Building The Wireless Future™

August 3, 1995

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W. - Room 222
Washington, D.C. 20554

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RE: Ex Parte Contact - Rule Making No. 8658

Dear Mr. Caton:

On Thursday, August 3, 1994, Mr. Randall S. Coleman, Vice President of Regulatory Policy and Law, Cellular Telecommunications Industry Association (CTIA), met with Dan Phythyon, Senior Legal Advisor, and Jay Markley, Telecommunications Policy Associate, Wireless Telecommunications Bureau. The discussions concerned the petition for rule making filed by HEAR-IT NOW, and expressed positions as previously filed in the above-referenced proceeding. The attached documents were provided to Messrs. Phythyon and Markley, and are being provided to the following Commission staff:

Ms. Rosalind Allen
Mr. Laurence Atlas
Mr. Rudy Baca
Ms. Lauren Belvin
Mr. Michael Buas
Mr. James Casserly
Ms. Jackie Chorney
Mr. John Cimko
Dr. Robert Cleveland
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Mr. Michael Wack
Ms. Kathleen Wallman
Ms. Karen Watson
Mr. Richard Welsh

Pursuant to Section 1.1206 of the Commission's Rules, an original and one copy of this letter and the attachments are being filed with your office. If there are any questions, please contact the undersigned.

Sincerely,

Robert F. Roche

Response to HAC Information Request of Gerry Vaughn, FCC

Technical Data:

1. What is the life span of hearing aids?

The Hearing Industries Association (HIA) has indicated that the lifespan of hearing aids is from five to six years. However, Dr. Jack Wojcik of the Spectrum Sciences Institute in Ottawa has indicated that this is a function of the health insurance system rather than hearing device longevity.[1] Moreover, the head of Self Help for the Hard of Hearing (SHHH) has indicated that while "most hearing aid users replace their aid every four to six years, on average, our members replace at least one of their hearing aids more frequently than the norm . . . . within the past three years."[2]

2. What are the number of hearing aid manufacturers?

There are reportedly 30-40 major manufacturers of hearing aids worldwide, although there are 75 registered with the U.S. FDA, and a preliminary list dated November 1992 includes 31 companies (including five of unknown address). Attachment A provides a listing of better known manufacturers and their models. The Hearing Journal Directory reportedly makes available a further listing of manufacturers and their models.

3. What are the number of hearing aid models made by the preceding?

The number of hearing aid models has been estimated to be in the hundreds, based on an average of ten models per manufacturer. See Attachment A.

4. What are the types of hearing aids (behind the ear, in the ear, in the canal, cochlear implants)?

Behind-the-ear (BTE) hearing aids house microphone, speaker and amplifier in a case that fits behind the ear. A tube conducts sound from the case to an earpiece fitting inside the ear. *Consumer Reports* reported in November 1992 that BTE's amounted to about 20 percent of the market because of perceptions that they were unattractive. However, newer models are reportedly smaller and less noticeable. *Consumer Reports* indicated that BTE's offer the advantages of (1) larger, longer-lasting batteries, (2) room for more circuitry and better sound quality control, (3) larger and more easily adjusted controls, and (4) more reliability, given component protection from wax.[3] Reportedly, behind-the-ear hearing aids are available that include a telecoil with a switch to permit the hearing

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[1] Letter from Dr. Jack Wojcik, President of Spectrum Sciences Institute, to Robert F. Roche, CTIA Director for Research, July 28, 1995, at 1.

[2] Donna L. Sorkin, "Understanding Our Needs: The SHHH Member Survey Looks at Hearing Aids," *SHHH Journal,* July/August 1995, at 32.

[3] "How to Buy a Hearing Aid," *Consumer Reports*, November 1992, at 716.

aid to receive sound directly from the telephone rather than from the hearing aid's external microphone, thus tuning out environmental/background sounds.[4]

In-the-ear (ITE) hearing aids include all components in a custom-molded housing that fits in the ear. The hearing aid, volume controls, and battery compartments are all smaller than those on behind-the-ear models.[5] Some models of ITE hearing aids are equipped with telecoils.[6]

In-the-canal (ITC) hearing aids fit entirely within the ear canal. Reportedly, because they sit deeper in the ear canal, they do not need to amplify sound as much as other types of hearing aids. In-the-canal hearing aids cost more than the other types of hearing aids.[7]

Cochlear implants are hearing devices designed to aid the profoundly deaf, transforming sounds into electrical impulses and transmitting them to the brain.[8] They are implanted via a surgical procedure, and provide variable benefits to users according to reports.[9]

Other forms of hearing aids include body worn aids, which use a speaker worn around the neck. Other forms include eyeglass mounted/incorporated hearing aids, bone conduction hearing aids, half-shell hearing aids, helix aids, canal aids (which are not completely in the canal), and cross and bi-cross hearing aids (which send the sound to the other ear).

Current/Interim Solutions:

1. How effective are solutions?

Dr. Wojcik has observed that the studies to date have proposed solutions which *may be* made effective, but which address only the issue of RF interference. These solutions include shielding of the hearing aid and/or decoupling RF capacitors added to the hearing aid circuit. Shielding has been proposed involving enclosing the internal hearing aid components (microphone, telecoil, and leads) or integrating the shielding with the external casing of the hearing aid through the use of metallic sprays.

