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Communications coverage-area modeling task

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Communications Coverage-Area Modeling Task

Task Objectives

A major objective of this task is to develop a reliable and accurate model that can determine the usable communication service area for a given transmitter location. It is expected that this model will be used either to identify uncovered regions for existing communications facilities, or to aid in the siting of new facilities. This work should also shed light on the data rates that can be realized under specific operational conditions.

An expected deliverable resulting from this task will be the capability to generate coverage area maps for a specified transmitter. In order to achieve this goal, measurements of radio signals in operational environment must be performed for the purpose of identifying faulty equipment and noise sources, and for validating propagation models used to estimate coverage areas.

Task Status Overview

As a result of past work on this effort, a terrain-sensitive propagation model has been identified that is capable of estimating received radio signal strength. The model has been modified for this application and has been interfaced to a terrain database, enabling it to produce signal estimates in a format that can be used to create coverage-area maps.

To ensure that the propagation model provides estimates that are sufficiently accurate, a data collection package has been developed (as reported in previous progress letters) that measures and records signal strength as a function of position. Work is ongoing to collect signal strength data in an effort to validate and, if necessary, modify the propagation model. Work has also begun to use the data collection package to measure small-scale fading and channel noise.

Task Status Specifics

Propagation Model Validation Results: As stated, one objective of collecting radio signal strength data is to verify that the propagation model can operate with sufficient accuracy to provide meaningful coverage-area maps. Although the propagation model used for this study has been validated in the past, there have not been enough comparisons made to provide a good statistical understanding of model accuracy. The limiting factor in the past has been the availability of quality measured signal strength data. However, the data collection package developed for this project has enabled us to efficiently and inexpensively collect sufficient data to make definitive statements regarding model accuracy for at least one particular scenario.

Determining whether an adequate signal exists for radio reception in a moving vehicle is confounded by a phenomenon known as small-scale fading. Small-scale fading is the result of multipath interference caused by reflections from other vehicles and stationary objects. These effects appear as a non-zero mean noise superimposed on the actual signal. Because of this, the assessment of signal strength cannot be determined from a single pass along a stretch of highway, but rather requires a number of passes so that the statistics of signal strength along that path can be determined.

To illustrate what small-scale fading looks like, Figure 2 plots measured signal strength as a function of distance from the transmitter for 18 separate passes on a road along with the mean value. These measurements were taken along a 26 mile section of highway (Route 4 between Durham and Concord NH as shown on the map of Figure 1) that involves a complex terrain profile between the transmitter and mobile receiver. Because a standard police band transmitter was not available to provide the source signal, a weather radio transmitter, WXJ-40, was used. This source appears to be ideal for this type of measurement since it is continually radiating, widely available, and has operational parameters closely approximating the standard police band transmitter (narrow-band FM at a frequency of 162.4 MHz, radiating power of 330 watts, isotropic radiation pattern, vertical polarization, and antenna height of 60 feet).

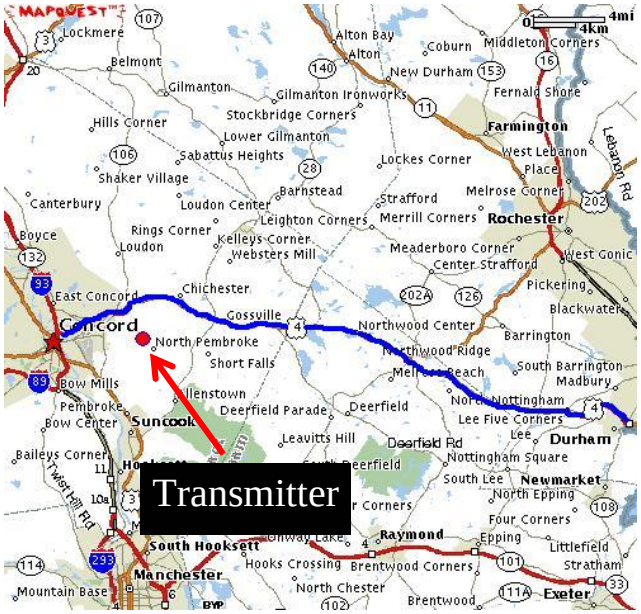

Figure 1 Map of the Part of Route 4 Where Repeatability Data Were Collected.

