Australian Centre for Radiofrequency Bioeffects Research (ACRBR)

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"ACRBR EME In Homes Survey: Final Report"

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ACRBR EME in Homes Survey

Executive Summary

With the expanded use of radiofrequency (RF) communication technologies, questions have been raised concerning the RF levels that the community is exposed to. Such questions relate to the amount of electromagnetic energy (EME) that people are exposed to from devices such as mobile phones, cordless phones, Wi-Fi and cordless routers, both individually and due to their cumulative exposure. The present study tested such RF EME levels in 20 suburban homes in Melbourne, Australia, assessing EME levels from devices in isolation, as well as from their cumulative exposure. Overall, measurements were very low, with the highest level for a particular home less than 1% of national exposure limits. In terms of individual devices, the highest level was less than 10% of national exposure limits, and the effect of having all RF devices on simultaneously in a home (cumulative exposure) had little effect on the results. This study suggests that the use of RF devices in an average suburban home results in very low RF EME exposure (compared to national exposure limits), and that this conclusion is not affected by having numerous RF devices operating simultaneously.

Background

In recent years that has been a great expansion of the use of mobile communication devices in the community. This has generated considerable community debate about the possibility that the electromagnetic energy (EME) that these generate may cause health problems.

Although research has failed to identify any such health effects of these technologies, some have suggested that scientific research has been limited in that it has tested for effects of EME at the levels designated to be safe by national and international standards bodies [ARPANSA], whereas there may be a possibility that levels in the community are higher than this. For example, some have speculated that the cumulative exposure of EME in the community due to a number of devices being concurrently in operation may exceed the safety limits.

A recent study in the US assessed this and determined that levels in that community were substantially lower than the safety limits [Foster et al]. Other studies have also confirmed this finding in other countries [Thuroczy et al]. Although we have no reason to expect different levels in Australia, due to possible differences between the US and Australian patterns of communication device use, it was considered prudent to conduct similar research in Australia to clarify whether EME levels in the community are also below safety limits.

The study, which examines a range of home environments that use wireless devices, such as cordless and mobile phones, Wi-Fi, wireless LAN, Bluetooth, wireless remote controls and baby monitors, visited participating homes in April through August 2008 to conduct measurements of the radiofrequency (RF) levels from the wireless devices in use in the home. This report describes the design, implementation and findings of the study, which have also been reported in a poster-paper presentation at the Australian Centre for Radiofrequency Bioeffects Research (ACRBR) community forum event, "Science and Wireless 2008, Wireless and Health – Unplugged and Uncertain", held

at the Swinburne University Hawthorn campus in November 2008 (see http://acrbr.org.au/SW2008/SW08.aspx).

The study was funded by a grant from the Australian Mobile Telecommunications Association (AMTA) and conducted independently by the ACRBR.

Aim

The study aimed to survey a sample of Australian homes to characterise the 'typical' RF environment (number and type of devices) present in the home, and to conduct a series of measurements to determine how exposure to RF fields in the home compares to general public compliance levels stipulated for such devices by the Australian Communications and Media Authority (ACMA) and as also described in RPS3 [ARPANSA]. The study aimed to consider exposure to individual devices as well as cumulative exposure to a number of devices operating concurrently in typical domestic configurations. A particular scenario to be considered was that of a typical desk or study environment where several wireless devices may be "clustered" together in close proximity to the desk or study occupant.

Hypothesis

The specific hypotheses tested by the study were:

- Each of the RF sources detected within the 'typical' home is within compliance levels for exposure from individual devices
- Summation of exposure from these RF devices does not exceed compliance levels at any location in the home

ACRBR Survey – Protocol

A sample of homes was recruited from the Melbourne area according to selection criteria that ensured a sufficient variety in type and concentration of wireless devices in each home so that the sample, though not statistically random, was nonetheless reasonably representative of Australian homes in general. Each home was then visited by a team from a NATA accredited RF measurement specialist 3rd party consultant (Consultants) where an information statement regarding the study was provided to the participant, and permission forms and site details were collected. General site details included the street address, floor plan and construction type of the home, and location of particular points of interest (study, lounge or living rooms, any location where a concentration of wireless devices might be expected or any location of particular interest to the participant). Proximity to external RF infrastructure such as mobile phone base stations was also noted.