The report by the Australian National Acoustic Laboratories entitled "Interference to Hearing Aids by the Digital Mobile Telephone System, Global System for Mobile Communications (GSM)," evaluated electrostatic shielding of various hearing aids using

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[4] Susan Phillips, "Using the Telephone," *The Exceptional Parent*, May 1995, at 55.
[5] *Consumer Reports, op cit.*
[6] *See* Current/Interim Solutions, below, at 3, and Long-Term Solutions at 6-7.
[7] *Consumer Reports, op cit.*
[8] "Cellular One Donates Phone for Hearing Impaired Research," *PR Newswire*, May 25, 1995.
[9] "Panel Expands Use of Cochlear Implants; National Institutes of Health Experts Endorse Use of Implants in Adults with Severe Hearing Loss," *Science* News, June 3, 1995. *See also* Joseph P. Pillion, "Hearing Impairment & Hearing Aids," *The Exceptional Parent*, May 1995, at 5.

silver paint, sputtered silver, electroless nickel plating and a decorative metal coating.[10] This analysis identified four means for increasing hearing aid immunity: (1) reducing internal interconnect wire lead lengths in hearing aids; (2) surrounding the amplifier with an electrostatic shield; (3) using shunt capacitors "effective at the radio frequencies involved, to reduce radio frequency voltages across the amplifier input transistors;" and (4) impregnating the plastic case parts with special stainless steel wire filler.[11]

2. How much does it cost to paint the inside of a hearing aid?

The cost of painting hearing aid interiors has not been quantified in the materials at hand, although further research is being conducted on the costs of various shielding approaches.

3. How much do hearing aid compatible phones cost?

The question of the cost of hearing aid compatible phones is impacted by a number of factors. One issue is how Hearing Aid Compatibility (HAC) is defined. Various parties have noted that the current definition does not mean that something classified as HAC is usable by the hearing aid-equipped community.[12] A wireline telephone is defined as "hearing aid compatible" if it "provides internal means for effective use with hearing aids that are designed to be compatible with telephones which meet established technical standards for hearing aid compatibility."[13] In practice, this has meant the ability of a telephone receiver to generate magnetic fields modulated with an audio signal which can be detected by a hearing aid equipped with a telecoil.[14] While a wireless phone may meet Part 68 HAC requirements, this does not mean that it is usable. Moreover, as the answer to question 3, under "Long-Term Solutions," below, indicates, such aids equipped with telecoils constitute a declining share of the market. Thus, the cost of rendering a phone hearing aid compatible in accord with that practice would not necessarily render the phone usable by the community of hearing aid users.

Indeed, Donald J. Bowen of AT&T Bell Laboratories has cautioned that "depending on the design parameters, it is not clear whether wireless phones can be made compatible with the telecoil of all hearing aids regardless of the cost."[15]

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[10] NAL Report No. 131, May 1995, at 17-21.

[11] *Id.* at 22.

[12] *See e.g.,* Comments of The Ericsson Corporation In Response to the Petition for Rule Making of HEAR-IT Now, filed July 17, 1995, at 3-4.

[13] 47 C.F.R. Section 68.4(a)(3). Wireless phones are currently exempted by Section 68.4(a)(1)-(2).

[14] Consistent with the technical specifications established in Section 68.316 of the Commission's rules. 47 C.F.R. Section 68.316.

[15] Memo from Donald J. Bowen, AT&T Bell Laboratories, to Robert Roche, CTIA Director for Research, July 26, 1995, at 1-2. AT&T has been quite active in access issues and device development. For example, AT&T has been active in developing sound processing technology used in ReSound's digital hearing aids.

Long-Term Solutions:

1. What is in the works re on-going research efforts?

Dr. Jack J. Wojcik, President of Spectrum Sciences Institute and Science and Engineering Advisor to APREL Laboratories in Ottawa, Canada, has prepared a summary of studies of hearing aid-wireless telephone compatibility. This summary is focused on identifying recent studies and publications relevant to compatibility issues, as a preliminary step towards further research.

Among the studies, papers and articles which have been identified are:

1. "GSM Phones and Hearing Aids," Michael T. Houghton, CTIA
2. "EMC and the New Modulation Technologies," Ole Lauridsen, Telelaboratoriet TELECOM Denmark, May 10, 1994
3. "Interference with Hearing Aids Caused by GSM Digital Cellular Telephones and DECT Digital Cordless Telephones," National Telecom Agency, June 28, 1994
4. "Report to the HIA on RF Interference to Hearing Aids from Digital Cellular Telephone Signals," Earl Geddes, May 23, 1994
5. "Effects on TDMA-Modulated Hand-Held Telephones on Pacemakers," Eicher et al., Swiss Telecom
6. "GSM Cellular Phone Interference with Implantable Pacemakers: In Vitro and In Vivo
7. Observations," Barbaro et al., Instituto Superiore di Sanita
8. "Mobile Telephones Interfere with Medical Electrical Equipment," Clifford et al., Monash Medical Centre & Telecom Australia
9. "GSM EMC Considerations," ETSI, Feb. 1, 1993
10. "GSM Interference Model," Jon Short, BT Laboratories, Feb. 22, 1990
11. "Summary Document on GSM-TDMA Interference," F. Mellish, RTL, July 1, 1991
12. "Guidance as to Restrictions on Exposures to Time Varying Electromagnetical Fields and the 1988 Recommendations of the International Non-Ionizing Radiation Committee, NRPB-GS 11, National Radiology Protection Board
13. "German Draft Standard DIN VDE 0848 Part 2, Safety in Electromagnetic Fields; Protection of Persons in the Frequency Range from 30 kHz to 300 Ghz," DIN VDE, DIN, Oct. 1, 1991
14. "Possible Interference and Health Effect Associated with GSM Mobile Phones," Ken Joyner, Telecom Research Laboratory
15. "Interference to Hearing Aids by the New Mobile Telephone System, Global System for Mobile (GSM) Communications Standard, Ken Joyner et al., National Acoustical Laboratories, March 30, 1993
16. "Interference from the TDMA Structure in Digital Mobile Communication to PSTN," Egil Hauger, Televerkets Forskningsinstitutt, October 6, 1992

17. "Potential GSM Hazards on Cardiac Pacemakers," ETSI, CSELT, May 21, 1991
18. "Working Party - DCT/HAC," Bob Corey
19. "Wireless Access Equipment and Hearing Aid EMI," L. Thorpe, November 25, 1992
20. "Subjective Assessment of CT-2 Interference to Hearing Aids," R. Corey, Department of Communication, January 21, 1993
21. "Susceptibility of Hearing Aid Devices to Radio Frequency Fields," Brian Kasper, Department of Communication, January 21, 1993
22. "EMI Interaction Between the CT2 Digital Handset and Hearing Aids," H. Arndt, Unitron, February 16, 1993
23. "CT2 Digital/Cordless Telephone Study Hearing Aid Compatability," H. Arndt, Unitron, March 13, 1993
24. "Answers to 'GSM Questions & Answers," F. Hillebrand, GSM-MoU Group, April 3, 1995
25. "GSDM - A Challenge to the Hearing Industry," N. Bisgard, Danavox, September 10, 1993
26. "Considerations Regarding Hearing Aid Compatibility of DCT Terminals," L. Thorpe, NT/BNR, February 16, 1993
27. "Wireless Access Equipment and Hearing Aid EMI," L. Thorpe, BNR, November 25, 1992
28. "European Digital Cellular Telecommunications System (Phase 2) GSM Electro Magnetic Compatibility (EMC) Considerations (GSM 05.90), ETSI, February 1, 1994
29. "Radio Frequency Immunity Requirements for Equipment Having an Acoustic Output Draft PN-3210 Issue 6, TIA/EIA, December 1, 1994
30. "Coupling Hearing Aids to Telephone Sets, Submission to CCITT SG XII, July 1, 1991
31. "TAPAC Digital Cordless Telephone Service Committee," S. B. Hahn, The Canadian Hearing Society, February 5, 1993
32. "Report on the Coupling of Telephones and Hearing Aids," J.J. Wojcik, APREL, November 1, 1983
33. "T515, Fourth Draft (TIA/EIA - 504A Draft PN-3399, CSA/TIA, CSA/TIA/EIA, May 30, 1995
34. "Parallel Universes," D. Sweeney, Audio, September 1, 1990
35. "The Intermodulation Problem in Mobile Communications," M. Lang, Microwave Journal, May 1, 1995
36. "Low Power Wireless Radiation Issues," Planning & Standards Group, Telecom Canada, August 1, 1991
37. "Safety Action Bulletin," Department of Health, Northern Ireland, November 1, 1994
38. "Partial Transcript of 'Tomorrow's World,'" Canada, October 29, 1993
39. "Hear-It Now Petition for Rulemaking," June 28, 1995
40. "Digital Cellphones & Interference with Hearing Aid Users," A. Greville, National Audiology Centre, August 1, 1993

41. "EMC Considerations for Digital Cellular Radio and Hearing Aids," J. Short, BT Laboratories

The Center for the Study of Wireless Electromagnetic Compatibility, at the School of Industrial Engineering, University of Oklahoma, is heading up a study of the interaction between various types of wireless telephones and hearing aids to be conducted at the University of Oklahoma.

Northern Telecom is involved in an ongoing research project with the Collier Institute of the University of Texas in Dallas.[16]

2. What is the research time-line?

The Center for the Study of Wireless Electromagnetic Compatibility is developing a Protocol for the study of hearing aid interaction with wireless phones, which should be finalized within several weeks. The first results of the study are expected within six months, with more study to be conducted as needed.

3. What can be done with wireless phones (rather than hearing aids)?

A variety of things can be done to make wireline and wireless phones "hearing aid compatible." However, as noted in the response to the previous question regarding the cost of hearing aid compatible phones, the definition of Hearing Aid Compatibility (HAC) does not mean that something classified as HAC is usable by the hearing aid-equipped community. A telephone is defined as "hearing aid compatible" if it "provides internal means for effective use with hearing aids that are designed to be compatible with telephones which meet established technical standards for hearing aid compatibility."[17] In practice, this has meant the ability of a telephone receiver to generate magnetic fields modulated with an audio signal which can be detected by a hearing aid equipped with a telecoil.[18] For example, wireline phones include an add-in device, called a flux coil, which emits such a magnetic field usable by hearing aids using telecoils.

