NOAA Weather Radio Performance Study

Outputs

- VHF receiver and transmitter measurements and testing.
- FSK simulation.
- Baseband waveform analysis.

The National Weather Service (NWS) tasked ITS to examine the NOAA Weather Radio (NWR) system from signal generation to signal reception. NWR broadcasts round-the-clock weather information to all U.S. states, coastal waters, and protectorates. The NWR network consists of over 900 FM transmitters operating at 100, 300, and 1000 watts. Each transmitter uses one of seven evenly-spaced frequencies between 162.400 and 162.550 MHz, with a bandwidth of 25 kHz. In addition to the familiar audio weather forecasts, NWR can provide a digital alert signal consisting of a two-tone frequency shift key (FSK) 521 symbol-per-second waveform. The symbols follow the NWR Specific Area Message Encoding (SAME) protocol system. An alert uses one of over 75 SAME event codes and numerous location codes to warn the public of natural and man-made hazards. There are four levels of alerts in increasing significance: statements, emergencies, watches, and warnings. Messages range from a High Wind Warning to more recently added events such as a 911 telephone outage emergency. As part of its mandate to be an all-hazards network, NWR also has been chosen to carry public notices of terrorist attacks and changes in the color-coded national threat level.

ITS conducted a series of receiver measurements that were based on tests outlined in the recent Consumer Electronics Association standard entitled "Receiver Performance Specification for Public Alert Receivers" (CEA-2009) which describes the proposed performance requirements of NWR receivers. These receivers are not only capable of decoding weather related SAME massages, but are also able to decode messages associated with the new mandate to make NWR an all-hazards public alert network. ITS performed CEA-2009 tests on a wide range of NWR receivers to ascertain their performance. Additionally, ITS devised a number of measurements not in the specification. This work will be used to determine baseline operational parameters (e.g., sensitivity and out-of-band rejection) for off-the-shelf NWR receivers and future NWR receivers as they are brought to the market. This information will aid the NWS in maintaining and developing enhancements to the NWR network.

A series of tools were developed during the course of this project, including software to simulate SAME waveforms, Audio FSK (AFSK) modulator and demodulation routines, and other tools to create waveforms to stress NWR receivers. Figure 1 shows output from one of the performance tests that made use of the ITS-developed SAME simulation tools. In this experiment, simulated NWR transmissions were made at frequencies at and near 162.425 MHz in order to determine the receiver's reception bandwidth.

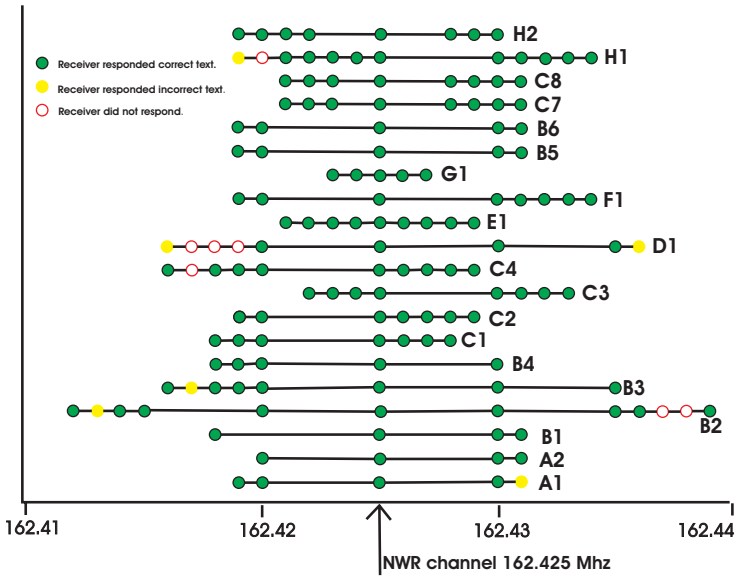

Figure 1. Output from receiver performance test. A black-bordered green circle indicates that the receiver responded at that frequency with text matching the event broadcast. A full yellow circle means the receiver responded with text other than that for the event broadcast. A red-edged empty circle means the receiver did not respond at that frequency.

