The Akrotiri Military Antennae Health Survey

University of BRISTOL

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Table of contents

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Executive Summary

There have been antennae on the Akrotiri Salt Lake military site for a number of years, but the proposal to erect Pluto 2, a larger antenna, was greeted with massive demonstrations and media campaigns. In January 2002 the village leader of Akrotiri sent a letter to the Ministry of Health of the Republic of Cyprus requesting the immediate commission of a health survey. It was decided that a team of consultants from the University of Bristol in the United Kingdom in collaboration with the Ministry of Health of the Republic of Cyprus should carry out the survey.

The objective of the study was to establish a baseline of the health status of two communities, Akrotiri and Asomatos, compared with a control community, Pano Kyvides and to measure their exposure to specific environmental factors. The health survey investigated the prevalence of specific symptoms and diseases, using specifically designed questionnaires; a risk perception survey; and a collection of health and mortality data from available registry and other sources. The measurement survey collected electromagnetic field (EMF) data. This report gives a brief review of the literature and describes the methodology that was used for both the health survey and the measurement survey. It presents detailed results and comments.

The analysis has shown that the three villages were in fact well matched and provided a good basis for the comparison of exposed and unexposed populations. The overall response rate was 87%. In analysing the questionnaire data a number of important issues have become apparent. Firstly the responses to the adult health questionnaire provided significant differences between the villages (and not just between exposed and unexposed). In Akrotiri there was an increased reporting of migraine, headache, dizziness and depression. A similar trend was noted in Asomatos although at lower levels. What was also observed in Asomatos was a significant increase in reported asthma and heart problems. Using a standard validated questionnaire (SF36) the villagers in Akrotiri reported a more negative view of their health than those from the other two villages. Akrotiri reported a higher degree of physical limitation, emotional distress and pain. In addition the risk perception sections of the questionnaire showed that Akrotiri respondents had a higher level of perceived risk than the other two villages.

In reviewing these findings in relation to the published literature there is no evidence of an association between asthma and heart problems and exposure to electromagnetic fields. On the other hand there is a consistent literature that cognitive and neurological effects are associated with electromagnetic field exposure. However, this is normally only found at higher levels and higher frequencies and associated with mobile phone use as covered in detail in the Stewart Report. There is subsequently only one report of an association between cognitive function and well-being effects at low exposures and the exposures levels recorded in that report were of 1 volt per metre. The measurement study here confirmed an average value of 0.57 volts per metre in Akrotiri and 0.46 in Asomatos. In Pano Kyvides the levels were less than 0.001 volts per metre. It is worth noting that the Pluto Antenna contributed 10% of exposure in Asomatos and about 20% in Akrotiri. The other sources are various broadcast antennae in particular the cell phone mast in Akrotiri. In the communities under study it is to be noted that the electric field levels from all sources

were less than the precautionary level generally applied in a number of countries. It seems unlikely that the EM level is contributing to the neurological symptoms reported by those living in close to the military antenna. Given the importance of the high levels of neurological symptoms reported in Akrotiri the information provided by the adult questionnaire gave the opportunity to analyse the relative importance of location (i.e. village) in explaining this outcome. The logistic regression analysis confirmed the importance of village, but also the contribution made by several other key factors including gender and education.

The findings from female questionnaires do not provide evidence of any differences between exposed and unexposed sites in gynaecological and obstetric history. Of particular interest, there was an absence of any difference in reported levels of miscarriage. Miscarriage has been associated with exposure to high levels of EMF in previous studies; however, this has not been found in this research.

Birth abnormalities have been associated with high-level EMF in the literature; no evidence of any abnormalities was found in the child questionnaire. There were, however, significant differences in the reporting of migraine, headache, dizziness and depression, with exposed sites reporting increased incidence. In relation to infectious diseases there were six conditions where increased levels were reported, five of these in Asomatos and one in Akrotiri.

The mortality studies produced results that were difficult to interpret, due to the different results produced by the different methods of estimating the Standardised Mortality Ratios. Although attempts were made to check the reliability of reporting systems, one against another, this was not entirely satisfactory.

One of the specific objectives was to establish whether there was an excess of brain tumours and leukaemias from Akrotiri. This did not appear to be the case but with such small numbers over a ten-year period the absence of evidence does not imply that there is no association; it would be impossible for this study to come to any definitive conclusions using data covering the period of operation for the antennae.

The report makes a number of recommendations including the following:

- The villages should be made aware that the health effects recorded in this study are associated with anxiety, and that the levels of electromagnetic fields recorded are not sufficient to account for these observations.

- The villages should be made aware that no long-term deleterious effects on pregnancy and childhood have been recorded.

1. Background

There have been antennae on the Akrotiri Salt Lake military site for a number of years, but specifically Pluto 1 was erected in 1999, and became operational in the same year. This was supplemented by a very much larger antenna – Pluto 2. Work started on this second antenna in May 2003, was completed in October 2003 and became operational in December that year.

A number of measurements had been made of Pluto 1, primarily by the SBAA engineers and verified by the National Physical Laboratory plus a study in August 2001 by France Telecom which confirmed a relatively low exposure of Akrotiri and Asomatos.

Nonetheless, following the proposal to erect Pluto 2, the residents of the adjacent communities, namely Akrotiri and Asomatos, expressed opposition. This was reinforced by massive demonstrations and media campaigns. On the 7th January 2002 the village leader of Akrotiri sent a letter to the Ministry of Health of the Republic of Cyprus requesting the immediate commission of a health survey. It had become increasingly clear that perceived health risk dominated among the areas of concern of the people living in the vicinity of the antennae.

The Ministry of Health of the Republic of Cyprus took the initiative for the conduct of the health survey and requested the Ministry of Foreign Affairs to undertake the negotiations between the Government of the United Kingdom (Sovereign Base Area Administration), the Ministry of Health and the representatives of Akrotiri and Asomatos villages. During the course of the discussions with the Ministry of Foreign Affairs, the Chief Medical Officer of the Ministry of Health expressed the opinion that the health survey was advisable to be conducted in collaboration with the Consultants of the University of Bristol who had the appropriate qualifications and had already been invited by the Sovereign Base Area Administration for a preliminary assessment of the existing situation. This suggestion was adopted and a detailed protocol statement of requirements was prepared by the parties involved.

In July 2002, the Council of Ministers of the Republic of Cyprus decided the conduct of the health survey and in May 2003 an agreement was signed between the Government of the Republic of Cyprus, the Government of the United Kingdom (SBAA) and the University of Bristol. The agreement was sent to the Attorney General of the Republic of Cyprus, the Sovereign Base Area Administration and the University of Bristol for their legal advice and each gave their approval. In December 2004 the Council of Ministers decided the extension of the time schedule for the completion of the study until the end of June 2005.

The objective of the study was to establish a baseline of the health status of two communities compared with a comparable control community in relation to their exposure to specific environmental factors. A cross-sectional survey was carried out at three village sites; Akrotiri and Asomatos comprised the exposed sites and Pano Kyvides was selected as the unexposed control. The survey consists of two distinct elements: a health survey and a measurement survey. The health survey investigated the prevalence of specific symptoms and diseases, using specifically designed questionnaires; a risk perception survey; and a collection of health and mortality data from available registry and other sources. The measurement survey collected electromagnetic field data.

The funding was shared equally between the Government of the Republic of Cyprus and the Government of the United Kingdom (SBAA). The study was completed on 30th June 2005.

2. Radiofrequency effects in humans – literature and standards

Introduction

Radiofrequency (RF) energy is the longer wave length part of the electromagnetic spectrum which starts with cosmic rays, x-rays and the ionising part of the ultra-violet spectrum, through the visible part of the spectrum into infrared energy. Radio waves have a wavelength which is longer than infrared and do not contain sufficient quantum energy to ionise molecules or bring about chemical change unlike the ionising and ultra-violet part of the spectrum.

Nevertheless, concerns about potential health effects of exposure to radiofrequency (RF) fields have been fuelled by the spectacular increase in communication systems both national and personal. The whole world now has communication cover and even on an individual basis the number of personal communication devices is now set to exceed one billion. Also, the general RF environment is rising through use of security devices and traffic control systems using RFID. It is only the ingenuity of the manufacturers and network providers in providing cheap units, effective use of radio spectrum, and wide coverage that determines the pace of increase. However, accompanying any new communication increase is a media-driven anxiety about possible adverse health effects in the areas of cancer, cerebro-vascular accidents (stroke), eye and memory damage, and similar worries about broadcast and base stations. This is in spite of the fact that radiofrequency sources have been transmitting for over 100 years since G. Marconi and W. Preece carried out their first radio transmissions across the Bristol Channel in May 1897. Much anxiety has been focussed on mobile phone masts, schools and the possible effect on children as well as large transmitting antennae in urban areas such as that at Droitwich, Sutton Coldfield and Vatican City. In 2005 there are some 47,000 masts in the UK alone, many sited on schools and in areas of high population density. The anxiety has centred on cancer and genetic modulation and malformation. Additional safety concerns are associated with electromagnetic compatibility (EMC) problems with prostheses such as pacemakers, and interference with safety, critical medical and control equipment, and interaction with vehicles and ambulances in particular. Only a few decades ago the RF background was measured in microvolts per metre, but most towns now have levels up to 2 Volts/metre.

This section will consider how guidelines for human exposure to RF are derived, known interactions with human tissue and their measurement, and the evidence for the existence of health effects.

RF effects in biological tissues

Interaction with tissue

The presence of a human modifies behaviour of electromagnetic waves which pass through tissue resulting in heating and absorption of RF. The wavelength compared to that in free space is shortened and this can be regarded as due to increased capacitance. Additionally the impedance of tissue compared with that of free space is low compared with the 377 ohms of free space. This has three effects on a wave meeting a tissue. Firstly, there is an impedance mismatch and some energy is reflected; secondly, the wavelength of the field in the tissue is decreased; and thirdly, the rate of attenuation is increased. The parameters that define these changes are the real and imaginary components of the relative dielectric constant ε. At radiofrequency and microwave frequencies the values are determined largely by the water content and since much of the content of human tissues consists of water (up to 85%) the properties of different tissues can largely be described by their water content. There is little evidence of resonances occurring in biological tissues (unlike pure water or ice) below about 100GHz, but relaxational effects can be observed. These are degenerated resonances arising because of the sluggish nature or viscosity of the water on which the structural proteins of cells reside. These have been described by Schwan[1] as three zones labelled α, β and γ, where the complex permittivity (or dielectric constant) relates to frequency for a typical tissue and decreases in a non-linear fashion due to the degraded resonances.

a) α region - Dominated by counter-ion relaxation and electrophoretic relaxation: this is a characteristic largely of live cells with intact membranes able to maintain a potential difference due to selective secretion of ions across the cell membrane.

b) β region - Resulting from inhomogeneous structures (Maxwell-Wagner effect, or interfacial polarisation where an inhomogeneous structure shows frequency-dependent dielectric and conductive properties which differ from those of the constituents of the mixture), which will characterise living or dead tissue *which has not undergone significant autolysis* i.e. there is still structure present.

c) γ region - Here defined by the behaviour of free water and extends from a few MHz to about 20GHz. There will be a contribution from the rotational motion of amino acids and in the region up to 2GHz the effects of the presence of larger proteins will be to increase the dielectric constant.

