Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	**WT Docket No. 01-309**
Section 68.4(a) of the Commission's Rules	)	RM-7658
governing Hearing Aid-Compatible Telephones	)	

To: The Commission

REPLY COMMENTS OF THE HEARING INDUSTRIES ASSOCIATION

1. The Hearing Industries Association ("HIA") hereby submits its Reply Comments in the above-captioned proceeding.[1] HIA is the national trade association of manufacturers of hearing aids, components, and related hearing health products.

2. It does not appear that there is any disagreement among the commenters that interference from digital cellular and PCS handsets causes harmful interference to many, if not most, hearing aids. Not surprisingly, however, organizations of hearing impaired people and hearing aid manufacturers call on the handset industry to make a greater effort to solve the problem, while the handset industry attempts to place that burden on hearing aid manufacturers. The Commission's task is to apply a specific statute, Section 710 of the Communications Act; and it is through the statutory mandate that the Commission should approach the problem.

3. Section 710 requires "reasonable access to telephone service by persons with impaired hearing."[2] It further requires all telephones manufactured or imported for use in the United States to "provide internal means for effective use with hearing aids…."[3] The clear

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[1] HIA submitted initial comments on January 11, 2002.

[2] Section 710(a).

[3] Section 710(b)(1)(B).

import of this language is that the telephones must work effectively for persons using hearing aids. It is result-oriented language, and it is directed toward telephones. While there is an exemption for public mobile service handsets, it must be revoked if four conditions are met.[4] HIA believes that the record in this proceeding demonstrates that all four statutory conditions have been met.

4. There is no dispute that the first two conditions have been met: The public interest would be served by increased accessibility by persons using hearing aids to digital public mobile telephone services, and hearing impaired persons are adversely affected by the current situation where digital handsets cause a buzzing sound in hearing aids.[5] HIA also submits that the fourth condition has been met: Compliance would not increase costs to such an extent that handsets could not be successfully marketed. HIA's initial comments noted certain handset models that appear not to cause interference to hearing aids and that are available at popular price points.[6]

5. The disagreement focuses on the third condition: technical feasibility. While some of the comments express doubt that eliminating all interference is technically feasible at present, no one strongly argues that point. Rather, the disagreement relates to what steps should be taken and who should take them.

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[4] Section 710(b)(2)(A)(i) and (C).

[5] *See, e.g.*, Comments of Telecommunications, for the Deaf, Inc. at p. 5.

[6] *See* HIA Comments at par. 3.

6. There are several aspects of the technical feasibility issue that are not in dispute. One is that certain steps can be taken to improve the RF resistance of hearing aids, including the use of capacitors and microphone adjustments.[7] There is no dispute that the hearing aid industry has already introduced these improvements.[8] Another technique advocated by handset interests is shielding. The hearing aid industry is aware of this technique and uses it where possible; but there are issues with size, weight, and physical irritation.[9] Everyone recognizes that there are limits to how much hearing aid manufacturers can do given the drive toward miniaturization and light weight in their products.

7. There also appears to be little dispute that improvements can be made in handsets, but HIA disagrees with the handset industry's claims about how little that industry can do. HIA does not quarrel with the fact that handsets must use sufficient power to reach the nearest cell base station and that digital technology requires pulsed emissions that cannot be eliminated if the telephone is to function properly and complete and not drop calls. However, two related factors that affect interference to hearing aids are variable: the power of the signal emitted by a handset transmitter and the distance of the handset antenna from the hearing aid. Antenna design can ameliorate both elements.

8. For example, the "clam shell" design, which separates the earpiece from the major electronics of a handset, places the handset antenna further from the ear than the "brick"

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[7] *See*, *e.g.*, Comments of Matsushita Electric Corporation of America at p. 8.

[8] *See* HIA Comments at par. 4.

[9] *Id*.

designd and appears to reduce interference.[10] Other antenna designs may also be helpful, as evidenced by the favorable experiences of hearing impaired people with certain Samsung handsets.[11]

9. Antenna design can also limit radiation directly toward the ear. Specific directional antenna options are discussed at Paragraph 7 of HIA's Comments. The Telecommunications Industry Association ("TIA") claims that a handset must "transmit in all directions" to function properly;[12] but that is apparently not so, because as discussed below, non-directional transmission does not exist when a handset is held close to the head. Rather, the head absorbs virtually all of the signal directed toward it. Therefore, no impairment of handset performance would result from intentionally directionalizing the signal away from the head; and it is apparent that such action would significantly reduce, if not eliminate, interference to hearing aids. The attached material provided by Aethos Communications Systems and a hearing aid manufacturer, indicates that digital handset interference to hear aids can be reduced by up to -26 dB, or 95%, by using a directional antenna aimed away from the user's head. Moreover, such antennas were found to reduce CMDA frame error rates by 61.5% and reduced handset power requirements by 82.2%. Thus implementation of this approach holds significant promise in terms of improving telephone performance rather than impairing it. It also offers the additional benefit of reducing the absorption of non-ionizing radiation by the body.

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[10] *See* the Telstra Report, Exhibit B to the Comments of the Cellular and Telecommunications & Internet Association ("CTIA") at Sec. 6(3).

[11] Of the two Samsung models discussed at par. 3(d) of HIA's Comments, the 6100 is a flip-style, where the earpiece is not separated from the electronics; the 3500 is a clamshell model.

[12] TIA Comments at p. 8.

10. Another approach suggested by some commenters is the use of hands-free technology, including neck-loops and speakerphones, to increase the distance between the antenna and the user's head. These methods may be helpful, but they are not compliant with Section 710, as they introduce an element of inconvenience that disadvantages hearing impaired users, contrary to the intent of the statute.

11. CTIA refers to the Australian experience, but the documentation provided by CTIA and the information available at the Australian website cited at footnote 34 of Exhibit B to CTIA's comments do not indicate that Australia has solved the interference problem. Only compliance with the Australian Class 2 standard appears to eliminate the interference problem, but Australia has not seen fit to make that standard mandatory, nor is it clear that the standard is readily achievable. Also, it appears that Australia is looking toward CDMA telephone technology for the best performance with mobile telephones. However, there is insufficient evidence that the problem can be solved only with CDMA technology to justify limiting the choices that hearing impaired users may make among service providers or to justify imposing a compliance burden on CDMA operators which is not imposed on other service providers.

12. The American National Standards Institute Accreditation Standards Committee ("ANSI") advocates reliance on its C63.19 technical standards to identify compatible hearing aids and handsets, but HIA disagrees with ANSI's assertion that the testing protocols in that standard are consistent or effective at the current stage of the development. As noted at Paragraph 8 of HIA's Comments, the trend toward miniaturization and in-the-air hearing aids has resulted increasing numbers of custom-shaped, very small hearing aid enclosures; and digitization of hearing aid circuitry allows for custom shaping of the audio response pattern to

an individual's needs. These custom features, which are becoming the norm rather than the exception, affect the characteristics of each individual hearing aid unit separately and make it difficult to repeat test results from one unit to another of the same model. Testing each individual hearing aid before delivery to the user would involve significant costs that would be a serious burden to hearing impaired persons and would be an impediment to the wider distribution of the most effective and attractive kinds of hearing aids.

13. Both the handset and hearing aid industries have voiced their commitment to work toward a solution of the interference problem. However, the comments establish that progress has not been fast enough to suit the hearing impaired community. HIA submits that the hearing aid industry has every incentive to maximize its efforts to improve interference immunity, because its entire customer base is made up of hearing impaired people who strongly desire such immunity. Hearing aids have been improved, and the hearing aid industry is doing its part. However, the telephone handset industry has not used all the tools at its disposal. For example, the telephone handset industry has refused repeated requests from hearing aid industry for data regarding design improvements that might help to further reduce the interference caused by their products to hearing aids, because of "proprietary and competitive concerns."[13] Additionally, handset manufacturers have rebuffed solicitations during the past several years by the hearing aid industry to co-sponsor additional testing and experimentation.

