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MOBILE SATELLITE RESEARCH ACTIVITIES AT THE UNIVERSITY OF QUEENSLAND

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1. Introduction

In August 1994, Australia launched its first domestic mobile satellite communication system (Mobilesat). Operated by Optus Communications (Optus), the system delivers satellite communication services to mobile users anywhere within Australia or up to 200km offshore. The mobile component of the system transmits and receives at L-band frequencies (1646.5-1660.5MHz and 1545.0-1559.0MHz) while the Ku-band satellite transponders relay the full-duplex signals to a base station using frequencies in the Ku-band (12263.5-12277.5MHz).

The design of antennas and associated components for the Australian Mobilesat has been the subject of research of the Microwave and Antenna Group at the University of Queensland since 1991. These activities have led to the development of two L-band Mobilesat antenna systems: (i) vehicle mounted, electronically steerable, 14-element array, and (ii) a fixed beam briefcase antenna which are described in the following sections.

2. Vehicle Mounted Mobilesat Antenna System

The equipment required to utilise the Mobilesat voice, fax or data service consists of an antenna system and a transceiving terminal with a telephone handset and additional modem equipment. Such equipment has already been introduced in Australia by Optus. The antenna offered by Optus is a bifilar helical whip antenna about 1m long which is suitably attached to a vehicle. This antenna provides an omnidirectional right hand circularly polarised radiation pattern with a low gain of approximately 6dBi. This type of antenna does not require a satellite tracking system however its performance can be affected by the presence of line-of-sight obstacles such as trees. In order to obtain a larger link margin, an antenna with an increased directional gain is required. Steerable L-band antenna systems with increased directional gain for the Mobilesat have been the subject of investigations in a number of research institutions in Australia [1]. The research activity at the University of Queensland has led to the development of a 14-element electronically steered antenna array [2].

The configuration of the University of Queensland electronically steered antenna array is shown in Figure 1. The antenna elements are positioned on a truncated cone at approximately 40° to the horizontal plane. This angle matches an average angle at which Optus B satellite is observed from different locations in Australia. The antenna elements are cavity-enclosed, dual patch electromagnetically coupled antennas with increased height above the ground plane. The right hand circular polarisation is obtained using two orthogonal feed probes and a 3dB quadrature coupler. Other types of elements such as aperture coupled microstrip patch antennas which can be included in the array have also been developed at the University of Queensland [4]. For the operation of the array, a switching system is used in which 3 out of 14 elements are turned on at once to form a switchable active sub-array. The developed antenna elements including a 3dB coupler features the return loss of 20dB across the required 7% Mobilesat frequency band. The axial ratio for the circular polarisation in the boresight direction does not exceed 1.5dB across the Mobilesat frequencies. The element's gain is in the range of 8.15 to 8.55 dBi. The gain of the 3-element sub-array (including losses in the 14-3-ON divider) is is between 11.7 to 12.4 dBi.

The structure of 14-3-ON switchable power divider/ combiner is shown in Figure 3. It consists of a coaxial feed and 14 microstrip ports [5]. At any instant of time 3 ports are activated and 11

deactivated by suitably designed switch sub-networks. The 14-3-ON divider features a 10dB return loss with approximately 1.5dB excess insertion losses across the Mobilesat frequency band.
To provide a beam steering capability for the designed array, a satellite tracking system is used. Two signals are used for the control. One signal comes from the signal strength indicator from the telephone terminal and the second one comes from an angular rate sensor. Two varieties of the satellite tracking systems have been developed. One of the developed systems is shown in Figure 2. Both systems use an angular rate sensor and a Motorolla 68HC11 microprocessor in conjunction with support chips. The satellite tracking algorithm is based on a combination of closed and open loop tracking techniques.
The field trials of the developed antenna system included the mounting of the antenna on a car and observing the signal strength and voice quality while the vehicle was in transit. The NEC designed Mobilesat™ transceiving equipment was used during these tests. It was noticed that whenever the vehicle would pass dense trees in line-of-sight to the satellite, the received power level would momentarily drop down as expected. Generally, the signal would be around level 12 on the handset (which is considered as a strong signal), and would drop to around 6 to 9 for reasonably dense trees. It was found that the signal strength would recover very quickly as soon as the obstacle was cleared. It was discovered that in such situations, the tracking algorithms which predominantly relied on the open loop mode were superior. The performance of the system on the motorways was very smooth with the only outages occurring during the phase of passing bridges.

3. Briefcase Antenna System

As the mobile array described above has to be permanently fixed to the vehicle's roof, this may be found inconvenient in some situations. Due to this reason, alternative, briefcase type antennas have also been developed at the University of Queensland [3](*). One of the completed briefcase antennas is shown in Figure 4. The radiating antenna structure including a two-element linear array and associated feeding elements, couplers and power dividers, is located in the lid of the briefcase. The antenna elements are identical to those already used for the 14-element array. The transceiving equipment, handset and batteries are inside the main compartment of the briefcase. The full testing of the briefcase antenna involved taking the system to various different locations to monitor the received power levels on the handset and to see if voice communications via the satellite could be maintained. The regions in which the antenna was tested were restricted to locations around South East Queensland, Australia. The power levels indicated on the phone handset were in the proximity of 10. In all the tests performed, good quality voice communication was always maintained.

4. Conclusions

An overview of research activities at the University of Queensland concerning the design and testing of antennas for accessing Mobilesat services in Australia has been presented. For accessing Mobilesat services, two antenna systems have been developed, one in the form of a 14-element electronically steered in azimuth cylindrical array and the other, a 2-element briefcase type antenna. The two antenna systems have been extensively tested and proved to be fully operational.

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(*) The second briefcase antenna configuration is based on a 2x2-element sequential array with aperture coupled microstrip patch antenna elements described in [4].