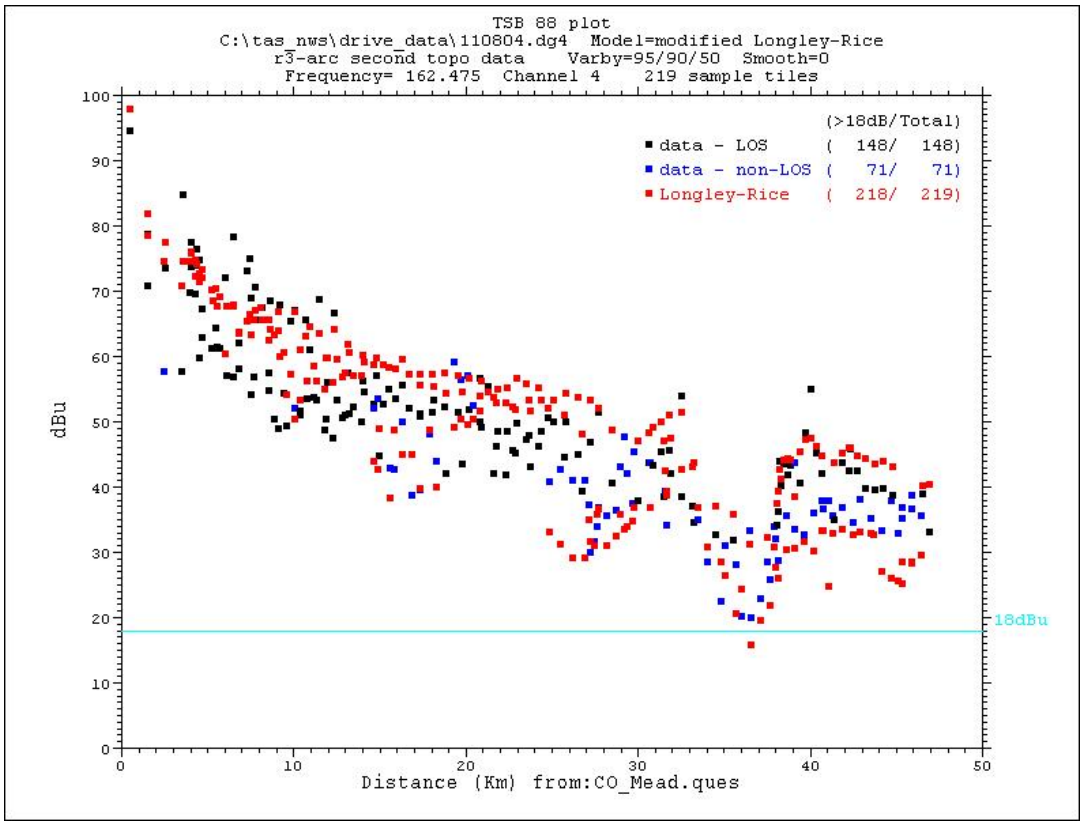

Figure 2. Scatter diagram output from drive test. The model-generated field strength estimate for each tile appears as a red dot. The black and blue dots are data points. These data points are different colors to differentiate between line of sight (LOS) locations and non-LOS, as determined by the terrain profile.

The study also identified measurement techniques that can be used to maintain and evaluate NWR transmitters at a high performance level. The general recommendations outlined in the study allow the NWS to conduct coverage and signal quality tests. The ITS transmitter measurement system was mounted in an automobile and driven through the area of interest. One of the most interesting outputs from the data collection and analysis software developed from this project can be seen in Figure 2. The scatter diagram is used to determine if the coverage criteria for a NWR transmitter has been satisfactorily met. Each dot represents a 1 km^2 tile in the coverage area. For each tile the drive test passed through, there may have been several subsamples taken. Each subsample was collected in such a way as to mitigate the effects of Rayleigh fading. Each subsampled tile was then compared to the ITS propagation model output from ITS's Telecommunications Analysis (TA) Services (pp. 36-37) and against prescribed performance criteria. In this case that minimum performance dictates that the field strength must be greater than 18 dBμV.

In the course of this work, interoperability of the baseband SAME encoders was examined in some detail. These are the devices that generate SAME messages at the command of local NWS offices. These devices are divided into two classes; those governed by NWS specification and those under FCC control as part of the Emergency Alert System (EAS). An effort was made to characterize these devices by examining such parameters as frequency stability, symbol time statistics and interface performance.

This is only a small sampling of the performance measurements and outputs that were conducted to evaluate the NWR system. ITS plays a pivotal role in evaluating the NWR network and other communications systems that are vital to the general public.

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