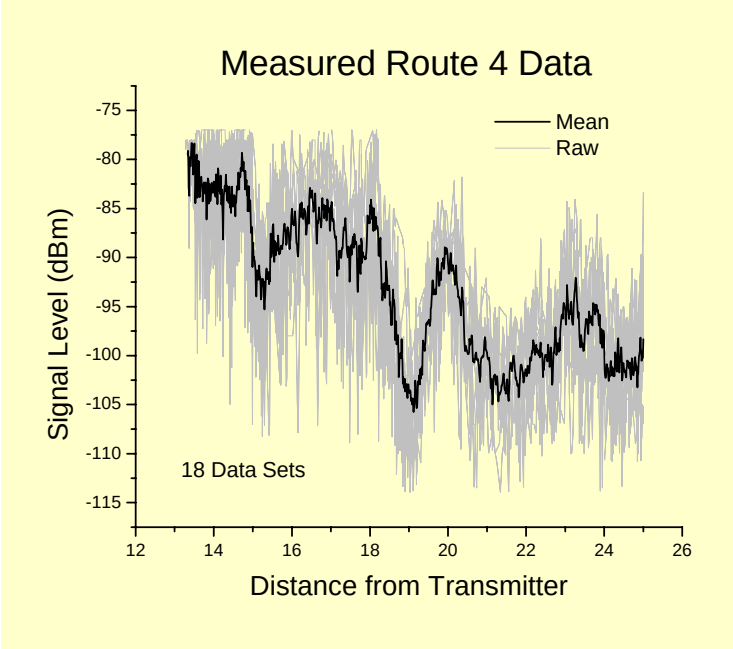

Figure 2 Plot of Raw and Average Signal Strength Data Along Route 4.

Referring to the individual signal strength data plotted in Figure 2, it is clear that a single measurement along Route 4 would not be adequate to accurately assess signal strength and hence would not be appropriate to use for validating a propagation model.

The standard approach for characterizing noisy data is to plot its mean value along with a confidence interval. An example of this is seen in figure 3, which plots the mean value of the signal strength collected along Route 4 along with a 95% confidence interval. That confidence interval is determined from the standard deviation of the measured data, and it indicates that 95% of the measured data fall within the region shown.

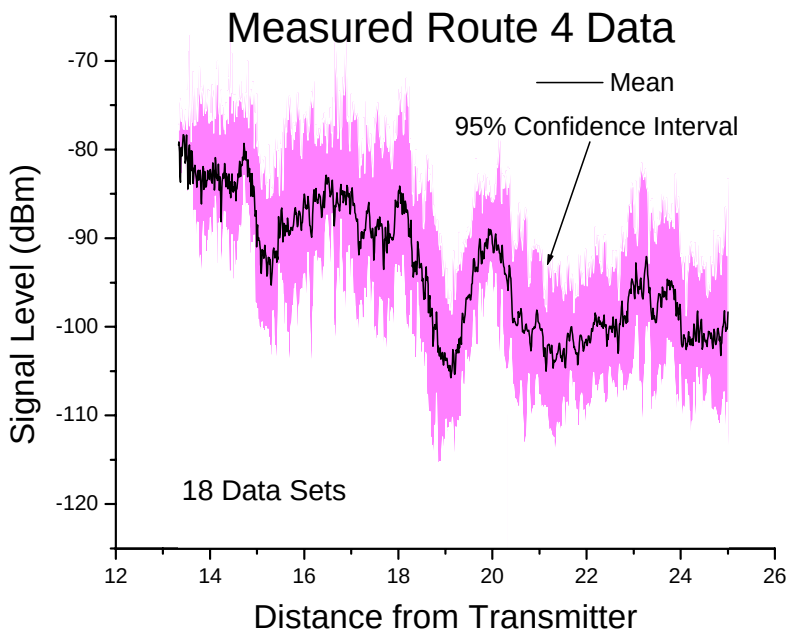

Figure 3 Mean Value Of 18 Sets Of Signal Strength Data Collected Along Route 4along With The 95% Confidence Interval.