[13] *See* CTIA Comments, Exhibit C, at numbered page 4.

14. Section 710 directs the Commission to remove the exemption when four conditions are met. HIA submits that the handset industry has not demonstrated persuasively that the exemption should be retained beyond perhaps a brief transitional period.

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Respectfully submitted,

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February 11, 2002

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DIRECTIONAL HANDSET ANTENNAS IN CARRIER NETWORK OPERATIONS

CARRIER FIELD TEST REPORTS

Directional handset antenna reduces CDMA frame error rates 61.5% and handset power Requirements 82.2 %

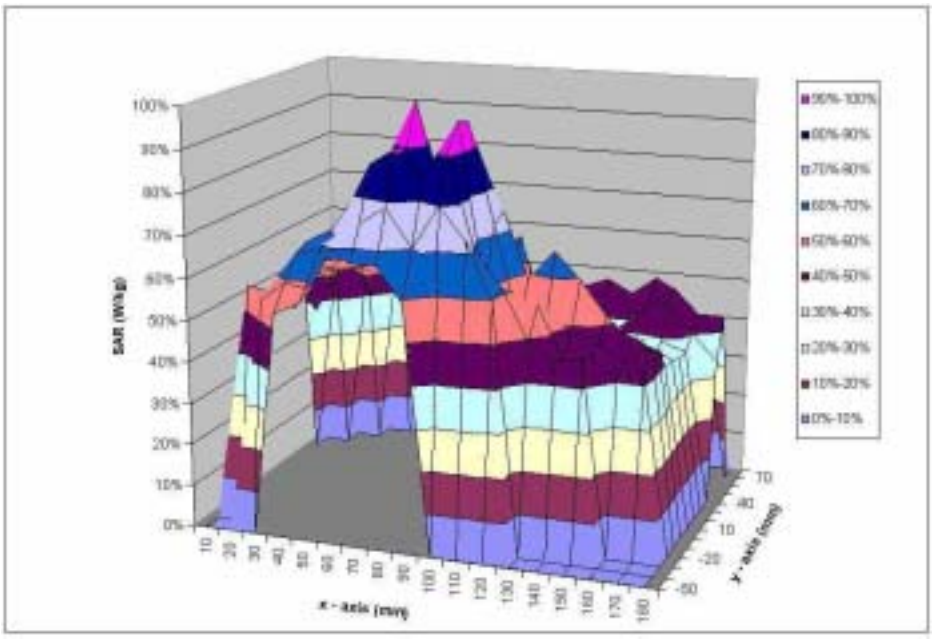
Field tests by a major carrier of a directional antenna attached to a CDMA digital cellular telephone handset showed that the directional antenna, as compared to the standard omni-directional antenna, reduced frame error rate (FER) by an average of 61.5% and handset power requirements by -7.5 dBm, or 82.2%. The digital handset was operated at 1.85 to 1.99 GHz over a 9.7 mile loop test route that crosses varied terrain surrounded by three laboratory controlled cell sites, each with a fixed transmitting power.

The digital handset under test was positioned vertically behind the windshield of a modified Safeco van equipped with an inertial navigation system and GPS. Four comparative test loops were driven around a 9.7-mile test route; two each with the digital handset equipped with the standard factory supplied omni-directional dipole and two with the handset equipped with the directional handset antenna.

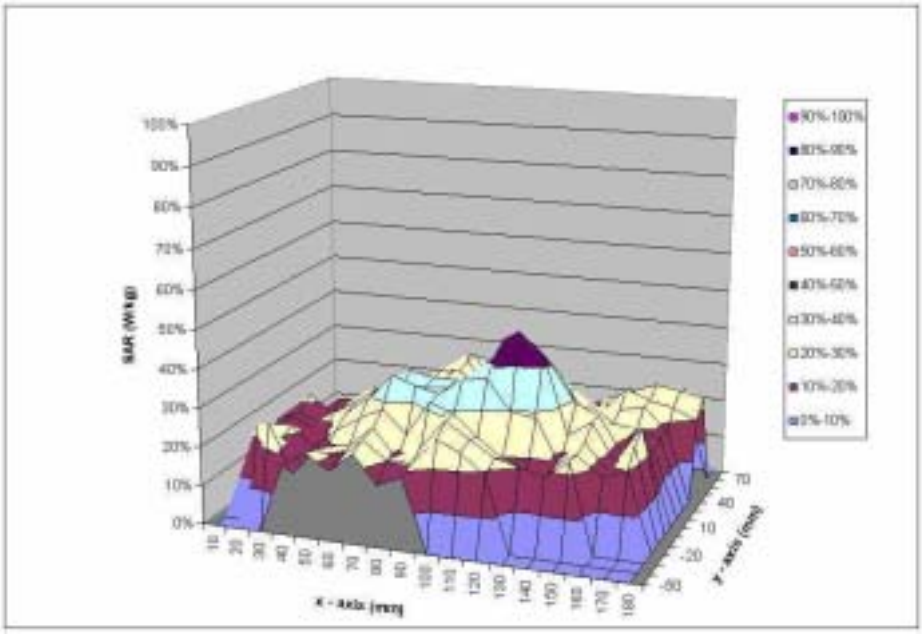
Unsatisfactory reception areas for the digital handset equipped with the dipole antenna occurred adjacent to trees and power lines paralleling the road or near power lines that intersected at right angles. One of the worst reception areas for the omni-directional dipole occurred directly in sight of the nearest transmission tower. Although strong signals were received, the multipathing, or reflection of the microwaves from surrounding objects caused the signals to arrive out of phase, which increased the FER to the point the radio was overburdened by conflicting information and dropped the call.

When comparative test loops were made through the same problem reception areas with the test phone equipped with the directional handset antenna, its stronger beam substantially reduced the FER which, in turn, substantially reduced dropped calls and provided better reception. According to the carrier's senior planner for RF technology who supervised the tests, the directional antenna provided an average reduction in FER of 61.5%, and an increase of 4.3 dBm in received signal power during the test runs.

Local SAR with the Omni-directional Antenna Normalized to Peak (%)



Local SAR with the Directional Antenna Normalized to Peak with the Omni-directional Antenna (%)



The red spikes of high SAR in the chart at the top of the page show the penetration of the microwave signals into the simulated head cavity from the omni directional antenna.

Directional Antennas on Digital Cellphone Handsets

Effect On SAR Exposures To The Head, APREL Laboratories Report

DIRECTIONAL ANTENNA REDUCES SAR UP TO 86%

In tests conducted at APREL Laboratories in Ottawa, Canada, a directional handset antenna was found to reduce handset SAR exposure up to 86%. The SAR measurements were made using a PCS handset supplied by a major manufacturer operated with its standard omni-directional antenna as compared to the same handset operated with a directional antenna. According to Paul Cardinal, the director of laboratory operations, indications were that the directional antenna emitted near zero SARs towards the simulated head, and that the cellphone handset was the source of the remaining SAR radiation (See SAR charts on the following page).

At the time the tests were conducted APREL Laboratories was listed by the FCC as one of the few laboratories in North America in compliance with their SAR test requirements. APREL had also conducted tests for the industry's trade organization, the Cellular Telecommunications Industry Association or CTIA. APREL's other clients at the time of the tests included such companies as AT&T, Nortel, Bell South, Pacific Telesis, Mitsubishi, Panasonic, and Sony.

Paul Cardinal, Ph.D., prepares SAR tests with a cellular telephone handset equipped with a directional antenna.