The Consultants then completed the survey of the home following a predetermined protocol, the major steps in which were:

- Audit number and type of devices in home including both RF and extremely low frequency (ELF, or power line electromagnetic fields emitting devices)
- Conduct individual measurements for each RF device identified above
- For each RF measurement taken, record two measurement values (an averaged value and a peak RMS value)
- Conduct a measurement for a few devices operating simultaneously in a "typical working desk" condition (a measure of cumulative exposure to a "cluster" of devices)
- Conduct a full background measurement at a reference location in the home (lounge or living area, with all devices switched off and then all devices switched on – a measure of cumulative exposure to all devices when inside the home)
- Conduct a full background measurement at a reference location outside the home (front or rear yard, with all devices switched off and then all devices switched on – a measure of cumulative exposure to all devices when outside the home)
- For measurement of individual devices, measurements were conducted at the following location:
    - Height of 1.5 m (head height for sitting adult)
    - 20 cm directly in front of the device (nearby but not hand held)
- For measurements at reference locations inside or outside the home, measurements were conducted at a height of 1.5 m above ground. For the working desk situation, the measurement was taken at 1.5 m above ground at the normal location of the desk occupant.

Other details of the measurement protocol may be obtained from Appendix 1 which contains a copy of the written protocol used by the Consultants and provided to the participants. Note that ELF devices were included in the initial audit to assist subjects participating in the study avoid confusion about what was and was not included in the survey (many subjects were not able to distinguish between RF transmitting devices and ELF emitting devices; they were assumed to be the same). ELF devices were noted and pointed out to the participants, but only RF devices were measured. It should also be noted that this protocol does not necessarily equate to those designed to determine compliance with the relevant health standard (for hand-held devices such as mobile phones, cordless phones and 2-way radios, the appropriate test standard is IEC 62209-1).

ACRBR Survey – Results

Overall exposure in each home is represented in Figure 1, showing a comparison of measurements at the reference location in each home for both all devices switched on and all devices switched off (or in an idle condition). Note that all measurements were significantly below the applicable exposure limits for the frequencies present. The worst case (closest to the limit) exposure occurred for a home in Tanner St, Richmond (inner city Melbourne suburb), which was dominated by the microwave oven and cordless phone base station measurements. In this case, the measured result of 3.31×10^{-3} W/m^2 is still less than 0.2% of the most stringent exposure limit for the frequencies present. On average, the inside reference measurement was about 5 times higher when the devices were switched on compared to when they were switched off, although this is highly variable between homes depending on what devices were present and the background levels present from

