exploration.

Satellite Measurement of Barometric Pressure

If atmospheric pressure at the surface could be measured from space, reliable weather forecasts could be made many more days in advance than is possible at present. The economic returns from such a capability would be substantial. Research in CSIRO has demonstrated the potential of a method for determining surface pressure by remote sensing, using very precise measurements of absorption by the oxygen A-band.

Similar techniques based either on absorption in the microwave region, or on lidar, which have been advanced in recent years, all face the problem of interference from water vapour in the atmosphere. The new method overcomes this problem. CSIRO has funded the development, with AUSPACE Ltd, of an airborne prototype instrument to verify the scientific principles, and is currently seeking funding to support further development leading to the construction of a functioning satellite-borne instrument.

The sensor has been identified by the International Polar Orbiting Meteorological Satellite (IPOMS) group as a candidate instrument for its spacecraft flight program, and senior representatives of several national space programs have expressed deep interest in the prototype instrument.

Airborne sensor development

An X-band Side Looking Airborne Radar was permanently acquired by CSIRO for remote sensing applications, and was flown over a number of sites, including several flight in conjunction with the multi-channel Ocean Colour Scanner (OCS). The OCS shows promising utility in, amongst other things, sewage outlet tracing, fire detection, ocean productivity research and fishing industry support. The tuneable 10.6 micron laser and the Atmospheric Pressure Scanner have all been successfully tested and are currently undergoing further development.

Attempts continued (unsuccessfully to date) to seek funding for development of an Airborne Imaging Spectrometer. CSIRO has authorised the preparation of a conceptual design, and has established for this purpose, scientific and technical expert committees. The AIS Science

Committee, comprising experts from a number of government agencies and the private sector, met in Canberra in February 1990.

The Volcanic Ash Detection Working Group convened by CSIRO, studied the technical feasibility of using remote sensing techniques to warn pilots of the presence hazardous volcanic ash in the flight path. Recommendations of the Working Group are currently being studied by the Civil Aviation Authority, the Bureau of Meteorology and by CSIRO.

International Collaboration
Highlights include :

> Liaison with the French Space Agency CNES and French aerospace industries to build a nose cone and perform other engineering tasks for French F27 research aircraft.
>
> Use of CSIRO's Research Aircraft to provide basic data for the planned NASA "Windsat" global wind profiling satellite system.
>
> Agreement with Florida State University in December 1986 to utilise CSIRO's F27 research aircraft to acquire data on the atmospheric sulphur cycle.
>
> Agreement with Pennsylvania State University in January 1987 to use the F27 to participate with CSIRO in the international Equatorial Mesoscale Experiment (EMEX).
>
> CSIRO led an Australian delegation to the Pacific International Space Year Conference in Hawaii in August 1987, and has since taken an active role in International Space Year planning through participation in Earth Observation projects under the auspices of the Space Agency Forum on the International Space Year (SAFISY)
>
> CSIRO co-sponsored the First International AVHRR (Advanced Very High Resolution Radiometer) Workshop, held in Melbourne in October 1986. This workshop was held under the auspices of the International Radiation Commission of the International Association for Meteorology and Atmospheric physics (IAMAP).
>
> The 1989 agreement between the Government of Australia and the Philippines for the construction of a $9M remote sensing centre in Manila followed a lengthy period of proposal development, in situ feasibility studies and negotiations between Filipino representatives and members of the Scientific Industries Steering Committee (SISC) Remote Sensing Working Group.
>
> CSIRO collaboration with the Rutherford Appleton Laboratories and the UK Science and Engineering Research Council has been critical to the continued viability of the Along Track Scanning Radiometer (ATSR) project for the ERS-l spacecraft. CSIRO and its research collaborators in Australia will play a crucial role in the calibration, validation and applications development of ERS-1 data.

CSIRO, together with NASA's Jet Propulsion Laboratory, conducted a month long series of remote sensing experiments in Australia in October 1985. Some 54 test sites were examined using CSIRO's F27 research aircraft and the NASA C130 aircraft, which is equipped with state-of-the-art instrumentation. The prime objective of the project was to develop practical remote sensing technologies for application in Australia in mapping, exploration, and monitoring and managing resources. Users of the technologies and potential manufacturers both stand to benefit from the results of the project. Other participants included the Bureau of Mineral Resources and Australian mining companies.

A memorandum of understanding (MOU) was signed in 1987 with the Indian Space Research Organisation (ISRO) enabling scientific cooperation in the field of civilian space research and applications, especially in remote sensing.

CSIRO staff attended the Committee for Earth Observation Systems (CEOS) meeting in Ottawa, the 3rd ASEAN Science and Technology Week in Manila, the Space Agency Forum on the International Space Year in Frascati, the Topex-Poseidon Science Working Group meeting in Pasadena, and the ERS-l Coordinating Investigator's meeting in Frascati, with the objective of representing the remote sensing interests of CSIRO researchers and their colleagues. A staff member joined the launch team for GMS-4 at the Tanegashima Space Centre.

In May and June 1989, international training courses in remote sensing application in agrometeorology and hydrology, and in the use of the Australian image processing system MicroBrian were held in Canberra and Brisbane. These were conducted by a broad group of Australian agencies, educational institutions, private individuals and companies, under the co-ordination of CSIRO. The courses were co-sponsored by the Australian government and a number of international agencies including the UN and its regional or specialist bodies ESCAP, WMO and the FAO.

Planning Management and Commercialisation

Ken McCracken retired in 1989 and was succeeded by Graham Harris as Director of COSSA. As a result of the CSIRO workshop on remote sensing in May 1989, a Steering Committee was established for COSSA as a means of assisting its policy and funding functions. The Executive Committee of CSIRO in November 1989 strengthened COSSA's role in the coordination of CSIRO remote sensing programmes.

By the end of 1989, substantial progress had been achieved in examining options for more effective commercialisation and the further development of CSIRO remote sensing technology/ software. A national expression of interest in the establishment of a single industry consortia for the marketing of existing CSIRO- derived image processing and Land Information System technology is expected to be released by the end of March 1990.

In February 1990, a multi-million dollar Research and Development Memorandum of Understanding was signed by CSIRO and BHP. Remote sensing was one of three major areas of collaboration nominated. A meeting to consider which specific remote sensing project areas are to be financed and conducted under the MOU is expected to be held soon. In Perth, links with universities and the private sector were strengthened with the establishment of a Western Australian Remote Sensing Industry Development and Education Centre (WARSIDEC), the preparation of ARC proposals for collaborative remote sensing research, and the formation of a joint CSIRO/private sector consultancy service based at Floreat Park.

