Shared Spectrum Company Memo

From: **Mark McHenry**
Date: **August 20, 2018**
Subject: Propagation Measurement Overview

1.0 Introduction

The objective of this test is to measure the local clutter 'enhancement' in the propagation loss surrounding a large number of federal satellite ground stations. This reflection scattering enhancement factor is then used to enable accurate propagation modeling for future protection zone predictions.

2.0 Measurement Locations

Measurements are made at more than 37 federal ground station locations in the continental United States, Hawaii and Alaska. The mobile transmitters are located on two automobiles that operate within 20 km of the ground stations.

3.0 Measurement Duration

Approximately two days of measurements are required at each location.

4.0 Test Overview

A CW signal is transmitted using transmitters located on two vehicles that drive around the ground station site. Two vehicles are used to reduce the time to collect the needed data. Different CW signal frequencies in the ENG 2025 MHz to 2110 MHz band are used in each vehicle so that both signal amplitudes can be determined at the same time. The exact frequencies are determined after coordination with the local Society of Broadcaster Engineer (SBE). The vehicle's GPS location is record using GPS time so that the received signal amplitude can be associated with the transmitter location. The vehicles drive around the ground station site at distance up to 10 km. The drive route is selected to maximize the number of locations with line-of-sight view of the ground station location.

Two CW signals (spaced approximately 10 kHz apart) are used. The test signals are out of band from the ground station signals, which reduces the chance that the test signal would cause interference to the ground station signals in the area. Using a CW signal enables the amplitude to easily be measured using a spectrum analyzer/digitizer with a narrow 10 Hz resolution bandwidth.

5.0 Test Equipment Configuration

A small, signal generator in combination with a one watt amplifier is used to create CW test signal. The onmi-directional antenna uses a large (1.5 wavelength), round ground plane to make the antenna pattern omni-directional in azimuth. Ferrite cores are used on the RF cable to reduce RF cable shield currents, to make the antenna pattern omni-directional in azimuth. The vehicle position relative to GPS time is recorded so that the received signal amplitude can be associated with the transmitter location.

An omni-directional antenna on a tripod is used. The propagation loss receiver is located within 10 meters of the ground station antenna. Cavity filters and a low noise pre-amplifier are used to maximize the receiver sensitivity. The receiver uses a decimation filter with a 100 kHz bandwidth centered near the ENG band MHz signals. The receiver records I/Q data using 100 msec integration periods to enable 10 Hz resolution bandwidths.

6.0 Calibration

The antenna gains, transmit power and receiver need to be calibrated. The antenna gains are assumed to be omni-directional in azimuth and have some pattern with elevation. The elevation range dependence is only evaluated at the horizon.

7.0 Data Analysis

The following describes the data processing steps. The measurements use the two test frequencies. This collection period includes 123 ms of data, which allows us to obtain narrow resolution bandwidths. The ability to achieve a 10 Hz bandwidth to maximize measurement system sensitivity depends on 1.) precise alignment of the frequency bins with the signal, and 2.) frequency drift of the signal. If the signal drifts while it is at low signal level, then there is no way to precisely align to the carrier. At higher power levels, the smaller detection bandwidth is not needed.

The total signal power is extracted from each snapshot using FFT processing centered on each transmitter's CW frequency. The size of the FFT bin range is large enough to account for transmitter frequency drift, but minimized to improve sensitivity.

Signal averaging is use to average out small-scale signal variations and to remove the Rayleigh fading component to recover the path loss. The collection is divided into 135 ms segments and then average each 123 ms of the collected data.

The data is manually inspected to determine the start and the stop times of the valid data collection period. Invalid data occurs when the transmitter is switched off. The times when the cars are transmitting is determined via the field test log sheet. The transmitter status is determined manually using the power versus time data. Each of the transmitters are operated independently, hence, each received frequency is checked separately. Each frequency can have different valid start and stop times. The start and stop times for each collection and for each transmitter is listed on a spreadsheet accompanying the data. All data outside of these limits are not used in future processing.

The transmitter and receiver GPS data are manually reviewed for dropouts, and large position errors. These may be caused by multipath propagation effects, boot up problems, loss of prime power, and/or operator error (e.g., forgot to switch on the GPS logging device). These problems are fixed in multiple ways. If the receiver GPS file had problems, the nominal NOAA antenna site location is used.

If the transmitter GPS file had problems over a short interval (< 30 seconds), the missing data is interpolated. We integrate transmitter and receiver GPS log files and interpolate to determine the receiver and transmitter positions at each measurement time. We then compute the transmitter-receiver separation and the elevation angle from the GPS coordinates.

We compute the calibrated Free-Space Path Loss (FSPL) using known equations; the calibrated transmit power and the transmitter/receiver distance. Then compute the measured clutter loss (total path loss - FSPL).