To insure this fundamental system of network operations works, every manufacturer installs commanded power steps that carriers can control into every phone that they make. If the phones did not have commanded power steps and only operated at the maximum allowable power (900 milliwatts in the U.S.) users would be limited to far less calling time than their handsets are now capable of delivering.

Directional Antennas on Digital Cellphone Handsets

Effect on Audio Interference with Hearing Aids

Starkey Laboratory Report

Background Information

Audio interference presents a problem for the users of hearing aids who also wish to use digital cellular telephone handsets. The interference is caused by the spectral components in the audio range produced by the cellphone's pulsed transmissions which, when demodulated by hearing aids, creates a "buzzing" noise for users which can range from moderately annoying to unacceptable levels.

Tests to determine the effectiveness of directional antenna designs on the handsets in reducing the noise caused by digital phones were conducted by Starkey Laboratories at their headquarters in Eden Prairie, Minnesota. Starkey is ranked as one of the largest hearing aid manufacturers in the world with manufacturing and assembly facilities in 17 nations.

Summary of Results

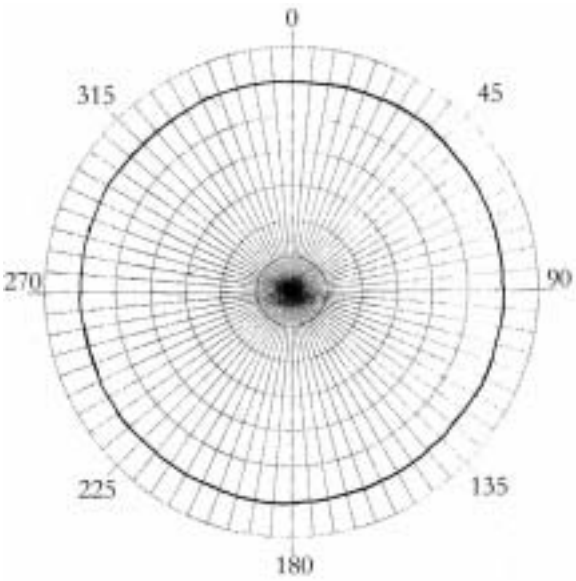
The Starkey tests indicated that digital cellphone interference with hearing aids can be reduced by up to -26 dB or 95%. The substantial interference reduction was achieved by replacing the handset's omnidirectional antenna with a directional antenna that redirects the handset's digital transmission signals away from the user's head.

Handset Directional Antenna Design	Noise Reduction	Avg. % Reduction
Directional Antenna Design 1A	-25 dB	94.4%
Directional Antenna Design 1B	-26 dB	95%

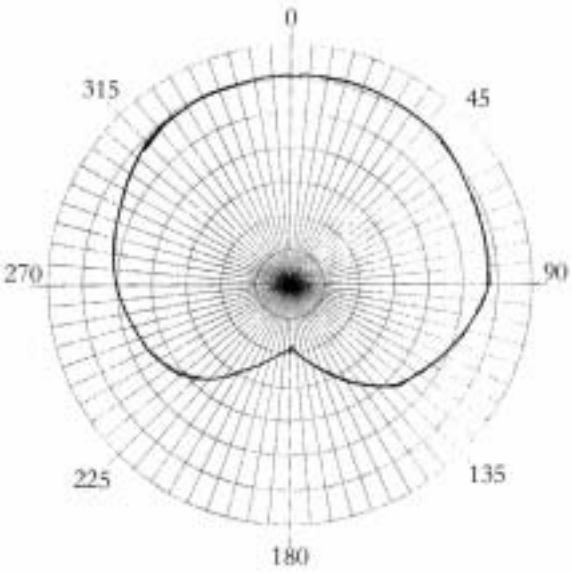
HOW DIRECTIONAL ANTENNA TECHNOLOGY ON HANDSETS WORKS

To picture how directional antenna technology for handsets works see the two signal patterns below. The antenna's in the center of each engineering plot. The pattern on the left is taken of a typical omni-directional antenna and the one on the right, the pattern transmitted by a handset directional antenna. When a handset is held up for use, the person's head would be inside the lower portion of both patterns at the bottom, or 180° position.