nearby fixed infrastructure such as television and radio broadcast signals and mobile phone network facilities.
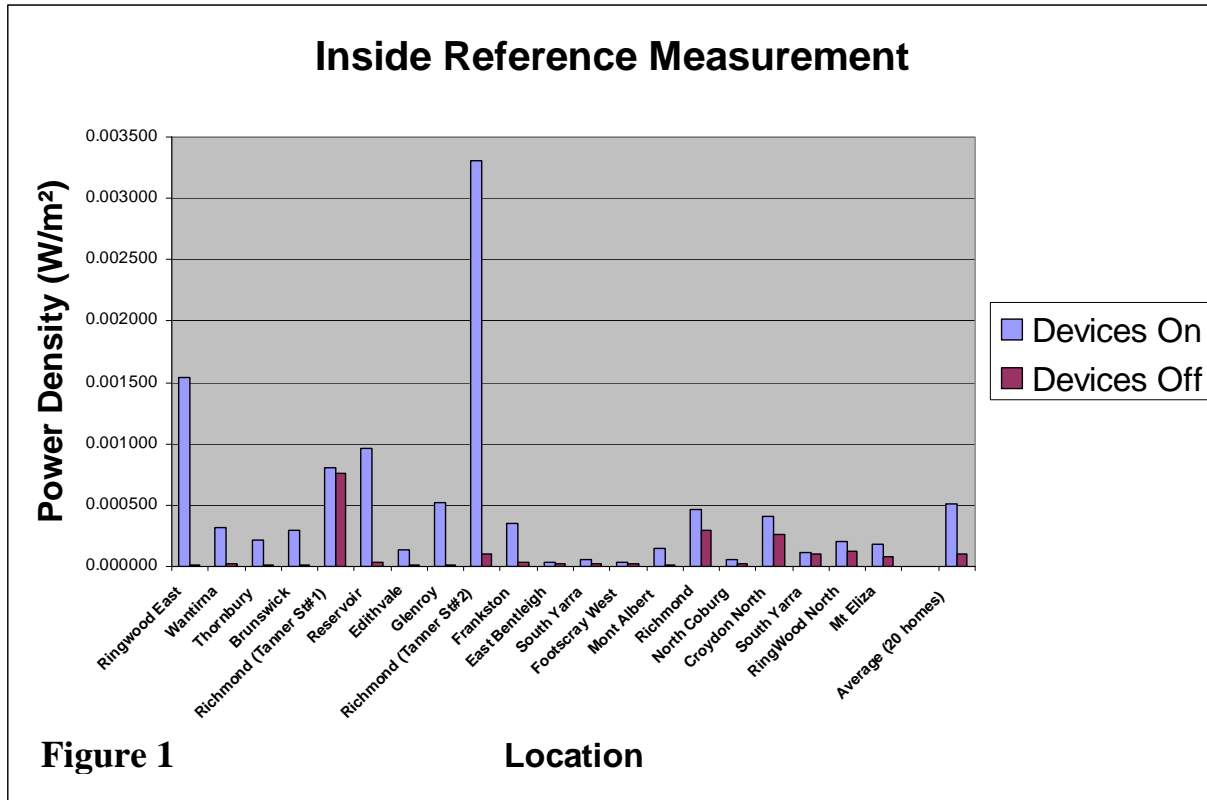
Figure 1

Exposure to individual devices in the home is represented in Figures 2, 3 and 4. Figure 2 shows the exposure from individual devices averaged over the 20 homes (averages are for the number of occurrences of the device in the overall survey, this may be less than 20 where certain devices are not present in all homes or more than 20 where there are multiple occurrences of a device in each home). Devices producing exposure levels > 1% of the relevant exposure limit included microwave ovens, cordless phone bases, 2-way radios (walkie-talkies), and a single wireless device (cordless phone jack). The maximum individual exposure was recorded for a 2-way radio, reaching 0.18 $W.m^2$, or almost 9 % of the exposure limit at the frequency of operation of this device.

Figure 3 illustrates which types of devices were most commonly the source of the highest individual exposures within each home. The percentages expressed here are based on all 20 homes, even if the device was not present in all 20 homes. The most striking feature of this chart is that in 15 of 20 homes (75%) the microwave oven was the device which produced the single highest individual exposure of any device in the home, a finding not previously reported elsewhere and not a factor considered *a priori* when conducting this work. This finding is in fact a little stronger when it is noted that in one home no microwave oven was present or measured, meaning that where a microwave oven was present (19 homes) it was the source of highest exposure 79% of the time. Averaged over the sample, exposure from microwave ovens was 0.440 W/m² (peak) or 0.065 W/m² (one minute average), representing 4.4% and 0.65% respectively of the allowable exposure limit at their frequency of operation (10 W/m² at 2450 MHz).

Other devices which were commonly found to produce the highest exposures included wireless routers (in download mode, 10%), cordless phones (5%) and cordless phone bases (5%).

Exposure to individual devices (average of 20 homes)

