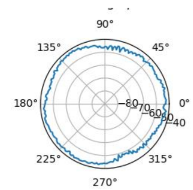
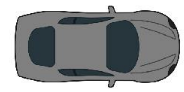
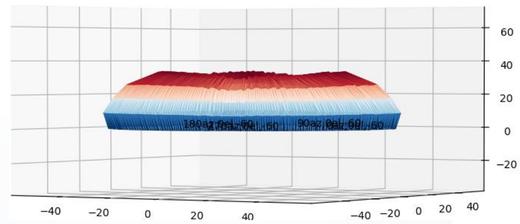
Drone Assisted Vehicle Antenna Pattern Measurements







The latest drone (sUAV) technology and modern USB powered test equipment can be used to make in-situ antenna measurements to support optimization of vehicle communication system performance. Drones can give a unique elevated view of antenna performance.This white paper will describe measurements made on VHF and 760 MHz public safety vehicle antennas. This work was performed as part of a comprehensive study of an agency communications system.

Figure 1

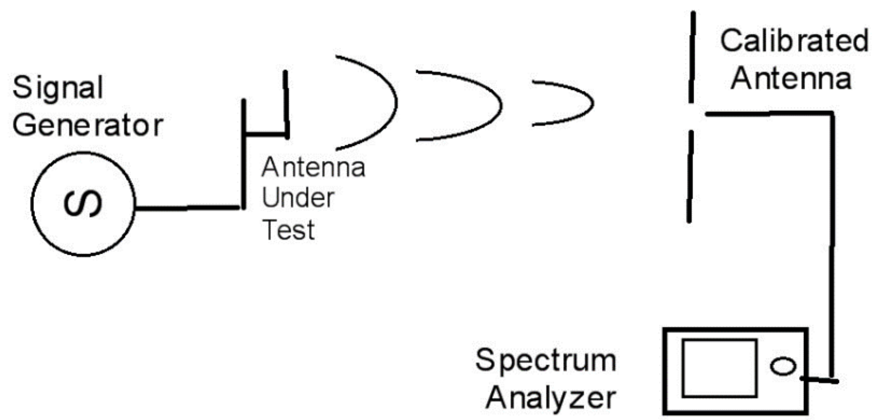
Phantom 4 drone with ½ wave dipole and +10 dBm signal generator at 10 degrees elevation 30 m from the test vehicle antenna

Antenna pattern measurements require a signal generator, receiver (spectrum analyzer) and a calibrated antenna with known antenna pattern. The signal from the CW signal generator is fed into one antenna and the signal strength is measured at the second antenna. One antenna is positioned around and above the second antenna maintaining a constant distance between the antennas. The position and signal strength are logged and plotted. See Figure 2.

RF propagation between the two antennas is reciprocal so the signal generator and spectrum analyzer can be exchanged. We used a small USB signal generator and an Anritsu portable spectrum analyzer.

For our testing, we used two calibrated antennas to set a reference level for analyzing the vehicle antenna performance. Testing was done in a flat open field away from other metal objects to reduce multipath variation error.

Figure 2
Basic elements for antenna pattern measurements



½ wave dipoles were built and cut to the specific measurement frequencies in the 156 and 760 MHz range. The antennas were light enough to be carried by the Phantom 4 drone. A dipole was chosen as the antenna on the drone needed to radiate down to the vehicle antenna. A distance of 30 m was chosen as it is in the far field range and the received signal levels were in the 40 to 60 dBm range well above the -90 dBm noise floor of the Anritsu spectrum analyzer (3 kHz RBW)

The vehicle antennas were ¼ wave NMO. The 760 MHz antenna was mounted in the center of the roof in front of the light bar and the VHF antenna behind the light bar.

To set a reference one ½ wave antenna was mounted on a wooden ladder at the same level as the vehicle and connected to the Anritsu spectrum analyzer. The second reference antenna was connected to the USB spectrum analyzer and a circle was walked around the ladder at 30 m distance. The Anritsu spectrum analyzer was set to 0 span, 3 kHz RBW and 3 min sweep time.

Vehicles were then moved to the center of the measurement area and each antenna connected to the Anritsu spectrum analyzer and a circle walked as before.

