学校编码：10384　　分类号____密级____
学　　号：23320141153242　　UDC____

厦门大学

硕 士 学 位 论 文

海上宽带移动无线信道建模研究

Research on Broadband Mobile Wireless Channel Modeling at Sea Surface

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论文提交日期：　2017 年　　月
论文答辩时间：　2017 年　　月
学位授予日期：　2017 年　　月

答辩委员会主席：_____
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2017 年　月

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摘　要

宽带移动无线网络几乎覆盖了地球上大多数的陆地，而海上宽带移动通信极大地落后于陆地无线通信，更多只能依靠昂贵的卫星进行通信。随着技术的发展，海上宽带无线通信系统的搭建有望实现。海上无线宽带信道建模是搭建海上宽带无线通信系统的基础。目前已有大量的针对海上无线信道测量工作展开。无线信道的测量工作耗时漫长，测量环境受限，无法准确地描述多变的海上无线信道。而通过仿真建模，可以快速模拟各种移动场景，得到较为精确的信道模型，修正经验模型的误差，因此对海上无线信道的仿真建模同样具有重要的意义。

借助于升空平台，可实现对海上无线网络的覆盖。本文模拟海上升空平台与船只通信的场景，对此场景下的海上无线信道特性进行研究，克服了海上无线信道实测带来的困难。首先，基于空间分区的射线追踪改进算法对海上电磁波传播路径进行追踪，得到海上无线信道空间到达角的统计分布，其服从于高斯分布或瑞利分布，与传统的陆地无线信道模型有较大的差异。到达角的统计特征可快速实现对海上无线信道的建模研究。其次，基于追踪结果，本文对海上移动信道进行仿真建模，得到接收信号和多普勒频移谱，接收信号幅值服从于莱斯分布。再次，本文对海上宽带时变信道进行建模，得到其时变信道冲激响应函数、时变频率响应、信道散射函数和平均功率时延分布，同时将仿真结果与相关实测数据对比，趋势基本吻合，进一步验证了仿真的可靠性。最后，基于搭建的简易无线信道损耗平台，对厦门近海海域进行了测量，得到开放频段短距离损耗模型，与仿真模型对比，进一步验证了仿真平台的可靠性。

本文通过对海上宽带移动无线信道建模研究，对搭建海上宽带通信网络的建设提供参考和指导。海上多径的分布与海面的运动规律具有相关性，下一步可以考虑探寻海面运动规律对于海上宽带时变信道的影响，修正传播模型。

关键词： 海上通信；宽带信道；移动信道

Abstract

With the mobile wireless network has covered most of the land on the earth, there are still lack of network coverage in the important channels and ocean operating areas. The broadband mobile communications are still relatively backward at seas. In most marine cases, only expensive satellite communications can be used. Thanks to the progress technology, it is expected to achieve wireless network coverage in remote areas and offshore areas. Modeling of marine broadband wireless channels is the basis of constructing a communication system. At present, there are a large number of radio channel measurement work carried out at seas. The time required for the measurement is long and the cost is huge. The channel measurement is limited by environments, and the changing maritime wireless channel can not be accurately described through the measurement. Through channel modeling simulation, it is possible to quickly simulate various mobile scenes and obtain more accurate channel model, and correct the error of empirical model. Therefore, over-sea surface channel modeling simulation is significant.

With UAV, the offshore wireless network coverage can be achieved. In this paper, a communication scene between a UAV and a boat is simulated. Then the marine wireless channel is studied. Firstly, an improved spatial partitioning ray tracing algorithm is proposed to track the propagation path of electromagnetic waves at sea surface. The distribution of AoA and EoA are obtained according tracking results, which is subject to the Gaussian distribution or the Rayleigh distribution. The results are greatly different from the traditional terrestrial wireless channel model. The distribution of AoA and EoA can help establish a wireless channel model quickly. Secondly, a mobile channel is simulated and modeled based on the track results. The Doppler frequency shift spectrum and the reception signal is obtained. The envelope of the received signal is subject to Rice distribution. Then, the time-varying channel is simulated and the time-varying channel response function, time-varying frequency

response, channel scattering function and average power-delay profiles (APDP) are obtained. The simulation results are compared with the measurement results comes from relevant references, and the results are broadly similar. By comparison, the reliability of the simulation is further verified. Finally, a loss measurement is carried out in the coastal waters near Xiamen based on the simple wireless channel loss measuring platform, and a loss model is built. Then a simulated path loss model is also taken to compare the measurement results the results indicates that both are close which verifies the reliability of the simulation.

In this paper, the research on the modeling of sea broadband mobile wireless channel is used to provide reference and guidance for the construction of maritime broadband communication network. The distribution of the multi - path at sea is related to the law of the sea surface. The influence of the sea surface motion law on the sea broadband time - varying channel can be explored next step and the wireless channel model can be optimized.

Key Words：Over-sea communication; broadband channel; mobile channel

目录

Contents