Handset omni directional pattern



Handset directional antenna pattern



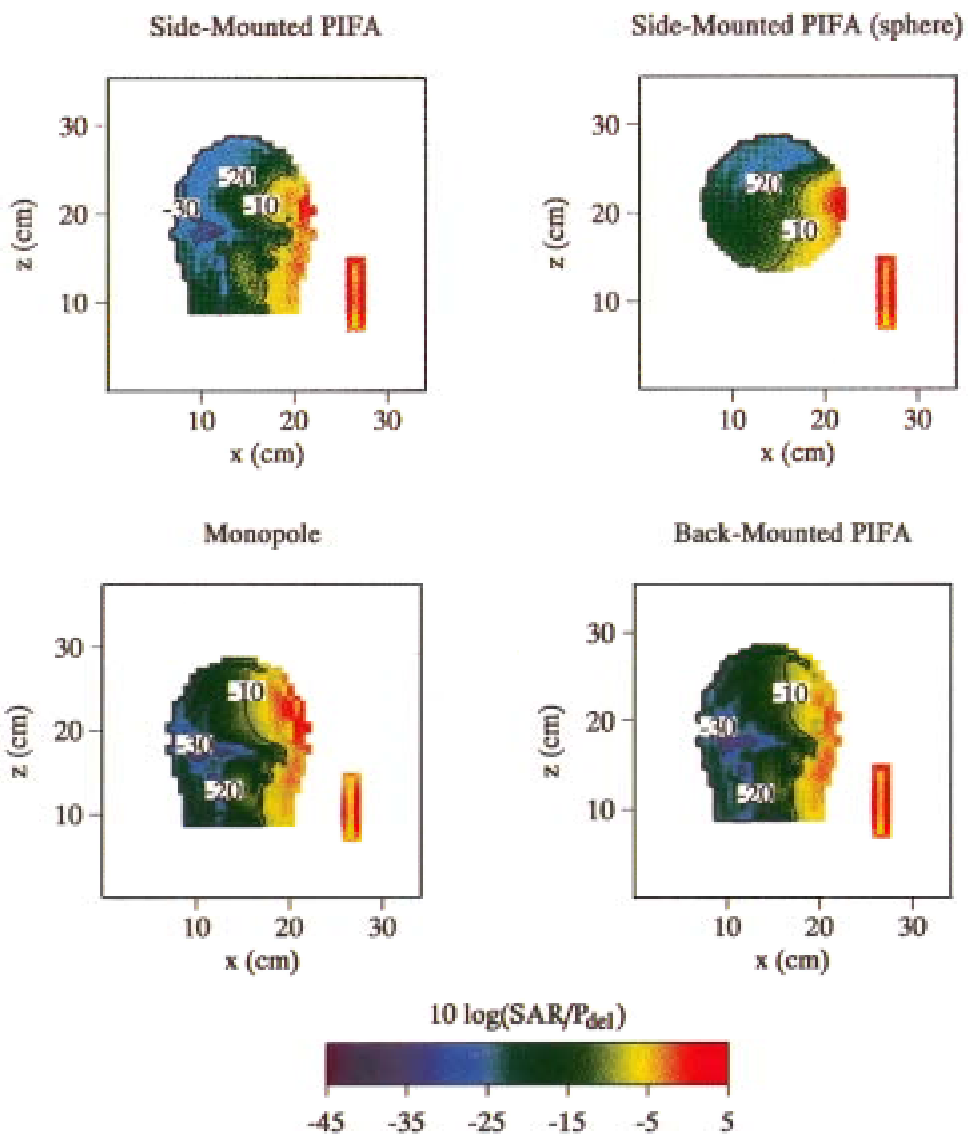
INDEPENDENT LABORATORY TEST REPORT

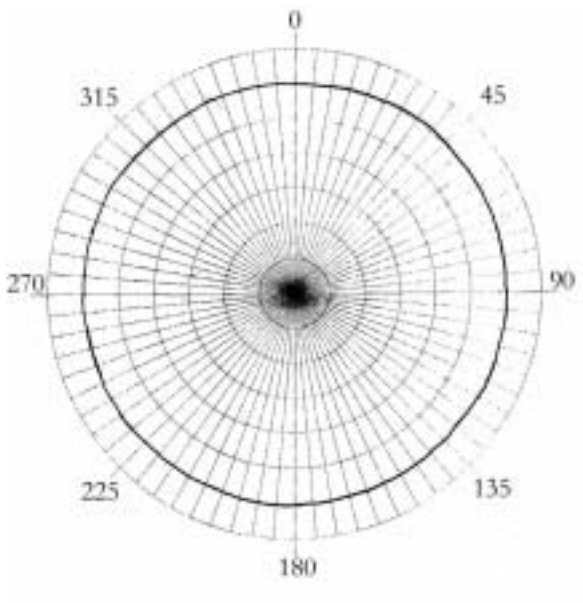
A substantial reduction has been achieved on a level of radiation directed to the head, which would be in the 180° position of the pattern. An average front-to-back ratio of 15 dB was achieved. This translates to a reduction in power in the direction of the head of approximately 95 %.

HOW CARRIERS CONTROL HANDSET POWER

The power level at which handsets operate is controlled by the carrier networks. Every phone has several of what are called commanded power steps, and when phones are turned on they instantly transmit their pin numbers, for billing purposes, to the nearest cell site. The cellular system logs the pin number and the phone's signal strength, and continuously adjusts the power so that each phone radiates sufficient signal power for the cell sites to read.

In a January 1995 cover story in the *Proceedings of the IEEE*, published by the Institute of Electrical and Electronics Engineers (the largest professional organization of engineers in the world) computer simulations conducted at UCLA graphically illustrate how and where the head absorbs the microwave radiation emitted by cellphone handsets when they transmit.





In addition, if you could see the microwaves radiating from a cellphone from its front, back, or side, they would appear in the form of a donut. When handsets are held up to the head for use however, research has shown more than 50 % of the microwaves radiated by the phones when they transmit is absorbed by the head. No microwaves get through the head.

HOW WIRELESS WORKS

OMNI-DIRECTIONAL VERSUS DIRECTIONAL ANTENNAS

ON HANDSETS IN CARRIER NETWORK OPERATIONS

From the beginning of the U.S. cellular phone industry in 1983 cellphone manufacturers have used omni directional antennas because they were readily available, and they transmitted signals in every direction at once. The theory was, if phones radiated their transmission signals in only one direction and that direction pointed away from cell sites, weak or unreadable signal transmissions would result.

What manufacturers failed to recognize was that, when the cellphone industry progressed from large car and bag phones to handsets engineered to be held up to the head just like every telephone receiver before them, user heads absorbed more than 100% of the signal strength aimed in their direction. No signals get through the head and it's handset signals beamed toward the head that cause digital cellphone interference with hearing aids.

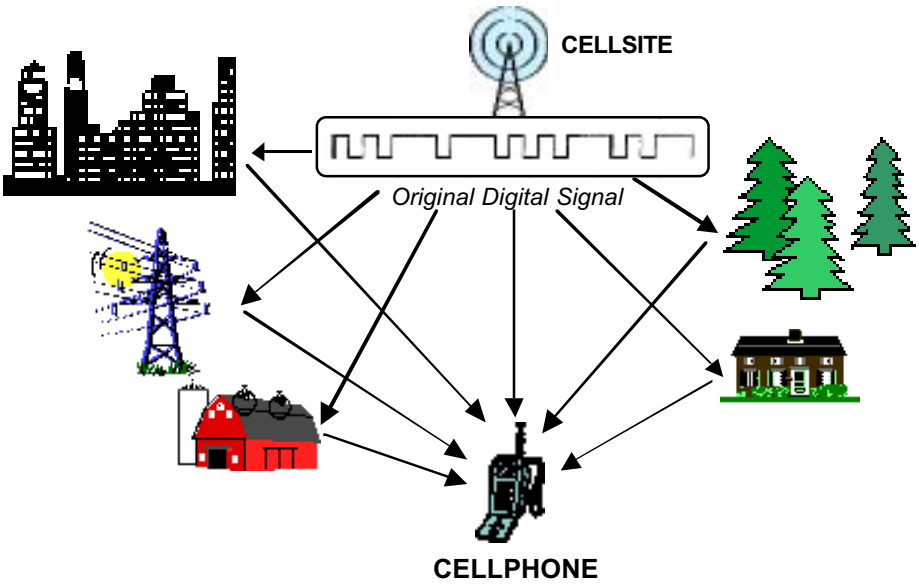
It's obvious to antenna engineers. When omni-directional antennas operate on handsets held next to the head, the only signal transmission available for cell sites radiate in the direction away from the head. Omni-directional antennas on handsets are 100% directional when they're held next to the head to make calls because 100% of the signal beamed into the head is absorbed by the head.

Directional antennas work as well or better in carrier network operations than omni-directional antennas because microwaves are a lot like sound waves. They bounce and reflect, or multipath off everything along the way, including buildings, power lines, barns, houses or trees. It's similar to listening to a portable radio. You can still hear it when you walk around or behind it because its sound waves reflect off nearly everything in sight.

So that it's easier to visualize how microwaves radiate from a cellphone's antenna, following is a typical engineering plot of an omni-directional signal pattern. The antenna is in the center of the circle, as if you were looking down at it from the top. The dark line just inside the edge of the circle represents the 360º radiation pattern

HOW DIRECTIONAL HANDSET ANTENNAS IMPROVE CALL QUALITY

Digital microwave signals are clear and easy to lock onto at cellsites. However, by the time they reach cellphones in a typical cellular network they've multipathed, or reflected like sound waves and light off every object along the way, whether buildings, powerlines, barns, houses or trees.



The time it takes microwaves to reach cellphones is determined by the distance they travel to get there. Microwaves traveling directly from cellsites to cellphones are received milliseconds sooner than the identical signals reflected to the same phones from objects along the way. Omnidirectional antennas receive all reflected signals at about the same strength, and identical signals arriving at different times, or out of phase with one another are difficult for software to lock onto, producing poor call quality and dropped calls.

