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UNLOCKING THE POTENTIAL OF HIGH-FREQUENCY BANDS: CHALLENGES AND OPPORTUNITIES IN KA, Q/V, AND W SPECTRUM COMMUNICATIONS

Abstract

As communication technologies continuously evolve, the utilization of high-frequency bands such as Ka (20-30 GHz), Q/V (40-50 GHz), and W (70-80 GHz) has become increasingly prevalent. These bands are crucial for meeting the escalating demands of global connectivity due to their significant bandwidth capacities, enabling ultra-high-speed data transmission. High Throughput Satellite (HTS) systems in the Ka band can deliver hundreds of Gbits/s, while Very High Throughput Satellite (VHTS) systems utilizing Q/V and W bands are projected to reach capacities in the terabit per second range. This capacity enhancement is vital for maintaining competitiveness with terrestrial networks and reducing the cost per transmitted bit.

However, these high-frequency bands face considerable challenges, primarily due to their sensitivity to atmospheric disturbances such as rain and water vapor. These phenomena can cause temporary but severe variations in the amplitude and phase of the transmitted signal—a phenomenon known as fading—which can drastically degrade signal quality, particularly in humid climates where these bands may become nearly unusable. Furthermore, technical issues such as the maturity of the technology and the associated costs of components for Q/V and W bands, traditionally reserved for defense applications, also present significant hurdles. These bands require further technological developments to become economically viable for civilian applications.

This paper explores the dual aspects of potential and challenges presented by high-frequency bands, proposing pathways to overcome the hurdles while maximizing the benefits of their substantial capacity and speed for global satellite communications.