NATURAL RESOURCES SYSTEMS PROGRAMME

FINAL TECHNICAL REPORT

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Project Title

Low cost satellite receiver high resolution reception by BURS

Project Leader

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Organisation

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High Potential

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FINAL TECHNICAL REPORT

Low Cost Satellite Receiver High Resolution Reception by BURS

Programme: RAFS then NRSP
Project Number: R5154 and A0457/X0283
Start date: 1/4/95
Finish date: 31/3/9

Executive Summary

This adaptive research project concerned the development of demonstration prototype capabilities to enable direct access to high resolution remote sensing satellite data and ultimately to utilise this technology for improved understanding and management of natural resources. The activities were based on conscious efforts to address in-country needs for remote sensing capabilities to be increasingly accessible to natural resources managers in developing countries. The work built upon previous (RAFS funded) work on the development of direct access to low resolution data from NOAA weather satellites and methodologies for extracting directly useful information from these data. The approach relied on detecting and tracking a unique beacon signal broadcast by the satellite of interest and then acquiring the associated 8 Ghz data stream. Project outputs comprise: (a) the tracking system which successfully located and tracked signals from a number of Earth observation satellites, (b) an 8 Ghz demodulator to produce the data signal, (c) a solid state memory framestore design for the storage of 1 Gigabyte of received (high bit rate) data, and (d) a simple text display so users can identify the satellite position and monitor system status. There are potential future research and implementation pathways in a number of countries, particularly Indonesia. Based on progress to date, funding has been obtained from the British National Space Centre (BNSC) to take this work forward. This will target data acquisition from the ERS (Radar) satellites which offer day or night observation capabilities unaffected by all but the very worst tropical rain events, cloud and weather conditions. An exploitation plan is also to be developed under this funding.

Background

The Environmental Science Department at NRI and their collaborators have demonstrated significant progress in the development of direct access to low resolution data from NOAA weather satellites as well as high resolution remote sensing data acquisition and analysis equipment. This has been complemented by development of approaches and methodologies for extracting directly useful information from these data.

This body of adaptive research has been facilitated under previous ODA (RAFS) research funding and has made great inroads into the development of remarkable capabilities for low cost, direct access to real time satellite data in-country. This has enabled a growing number of institutes and organisations in developing countries to access and utilise this technology for improved understanding and management of natural resources.

The great potential of high resolution Synthetic Aperture Radar (SAR) and other active microwave remote sensing instruments has been demonstrated experimentally in recent years for a number of different applications. The experience gained from a number of satellite based radar missions (SEASAT, GEOSAT, ERS) has shown that the physical nature of the environment can be observed in most weathers, day and night. Operational and potential users of Earth observation (EO) data are therefore starting to expect delivery of reliable information through utilising and adapting this technology. Not least of these are users in the developing countries, often cited as where the comparative advantage of SAR all weather and illumination capabilities will be of most direct benefit.

Access to capabilities for high resolution (optical and SAR) satellite data capture in-country is required in regions where there are constraints of infrastructure (e.g. poor regional dissemination) and/or environment (e.g. continuous cloud cover) and thus where the needs for such detailed environmental information are likely to be acute.

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Project Purpose:
The purpose of Projects R5154 and A0457 was to see the development and manufacture of a demonstration system for high resolution satellite data capture through to completion following significant progress in this area under the former Resource Assessment (RAFS) Programme. The project concerned the development of generic (PC based) satellite receiver equipment suitable for application to the direct reception of data from high resolution (10 - 100 metre pixels) Earth observing satellites. Typical amongst these are Landsat, SPOT, ERS-1 (ERS-2 launched recently), Indian satellites (IRS series) and a number of other potential platforms likely to be launched in the future.

Research Activities
The research activities and progress to date were based on conscious efforts to address in-country needs for remote sensing capabilities to be increasingly accessible to natural resources managers in developing countries by generating timely, reliable, useful information rather than just data products. Parallel activities under a programme known as the "Africa Regional Project" assist these efforts by establishing appropriate, standardised software interfaces such as the "NOAA Operations Manager" (NOM). Based on the impressive progress to date, other parallel funding has been obtained from the British National Space Centre (BNSC) to take this work forward by targeting the developments at demonstrating data acquisition from the ERS (Radar) satellites which offer day or night observation capabilities unaffected by all but the very worst tropical rain events, cloud and weather conditions.

The approach relies on detecting and tracking a unique beacon signal broadcast by the satellite of interest. Each satellite has a certain "known" beacon frequency (around 2.2 Ghz) which changes with time (a phenomenon known as "ageing"), temperature, movement (Doppler frequency shift) and, in the case of ERS, from ground control. The best that can be done is to start searching from a predicted position. How one searches has been the subject of great (largely secret) research as minimising the time to locate a particular target is an essential requirement of missile systems. The solution had to be relatively simple to implement and one which would find the target signal within 1 or 2 seconds of the satellite "appearing in the dish" (i.e. entering the region of the sky at which the antenna is pointing). The technique adopted was one of a coarse look followed by a fine look followed by a confirmation.