There are large differences in tissue dielectric values ranging from ε=5-15 for fat, ε=49 for muscle, to ε=56 for brain at about 1GHz. The most important effects are (1) the contraction of wavelength in the tissue by $\sqrt{\varepsilon}$, so that for example the wavelength in tissue will be $n.\sqrt{49}$ of the free space size, and (2) the losses determined by conductivity σ at lower frequencies, or defined by dielectric relaxational losses at higher frequencies. Conductivity increases with increasing frequency, which results in more limited penetration with increasing frequency (the rate of energy deposition increases). The converse of this is that at lower frequencies the rate of energy deposition decreases. Also the physical size of humans means that the body can act like an antenna at around 70 MHz. These are complex problems for setting the limits but this is done with the human body in mind and taking note of the known biological effects of RF as well as the physics of the behaviour of radio waves.

Measurement techniques

Measurement in plane wave (far field) conditions is relatively straightforward, but if the source is close to the target volume there are additional problems. Not only are the wave fronts curved and varying spatially along the source, but near field measurement is difficult because of the arbitrary phase relationship of the three components of each of the fields. It is usual (in air) to infer equivalent plane wave power density D from:

$$D = \frac{|E|^2}{377} \quad \textbf{or} \quad D = 377|H|^2$$

It is usual to assume that far field conditions exist from about 0.5 wavelength. This is about 17 cm for mobile phones and about 7.5 metres at 20 MHz – one of the operating ranges of Pluto 1 and 2.

Measurement probes for human exposure assessment

Radiation hazard meters are available for different frequency ranges and for most applications an isotropic probe is preferable to cope with unknown polarisation for near-field measurements, and where there may be multi-path reflections. An H-field probe is needed for near-field conditions in particular. Below 100MHz except at large distances from the antenna, induced currents and contact currents are important and need to be considered in addition to spatially averaged E and H field measurements. However, at high RF and microwave frequencies it is convenient and usually accurate to measure either the E- or H-field component and to relate these on the basis of the medium in which measurements are to be made. This is the basis of the broad-band measurements used in Akrotiri since in all cases the fields can be assumed to be far field.

E-field probes have been reviewed by Chou et al[2] and Stuchly[3] and these fall into different groups:

Simple diode-based probes are effective up to 1Wcm^{-2} over the range 400kHz to 12GHz but have a complex power/output relationship because of the square law behaviour. At lower levels the output voltage is proportional to $[E]^2$ or $[H]^2$, but at higher levels is proportional to E and H directly. Diodes also have a high temperature coefficient (0.05dB^{o}C^{-1}). The use of resistive, non-perturbing leads typically with static impedance of about 100KΩ/m to 1MΩ/m gives a high time constant leading to difficulty in measurement of short pulses, particularly where these are high with respect to the average power. Diode probes are relatively resistant to damage by overload.

There are other designs but these are not really suitable for low level environmental measurement and for the task a calibrated system was purchased from Narda, covering the whole range of frequencies likely to be encountered.

In order to track the exposure due to Pluto the only acceptable method is to use a spectrum analyser which can be locked to the output frequency of the antenna. When this is done the noise from all other sources becomes negligible and makes accurate measurements possible.

Health effect

Thermal and non-thermal

Most countries have set out guidelines which limit the significant thermal effects of radio-frequency exposure. However, public concern has been expressed over the possibility that RF fields can cause non-thermal biological and health effects at levels below those causing thermal effects. The three terms applied to biological effects of radio-frequency exposure are “thermal”, “a-thermal” and “non-thermal”. These are all relative terms and therefore it is not possible to define the zone at which these cross over. They can be interpreted as follows:

a) Thermal effects occur when sufficient RF energy is deposited to cause a measurable increase in the temperature of the sample, e.g. 0.1^{o}C.
b) A-thermal effects are those that occur when sufficient energy is deposited to cause an increase in the temperature of the sample but no changes of any significance in temperature actually occur because of temperature control in the body.
c) Non-thermal effects are those defined when the energy deposited in the sample is less than those associated with normal bodily functions and is otherwise undetectable.

In-vitro research
All depositions of RF energy in the MHz and GHz region will result in some degree of temperature elevation but below 0.1^{o}C these could be considered physiologically and biologically insignificant. There have been a number of studies of non-thermal effects and the most appropriate to these are in cellular cultures which are amenable to detailed control.

Two examples of the kind of research illustrate the problems of interpretation: Cleary[4] has carried out numerous studies of cell proliferation and the cell cycle kinetics under continuous wave radio-frequency exposure at 2450MHz and 27MHz. They reported increased proliferation of cell growth at 1, 3 and 5 days following a single 2-hour radio-frequency exposure at either of these frequencies. The measure of increased proliferation was the uptake of radio-labelled nucleic acids in DNA synthesis and this was seen at specific SARs of 5 and 50W.kg^{-1}. Potentially this is in the thermal region but the design of the experiments maintained the temperature to less than 0.1^{o}C change even in the presence of strong RF fields. They reported very similar effects on human peripheral lymphocytes exposed under the same conditions. Stagg et al [5] exposed a number of brain cell lines to radio-frequency signals very similar to mobile phone signals for 24 hours but at considerably lower exposure levels than those of Cleary. At an SAR of 5.9 mW.kg^{-1} increases in nucleic acid uptake in DNA synthesis were observed but not at a lower or higher SAR. The actual growth curve of the cells was not altered by any of the systems of exposure. A counter experiment by Kwee & Raskmark[6] looked at transformed human epithelial amnion cells exposed to 960MHz at a range of low SARs up to 2.1 mW.kg^{-1}. A decrease in cell growth was seen for exposures of more than 30 minutes.

These changes in DNA proliferation are suggestive of alterations in growth even though the evidence is somewhat confusing as some exposure conditions seem to cause an increase in growth and other ones a decrease. This kind of confusion of the science continues today even though the widespread use of mobile phones and siting of cell-phone masts have caused the amount of research to multiply hundredfold.

In-vivo research
The in-vitro observation of growth gene expression and the widespread growth in phone use and worries about carcinogenic potential have prompted a number of studies which have sought to look at this situation and thereby assess the possible implications to human exposure. There have been a number of studies in animal systems which could be classed as in-vivo exposure experiments. One of these[7] looked at the spontaneous tumours in rats and carcinogen-induced central nervous system tumours in rats and showed that there was in fact a reduction of growth in

tumours after exposure to 837MHz 1-1.2W.kg^{-1} for 2 hours per day, 4 days per week for exposures of two years. Another study by Imaida et al[8] looked at 930MHz 1-2W.kg^{-1} in rat liver cancer and showed no promotional effect on the development of tumours. A study by Salford et al in 1994[9] showed no increase in implanted brain tumour cells in Fisher rats exposed to 0.4W.kg^{-1} of 915MHz radio-frequency radiation for 2/3 weeks. This showed no increase in growth of such tumours. The one outstanding piece of information that goes contrary to the above studies was that by Repacholi et al[10] who exposed transgenic mice with a genetic alteration that made them prone to lymphomas. The exposure was GSM pulses at 900MHz of about 0.13 to 1.4W.kg^{-1} for an hour per day for eighteen months and in this case showed a doubling of the incidence of tumours. This particular result could not be repeated.

Therefore it seems difficult to demonstrate with any consistency either direct effects on cells or on the whole animal system with particular designed tumour models. At a molecular level the evidence is equally confusing. There have been suggestions that specific genes involved with the growth processes or with control of carcinogenic development might be affected. The most researched examples are the P53 gene thought to be responsible for clearance of damaged cells by the process of apoptosis, and C-fos and C-jun which are growth genes. These are recognised by protein markers associated with the gene functioning and many hours of research have been concentrated on these markers. They involve much new, long and difficult technology in molecular biology and can therefore go wrong or be easily upset. Goswami et al[11] showed no increase in one stress protein marker (*jun*) but a change of another (*fos*) at 0.6W.kg^{-1} in fibroblast cells whereas another study by Ivaschuk et al[12] showed changes in *jun* but not in *fos* at 46mW.kg^{-1}. Phillips et al[13] showed an increase in DNA damage and subsequent repair whereas Stagg et al[14] showed no change at about 0.1 to 59mW.kg^{-1}, in the same parameters as the previous study. Another study by Fritz[15] to GSM type transmissions as up to 1.5W.kg^{-1} showed no changes in *fos* and *jun*. On the basis of this conflicting data it has to be assumed that the effects are either subtle or too ephemeral for detection by conventional laboratory methods.

Effects on DNA

The greatest controversy surrounds the occurrence of DNA strand breaks which have been demonstrated by Lai and Singh[16] on rat brain cells at 50 Hz and 2450MHz both CW and pulsed at between 0.6 to 1.2W.kg^{-1}. This is demonstrated by a technique called the COMET assay which looks for the production of single strand or damaged DNA by a technique of electrophoresis which separates the damaged DNA from the native source DNA. However, Malyapa et al[17] studying the same model, i.e. rat brain cells, also at 2450MHz at 1.2W.kg^{-1} did not show this effect and claimed the previous results were an artefact of the method. Until this controversy as to whether there is DNA damage from non-thermal levels of microwave exposure is resolved the arguments about safety are not going to be concluded. The recent REFLEX study carried out for the EU has now suggested that indeed there may be DNA damage at levels well below the public exposure levels. This is a result that even the consortium that did the work seems unable to agree on.
(http://www.itis.ethz.ch/downloads/REFLEX_Final%20Report_171104.pdf)

Epidemiology

There are two epidemiological studies that have examined the possibility that mobile phone exposure may be associated with malignancy. The first was by Rothman et al[18] that looked at 250,000 phone users to follow them for one year. There was no evidence that the death rate was any different in users of hand-held phones compared with the suitcase-based mobile phones. Indeed the heaviest users of hand-held phones had a lower malignancy risk than the other group. If there had been any significant association between RF exposure and malignancy it would have been expected to show up in such a large cohort of users. What this study does not take into account is the possible long induction period between initiation and development of a cancer, nor was the question of exposure/dose adequately addressed.

