RADIO SCIENCE ACTIVITIES IN AUSTRALIA

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Introduction

Australia has benefited from radio communications since the early days of the technology and is now an eager participant in the information age, motivating strong research and development activities in the area. This work is shared between Australian universities, the Defence Science and Technology Organisation (DSTO) [1], the Commonwealth Scientific and Industrial Research Organisation (CSIRO) [2], which all receive public funding, and private industry. A complete account is not possible in a short paper, so the sections below aim to sketch the geographical and political environment and to illustrate by example present R&D activities and the commercial sector.

Geography and Politics

Australia is geographically large with most of its population in distant urban centres, located mainly on the sea board, and the remainder scattered in small rural communities. This provides challenges for radio communications: the need for a wide coverage, for interactive remote schooling systems, and the commercial use of multimedia sources. Australia has an extremely long coastline and relies on radio propagation to monitor it for customs, immigration, and security purposes. The distance to many of Australia's markets is large and radio communications is a vital element in the Australian economy.

Australia is greatly affected by the globalisation and diversification of communications networks. There is a growing need for faster information rates, interleaving of data streams, and free-ranging interconnectivity. This is driving greater interest in the Australian market for wide-band solutions, more spectrum allocation, and greater integration of communication services. This in turn has led to the political decision to licence portions of the spectrum rather than the apparatus that uses it. Licences are held for 15 years and are marketable assets. The Australian government [3] believes that market forces are the fairest method of determining spectrum value – the recent auction of parts of the 1.8 GHz band reaped more than A$1.3 billion – and that this will encourage greater use of technology in spectrum usage.

The International Telecommunication Union, Radiocommunication Sector, ITU-R is taking a leading role in standardising radio communication technology and radio frequency usage as demanded by globalisation of services. Australia has a significant interest and involvement in ITU-R matters, participating at the Study Group, ITU-R management, and World Radio Conference levels. Australia chairs Study Group 3 on radiowave propagation and vice-chairs Study Group 7 on science services, and chaired last year's Conference Preparatory Meetings. Australia is a member of the Asia-Pacific Telecommunity which debates current radio communication issues and coordinates future spectrum requirements within the region.

Communications Research

Several Australian universities (in alphabetical order) have significant involvement in radio communications research.

The Australian National University [4] is investigating a new antenna technology, the plasma antenna, to provide internet access to remote parts of countries like Australia that have large areas of low population density. The plasma antenna, comprising a confined column of RF-heated ionised gas, could help to solve the antenna-ringing problem that

inhibits the use of spread-spectrum techniques at HF and VHF frequencies. The potential of plasma antennas for security use is being studied jointly with DSTO.

Griffith University [5] investigates smart antenna technologies. These include wire, patch, and reflector antenna structures that use switched parasitic techniques to achieve rapid, accurate beam steering. Through the use of high dielectric and high magnetic permeability materials, the size of these structures can be made relatively small. Applications include cellular telephone handsets and networks, anti-collision technologies for vehicles, and satellite tracking. A cellular antenna has been patented and prototypes are being made by an Australian manufacturer.

Research at James Cook University [6] in tropical northern Queensland has a strong regional flavour. Propagation in tropical regions is discussed below. Other projects include microwave radar sensors for industrial applications and identification and treatment of interference problems in radio control systems for sugar-cane locomotives.

The RMIT University [7] has performed significant research on printed antennas exploring techniques to enhance the bandwidth, improve the efficiency, decrease the physical size, reduce the back radiation, and integrate these antennas with microwave and photonic devices. The proposed antennas are now being used in a variety of applications ranging from mobile communication handset terminals to optical-fibre-fed LMDS networks.

The University of Queensland [8] has been successful in the field of antennas for mobile satellite communications, developing prototypes of switched-beam arrays, phased arrays, and briefcase antenna systems. Active reflect-arrays and transmit-arrays are part of a research effort to build new types of solid-state power amplifiers. A radial line-slot array for point-to-point communications and DBS TV reception has been patented. Adaptive signal processing is being incorporated into hand-held terminals for low-earth-orbit communications to reduce the effects of multi-path, shadowing, and human-body interactions.