References

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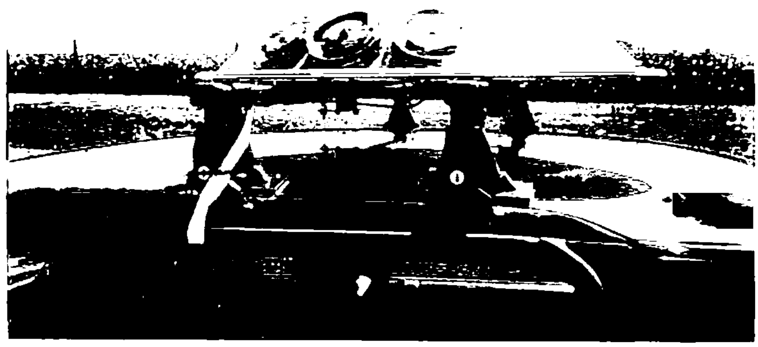
(a) mounted on the roof of a car



(b) underside view

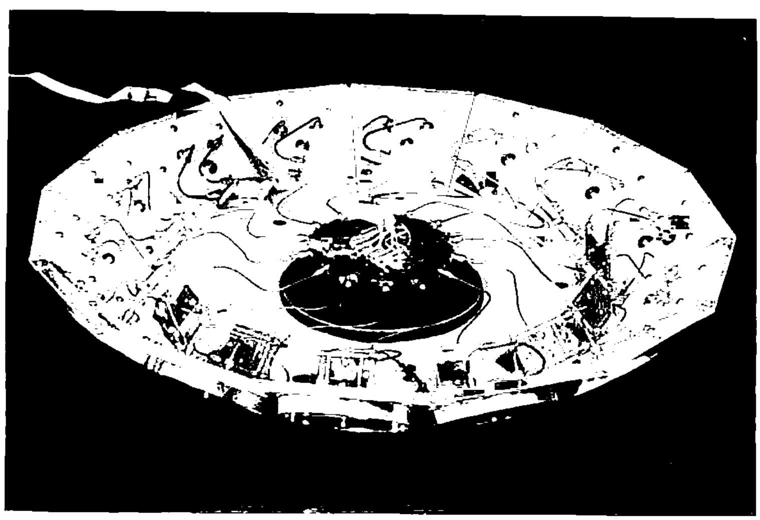


Figure 1. Mobilesat antenna array

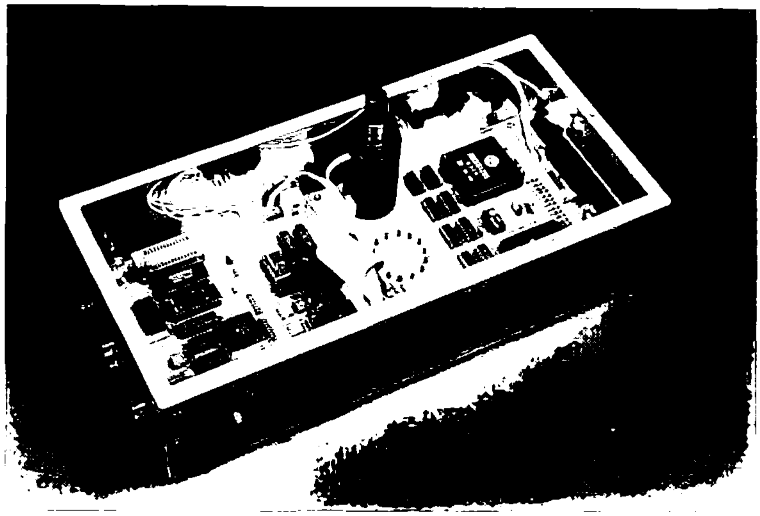


Figure 2 Satellite tracking electronics

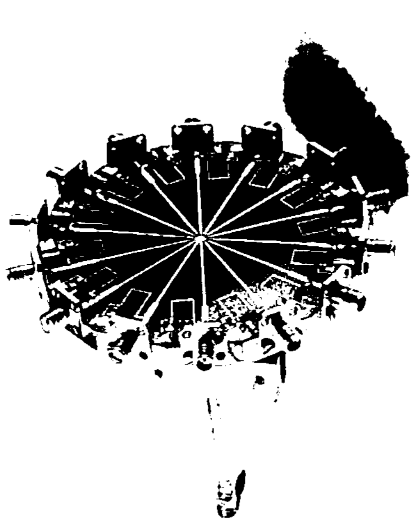


Figure 3 A 14-way 3-on radial switch.

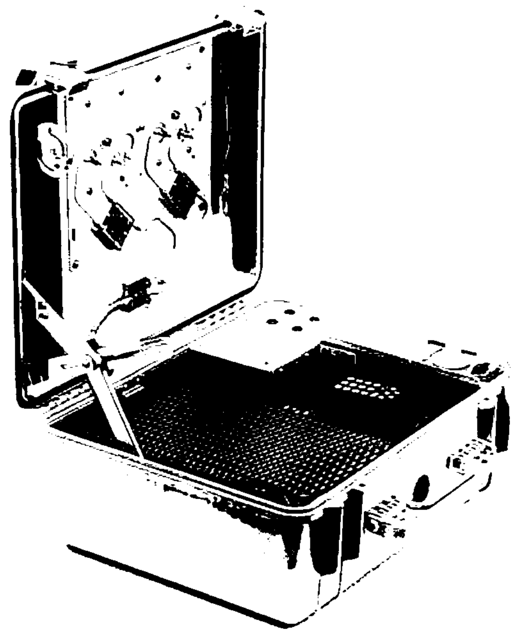


Figure 4 A briefcase antenna system.