Summary and Conclusion

CSIRO faces the new decade confident that it is better prepared than ever to assist the Australian economy through the application of remote sensing research results to national interest programmes, to environment and resource management, and import replacement and export oriented data.

NEW SOUTH WALES

NSW has been heavily involved in satellite remote sensing since the first LANDSAT satellite was launched in 1972 and a number of major initiatives have come from organisations based in NSW during the last ten years.

In 1979 the NSW Surveyor- General launched the Remote Sensing Committee and the Remote Sensing Working Group to coordinate the State's remote sensing activities. These bodies were instrumental in establishing digital image processing within the NSW Government. The Committee was also effective in keeping the general community aware of the latest developments in satellite remote sensing through meetings, displays and seminars. Today the representative bodies have changed to reflect the maturation of remote sensing and the increased needs for integrating spatially referenced data of all types.

Currently the technical community meets regularly on the restructured Remote Sensing Committee. Policy, management and funding support is obtained from a separate group of senior executives who also meet regularly on the Remote Sensing Council.

Collaborative projects have made a large impact on the acceptance of remote sensing technology within organisations in NSW. Pioneered by the NSW Department of Agriculture and Fisheries, the collaborative project concept has given a number of organisations, who would not have had the necessary resources, the opportunity to carry out monitoring work that traditionally may not have been possible.

In the late 1970s, the only organisations able to afford image processing facilities were the then CSIRO Division of Mineral Physics and a number of exploration companies such as ESSO. The remote sensing community was boosted in the early 1980s by the acquisition of DIPIX Aries II image analysis computer systems by the Department of Lands, the University of NSW and Technical and Field Surveys Pty Ltd.

Most of the State Government's image processing has been, until quite recently, carried out on the DIPIX equipment housed within the NSW Department of Lands. Most of the DIPIX systems have now been replaced with much cheaper networked workstations and personal computers.

With the proliferation of affordable in-house systems, the Remote Sensing Committee has had to develop policies to maintain the compatibility of a single user system.
Most universities in NSW supply some remote sensing training with specialist remote sensing degree and diploma courses available from the Centre for Remote Sensing at the University of NSW and the Faculty of Resource Management at the University of New England.

Specialist centres exist within the Centre for Remote Sensing at the University of NSW and the Centre for Image Analysis at the Charles Sturt University (Riverina).

The University of NSW also specialises in providing remote sensing short courses throughout the Asian region.

NSW has two ACRES Distribution Centres and six ACRES Reference Centres which is an indication of how well the technology has been adopted in the State.

By far the biggest purchaser of satellite data is the geological and exploration community.

The NSW Government also has a big commitment to the use of satellite data in the natural resource disciplines. For example, the NSW Department of Agriculture and Fisheries has a large archive of LANDSAT MSS photographic products. This Department also has a large number of trained field staff who regularly acquire satellite data.

With a land degradation problem costing over $200 million a year in lost revenue alone, the NSW Government is spending at least $2 million in 1990 on new computer equipment for image processing spread amongst a number of agencies. This figure increases greatly if the cost of land information system equipment is added.

The expertise developed within NSW, especially agricultural remote sensing, is in constant demand overseas as exemplified by the success of a NSW based consortium in winning the recent competitive tender to supply remote sensing expertise and services to an AIDAB funded project in the Philippines.

Over the next ten years, organisations in NSW will become more reliant on the use of satellite data especially for regionally based projects involving collaborative efforts across many disciplines. Accordingly, a number of State Government agencies are relocating from the Sydney CBD to regional centres to more appropriately address these regional concerns. Ultimately NSW will have a standardised approach to such things as field data collection, data integration, data interrogation and output. The end result will be a more efficient system producing dependable predictive models of the behaviour of world climatic and environmental processes.

VICTORIA

Victoria's involvement in remote sensing began in 1972 when officers of the Forests Commission acted as principal investigators to NASA in the evaluation of the first Earth Resources Technology Satellite (later known as LANDSAT-1). Enthusiasm for this new form of imagery was high and throughout the 1970s, various Government departments purchased LANDSAT scenes on a regular basis often just to maintain an up-to-date overview of the State.

Routine application of the imagery began in the early 1980s with the regular mapping of wild-fire damage in Victoria's dry north-west. At the same time impetus was increasing for the acquisition of a digital image analysis system for use by State Government departments. The Victorian Remote Sensing Committee prepared a submission for Cabinet in 1986 seeking substantial funding for the creation of a central processing facility. Despite a sympathetic response, the submission failed, largely as a result of significant economic restraint at the time. The Committee subsequently advised members that the immediate future lay in the establishment of smaller facilities within individual Departments. Since then the Department of Conservation and Environment, (formerly Department of Conservation, Forests and Lands), the Board of Works, the Department of Agriculture and Rural Affairs and the Country Fire Authority have developed remote sensing units with digital capabilities.

Strong growth in remote sensing expertise is also occurring in many of Victoria's tertiary institutions, including the Royal Melbourne Institute of Technology, Melbourne, Monash and Deakin Universities and the Ballarat College of Advanced Education. In the commercial sector, the Melbourne based firm MPA Pty Ltd, in partnership with the CSIRO Division of Water Resources, are continuing to successfully develop and market the microBrian image analysis system.

One of the Daedalus airborne scanners, the entire tape library and Spectron radiometer of the former National Safety Council of Australia - Victorian Division were recommissioned in Victoria in early 1990, following their purchase by the Department of Conservation and Environment.

With three percent of Australia's land area and 27 percent of the Australian population, Victoria's remote sensing future lies in the application of repetitive, high resolution, synoptic imagery. There is a need to continue the development of a strong local educational system in remote sensing. This will ensure the provision of value-added skills to permit Victoria's resource managers to pursue applications of vital importance to the local environment and economy, including the monitoring of salinity, declining tree cover, land degradation, wild fire damage assessment and coastal and marine management. As the new decade approaches, Victoria is poised to reap substantial benefits from this technology.

QUEENSLAND

Queensland has committed significant financial and human resources to the development of remote sensing technology for over 15 years. As early as the mid 1970s, State Government Departments such as Primary Industries and Mapping and Surveying were using MSS imagery to produce small scale mapping and land resource information for remote areas. Queensland University was fortunate to have on staff at that time, one of the world leaders in cartographic applications, Dr Alan Falconer. In 1978 the University purchased a $100 000 I2S multi-spectral viewer for educational and research applications. Emphasis on education, research and equipment has enabled Queensland to become one of the leaders in remote sensing technology development.

