Drive Test Report

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July 2001

Drive Test: Handset Antenna Performance Comparison

Executive Summary

SkyCross, Inc. is a company focused on providing engineering solutions for the wireless industry through advanced RF design and development. It is uniquely positioned to transfer antenna and communications technology from the military and academic sectors to the commercial world. As a developer of high performance low profile antennas SkyCross has significant interest in understanding and improving the real life operational performance of cellular phones and other portable devices. In this regard, SkyCross has recently tested two new antennas that offer significant advantages in terms of increased efficiency and fewer dropped calls.

In order to quantify the amount of performance improvement achievable with this new technology, SkyCross contracted with Agilent Technologies, a leader in system performance testing, to perform a series of drive tests that mimic real world operational conditions. These include the operation performance assessment of the standard model phones in a cradle for “hands free” and operation next to a users head to account for signal reflection and absorption in standard handheld use. This report compares off-the-shelf handsets under both conditions of operation using standard vendor supplied antennas and SkyCross high efficiency antennas. The SkyCross antennas are affixed to standard phones which otherwise operate normally.

Drive testing was conducted to determine the performance of SkyCross antennas in comparison to standard existing handset antennas as delivered from the manufacturers. Qualcomm QCP-1960, Nokia 6160, and Nokia 6161 handsets were chosen to test 1900 MHz CDMA, 1900 MHz TDMA, and 800 MHz TDMA system performance of the handsets. To insure a fair comparison without extensive case redesign, one of the Qualcomm handsets was modified to incorporate the SkyCross “186” antenna, and the manufacturer installed external antenna connector was used to attach the “186”, and the “UWB” antennas externally to the Nokia handsets.

In standard CDMA 1900 MHz drive tests of the SkyCross “186” antenna compared with the Qualcomm whip, and the Nokia stub antennas, results show SkyCross uses less transmitter power 92% of the time.

Sixteen different drive tests were performed on identical handsets, under equivalent conditions. The required transmitter power was measured for both handsets at identical sample times and compared. In each drive test one handset was equipped with a standard antenna as supplied from the manufacturer, and one was modified to use a SkyCross antenna. In each of the sixteen drive tests approximately 2000 individual measurements of handset performance were made. These data were then analyzed, computing the mean value of the data for each individual test, thus giving a measure of the average power transmitted by the handset over the entire drive test time. This data is representative of the total energy supplied by the handset and therefore the overall battery life. Comparisons of these averages represent a reasonable method of estimating the relative efficiency of the antennas tested in a real life mobile communications scenario and improvements in the antenna performance are readily apparent in the average energy figures.

SkyCross antennas, although smaller than the external antennas that are standard equipment on the mobile phones tested, would result in significant reductions in battery usage based on reduced transmitter power requirements. This would allow for longer talk times, or a reduction in size, weight and the cost of the batteries used in mobile phones.

In one test scenario the performance of the SkyCross antennas was measured with the handset held close to the head to simulate conditions found during normal cell phone conversations. In the second scenario the handsets were tested in a free standing configuration. When the former data were separated from the total set of experiments the results show a 1 dB reduction in required transmitter power versus 2.33 dB when all tests are averaged using the standard Qualcomm antenna.

A Qualcomm phone with the original standard antenna required an average of 2.33 dB more power than did an identical Qualcomm phone with the SkyCross antenna installed.

Two different SkyCross antennas were tested at 800 MHz using TDMA systems. In the case of the "186" antenna, an average decrease in transmitter power output of about 0.5 dB was required to complete the link in 9 out of 11 tests, i.e. 82% of the tests showed the SkyCross antenna to require less transmitter power.

The SkyCross "186" outperformed the Nokia stub antenna in an 800 MHz TDMA system. Transmitter power requirements were reduced in 82% of the tests. An average Power reduction of 0.5 dB was measured over 11 tests performed.

The Ultra Wide Band Antenna (UWB)

The SkyCross Wide Band (UWB) antenna was also tested at 800 MHz using the Nokia 6160 phone. This antenna proved to have identical performance to that of the standard antenna supplied. Considering that the UWB antenna is an embedded antenna, this performance is remarkable. Embedded antennas provide advantages in terms of packaging, over the standard stub and whip antennas.

The UWB antenna is also expected to provide performance in the PCS band that is comparable to the other SkyCross antennas tested in this study.

Introduction

This document presents the results of sixteen drive tests performed by Agilent Technologies June 20 – 21, 2001. The entire set of tests that were performed is listed in Table VII (last page), which summarizes the various configurations that were used. Two SkyCross antennas were evaluated in this series. The majority of the tests were focused on the SkyCross 222-0186 dual band antenna. The last two tests were conducted on the BBH1 broadband antenna. Four different test SkyCross scenarios were used. These four SkyCross scenarios represent typical operation of a Cellular phone handset.

SkyCross scenarios used in these tests and described in this report are:

1. Cross Country route from Melbourne to Vero Beach, Florida
2. Small geographical loop for demonstration of head-antenna interaction
3. Few geographical loop traverse of Vero Beach Metropolitan Area
4. Multiple geographical loop traverse of Vero Beach Metropolitan Area

Data summarized in the body of this report are derived from this test session. Transmitter power was chosen from the parameters measured to be representative of the antenna performance and will be used in this report for comparing handset operation with the SkyCross antenna. Data are plotted in amplitude versus time, and amplitude histograms for this report. The data are also plotted using Geographical (Map) coordinates.

Test configurations

There were two test configurations used. First the four handsets under test were mounted in test holders along the back of the test vehicle. The vehicle was driven along a planned route Figure 1 and 2 show the orientation of the handsets in the van and locate individual devices.

Figure 1. Rear test rack with phones installed.

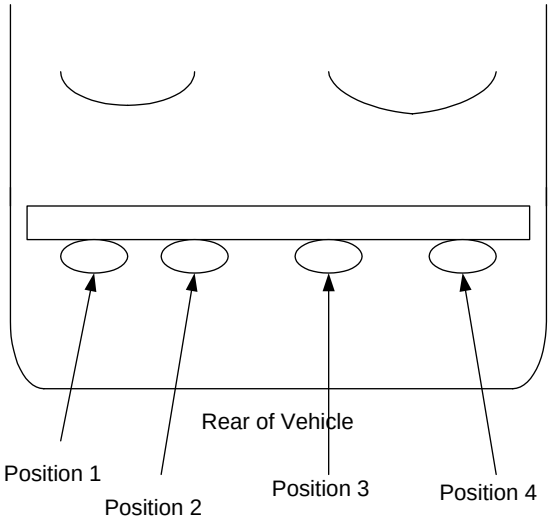


Figure 2. Test Rack with handset positions noted.

Population of the test rack
Four phones were installed in the test rack. The positioning of the phones on the rack is given below:

Position 1 - Qualcomm QCP-1960 With original whip antenna
Position 2 - Nokia 6160,6161With original stub antenna
Position 3 - Nokia 6160,6161 With SkyCross 222-0186 Antenna, or BBH1
Position 4 - Qualcomm QCP-1960 With SkyCross 222-0186 antenna, or BBH1

Data Discussion

CDMA Data: 1900 MHz Qualcomm Phones, Verizon System
What follows is a description of the recorded data and its significance. All points plotted represent an average of several (typically four to ten) raw data points. All averages were computed over complete routes and represent approximately 2000 data points each. Transmitter power is the parameter of interest in these data.

Test Scenario 1: Cross Country route from Melbourne to Vero Beach.
This route was driven several times in both directions in two variations. Figure 3 shows the general area and basic route used for theses tests.

Figure 3. The basic area covered by the cross-country drive routes.

These routes represent a wide variety of terrain form urban to rural, and span two BTA's.

Figure 4 (next page) is an example of the transmitter power plot for one portion of one of the cross-country routes. These data were recorded in part of the region shown in the Map M1 and represent a portion of the route from Melbourne to Vero Beach. Table I (next page) summarizes the results of the four cross-country route measurements.