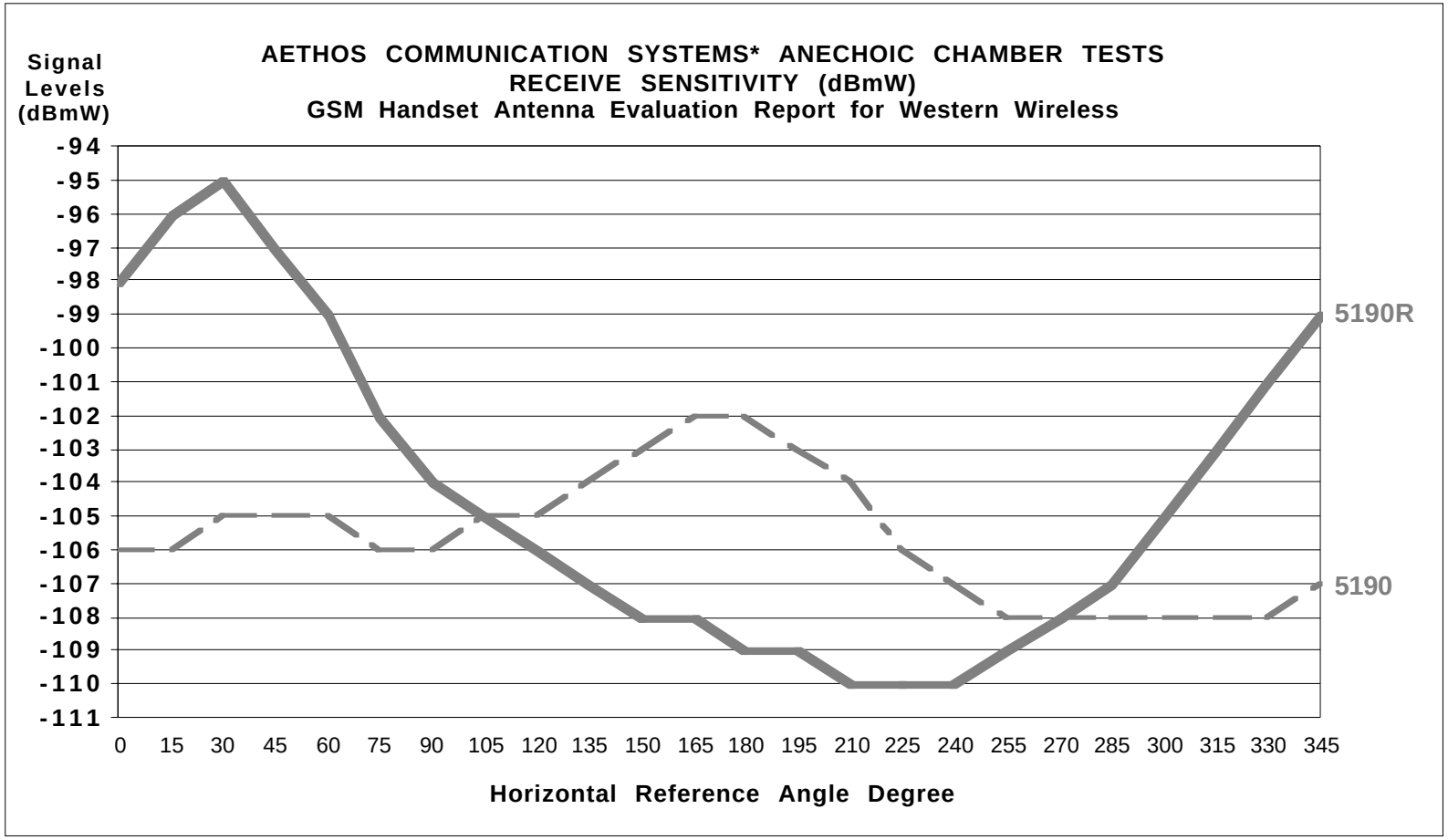
Multipath Signal Reception as seen through Omnidirectional Antenna

Directional antennas however, with a gain of 3 dB or more at the peak of their beamwidth, deliver a single more clearly defined signal that is easier for handset software to read, which produces better call quality and fewer dropped calls.

Multipath Signal Reception as seen through a Directional Handset Antenna

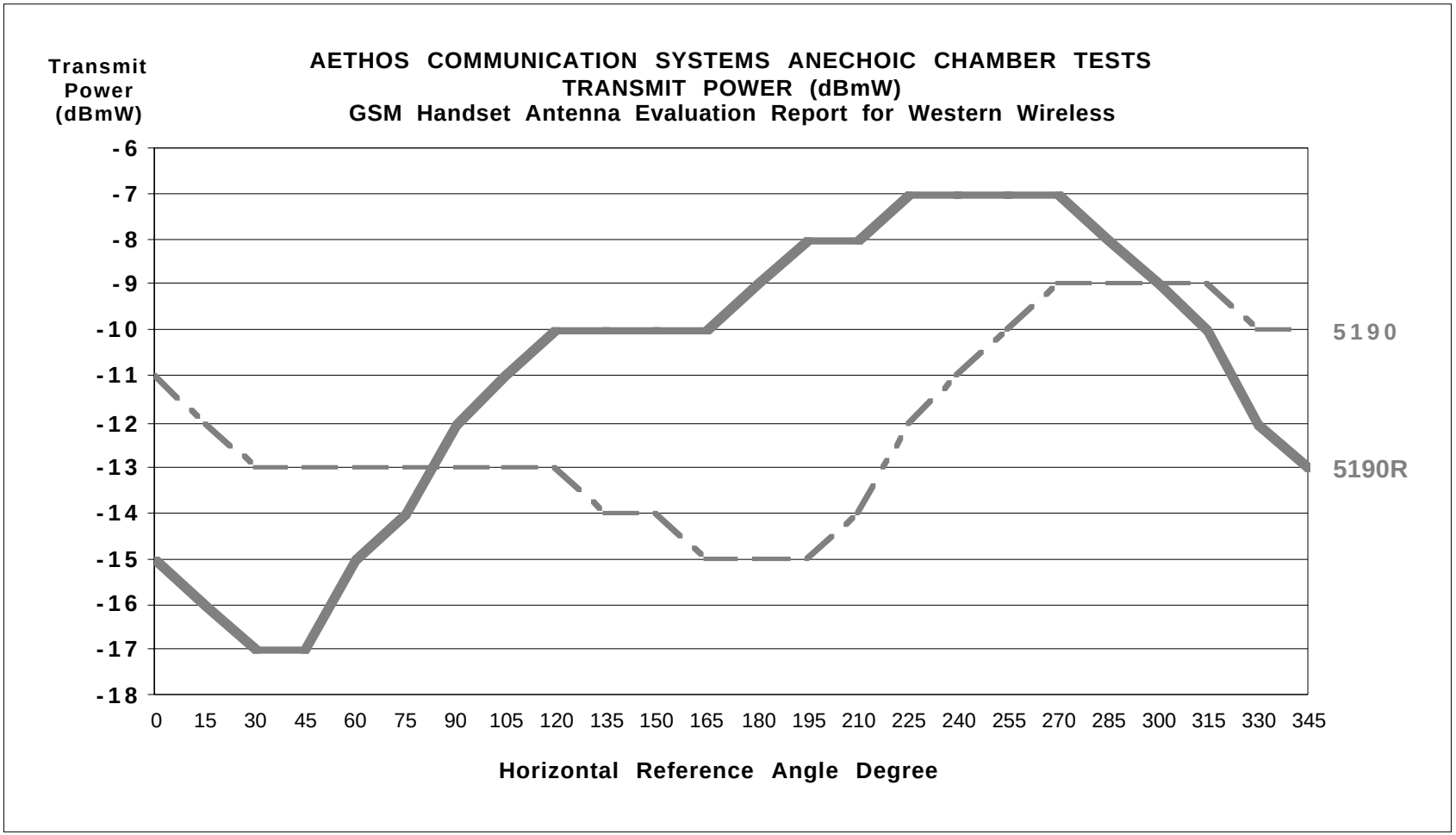
Aethos Communication Systems Laboratory & Carrier Network Test Report

Directional Antenna Increases Transmission Power Signal Levels 400% …Reduces Signal Loss to the Head More than 60%



Note: 5190R = Nokia 5190 with clip-on Directional Antenna. 5190 = Nokia 5190 with Omnidirectional PCS Antenna

*** Aethos Communication Systems** provides system design, systems integration, handset performance evaluation, and optimization of cellular network performance to network operators such as Western Wireless, Aerial Communications and other major service providers in the U.S. and throughout the world. Aethos has offices in Dallas, Texas and Almondsbury, Bristol, United Kingdom


AETHOS COMMUNICATION SYSTEMS ANECHOIC CHAMBER TESTS
TRANSMIT POWER (dBmW)
GSM Handset Antenna Evaluation Report for Western Wireless
Transmit Power (dBmW)
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345
Horizontal Reference Angle Degree
5190
5190R

Independent Directional Antenna Tests (Notes)

AETHOS ANECHOIC CHAMBER TESTS

Horizontal Ref. Angle Degree: Represents horizontal reference points in free space at which GSM performance measurements were taken of a Nokia 5190 phone with factory OEM antenna **(5190)** as compared to the same phone equipped with a directional antenna **(5190R)**. **"0°"** indicates the measurements taken with the phone front (earpiece, keypad and LED display which represents the side of the phone facing toward the head) facing the anechoic chamber's horn antenna and **"180°"**, the measurements taken with the phone back facing the horn.