Today, in excess of 20 Queensland organisations are regularly using satellite generated data for land resource applications. In addition to the sophisticated image processing systems operating in a number of State Government Departments, computer based remote sensing consultancy services are offered in a number of Commonwealth organisations, academic institutions and two private organisations. A measure of this increase in usage is the number of image processing systems now in use - 32 in total.

The Australian Key Centre for Land Information Studies (AKCLIS) and James Cook University both offer undergraduate, postgraduate and regular short courses on remote sensing. AKCLIS microBrian courses are attracting participants from South East Asia as well as around Australia. Where there is suitable demand, these courses are run in the host area, e.g. in the Northern Territory or as far afield as Saudi Arabia. Continuing professional development is fostered through the Queensland Remote Sensing Association and, in North Queensland, the Tropical Environments Remote Sensing Group. Regular technical meetings have ensured that research developments and problems are shared by the remote sensing community.

In addition to the extensive use of TM and MSS data, several Queensland organisations have been involved in the evaluation of airborne scanner data (both from the former National Safety Council of Victoria, and the US NS001 scanner), CZCS and SPOT imagery. NOAA data are being used routinely by the Departments of Primary Industries and Lands to assess pastoral conditions across the State.

The main areas of application of remotely sensed data have been:

Forestry - stratification and mapping, disaster impact (cyclones and fires), and identification of relic pre-European communities

Coastal - bathymetry, chlorophyll content, sea grass, mangrove, coral reef and marine habitat mapping

Cartographic - SPOT, TM and MSS applications for topographic and image mapping

Agriculture - sugar cane mapping and monitoring

Environmental degradation - invasion of noxious species (e.g. Mimosa pigra) and drought monitoring

Resource identification

Geology.

EXPO 88 provided the catalyst for the development of the Sunmap Technology Centre at the Department of Geographic Information, and an International Symposium on Remote Sensing in Coastal Zones. Over 500,00 people took the opportunity to visit the Centre and learn more about remote sensing and land information systems.
Perhaps one of the most exciting aspects of Queensland's approach to remote sensing has been the emphasis on the integration of remote sensing and Land Information Systems (LIS) technology. Departments such as Primary Industries and Lands have highlighted the tremendous contributions which information systems can make to all aspects of resource management.

Queensland's efforts in the development of this technology have, over the last couple of years, concentrated on overseas markets. Trade missions to several SE Asian countries have sought to identify potential projects, develop contacts with key people, determine international markets, and to emphasise Queensland's willingness to educate and provide expertise. These efforts have been rewarded with several international joint projects and staff training programmes.

Mapping and Monitoring Technology in particular, have been successful in being awarded several AIDAB contracts and other overseas consultancies.

SOUTH AUSTRALIA

Background

During 1984 the South Australian Centre for Remote Sensing (SACRS), previously within the Remote Sensing Applications Branch, Department of Environment and Planning, was established as a separate entity at Technology Park. It was officially opened in July 1985 with a charter to establish a higher profile for the technology, market and expand its capabilities in remote sensing applications, and increase its cost recoverability. The Centre was also charged with the responsibility of transferring the benefits of remote sensing technologies to the user community through a bureau service.

Progress

The Centre has been carrying out these tasks for the past four years. Some areas have been more successful than others.

In order to provide a wider operational base and range of integrated services, products and skills mix, the Centre became a business unit of the Survey Division, Department of Lands, as from July 1989. This change has provided an opportunity to integrate remote sensing as a component of the wider land information system of the State.

The Future

SACRS has gained accreditation as an approved Research and Development Centre for the purposes of 150% tax concession. Though most of the research work carried out at present is in conjunction with State Government bodies, it is anticipated that some joint enterprises with tax beneficiaries will become operational in the near future.

SACRS will continue to provide a bureau service in remote sensing applications to the wider user community. This client base includes State Government bodies, private companies and overseas agencies, and is expected to expand.

WESTERN AUSTRALIA

Western Australian involvement in satellite remote sensing began in earnest in 1974 when CSIRO and a number of mineral exploration companies became actively interested in LANDSAT-1 (formerly ERTS-1) data. This interest was developed by Dr Frank Honey (then CSIRO Division of Land Resources Management) using ERTS-1 satellite data and applied by the Surveyor General's Division, Department of Land Administration (formerly Lands and Surveys), to study a major flood which cut the Trans-Continental Railway line in 1975.

The State Government was quick to realise the potential of this technology and appointed a coordinator responsible for both State requirements and collaboration with CSIRO to develop applied uses in water resource management, agriculture, forestry and environmental monitoring. Capability to analyse satellite data, produce hard copy imagery and undertake ground validation surveys was progressively developed at both CSIRO and the Department of Land Administration.

In these early years, the then Surveyor-General, Mr John F Morgan, as the State's single contact for remote sensing matters, organised representations to the Commonwealth Government supporting the establishment of an Australian LANDSAT reception and processing centre. In 1978, State Cabinet approved the appointment of a State Liaison Committee on Remote Sensing (SLCORS), chaired by the then Surveyor- General (now by Mr Henry Houghton) with representatives from Departments of Agriculture, Water Authority, Mines, Forest, Environment, Industry, CSIRO and Education. SLCORS acts as a forum to provide a consolidated view to the State Government and ALCORSS on the remote sensing requirements of the State.

Following the commissioning of the Australian LANDSAT Station in 1980, interest in applied use grew rapidly with a corresponding research and development effort. Today that investment of a decade ago has resulted in the formation of a number of specialist companies providing remote sensing and related services, an active strategy to develop export markets and strong research and development, training and application organisations.

Since 1986, a West Australian Satellite Technology Applications Consortium (WASTAC), consisting of State Government (Department of Land Administration), CSIRO, Curtin

University of Technology and the Bureau of Meteorology, has been acquiring NOAA/AVHRR satellite data on a daily basis as a long term archive for resources management and meteorological purposes. To ensure the continuing interaction of various industry sectors, several staff co-appointments have been made for research into exploration geoscience and environmental monitoring remote sensing.

During 1989 a co-location proposal was developed to promote a West Australian Remote Sensing Industry Development and Education Centre (WARSIDEC).

This involved :

- CSIRO
- State Government
- Tertiary institutions and remote sensing companies
- WARSIDEC's image processing, land information systems and satellite environmental monitoring.

The co-location will encourage participation in projects based on value-added processing of land information products with application to mining, agriculture, defence, fisheries, land management and the environment.