Next the USB signal generator (+10 dBm CW) and reference antenna was mounted on the Phantom 4 drone and the drone placed at 0, 10, 20,30, 45, and 90-degree elevation, maintaining a constant 30 m distance.

We did not have time to fly many arcs above the vehicle. As the vehicle antennas were simple ¼ whip on roof ground plane, an assumption was made that elevation data applied equally to all axial measurements.

Measurement results

Figure 3 below shows four polar plots for the VHF antenna performance at 0 degrees elevation

1. Propagation between the reference antennas
2. Antenna pattern for a Ford Explorer ¼ wave whip on the mid center of the roof
3. Antenna pattern for a Chevrolet Caprice with ¼ wave whip on the mid center of the roof
4. Antenna pattern for a portable radio on the right hip

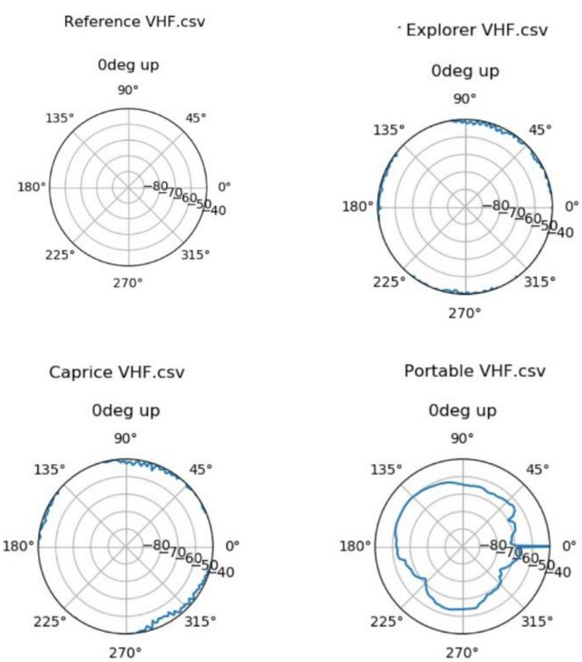


Figure 3

VHF polar plots of at 0 elevation antenna patterns

The antenna performance, at 0 elevation, for the vehicle mounted ¼ wave whips was nearly the same as the reference antenna. This is consistent with the expectations for a ¼ wave whip. There appeared to be a minor reduction in propagation in the forward direction of the lightbar. The portable on-hip performance showed the expected 10 to 20 dB degradation depending on the rotation of the user.

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Figure 4 below shows four polar plots for the 760 MHz antenna performance at 0 degrees elevation

1. Propagation between the reference antennas
2. Antenna pattern for a Ford Explorer ¼ wave whip on the front center of the roof
3. Antenna pattern for a Chevrolet Caprice with ¼ wave whip on the front center of the roof
4. Antenna pattern for a portable radio on the right hip

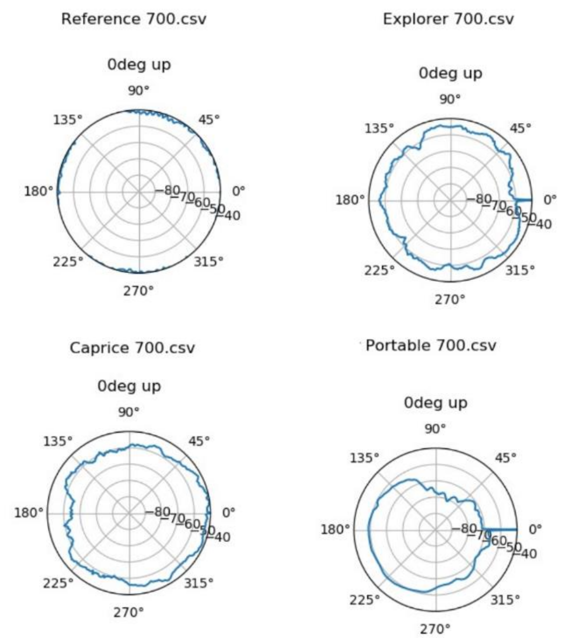

Figure 4

760 MHz polar plots of at 0 elevation antenna patterns

The antenna performance, at 0 elevation, for the vehicle mounted ¼ wave whips was slightly less than the reference antenna. The difference could have been due to larger cable loss for the antennas on the vehicles. The portable on-hip performance showed the expected 10 to 20 dB degradation depending on the rotation of the user.