Figure 2

Max exposure in homes by device

Other (5%)
Cordless Phone (5%)
Cordless Phone Base (5%)
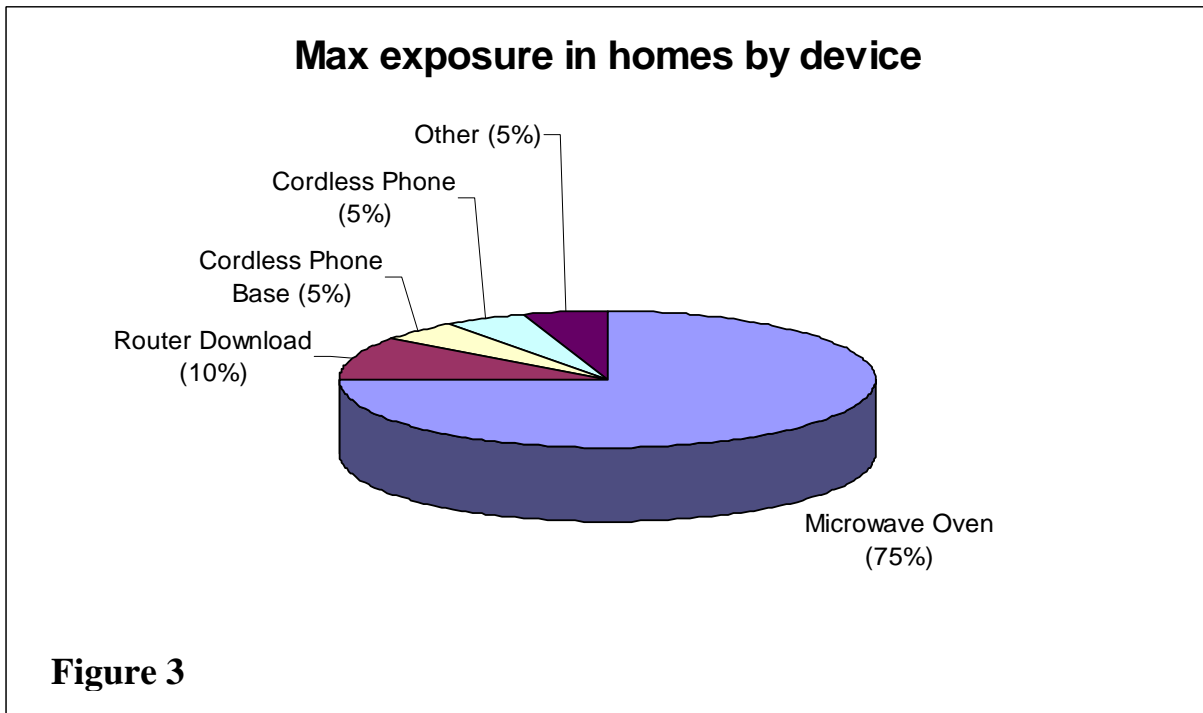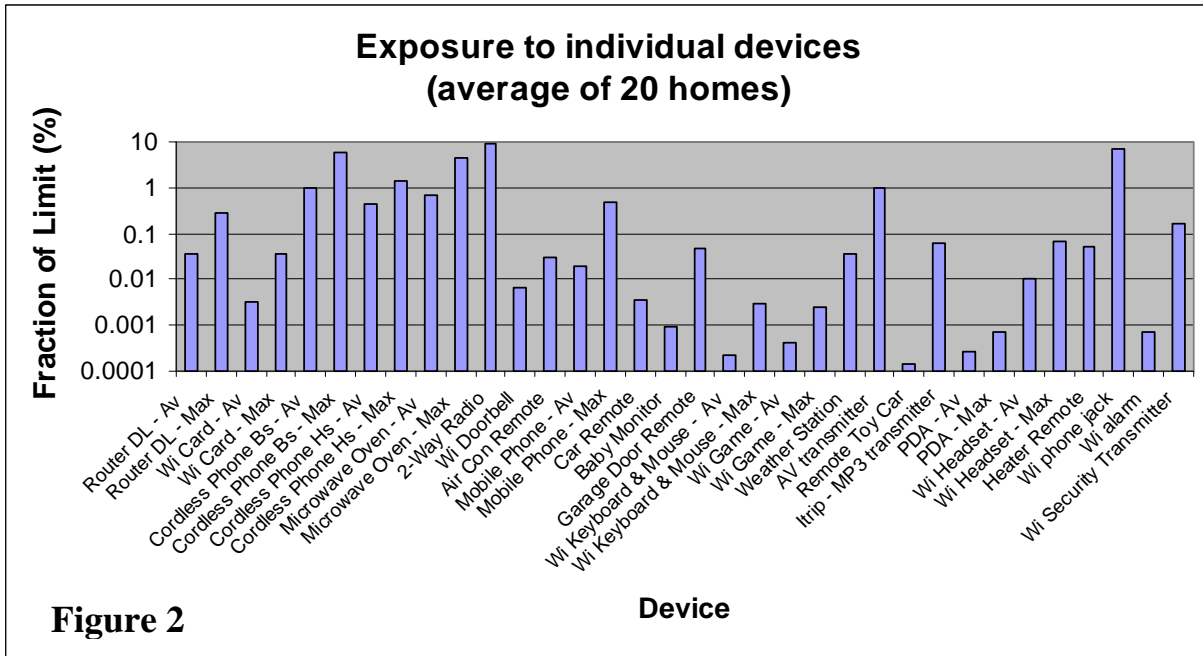Router Download (10%)
Microwave Oven (75%)