TASMANIA

TASMAP, the Departmental marketing agency for the State's map series, is the ACRES agent in Tasmania, and as such receives monthly microfilm catalogues for public inspection. For the past seven years, the University of Tasmania has offered a third year course in Environmental Remote Sensing run by the Department of Geography & Environmental Science. The unit, which mainly attracts students from the Science, Engineering and Survey streams, covers radiative properties of earth surfaces, aerial photography and imagery systems, including interpretation, digital processing and their application in the fields of resource inventory, land use mapping and environmental monitoring.
Post graduate research thesis studies are also available, and amongst the topics currently under investigation are :

- mapping rainfall in South West Tasmania;
- mapping vegetation types in the Picton area of Southern Tasmania;
- mapping ocean atmosphere heat flux in the Pacific Ocean.

The Department of Primary Industry (Agriculture) is also engaged in a research project using satellite imagery to assess pasture quality of selected ten hectare sites in the Derwent Valley. Changes in growth vigour is recorded after dressing with graded densities of superphosphate. Most of the projects mentioned above are operated in conjunction with the CSIRO, who have an extensive Remote Sensing Programme in Oceanographic research, based in Tasmania.

NORTHERN TERRITORY

Education

In 1988, the Northern Territory University Faculty of Science introduced remote sensing subjects into its undergraduate course programme. A microBrian image processing system has been acquired to support the laboratory work. Three subjects currently offered are :

- Introduction to Remote Sensing
- Aerial Photo Interpretation
- Digital Image Processing.

Training

Short courses run by the University of Queensland Department of Geographical Sciences are conducted on a regular basis in Darwin. Three day introductory courses were held in 1986, 1987 and 1988, and five day microBrian courses in 1987 and 1988. A five day geology/geomorphology short course using microBrian was held in 1989.

Applications

- the NT Power and Water Authority are using microBrian for hydrogeological investigations.

- the Arid Zone Research Institute within the NT Department of Primary Industry and Fisheries in Alice Springs are using microBrian for rangelands management.

- the CSIRO Unit in Alice Springs is continuing to research the application of remote sensing to aspects of environmental land management. This Unit has developed an erosion modelling software module Alice for use with microBrian.

- the Department of Primary Industry and Fisheries in conjunction with the University of Queensland is investigating the application of LANDSAT Thematic Mapper imagery to monitor the spread of the aquatic weed Mimosa pigra across Top End wetlands.

- the Bushfire Council of the NT is using AVHRR data on microBrian to estimate fire fuel levels.

TERTIARY EDUCATION

This decade, 1979-1989, saw an enormous increase in activity in the University sector in remote sensing. In the early to middle 1970s several universities had some fragmented teaching activity in remote sensing supported by individual staff efforts in research. There was very little coordination, apart from that provided through organisations such as the various State remote sensing interest groups. In the 1980s however there were major developments that served to coordinate and encourage the growth of remote sensing activity in the university sector.

In October 1981, the University of New South Wales formally established its Centre for Remote Sensing as the first of its kind in Australia dedicated both to teaching and research. Its major role has been to coordinate and encourage those relevant activities within the University and to act as a point of focus for outside individuals and organisations who wish to contact the University in this field of technology. The Centre has proven a highly successful enterprise and was responsible for introducing tertiary educational short course activities in this country. The Centre was also a participating research agency (as one of 40 worldwide) in the NASA SIR-B Synthetic Aperture Radar Research programme. Along with other tertiary centres, the Centre for Remote Sensing is now an active participant in off-shore short course programmes.

Under the provisions of the Commonwealth Department of Education, Employment and Training's Key Centre programme, the Australian Key Centre for Land Information Studies (AKCLIS) was established in 1984 jointly between the University of Queensland and the (now) Queensland University of Technology. Although principally concerned with land information in general terms, the AKCLIS has instituted substantial education programmes in remote sensing, including professional short courses offered both in Australia and in Asia. In its association with State Government activities in Queensland, AKCLIS is a participant, as is the Centre for Remote Sensing at the University of New South Wales, in the forthcoming ERS-1 European Satellite Programme.

Three further centres with special emphasis on remote sensing and the image analysis aspect of remotely sensed data have recently been established. First, the Centre for Image Analysis at Charles Sturt University (Riverina Campus) was set up in 1989 to concentrate that University's remote sensing research and to act as a coordinating agency in remote sensing. During 1989 planning was completed for the commencement in 1990 of a Centre for Remote Sensing at the James Cook University of North Queensland. In 1990, the Royal Melbourne Institute of Technology (RMIT) also commenced teaching remote sensing.

Several universities during the 1980s introduced specialised post-graduate course work programmes in remote sensing. These include the Masters of Applied Science and Engineering Science degrees in Remote Sensing at the University of New South Wales and the Graduate Diploma in Remote Sensing also at that University. The University of New England offers Masters and Diploma Programmes in Natural Resources with remote sensing majors whilst the Department of Geographical Sciences at the University of Queensland also offers a Postgraduate Diploma in Remote Sensing. For 1990 the Department of Geography at the University of Adelaide has introduced a Graduate Diploma in Applied Remote Sensing and the newly established centre at James Cook University will offer both masters and postgraduate diploma programmes in remote sensing. The Department of Electrical and Electronic Engineering at Curtin University offers a Postgraduate Diploma in Remote Sensing as part of its continuing course work programmes. Besides these specialised degree programmes many universities now include undergraduate and postgraduate studies in remote sensing in their curricula dealing with engineering, science and earth sciences. Full details of these activities can be found in a recently completed report by ALCORSS entitled 1989 Survey of Remote Sensing Teaching in the Tertiary Education Sector. This can be contrasted with the situation in 1982/83 summarised in the previous report, Survey of

Tertiary Educational Remote Sensing in Australia, carried out for the Agricultural Remote Sensing Committee.

Besides vibrant teaching activities, Australia's universities have been particularly strong in developing their remote sensing research programmes during the 1980s with several hundred formal publications, conference papers and text books having been produced. Apart from NASA SIR-B participation and ERS-1 involvement, Australian university academics have been chosen to take part in the SPOT PEPS programme and in the forthcoming SIR-C experiment. Research activities have ranged over the full scope of applications of optical data and associated image processing techniques, to the emerging area of remote sensing by radar. In support of research and teaching, university departments have been quick to acquire and install a range of digital image processing systems, with a shift over the decade from large and expensive dedicated systems to laboratories of networked general purpose workstations capable of supporting image analysis and more general operations.

