In the Matter of

Amendment of the Commission's Rules Governing Hearing Aid-Compatible Mobile Handsets	)))	**WT Docket No. 07-250**
	)	
Section 68.4(a) of the Commission's Rules Governing Hearing Aid Compatible Telephones	)))	**WT Docket No. 01-309**

REPORT
FROM
AMERICAN NATIONAL STANDARDS INSTITUTE
ACCREDITED STANDARDS COMMITTEE C63® (EMC)
ANSI ASC C63®

A recent FCC Order[1] has raised the issue of hearing aid compatibility (HAC) for mobile phone handsets with multiple transmitting antennas, specifically those that have added Wi-Fi transmitters. The Commission has expressed its desire that HAC compatible mobile phone handsets demonstrate compliance with ANSI C63.19 limits for all relevant air interfaces in which they may operate. However, given a) mobile phones with Wi-Fi transmitters are already penetrating the market, b) no current limit exists for Wi-Fi transmitters in the ANSI C63.19 (2007) standard, and c) Wi-Fi technology may offer non-voice features that benefit the hearing disabled, the Commission has left the record open regarding Wi-Fi until it can collect additional information on which to make a more definitive ruling. This interim report from ANSI ASC C63® offers information relevant to the above issue, as was requested by the FCC OET and WTB during a recent meeting between ASC C63® representatives and the two FCC groups on April 8, 2008.

Preliminary data on Wi-Fi Transmitters:

1 FCC Report and Order 08-68, released February 28, 2008; WT Docket 07-250; ¶¶ 58-68

The air interface defined by IEEE 802.11 standards[2] and certified for conformance to the industry standard for Wi-Fi[3] is increasingly being deployed on mobile phone handsets allowing them to operate on wireless local area networks (WLAN), most often deployed in buildings or across limited "hot-spot" areas. Although initially designed for data transport, the voice-over-internet-protocol, or VoIP, supports voice communication over the Wi-Fi air interface and thus makes it a candidate for HAC limits and certification. Individual user handsets transmit Wi-Fi signals over a single 20 MHz or 40 MHz channel contained within unlicensed spectrum at 2400-2500 MHz, 5.15 - 5.35 GHz, 5.47 - 5.725 GHz, or 5.725-5.825 GHz. The modulations associated with Wi-Fi (OFDM, BPSK, QPSK, and CCK) all have time domain characteristics that are assumed[4] to be too rapid to be detectable as acoustically perceptible modulation artifacts. Because of this rapid modulation scheme and closely spaced sub-carriers, the assumption has been made that the perceptible interference effects due to the Wi-Fi modulation may be similar to CDMA / WCDMA - which shares a wide and somewhat noise-like audio frequency demodulation spectrum. Operating on this assumption, the articulating weighting factor and category limits for CDMA / WCDMA as defined in the current ANSI C63.19 2007 standard (> **960 MHz; M4 = 63 V/m and 0.19 A/m**) have been used as approximate thresholds for perceived audio interference in hearing aid users from Wi-Fi emissions.

The E- and H-field measurement data below (Figure 1) have been provided from five different wireless handset manufacturers on representative handsets measured using either the ANSI C63.19 2006 (i.e., 10mm probe distance) or 2007 (i.e., 15mm probe distance) standard.

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2 IEEE P802.11™-2007 (Revision of IEEE 802.11 1999 / ISO/IEC 8802-11: 1999; rev 2007) IEEE Standard for Information Technology- Telecommunications and information exchange between systems- Local and metropolitan area network—Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications (IEEE P802.11™ - 2007 includes all supplements and amendments for IEEE 802.11a™, IEEE 802.11b™, IEEE 802.11d™, IEEE 802.11e™, IEEE 802.11g™, IEEE 802.11h™, IEEE 802.11i™, IEEE 802.11j™)
3 http://www.wi-fi.org/
4 It is an ASSUMPTION for the purpose of this preliminary exercise that the modulation of WiFi and CDMA are similar in terms of modulation based audible interference characteristics. Development of WiFi limits (or exclusions) in future revisions of the ANSI C63.19 standard will address each signal independently.

Since many handsets are designed to operate at 16-18 dBm (40-60 mW), a column has been added to calculate E- and H- field measurements assuming a theoretical transmit power of 120 mW and a constant near field energy pattern for each handset (blue columns)[5]. Importantly, the numbers listed below DO NOT include the 3-grid hot-spot exclusion currently allowed in all versions of the ANSI C63.19 standard[6].

Table 1: E- and H-field peak measurements (no hot-spot exclusion) over the speaker area of representative Wi-Fi handsets.

