A Simple Ka-band LEO Satellite Channel Simulator Based upon the EXCELL Rain Cell Model

Jueren (Steven) Ma, Boubacar Diallo, and David G. Michelson
Department of Electrical and Computer Engineering
University of British Columbia
Vancouver BC, Canada V6T 1Z4
Email: {juerenma, davem}@ece.ubc.ca

Fading due to rain events occurring along earth-space paths can be especially troublesome at Ka-band. Numerous measurement campaigns conducted during the 1990's, *e.g.,* those conducted using the Olympus and ACTS satellites, have contributed greatly to both our understanding of rain fading at Ka-band on fixed links to satellites operating in geostationary orbit. In such cases, temporal variation in fading intensity is due to a combination of the slow drift of rain cells through the slant path between the terminal and the satellite and natural variations in rain rate and rain drop size over time. Appropriate design rules have been developed.

Interest in the use of Ka-band links by satellites operating in low earth orbit has increased markedly in recent years. However, the fading environment is quite different because the motion of the satellite across the sky causes the earth-space path to change rapidly and pass through any rain cells in the vicinity very quickly. The result is very rapid fading and relatively steep fade slopes compared to the geostationary case. Because comprehensive measurement data have not yet been compiled for LEO links, we require a method for simulating fading on such links so that the performance of alternative fade mitigation techniques can be fairly assessed and compared.

Here, we propose a simple earth-space channel simulator based upon: (1) the well-known EXCELL model of horizontal rain structure that was developed by Capsoni *et al.* (1987) and (2) a method for obtaining the parameters of the EXCELL model from ITU-R rain zone parameters that was developed by Goldhirsh (2000). As the satellite sweeps across the sky, the intersection of the path with rain cells in the vicinity is determined, the rain rate and rain drop sizes are predicted, and the specific and total attenuations computed. The result is a prediction of the slow fading to be expected in such cases. Fast fading due to tropospheric scintillation and other effects can easily be incorporated if required.

We have compared our simulator's prediction of the statistics of instantaneous frequency scaling ratio (IFSR) of attenuation with respect to clear air (ACA) at 20 and 30 GHz against measured statistics obtained using the Olympus geostationary satellite and found reasonable accuracy. If a more realistic model of the spatial structure of the rain field and time domain variation of rain itself can be provided, the accuracy of the model can be further improved.