INDUSAT (Private Industry)

INDUSAT was formed in 1977 to act as a forum for industry to discuss issues arising from the developing technology of remote sensing and to represent to government, industry's views on how policy for the new technology should develop. Because industrial users of remote sensing products have come predominantly from the non-renewable resources sector, INDUSAT membership has been dominated by the mining and oil exploration industry.

In 1985-86, INDUSAT commissioned a major survey to determine the level of usage of remote sensing in all sectors of Australian industry, government, universities and research institutions. The aims of the study were to demonstrate the economic arguments in favour of the construction of an Australian receiving facility for LANDSAT TM, SPOT and other forms of satellite-borne remote sensing which were then available but not being captured. The results of the study were used by INDUSAT to effectively lobby government ministers and other policy-makers. INDUSAT considers that the study was a significant factor in persuading the government to allocate funds for the upgrade of the Alice Springs receiving station. Within the mining industry six or seven exploration companies currently have a strong commitment to remote sensing and have in-house processing facilities. In addition, there are approximately eight remote sensing image processing consultants. This group provides services to an estimated 30-40 regular users. The majority of remote sensing data utilised by the non-renewable resource exploration industry are from the LANDSAT TM sensor although some SPOT data is also used. A limited amount of airborne data is also being employed, largely on a research and evaluation basis.

The mining industry continues to support CSIRO research activities in remote sensing with four major AMIRA-sponsored projects current. Three are applications-oriented, the other being concerned with technology transfer. In 1986 the exploration industry financed, jointly with CSIRO, the construction of the temporary receiving station, at Alice Springs, which served to acquire all Australian and Papua/New Guinea LANDSAT TM data between 1986 and 1989.

As with many remote sensing applications, the current trend in remote sensing for exploration is towards the integration of data sets from various sources and the development of a LIS-based approach to image processing.

FUTURE DIRECTIONS

Remote sensing impacts on the Australia economy in two important ways :

- it provides data and techniques to enhance the development and efficiency of resources

- the mix of advanced technologies and a highly skilled labour force, coupled with resource applications and a strong global demand make it an appropriate commercial business for Australia.

The remote sensing industry in Australia is very small and fragmented with a low level of private investment. The industry is characterised by a high level of government and university/ research involvement, particularly in areas such as research and development of hardware and software, the provision of services and training. The future cooperation of the various remote sensing sectors is essential if Australia is to develop a viable commercial sector.

A recent study by the Australian Space Office, based on United States Department of Commerce estimates, indicates a current service market potential of $21 million, rising to $131 million by 1997, excluding space and ground sector activities.

The ASO considers that Australia has a definite competitive edge in some specific areas of the remote sensing market, and those that should be exploited include :

- value added services, in particular,
  - mineral and oil exploration
  - topographic, hydrographic and thematic mapping
  - fishing and agriculture
  - ecological monitoring and environmental management
  - regional planning
  - defence and public safety
- image processing systems and software

Australia has proven international expertise in this area which has significant growth potential. Australia already has the capabilities to address the whole market range of image processing, from ground station rapid data processing to micro computer stand alone systems. A significant international impact can only be achieved through collaborative efforts between the private, government, research and university sectors.

Education and training

Australia already has a well established education and training presence in South East Asia. There are excellent opportunities to provide additional training in remote sensing, with significant commercial spin-offs.

Of prime importance to Australia is the long term benefits of remote sensing for the surveillance and monitoring of the national estate and the environment. Without doubt, environmental issues will be a pre-occupation of Australia and its neighbours as we move towards the 21st century. Australia, by virtue of its strong commitment to the development and utilisation of remote sensing technologies throughout the government, tertiary and private sectors has established a base of expertise well able to meet this challenge.

APPENDICES

A. GLOSSARY
COMMONLY USED ABBREVIATIONS AND ACRONYMS

AKCLIS	Australian Key Centre for Land Information Studies
ACERTS	Australian Committee for Earth Resources Technology Satellites
ACRES	Australian Centre for Remote Sensing
ADEOS	Advanced Earth Observation Satellite
AIDAB	Australian International Development Assistance Bureau
ALCORSS	Australian Liaison Committee on Remote Sensing by Satellite
AMIRA	Australian Mineral Industry Research Association
ASB	Australian Space Board
ASO	Australian Space Office
AVHRR	Advanced Very High Resolution Radar
AUSLIG	Australian Surveying and Land Information Group
COSSA	CSIRO Office of Space Science and Applications
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CUCRS	Commonwealth User Committee on Remote Sensing
EOS	Earth Observation Satellite
FAO	Food and Agriculture Organisation (of the United Nations)
GMS	Geostationary Meteorological Satellite
LIS	Land Information System
MOS	Marine Observation Satellite
MSS	Multi-Spectral Scanner
NASA	National Aeronautics and Space Administration Agency (of the USA)
NASDA	National Space Development Agency (of Japan)
NOAA	National Oceanic and Atmospheric Research Administration (of the USA)
SACRS	South Australian Centre for Remote Sensing
SLAR	Sideborne Looking Airborne Radar
SPOT	System Probatoire d'Observation de la Terre
TERSS	Tasmanian Earth Resources Satellite Station
TM	Thematic Mapper
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WASTAC	Western Australian Satellite Technology Applications Consortium
WMO	World Meteorological Organisation

B. Terms of Reference of ALCORSS

Objective of the Committee
To provide a forum for consultation, liaison and cooperation to encourage the efficient and effective use of remote sensing in Australia.

Functions of the Committee

a. To advise the Department of Administrative Services on matters relating to the operation of the Australian Centre for Remote Sensing.

b. To examine and recommend on the national need for data manipulation and interpretation processes.

c. To encourage collaborative research and applications programmes in the field of remote sensing.

d. To maintain continuing liaison with other committees and agencies with interests in remote sensing.

e. To encourage improvements to and, as appropriate, co-ordination of remote sensing methodologies and equipment.

f. To monitor programmes of education and training in remote sensing.

g. To encourage the collection, storage and dissemination of information relating to remote sensing.

h. To consider any other matters appropriate to the stated objective of the Committee.