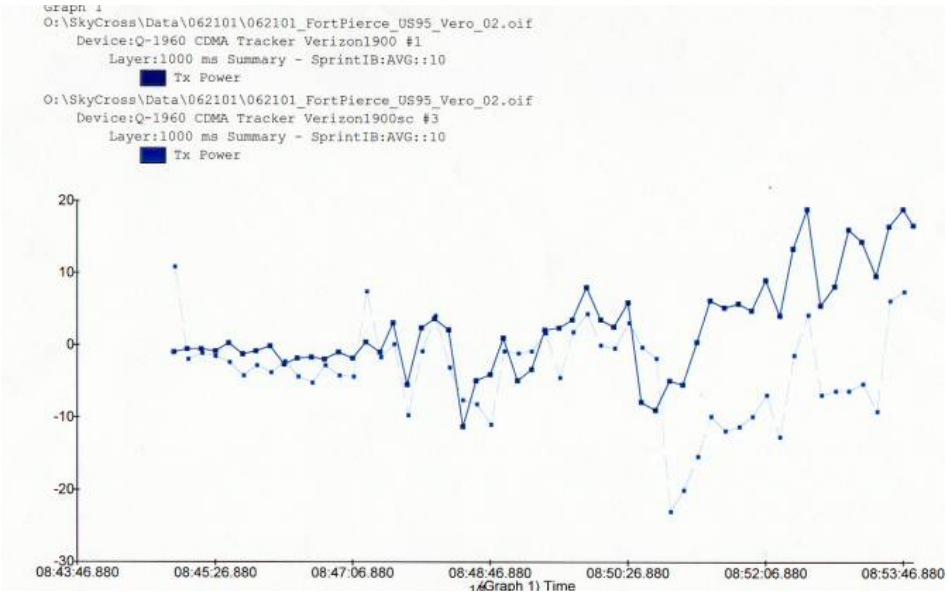


Figure 4. Transmitter power, for the Qualcomm handset equipped with the standard antenna, and the Qualcomm handset equipped with the SkyCross 222-0186 low profile dual frequency antenna. (Bold line is the data for the handset equipped with the standard antenna; the fine line is the data for the handset with the SkyCross antenna. The horizontal axis is actual chronological time.)

Table I (below) provides a data summary for the aforementioned test and compares transmitter power required for Qualcomm 1960 CDMA handset with standard antenna and an equivalent Qualcomm 1960 CDMA handset with SkyCross "186" Antenna. The SkyCross antenna requires about 3.6 dB less transmitter power that the standard Qualcomm handset.

Table I: Cross-Country Route Comparison Of Tx Power

Transmit Power dBm	Qualcomm Antenna	SkyCross Antenna	Difference
Vero Melbourne Routes	3.53	-1.06	4.59
Vero Melbourne Routes	-2.85	-6.21	3.36
Vero Melbourne Routes	0.87	-2.65	3.52
Vero Melbourne Routes	-0.55	-3.38	2.83
Average Tx Power[dBm]	0.25	-3.33	3.58

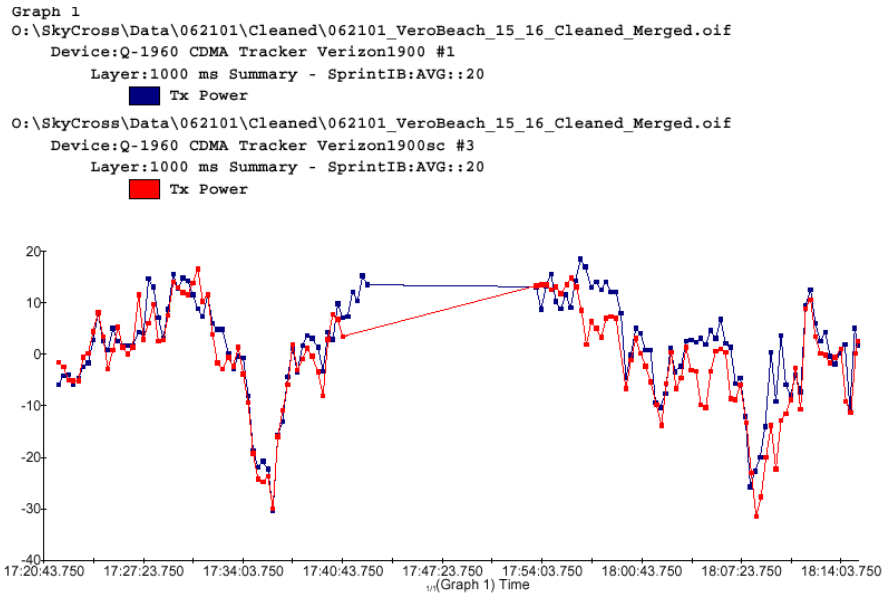


Figure 5. This graph shows the transmitter performance of the Qualcomm 1960 CDMA handset with the standard antenna in Blue and the Qualcomm 1960 CDMA handset with the SkyCross antenna in Red. Taken on a different portion of the route, and at a different time of day (roughly 17:30).

The data shown in Figures 4 represent test duration of about ten minutes. Many of the tests lasted 30 minutes and the multi-loop tests required more than 2 hours to complete.

During this time the SkyCross equipped handset continually required less transmit power than the conventional handset. Figure 5 (above) shows a longer duration set of data, however the same basic conclusion can be made. The performance of the SkyCross antenna reduces the transmitter power required to complete the link. This reduction in required power results in more battery life, less interference, which would provide improved channel performance.

Test Scenario 2: Test of handset in normal position for communication.
This set of tests is designed to compare the performance of the handsets equipped with conventional and SkyCross antennas when held in position against the head, as would be the case for normal use of the handsets. Two handsets were tested at the same time - one on the left side and one on the right side. Figure 6 shows the nomenclature for the position of the test subject and the position of the two handsets during the tests.

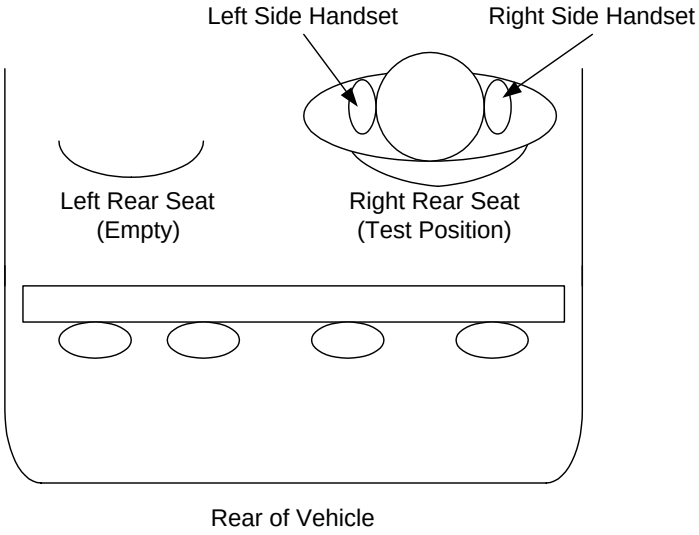


Figure 6. Position of test handsets for the head effect tests

Drive test route for head interaction tests
The test drive route shown in Figure 7 (below) was chosen from a survey of the Vero Beach area to be a location where the signal conditions were poor. There were several dropped calls during the drive testing in this area due to low signal strength. Long leaf Australian Pines trees lining the roads along part of the route also confounded the data. Rain was experienced during some portions of the testing route and introduced strong path loss absorption at 1900 MHz where the pines lined the roadside.

