Challenges in Modeling Shipboard Wireless Propagation Environments

David G. Michelson, Yiqinq Huang, Zahra Vali and Aresh Rizvi
The University of British Columbia, Vancouver, BC, Canada V6T 1Z4

Shipping will soon undergo its most radical transformation since sail gave way to steam at the end of the 19th century. Many of the same environmental and safety concerns that are driving change in land transportation are also driving change in the marine industry. In particular, the marine industry is pursuing four *grand challenges* that aim to protect the environment and improve safety and security: 1) *Dramatically improve the efficiency of ships and reduce GHG emissions from international shipping.* Climate change is an urgent concern, and the International Maritime Organization (IMO) is vigorously seeking swift implementation of new measures to improve energy efficiency and reduce GHG emissions from international shipping. 2) *Greatly reduce noise pollution caused by shipping and other marine enterprises*. The noise produced by ships can travel long distances, and marine species who may rely on sound for their orientation, communication, and feeding, can be harmed by this sound pollution. As a result, the marine industry is actively developing ship noise mitigation technologies. 3) *Improve shipboard safety and reduce the possibility of collisions at sea*. As ships become larger and more numerous and as ship's crews become smaller, it is increasingly vital to dramatically improve situational awareness and help to avoid the human, economic and environmental impacts of shipboard incidents and collisions at sea. 4) *Upgrade the sensor, information, and decision systems aboard ship.* Accurately and timely indications and warnings of surface and near-surface threats to both merchant shipping and naval forces are essential to save lives and protect commerce. New hull designs, advances in power conversion technology, and innovative sensors, navigation, automation and control techniques, all linked by next-generation shipboard communications networks, will all play important roles in achieving these goals.

For most of the twentieth century, most wireless studies aboard ship focused on electromagnetic compatibility between the numerous antennas that are installed on the ship's superstructure. With the advent of short-range wireless data and sensor networks in the early 2000's, researchers began to assess the nature of wireless propagation below decks and the potential role of personal communications and personal, local area, and sensor networks in such environments. As expected, the confined spaces below decks, with their numerous reflecting surfaces and bulkheads, severely attenuate and distort wireless signals and greatly complicate wireless system planning. Moreover, the propagation environment is highly variable and greatly affected by the opening and closing of watertight doors and loading or unloading of cargo and stores. Here, we review progress in measurement and modeling of shipboard wireless propagation environments over the past fifteen years. Although advances in wireless test and measurement technology have somewhat eased the task of conducting link-level measurements and assessing signal attenuation and distortion, such information is insufficient to support design of modern shipboard wireless networks. The most important challenges remain: 1) characterizing the variability of individual wireless links and 2) assessing the implications of such variability for the topology of wireless networks and the routing protocols used to ensure reliable communications over such networks. Accordingly, it seems likely that network performance data obtained from live networks will be as or perhaps even more important as link-level data obtained using lab-grade test and measurement equipment going forward.