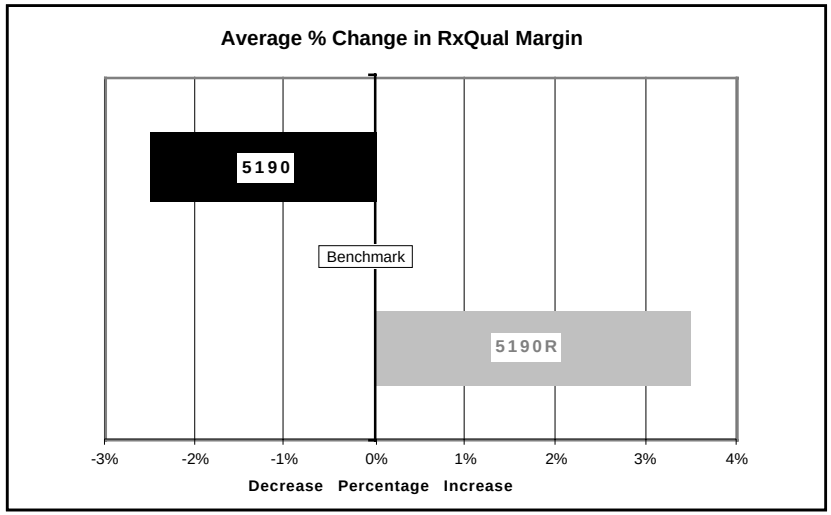
Signal Levels (dBmW): Represents transmit/receive signal measured by the anechoic chamber horn antenna in decibels miliwatts.

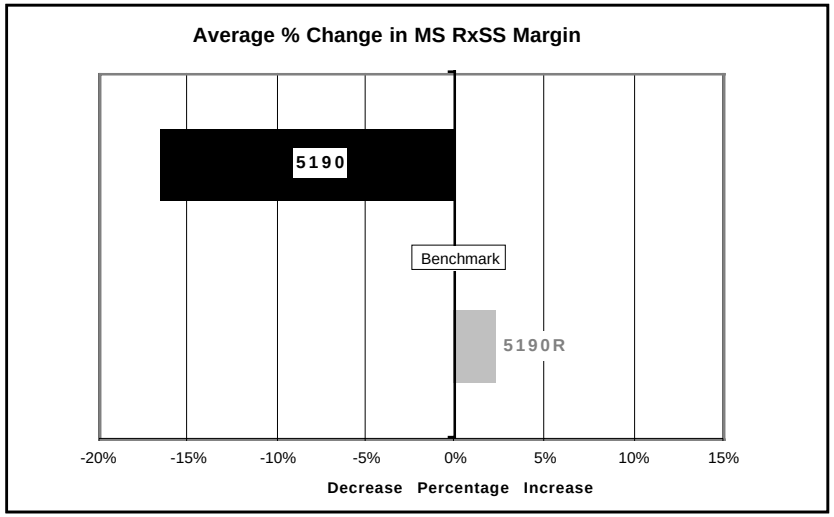
Receive Sensitivity: The receive sensitivity is determined at the signal level at which the phone is able to produce an average residual bit error rate (RBER) of 2%. At the **"180°"** position with the phone back facing the transmitting horn antenna, the OEM antenna had a receive sensitivity of -102 dBmW and directional antenna -109 dBmW. The difference of 6 dB represents a 400% increase in receive sensitivity produced at the**"180°"** position. At the **"0°"** degree position with the phone front facing the transmitting horn antenna, the OEM antenna had a receive sensitivity of -106 dBmW and the directional antenna -98 dBmW. The difference of 8 dB represents an approximate 75% reduction in receive sensitivity. However, in actual use the substantial portion of the radiation that reaches the front of the phone is absorbed by the head. Thus, this reduction in receive sensitivity at the phone front does not represent a degradation in overall receive sensitivity.

Transmit Power: At the **"0°"** position with the phone front facing the horn antenna, the OEM antenna produced a transmit signal level of -11 dBmW and the directional antenna -15 dBmW. The difference represents a decrease in signal level transmitted in the direction of the head of 4 dB, which equals a reduction of more than 60% in electromagnetic radiation absorbed by (lost in) the head*****. At the **"180°"** position with the phone back facing the horn, the OEM antenna produced a signal level of -15 dBmW and the directional antenna a signal level of -9 dBmW. The -9 dBmW represents an increase in signal levels of 6 dB, which equals a 400% increase in transmit power directed away from the head.

***** If .6 watts is transmitted toward the head and it is reduced by 4 dB, 4 dB equals a 61% reduction in power transmitted toward the head. Conversely, if .6 watts are transmitted away from the head and it is increased by 6 dB, which equals a factor of 4, the 6 dB increase equals an effective radiated power (ERP) of 2.4 watts, which represents a 400% increase in power transmitted away from the head.

Aethos Directional Antenna Moving Field Tests Report





IMSI Trace Statistics for Moving Field Tests: Represents the moving field test results of relative mobile station received strength levels and relative receive quality between the selected benchmark Nokia 2190 compared to the performance of a Nokia 5190, and a Nokia 5190R (the Nokia 5190 equipped with the directional antenna)

MS RxLev <=20 dBm represents mobile station receive signal strength levels in percentage terms compared to the benchmark. The MS RxSS Margin for the 5190 in tests #1 & #2 was -8.2% and -24.7% respectively, and for the 5190 with the directional antenna, +6.2% and - 1.5% respectively. This represents an average MS RxSS Margin of -16.4% for the 5190 and +2.3% for the 5190R, or an overall increase in performance by the 5190 equipped with directional antenna of +18.7%. In addition, the **MS RxQual Margin** for the 5190 in tests #1 & #2 was +2.4% and -7.4%, and for the 5190R, +4.5% and +2.5%. This represents an average MS RxQual Margin of -2.5% for the 5190 and +3.5% for the 5190R, or an average increase in RxQual Margin by the 5190 equipped with the directional antenna of 6%.

Reported RxLev and RxQual: Consistent results in the RxLev-105 and –106 range and Rx Qual 3 to 4 range indicate that no penalty in phone performance throughout the horizontal ref angle degrees is created by the addition of the directional antenna.