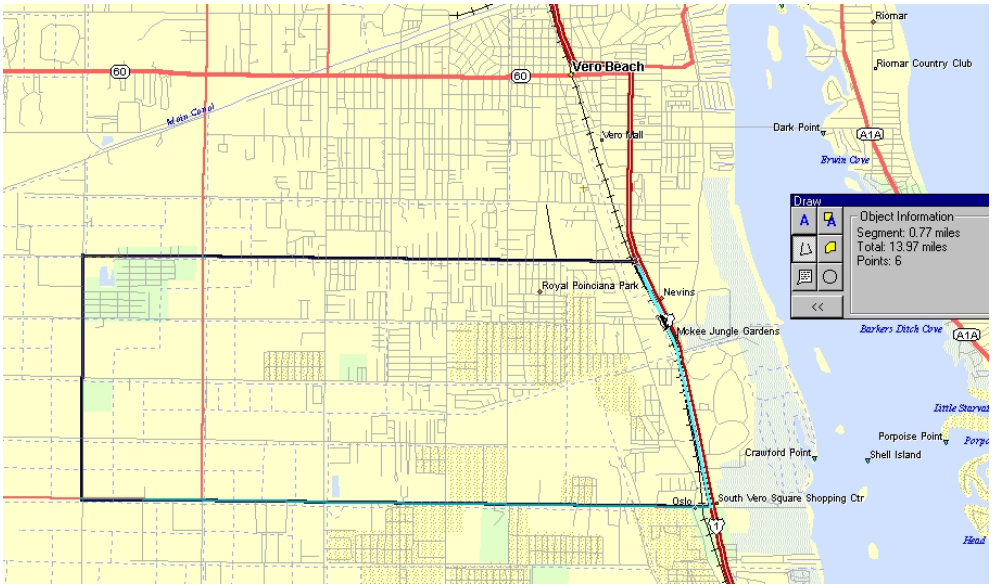
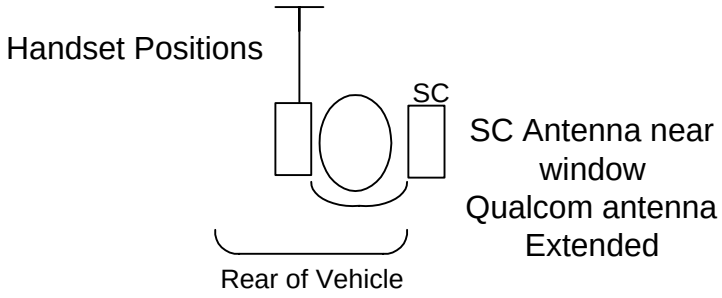


Figure 7. The drive route for the head test scenario started in the North East corner and was driven in a counter clockwise direction. The drive time was about 30 minutes.

Test of the Qualcomm handsets was conducted by placing one handset on the left side and one on the right side of the test subject's head in a position normally used when talking on the phone. The route was then traversed in a counter clockwise direction while recording data. The position of the two handsets was reversed and the route driven again to eliminate any bias associated with being in the center of the car or next to the window. Each antenna configuration was tested in this manner.

Test number 1



Test number 1 of this set is with the Qualcomm CDMA (1900 MHz) phones. The Qualcomm whip is extended and the handset with the whip is on the left side. The SkyCross equipped handset is on the right side of the head closest to the window. Figure 8 shows a plot of the transmitter power used by the two handsets to maintain communications while driving the route. Transmitter power is plotted on the vertical axis in dBm, and time is plotted on the horizontal axis.

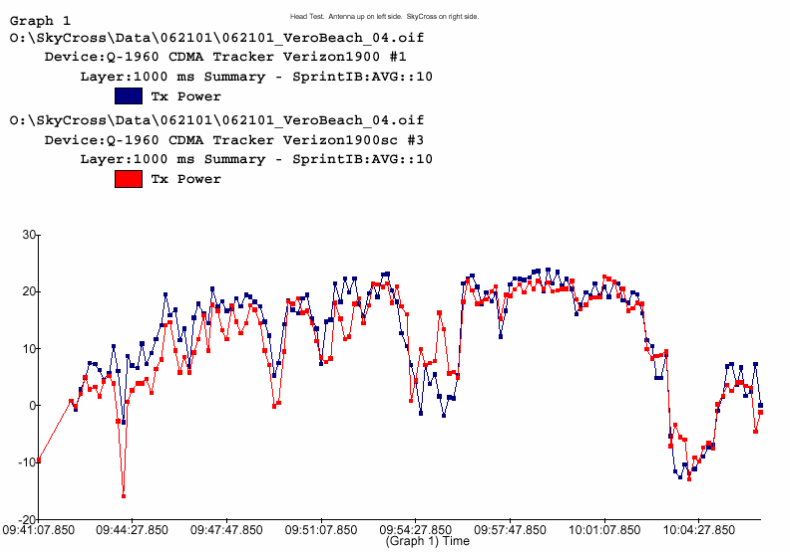


Figure 8. The transmitter power for two Qualcomm handsets one equipped with the original antenna (blue line) and one with the SkyCross 222-0186 low profile dual band antenna (red line).

The data shown in Figure 8 (above) shows the transmitter power required to complete the radio link for the CDMA Qualcomm handset to the tower during the drive test with the phones held at the head of the test subject. The red line is the power required by the SkyCross antenna, while the blue line is for the Qualcomm handset with the standard antenna. The Qualcomm whip is extended and the handset with the whip is on the left side. There is a preponderance of points 65% (81/138) of the time where the SkyCross antenna requires less power than the Qualcomm whip, in this configuration. In 23% of the samples (32/138), the power required by both systems was the same. 18% of the samples (25/138) show less power required by the whip configuration.

The SkyCross antenna required less power than the Qualcomm QCP 1960 standard antenna to complete the link in the majority of data points.

The transmitter power distribution and the mean value of the data were also computed; Figure 9 and Figure 10 show these distributions. The mean values for the two phones were compared and the results showed that the handset equipped with the standard antenna required 1.65 dB more power than the phone with the SkyCross antenna.

Qualcomm phone with the original antenna required 1.65 dB more power than the equivalent phone with the SkyCross antenna.

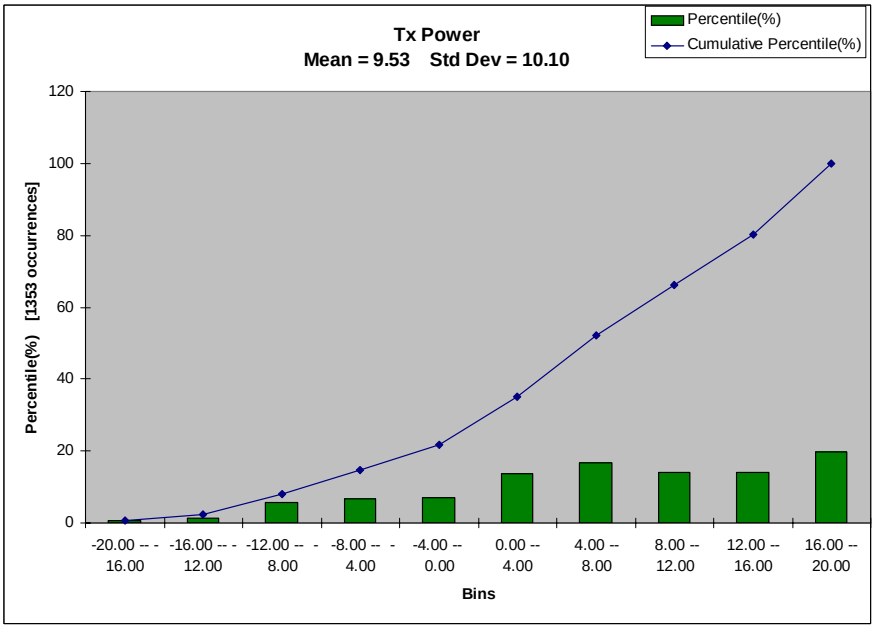


Figure 9. Histogram of power level for drive test with handset next to head. Handset equipped with the SkyCross antenna.

