Refractive Turbulence, Transient Propagation Disturbances, and Space Situational Awareness

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This paper examines the proposition that mission limiting space situational awareness (SSA) has important and fundamental turbulence and propagation physics issues to be investigated. We propose to call these aspects, propagation situational awareness (PSA). Transient disturbances can be present in communication to and from ground stations and satellites and in the performance of ground based and space based optical and infra-red imaging and tracking systems. Propagation frequency is important in characterizing whether the source of the disturbance lay in the electron density fluctuations of ionosphere or the refractive turbulence of the neutral atmosphere. Over the past ten years high altitude airborne measurements of clear air and refractive turbulence were made in Australia to support design and performance evaluations of the Airborne Laser. More recently in collaboration with the Australian Defence Science & Technology Organization (DSTO) smaller aircraft were used to investigate the effect of ducting layers on the signal strength of an airborne emitter as a low cost simulation of potential for loss of track in the coverage pattern of an airborne radar. From 2002 onward we were also tasked to do fundamental investigations of clear air turbulence for flight safety evaluations of both manned and unmanned high altitude surveillance aircraft. These investigations covered a wide spread in frequency, from infra-red to microwave. Most of these investigations were confined to measurement days and altitudes where strong turbulence was expected. The decision to measure was based on predictions of the location of jet streams relative to the measurement area as well as bulk gradient Richardson (Ri) vertical profiles derived from radio sound measurements from stations surround the potential measurement location. We will show how all these analyses and decision aids, including the Ri profiles, can be used to estimate potential for propagation disturbances to SSA. Current DOD interest in net-centric communications, airborne networks, and joint space and airborne networks all can have critical Space Situational Awareness aspects under disturbed propagation conditions.

Two- aircraft combined propagation measurements at 10 GHz and refractive and clear air turbulence measurements are planned jointly with DSTO in Australia in their winter season in 2008 and 2009. These two-aircraft measurements are fundamental to developing a PSA analysis scheme and supporting progress in propagation modeling through strong and weak turbulence. It will also be interesting to apply the results of these measurements to the assessment of the role that Kolmogorov and non-Kolmogorov scaling play in interpreting interstellar scintillation and the power law behavior at scales between what astronomers call refractive and diffractive scintillation and its ultimate relevance for ionospheric scintillation.