W-band Propagation in the Maritime Environment

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The maritime environment is a complex medium for understanding and predicting the propagation of electromagnetic energy in the millimeter-wave band. Many refractive effects, such as ducting, that may be considered "anomalous" overland can be commonplace overwater or in coastal regions. Additional impacts, such as the attenuation from water vapor, sea spray and the dynamics of scattering off ocean waves, can make signal propagation highly dependent upon the environmental conditions. W-band (75 - 110 GHz) is an attractive candidate for communications and radar systems due to the wide bandwidth available and its low gaseous attenuation relative to adjacent millimeter-wave bands. As the cost for components decreases and their performance capabilities increase, W-band systems will become more prevalent. Understanding how this frequency band propagates in a maritime environment will enable system designers to better account for the expected variability due to environmental factors.

The JHU/APL-developed Tropospheric Electromagnetic Parabolic Equation Routine (TEMPER) has been used to demonstrate some of these effects. The results show that near-surface, horizon-oriented paths are highly susceptible to the effects of evaporation ducting. While this phenomenon often leads to over-the-horizon propagation, which can extend communication and surface-search radar ranges, the complexity of the multipath fading inside the duct can lead to signal fading locations that vary much more dramatically with range, height and frequency than are seen at lower frequencies. Ship-mounted systems with antennas at multiple heights and frequency diversity of several GHz will be more adept at overcoming these fades.

To validate the predictions of the TEMPER model, several measurements were made of the W-band propagation during October 2015 off the coast of North Carolina as a part of the Coupled Air Sea Processes and Electromagnetic ducting Research (CASPER) program. Alongside the RF measurements, the atmospheric and ocean wave conditions needed to model the refraction, attenuation and scattering effects were also measured with various instruments. Preliminary results comparing these measurements will various models will be presented.