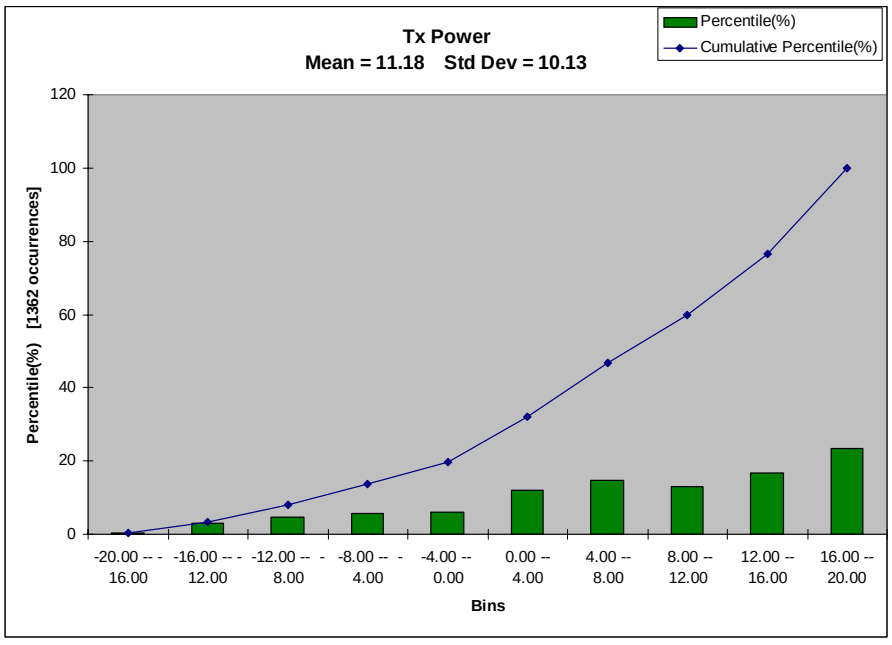
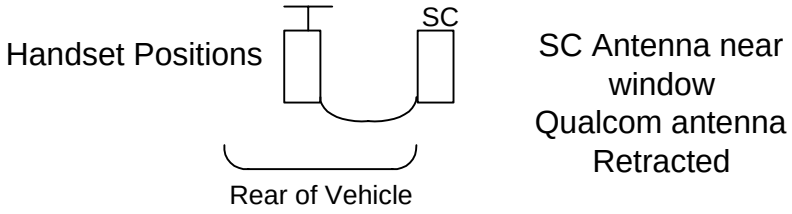


Figure 10. Histogram of power level for drive test with handset next to head. Handset equipped with the Qualcomm antenna.

Test number 2



Test number 2 of this set uses the Qualcomm CDMA (1900 MHz) phones. The original Qualcomm whip is retracted and the handset with the whip is on the left side. The SkyCross equipped handset is on the right side of the head. Figure 11 shows the transmitter power used by the two handsets to maintain communications while driving the route.

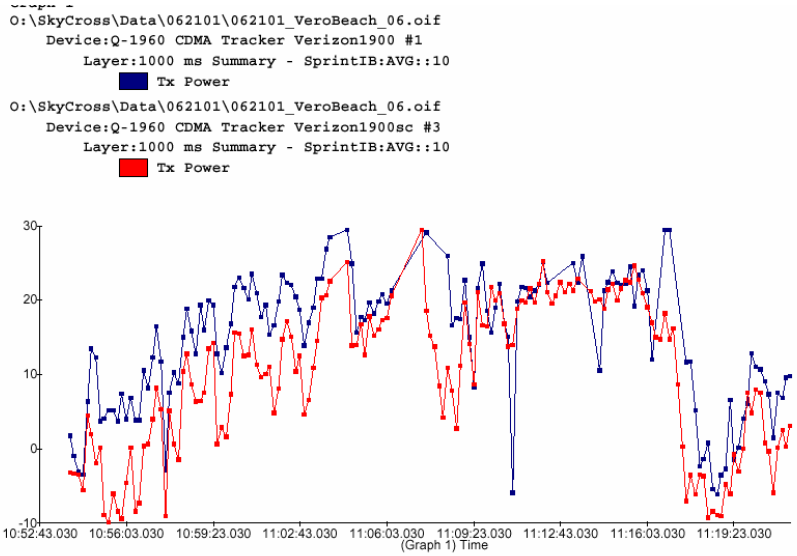


Figure 11. The transmitter power for two Qualcomm handsets, one equipped with the original antenna (blue line) and one with the SkyCross 222-0186 low profile dual band antenna (red line).

The data shown in Figure 11 (above) shows the transmitter power required to complete the radio link for the CDMA Qualcomm handset system to the tower during the drive test with the phones held at the head of the test subject. The red line is the power required by the SkyCross antenna, while the blue line is for the Qualcomm handset with the standard antenna. The Qualcomm whip is retracted and the handset with the whip is on the left side. There is a preponderance of points 94% (126/134) of the time where the SkyCross antenna requires less power than the Qualcomm whip, in this configuration. In four percent of the samples (5/134) the power required by both systems was the same. Two percent of the samples (3/134) show less power required by the whip configuration.

This test shows that the SkyCross antenna required less power to complete the link in the majority of data points.

The transmitter power distribution, along with the mean value of the data were also computed, figure 12 and figure 13 show these distributions.

Qualcomm phone with the original antenna retracted, required 4.93 dB more power than did the phone with the SkyCross antenna.

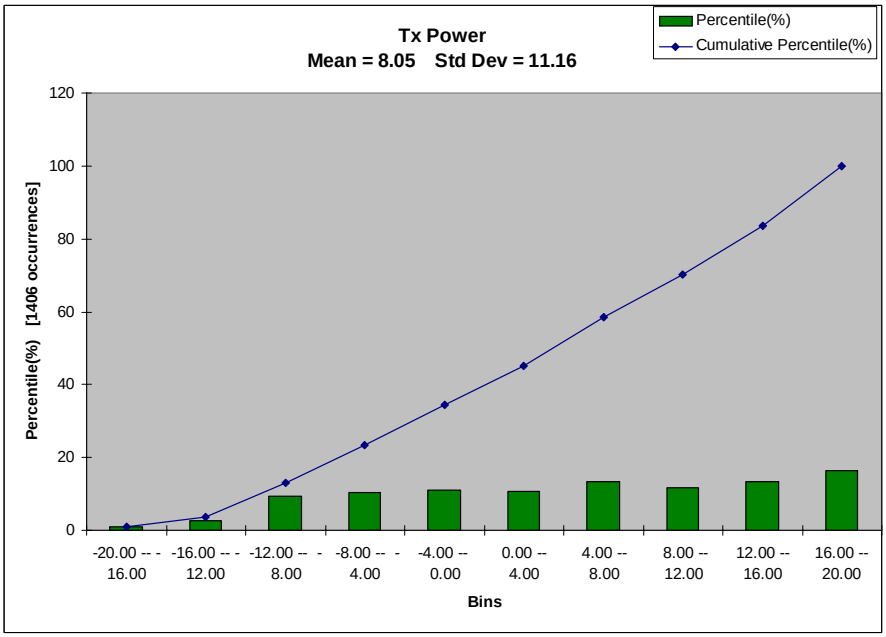


Figure 12. Histogram of power level for drive test with handset next to head. Handset equipped with the SkyCross antenna.