Figure 3

Figure 4 provides a similar analysis for devices producing the lowest exposure in the home. In this case, a wider range of devices is present, indicating that these very low exposures are more typical of the sorts of levels produced by wireless devices in general. The list included a range of small short range wireless devices such as LAN cards, keyboards, a door bell, car and garage remote controls and a cordless game controller. One notable feature is that cordless phones are present in both Figure 3 and Figure 4, so that in some cases they produced the highest exposures, and in some cases they produced the lowest exposures. This highlights the enormous range of scenarios and device performance parameters which characterise the typical Australian home.

Figure 4
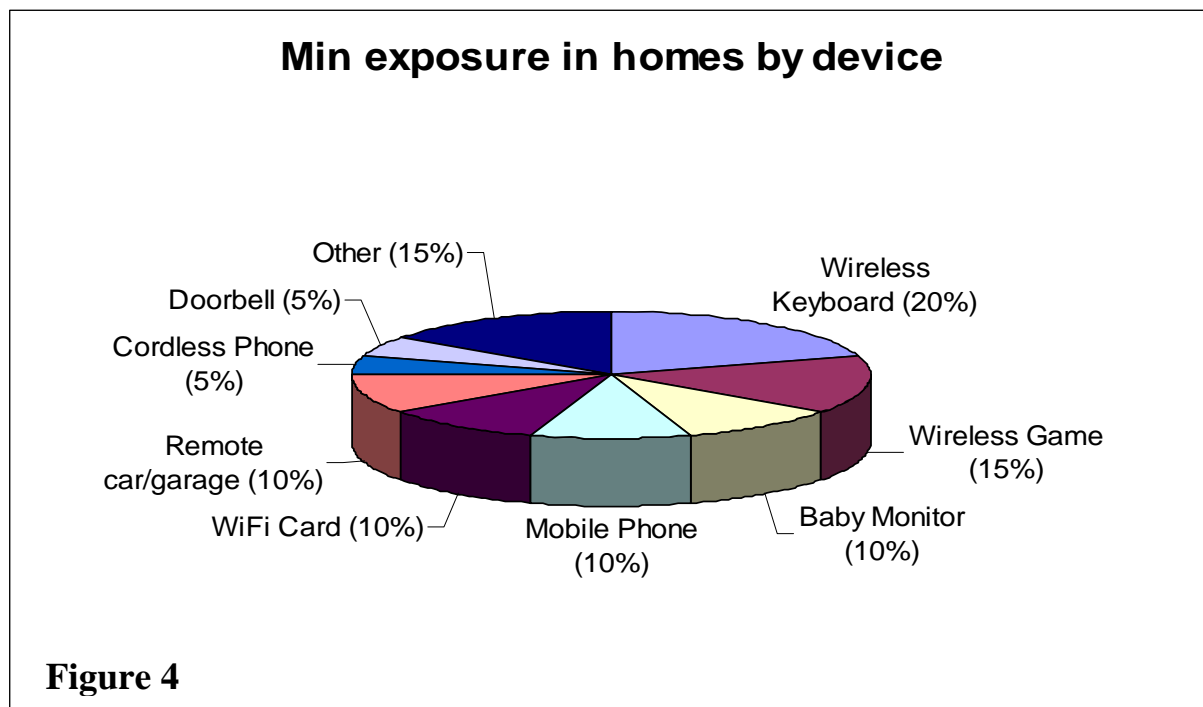
The final scenario considered in this study is that of the typical desk or study environment where several wireless devices may be in use simultaneously. The actual desk or study environment assessed in each home was determined in consultation with the occupant, and consequently the detailed arrangement of devices varied considerably. However, typically, a desk or study environment included a cordless phone, mobile phone, router and wireless laptop card and/or a wireless router. Measurements of the combined electromagnetic fields produced by these devices when operating in their maximum output conditions are presented in Table 1. For comparison, Table 1 also presents the measurements for the whole home combined, both inside and outside the home with all appliances turned on, and also the overall maximum and minimum values recorded for these.