The University of Technology, Sydney [9] is a participant in the CRC for Satellite Systems (see below), and recently developed a Ka-band earth station for FEDSAT1. The telecommunications engineering group is also developing novel mixed-resonator filters, extensions to FDTD techniques for filter and antenna analysis, miniaturised antennas and arrays for medical microwave applications, antennas for diversity reception, and channel modelling and smart antenna algorithms for indoor wireless communications.

Radio science finds application in numerous DSTO activities, mostly within the areas of communications and surveillance. The Jindalee Operational Radar Network is a bi-static HF skywave radar system that is nearing completion. Substantial gains have been made in the design of adaptive signal processing techniques for external noise rejection. An integrated scheme for assimilating sounding measurements into an ionospheric model has been implemented. An HF surface-wave radar is also being developed and has potential for commercialisation. Other studies in DSTO address plasma antennas (mentioned above), direct RF-to-digital conversion to avoid signal distortion, field distributions on complex platforms, and ultra-low phase noise waveform generation.

A major area of expertise of CSIRO [10] is the design of electromagnetic antennas, passive components, and feed systems for wide-band and multi-frequency applications. Analytical and numerical techniques for analysing electromagnetic fields in both closed and unbounded environments are developed, supporting work on earth-station antennas, satellite antennas, high-power feed systems for radar applications, and millimetre-wave antennas.

Australia has a system of Cooperative Research Centres that promote projects with industry and non-industry partners. The CRC for Satellite Systems [11] is building a low-earth-orbit microsatellite FEDSAT1 for launch in 2001 and an experimental communications package will be a key payload. CSIRO, the University of Technology, Sydney and the University of South Australia [12] are collaborating to build this payload and foster flight-hardware expertise in Australia.

Propagation Studies

Propagation research is necessary to preserve the integrity of radio communications and Australia's geographical diversity has encouraged a variety of experimental and

modelling work. In studying tropospheric propagation in clear air, emphasis has been placed on the refractive index structure in coastal and off-shore environments. James Cook University [6] and DSTO have collaborated to collect statistics on evaporation ducts in the north of Australia, leading to a study of turbulence mechanisms in the atmosphere and modelling stochastic propagation effects. Canberra University [13] has joined this group to investigate remote sensing of the evaporation duct height. DSTO and Airborne Research Australia [14] have begun studying turbulence phenomena in jet streams (collaborating with the US Air Force Phillips Laboratory) and microscale/mesoscale meteorological processes in the formation of advection ducts (collaborating with Flinders University).

Propagation in rain is of great interest for the tropical and sub-tropical regions of Australia. Current empirical prediction methods are based on data from Europe and North America, and do not describe high rain-rate regions well. James Cook University has studied rain attenuation on satellite communications for a number of years. They have also developed a unique digital beacon receiver system that allows simultaneous beacon and radiometer measurements. Recently, CSIRO has started measuring the rain effects on a terrestrial 38 GHz link. Data from these experiments will be supplied to ITU-R Study Group 3 to help improve rain attenuation prediction methods.

With the growth of wireless LANs and urban micro-cellular communication systems, radio propagation for indoor and short-range urban systems is an increasingly important area. CSIRO has developed a mobile communications testbed which is used for the measurement of path loss and delay spread in a number of short-range environments in the frequency range 2.4 to 40 GHz. Measurement of indoor-to-outdoor building material loss is of particular interest to characterise the coverage and interference potential of WLANs. CSIRO leads the work on short-range propagation within ITU-R Study Group 3. Studies at the University of Technology, Sydney [9] aim at full characterisation of the wave propagation inside built up environments. The depolarisation and angles of arrival of multipath signals have been characterised both theoretically and experimentally around 1 GHz. Algorithms for predicting indoor channel characteristic maps have been developed along with techniques to predict angles of arrival.