AETHOS COMMUNICATION SYSTEMS TEST SUMMARY

GSM Handset Antenna Evaluation For Western Wireless

RECEIVE SENSITIVITY (dBmW)

	Nokia 6190 with OEM Antenna		Nokia 6190 with Directional Antenna	
	Horizontal Ref. Angle Degree	Signal Levels (dBmW)	Horizontal Ref. Angle Degree	Signal Levels (dBmW)
0˚= Phone Front facing horn	0	-106	0	-98
	15	-106	15	-96
	30	-105	30	-95
	45	-105	45	-97
	60	-105	60	-99
	75	-106	75	-102
	90	-106	90	-104
	105	-105	105	-105
	120	-105	120	-106
	135	-104	135	-107
	150	-103	150	-108
	165	-102	165	-108
180˚= Phone Back facing horn	180	-102	180	-109
	195	-103	195	-109
	210	-104	210	-110
	225	-106	225	-110
	240	-107	240	-110
	255	-108	255	-109
	270	-108	270	-108
	285	-108	285	-107
	300	-108	300	-105
	315	-108	315	-103
	330	-108	330	-101
345˚= Phone Front facing horn	345	-107	345	-99
	Average	-105.6	Average	-104.4

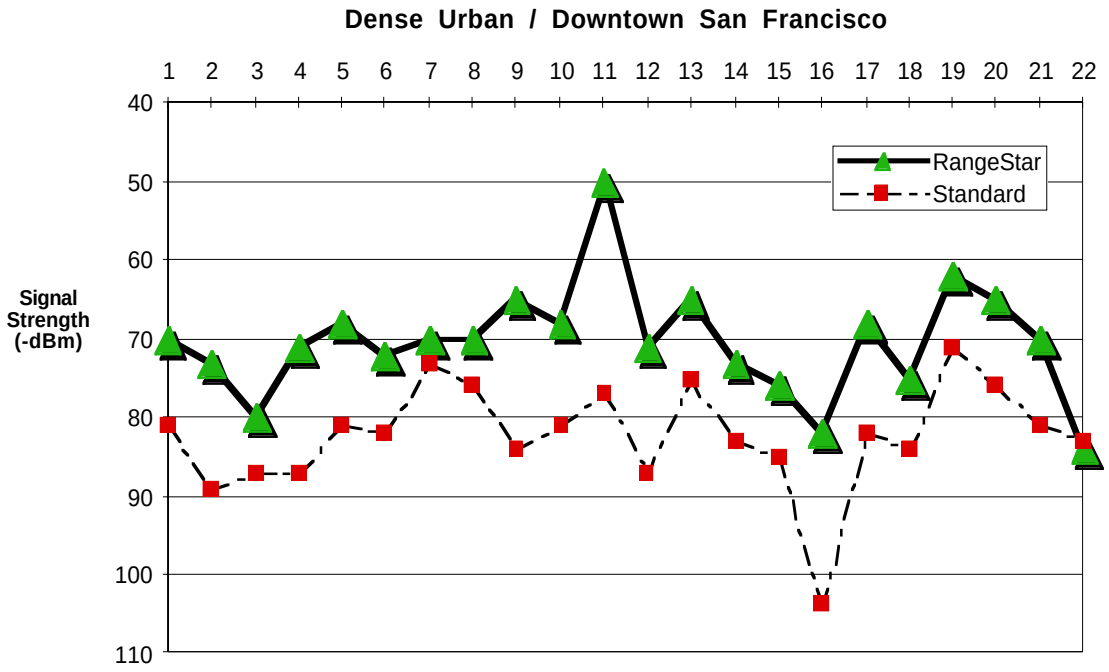
TRANSMIT POWER (dBmW)

	Nokia 6190 with OEM Antenna		Nokia 6190 with Directional Antenna	
	Horizontal Ref. Angle Degree	Transmit Power (dBmW)	Horizontal Ref. Angle Degree	Transmit Power (dBmW)
0˚= Phone Front facing horn	0	-11	0	-15
	15	-12	15	-16
	30	-13	30	-17
	45	-13	45	-17
	60	-13	60	-15
	75	-13	75	-14
	90	-13	90	-12
	105	-13	105	-11
	120	-13	120	-10
	135	-14	135	-10
	150	-14	150	-10
	165	-15	165	-10
180˚= Phone Back facing horn	180	-15	180	-9
	195	-15	195	-8
	210	-14	210	-8
	225	-12	225	-7
	240	-11	240	-7
	255	-10	255	-7
	270	-9	270	-7
	285	-9	285	-8
	300	-9	300	-9
	315	-9	315	-10
	330	-10	330	-12
345˚= Phone Front facing horn	345	-10	345	-13
	Average	-12.1	Average	-10.9

IMSI Trace Statistics for Moving Field Tests

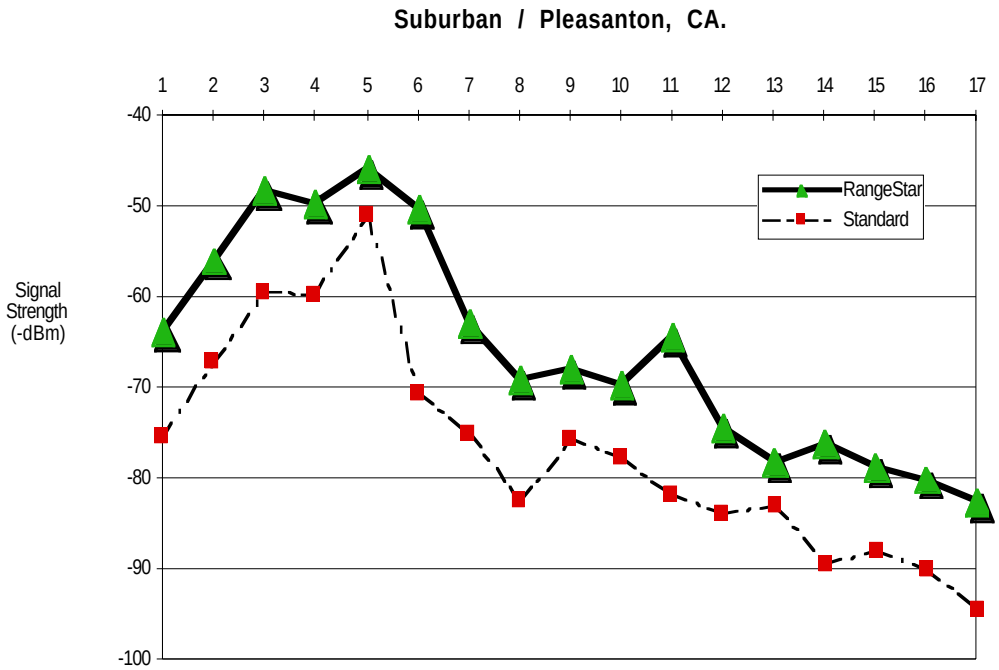
Mobile Stations	MS RxLev <=20 dBm	MS RxQual =>3	MS RxSS Margin	Average MS RxSS Margin	MS RxQual Margin	Average MS RxQual Margin
Benchmark	33.8%	22.0%				
No. 5190 #1	42.0%	19.6%	-8.2%	-16.4%	2.4%	-2.5%
No. 5190 #2	58.6%	29.4%	-24.7%		-7.4%	
Benchmark	49.6%	24.5%				
No. 5190R #1	43.4%	19.9%	6.2%	2.3%	4.5%	3.5%
No. 5190R #2	51.1%	22.0%	-1.5%		2.5%	

Performance Measure:
Received Signal Strength



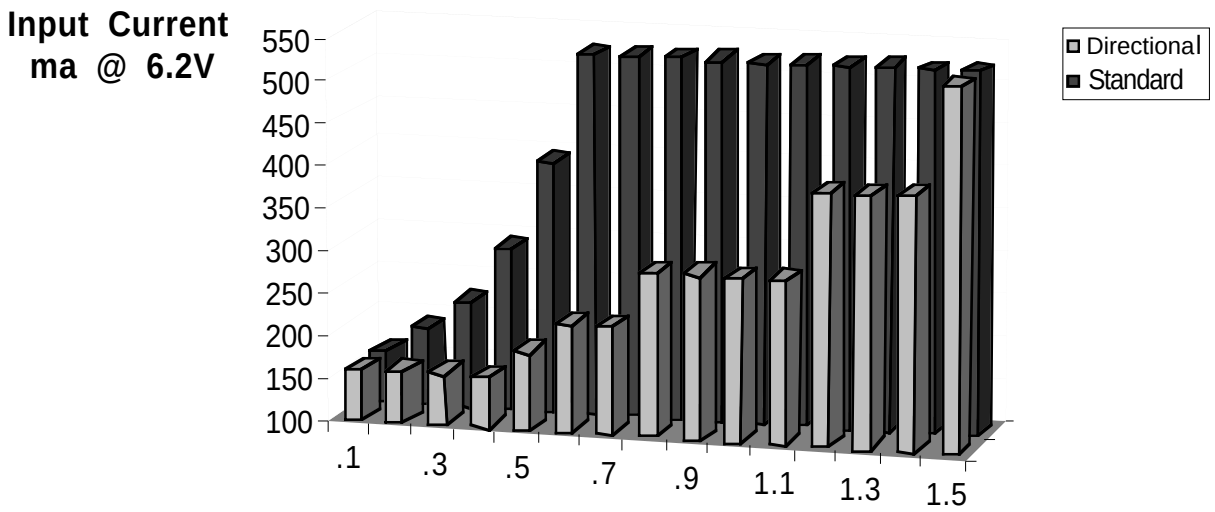
Even in dense urban areas, directional antennas consistently improve performance

Performance Measure:
Received Signal Strength



Directional antenna significantly improved average performance by 10 dBm.
Benefits are greater range, fewer dropped calls, optimal voice quality.