The second study was a case control study in Sweden of patients with brain tumours carried out by Hardell et al[19]. In this case the risk of brain tumours was not elevated in subjects using mobile phones, either for analogue or digital models. There was, however, an association between the reported side of use of the phone and the side of occurrence of the tumours. There are a number of problems with this study, namely, the failure to identify all the possible subjects that might have been expected and also the impossibility of eliminating recall bias when subjects are questioned about the side that they normally use the phone. As a result of concern about this possible association and the lack of robust data, the European Community has funded through IARC (International Agency for Research on Cancer) a study which is intending to recruit 2000 brain tumour subjects. This will examine the possible association of phone use with brain tumours, acoustic neuromas and salivary gland tumours as well as examining the confounders that could be associated with phone use. One of the reasons for these concerns is a study carried out in Poland of military personnel with occupational exposure to radio-frequency. In this study Szmigielski[20] suggested a six-fold elevation in the risk of lymphatic and blood cancers. However, the methodology of this study is considered to be unsatisfactory and the various methods used in the research are not adequately described. There have been other studies which have been reviewed (Molder et al, 1999[21]: Royal Society of Canada, 1999[22]) of groups of people exposed to radio-frequency radiation through their work or hobbies (for example, radio amateurs). The commonest reported diseases are lymphoma and leukaemia and brain cancer. There have been a number of reported cases of clustering of cancer incidence in the neighbourhood of television and radio transmitter antennae. One example of these was studied by Dolk et al[23, 24] and showed an increase of leukaemia within 2km of a television and radio transmitter in Sutton Coldfield, England. But when this study was extended to other medium wave and VHF transmitting antennae no similar clusters were found in other parts of the country.

A study on behalf of by the German Federal Agency for Radiation Protection by Eger, Hagen, Lucas, Vogel & Voit (unpublished data) examined whether people living within 400 metres of a mobile phone mast were more at risk of developing cancer.

Newly diagnosed cancers were significantly higher among those who had lived for 10 years within 400 metres of the mast, in operation since 1993, compared with those living further away, and the patients had fallen ill on average 8 years earlier. People living within 400 metres of the mast had three times the risk of developing cancer than those living further away. This study is still not published and could be beset with all kinds of problems when a study of this kind is done.

In Spain researchers from Valencia University in Spain, investigated people's health in a small town near Murcia, where two mobile phone masts had been erected in the past 7 years.

There was a reported increase of 'microwave sickness' with exposure to microwave radiation, in particular depression, fatigue, concentration loss, appetite loss, and heart and blood pressure problems. These occurred at radiation levels found around most masts (of about 1-2 V/m). Symptoms were:- depression which increased by up to 64-fold, fatigue which increased by up to 37-fold, appetite loss increased by up to 25-fold. Again, this is an unpublished study but a copy is available from: (http://www.powerwatch.org.uk/reports/20040809_kos.pdf).

There has also been a study of cell phone mast exposure carried out by the TNO organization in the Netherlands. At 1 V/m they recorded alterations of well-being under test laboratory conditions which seems to supplement and confirm the Spanish study. Again that study has not been published, but widely available before being withdrawn from the TNO website.

Hocking et al[25] in Australia carried out a study to determine whether there is an increased cancer incidence and mortality in populations exposed to radiofrequency radiations from TV towers using an ecological study comparing cancer incidence and mortality, 1972-1990, in nine municipalities, three of which surround the TV towers and six of which are further away from the towers. Cancer incidence and mortality data were compared with the calculated power density of the radiofrequency radiation in the exposed area. This ranged from 8.0 microW/cm^2 near the towers to 0.2 microW/cm^2 at a radius of 4km and 0.02 microW/cm^2 at 12 km. For all ages, the rate ratio for total leukaemia incidence was 1.24 (95% confidence interval [CI], 1.09-1.40). Among children, the rate ratio for leukaemia incidence was 1.58 (95% CI, 1.07-2.34) and for mortality it was 2.32 (95% CI, 1.35-4.01). The rate ratio for childhood lymphatic leukaemia (the most common type) was 1.55 (95% CI, 1.00-2.41) for incidence and 2.74 (95% CI, 1.42-5.27) for mortality. Brain cancer incidence and mortality were not increased. The conclusion was of an association between increased childhood leukaemia incidence and mortality and proximity to TV towers. Problems with this study is common to all ecological studies – a difficulty in determining the population and variations in social class near towers, and housing density which are difficult to correct.

Perhaps most relevant to the present study is one carried out in Korea in 2003 by Ha et al[26] in areas proximate to 42 amplitude modulated (AM) radio transmitters, 11 high-power study sites (i.e., areas exposed to 100-1500-kW transmission power) and 31 low-power study sites. The incidence of cancer within a 2km radius of each transmitter was obtained from (a) Korean medical-insurance data for the years 1993 to 1996, (b) population census data for the year 1995, and (c) resident registration data for the year 1995. The authors calculated age-standardized rate ratios for total cancer, leukaemia, malignant lymphoma, brain cancer, and breast cancer, and compared the incidence of cancer within 2 km of the high-power transmitters vs. the incidence within 2 km of the low-power transmitters. Four control areas for each high-power transmitter were also selected. The control areas were located in the same, or nearest adjacent, province as the high-power sites, but were at least 2 km from any of the transmitters. The authors found no significant increase in age-standardized rate ratios of cancers for high-power vs. low-power sites, with the exceptions of total cancer and of brain cancer in women.

Cognitive effects in humans

Identification of effects in humans has been carried out by a number of researchers. Usually evoked responses are used as indicators of response. There have been three studies of evoked responses to GSM-like signals. Urban et al[27] looked for visual sensory responses to checkerboard reversal and found that these were not affected. However, two other studies (Eulitz et al,[28] and Freude et al,[29]) reported positive effects. The other types of studies have involved analysis of sleep responses and a study by Borbeley et al[30] indicated that sleep to a certain extent was affected in that the EEG was somewhat more active which could be interpreted as a degree of arousal occurring during radio-frequency exposure. That study involved exposure during sleep. More recently another group has found a similar effect, but from exposure before sleep[31]. The indication is that exposure effects last for up to 30 minutes after the end of a call. The obvious importance of this kind of study is in trying to analyse the possible effects of cellphone antennae or other antennae placed on buildings where the subjects are sleeping. Alteration in sleep patterns lead to other psychological effects such as depression and anxiety. Direct provocation studies on humans during cognitive testing have been carried out by Preece et al[32] and Koivisto et al[33]. Both these studies indicated that radio-frequency exposure to the brain resulted in enhanced cognitive performance related to changes in reaction time. The sum total of the sleep, cognitive and electrophysiological studies suggest indeed that there is an effect of radio-frequency on the brain, whether it is analogue or pulsed. The mechanism for these is important. If indeed it is simply heating then this is probably of very little physiological significance and very likely to be unrelated to any health effects and therefore really have little implications for safety. It has been pointed out however that most of the exposures to handset antennae result in a very minimal degree of temperature elevation, probably not more than 0.1 of a degree, as clearly shown by both calculation and experiment by van Leeuwen et al[34].

Therefore the mechanism may be somewhat more complex and there are two other possible candidates. One of these is the direct effect on the synapses in the brain which is in the reaction time determining processes, a glutamate response. This requires the release of a neurotransmitter in response to an electrical signal. The electrical signal in the neurone that leads to the neurotransmitter release area is held at a particular potential until triggered. The supposition is that the superposition of a radio-frequency alternating signal on this potential means that the threshold for the triggering can be achieved more easily, thus leading up to a speeding up of response. This is exactly the kind of reaction seen both in the Preece (15millisecond speeding up) and the Koivisto study (19millisecond speeding up) in reaction time. The third possibility which may have more serious implications because of the possible long-term effects is that these changes could be mediated by protein alterations. One candidate is the change in heat shock protein (in particular HSP70) which has been demonstrated to be altered in some simple animal models. A study by De Pomerai et al[35] shows that non-thermal levels of radio-frequency lead to the alteration in the production of HSP series of compounds. This effect has been seen in other in-vitro systems and in cellular systems, also at electromagnetic frequencies from 50Hz to 2.5GHz.

There is obviously much more research needed but the existence of these effects has led to intervention levels being lowered for the general public. The new NRPB guidelines now align with the ICNIRP levels.

Interaction with safety critical equipment

The levels of radiation likely to cause problems for electronic devices are probably lower than for people. The EN60601-1-2, the EMC standard for medical devices, specifies an immunity of at least 3volts per metre to radiation frequencies from 26MHz to 1GHz. This is in contrast to the recommendation for personal exposure of 87 volts per metre at medium wave frequencies. The Food and Drug Administration of the USA who license medical devices and report adverse incidents has recorded over 100 incidents in a fifteen-year period, some of which incidents involve devices other than mobile phones. Devices particularly at risk are ventilators and infusion pumps - the kind of equipment carried on ambulances. For personal devices, those at risk are hearing aids and cochlear implants, but it is unlikely that pacemakers would be at risk. The question of interference with pacemakers is potentially a serious one but fortunately the risk to an implanted pacemaker is very small indeed. Many of these devices do show interference when on the bench but once implanted the conductivity of the tissue which surrounds them is a highly protective device. The field strength in air at any distance d from an antenna is approximately:

$$E = \sqrt{(30PG)} \Big/ d \ \text{V.m}^{-1}$$

where P is power in Watts, and G the antenna gain.

A survey was carried out by the Medical Devices Agency (MDA) in the UK. This is fully reported in a bulletin[36].

Exposure guidelines for RF radiation

An approach to risk management is to set up defined exposure guidelines to define the level below which health effects should not occur. In the UK the NRPB have reviewed the epidemiological evidence (NRPB GS11)[37] and concluded that the only basis for control is a thermal one. The evidence at the time, in the years 1988 and 1993, gave no indication of a detectable health hazard from non-thermal levels, and that protection from thermal overload was the correct objective. Thermal loads that can be tolerated are, in humans, about a 4^{o}C rise which causes distress, headaches, nausea and disorientation. Cell killing starts to become significant over about 41-43^{o}C so that a limit of 1^{o}C has been suggested. At 1^{o}C elevation of temperature a human simply sweats and may feel vaguely uncomfortable. Normally the body generates its own heat as a result of its basal metabolism. This is of the order of 40kilocalories/m^2/hr, so for a standard 70kg man of 1.7m^2 surface area this represents about 1.13W/kg. Experimental studies on animals and man indicate that a thermal load from inside or outside the body in addition to the basal metabolism results in a 1^{o}C body temperature rise, after which the thermoregulatory mechanisms control and lower temperature. This is easily achieved by internal energy expenditure occasioned by gentle jogging. The external thermal load to create this rise over about 15 minutes is about 4Wkg^{-1}. Radio-frequency energy is no different, so using a suggested safety factor of 10 results in a whole body exposure limit of 0.4Wkg^{-1}. However, for partial body exposures, the presence of a blood circulation means that the thermal load can be 'shared' with the rest of the body and in particular the limbs and head, which are the most likely to receive higher exposure, are allowed $10Wkg^{-1}$.

Unfortunately, body SAR is a very difficult parameter to measure and has to be inferred from the E or H components.