Incorporating such a flux coil into a wireless phone is possible, however there are several factors to be considered. First, the market share of hearing aids using telecoils is small (reportedly approximately 25 percent of hearing aids used in the U.S., and 40 percent of the hearing aids used worldwide) and declining, because the public prefers less detectable hearing aids, and adapting telecoils to in-the-ear hearing aids is difficult given

[16] "Effect of GSM on Hearing Aids Brought to FCC Attention; Proponents Call Information 'Carefully Orchestrated Campaign,'" *Mobile Phone News*, March 27, 1995.
[17] 47 C.F.R. Section 68.4(a)(3).
[18] Consistent with the technical specifications established in Section 68.316 of the Commission's rules. 47 C.F.R. Section 68.316.

the existence of less room for control switches.[19] (ReSound is manufacturing a line of remote controls for such hearing aids, making possible incorporation of telecoils.) Second, the flux coil consumes power, and thus constitutes a drain on the power of the wireless unit. This raises the questions of (1) how much does it cost for the power, and (2) how much power is consumed by the coil.[20]

According to Donald J. Bowen of AT&T Bell Laboratories, the presence of a radio and associated circuitry in a cellular phone complicates the situation:

> In addition to the direct radiation of electromagnetic energy by the antenna which could be picked up by a telecoil (or by other elements of the hearing aid circuit), spurious emissions from RF and related digital circuitry also pose a problem. For example, pulsed RF transmitters can draw up to 1 amp of current, generating potentially significant magnetic fields, which a telecoil is exquisitely sensitive to.[21]

All of this constrains what can be done with wireless phones to ensure hearing aid compatibility. However, it is notable that "as cell sizes become smaller, the amount of power transmitted is dramatically lower, and the interference problems are correspondingly reduced. So, somewhat ironically, installing more cell sites causes a typical phone to transmit using less power, consequently easing interference problems."[22]

Other options include Phoenix Management Inc.'s HATIS™ device, or "Hearing Aid Telephone Interconnect System," which uses inductive coupling to work with behind-the-ear and in-the-ear hearing aids, and cochlear implants, equipped with telecoils.[23]

Alternately, as Mr. Bowen indicated, radical design changes to wireless phones, such as remote antennas which users could clip to their waist, "could ameliorate interference, though customers typically object vigorously to such cumbersome arrangements."[24]

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[19] Reportedly, between 4 million and 5.8 million Americans own hearing aids in the U.S. *See* Reply Comments of HEAR-IT NOW, RM 8658, filed August 1, 1995, at 2. *See also* Hearing Industries Association Comments on Petition for Rule Making, RM 8658, filed July 17, 1995, at 3.

[20] Oral communication from Charles Spann, Northern Telecom, to Robert Roche, CTIA Director for Research, July 27, 1995. Further information from Dr. Jack Wojcik, Spectrum Sciences Institute, July 28, 1995.

[21] Memo from Donald J. Bowen, AT&T Bell Laboratories, to Robert Roche, CTIA Director for Research, July 26, 1995, at 1.

[22] *Id.* at 2.

[23] Comments of CTIA in RM 86-58, HEAR-IT NOW Petition for Rule Making; Section 68.4(a) of the Commission's Rules: Hearing Aid Compatible Telephones, July 17, 1995, at 15.

[24] Bowen, *op cit.*

Attachment A

Hearing Aid Manufacturer List

3M Hearing Health.[25]

Acousticon Electronics (unknown address) is reportedly the manufacturer of the Acousticon hearing aid, as are **A&M Hearing Aids Ltd.** of Sussex, England, and **Angus & Coote Hearing Care Centers** of Sydney, Australia.[26]

Apex Acoustics Ltd. of Oxford, England, is listed as the manufacturer of the following models of hearing aids: Apex, Belcare, Gem, Microson, Nova, and Pulsar.[27]

Argosy Electronics Inc. of Minneapolis, is the manufacturer of the following models of hearing aids, according to a December 1992 Hearing Journal Directory: Argosy CCA, Argosy HS, Argosy Shado, Aristocrat CCA, Eclipse, Manhatten Circuit, Passport, and Shado Low Profile.

