High-Bandwidth Communication in the Maritime Environment for Tactical Applications

R. Sova*, R. Rottier*, D. Terry*, J. Juarez*, J. Sluz*, D. Young*, B. Brandenburg*, T. Hanley*, C. Etheridge*, J. Makowski*, F. Davidson†, and C. Nelson†

*JHU Applied Physics Laboratory, Laurel, MD; and
†JHU Department of Electrical and Computer Engineering, Baltimore, MD

The U.S. Navy forces rely heavily on low-bandwidth RF communication networks for tactical applications. This reliance creates two major issues for the operational Navy: bandwidth availability for increasing bandwidth demand of advanced high-resolution sensors and lack of contingency capability for jamming and detectability. Free-space optical (FSO) communication links provide high-bandwidth communication that is difficult to jam or detect but is inoperable in the presence of clouds or fog. One solution is a hybrid RF/optical link that can operate under most weather conditions and provide high-bandwidth, secure, jam-proof communications during optimal conditions.

The purpose of this research is to evaluate hybrid RF/optical communication links in a maritime environment. RF link performance is driven by inhomogeneities in the vertical refractive index profiles that lead to atmospheric ducts. The ducts can be categorized as subrefraction, superrefraction, or surface trapping. They lead to anomalous RF propagation that has a direct impact on transmission fading. The index of refraction at microwave frequencies is a function of temperature and humidity; therefore, vertical profiles of temperature and humidity are needed to understand the RF propagation conditions.

Ignoring attenuation effects attributable to clouds or fog, optical link performance is driven by optical turbulence along the horizontal laser beam path between the transmitter and receiver. Optical turbulence is caused by variations in the refractive index due to temperature fluctuations. Heating and cooling and motion of the air mass within the optical path have direct impacts on the strength of the optical turbulence, leading to large fluctuations in the optical signal strength and increased laser beam divergence. The turbulence strength is measured by using a scintillometer, and the impact on the laser beam propagation is characterized by measuring the beam profile at the receiver and the temporal statistical properties of the received optical power.

To evaluate the performance of a hybrid RF/optical link, a field test was performed off the mid-Atlantic coast near Wallops Island, Virginia, in July 2009. A ship-to-shore link was set up between a former Coast Guard lookout tower located on Cedar Island, Virginia, and the APL research vessel *Chessie* over a range of 1–20 km (optical horizon). The hybrid link consisted of an RF link operating in the C-band and a bidirectional optical link operating in the near-infrared at 1550 nm (Figs. 1 and 2). A time series of received signal losses was collected for both links and bit-error rate statistics of a 2.5 Gbps signal were collected for the optical link. The hybrid link was well instrumented to characterize the vertical refractive index profile for RF propagation and the optical turbulence properties along the horizontal path for optical beam propagation.

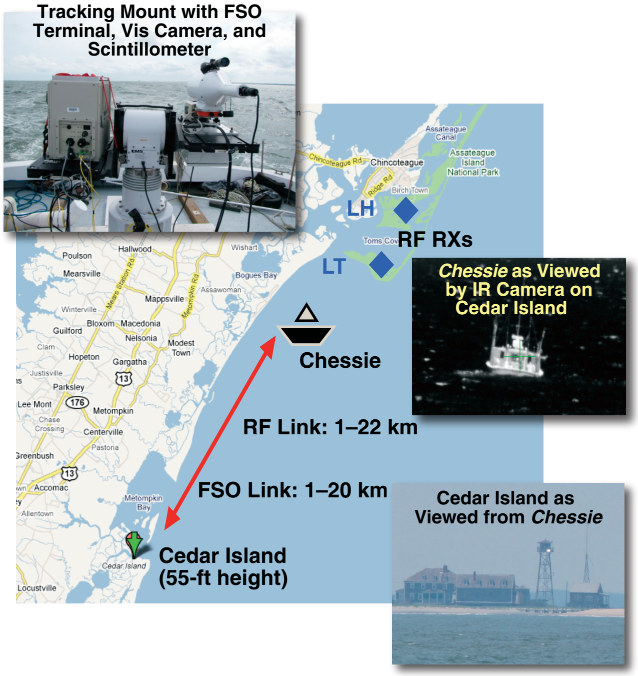

Figure 1. Field test performed near Wallops Island, Virginia, in July 2009.

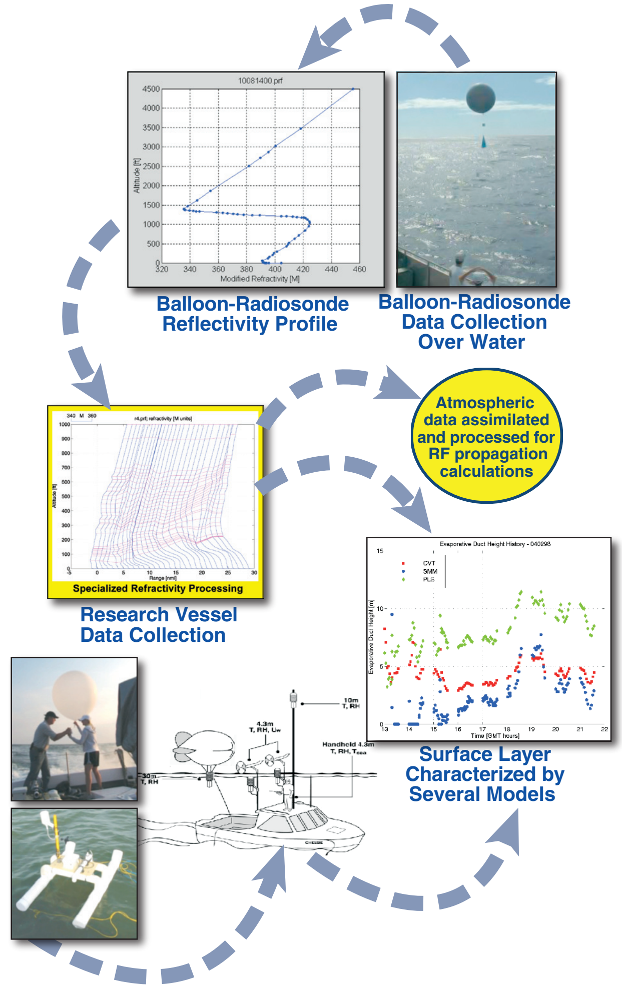

Figure 2. Atmospheric and surface data were collected and processed for RF propagation calculations.

A unique data set was collected on 10 July 2009, when the atmospheric conditions were very stable and homogeneous over the entire testing period. This data set provides well characterized channel properties that will be used in conjunction with theoretical RF and optical propagation models to evaluate link performance and compare with measured link data. The test data also provided insights into new methods for optimizing optical link performance.

For further information on the work reported here, see the references below or contact raymond.sova@jhuapl.edu.

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