For use in the near field frequency range 10MHz to 100MHz, INIRC (International Non-ionising Radiation Committee) - the following calculation is recommended to give the equivalent plane wave power.

$$P_{eq} = \frac{5}{6}\left(E^{2}/120\pi\right) + \frac{1}{6}\left(120\pi H^{2}\right)$$

This can be applied to calculate the following derived exposure limits for workers and the general public. Some of these are shown in Tables 1 and 2.

Table 1. INIRC recommended derived occupational exposure limits to radio-frequency electromagnetic fields

Frequency (MHz)	Unperturbed RMS field strength		Equivalent plane wave power density P_{eq} ($W\ m^{-2}$)
	Electric E ($V\ m^{-1}$)	Magnetic H (Aa/m^{-1})	
0.1-1	614	1.6/f	-
1-10	614/f	1.6/f	-
10-400	61	0.16	10
400-2000	$3\sqrt{f}$	$0.008\sqrt{f}$	f/40
2000-300000	137	0.36	50

Table 2. INIRC recommended derived general public exposure limits to radio-frequency electromagnetic fields

Frequency (MHz)	Unperturbed RMS field strength		Equivalent plane wave power density P_{eq} ($W\ m^{-2}$)
	Electric E ($V\ m^{-1}$)	Magnetic H (Aa/m^{-1})	
0.1-1	87	$0.23/\sqrt{f}$	-
1-10	$87/\sqrt{f}$	$0.23/\sqrt{f}$	-
10-400	27.5	0.073	2
400-2000	$1.375\sqrt{f}$	$0.0037\sqrt{f}$	f/200
2000-300000	61	0.16	10

These recommendations were then updated in 1993 (documents of the NRPB, Vol 4; No. 5) to give the values used in the UK to date. The field strengths listed in Tables 1 and 2 define the environmental exposure limits that can be measured by physical instruments. In order to define the absorbed energy, as has been suggested above, translating this into SARs is difficult. Nevertheless this parameter is the critical one that defines the effect on the body. Table 3 lists a summary of the main end points that will avoid taking into account factors such as shape, resonant size and the degree of localisation of the exposure. This is the UK guideline which is of value in assessing whether any device is causing exposure that might be of concern.

Table 3. Summary of the basic restriction and investigation levels for exposure of whole or part body to electromagnetic radiation, based on the specific absorption rate

f	SAR Av over body	SAR Limbs	SAR Head	Environmental power density
	Wkg^{-1}	Wkg^{-1}	Wkg^{-1}	Wm^{-2}
100kHz-10MHz	0.4	20	10	Mag.flux=$23/f^2$μT
10MHz-10GHz	0.4	20	10	variable
10GHz-300GHz	-	-	-	$100Wm^{-2}$

In addition to the thermal effects there are indirect effects that can arise, for example those involving interaction with an object at different electrical potential from the body. One of these effects is the direct simulation of peripheral nerves and muscles. However, this is not likely to be a particular problem at radiofrequencies above 10-40kHz since stimulation of nerves, either peripheral or central normally ceases at the maximum frequency of an action potential. Nevertheless there is always the possibility of causing burns by body parts making contact with conductive objects and producing tissue heating from the passage of current through the tissue. Guidelines to these possible health effects are normally in two levels of protection depending on whether the subjects are the general public and not controlled by health checks, protective clothing or procedures, or whether subjects are workers in controlled environments or controlled working practices as explained in d) (below). This is supplemented by introducing the concepts of “basic restriction” and “reference levels” and is interrelated by the following considerations:

a) Basic restrictions are based on established health effects.
b) Reference levels are derived from measurement or computed predictions. These are used to provide practical exposure assessment to determine whether the basic restrictions are likely to be exceeded.
c) If a reference level is exceeded it does not necessarily follow that the basic restriction is exceeded. However, the compliance with the basic restriction has to be tested in order to comply with regulations.
d) Guidelines thus often differentiate between occupational exposure and general public exposure. These can be defined as occupational/controlled exposure which is appropriate when persons who are fully aware of the potential for exposure and are therefore able to exercise control over the exposure system or the levels in their environment. These levels would also apply if on a location which might involve temporary occupancy providing there is adequate warning in the form of signs and other indicators. For the general population one uses the term ‘uncontrolled’ exposure which applies when the persons who are exposed may not be aware either of the levels of fields that exist or of the possible consequences of their exposure. The NRPB guidelines (NRPB 1993)[38] consist of basic restrictions

and reference levels according to the table above but this does not distinguish between members of the public and occupationally exposed workers. In a number of summaries since the production of the 1993 guidelines NRPB have questioned the scientific justification of a blanket approach and of the wisdom of further reductions in exposure. Peak levels experienced from pulsed RF field conditions are only restricted in so far as required to avoid the effect of microwave auditory effects in people with normal hearing and all other limits are based on average levels.

e) Since 2004 these levels are now revised to include a further safety margin of 5 to the levels for public or uncontrolled exposure that effectively aligns the NRPB and ICNIRP levels. (http://www.hpa.org.uk/radiation/publications/documents_of_nrpb/pdfs/doc_14_2.pdf)

ICNIRP

ICN1RP[39] guidelines are set out in two levels of protection (for the general public and for the healthy worker) under the following conditions:

a) All SAR values are averaged over any six-minute period and localised SAR values are averaged over 10 g of tissue in a single mass.
b) For pulses of duration T, the equivalent frequency is determined by 0.5 T.
c) For pulsed exposures in the range 0.3 to 10GHz and for localised exposure of the head, the specific absorption should not exceed 10 mJ kg^{-1} averaged over 10 g.

The ICNIRP guidelines have been arrived at by general consensus by a number of European committees and do not yet have the force of law in the UK but are used as guidelines. In this study it is the ICNIRP levels that will be used for reference.

USA, Canada and Australasia

The Federal Communications Commission (FCC)[40] sets out the following:

a) Two levels of exposure limits based on occupational/controlled and general population/uncontrolled exposures.
b) Maximum permissible exposure limits are based on recommendations of the NCRP[41] and the IEEE[42].

There are other standards which apply in Australia, New Zealand and Canada. In 1998 Australian and New Zealand standards were merged as an interim standard (AS/NZS2772.1 (INT); 1998). These adopted a standard allowable general public exposure limit for the frequency used by mobile phone companies for example of 0.2 $mW.cm^{-2}$. This is a large factor lower than the FCC, ANSI/IEEE, ICNIRP and NCRP standards. The Canadian standard is laid out in "Health Canada: Limits of Exposure to Radio-frequency Fields at Frequencies from 10KHz - 300GHz, Safety Code 6, Canada Communication Group, Ottawa, Canada, (1993). This appears to be very similar to the FCC standard.
The following bodies have set up guidelines which have been generally adopted starting with NCRP (1986), ANSI/IEEE (1992), NRPB (1993)[43], CENELEC (1995), FCC[44], ICNIRP. There is as yet no consensus on which of these standards are adopted in any countries except in the USA which has consistently adopted the FCC limits based on the original ANSI/IEEE (1992) standards.

Recent reviews

A number of bodies have produced detailed reports on reviews of the potential health risks of radio-frequency fields, particularly based on wireless telecommunication devices. The two most recent of these are a report by the Royal Society of Canada[45] (also on web-site)[46] and by an independent expert group on mobile phones under the chairmanship of Sir William Stewart (Mobile Phones and Health 2000)[47]. The Royal Society of Canada produced their report for Health Canada and looked at all peer-reviewed literature on radio-frequency fields and health, examining both epidemiological data, studies on mechanisms and laboratory cellular and animal work. Their conclusion, not surprisingly, is that there is no good evidence to date that the few observed non-thermal effects have any links to adverse health effects. However the review identified desirable areas of research and a set of specific questions. In particular, effects on the eye, on melatonin secretion and on the various neurotransmitter systems need to be studied, as well as obtaining a better understanding of the biophysical detection mechanisms that must exist. It was estimated that a 5 to 10 year programme of research would be desirable. It was felt, however, that the current guidelines were adequate to protect against thermal hazards. The study is a good resource of literature review.

The Stewart report (more correctly the report of the "Independent Expert Group on Mobile Phones" (IEGMP)) was produced in response to the advice of a Parliamentary Select Committee on Science and Technology[48] which asked NRPB to set up an independent review. This examined the pre-existing evidence for both thermal and non-thermal effects, but re-examined much of the evidence critically in order to decide what weight to apply to the published data. The conclusion of this group (available on a web-site)[49] also was that there was evidence of a biological response to low levels of RF, but again no evidence that these responses were either harmful or even potentially so in the long term. Nevertheless, as such responses were occurring below the existing guidelines and as a precautionary approach it would be desirable to adopt the ICNIRP guidelines which took account of the difference between controlled occupational and uncontrolled public exposure. In addition the question of public perception of risk was addressed for the first time. The recommendations that the exemption from planning regulations for small (less than 15m high) masts bearing antennae should be stopped and that the public should be consulted through normal planning processes, that siting masts on schools should be avoided, that the ALARA (as low as reasonably achievable) principle be used for public exposure and that the phones should be identified with the SAR achieved under standard test conditions. The Committee also recommended that more research ("a substantial research programme") should be sponsored and part financed by the industry, but initiated and monitored by an independent body. In particular they recommended that a register of occupationally exposed workers be established and that cancer risks and mortality be examined to determine whether there are any harmful effects. If any adverse effects of exposure to RF radiation are identified then the Health and Safety Executive should establish a system of health surveillance.

Following this report the IEE (Institute of Electrical Engineers) issued a position statement. In this, with respect to RF exposure, the possibility of the existence of health effects is dismissed as unlikely, and even those studies the IGEMP had considered significant, require replication before being considered to indicate a response. The overall consensus (of the IEE) was that there is no need for a precautionary approach and "that there is no scientific basis to the measures recommended" (*by the Stewart Committee*). Unfortunately this has not resolved the public risk perception problems. The whole scene has been heavily reviewed by NRPB (now the Health Protection Agency) in "Documents of the NRPB: Volume 14, No. 2 *Health Effects from Radiofrequency Electromagnetic Fields: Report of an independent Advisory Group on Non-ionising Radiation*", resulting in new proposals which align with ICNIRP[50].

With respect to power frequency fields there is a further cautionary note. It has been recognised that power frequency (that is 50 or 60Hz) fields are a possible human carcinogen and that exposure long term to fields above 0.4 microtesla may put children at double the risk of developing leukaemia.

Conclusion

- Thermal effects and their consequence are well established, and national guidelines, albeit at variance with each other, have been set out to control these.
- Non-thermal effects have been seen to occur at low levels and probably represent no more than minor physiological responses.
- The greatest (and only established) effects are seen from mobile phones.
- No real evidence of direct effects of exposure to transmitters (below the ICNIRP) guidelines have been demonstrated.
- There is no confirmed evidence of health effects (defined as alteration of well-being) whether minor or more serious. However there are certainly anecdotal reports of subjective effects on well-being.
- The other hazards to health are interference with medical equipment and aircraft guidance systems and need to be controlled.
- For radiofrequency the UK now aligns with Europe and the USA, and all are moving towards common standards of exposure.
- There is need for further research to clarify the fears and prejudices of people, and this research has been prompted by the recent growth on the communications industry. Results will become available over the coming years.