Ascom Holding AG is a multinational firm, ultimately held by Hasler Werke Foundation, with 65 principal subsidiaries in 18 countries. Among its subsidiaries' products are hearing aids.[28]

Audiotone of Golden Valley, Minnesota, is the manufacturer of the following hearing aid models: AMP, AMP-X2, Audiotone, Avatar, Gem, Imperial Micron, Mirage, MSP, Radio-Cros, Secret. Audiotone is a subsidiary of Dahlberg Inc., and ultimately of Bausch and Lomb.[29]

Beltone Electronics Corp. of Chicago, Illinois, is the maker of a variety of hearing aids and devices. Brandnames and types of aids and devices which Beltone manufactures include: Alto, Profile, Trio (in-the-ear aids); Composer (programmable hearing aid); Ode, Opera, Petite, and Voice Enhancer (in-the-canal aids); and the Audio Scout (portable audiometer) and Clear Voice (hearing aid circuits) devices.[30]

Bernafone Inc. of Edina, Minnesota, is the manufacturer of the following hearing aid models: Bernafon, Colibri, Opus, and Phoxy.[31]

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[25] Gabrille Sandor, "Hearing A New Market," *American Demographics,* November 1994, at 48.
[26] Per November 1992 hearing aid directory listing.
[27] Per November 1992 hearing aid directory listing.
[28] Anon., *Ascom Holding AG - Company Report*, FT Analysis, January 24, 1995.
[29] Audiotone Inc. Company Intelligence, Information Access Company, September 20, 1994.
[30] Beltone Electronics Corporation, National Register Publishing Company, Reed Elsevier Inc. Directory of Corporate Affiliations.
[31] Per November 1992 hearing aid directory listing.

Best Laboratories of Pinellas Park, FL, is a manufacturer of orthopedic and surgical appliances, and is the manufacturer/wholesaler of Best Labs model hearing aids.[32]

Cochlear Corporation is the manufacturer of the cochlear implant hearing device.[33]

Computer Hearing Aid Corp. of San Diego, CA, is the manufacturer of the Computer model hearing aid.[34]

Dahlberg, Inc., is one of the largest international manufacturers and retailers of hearing aid instruments. Since 1992 it has been a subsidiary of Bausch & Lomb, and it is the manufacturer of Miracle-Ear® and Mirage™ (a "completely in-the-canal" or CIC) hearing aids. It is headquartered in Golden Valley, Minnesota. In 1994 it was classified as the nation's third-largest hearing aid manufacturer.[35] Hearing aid models also include the Audiotone hearing aid system.[36]

Danavox Do Brasil Industria & Comercio LDA of Sao Paolo is reported to be the manufacturer of the Belvox model hearing aid.[37]

Electone Inc. of Longwood, Florida, is the maker of the Gold Series, Faro I and II, Neptune, and M30 hearing aids.[38]

GN Danavox of Minnetonka, Minnesota, is the maker of the DFS Genius hearing aid, which reportedly relies on digital technology to break down sound waves, extract feedback, and reconstruct amplified sound in a behind-the-ear hearing aid.[39] Other Danavox models include: Birdsong, Concha, Danafocus, Danamax, Danamite, Danasound, Danavoice, Danavox, DCE, DHE, and Lite hearing aids.[40]

GN Great Nordic of Denmark is involved in telecommunications, data equipment, electronics and electric equipment, operating mobile operator Sonofon and manufacturing hearing aids.[41]

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[32] Best Labs, ABI US Business Directory, ABI No. 401735766. Best Labs, Database America All Business File.

[33] Lauran Neergaard, "Scientists: Cochlear Implant May Replace Hearing Aids for Some," *Associated Press*, April 21, 1995.

[34] Per November 1992 hearing aid directory listing.

[35] "Virtually Invisible Hearing Aid Introduced," *PR Newswire*, September 26, 1994.

[36] Dahlberg Inc., National Register Publishing Co., Reed Elsevier Inc. Directory of Corporate Affiliations.

[37] Per November 1992 hearing aid directory listing.

[38] Electone Inc. Company Intelligence, Information Access Company, March 21, 1995. Christopher Connell, "Hearing Aid Makers Told to Tone Down Their Advertising," *Associated Press*, April 26, 1993

[39] Health Business, Faulkner & Gray, Inc., December 4, 1992

[40] Per November 1992 hearing aid directory listing.

[41] "Europe: Ranking - Europe's Best Companies - From Sweaters to Sausages." *Euromoney*, August 17, 1994.

HEI Incorporated is a manufacturer of electronic components and products, including hearing aid components. The hearing aid market was the company's original line of business, and it manufactures custom microelectronics for major hearing aid makers.[42]

Magnatone Hearing Aid Corp. of Casselberry, Florida, is the manufacturer of the following models: Bach, Beethoven, Brahms, Choice, Chopin, Classic, DB/LD, DE, DR, EMC, Image, Interton, Magnatone, MBC, Mozart, MRC, Pearl, Piccolo 10A, Rechargeables, Signature, Snip, SL Low Profile, Sousa.[43]

Matsushita Communication Industrial Co., is a manufacturer of hearing aids in Japan.[44]

Mid-States Laboratories of Wichita, Kansas, is the manufacturer of the AUDTEX-85, Lok-tite, Marvel-Tex, Mid-States, Sof-Tex, and MSI model hearing aids.[45]

Omni Hearing Systems of Carrollton, Texas, is the maker of the Enviro 2000 hearing aid.[46] Other models include Expan, Minocon, and Oticongress.[47]

Oticon is a Danish hearing aid manufacturer, and reportedly the third largest manufacturer of hearing aids in the world in 1992.[48]

Phonak Holding of Switzerland is a manufacturer of hearing aids.[49]

Phonemics Inc. (unknown address).[50]

Phonic Ear of Petaluma, CA, is a manufacturer/wholesaler of orthopedic and surgical appliances, and hearing aids.[51]

Qualitone of Minneapolis, MN, is a manufacturer of orthopedic and surgical appliances, and retails the following models of hearing aids: Adjustrette, Electrette, Elegance,

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[42] S. Novick, *HEI Incorporated - Company Report*, Thomas James Associates, May 4, 1993.