C. MEMBERSHIP

CHAIRMAN Mr G K Lindsay
General Manager
Australian Surveying & Land
Information Group

JURISDICTION MEMBER

COMMONWEALTH Mr C Simpson
Remote Sensing Group
Bureau of Mineral Resources

Dr G Harris
Director
CSIRO

NEW SOUTH WALES Mr D M Grant
Surveyor-General
Dept of Lands

VICTORIA Mr R Smith
Resource Assessment Section
Division of Forests & Lands
Dept of Conservation, Forests & Lands

QUEENSLAND Dr N G Divett
Assistant Director-General
Division of Geographic Information
Dept of Lands

SOUTH AUSTRALIA Mr F L Bryant
Director
SA Centre for Remote Sensing

WESTERN AUSTRALIA Mr C A Grant
Director of Mapping and Survey
Dept of Land Administration

TASMANIA Mr C Rowe
Surveyor-General
Dept of Environment and Planning

NORTHERN TERRITORY Mr T W Menzies
Head, Land Information Systems Branch
Land Information and Survey Division
Dept of Lands & Housing

TERTIARY EDUCATION Professor J A Richards
Dept of Electrical Engineering
University College
University of New South Wales

COLLEGES Professor K Kubik
Head, Dept of Surveying
Queensland University of Technology

INDUSAT (Private Industry) Dr E Swarbrick
President, INDUSAT

D. MEETINGS OF ALCORSS

INTERIM ALCORSS

29 March 1979	Canberra
10 July 1979	"

PERMANENT ALCORSS

4 June 1980	Canberra
10 June 1981	"
3 February 1982	"
30 September 1983	"
17 November 1983	"
23 February 1984	"
22 May 1984	"
25 October 1984	"
20-21 February 1985	Adelaide
30-31 October 1985	Canberra
4-5 June 1986	"
20-21 October 1986	Perth
26-27 February 1987	Hobart
15 February 1988	Canberra
28 July 1988	"
24 February 1989	"
28 March 1990	"

E. Remote Sensing - a Background

Remote Sensing is the science of acquiring data about some object without actually being in contact with that object. The most common example of remote sensing is photography where information is captured on film using light reflected from objects. Technology allows us to not only use electromagnetic radiation (EMR) in the visible part of the spectrum (light as we know it) but also EMR in the short wave infra-red (SWIR), infra-red (IR), microwave (radar) and thermal (heat) regions.

A Brief History of Remote Sensing

The placing of remote sensing instruments in space for the purpose of making earth observations began in the early 1960s as an off-shoot of the decision by the USA to land men on the moon. Aircraft flights to develop instruments to be carried on lunar orbiting satellites with the object of determining the suitability and safety of candidate moon landing sites revealed the value of the information which could be extracted for general geological studies.

The NASA Earth Resources Survey Programme was established and the scope of activities broadened to include test sites for agriculture, forestry, geography, geology and mineral resources, hydrology and water resources, oceanography and marine resources, and urban and regional studies. Photography and remote sensing observations from manned flight programmes and adaptation of weather satellite data further demonstrated the advantages and potential value of remote sensing from space.

The first satellite designed specifically for remote sensing of the earth's resources was the United States NASA Earth Resources Technology Satellite (ERTS-1) launched in July 1972. Its primary objective was the development of the technology which would be needed firstly for an experimental earth resources satellite remote sensing programme under NASA auspices and eventually an operational programme under some other Agency. So successful was ERTS-1 that with the launching of the second satellite in the series in July 1975, the project was re-named LANDSAT indicating its elevation to the NASA experimental programme status. The third satellite in this series was launched in March 1978.

A decision was also taken about this time to continue to provide the low resolution Multi-Spectral Scanner data from the first two satellites in the follow-on LANDSAT D programme, mainly in response to requests from the "foreign stations" (foreign to the USA that is), which had made substantial investments in their own direct reception and processing facilities. LANDSAT-4 was launched in July 1982 but due to onboard problems LANDSAT-5 was launched in March 1985 and is the current operational satellite.

SPOT Image currently markets data from the French SPOT satellite SPOT-1 launched February 1986. SPOT-1 provides higher resolution data than LANDSAT as well as off-nadir viewing.

The Electromagnetic Spectrum

Everything on the earth above absolute zero (-273 degrees C) radiates electromagnetic energy, with every object emitting a characteristic radiation. This emission serves as the signature for the particular object's identification. The human eye cannot detect all such radiation as the eye is sensitive only to a small portion of the electromagnetic spectrum from 0.4 to 0.7 um (micrometer) known as light; in contrast, sensors developed in recent times can detect several wavelengths.

The sensitivity of film emulsions and the range of lenses have increased considerably to exploit the region suited to them, viz. the visible and the solar infrared (IR) (0.4 - l um). Development of multispectral photography allowed the recorded individually so that the band with the best contrast could be chosen. The next advance was the development of photoelectric devices, instead of photochemical sensors, that could split incident energy into multiple spectral bands so that detectors sensitive to specific wavelengths could identify and record the emission for interpretation. These are known as multispectral scanners (MSS) and operate over a wide range of wavelengths from the visible to the thermal infrared in 0.3 - 15 um.

Different limits are sometimes specified for particular segments of the EMR, as mentioned above. Thermal infrared from 8 - 14 um is re-emitted solar energy, dependent only on the temperature of the object, unlike reflected infrared radiation. This region can be operated at night and is particularly suited to geological mapping, while the region 1 - 3 um in the middle (reflected) infrared is ideal for determining the composition of observed minerals and rocks. Infrared photography is possible in the region 0.7 - 1 um. Strong reflectance from vegetation is present in near-IR, while water is most distinctly identified at the visible portion.

Data Acquisition

A multispectral scanner records reflectance and emission in a range of wavelengths, with the data on the radiated energy converted into corresponding electrical pulses. Detectors can identify 256 levels of relative reflectance as against a maximum of 16 grey levels distinguished by the eye.

The relationship between the physical size of the individual detectors in the detector array and the earth determines an area on the ground called a pixel or picture element. In practice the pixel size becomes the resolution of the system. Therefore, a LANDSAT TM pixel of 30 m means that objects on the ground with dimensions greater than 30 m will be resolved. However, it has been found that due to the contrast of objects, objects less than 30 m can be interpreted. A grid of these pixels with their digital value is transmitted to a ground station and reconstituted to form an image that can be displayed.

Spaceborne Sensor Systems

At present there are three main satellites acquiring remotely sensed data :

LANDSAT having on board the multispectral scanner (MSS) and the thematic mapper (TM).

NOAA having on board the AVHRR sensor (Advanced Very High Resolution Radiometer) and TOVS (TIROS Operational Vertical Sounder).

SPOT having on board sensors to acquire multispectral (XS) and panchromatic (PA) data.

For more detailed information, pages 8-14 of the Asian Development Bank Economic Staff Paper No. 33 of December 1986 entitled Satellite Remote Sensing in the Asian and Pacific Region should be consulted.