The University of South Australia (Institute for Telecommunications Research) [12] is tackling major protocol issues for the provision of services over wireless systems. The Institute has been working with Telstra [15] on satellite and mobile data systems where the focus is on data services, web browsing, and seamless integration of networks – satellite or terrestrial, indoor or outdoor.

In a number of areas of Australian life, such as security and transport by air, land, and sea, HF communication remains the most practical and least costly alternative. To optimise the value of these systems, the IPS Radio and Space Services [16] provide automatically updated maps of ionospheric conditions in the Australian and New Zealand areas. These are based on real-time data from observatories within Australia, Papua New Guinea and Antarctica. Other data provided by CRL, Japan, the US Air Force, Italian National Institute of Geophysics, the British Rutherford-Appleton Laboratory, and the Swedish Institute for Space Physics, form the basis for real-time maps of ionospheric conditions in the Japanese, North American, and European regions respectively. IPS internet services include charts which identify suitable communication frequencies for HF circuits in these regions. Total Electron Content data are also available through the IPS and the Australian Land Information Group.

A significant new project to monitor the ionosphere-magnetosphere to the south of Australia is the Tasman International Geospace Environment Radar (TIGER) [17], developed by La Trobe University, the Australian Antarctic Division, the IPS, DSTO, Newcastle University, and Rochester-Lockheed-Martin Systems. The information on waves in the ionosphere, on radiation storms at high latitudes, and on the position of the auroral oval and the high-lattitude trough will allow better management of communications systems.

Commercial Enterprise

Australia has a healthy economy and a well-educated population that by world standards is extraordinarily eager to take up new technology. This environment has

encouraged the growth of several companies based on radio communications. Remaining competitive in this area always involves significant effort in research and development, so such companies are valuable contributors to radio technology as well as our economy. Some are long-standing. For example, Radio Frequency Systems (Australia) [18] has three main product areas: VHF and UHF transmitting antennas and combiner networks for broadcasting, antennas and filters for cellular radio systems, and HF communications and radar antennas. All RFS products are designed and manufactured in Australia, and over half the output is for export.

There are also newer companies that take advantage of specific markets and commercialise research done in Australian universities and CSIRO. Two examples will illustrate this trend. Wavenet International [19] is a recently floated company based in Western Australia. Using wireless modem technology based on Motorola's RD-LAP protocol, Wavenet has developed cheap and spectrally efficient products for mobile data networks. They are ideal for short and broadcast messaging applications (such as mobile EFTPOS, meter reading, security systems, and tracking systems) and for use in developing nations without an existing telecommuncations infrastructure. Recent world-wide unlicenced access to parts of the 5 GHz radio spectrum has spurred some commercial development. Radiata Communications [20] supplies chipsets, reference designs, antennas, and software for high-speed wireless network access, starting with a complete IEEE 802.11a WLAN solution. These provide the indoor networking market with data rates an order of magnitude faster than anything else currently available.

Nevertheless it can be difficult to obtain funding for the commercialisation of Australian research. The Australian market is not seen as large enough by providers of venture capital, and the international market is dominated by large corporations with their own research teams. There is a perception that geography makes it difficult to do business in Australia. It is hoped that economic performance will show that this view has little basis in truth.

Keeping in Touch

Australian radio scientists and engineers maintain an effective network through two meetings that have become regular events. The Australian Symposium on Antennas occurs in February of every second year and provides a forum for work on antennas and propagation. A wider community is served by the Workshop on Applications of Radio Science that also occurs every second year. Although these meetings concentrate on Australian work, overseas visitors are always welcome – contact the first author for more information. In December this year Sydney, Australia will host the Asia-Pacific Microwave Conference at which much of the work above will be reported to the international community.

Acknowledgments

The authors' knowledge of current activities in Australia is due to the generous assistance of colleagues. They are grateful for the thoughtful conbributions of Rusmir Ahmic, Stuart Anderson, Bevan Bates, Marek Bialkowski, Gerard Borg, Andrew Kulessa, Noel McDonald, Ananda S Mohan, David Thiel, Neil Weste, and Graham Woods.

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