[43] Per November 1992 hearing aid directory listing. *See also* Magnatone Hearing Aid Corp., ABI US Business Directory, ABI No. 003945045.

[44] Yomiuri Shimbun, "Choosing Right Hearing Aid is Sound Advice," *The Daily Yomiuri*, June 29, 1995.

[45] Per November 1992 hearing aid directory listing.

[46] According to the *Healthcare PR News*, May 6, 1993, Omni Hearing is a subsidiary of Starkey Laboratories.

[47] Per November 1992 hearing aid directory listing.

[48] Bill Sharp, "Image is Nearly Everything; HP's Advanced Imaging Management System Image Processing Technology," *HP Professional*, July 1992, at 32. *See also* Elaine Lewis, "'Greening Up' The Office," *Municipal & Industrial Water & Pollution Control*, April 1992, at 16 "Denmark: Oticon Issues Share Prospectus," *Borsen*, May 1, 1995.

[49] "Switzerland: Phonak Holding Reports 17% Growth in 1994/95 Group Turnover," *Neue Zuercher Zeitung*, May 24, 1995.

[50] Per November 1992 hearing aid directory.

[51] Phonic Ear Inc., ABI US Business Directory, ABI No. 453762973. Phonic Ear, Database America All Business File

Genesis, Multi-vents, Multisonic, Powersonic, Qualitone, UC3, Ultra Iros, Ultra Lite, Ultra Lite****, Ultra Miniature, Ultra Power.[52]

QSound Labs, formerly Archer Communications Inc., develops and manufactures custom hearing aids. Established in 1988, it has developed and marketed sound products to the video game market, with agreements with IBM Microelectronics, AT&T Microelectronics, Sierra Semiconductor, Mitsumi Electric Co., Capcom of Japan and Sega of America. In 1991, QSound entered into a joint venture agreement with House Ear Institute to develop a "binaural hearing aid design capable of producing clear, undistorted natural sound," leading to a 1993 QSound technology rights agreement with Starkey Laboratories.[53]

ReSound Corporation of Redwood City, California, designs, develops and manufactures acoustic hearing products using AT&T Bell Laboratories sound processing technology.[54] From 1984 through 1989 ReSound was primarily involved in research and development, beginning shipments of in-the-ear hearing aids and a Digital Hearing System (DHS) hearing testing system in late 1989. In 1994, ReSound acquired Sonar Design & Hortechnik GmbH, a leading manufacturer/distributor of custom ITE hearing devices, and Viennetone AG, a designer, manufacturer, and distributor of BTE, ITE and other hearing devices and components.[55] Models include: Sculpture™ In-the-Ear and Power™ Behind-the-Ear, and it is investing in the Earlens® Hearing System and planned to conduct clinical trials of its Soundlink™ Coil in the first quarter of 1995.[56] ReSound is also partnered with Hoya Medical Corp. in Japan, and the Cha Group in Hong Kong.[57]

Rexton Inc. of Plymouth, MN, is a manufacturer of electromedical apparatus, and retails hearing aids.[58]

Rexton Hearing Systems is reportedly an affiliate of Siemens, operating at the Singapore-Suzhou Industrial Township.[59]

Siemens Hearing Instruments of Piscataway, N.J., is the maker of the LifeSound model hearing aids. Other models include: Audivisette, Auriculina, Mini-Fonator,

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[52] Per November 1992 hearing aid directory listing. Qualitone, Database America All Business File.
[53] QSound Labs Inc., Disclosure Database, Disclo Company No. Q018200000.
[54] "ReSound Corp. Receives Clearance from FDA to Advertise," *Business Wire*, February 27, 1995.
[55] "BTR's Pounds 17m Sale," *Financial Times*, December 13, 1994. Neil Bennett, "Jackson's Job," *The Times*, December 13, 1994.
[56] "ReSound Corp. Reports Third-Quarter Results." *Business Wire*. October 26, 1994.
[57] *Id.*
[58] Rexton Inc., Database America All Business File.
[59] Alvin Tay, "Keppel Integrated Engineering Signs Deal to Supply Gases for Township," *Business Times*, May 23, 1995, at 17. Bertha Henson, "Suzhou Township Celebrates First Year; US$1.25b Committed," *The Straits Times*, May 23, 1995.

Monotonator, Polytonator, Servox, Siemans, Stratos, and Telos.[60] Siemens also manufactures the Cosmea range of hearing aids in Singapore.[61]

Starkey Laboratories Inc. of Eden Prairie, Minnesota, is the maker of the Secret Ear hearing aids, and has been described as "the world's largest manufacturer of custom hearing aids."[62] Models include: Anthem-C, Anthem-E, Anthem-S, Helix, Hollow-Flex, Intra, Omega, Starflex, Starkey CE, Starquick, and X-Acto.[63]

Telex Communications Inc. manufactures and markets a variety of communications and electronics products, including hearing aids and wireless receiving devices.[64] Models include: Accuratone, Ampli-Twin, Amplitone, Automagic Comfort Sound, Electron Ear, Magna-Twin, Radient, Telecros, Televibe, and Tynamite.