VHF performance with elevation

Figure 5 shows the 3-dimensional performance of the vehicle antennas based on adding the drone elevated measurements a 0, 10, 20, 30, 45, and 90 deg elevations. The plots show the ¼ wave whip antennas perform best at 15 to 30 degrees of uptilt. The ¼ wave whip on the flatter / larger Ford Explorer roof had more uptilt than the Chevrolet Caprice.

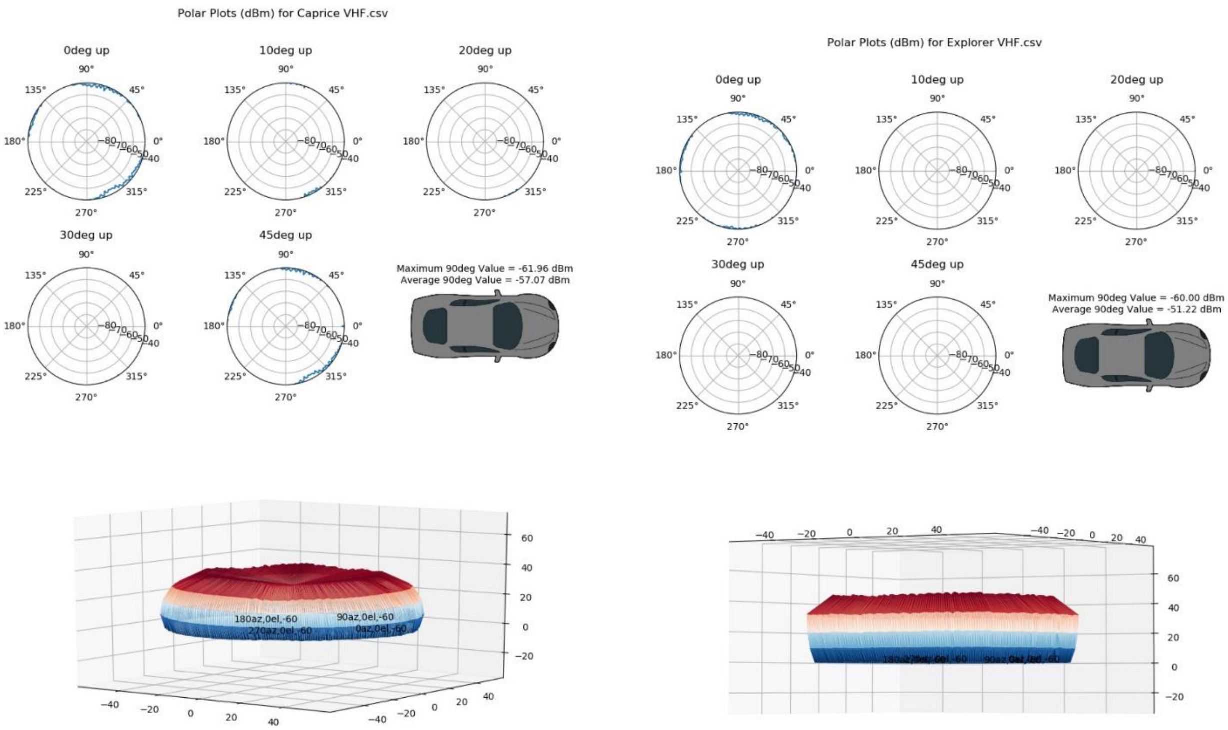

Figure 5

3-Dimensional plots of the vehicle VHF performance

Conclusion,

The latest drone (sUAV) technology and modern USB powered test equipment can be used to make in-situ antenna measurements to support optimization of vehicle communication system performance. Drones can give a unique elevated view of antenna performance. I plan to enhance this measurement process by rotating the vehicle. This can further reduce multipath variations and reduce the time to gather drone elevated measurements.

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