The beacon power (at 2.2. GHz) is so low that with a small antenna there is difficulty in achieving sufficient signal/noise power to generate strong enough error drive signals that keep the aerial on target (i.e. on the peak of the transmission beam power) throughout an orbit. Changing to a 3.7m dish, or larger, would reduce this problem but would increase the need for improved initial target beacon detection. The current performance is such that, with a 2.5 m dish, the aerial will pull in (i.e. "lock on" to the signal) provided that the satellite passes within ± 5° or so of the dish axis. The antenna beamwidth is relatively wide and draws (low levels of) energy from a more diffuse area of the sky. With a 4 metre dish the antenna beamwidth is narrower (higher energy) and the pull in performance will probably reduce to within ± 3° of the dish axis. Hence it is necessary to be able to predict the position of the satellite accurately enough and then move the aerial accurately enough the achieve this initial positioning to ± 3°. All the orbit prediction modelling has been done to provide predictions to better than ± 1° and position pick off devices accurate to about ± 0.5° have been attached to the aerial system to ensure initial pre-track pointing to within the ± 3° requirement.

Besides the patch detectors which are used for tracking the satellite (using the beacon signal), a further signal detector is placed at the focus of the dish to receive the data signal on 8 Ghertz. This signal is amplified and demodulated to produce the data signal along with the extracted data channel synchronisation ("clock") information ready to be linked into a storage/computer system. Once the tracking system has located the beacon signal and successfully locked on to it, the 8 GHz data stream can be received. An 8 Ghz demodulator has been produced as part of the receiver development.

Outputs
A tracking system (comprising receiver, dish and motor driven gantry) has been produced. This equipment has successfully located and tracked signals from a number of Earth observation satellites. Indeed, target tracking is now considered as a routine operation. Once the tracking system has located the (2.2 Ghz) beacon signal and successfully locked on to it, the 8 GHz data stream can be received. Data signals have been observed for SPOT, Landsat and ERS for part of the orbit (up to within ± 30° of overhead for the experimental system). At times signals for ERS have not been seen, this may have been due to a failure to track accurately enough or the fact that ERS SAR data was not being transmitted at the time (only 10

minutes per 100 minutes orbit, but mostly over Europe). More work is needed to achieve the precision necessary for consistent capture of ERS data. This will done under follow on BNSC funding.

An 8 Ghz demodulator has been produced as part of the receiver development. This demodulator receives signals from an 8 GHz detector placed at the focus of the beside the patch detectors (which are used for tracking the satellite using the 2.2 Ghz beacon signal). The 8 GHz signal is amplified and demodulated to produce the data signal along with the extracted data channel synchronisation ("clock") information ready to be linked into a storage/computer system.

A solid state memory framestore design has been completed for the storage of 1 Gigabyte of received (high bit rate) data signals. This is equivalent to of the order of 90 seconds of transmission, which represents enough data for approximately 3 standard Landsat scenes or up to 6 standard ERS images. The data decoding required to reconstitute images from the data has not been implemented and will be researched further under BNSC funded work. The framestore has not been populated with RAM chips to date as (a) the price of these components fluctuates markedly, and (b) recent developments in computer disk technology present an option to move away from the solid state framestore design towards high speed disk configurations. This would also introduce a cost saving in the final hardware configuration which will be investigated further in follow on research activities.

A simple text display has been developed so that users can see only the most useful information to identify where the satellite is along its orbit and monitor what state the system is in (e.g. calibration, initial positioning, located, tracking, receiving data, etc.). However, the system developers (BURS) need to see all variables at all times (perhaps selectable) and this can also be achieved using a similar, simple text display. (Previous early work with NOAA satellites identified those routines which worked most efficiently on a text screen as much work was done timing the many instructions available to write to a display).

Contribution of Outputs
Success with the development and deployment of direct, real-time, in-country reception of NOAA data and the outputs described above have clearly demonstrated the capability for enabling access to high resolution environmental satellite data and have stimulated thinking on how to utilise these data effectively. When available, this will help to further enable local managers to acquire detailed up-to-date information on events, phenomena, trends, etc. that might otherwise be only hinted at in lower resolution data.

Increasingly, NRI and collaborators are being encouraged by the degree of convergence of the different activities within research and TC projects towards an approach to environmental management based on a system of integrated environmental information from a variety of remote sensing data sources. It is clear that significant generic capabilities have been developed, aimed at delivering practical useful information. It is anticipated that demands for these capabilities will grow and that research is required to refine them, make them more accessible and easy to use, and to develop more integrated and user orientated approaches to make best use of the information generated.

Dissemination Outputs

Publications
J.B. Williams (1995), Towards Integrated and Sustainable Environment Monitoring in Indonesia, Proceedings of the Conference on Remote Sensing and GIS for Environmental Resources Management - the Indonesian European Experience, Jakarta, June 1995

Other Outputs
Project Progress Reports, September 1995, March 1996
Project Annual Report, November 1995
Project Completion Summary Sheet, May 1996