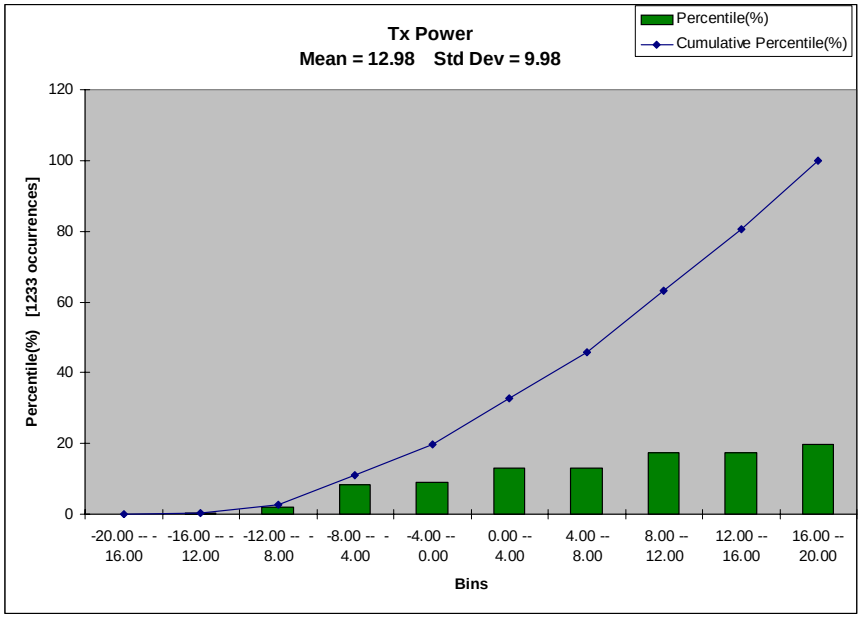
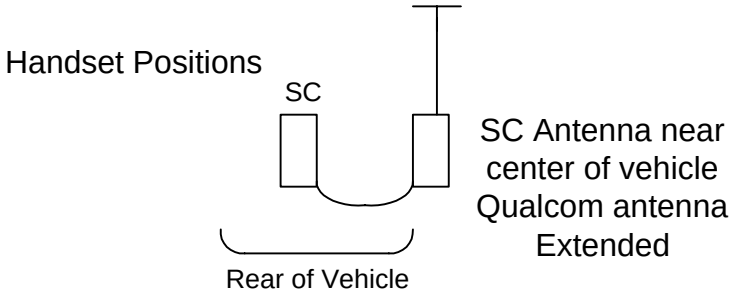


Figure 13. Histogram of power level for drive test with handset next to head. Handset equipped with the Qualcomm antenna.

Test number 3; CDMA, Qualcomm Phone



The Qualcomm original whip is extended and the handset with the whip is on the right side. The SkyCross equipped handset is on the left side of the head. Figure 14 shows the transmitter power used by the two handsets to maintain communications while driving the route.

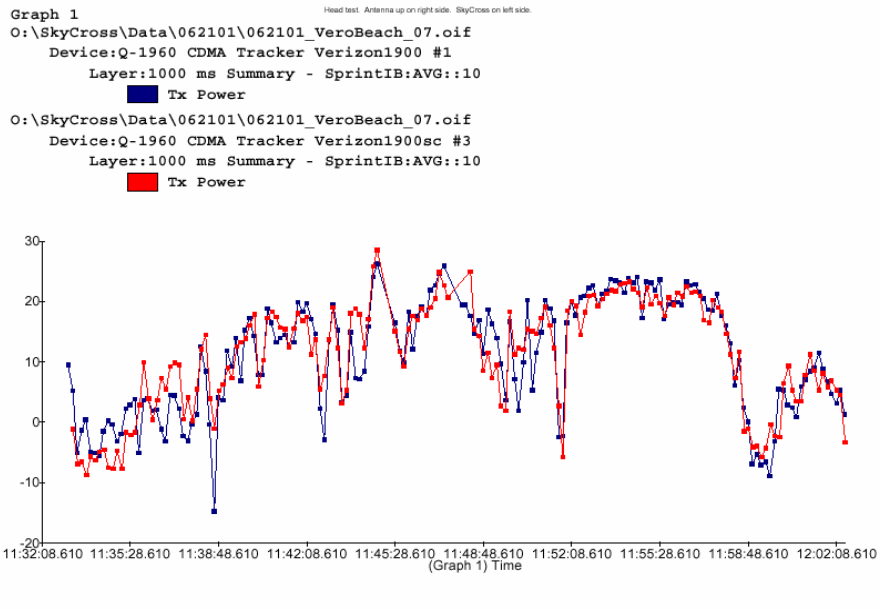


Figure 14. The transmitter power for two Qualcomm handsets, one equipped with the original antenna (blue line) and one with the SkyCross 222-0186 low profile dual band antenna (red line).

The data shown in Figure 14 shows the transmitter power required to complete the radio link for the CDMA Verizon handset system to the tower during the drive test with the phones held at the head of the test subject. The red line is the power required by the SkyCross antenna, while the blue line is for the Qualcomm handset with the standard antenna. The Qualcomm whip is extended and the handset with the whip is on the right side. The responses of both handsets in this configuration are nearly identical.

The transmitter power distributions, along with the mean values of the data were also computed, and are displayed in figures 15 and 16. The mean values for the two phones were compared and nearly the same.

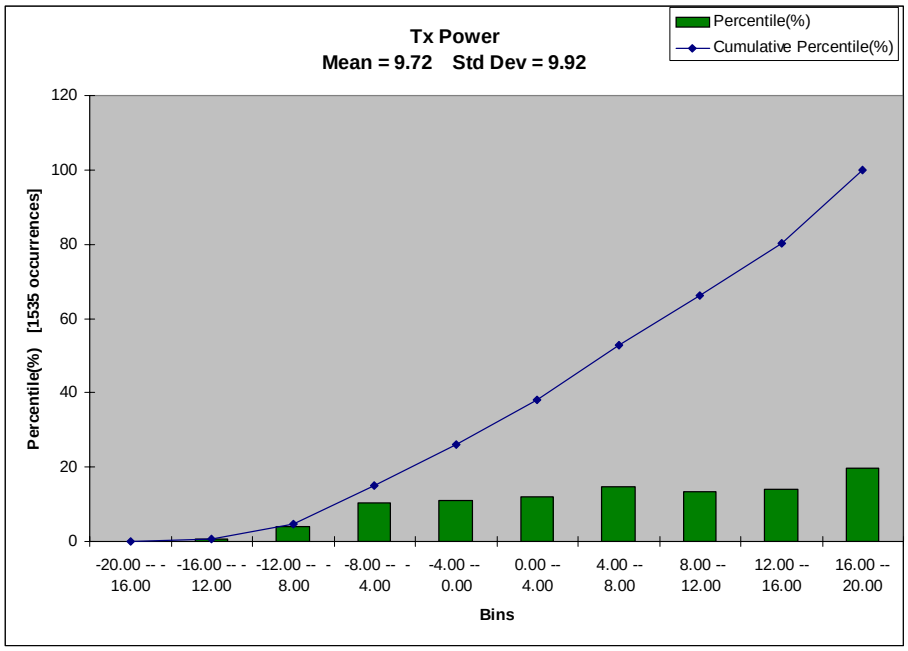


Figure 15. Histogram of power level for drive test with handset next to head. Handset equipped with the SkyCross antenna.

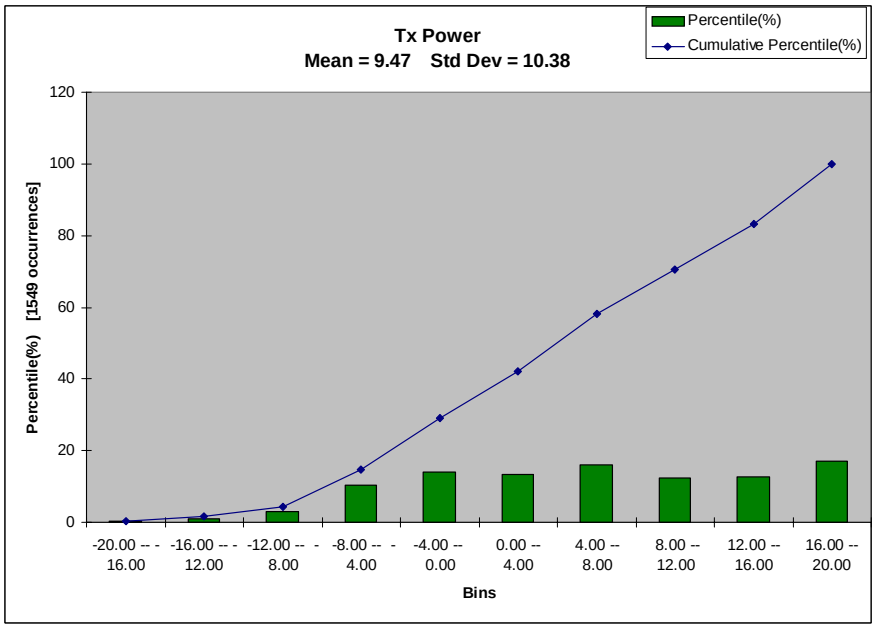


Figure 16. Histogram of power level for drive test with handset next to head. Handset equipped with the Qualcomm antenna.