Yellow boxes indicate the actual handset performance (at maximum rated power). Blue boxes indicate theoretical field strengths if that handset were to transmit at 120 mW.

Manuf.	Band (MHz)	probe distance (cm)	Tx pwr (mW)†	E-Field Strength (V/m)	M-class	H-Field Strength (A/m)	M-class	E-Field Strength (V/m)‡	H-Field Strength (A/m)‡
Motorola	2450	15	50	10.00	4			15.49	
	2450	15	50	12.89	4	0.04	4	19.97	0.06
	2450	15	50	11.58	4	0.03	4	17.94	0.04
Ericsson	2450	10	100	35.00	4			38.34	
Cisco	2450	10	100	34.50	4			37.79	
	5000	10	100	28.50	4			31.22	
RIM	2450	10	63	14.40	4	0.04	4	19.88	0.05
	2450	10	63	25.59	4	0.05	4	35.31	0.07
	2450	10	63	28.71	4	0.04	4	39.62	0.05
	5000	10	50	13.11	4			20.31	
	2450	10	63	29.41	4	0.09	4	40.59	0.12
	5000	10	50	13.11	4			20.31	
Nokia	2450	15	50	14.00	4	0.04	4	21.69	0.06
	2450	15	50	18.20	4	0.05	4	28.20	0.08
	2450	15	50	22.10	4	0.06	4	34.24	0.09

† Max Tx pwr (mW) = the maximum power for which the handset is rated

‡ Theoretical E- and H- field strength measures assuming a 120 mW transmission

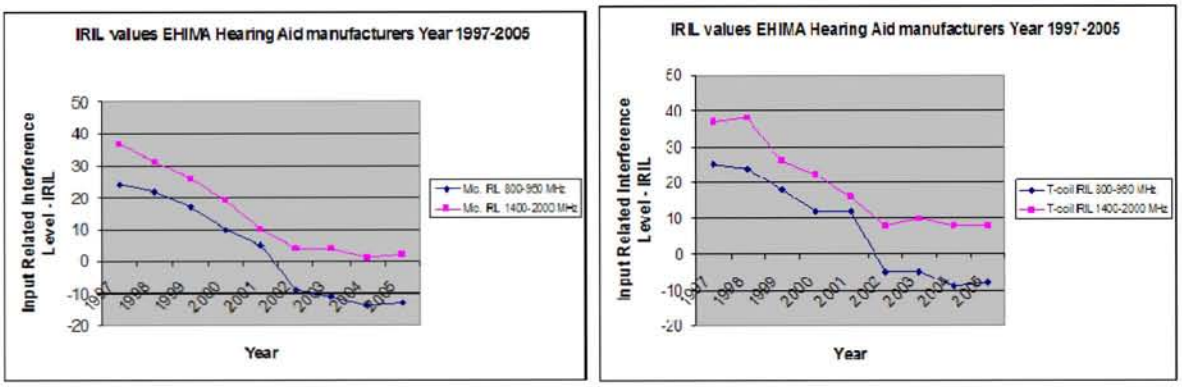
2. Hearing aid immunity measurements: Recent presentations by Starkey representatives at the

5 Theoretical E- and H- field measures for each handset assuming 120 mW Tx pwr performed by multiplying the initial field value (V/m or A/m) times the square root of (120/normal Tx pwr)

6 ANSI C63.19 (2007) American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids; section 4.4 - Near Field Test Procedure, ¶ 5

March 2007 ANSI ASC C63® meeting and the April 8, 2008 meeting with the FCC reported the results of comprehensive testing by Delta Labs (Denmark)[7] showing significant increases in hearing aid immunity (~30 dB) over the last 10 years across the wireless communication frequency range (Figure 2). In frequency ranges above ~1600 MHz (Figure 3), hearing aid immunity does decrease. To compensate for this decrease in immunity at higher frequencies, ongoing revision by IEC TC29 WG-13 of IEC 60118-13[8] have **proposed 35 V/m for frequencies between 2.0 and 2.48 MHz**. Even with this more conservative immunity threshold at 2450 MHz, the majority of RF measurements in Table 1 are below 35 V/m, and with a 15 mm test distance and hot-spot exclusion the rest would almost certainly be below this threshold as well. We do not currently have data to evaluate hearing aid immunity at 5 GHz. What we do know is that HAC measurements we obtained for three WiFi handsets operating at 5 GHz were below 35 V/m (all tested at 10 mm and without the 3-grid hot-spot exclusion), and that the majority of existing WiFi enabled handsets operate on the 2450 MHz band.