It should be noted that the mean and 95% confidence interval derived from five sets of measured data is quite similar to the plot of Figure 3. Ongoing work at UNH is being performed to determine the minimum number of data sets that will be necessary to reasonably estimate the mean values and confidence intervals.

Because the confidence interval represents the range of values were the measured data on most likely to fall, that confidence interval, rather than the mean value of the measured data, is what is most commonly used to validate a prediction model. An example of this is seen in Figure 4, which plots the result of a propagation model (the APM model developed by the Navy) and the confidence interval determined from the measured data. As seen in the figure, the model estimate of signal strength is within the 95% confidence interval of the measured data for nearly the entire range of distances. This close agreement between measured and modeled propagation data is unprecedented for this type of complex propagation path.

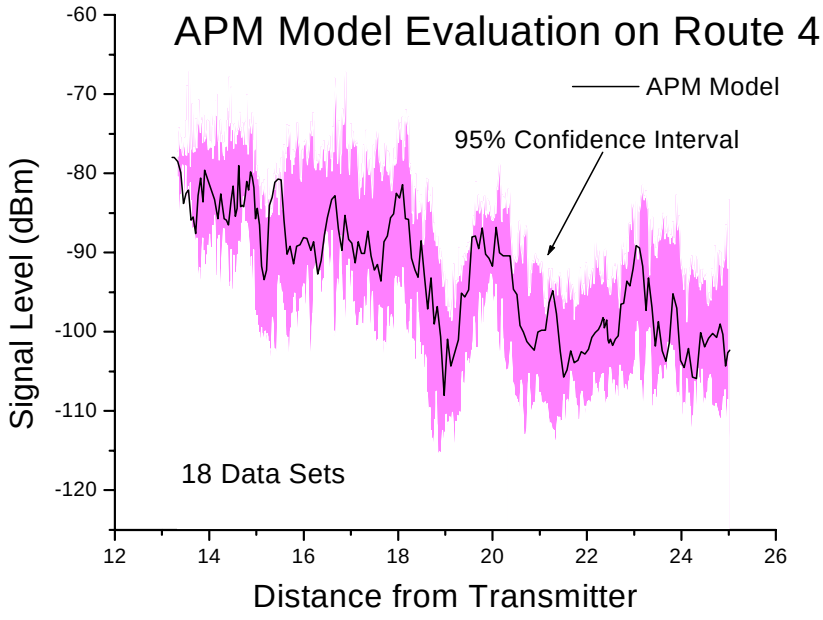

Figure 4 Modeled Signal Strength for the Route 4 Path Along With the 95% Confidence Interval for Measured Data.

An overview of the work presented here was given at the 2003 International Union of Radio Scientists (URSI) meeting in Columbus Ohio[1]. The feedback from others working in the area of radio

[1] Kent Chamberlin, Maxim Khankin, and Amalia Barrios, "Progress on the Validation of Short-Distance, Ground-to-Ground Propagation Models at VHF Frequencies", presented at the 2003 URSI Conference in Columbus, Ohio, June 24, 2003.

propagation was quite positive, and suggestions for future validation measurements were made. The clear consensus was that the work reported was being performed correctly and was yielding useful information on radio coverage.

Future work on this task will involve in-depth analyses of measured and modeled data along other routes. If the propagation model continues to provide estimates in close agreement with measured data, the validation portion of this task will be concluded, and the propagation model will be incorporated into a program that can generate coverage area maps. Additional work will be performed to determine the statistical confidence of model predictions. In other words, a region on a coverage area map will be shown as having radio reception only if there is a 95% likelihood that an adequate signal exists in that region. Collection of additional validation data will be necessary before such statistical estimates can be determined.