REPORT ON NAPEX XIII

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1. INTRODUCTION

The NASA Propagation Program has been supporting research on Earth-space propagation, largely at universities, since the sixties when the Advanced Technology Satellites (ATS series) were first launched. In 1980 the management of the program was placed in the Jet Propulsion Laboratory (JPL) in Pasadena, California. The NAPEX (NASA Propagation Experimenters) Meetings date from the 1980 JPL involvement in the program. During the early eighties, the program addressed propagation impairments to communications at frequencies above 10 GHz with emphasis on measured data from satellite beacons, the effects of rain, and the modeling of rain effects. With the advent of interest in land mobile-satellite communications, a transition occurred, and primary attention in the Program was focused on frequencies between 800 and 1600 MHz and particularly on attenuation from signal blockage by roadside trees. The program is again in a transition period. Redirection by John Kiebler from NASA Headquarters and Dr. Faramaz Davarian from JPL is apparent in the work and future plans reported at NAPEX XIII (San Jose, California June 30, 1989).

2. OVERVIEW OF NAPEX XIII

The Agenda for NAPEX XIII consisted of three Technical Sessions treating

- #1 Mobile Satellite Propagation Experiments,
- #2 Propagation Experiments above 10 GHz, and
- #3 ACTS.

Papers in Session #1 treated the JPL MSAT-X Program; measurements made in Australia of the Japanese satellite ETS-V, with the support and assistance of AUSSAT; Japanese measurements of ETS-V and plans for ETS-VI; and reports on simulation and LMSS modeling. Papers in Session #2 treated the inter-laboratory consistency of data sets; radar rain studies; radiometer studies; a low-elevation angle data set; an optical study; papers dealing with proposed European propagation experiments on the Olympus Satellite; and proposed Italian experiments on Italsat. Session 3 was on the NASA Advanced Communications Technology Satellite, ACTS and concerned mostly management-oriented papers with the exception of a paper by Stutzman and Campbell on U.S. experiments for the OLYMPUS satellite, a precursor of experiments for ACTS.

3. MEASUREMENTS OF ETS-V and INMARSAT IN AUSTRALIA AT L-BAND

Land mobile-satellite propagation measurements were made at 1.5 GHz in South-Eastern Australia during an 11 day period in October 1988. These measurements were part of a continuing examination of propagation effects due to trees and terrain for the land mobile-satellite service (LMSS). Transmissions (cw) from the Japanese ETS-V and INTELSAT INMARSAT Pacific geostationary satellites were accessed. Previous measurements by the authors were performed at both L-band (1.5 GHz) and UHF (870 MHz) in Central Maryland, North Central Colorado, and the southern United States region from New Mexico to Alabama (4, 5). Some objectives of the Australian campaign were to expand the previous data base acquired in the U.S. to another continent, validate a U.S. model for estimating the fade distribution, establish the effects of directional antennas, and assess the isolation between copolarized and crosspolarized transmissions. Generous assistance from Australian and Japanese scientists and authorities made it possible for all these objectives to be met.

Left-hand circularly polarized (LHCP) cw transmissions from the Japanese ETS-V satellite (EIRP = 55.9 dBm) were received at a frequency of 1545.15 MHz. Elevation angles ranged from 51 degrees in Sydney to 56 degrees at Coolangatta. The ETS-V transmissions were the predominant measurements (28 runs, 446 km). Measurements of transmissions at 40 degrees from INMARSAT Pacific (RHCP, 1541.5MHz) were also made (10 runs, 68 km). Quadrature detector (BW=500 Hz) and power detector (BW = 200 Hz) output were monitored, the latter with an unshadowed signal-to-noise ratio of 22 and 32 dB employing high- and low-gain antennas respectively. Only signal levels with fade margins greater than 15 and 25 dB respectively were considered in the analysis (i.e. no less than a 7 dB signal-to-noise ratio in either mode). The received data were sampled at a 1 KHz rate and the samples stored on magnetic disk via a PC system.

A comparison of measurements made over 403 km in Australia with a U.S. derived prediction model indicated an agreement within 2 dB in the 1 to 20% exceedance range. Attenuation by trees was systematically higher (up to 3 dB at the 4% probability level) for the high-gain than for the low-gain antenna, as would be expected, but the high-gain antennas still significantly outperformed the low-gain ones.

4. RADIOMETER STUDIES

Over the years the NASA Propagation Program has been involved in many studies which included radiometers. At first these were carried out in parallel with beacon satellite measurements and served to calibrate radiometer attenuation determinations against the direct measurements. Later, in the eighties, following the demise of COMSTAR 4, riometers were used to continue attenuation determinations from sites where direct measurements were deemed inadequate. With the advent of interest in higher frequencies and of services willing to tolerate more severe outage times (e.g. 1% and 5% instead of 0.01%) attention shifted to cloud and light rain impairment. The study by Westwater et al. of the Wave Propagation Laboratory (WPL) of NOAA (2) is a consequence of this latter concern.

Over the past decade WPL has gained extensive experience using both zenith-viewing and steerable dual-frequency instruments operating at 20.6 and 31.65 GHz (6,7). These instruments provide unique observations of precipitable water vapor and integrated cloud liquid. Within the last year, 90 GHz has been added to the steerable and transportable radiometer. All three channels have equal beamwidths of 2.5 degrees and point in the same direction from the same location. Measurements have recently been carried out at San Nicholas Island, California and Denver, Colorado. From these data, several statistical and physical quantities, relevant to radio propagation studies have been determined and compared with theory.

The data, after conversion to attenuation by use of the mean radiating temperature approximation were processed to derive attenuation statistics. Both clear and cloudy attenuations statistics were examined and compared with results of recent theories. For the clear atmosphere, water vapor models of Waters (8) and Liebe and Layton (9) were compared. At 20.6 and 31.65 GHz, the model of Waters agrees better with measurements; at 90.0 GHz the model of Liebe and Layton is far superior. For clouds, comparison of average mass absorption coefficients between measurement and theory for liquid water generally agreed to within 30%. It was found that attenuation for any two channels can be used to predict that of the third to within 25%.

5. PROPOSED U.S. MEASUREMENTS OF OLYMPUS

The proposed Olympus measurement program (3) in the U.S., led by the Satellite Group from Virginia Tech, has the dual objective of acquiring low-angle data and producing receivers which can then be used for ACTS, NASA's Advanced Communications Technology Satellite. Several facets of this study were presented at the Olympus Utilization Conference in Vienna in April, 1989 (10). The Virginia Tech Group will conduct a propagation experiment in 1990 using the 12, 20, and 30 GHz beacons on Olympus. This will be carried out in Blacksburg, VA at an elevation angle of 14.5 degrees. The objectives will be to investigate fade slope and duration, frequency scaling, and uplink power control. Other proposed projects include the Cooperative Data Exchange Experiment (CODE); a 20/30 GHz Personal Access Satellite Experiment (PASS), a rain scatter interference measurement program and a small diversity experiment.

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