Performance Measure:
Commanded Power/Battery Consumption

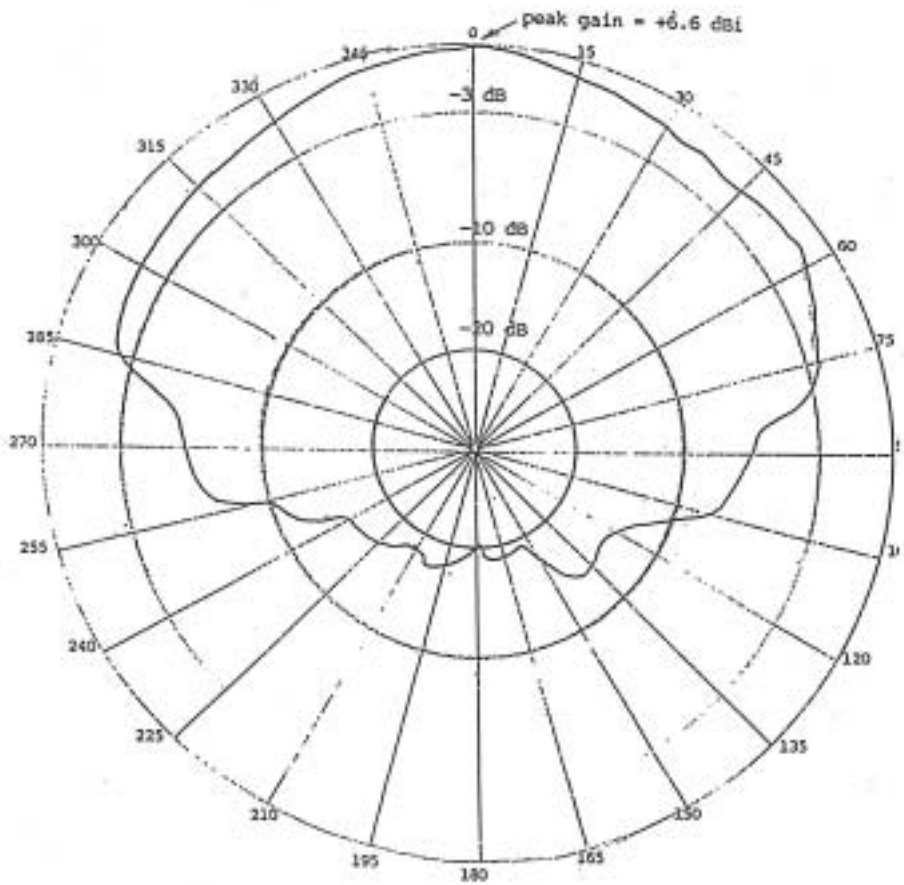


Directional antenna equipped phone drew considerably less power through 86% of distance test

Signal Antenna Systems (SAS) Tests

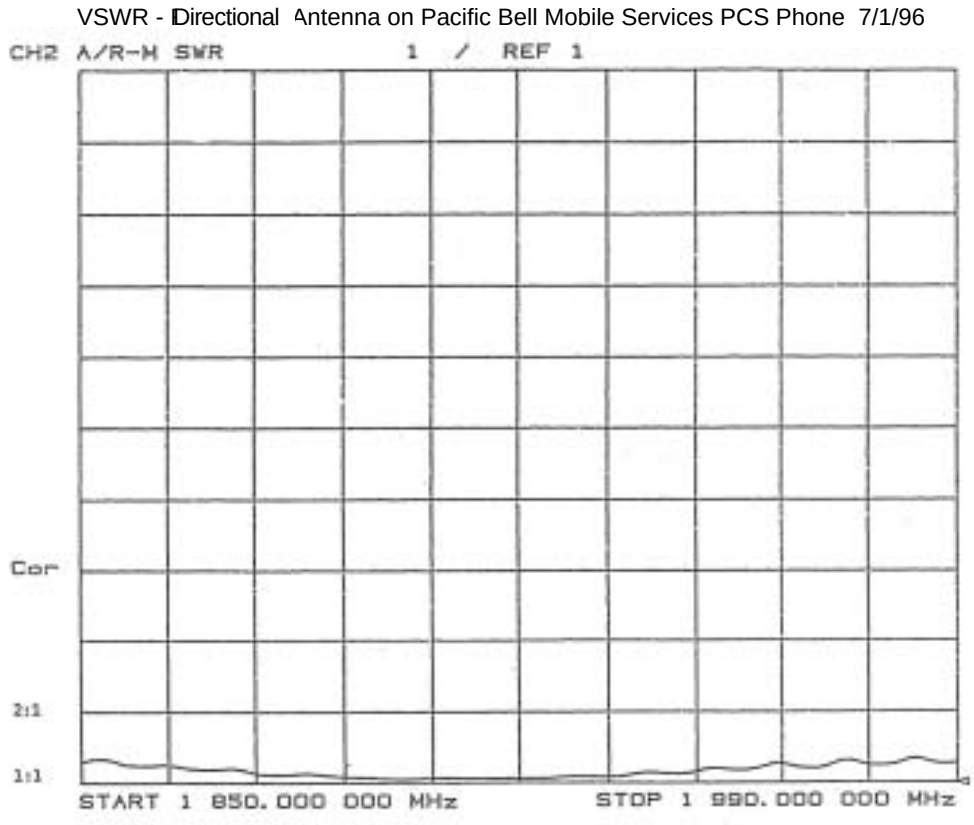
ANTENNA TYPE: Directional antenna on Pacific Bell PCS Phone FREQUENCY: 1920 MHz

PATTERN TYPE: AZ POLARIZATION: Slant linear DATE: 7/18/96



Performance Measurements: VSWR

Signal Antenna Systems (SAS) Tests



The directional antenna performed at excellent levels throughout the full PCS range

Handset Directional Antennas
Typical Hearing Aid User Comments

"The phone with the standard antenna was very annoying with the buzz in the background, while the same phone with the directional antenna was very quiet, and quite acceptable."

Naomi Fleer

"The phone equipped with the directional antenna was very clear. No noise. No static. When you put the directional antenna on there, all the noise just stopped."

Paul Fredrickson

"The directional antenna equipped phone was far better and clearer and did not have any buzz or background noise to it. The same phone with the standard antenna was unacceptable for noise and clarity, especially the noise."

Richard Fleer

CERTIFICATE OF SERVICE

I, Donna L. Brown, do hereby certify that I have, this 11th day of February, 2001, caused to be sent by first class United States mail, postage prepaid, copies of the foregoing "Reply Comments of the Hearing Industries Association" to the following:

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