Data Reception and Analysis

Earth stations or terminals receive signals from the satellite, and extract the data from the signals to produce different data products. It is not necessary to have an earth station if direct reception is not required and if data can be obtained from the archives of the space system operators. Facilities for data interpretation are needed even when the data are obtained from archives.

Data are stored on magnetic tape and with the cost of computing systems being reduced, analysis and interpretation of the data is performed on systems that use computer compatible tapes (CCT's) available from the ground stations.

Satellite remote sensing produces very large quantities of digital data. A single LANDSAT TM scene covering a ground area of 170 km x 185 km contains 273 Mbytes of data and occupies seven magnetic tapes when written at a tape density of 1600 bits per inch. NOAA satellites can produce over 2500 Mbytes of data from the AVHRR each day, although fortunately they do not do so. The volumes of data involved in satellite remote sensing are large. Digital processing is the only sensible way of handling these vast quantities of information.

Humans are good at interpreting images, but our eyes restrict us to looking in black and white at one band of data or in colour at a combination of three bands of data. With LANDSAT TM data there are seven bands available and with NOAA AVHRR five bands. It is only possible for human beings to look at a selection of any three of these at one time. Additionally, the eye cannot divide one picture by another, but the ratio of the near infrared to red reflectance provides useful information on vegetation. Many of the techniques required are only possible by using digital image analysis and could not be achieved by visual interpretation alone. This is not to suggest that visual interpretation of satellite imagery is not useful: it is, and using conventional procedures of interpreting image tone, colour, size, shape, texture and context useful analyses of satellite images can be obtained.

In recent years, companies have developed image processing systems attached to standard computers. These so-called turnkey systems provide the hardware and the software ready for image processing as soon as the machine is installed and switched on, and typically consist of four main components :

(1) Input of digital data using a magnetic tape drive as most digital remote sensing data are published on computer-compatible tapes (CCTs).

(2) Storage of data on disk for fast access.

(3) Processing of the pixel data using the software provided.

(4) Display of the data and of the analyses performed on the data on a colour monitor.

In addition, a permanent form of the display results may be recorded using a camera attached to the colour monitor or by a laser plotter which creates images on transparent film. The image processing system is attached to a host computer such as the DEC PDP11 or VAX series.

Minicomputers can now provide algorithms for image coding and registration. They can correct, improve, recognise patterns and objects and evaluate multispectral and multitemporal images. Digital image processing capabilities vary, in terms of price and performance, from the latest technology high-speed super minicomputers, to the common personal computer. The software can accomplish clustering, geometric correction, and multiband supervised maximum likelihood classification. The image data from magnetic tape can be read in several formats.

In contrast, microcomputer-based image processing systems are built around standard personal computers. Additional graphics processing boards and colour functions can be done :

filtering
arithmetic combinations of bands
principal components analysis
geometric correction
supervised and unsupervised classification.

The software may also include geographic information system functions that allow combination of image data with non-image data. The system is easy to operate and commands are in simple English.

Interpreting data with the aid of computers comprises three basic techniques, viz. processing, image enhancement and digital classification. The computer compatible tape is preprocessed and geometric and radiometric corrections made. Some special corrections may also be required to offset the illumination differences.

Image enhancement involves the digital manipulation of pixels, or picture elements, which are parts of the image that correspond to the ground resolution, indicating the scale of representation. For instance, a pixel of the size 0.3 x 0.3 mm corresponding to a ground area of 30 m x 30 m represents it at 1:1100 000 scale. Contrast stretching, ratioing of any combination of bands, and colour coded display of classified data are also image enhancement tasks.

Classification of the image in terms of spectral signatures is done in a series of steps. First, a training area sample is selected from the total (representing 185 x 185 km) and the spectral signatures in it are analysed. If previous information about the spectral signatures is known (based on extensive ground data and sampling), then the expert handling it can command the computer to locate similar specific groupings in the entire image. This is called supervised classification, where the spectral image generated is on the basis of a given known "window". In the unsupervised classification, no prior information is assumed and the computer is required to find out the different features on the basis of clustering pixels of similar gray tones or reflectance values. Unsupervised classification is time-consuming and is not as accurate as the supervised classification, since in the former method the spectral information may not be fully known. It is always necessary to check the relevance of spectral signatures. For example, wheat and barley will look the same and distinguishable only from multidate imageries coinciding with the different crop calendars. In an interactive mode, an expert can refine the spectral signatures. Imageries taken at different times can be studied at the same time.

The Advantages of Satellite Remotely Sensed Data

Satellite remote sensing techniques offer several advantages :

large area coverage with synoptic view (e.g. each LANDSAT image covers 185 x 185 km, or 34 225 sq km)

enhanced ground resolution (e.g. 10 m) rendering the data suitable for microlevel (district level) planning of resources

a good complementary for aerial surveys

cost-effective means of narrowing the areas of exploration for water, minerals, etc.
discovery of the ideal and real use of land surveyed so that an optimal mix of uses can be evolved

quick and objective assessment of resources, including real time applications
repetitive coverage, enabling monitoring of quick changing phenomena (flood damage, forest clearing, etc.)

applicability of computer processing of data collected yielding image allowing image enhancement use of the data base for several applications in resource monitoring, assessment and management

quick production of thematic and other maps, and integration of visual and non-image information for data analysis and policy making

monitoring of large areas for environmental changes.

The Limitations of Satellite Remotely Sensed Data

Though immensely useful, satellite remote sensing is only a means to an end and has its limitations. There are some general issues of a fundamental nature that set the broad limits to this technology, e.g. cost of data, continuity of data, and compatibility of the ground systems with the satellites. While these limitations would affect the availability of the technique, there are some inherent limits to the technique itself. Not all these limits are universal, most are country specific or project specific.

Some of the major limitations that have been experienced so far are :

too few experiments and publication of doubtful results or incomplete conclusions

inadequate appreciation of the distinction between experimental and operational nature of individual applications

lack of sustained operations in fields of promise

passive nature of the sensors deployed and the presence of clouds

unavailability of active sensors for experiments

delay in the distribution of data of an advanced level precluding immediate usage
inadequate application of processing equipment
lack of an overall plan for natural resource management incorporating a clear-cut role for satellite remote sensing

insufficient training in state-of-the-art techniques in data interpretation, particularly for middle-level managers of natural resources.

Remote Sensing Benefits

Since the launching of LANDSAT 1 in 1972, satellite derived data and imagery have made an increasing contribution to the knowledge of the world's physical resources. Researchers in many countries have developed a wide range of analytical techniques and applications. There is now a body of expertise in the developed and much of the developing world which allows the extension of existing commercial applications of remote sensing and the expansion of its uses into new areas.