Unitron Industries Ltd. of Kitchener, Ontario, is a hearing aid manufacturer delivering hearing aids worldwide.[65] Unitron Inc. in Port Huron, Michigan, is a subsidiary of Unitron Industries.

Widex Hearing Aid Co. of Long Island City, NY, is a manufacturer of orthopedic and surgical appliances, and retails the following hearing aid models: Audilens, A.U.P. Consort, Compact, Elite, ES2, Locator, M1 Micromizer, Minarette, Mini-Compact, Mini-Power BTE, Quattro, Sight-N-Sound, Video Sound, Wide Range, Widex and Winner.[66]

Zenitron (unknown address).

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[60] Per November 1992 hearing aid directory.
[61] "Siemens Unveils Hearing Aids Custom-Made in Republic." *The Straits Times*, November 4, 1994.
[62] QSound Labs Inc., Disclosure Database, *op cit*
[63] Per November 1992 hearing aid directory.
[64] Telex Communications Inc., Disclosure Database, Disclo Company No. T263000000.
[65] Unitron Industries Ltd., ABI Canada Business Directory, CBI No. 016478455.
[66] Per November 1992 hearing aid directory. Widex Hearing Aid Co., Database America All Business File.

July 28, 1995

Mr. Bob Roche
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Cellular Telecommmunications Industry Association
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Dear Bob,

Further to our conversation regarding the FCC's question on hearing aid compatibility, the following is a discussion of some of the points raised in the query.

For the purpose of this discussion, a hearing aid is an electronic device which amplifies sound in order to compensate for hearing deficiency of an individual wearing such device. Devices such as implants, FM hearing aids and infrared hearing aids are not included in the scope of this discussion.

The life span of a hearing aid is estimated by European and Australian sources to be 5 years. This is based on the health insurance system rather than on the longevity of the device. In cases where health insurance system does not effectively determine the time frame in which the hearing aid may be replaced, changes in technology may be a dominating factor determining the aids' life cycle.

There are an estimated 30-40 manufacturers of hearing aids worldwide. Better known names of existing hearing aids are: Audiotone, Beltone, Bernafone, Danavox, Ensoniq, Etymotic Research, Hansaton, Maico, Nicolet, Oticon, Philips, Phonak, Phonic Ear, Rexton, Siemens, Starkey, Unitron, Widex, Zenitron, 3M. Assuming, on average, 10 models per manufacturer, this would imply approximately between 300 and 400 models. Not all models would be available in the USA.

Hearing aids may be classified by their use position: body worn, behind- the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC) and bone conduction hearing aids. Hearing aids may have linear amplification or be equipped with compression, automatic gain control (AGC) or other non-linear, variable gain circuits. Hearing aids may be worn individually (on one ear) or on two ears as individual units or in a "cross" configuration.

The main input transducer of all hearing aids is a microphone (acoustic input). Some hearing aids are also equipped with a telecoil (magnetic input) - estimated 40%, and an electrical direct input standardized by International Electrotechnical Commission (IEC 118-6) - estimated 10%. The output transducer is an earphone having a radiating port located in the ear canal. Exception is the vibrating transducer used in bone conduction hearing aids - estimated 5%. Controls on hearing aids are manual or remote (infra red, RF analogue or RF digital).

Introduction of digital controls in hearing aids is the first step toward fully digital (DSP) aids. This new generation of hearing aids is believed to alleviate the problem of "... unnaturally loud background noise and uncomfortably intense transient reproduction which have plagued hearing aid wearers since the dawn of electronically amplified aids more than 60 years ago." [D. Sweeney, *Parallel Universes*, Audio, September 1990].

Introduction of significant improvements to hearing aid performance in general, or for specific auditory environments may significantly precipitate the interest of hearing aid wearers in replacing their existing devices. One such improvement could be hearing aid immunity to electromagnetic fields generated by today's electronic devices, and in

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particular immunity improvements addressing concerns in relation to wireless telephones, computers, etc.

There are several studies reported on the issue of electromagnetic interference caused by electromagnetic fields radiated by wireless telephones during transmission from the telephone to the base station. There are two aspects to this issue. One is that the majority of hearing aids are susceptible to relatively low electromagnetic fields, and the second is that hearing aids with high immunity exist but are not identifiable to users nor to dispensers. This RF susceptibility is the primary concern; however, other areas of concern are also indicated by authors of various studies. They are as follows:

- Significant amplification available in modern telephones, including wireless, may cause acoustic feedback, in some hearing aid gain conditions, manifesting itself as howling or whistling.
- Hearing aid immune to high frequency (RF) (e.g. 900 MHZ or 1900 MHZ) electromagnetic field may still be disturbed in telecoil operation, at short distance, by magnetic field generated by low impedance circuits in the telephone (e.g., power supply/battery) or by other magnetic fields.
- Near field phenomena around hand held radios cause effects which are not well predicted from extrapolation of electromagnetic field characteristics in far field.
- Subjective experiments on some hearing aids (more notably ITE and ITC) yield different results when worn in their intended position as compared to the "free field" location.
- Attempts at quantification of audible effects associated with one technology versus another are dominant at the expense of quantification of electromagnetic compatibility of hearing aid in the sense of its characteristics being (or not being) affected by the environment in which they have to operate now.