Data Summary: Measurements in proximity to the human head
Six sets of measurements were taken comparing two handsets one with the standard antenna extended to full length and the other with the SkyCross “186” antenna. On average the SkyCross antenna requires about 1.1 dB less transmitter power than the handset equipped with the standard antenna. One case showed the reverse result, where the Qualcomm standard antenna was next to the window and the SkyCross antenna was in the center of the vehicle. If we compare only those tests run with the Standard antenna extended, the tests 1, 2 and 4, these data show an average difference in Tx power required of 0.89 dBm with the advantage going to the SkyCross equipped handset. The entire data set which includes all of the test conditions (Head test number 1 through 6,) represents all of possible extremes to operation of the two handsets. This results in an advantage to the SkyCross equipped handset of 1.09 dBm. It is reasonable to conclude that a 1 dB advantage is gained with the SkyCross antenna.

Table II: Comparison Of Tx Power (dBm)

Transmit Power dBm	Qualcomm Antenna	SkyCross Antenna	Difference
Head Tests 1	11.18	9.53	1.65
Head Tests 2	9.1	8.82	0.28
Head Tests 3	9.47	9.72	-0.25
Head Tests 4	6.54	4.92	1.62
Head Tests 5	6.41	4.83	1.58
Head Tests 6	6.67	5.04	1.63
Average Tx Power	8.23	7.14	1.09

Table II compares the transmitter power required for Qualcomm 1960 CDMA handset with standard antenna and an equivalent Qualcomm 1960 CDMA handset with SkyCross “186” Antenna installed. Both handsets were placed against the head of a human test subject. The SkyCross antenna requires about 1.1 dB less power that the standard Qualcomm handset. The position of the handset was tested both on the right and left sides of the head to reduce the bias of position in the vehicle.

Table III: Performance Comparison Summary Of Tx Power

File	Tx Power[dBm] QC Antenna	SC Antenna	Delta
Init Vero	3.53	-1.06	4.59
VR1_56	1.65	-2.98	4.63
VR1_7	-0.86	-2.3	1.44
VR1_8	-2.85	-6.21	3.36
VB123	0.87	-2.65	3.52
VB4	11.18	9.53	1.65
VB5	9.1	8.82	0.28
VB6	12.98	8.05	4.93
VB7	9.47	9.72	-0.25
VB8	13.68	10.64	3.04
VB9	2.98	2.01	0.97
VB10_11	6.54	4.92	1.62
VB12	6.41	4.83	1.58
VB13	6.67	5.04	1.63
VB14	-4.28	-5.67	1.39
VB15_16	-0.55	-3.38	2.83
Avg Tx	4.78	2.46	2.33

Table III summarizes the overall performance of the Standard and SkyCross a"186" antennas over all drive tests performed. It should be noted that the SkyCross antenna performs as well or better than the Qualcomm antenna in15 out of 16 measured cases. The SkyCross antenna shows an average performance improvement of 2.3 dB over the Qualcomm standard antenna in transmitter power required for completion of the link.

The SkyCross antenna out-performs the original Qualcomm whip in 15 out of 16 tests performed.

Considering only the tests in proximity to the head, the measured data shows that 1.93 dB less power is required by the SkyCross antenna than the Qualcomm antenna.

Test Scenario 4:m TDMA testing of the "186" antenna 1900 MHz Tests
Two measurement were made with the SkyCross "186" antenna at 1900 MHz TDMA service. The results showed no difference between the two antennas for this service.

Table IV: Comparison of Tx Power in TDMA System at 1900 MHz

File	Tx Power[dBm] Nokia Stub Antenna	SC Antenna
Init Vero	2.06	2.11
VR1_56	2.01	2.01

Test Scenario 5 TDMA testing of the "186" antenna 800 MHz Tests
A series of measurements on the "186" antenna at 800 MHz are summarized in Table V.

Table V: Comparison of Handset Tx Power for 800 MHz TDMA

	Tx Power[dBm]	
File	Nokia Stub Antenna	SC Antenna
Init Vero		
VR1_7	3.3	2.71
VR1_8	3.56	2.59
VB123	2.81	2.32
VB4	2.8	2.17
VB5	3.48	2.59
VB6	3.3	2.96
VB7	3.16	2.59
VB8	3.13	2.67
VB9	3.59	3.14
VB10_11	2.29	2.33
VB12	2.67	2.24
Avg Tx	3.10	2.57
Delta Tx[dI	0.53	
SkyCross F	0.886042483	

Figure 17 shows the results from Table V in a graphical format. The graph shows the reduced transmitter power setting used for the SkyCross equipped handset.

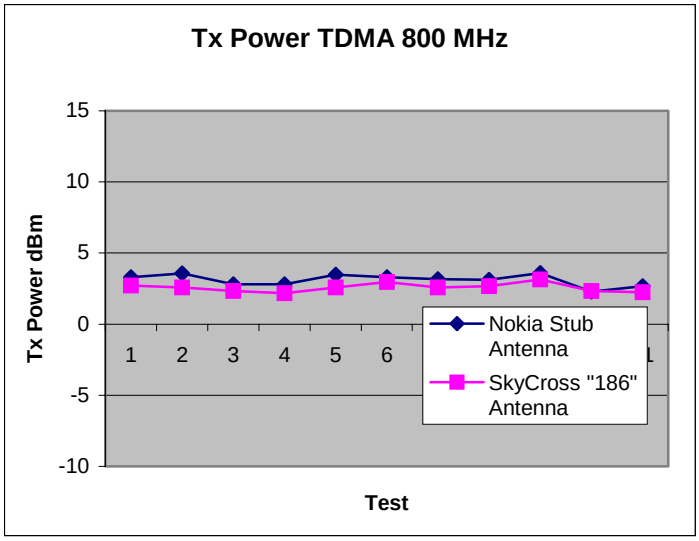


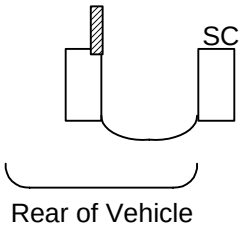
Figure 17. Comparison of required transmitter power for the Standard Nokia, stub antenna and the SkyCross "186" antenna.

The average difference in transmitter power required is 0.53 dB in favor of the SkyCross antenna. This represents about 10 % less power required to complete the link.

Test Scenario 4**:** The Ultra Wide Band antenna BBH1

The Ultra Wide Band antenna BBH1 was tested in two different cases, first in a drive test with the handset held against the head, and then in a drive test with the handset equipped with the BBH1 in the rack.

Test 1



First the SkyCross Ultra Wide Band antenna BBH1 was tested on the Nokia 6160 in the 850MHz band against a Nokia 6160 with the supplied stub antenna. The two handsets were held to the head of the tester and the drive route shown in Figure 7 was driven. The SkyCross antenna was on the right side and the Nokia handset and antenna were on the left side. The graph shown in Figure 18 is a plot of transmitter power settings of the two TDMA phones.

