Towards Robust Evaluation of LTE Coverage and Quality using Unmanned Aircraft System

Vivek Adarsh, Michael Nekrasov, Udit Paul, and Esther Showalter, Morgan Vigil-Hayes*, Ellen Zegura§, Elizabeth Belding

*University of California, Santa Barbara; *Northern Arizona University; §Georgia Tech*

Motivation

- Despite widespread LTE adoption and dependence, rural and tribal areas lag behind in coverage availability and quality.
- Uncovering ground truth can be resource, time and labor intensive. Hence, there is a need to develop more scalable platforms to collect accurate measurements.
- In this work, we present several measurement solutions to capture LTE signal strength measurements, and we compare their accuracy.

Overview

To evaluate actual user experience, physical assessments of cellular coverage and quality are essential. However, this process can be cumbersome and expensive. In this study, we collect ground and air measurements in two regions in Rio Arriba county, NM over a period of five days. We deploy six unique RF sensing methodologies to capture LTE signal strength measurements, and compare their accuracy.

Can we devise scalable platforms for cellular coverage and quality measurements?

Methodology

We compare different collection methods including:

- Ground-Driven User Equipment (UE) Sensing
- Ground-Driven Spectrum Analyzer
- Ground-Driven USRP
- Ground-Driven RTL-SDR
- Aerial Sensing Platform
  - Horizontal Coverage Mapping
  - Impact of Altitude
- Stationary Box

(a) UE (b) Ground Measurement Kit

(c) UAS (d) Stationary box.

Analysis

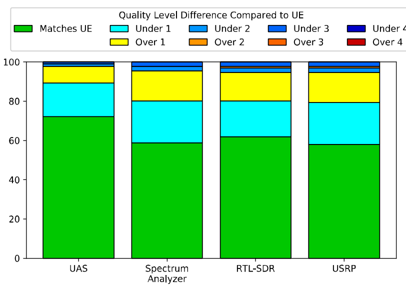

Figure 1. Accuracy of signal collection methods as compared to the UEs.

Aerial measurement techniques have 72% accuracy relative to the ground readings of UEs.

Accuracy of Data Collection Methods

- Analyzed 2,637 geographical bins, each 110m² in area.
- UE readings as the ground truth.

Longitudinal Analysis

- Analyzed 684,096 readings.
- Majority of readings fell within 1 dBm of each other.

95% accuracy in all methods, with one gradation of error margin.

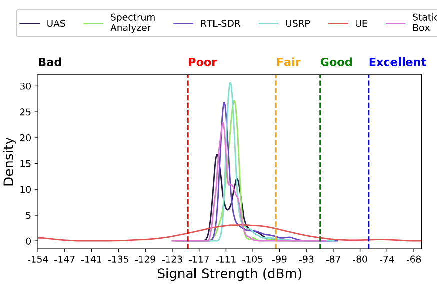

Figure 2. Kernel density estimation of transformed distributions by signal collection method.

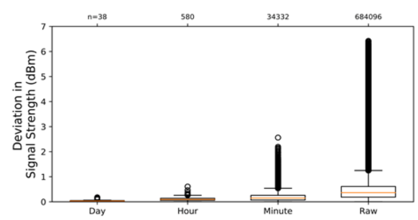

Figure 3. Distribution of deviation from mean signal strength of all LTE frequencies (stationary box).

UAS Evaluation

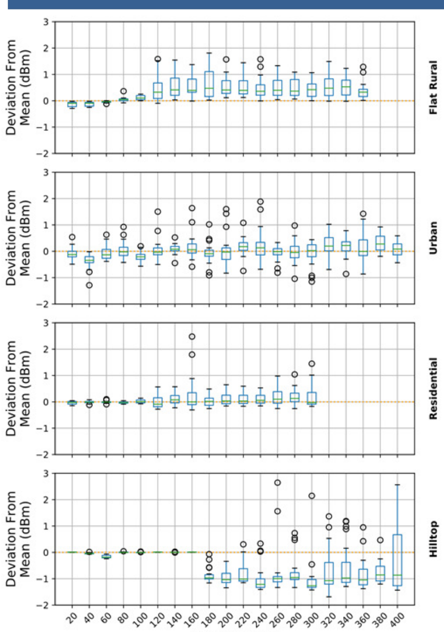

Figure 4. Deviation of (UAS) signal strength from mean.

Flat rural and residential locations: Signal strength increases with altitude.

Impact of Altitude

- Analyzed 20-foot altitude bins across all locations.
- Signal strength variation is sensitive to physical location.

Urban and hilltop locations: Altitude had less correlation with increasing altitude.

- UAS-mounted RTL-SDR adequately provides ground truth LTE signal strength measurements.
- Our low-cost solution enables accurate coverage mapping and quality assessment in regions typically neglected by other forms of assessment.

Altitudes over 160ft showed a drop in signal strength across most of the monitored LTE frequencies.

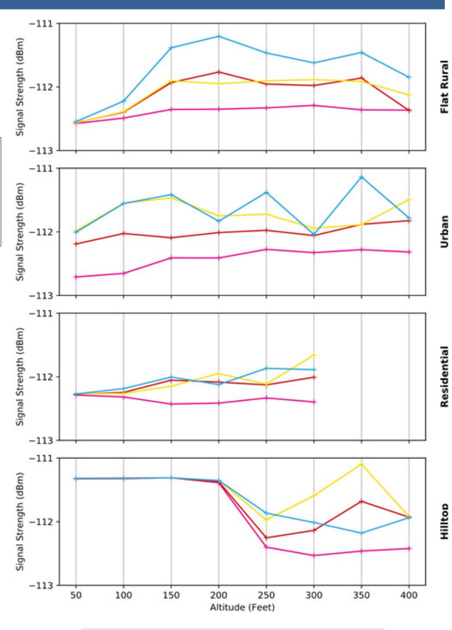

Figure 5. Signal strength change by altitude and network.

UC SANTA BARBARA

MOMENTLab Mobility Management and Networking