The previous studies (SBAA and France Telecom) indicate that exposure levels meet ICNIRP standards by a very large margin within the villages of Akrotiri and Asomatos.

Precautionary approaches

The story does not end here. A number of countries have as a result of public and media pressure tended towards tighter limits. These are worked on the principle that if electromagnetic compatibility requirement for electrical equipment is in the order of 3 to 10 Volts/metre then there is no reason not to use such for human exposure. This leads to some precautionary levels for effects that might happen but have not yet been demonstrated.

An example is shown below with the original UK limits, as applied to DCS mobile phone radiation.

Table 4. 1800 MHz public exposure guidelines

	Power density **uW/m2**	Equivalent electric field **V/m**
NRPB prior to IEGMP (Stewart) Report	100 000 000	194
ICNIRP (1998), WHO	9 000 000	58
Belgium (ex Wallonia)	1 115 000	21
Italy (sum of frequencies)	100 000	6
Russia, PRChina	100 000	6
Switzerland, Lichtenstein, Luxembourg	95 000	6
Belgium Wallonia	24 000	3
Wien (sum GSM)	10 000	1.9
Italy (single frequency)	1 000	0.6
Salzburg 1998 (sum GSM)	1 000	0.6
EU-Parl, GD Wissenschaft, STOA GSM (2001)	100	0.2
Salzburg GSM/3G outside houses (2002)	10	0.06
Salzburg GSM/3G inside houses (2002)	1	0.02
Bürgerforum BRD proposal, waking areas (1999)	1	0.02
Bürgerforum BRD proposal, sleeping areas (1999)	0.01	0.002

In practice some of the lower levels cannot be achieved – the use of a mobile phone would become illegal for example since it generates up to 70 volts per metre in air and even up to 30 volts per metre in brain.

3. Protocol development

In devising the Health Survey protocol it was necessary to address the existing deficiencies of the health record system emanating from incomplete death registration or death certification without cause of death (for almost 30% of the cases), lack of reliable data in cancer registration (before the year 1998) and no reliable registration for congenital abnormalities. The selection of the control community and electromagnetic fields measurements sites were finalised after considering many alternative options.

Several meeting were held between Professor Alan W Preece of the University of Bristol, Dr. Andreas G Georgiou, Chief Medical Officer of the Ministry of Health, Professor Stephen Farrow of the University of Middlesex and Miss Elizabeth Dunn, Research Scientist of the University of Bristol in order to address the aforementioned problems. The study was finalised and granted approval by the Biomedical Ethics Committee of the Pancyprian Medical Association, the Commissioner for the Protection of Personal Data of the Republic of Cyprus and the United Bristol Health Care Trust Ethics Committee.

The official commencement of the study was effected in October 2003 by signing a contractual service agreement with Miss Antigoni Menelaou, Research Assistant of the study.

4. Methodology

4.1 Questionnaire development

Data collection requirements

The research protocol devised for the Akrotiri Military Antennae Health Survey required a cross-sectional survey conducted across three sites; the ‘exposed’ sites of Akrotiri village and the smaller community of Asomatos, and the ‘unexposed’ Pano Kyvides. A comparison could then be made between the electromagnetic field (EM) profiles and health information collected in the exposed and unexposed sites. The village leaders provided an estimate of the numbers of households to assist in the survey planning (see Table 5 below). The numbers reported suggested that the entire population of all three sites be included in order to in achieve sufficient numbers for a reliable picture of community health and to conduct meaningful statistical analysis of the data collected.

Table 5: Village population estimates

Numbers	**Akrotiri**	**Asomatos**	**Pano Kyvides**
Households	250	120	180
People	650	500	700
Nursery school children	25	10	30
Elementary school children	70	30	133
Secondary school children	60	15	75
All children	155	55	238

Developing the health survey questionnaires

The questionnaires were intended to provide a detailed overview of the current health status reported by the residents of all three communities and an indication of past health problems and illness. Previous research (listed in section 2) conducted on the health of populations living near broadcast media sites and electricity installations provided an indication of diagnoses and disease patterns that the survey should be concerned with.

It was not appropriate to use one single questionnaire for completion by all residents, as some of the health issues of concern were very gender or age specific. It is widely acknowledged in epidemiology and the social sciences that response rates for lengthy, complicated questionnaires are lower, and maximising the participation amongst residents was a major concern. As a result three distinct questionnaires were developed for use in this survey as follows:

Adult

This was the longest questionnaire devised for the Health Survey and intended for completion by all adults resident in the communities.

- Section One requested basic demographic information (such as date of birth, education and occupation).
- Section Two contained a list of specific conditions or illnesses (previously identified as possibly affected by proximity to EM fields). Respondents were simply asked to state whether or not they had had each condition. This section went on to explore certain health behaviours such as smoking and

mobile phone use, which may have had a confounding effect on other responses.

- Section Three utilised the SF-36 as a standard measure of health status. This is a multipurpose, 36-item survey that measures eight domains of health: physical functioning, role limitations due to physical health, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems, and mental health. It has been widely used in epidemiology and health services research to measure the general health of populations (including quality of life).
- Section Four was concerned with an individual's relative perceptions of risk. A series of questions previously developed at Bristol University from a Swedish Occupational Health study and also used in the USA[51],[52], and [53] were adapted and refined for use with regard to proximity to military antennae. Respondents were invited to consider a series of situations and apply a 'risk category' to each. This approach allows perceptions of 'perceived' risk to be examined. The majority of items were identical to questions used in the UK so that these were available as a cultural comparison.

Female

This was an additional questionnaire for completion by all women aged 18-50 years and resident in the communities. As previous research had suggested that EM field exposure may be associated with certain reproductive health effects[54]. This questionnaire was concerned with eliciting information about reproductive history including pregnancy, incidence of miscarriage and foetal loss and infertility.

Child

Children (under 16 years) resident in the communities had a questionnaire completed by their parents. Demographic data such as gender, date of birth, length of residency and schooling information was requested. It was felt appropriate to include a question concerning mobile phone use because even though research is not showing either differences between adult and child responses, or long-term persistent deleterious effects of phone use. In addition a series of checklists were included relating to the child's health to date. Parents were asked whether a child was born with certain congenital abnormalities, had been diagnosed with certain conditions, and finally what childhood illnesses and infections they had had.

It was important that respondents were offered an opportunity to include comments of their own, and not just an answer to a series of 'closed' questions. Valuable data can often be obtained this way, in particular an insight into the general opinions and beliefs held by the sample groups. Each questionnaire included a final section that asked for additional comments on health issues.

Copies of all three questionnaires (and appropriate translations) can be found in the appendices.

All questionnaires underwent a lengthy and rigorous process of translation into Greek and back translation into English to guarantee that they were understandable and relevant to the intended respondents, and that interpretations and meanings were consistent. This process also ensured that any cultural issues were considered and amendments made if necessary. In the case of the SF36 a Greek version was available from the SF36 questionnaire designers. This too was subject to back translation because of possible differences between mainland Greek and Cypriot Greek.

Collection of mortality data

The information collected by the questionnaires listed above provided the main source of morbidity data. However these questionnaires could only provide information on the living. It was vital that the Health Survey also took into account the patterns of death reported in all three sites.

In the UK such information would be collected from official registry sources such as Cancer Registries and Death Certification. As mentioned above there were some limitations in the system of routinely collected and validated mortality data in Cyprus. Nevertheless information was available from the Ministry on registered deaths by village of residence for the last two years.

In order to obtain the information required on mortality in the villages an alternative approach was devised. Each family was asked to complete a further questionnaire concerning family members (who were resident in the village) who had died within the previous 10 years. Details pertaining to the cause of death and attending physician were requested for each death reported. These data were then checked later against hospital records to confirm diagnosis. Because of the interest in brain tumours and leukaemia special attention was paid to checking the cause of death and the site of specific cancers.

It was also possible to estimate the number of deaths from the cemeteries. In both Akrotiri and Asomatos there are two cemeteries and in Pano Kyvides one. Information on age and date of death was collected from the gravestones.

This method (though crude in many ways) provided the only possible mechanism for calculating Standardised Mortality Ratios (SMRs) for all three sites.

(A copy of the Mortality Questionnaire can be found in the appendices).

Method of administration

There are several recognised methods of collecting data using questionnaires including self-completion by the respondent and interviewer administered (in person or by telephone). The particular design of an individual questionnaire must take into account which method will be used, as this has implications for the layout and content.

Due to the size of the potential samples involved it was apparent that (having considered time, financial and logistical considerations) a questionnaire that the villagers could complete themselves would be most appropriate. Use of such methods is widely practised in the UK, and accepted by the public. Following discussions about Cypriot society it became apparent that such an approach could not be assumed to work in Cyprus. Valid concerns were raised, relating to literacy and the ability to complete a questionnaire and also cultural norms of behaviour. It became apparent that the questionnaires should be designed and phrased in such a way that health information could be collected from the residents via either self-completion or an interview administered methods as required. A data collection procedure was formulated to ensure that questionnaires were administered in a consistent manner.

It had been intended that the questionnaires would be distributed using information on the family structure of each household, provided by each village leader, in order to decide which questionnaires were appropriate. Questionnaire administrators would then visit each home and after explaining clearly what was required, leave the questionnaires for self-completion by adults in the household. The interviewers would return by agreement after a few days to collect the questionnaires and to assist in the completion of any missing items or provide explanation or clarification of any issues.

Initial low response rates necessitated a re-evaluation of methods. It became apparent that, in order to achieve the participation that was required, the majority of the questionnaires had to be completed by the administrators during a meeting with each household. As has already been explained, this slight amendment to the method of questionnaire administration is not of concern. The questionnaires were formulated and designed in such a manner that either method was acceptable. Their structured format ensured that all the questions were asked in a consistent manner to all respondents and the opportunities for administrator-introduced bias were minimised.

Despite the numerous obstacles that were faced in collecting the health survey information, a robust response was achieved. Further analysis of the respondent's demographic characteristics confirmed that the sample was representative of the wider populations of the three data collection sites and was not skewed or biased in any way.

4.2 Measurement philosophy

Measurement of radiofrequency fields

Visually at the approach to Akrotiri are a large number of antennae, some of which are rotary log-periodic in design, others of wire configuration and of particular interest is an array of wire antennae attached to vertical masts – the Pluto project.

Before mid 2004 there was one array, with a second array added in mid 2004. These are communications antennae designed as a dipole curtain. Details are available at: http://www.tcibr.com/PDFs/611webs.pdf. This information includes details such as maximum input power, elevation and azimuth ranges, and frequency range. Details of operation on the Akrotiri site were not provided nor required for this study, but sufficient information was available to be able to relate the measurements to the maximum possible performance of the system. In this case the manufacturer's information provided for a maximum input power of 500 kW, a maximum slew of 30^0 and a frequency of about 17 MHz as the centre of the operating range.