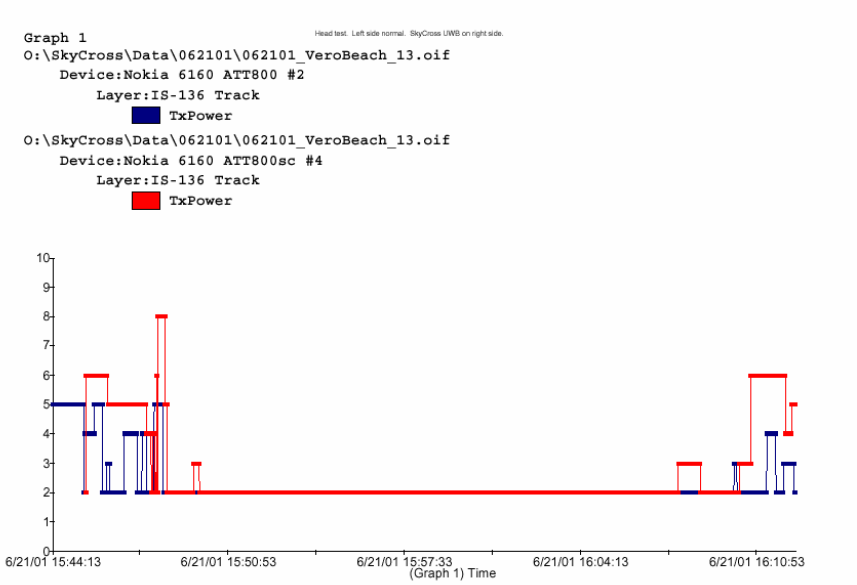


Figure 18. The transmitter power for two Nokia handsets, one equipped with the original antenna (blue line) and one with the SkyCross BBH1 Ultra wide band antenna (red line).

The levels reported for the TDMA system represent a much coarser resolution than does the CDMA Tx power parameter. This leads to the flatter appearance of the data graphs for the TDMA measurements. The drive test data shows that during the majority of the drive test time with the head involved, the two phones performed identically. Figures 19 and 20 show the histogram of the transmit power settings for the two phones; both phones have virtually identical average power requirements.

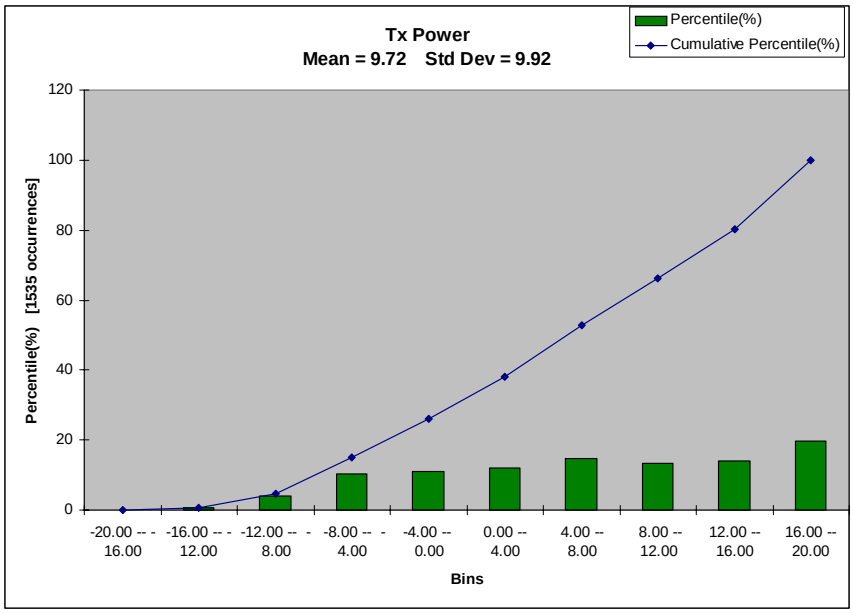


Figure 19. Histogram of power level for drive test with handset next to head. Handset equipped with the SkyCross antenna.

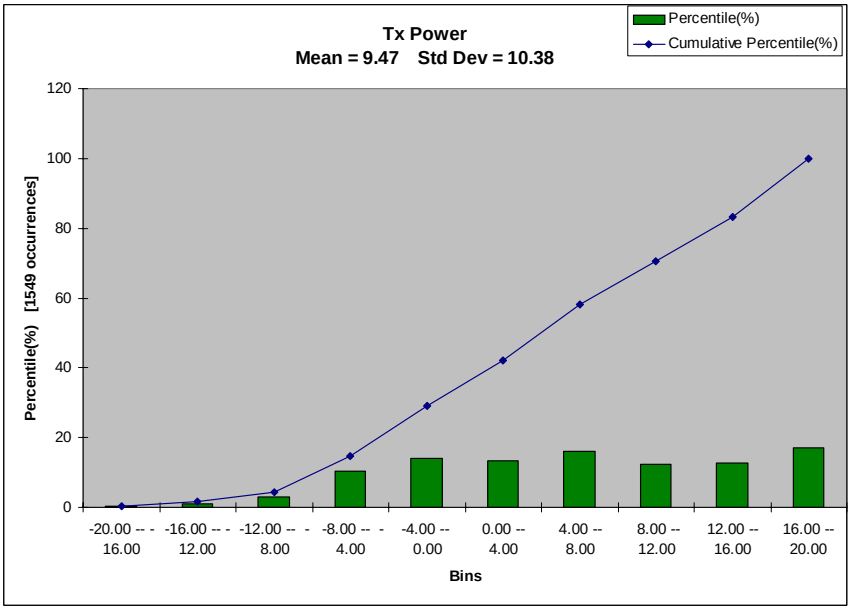


Figure 20. Histogram of power level for drive test with handset next to head. Handset equipped with the Nokia antenna.

The final test performed during this test session was the drive testing of the BBH1 in the standard mounting rack in the van. The mounting positions of the Nokia phones were the same as in the other rack-mounted tests. The drive route used was a partial set of the full drive test route; the route is shown in Figure 21. The TDMA phones occupied

positions 2 and 3. Figure 22 shows the transmitted power for the two phones during the drive test.

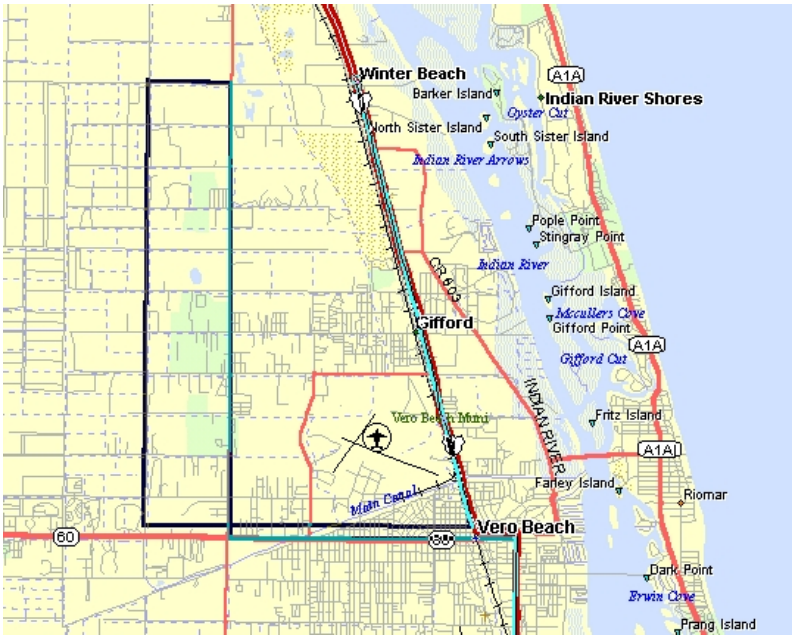


Figure 21. Shortened drive route used for the testing of the BBH1 antenna at 850 MHz

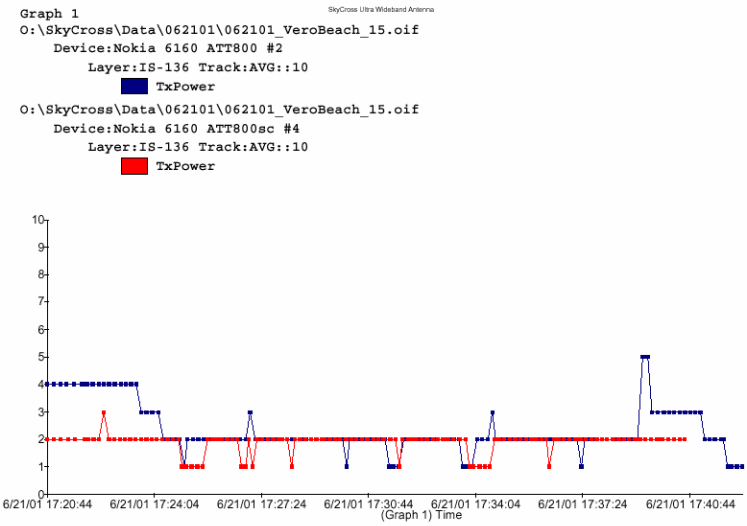


Figure 22. Transmitter power for the BBH1 antenna.

