Research Report - Phase 1

Assessment of Interference to Hearing Aids used in Australia by CDMA Digital Mobile Phones

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(trading as Australian Hearing).

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1. Executive Summary

Telstra recently announced that it would introduce a new digital mobile communication system during 1999 based on code division multiple access technology (CDMA) in the 800 MHz band. The CDMA system is being progressively introduced throughout Australia and will provide reasonably equivalent coverage to the existing analogue mobile phone system (AMPS), which will shut down in many areas from 1 January 2000.

Research conducted in Australia and overseas has shown that digital mobile communication systems may cause interference to some models of hearing aids [1,2]. A hearing aid wearer may experience this in an incidental situation, i.e., when a nearby person is using a digital mobile phone, or when the hearing aid wearer wishes to use a digital mobile phone. The level of interference experienced by an individual user is influenced by many factors including the nature of their deafness, the immunity of the hearing aid and the nature of the mobile phone technology. Users of AMPS phones have not generally reported interference. The University of Oklahoma [4] conducted testing on the compatibility of CDMA phones with a range of hearing aid models and assessed effects on speech intelligibility and reported levels of annoyance.

CDMA handsets vary both the radio frequency (RF) transmitting power and vocoder (data) rate in response to the changing network conditions [5]. This causes interference that is static-like in nature when using variable vocoder rate and more like white noise when using full vocoder rate. Work by the University of Oklahoma and the US Center for Devices and Radiological Health (CDRH) [2] has shown that the level of interference from CDMA handsets is less when the handset operates in the full-rate mode.

The National Acoustic Laboratories, a division of Australian Hearing Services, an Australian Government Statutory Authority (trading as Australian Hearing) has undertaken research to characterise the interactions between CDMA phones and hearing aids. This report covers results from the first phase of that research, a short duration project to determine the level of interaction between a CDMA "clam"[1] phone and a small representative sample of hearing aid models selected from those characterised in earlier research [1].

For the class of handsets that will be used with the Telstra network, the CDMA standard [6] specifies a tolerance, for the open loop control maximum power, of 18-30 dBm with a nominal power of +23dBm (200 mW) [5]. For the available handset, the maximum power that could be achieved was +27 dBm so this was used for the testing program. In a CDMA system, interference control is very important to maximising system capacity, so the handset will generally operate on much lower power levels when under network control. Thus the results for interference to hearing aids documented in this report may tend to over estimate the level of interference encountered in practice. This will be further investigated in the second phase of this project.

The spectral results indicate that the interfering noise in the full vocoder rate is rather flat in response up to 5 kHz and sounds very much like white noise. In the 1/8, ¼ and ½ vocoder rate the interfering spectra has a more repetitive structure that decreases with increasing frequency and has more energy than the full rate vocoder interference. In addition, the amplitude and response shape of the interfering spectra fluctuates with time.

In the analysis of results it is useful to have some idea of the number and percentage of hearing aids tested that are currently fitted to the Australian population. As a starting point the life of a hearing aid will be assumed to be 4 years. Under this condition Australian Hearing would have about 350,000 hearing aids fitted to about 240,000 clients. It is also assumed that Australian Hearing has fitted hearing aids to about two thirds of all hearing aid users in Australia. The bulk of Australian Hearing clients are fitted with programmable hearing aids that can be adjusted to match the individual needs of clients. The three models of programmable hearing aids tested are fitted to approximately 82% of Australian Hearing clients and cover about half of hearing aid users in Australia. In this first phase of testing, models representing 18% of hearing aids fitted by Australian Hearing were not tested. The majority of the remaining hearing aid models fitted by Australian Hearing also are programmable.

[1] The CDMA mobile used in this research is a "clam" phone that opens similar to a clamshell. One half of the clamshell contains the earpiece and battery pack. The other half contains the microphone, keypad, display, bulk of the electronics and the antenna that is situated near the hinge of the clam and is positioned more away from the head than is the case with a small "brick" type of construction.

The compatibility of hearing aids with a CDMA “clam” phone in different test situations and operating at the maximum test power of 500 milliwatt has been assessed. Testing has been carried out with the hearing aid and mobile phone mounted on a test bench at a typical user distance as well as testing with the hearing aid mounted on the head. Two people whose hearing is on the lower side of the normal range made a subjective evaluation of any interference. The criterion for “useability” is based on the level of interference generated in the hearing aid by the CDMA mobile phone, being described as “not perceptible” or “just perceptible”.

Using the bench test results with the hearing aid at 2.5 cm from the CDMA "clam" phone antenna as indicative of what may be the performance of a CDMA phone built as a small "brick" construction, it is possible to estimate successful phone usage at the maximum test power. Preliminary estimates indicate that at least 107,000 hearing aid users in Australia will be able to use a standard small "brick" CDMA phone to gain access to the CDMA network when operating in the variable vocoder rate.

A standard small "brick" CDMA handset operating in the full vocoder rate mode is estimated to allow at least 187,000 hearing aid users in Australia to gain access to the CDMA network.

When expressed in percentage terms, for hearing aid users fitted by Australian Hearing, it is estimated that at least 46% will be able to use a standard small "brick" CDMA phone in the variable vocoder rate and 80% will be able to use a standard small "brick" CDMA phone in the full vocoder rate.

Testing with the hearing aid mounted on the head indicates that all clientele using any of the three programmable hearing aid models will "not perceive" any interference with the CDMA "clam" phone oriented in the normal usage position and operating at the maximum test power in the full vocoder rate. Estimates indicate that this applies to 191,000 hearing aid users. When operating in the variable vocoder rate at the maximum test power, 78% of Australian Hearing clientele corresponding to 182,000 hearing aid users will have interference that is either "not perceptible" or "just perceptible".

Preliminary results indicate that the CDMA "clam" phone construction allows more hearing aid users to gain access to the CDMA network than those using the standard small "brick" construction. It is intended that this will be further investigated in the second phase of the testing program by the inclusion of additional phone models.

In any of the test conditions investigated, the full vocoder rate, if available, will allow more Australian Hearing clientele to use a CDMA mobile than if any of the other rates are used. For hearing aid users this is particularly significant when using the standard small "brick" construction CDMA mobile phone.

The above estimates apply to Australian Hearing clientele who are a significant proportion (approximately two thirds) of the total hearing aid users in Australia.

Many current hearing aid users will be able to use CDMA phones with hearing aids.

As noted above, in normal use CDMA phones typically transmit at power levels considerably below the maximum power used for these tests. Under typical operating conditions more hearing aid users will be able to use CDMA phones in every day use than these preliminary estimates indicate when operating at the tested maximum power level.

Improvements in hearing aid technology should increase the immunity for future model hearing aids.

The first phase of this research is now complete. The second phase will involve objective measurements of hearing aid immunity using the waveguide apparatus and then relate these to subjective assessments with actual hearing aid wearers. A range of hearing aids, representative of those in general use, will be selected.

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