The local perception reported by the media was an anxiety that the radiofrequency fields were damaging to health. At a meeting at the Akrotiri Community Centre in June 2002 there was considerable resistance to plans to install the larger (lower frequency) antenna, based on considerable confusion between the science of studies on power-lines and understanding of the effects of radiofrequency which have led to the setting of limits for public exposure. This study, the Antennae Health Survey, was designed to look for evidence of health detriment in the populations within sight of the antennae. In order to get the possible health effects into context, it was also decided that although the radiofrequency fields had been fairly well characterised by at least two studies of the area, additional independent measurements would be taken that had a component of time in the study. This was to assure both the researchers and the study population that no RF exposure could occur that was not understood or expected during the study.

It was also understood that the populations under study would be exposed to a myriad of electromagnetic field sources of highly variable content, but the source of interest was the Pluto system and this would need to be well characterised.

Sources of electromagnetic fields in the area

Power frequency – largely 50 Hz. and derived from the electricity supply to the area, the domestic wiring and use of appliances. The fields, both magnetic and electric from power frequencies are ubiquitous, are common to all three population areas under study, and are thought to have, in excessive amounts, a possible health effect. *"Power frequency electromagnetic fields are a possible human carcinogen"* is a statement from the NIEHS (USA), NRPB (UK), and IARC (EU) based on a large number of epidemiological studies carried out in the '80s and '90s and summarised in meta-analyses by Ahlbom et al[55] and Greenland et al[56]. They showed that chronic exposure to power frequency levels above 3–400 nT was associated with a doubling of childhood leukaemia. Power frequency exposure as a possible confounder was considered, but since there were no high voltage power-lines in the area, measurements of EM fields were found to be very low (compared with background levels in the UK for example), and as the population under consideration was far too small to be able to study such a rare condition as childhood leukaemia, no controlled study of these frequencies was undertaken.

Medium wave – Broadcast

This covers the range 500 kHz to 108 MHz and was obviously operational in the area to provide local and Forces radio. There have been health studies of these sources by Dolk et al[23, 24,] Hocking et al [25,] and Michalozzi et al[57]. It has not been possible to draw a conclusion regarding a health effect from these studies and results are still disputed. However there were no especially prominent sources near the study areas, and fields from these would have been relatively small, uniform between the populations and exposure was captured by the broadband measurements undertaken.

High frequency 12-32MHz

Communications and broadcast sources abounded in the area including a BBC World Service antenna. These were a real source of confusion and were accounted as broadband measurements of the electric field. None of the sources was particularly close to the study areas, but the presence was measurable at all times.

Cell-phone source

In the village of Akrotiri there was a very prominent CytaGSM mast close to the church and below the level of the hill to the south of Akrotiri. This presumably served the area of Akrotiri, Asomatos and the Base, as well as a part of the Limassol area. In buildings close to the Church the field from this could be expected to be significant and a real confounder to measurements of radiofrequency fields. Typically one could expect the field to be in the order of 1 Volt/metre at up to 150-200 metres from the antenna. Whilst this could be filtered out by use of a spectrum analyser, its presence would be felt in any broad-band measurement and was a problem for long term measurements.

High frequency 8-32MHz

The Pluto system is situated at the western end of the Akrotiri peninsula on the edge of the salt lake in the approximate position marked 'P' (Fig. 1). This could be operated at a range of different frequencies and a range of different elevation and azimuth. However there are constraints on the power available to energise the system and the need to avoid the RAF base at Akrotiri. This would suggest a normal operation in an easterly direction, over Lady's Mile beach and Akrotiri Bay. Measurement of the Pluto system as a source of radiofrequency fields was best accomplished with a spectrum analyser, windowed to the agreed frequency of operation, using a calibrated antenna system.

Co-operation with the SBAA allowed an extended period of operation at an agreed frequency, agreed orientation of the beam (maximum deviation towards Akrotiri, and maximum deviation towards Asomatos) and an agreed power level which had a fixed relationship to the maximum normal operating power and the maximum rated input power of the antenna. These measurements were carried out during the usual non-operational periods. A system of relatively rapid spot measurements was devised, and is described below.

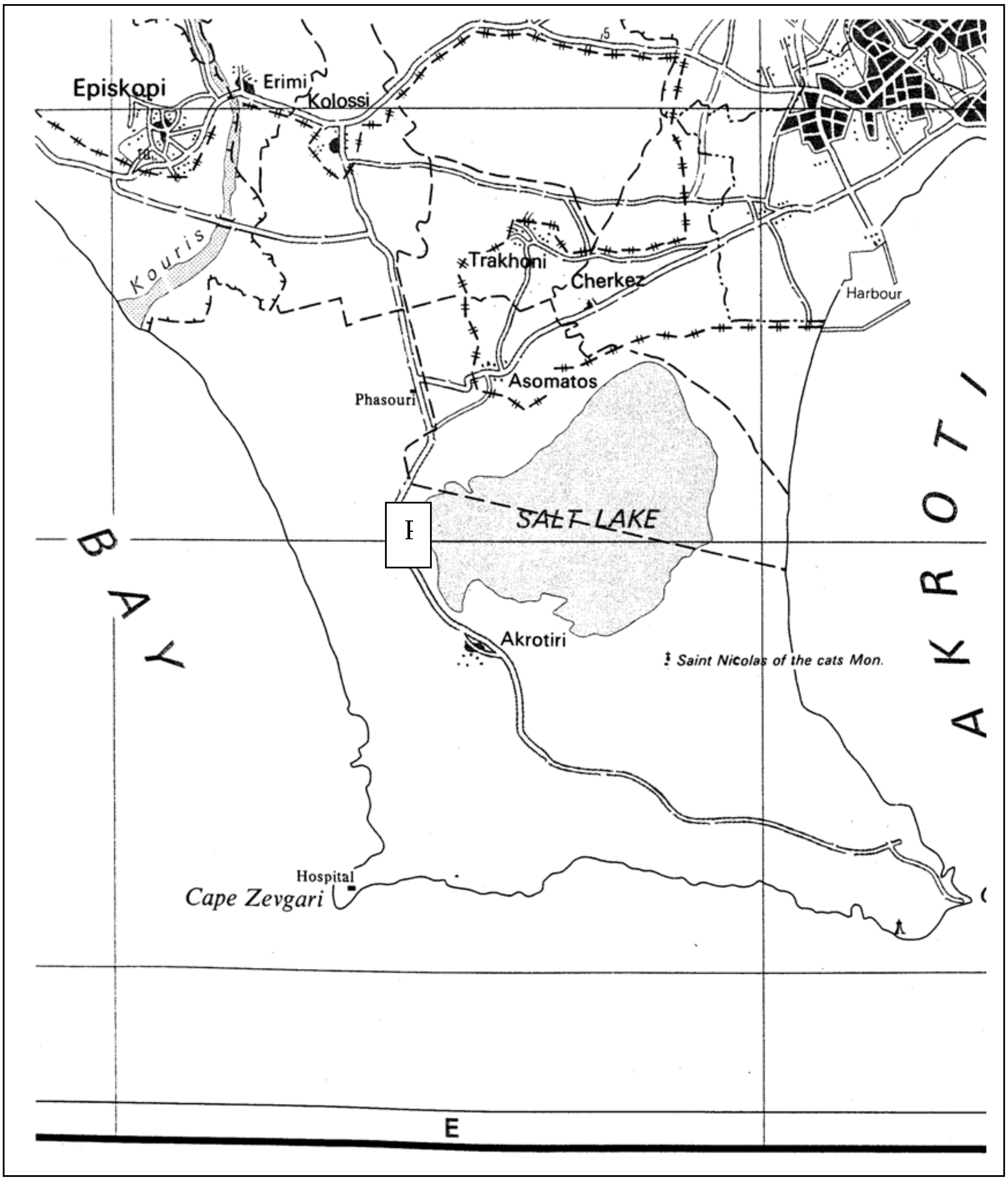


Fig.1 Map of the Akrotiri Peninsula to show the relative positions of the antenna and communities

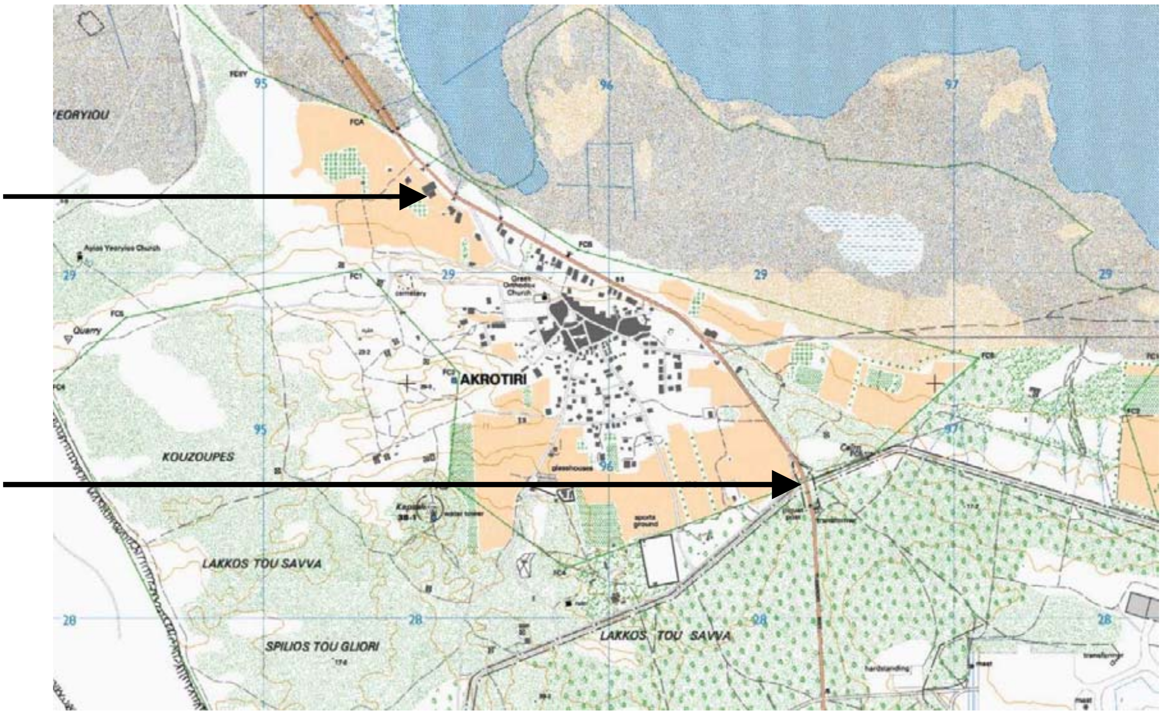


Fig 2 – Map of Akrotiri and the limits of measurement survey

Measurement philosophy

The area had numerous sources of RF, and in particular Akrotiri has a strong cell-phone microwave source that on preliminary measurement appeared to be stronger than the high frequency. This suggested the need to be able to discriminate between the different classes of radiofrequency. Also the local perception was that when measurements were being undertaken then the equipment was not operated at full power, or was steered away from the site. This suggested that a continuous method of monitoring was needed. Both these requirements were addressed by development of a simple high frequency and low frequency logger that sampled every 10 minutes throughout the day and night, and the use of a spectrum analyser to measure the contribution of Pluto to the melange of radiofrequency fields.