Figure 22 shows that on the average the two antennas performed equally well, however there were two regions at the beginning of the session and at the end where the SkyCross antenna performed significantly better than the standard Nokia antenna. Each power bin represents 4 dB differences and so the two bin difference at the beginning is a 8 dB reduction in required power when using the SkyCross antenna. At the end of the test there was a shorter but larger difference in the required power, again in favor of the SkyCross antenna.

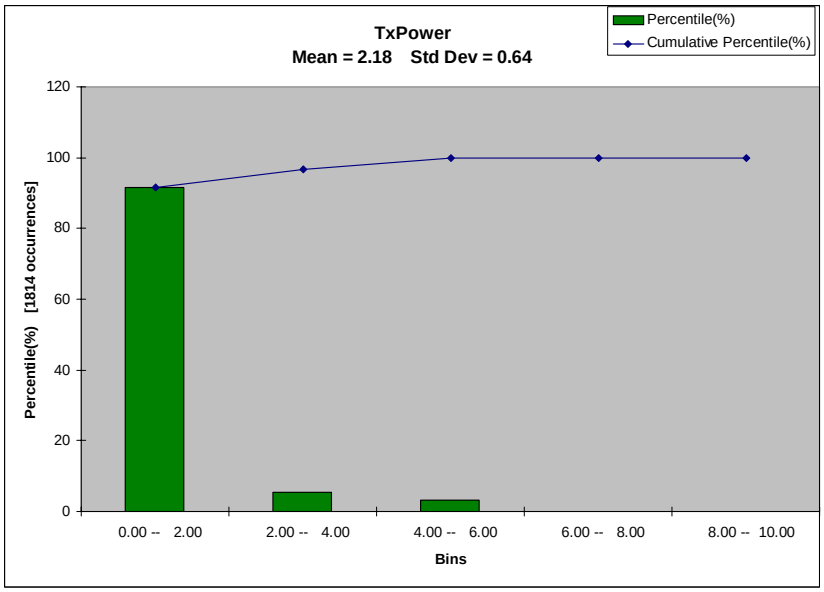


Figure 23. Histogram of transmitter power for drive test for Nokia phone equipped with the SkyCross BBH1 antenna.

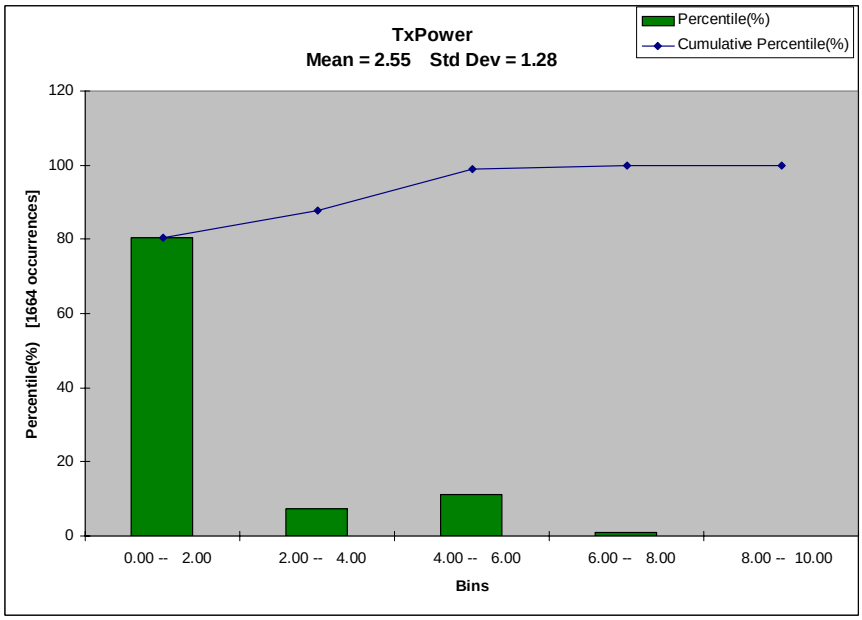


Figure 24. Histogram of transmitter power for drive test for Nokia phone equipped with the Nokia stub antenna.

Table VI: Comparison Of Required Handset Tx Power At 800 Mhz Using The SkyCross UWB Antenna

File	Tx Power[dBm] Nokia Stub Antenna	SC Antenna
VB13	2.18	2.55
VB14	3.72	3.75
VB15_16	3	2.79
Avg Tx	2.36	3.03

Conclusions

The data presented in this report demonstrate the kind of improvement in performance that can be expected from SkyCross embedded antennas when employed in CDMA and TDMA cellular communication systems. The tests conducted were designed to mimic natural use characteristics as much as possible.

General conclusions are that the SkyCross antenna performed better than the original antennas at both the CDMA (1900 MHz) and TDMA (850 MHz) bands. The two phone types tested showed better performance with the SkyCross antennas than with the original Qualcomm antenna that came with the handsets. Performance increases as measured by the transmit power required to complete the link showed reductions in required power from one to four dB over all of the tests

The decrease in required transmitter power seen with the SkyCross antennas will result in an increase in useable battery time between charges.

In the case of the CDMA system there is an added benefit in decreasing the transmitter power. By reducing the transmitter power output there is less interference between simultaneous calls, resulting in a lower Bit Error Rate (BER) and thus an increase in Quality of Service (QOS). Second order effects (resulting from non-linearities of the transmitter) will also be reduced with the reduce power output.

All these effects lead to significant improvement of performance when using the SkyCross antenna.

Table VII: Drive Test Summary

Date	Route	Test	Position	Files used
6/20/2001	Initial Vero	Tracker 1: Verizon CDMA 1900 - Ant Dn; Tracker 2: Cingular TDMA 1900 - normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: Cingular TDMA 1900 - SC	Cradle	1, 3
6/20/2001	1	Tracker 1: Verizon CDMA 1900 - Ant Dn; Tracker 2: Cingular TDMA 1900 - normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: Cingular TDMA 1900 - SC	Cradle	5, 6
6/20/2001	1	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Cradle	7
6/20/2001	Vero to Melb.	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Cradle	8
6/21/2001	Melb. To Vero	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Cradle	1, 2, 3
6/21/2001	2 (Short)	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T2 & T4: Cradle	4
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T2 & T4: Cradle	5 (corrupted)
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T2 & T4: Cradle	6
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T2 & T4: Cradle	7
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T2 & T4: Cradle	8
6/21/2001	Dropped Call	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Cradle	9
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T1 & T3: Cradle	10, 11
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC	Hd; T1 & T3: Cradle	12
6/21/2001	2	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC UWB	Hd; T1 & T3: Cradle	13
6/21/2001	1 (partial)	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC UWB	Cradle	14
6/21/2001	Vero to Melb. (2)	normal; Tracker 3: Verizon CDMA 1900 - SC; Tracker 4: AT&T TDMA 800 - SC UWB	Cradle	15, 16