Studies to date propose solutions which may be made effective but they address only the issue of RF interference (electromagnetic fields at carrier frequency). These solutions are: shielding of the hearing aid and/or decoupling RF capacitors added to the hearing aid circuit. Shielding is proposed to be achieved by enclosing the sensitive internal components of hearing aid circuitry (including microphone, telecoil and associated leads) or integrating shield with the hearing aid external body (through use of metallic sprays, *etc.*). Experiments with more advanced (and less expensive in manufacturing) solutions such as selective ground plane or selective filtering have not been reported. Shielding of hearing aids for frequencies 900 - 2,000 MHZ may be implemented in small and larger hearing aids without increase of size.

Shielding and decoupling are not expensive solutions when *implemented at the manufacturing level*. The process (*once* defined) will negligibly increase manufacturing cost. Cost of materials required to achieve immunity (shielding or otherwise) is negligible in comparison to other components of hearing aid circuitry.

For existing hearing aids, modifications are also technically feasible. However, the retrofit of existing hearing aids (presumably low volume or individual devices) will have to be treated individually and logistics to handle this kind of operation properly do not exist today. These logistics of handling may be more costly than the retrofit itself and therefore is considered by authors of studies as impractical. The first step i.e. identification of immunity level and causes of susceptibility of an individual type of hearing aid seems to be the most costly element in the process of implementing solutions.

Use of less expensive methods of hearing aid susceptibility qualification such as usage of actual wireless transmission signals may lead to wrong conclusions. Detection of complex modulation or transients may not be easily identifiable. This is why in EMC standards and regulations (military, EIA/TIA, IEC, etc.) the simulated interfering RF carrier has well defined modulation. For the same reason, in more advanced studies on GSM/hearing aid interference (in Denmark and Australia), the RF signal used is 80% amplitude modulated with a 1000 Hz tone. This method provides information on hearing aid susceptibility to any type of RF signal regardless of the modulation actually used or its origin (computers, wireless phones, fluorescent lights, etc.).

Hearing Aid Compatibility (HAC) requirement for wireline telephones specifies magnetic output from the telephone

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receiver and is achieved by appropriate design of a magneto-electric (dynamic) transducer or by adding a flux coil to other technology transducers such as piezoelectric. New Proposed Rule of the FCC's Hearing Aid Compatibility Negotiated Rulemaking Committee (section 47 C.F.R. § 68.113) requires volume control gain of not less than 12 dB and up to 18 dB. The latter requirement is possible to meet, probably without additional cost to design and manufacturing. Current wireless telephones all have volume control.

Research conducted in other parts of the world does have some relevance to the North American scenario, however not all parameters of studies are directly transferable (differences in power, frequency, environmental, etc.). Therefore, conclusions and recommendations may need to be reworked as part of new planned research. Attention must be paid to two factors. Firstly, the variables have to be clearly identified and analysed in separation. Secondly, the repetition of methodologies used may result in "just another study" and not contribute as much as expected. "Human factor" subjective studies on some audible symptoms and "real transmission" presentations may help to identify new issues and specific needs for research direction. However, already today, the number of issues identified is large and need for quantification of effects and parameters rather than qualification is paramount. Addressing issues in detail and systematically may require longer time than the technology turnaround can afford. Parallel approach to investigations, involving multidisciplinary teams with different orientation is required.

The short term objective (1-2 years) should be to correctly assess technologies on both side of the equation (wireless telephones *and* hearing aids) and to define solutions to minimize adverse effects and achieve interim remedies. This short term objective should include adoption of criteria, development of procedures and implementation of certification program for hearing aid electromagnetic immunity for compatibility with wireless telephones. This should happen in shorter time frame than in Europe or Australia, where the subjects are still "under consideration", 5 years since the studies first showed that susceptibility of hearing aids makes them an obstacle in achieving compatibility with the GSM system. Development of a special model of wireless telephone set with one or more improvements as discussed earlier, designated for hard of hearing, should be considered. This may be achieved by providing the hard of hearing user with special auxiliary devices. In parallel, technical information geared to practical usage-related solutions should be disseminated to the hard of hearing community and the hearing aid industry. This may result in the resolution of many individual problems.

The long term research objective should be to support creation of knowledge and tools allowing avoidance of problems or allowing more immediate reaction to problems which are not easy to anticipate. Research should include development of knowledge on needs for special services for users who do not fall into statistical marketing considerations (e.g. hard of hearing, physically handicapped, etc.) and knowledge of their environments. In case of hard of hearing a good knowledge of their auditory environments should be developed and made available to telecom industry developing new generations of products. To meet these objectives, dedicated research centres such as University of Oklahoma, Spectrum Sciences Institute and others should be welcomed and supported by industry.

I look forward to hearing of your concurrent findings. Should you have additional questions, or wish to discuss further items, please do not hesitate to call me.

Kindest regards,

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