Measurement protocols

Longitudinal loggers

The survey required long-term monitoring. This limits the rate of sampling and the amount of data that could be stored. However it was felt important to give a baseline of field strengths by which the spot measurements could be validated, i.e. to record the maximum values of RF exposure over a long period of normal operation. It was decided to attempt to collect data for at least 12 months at some key sites and to cover the operation of the new Pluto antenna.

The sites chosen were the Community Centre in Akrotiri, the new church at Asomatos and the Medical Centre in Pano Kyvides. At one point, because of refurbishment of the building, the Community Centre logger was moved to the Bank and remained there. After almost six months of recording at Asomatos that logger was moved to the Akrotiri Community Centre, since little activity had been recorded in Asomatos. Part of the Pano Kyvides data was lost when the supply had been disconnected for a long period; nevertheless some months were successfully covered.

Data loggers

Nothing suitable was found commercially so three loggers were commissioned from Delta-T Products. These are multi-channel storage devices with data backup and download facilities used for a range of environmental studies. (http://www.delta-t.co.uk/) A spectrum analyser would have been ideal but would have needed a prohibitive amount of memory, thus a simple amplifier pair with crossover of response in the VHF region was constructed for each logger and connected to a single antenna. Sensitivity was chosen to record up to 10V/m (approx) and sensitivities set at 27 and 900MHz. The separation was not perfect but gave a sensitivity differential at the calibration frequencies of about 10:1 Loggers were sampled every 10 minutes and recorded Maximum, Average and Minimum at HF and UHF. The CMOS memory had battery backup and the amplifier and logger function was backed up by eight x AA batteries to guard against short-term power cuts.

Normal function was with a mains supply that of course required a sheltered site within the buildings. The Akrotiri logger had line-of-sight view through the window of the Pluto antenna, albeit at the edge of the operating polar pattern of radiation. In the Bank at Akrotiri the logger could also be sited near a window, but outside were overhead telephone and power-lines that would have given a degree of screening. A view of the antenna was not possible with the Asomatos logger, even though several possible sites were considered. The operation at 10 minute sample rate was for some four months, allowing a reasonable time between visits to collect data, reset and re-battery the loggers. At one point, construction work at the Community Centre necessitated removal of the logger to the Bank. It probably would have been ideal to have had the loggers outside, positioned high and in the clear. However this would not have reflected true domestic exposure of individuals. Provided that the loggers could remain relatively undisturbed, this arrangement allowed them to detect any changes in the radiofrequency field as a proportion, since the attenuation due to the building remains relatively constant. In any case, the SBAA confirmed plans to have at least one logger mounted on the top of the Community Centre roof. Data from this was relayed directly to the Ministry of Telecommunications by mobile telephone.

Spot measurements

Advice from SBAA suggested that continuous CW operation for extended periods at maximum power was undesirable. Therefore a procedure was chosen whereby a short burst of maximum power would be followed by an extended period of known power, with a fixed elevation and steered either maximally towards Asomatos or Akrotiri as appropriate. To undertake these measurements a vehicle mounted system was devised in order to be able to move rapidly between measurement points. The objective was to be able to take up to 10 or 12 measurements within an hour, and record their location. This would record both the single frequency of Pluto and at the same time an isotropic measurement of e-field in order to account for all the other sources.

An Instek GS827 spectrum analyser (http://www.instek.com/GSP-827.htm) was chosen for this study. This has a 100kHz to 2.7GHz response with data output. The antenna was a Maplin ScanKing loaded vertical with a claimed response of 0.05 to 2000MHz. A suction clamp was fitted to the base for roof mounting on a vehicle.

The system was calibrated in the UK using a “three antenna” technique, where the antenna and analyser were mounted on and in a similar 4x4 vehicle and compared with a calibrated Narda probe using a 5 Watt 27 MHz source to calculate an antenna factor. This was supplemented on site with measurements close to the operating Pluto antenna to check that the responses were as predicted. Both for calibration of the antenna, and for on-site measurements the reference meter was a Narda EMR 21C with a type 18 probe (100kHz-3GHz).
(http://www.narda-sts.com/en/produkte/emr2030.htm)

Spot measurement procedure

Software was written to record both the spectrum analyser 512 point scan and a GPS position. Points were selected in each village to give a representative spread of measurements. The sites, where possible, were selected to avoid being directly under overhead wires or close to screening buildings, although this was not always possible. The procedure used was to agree a start time of transmission by telephone, drive to the location and record the field at that position (about 3 minutes per scan).

During the first measurement visit a successful survey of Akrotiri was followed by a failure of the spectrum analyser at Asomatos. The replacement equipment with upgraded software was not compatible with the written peak search and position recording software. Thus the measurements were repeated with a new analyser and Instek screen recording software with manual position logging.

4.3 Method of analysis

The numeric data from the three questionnaires were entered into a database and checks were undertaken to ensure that all entries were within the range of acceptable responses. Many variables were coded Yes/No, others fell within a range of five or six possible responses. The initial analysis produced frequency tables and these were reviewed to ensure that there were no responses outside the permitted values. If following checks the validity of coding could not be established, these responses were recoded as missing values. Analysis was carried out using a standard statistical package (SPSS Version 11.5). Most of the analysis was simple, for example, cross-tabulations of non-parametric data. Chi squared tests were used to establish statistical significance.

In analysing the SF36 data the individual answers were aggregated into eight scales as recommended by the SF36 guidance on standard analysis. This form of analysis produces scores between 0 and 100 for each of the domains. Aggregated scores were tested for significance using standard parametric tests, for example, t-tests and analysis of variance. The analysis of the risk perception data followed the general guidance issued by those who had developed the questionnaire. Non-parametric testes were carried to establish the significance of the responses from those living in the different villages.

Logistic regression analysis was carried out when analysing the specific outcomes of migraine, headache, dizziness and depression. This was chosen because in each case the outcome (dependent) variable took on a binary form that is they were either absent or present. Models were developed, incorporating all independent variables that had been shown to have an association with the particular outcome when looked at singly. Again mainly non-parametric tests were used.

5. Questionnaire results

5.1 Response rates

The village leaders provided estimates of the numbers of people living in each village. In Akrotiri the estimated number of residents was 800: in Asomatos it was 350 and in Pano Kyvides it was approximately 1000. In Akrotiri questionnaires were given to 230 households and there were 201 returns (a response rate for households of 87%). In Asomatos questionnaires were given to 104 households and there were 80 returns (a response rate for households of 77%). In Pano Kyvides questionnaires were given to 196 households and there were 181 returns (a response rate for households of 92%). The overall response rate was 87%. This is an excellent response rate for community studies of this nature.

5.2 Adult questionnaire

This questionnaire was organised into four sections.

Section 1. General personal information

There was no overall significant difference between villages when looking at age. The ages were assigned to ten-year groups and then further grouped into five categories so that the overall numbers in each group were similar: 18-30; 31-40; 41-50, 51-65 and over 65. There was no overall significant difference on Chi squared analysis although there was a significant linear by linear association. Amongst those adults who were 51 years and over the percentages for each village were 43.3% for Akrotiri, 43.0% for Asomatos and 33.2% for Pano Kyvides. Pano Kyvides had a lower percentage of older people than the other two villages. Nevertheless the villages were generally well matched for age.

There were 490 men and 515 women across the three villages and no significant differences in the male: female ratio in any of the villages. The differences in marital status were of borderline significance. Nevertheless, in Asomatos there were slightly more single adults, slightly fewer adults who were married or living together, and slightly more who were separated, divorced or widowed compared with the other two villages. There were small differences in educational level that were just significant (p value 0.048) but there was no consistent pattern. Amongst those who had no schooling there was a greater percentage from Akrotiri. However when looking at those who stayed in education beyond the age of 15 there was no difference between the three villages. On the other hand there were differences in the number of years that adults had lived in each of three villages. These results were highly statistically significant. Taking those who had lived in their village for more than 20 years the percentage for Akrotiri was 77.6% and for Pano Kyvides 72.9%. By contrast, only 57.6% of adults had lived in Asomatos for more than 20 years. With the exception of the length of time that people had lived in a particular village it can be concluded that the exposed and unexposed villages were well matched. This level of matching should give confidence in the subsequent analysis.

Section 2 Your health

This section asked questions about eleven conditions or health problems that the adults may have had. Table 6 shows the results of each health condition by village.

Table 6 Summary of conditions reported by adults

Table number	Condition	Significance	P value
Table 6 of B1	Diabetes	Not significant	.133
Table 7.1 of B1	Asthma	Significant	.002
Table 8.1 of B1	Other breathing/lung problems	Significant	.021
Table 9.1 of B1	Epilepsy	Not significant	.284
Table 10 of B1	**Migraine**	**Highly significant**	.000
Table 11 of B1	**Headaches**	**Highly significant**	.000
Table 12 of B1	**Dizziness**	**Highly significant**	.000
Table 13 of B1	Depression	Significant	.002
Table 14.1 of B1	Heart problems	Significant	.007
Table 15.1 of B1	Diseases of the nervous system	Not significant	.410
Table 16.1 of B1	Cancer or leukaemia	Not significant	.127

In the case of asthma there were significantly different responses between the villages. Asthma was present in 9.4% of adults in Asomatos compared with 3.2% in Akrotiri and 3.1% in Pano Kyvides. In the case of other breathing/ lung problems the results were also significantly different. In Akrotiri 7.2% experienced other breathing/ lung problems compared with 5.6% in Asomatos and 2.9% in Pano Kyvides. There were highly significant differences by village for migraine, headache, dizziness and depression. These differences are summarised below in Table 7. It shows the percentage of adults complaining of those symptoms for each of the three villages. In fact, for migraine, headache and dizziness there is a marked gradient with Akrotiri having the highest figures and Pano Kyvides having the lowest figure.

Table 7 Percentage responses for health problems or illnesses

Condition	Table	Akrotiri	Asomatos	Pano Kyvides
Migraine	10 of B1	23.1%	14.8%	9.9%
Headache	11 of B1	51.3%	35.1%	22.2%
Dizziness	12 of B1	35.7%	20.9%	10.2%
Depression	13 of B1	10.2%	9.7%	3.9%

These differences are substantial and further analysis is undertaken below to describe the association of these illnesses with other factors.