The technique has thus generated considerable interest and investment in time and resources. While the impact of the technique has been substantial in some areas, satellite remote sensing applications remain largely experimental. However, as new systems are developed and new imagery and data become available, more extensive use of satellite remote sensing is inevitable in the future.

Potential Applications of Remote Sensing

The primary benefit of remote sensing in the physical resources area is its ability to provide extensive coverage of a country or region rapidly and at comparatively low cost. It is also almost the only technique available for monitoring change in the environment on an extensive basis. The fact that an archive of prior data is available, more or less on request, is also of great significance as it allows rapid definition of the rate of change (eg, of forest cover) over various time periods.

The potential applications and benefits of satellite remote sensing are reviewed in a report published by Asian Development Bank (1986). The main application areas are classified as follows :

forestry
forest inventory mapping
forest degradation and destruction monitoring
land resource evaluation
land use planning
wasteland definition
agriculture
crop area and yield estimation
disease and pest monitoring
soils mapping
water resources
watershed management
surface water monitoring
marine resources
geological features mapping
lineaments and minerals
geobotanical indicators
groundwater exploration
geomorphological changes
cartography.

Costs

Although data acquisition costs are low by comparison with all other current techniques such as aerial photography or ground survey, the operating and downstream costs can be considerable and will often be incremental to existing agency budgets. In addition to the cost of equipment and its operation, costs will be incurred in three main areas :

ground truthing
mapping
results application.

Data and maps are not intrinsically productive. For a country to generate economic returns, the utilisation of the data is required, often reinforced by powers of regulation and enforcement. Thus in the environmental protection area, the identification of, for example, an increasing rate of de-afforestation or erosion will not, in itself, solve the problem. Sanctions against illegal loggers must be enforced and extension provided to farmers employing practices leading to land degradation. The development of legislation and/or projects to protect the environment may be required. Thus in this sector, the realisation of economic benefits requires the development or extension of the infrastructural and legislative network, involving cost to the nation.

Under current conditions of financial stringency, it is likely that many of the costs involved will need to be found by economising in other areas of the bureaucracies. To achieve this, administrators will need to recognise that the benefits of employing the technique are greater than the opportunity cost.

The main benefit of the training component will be the expansion of capability among staff involved in remote sensing analysis and thus contribution to a potentially wide range of applications. The personnel to be trained include administrators (familiarisation course), researchers and applications staff (short courses) and undergraduate/postgraduate students (degree courses). Staff involved in ground truthing and in hard copy image interpretation in the regions would also be trained in regionally based short courses, contributing directly to other aspects of the national remote sensing programme and to improved efficiency of agricultural extension.

Benefits

Benefits usually stem from the applications areas. Some of the more important areas are as follows.

General Mapping Applications
Improved efficiency of mapping is possible using satellite imagery. Satellite data is thus expected to contribute to improved efficiency of mapping and to cost savings through contributing to the preparation of a range of thematic and other maps, the project should lead to improvement of the national natural resources data base.

The provision of hard copy imagery to agricultural and extension officers has assisted in broadening their understanding of their area.

Mining Industry
The mining exploration companies in Australia are the major users of satellite imagery, accounting for over half of all sales of data. The Australian environment is particularly favourable for mining sector applications due to its atmospheric clarity, extensive areas with arid environment or seasonally dry conditions. However, even in Australia, satellite imagery

is only looked on as one of a number of techniques to be used in exploration activities and few examples of mines primarily identified by remote sensing data analysis can be cited. The costs of aerial and ground survey should be reduced on a unit area basis through the use of remote sensing, while the extent of coverage should permit an expansion of the area which can be explored.

Fisheries Applications

The fisheries sector holds considerable long-term promise for the development and application of satellite imagery analysis. Sea surface temperature measurement (using NOAA or radar data) can be of assistance in locating fish schools (pelagic fish often congregate near upwellings or thermoclines) while ocean currents and gyres (circular currents induced by prevailing monsoonal winds) have been shown to have significant impact on breeding patterns, offering the long term potential for seasonal limitation of fishing effort based on measurements of water temperature.

Estimation of primary productivity through sea colour measurement (correlated with phytoplankton biomass) may also improve the country's knowledge of its fisheries. If regular data can be gained at adequate resolution, monitoring of red tides is possible, with improved possibility of understanding the causal mechanisms.

Coastal Zone Mapping

The coastal resources face threats which are almost as severe as the land degradation. Indeed, the two are often linked and for example, the siltation experienced on many coral reefs stems from catchment area de-afforestation and erosion.

Mapping of offshore reefs, sea mounts and pinnacles is also possible using remote sensing data. This provides potential benefits to the fisheries sector through the identification of new drop-lining or trap fishing grounds and to fisheries regulators and enforcement agencies through the ability to improve control of destructive techniques of reef fishing such as muro-ami. The mapping of shallow reefs would also be of potential benefit to navigation and could be a valuable input to the sea land research.

Cost and Time Effectiveness

There are three main techniques available for the collection of data concerning an area of land :

- ground survey
- aerial photography
- satellite remote sensing.

Ground survey is expensive, costing several hundred dollars per square kilometre, and its use is therefore limited to small area applications, where accuracy is required, such as in irrigation area delineation.

While there will continue to be a role for aerial photography, most mapping applications will in future be based largely on satellite imagery, due to its improved cost and time effectiveness. No effort is required of the country in the obtaining of imagery, apart from placing an order with the appropriate ground station. Images are available on a regular basis, and, though many are not fully usable due to cloud cover, a mosaic of a country or region can usually be built up far more quickly with satellite imagery than with aerial photography. One satellite image covers the equivalent of about 50 aerial photographs. For many mapping applications, the simplicity of using the larger scale images plus the digital analysis possible with satellite data will further simplify and streamline the mapping operation.

Rajan (ADB 1986) estimates the cost of a LANDSAT survey at US$0.70 per square kilometre, or about 4 per cent of the cost of an aerial survey. "Even if an allowance is made for 20 per cent ground truth verification, the cost of satellite operation is considerably less." The imagery should provide senior extension officers with improved information on conditions prevailing in the area and thus allow improved direction of the extension effort. The series of satellite images available over the past 15 years provides a unique record of historical change in land use or quality. This provides planners and administrators with the ability to measure temporal change on a short term basis (through the use of time series satellite data) and reduces the need to acquire specific data for a particular monitoring function.

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