Averaged over the 20 homes, the combined desktop environment produced an exposure of 0.0025 W/m², or about 5 times that measured at the reference point for the whole home (lounge or living room) when all devices in the home were switched on. However, as the devices in the desktop environment were all operating above 2000 MHz, while many of the devices in the home were operating below 400 MHz, different exposure limits apply [RPS3]. The effect of different field levels and different exposure limits combine so that as a percentage of the applicable exposure limit the exposure in the desktop environment is approximately the same as that for the whole house.

Exposure Location		Average (W/m²)	Max (W/m²)	Min (W/m²)
Home	Inside	0.000507	0.003305	0.000029
	Outside	0.000215	0.000839	0.000017
Desk		0.002487	0.016720	0.000018

Table 1 – Measured exposure levels at reference (with all appliances turned on) and desktop locations.

The overall maximum and minimum values presented in Table 1, for any of the environments considered, serve to highlight the large disparity between individual results in this survey. This should be taken into consideration when assessing the average results reported here. The actual fields measured in each home varied widely between different locations and different devices. A key limitation on any of the results from this study is that the survey can only present a "snap-shot" in time of the actual exposure from the wireless devices that were present in these homes. In different homes, or at another time, a similar survey may produce quite different results.

Discussion and Conclusions

The ACRBR EME in Homes Survey has provided a useful insight into the typical RF environment in modern Australian homes, and determined the characteristic exposure of the occupants of these homes to EME levels, from both individual devices and from combinations of devices, for the whole home and for particular combinations of devices such as in study or desk areas.

Overall, the cumulative exposure at the reference point (lounge or living room) or in the study or at the desk was determined to be, on average, hundreds or thousands of times below the safety limits stipulated in the Australian RF exposure standard [ARPANSA]. This is in agreement with previous studies of this type in other countries [Foster et al, Thuroczy et al], which similarly found very low exposure levels from wireless technology in public areas in urban environments.

Exposure to individual devices measured 20 cm from the device were higher, although still more than 20 times less than, the exposure limit in worst cases. A particular feature of the ACRBR study was that in Australian homes, individual exposure tended to be dominated by microwave ovens. This was somewhat unexpected as microwave ovens are not generally associated with the general public's concern when considering their exposure to EME at home. Other devices which dominated exposure to EME in the home (but at lesser levels) included cordless phones and wireless routers in download mode.

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References

Foster KR, "Radiofrequency exposure from wireless LANs utilizing Wi-Fi technology", Health Phys. 2007

ARPANSA, "Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz", Australian Radiation Protection and Nuclear Safety Agency, Radiation Protection Series No. 3, (2002)

Thuroczy G, Molnar F, Janossy G, Nagy N, Kubinyi G, Bakos J, Szabo J., "Personal RF exposimetry in urban area", Ann Telecommun. 2008 Feb; 63(1-2):87-96

Acknowledgements:

Appendix 1 - ACRBR EME in Homes Survey Protocol

Introduction

The following section outlines the general research protocol that should be followed by RadHaz personnel in conducting a survey of wireless devices in a 20 home sample of Australian homes in accordance with the agreement between RadHaz consulting and the Australian Centre for Radiofrequency Bioeffects Research (ACRBR). Adherence to this protocol should ensure that sufficient and accurate data is recorded at each site so that ACRBR can complete an analysis of the data and produce findings which contribute to a better understanding of the exposure experienced by members of the general public from the radiofrequency devices in their own homes. The methodology below provides a general guide to the sequence of steps that should be undertaken for each survey, although minor adjustments to this order of proceedings may be made to suite the particular requirements at each site. Any significant departure from this methodology must be recorded in comments included in the reporting tool, providing details of what was done and why.