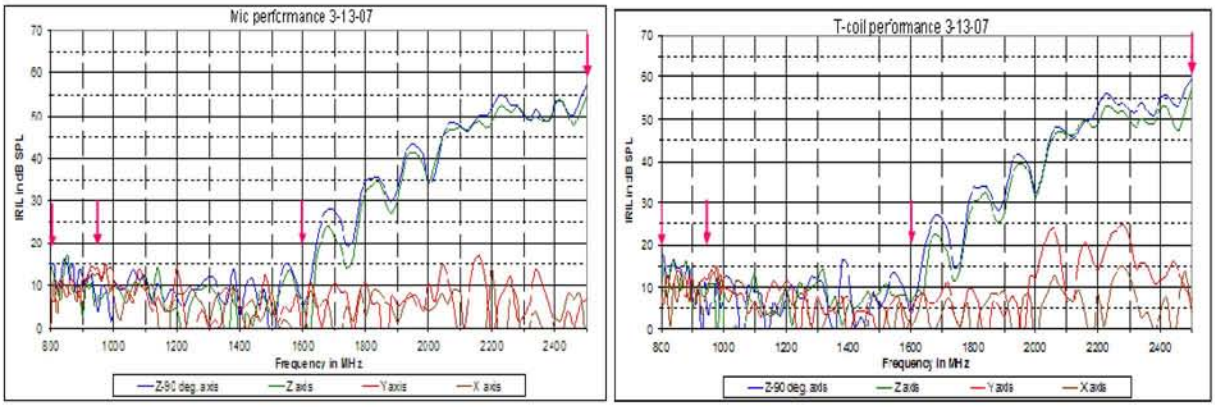
Figure 2: Average RF and T-coil immunity of hearing aids by year since 1997



Microphone Mode RF Immunity T-Coil Mode RF Immunity

7 Delta (2003). Improvement in hearing aid immunity. Project No. A930005-1 performed by the Technical-Audiological Laboratory for EHIMA, 6-30-03, Odense, Denmark.
8 IEC 60118-13 (2004) Hearing aids - Part 13: Electromagnetic compatibility (EMC).

Figure 3: Average relative input reference interference level in hearing aids across the frequency range from 800 to 2450 MHz



Microphone Mode RF Immunity T-Coil Mode RF Immunity

ANSI ASC C63® is a science-based standards organization and does not promote any interest or position on the Wi-Fi / multi-transmitter issue. An objective analysis of the preliminary data collected on a modest sample of Wi-Fi transmitters seems to support, however, that Wi-Fi transmitters operating < ~120 mW and measured according to the ANSI C63.19 (2007) version of the standard are not likely to pose a significant or immediate interference problem for most hearing aid users. Although this data is preliminary and based upon certain assumptions, we hope it is sufficient to enable OET and WTB to make an informed decision regarding whether to leave the issue of mobile phones with Wi-Fi transmitters "open" until more definitive limits and/or exclusions can be developed and published in the next revision of ANSI C63.19 which is actively underway.

In addition to data on Wi-Fi transmitters and hearing aid immunity levels in support of the specific request by FCC OET and WTB, ANSI ASC C63® would also like to provide an update on the progress of additional ongoing HAC work shown in Annex A. The

investigations in Annex A specifically address the FCC request to develop HAC limits for 700 MHz technologies as well as development of a predictive model that can be applied to new and emerging technologies. ANSI ASC C63® would like to follow-up with another interim report in 60 days to show more details of this work and keep the FCC OET and WTB well informed of our continued progress. We will work with your staff to find an acceptable date for this briefing.

Respectfully submitted,

ANSI ASC C63®

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Annex A

Progress by ASC C63® on HAC Studies in the new 700 MHz band

Studies at the House Ear Institute in Los Angeles: In addition to Wi-Fi, an earlier FCC Order[9] requested that ANSI ASC C63® further revise its ANSI C63.19 standard to include HAC limits for communication technologies operating on the newly allocated 698-806 MHz spectrum[10]. In an effort that is receiving support from wireless handset manufacturers, wireless carriers, and hearing aid manufacturers, human provocation studies will address this and other relevant wireless communication technologies and provide data in support of ANSI C63.19 revisions. Efforts over the last 6 months have focused on development of a prototype exposure system that will provide uniform and predictable RF exposure, a wide dynamic frequency range, sufficient field strength to drive interference across all hearing aid types, and careful measurement of SAR to avoid over-exposure of subjects. Efforts have also focused on assembling a statistically sufficient study population from the House Ear Clinic having a distribution of hearing loss and hearing aids combinations representative of the US. Existing Agilent Signal Studio software packages to simulate communication signals include the following:

Product Code N7602B: GSM / EDGE
Product Code N7600B: 3GPP W-CDMA
Product Code N7624B: 3GPP LTE
Product Code N7617B: 802.11 WLAN
Product Code N7615B: 802.16 WiMAX
Product Code N7606B: Bluetooth

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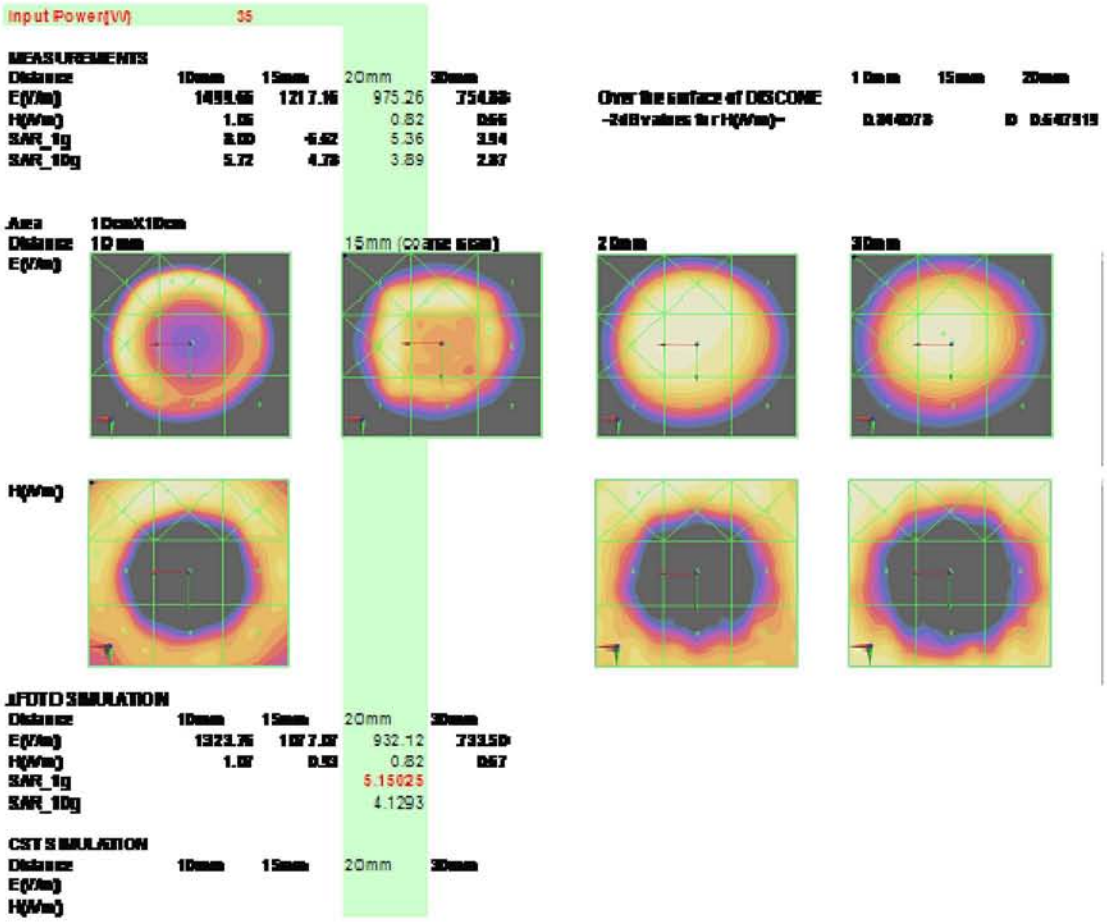
9 FCC Report and Order 07-72, released April 27, 2007; WT Docket 01-309

10 Service Rules for the 698-749, 747-762 and 777-792 MHz Bands, FCC WT Docket No. 06-150, Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems and Section 68.4(a) of the Commission's Rules Governing Hearing Aid-Compatible Telephones, CC Docket No. 94-102, WT Docket No. 01-309, Notice of Proposed Rule Making, Fourth Further Notice of Proposed Rule Making, and Second Further Notice of Proposed Rule Making, 21 FCC Rcd 9345 (2006) (700 MHz Commercial Services Notice).FCC WT 06-150

The principle investigator (Dr. Sig Soli) is currently in China and will return in mid-June. Immediately upon his return, subjects will be brought in for study with an immediate emphasis on 2450 MHz (Wi-Fi) and 700 MHz technologies (WiMax, LTE, EVDO-like / CDMA).

Figure 4. The current discone antenna and exposure system to be used in human studies at the House Ear Institute, as well as field and SAR characterization. This antenna yields highly reproducible E-fields.



