# Radio Engineering: First Lab Session

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## 1 Introduction

In 2012, Eurecom carried out a measurement campaign to study wireless broadband communications between boats on the sea. Because of the wide availability, reasonable prices, and high peak throughput, the IEEE 802.11n standard was chosen.

IEEE 802.11n is an amendment to the IEEE 802.11 wireless networking standard. Its purpose is to improve network throughput over the two previous standards—802.11a and 802.11g—with a significant increase in the maximum net data rate from 54 Mbit/s to 600 Mbit/s.

The questions that will be answered in this lab session is which data rates can be supported as a function of the distance of the boats.

### 1.1 Hardware

The hardware used for the measurements is the Javelin system from Wittelcom. This box can be used both as a master (access point) and as a slave (user terminal). It comes either packed together with a directional antenna (JL-55-23) or in an individual box that can be connected to an external antenna, such as the omi-directional antennas (ANT4958Q12VH) from Foshan Lanbowan Communications.

### 1.2 Measurement Description

For the measurements we used the JL-55-23 as an access point and the omni-directional antenna as a slave. The access point was mounted on land at a height of approximately 25m (above sea level) and the omni-directional antenna was mounted on the boat at about 3m above sea level. We used a carrier frequency of 5.6GHz, a bandwidth of 40MHz, and the maximum transmit power of 23dBm. During the measurements we recorded amongst others the received signal strength for both polarizations.

The measurement data is stored in the file `rssi_distance_omni_boat.mat`[1]. The file contains two data pairs (rssi1,d1) for horizontal polarization and (rssi2,d2) for vertical polarization. The RSSI is measured in dBm and the distance in kilometers.

[1] The file can also be downloaded from the course webpage

# 2 Tasks

1. The data-sheet fo the JL-55-23 specifies different RX sensitivity levels for different data rates. Additionally, assume that for the correct decoding of the lowest modulation and coding scheme (MCS) a SNR of 0dB is required. What is the maximum allowed receiver noise figure at room temperature ($T = 300\text{K}$) for the given system?

2. Plot the measurement data (RSSI vs distance) for both polarizations. Try to explain where the difference between the two polarizations comes from!

3. Take the two-path model without the large distance approximation (Equation (4.55) from the Appendix), and compute the received signal strength according to
$$P_{\mathrm{Rx}}(d) = |E_{\mathrm{tot}}(d)|^2 A_e,$$
where $A_e$ is the receive antenna aperture, which is related to the receive antenna gain by $G_{\mathrm{Rx}} = \frac{4\pi}{\lambda^2} A_e$. Further use $|E(d)|^2 = \frac{P_{\mathrm{Tx}} G_{\mathrm{Tx}}}{4\pi d^2}$ to compute the power density at 1m. Implement this as a function in Matlab.

4. Plot the received power based on the previous function on top of the measurement data. Does the model fit the data? Try to explain why or why not!

5. Using the path loss approximation for large distances (4.59) from the Appendix, and assuming a fading margin of $M = 10$ dB, determine the maximum range of one cell for the lowest and the highest MCS.