Methodology

- Use the measurement reporting tool to record all relevant household details including:
  - a. Number of occupants
  - b. Type of structure – i.e. brick, roof type, window coverings etc
  - c. Orientation of structure
  - d. An audit of the RF *and* ELF emitting devices in the home *and* their location in the home
    - Use the separate tables for RF and ELF devices in the reporting tool and included in this protocol as a guide for completing the audit
  - e. Proximity to RF transmitting infrastructure (i.e. mobile base stations)
  - f. Details of all RF measurements taken in the home
- For each RF measurement taken, two measurement values should be recorded:
  - An averaged value (over 1 minute) to allow integration over the signal band
  - The peak RMS value(s) over the band
- Undertake individual measurements for each and every RF device identified above.
  - Measurements will be taken at 0.20 m in a direct line from the device, with other mobile devices, such as mobile phones, switched off, or if this is not possible, being away from the measurement point (> 2 m)
  - Orientation of devices should be noted
- Undertake a measurement for a few devices operating simultaneously in a 'typical working desk' condition
  - RF should be measured at 1.2m (estimated sitting head height) at the normal location of the desk occupant
  - The distances from the devices to the measurement point should be noted
- Undertake a full background measurement (full spectrum, at least 27 MHz – 3 GHz) at a reference location in the home (e.g. lounge room or living room, with the intention to use the same reference location at all sites)
  - The background measurement should be conducted with all devices switched off, or where this is not possible, mobile devices removed from the room, or at least 2 m from the measurement point
  - The background measurement should then be repeated with all devices that have typical duty cycles which are not short compared to the measurement time (i.e. do not include transiently transmitting devices such as remote controls), in operation either at their normal location (where this is fixed) or in the room but > 2 m from the measurement point

- Undertake a full background measurement (full spectrum, at least 27 MHz – 3 GHz) at a reference location outside the home (e.g. backyard, with the intention to use the same reference location at all sites)
  - The background measurement should be conducted with all devices switched off, or where this is not possible, mobile devices at least 2 m from the measurement point
  - The background measurement should then be repeated with all devices that have typical duty cycles which are not short compared to the measurement time (i.e. do not include transiently transmitting devices such as remote controls), in operation either at their normal location (where this is fixed) or in a location inside the home which is > 2 m from the measurement point
- External source (background) measurements will be recorded as measured at the time of the survey and not time averaged (except for as noted above). Integration over a band of signals will be performed
- All devices will be measured whilst at normal operating levels (e.g. *upload* video using Wi-Fi, microwave oven at full power with a glass of water, mobile phone *transmitting* voice)
- Devices may have various modes of transmitting (e.g. mobile phones may transmit in both voice and data modes), Measurements with the device in each possible mode will be performed
- Measurements will also be taken for all VDU monitors in use at the home following the international standard procedure for measuring VDUs
- Provide tabulated scans/plots of all survey results taken
- RadHaz will provide a report with break-up data in Excel

RF emitting devices at home	
Remote control for garage door	Cordless headset
Mobile Phone (on speaker mode, speaking to it; and in different data modes where applicable)	Microwave Oven (Full Power: with a glass of water in it when measured)
Router for wireless internet	Baby Monitor
Laptops with wireless card	Air-conditioning/Heating Remote
Cordless Phone	Wireless Doorbells
Wireless Security System	TV re-broadcaster
Cordless Keyboard/Mouse (Bluetooth)	Cordless game device (NOT infra-red)
Others	Car remote control

ELF emitting devices at home	
TV	VDU
Hair-Dryer	Electric blankets
Electric motors (e.g. garage doors)	Induction cooker
Welders	Fridge
Power tools	Dishwasher
Heater/Fan/Air-con	Washing machine/Dryer
Kitchen power appliances	Garage power tools
Others	