Input Power(W) 35

MEASUREMENTS

Distance	10mm	15mm	20mm	30mm
E(V/m)	1499.66	1217.16	975.26	754.86
H(W/m)	1.05		0.82	0.66
SAR_1g	8.00	6.62	5.36	3.94
SAR_10g	5.72	4.78	3.89	2.87

Over the surface of DISCONE

-2dB values for H(W/m)-

	10mm	15mm	20mm
	0.844073		0.647919

Area 10cmX10cm

Distance 10 mm 15mm (coarse scan) 20mm 30mm

E(V/m)

H(W/m)

µFDTD SIMULATION

Distance	10mm	15mm	20mm	30mm
E(V/m)	1323.76	1077.07	932.12	733.50
H(W/m)	1.07	0.93	0.82	0.67
SAR_1g			5.15025	
SAR_10g			4.1293	

CST SIMULATION

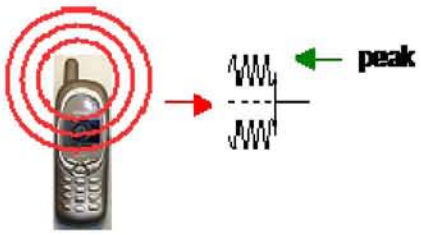
Distance	10mm	15mm	20mm	30mm
E(V/m)				
H(W/m)				

Studies at Gallaudet University in Washington DC: A proposal for a Rehabilitation Engineering Research Center (RERC) on Hearing Enhancement has been submitted to the National Institute on Disability and Rehabilitation Research (NIDRR) by Gallaudet University. One of the

proposed research projects in the center will more closely evaluate the correlation between hearing aid and cochlear implant immunity testing using the near field / dipole method (section 5) vs. the alternate far-field like / G-TEM cell method (section 5.4) as described in the current ANSI C63.19 (2007) standard, with free-field testing in an anechoic chamber representing a baseline method. Since the IEC 60118-13 immunity standard protocol for hearing aid immunity uses the G-TEM method, there is a desire by hearing aid manufactures to maintain consistency and avoid duplicative testing. Although preliminary data has suggested the G-TEM method is more conservative than the dipole method, it is necessary to validate whether a true correlation is maintained between the two methods across hearing aid types and communication signals. Combining immunity testing results with additional tests of wireless device emissions and coupled interference when the wireless devices and hearing devices are paired will enable evaluation of which device testing methods are the most predictive of in-use results. The proposal also includes human subject testing on cochlear implants using previously recorded noise files that represent mobile phone signals and the comparison of this data to previously obtained data on hearing aid users to better quantify the signal-to-interference needs of this user subgroup.

Predictive models: ANSI C63.19-2007 rates the audio interference-causing potential of a wireless device (WD) on the basis of its measured peak RF signal strength within a detected 20 kHz bandwidth.

Figure 5. Schematic of the peak and average power emitted by a digital mobile phone handset



To more closely relate this peak value measurement to the resultant perceived audio interference, a modulation-specific “articulation weighting factor” (AWF) is added. While this factor has so far been subjectively determined for individual modulation protocols, it is important looking forward to develop an objective methodology for determination of wireless device interference potential that can be applied both in measurement and in a proactive, predictive sense. The goal of this exercise is the development of a robust model and corresponding Generalized Interference Level measurement method allowing level correlation between a given field strength measurement from a digital mobile phone emission with a given immunity level from a hearing aid that will predict the impact of audio band interference products for a given hearing aid + mobile phone handset combination. The results of the Gallaudet University RERC study will also be instrumental in completing this model.

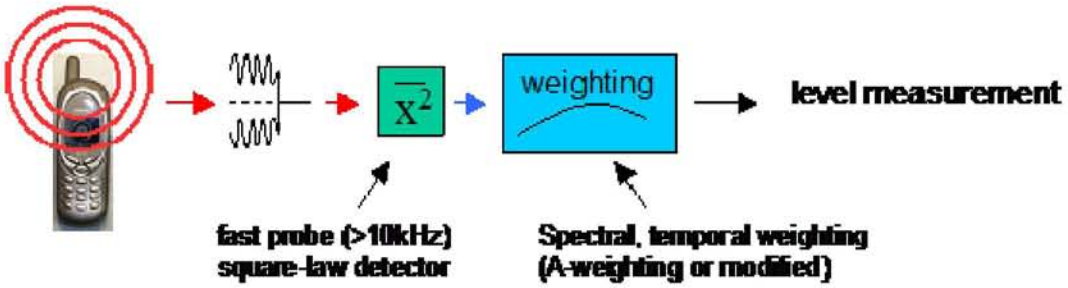



Figure 6. Current Generalized Interference Level model using a fast probe square law detector