There were significant differences between the villages in heart problems, with Asomatos showing 16.2% of the adult population having heart problems compared with 10.5% in Akrotiri and 7.1% in Pano Kyvides. There were no significant differences between villages for diseases of the nervous system or for cancer or leukaemia. The final questions in this section concerned smoking and mobile phone use. With regard to smoking there were no significant differences across the three villages, the overall smoking percentage being 25.8%. There were, however, small differences with Asomatos recording 30.9%, Pano Kyvides 27.0% and Akrotiri, 22.9%. On the question of number of cigarettes, these were recoded into four groups, 1-10, 11-20, 21-30 and over 30. The differences were of borderline significance (p = 0.039). When comparing those smoking 21 or more cigarettes per day the percentages for each village were Akrotiri 39.8%, Asomatos 36.7% and Pano Kyvides

50.5%. There were no significant differences between villages on the number of years that people smoked or on the question whether the adults had ever smoked.

On mobile phone use there were small differences between villages. The percentage results were 58.2% for Akrotiri, 62.4% for Asomatos and 65.9% for Pano Kyvides but these were not statistically significance (p = 0.073). There were no significant differences in response to the question 'How long have you used one?'. 'Less than a year' or 'More than a year'. On the question of frequency of use there were significant differences (p = 0.013). The responses were recoded into 'several times a day' and 'less frequently'. The percentage results for several times a day were 74.3% for Akrotiri, 68.9% for Asomatos and 81.1% for Pano Kyvides.

Section 3 SF36

This section contains the 36 questions that comprise the validated health questionnaire, the SF36. When analysing the SF36 there is general guidance on how to aggregate responses in order to produce what are called 'scales'. It is worth noting that the SF36 is internationally recognised and considered to be one of the best questionnaires for assessing self-reported general and mental health. There are eight scales and Table 8 shows how these scales are constructed from the individual questions as listed in the in the standard questionnaire. Each scale value is a number between 1 and 100.

Table 8 SF36 scales

Name of scale	**Individual questions within the scale**
Physical functioning	3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j
Role physical	4a, 4b, 4c, 4d
Bodily pain	7,8
General health	1, 11a, 11b, 11c, 11d
Vitality	9a, 9e, 9g, 9i
Social functioning	6, 10
Role emotional	5a, 5b, 5c,
Mental health	9b, 9c, 9d, 9f, 9h

The following table gives the values of each scale by village.

Table 9 Values of each SF 36 scale

Name of scale	**Village**			**Significance**
	Akrotiri	**Asomatos**	**Kyvides**	
Physical functioning	75.7	70.7	80.9	0.000
Role physical	71.4	71.5	81.0	0.001
Bodily pain	72.1	71.2	79.9	0.001
General health	55.2	56.9	59.6	0.025
Vitality	56.7	55.4	62.9	0.000
Social functioning	72.3	70.8	82.4	0.000
Role emotional	74.2	73.3	82.4	0.004
Mental health	64.6	63.1	73.6	0.000

The ‘physical functioning’ scale ranges from very limited performance of all activities including bathing or dressing (0), to the ability to perform all types of vigorous activity (100). This scale shows highly significant differences between the three villages. Most noteworthy is the low level of physical functioning experienced by adults in Asomatos, 70.7 compared with 75.7 in Akrotiri and 80.9 in Kyvides. The ‘role physical’ scale assesses problems with work or other daily activities and is concerned with the extent of the physical impact on the adult’s role. ‘0’ means that there is a high level of impact on the adult role. ‘100’ means there is a low impact. The differences between Akrotiri and Asomatos are small. The principal finding is that Pano Kyvides differs from the other two villages. The value of 81.0 means that those living in Pano Kyvides have fewer problems relating to their ability to carry out their role.

The third scale is that of ‘bodily pain’. At one end of the scale is very severe and extremely limiting pain (0) and at the other end no pain at all (100). Pano Kyvides has a score of 79.9 and this is significantly different from the other two villages. The fourth scale is ‘general health’ and represents the subject’s evaluation of their own health. At one end is poor health (0) and the belief that it is likely to get worse. There is a significant difference between Pano Kyvides and the other two villages.

The ‘vitality’ scale ranges from feeling tired and worn out all of the time (0) to feeling full of energy all of the time (100). Again Pano Kyvides scores significantly higher than the other two villages. The ‘social functioning’ scale addresses the issue of extreme and frequent interference with normal social activities due to physical and emotional problems (0). Again Pano Kyvides scores significantly higher than the other two villages.

The ‘role emotional’ scale addressed the issue of emotional problems and whether they had had an impact on carrying out activities. Very high impact would score ‘0’; very low impact would score ‘100’. Again Akrotiri and Asomatos performed similarly with high impact compared with low impact in Pano Kyvides.

The final scale, the ‘mental health’ scale ranges from feelings of nervousness and depression all of the time (0) to feeling peaceful and happy and calm all of the time (100). It showed highly significant differences. Akrotiri and Asomatos had high percentage responses in feelings of nervousness and depression.

The above summary illustrates the extent of the differences in self-reported health between the villages. Of particular interest is the similarity between Akrotiri and Asomatos and the sharp differences between residents in these two villages and those in Pano Kyvides.

Section 4 Risk perception

The final section of the adult questionnaire asked questions about risk perception. There were 22 questions and respondents were invited to select one of five comments; ‘no possible harm’; ‘low harm’; ‘moderate harm’; ‘high harm’; or ‘extremely high harm’. Table 10 shows the mean values for each of the three villages, together with the total for all villages and the significance value of the differences between villages.

Table 10 Risk perception results for the 22 questions

Question number	Statement	Akrotiri	Asomatos	Pano Kyvides	Total	P value
S4Q1	Smoking	4.58	4.03	4.36	4.40	.000
S4Q2	Passive smoking	4.63	4.41	4.64	4.60	.007
S4Q3	High levels of alcohol consumption	4.64	4.55	4.62	4.62	.515
S4Q4	Moderate levels of alcohol consumption	3.54	3.15	2.36	3.01	.000
S4Q5	High fat diet	4.35	4.37	3.87	4.16	.000
S4Q6	Low fibre diet	3.80	3.72	3.51	3.67	.001
S4Q7	Sedentary lifestyle	4.11	4.17	3.81	4.00	.000
S4Q8	Exposure to chemicals released by industry	4.83	4.62	4.81	4.79	.001
S4Q9	Living near a nuclear power plant	4.85	4.75	4.87	4.84	.104
S4Q10	Living near an electricity power station	4.45	4.55	4.24	4.39	.001
S4Q11	Radioactive fallout from nuclear plant	4.88	4.86	4.85	4.87	.802
S4Q12	Living near a mobile phone transmitter	4.26	3.83	4.01	4.10	.000
S4Q13	Living near an overhead powerline	4.66	4.42	4.64	4.62	.020
S4Q14	Using a mobile phone	3.82	3.21	2.95	3.39	.000
S4Q15	Exposure to EMF from overhead powerline	4.69	4.37	4.70	4.65	.000
S4Q16	EMFs in the home from appliances	2.37	2.68	2.13	2.31	.000
S4Q17	Living near a military antenna	4.85	4.62	4.62	4.73	.000
S4Q18	Exposure to noise	4.58	4.02	4.05	4.29	.000
S4Q19	Exposure to poor air quality	4.70	4.54	4.66	4.66	.086
S4Q20	Driving with twice the legal limit of alcohol	4.81	4.82	4.86	4.83	.383
S4Q21	Being involved in a road traffic accident when sober	4.31	3.05	4.35	4.16	.000
S4Q22	Exposure to radiation from a single medical X-ray	2.44	3.60	2.36	2.59	

Amongst the significant results, adults living in Akrotiri have the highest mean score of the three villages for smoking, moderate levels of alcohol consumption, low fibre diet, exposure to chemicals released by industry, living near a mobile phone transmitter, using a mobile phone, living near a military antenna and exposure to noise. On the other hand on no occasion do they have the lowest mean score.

Amongst the significant results, Asomatos has the highest mean score for risks relating to high fat diet, sedentary life style, living near an electricity power station, EMFs in the home from appliances and exposure to radiation from a single medical X-ray. On the other hand they have the lowest mean scores for smoking, passive smoking, living near a mobile phone transmitter, living near a military antenna, exposure to noise and being involved in a road traffic accident when sober.

The differences between villages in respect of individual questions are considerable and significant, however before trying to interpret this information it is useful to compute an overall risk score.

Computed perceived risk score
As described above, the subjects were asked to give their perceived risk to a total of 22 statements. From their responses the average risk score for each subject was computed. This was calculated by adding the scores for each question that the subject had answered and then dividing that number by the total number of responses from a possible maximum of 22.

Table 11 Median risk score

Village	Median	Lower Quartile	Upper Quartile
Akrotiri	4.41	4.13	4.62
Asomatos	4.27	3.90	4.58
Pano Kyvides	4.14	3.89	4.36

Analysis showed that there was a significant difference between the villages (χ^2 = 80.67, 2 df, p <0.0001). In summary it can be said with confidence that residents in Akrotiri have the highest perceived risk across the whole range of risks. Residents in Asomatos are intermediate and those in Pano Kyvides have a lower perceived risk. Similar studies in the United Kingdom have produced lower scores for all the 22 variables.

The numbers in the table appear to be significantly above the 2.5 mean score that the questionnaire was originally designed to achieve in a ‘normal’ population. Therefore a useful comparison is with the Department of Health study carried out in Bristol for people living within site of cell-phone antennae and powerlines shown in the table below.

Table 12 Comparison with UK baseline risk perception

RISK PERCEPTION QUESTIONNAIRE	Score
1. Smoking of tobacco?	2.69
2. Passive exposure to tobacco smoke?	2.77
3. High levels of alcohol consumption (about 100 units a week)?	2.69
4. Moderate levels of alcohol consumption (up to 20 units a week)?	2.18
5. A high fat diet?	3.16
6. A low fibre diet?	2.56
7. A sedentary lifestyle (no exercise)?	2.99
8. Exposure to chemicals released by industry?	3.22
9. Living near a nuclear power plant?	2.66
10. Living near an electricity sub station?	2.28
11. Radioactive fallout from a nuclear power plant?	3.18
12. Living near a mobile phone transmitter?	2.08
13. Living near an overhead powerline?	2.34
14. Using a mobile phone?	1.96
15. Exposure to electromagnetic fields from overhead powerlines?	2.38
16. Electromagnetic fields in the home from appliances such as hair dryers, hi fi's?	1.97
Other sources of electromagnetic fields in the home e.g. microwave?	*2.12*
Exposure to radon gas?	*2.49*
17. Living near a military antenna?	-
18. Exposure to noise?	2.68
19. Exposure to poor air quality?	3.4
20. Driving with twice legal limit of alcohol?	2.94
21. Being involved in road traffic accident when sober?	2.92
22. Exposure to radiation from a single medical X-ray?	2.08
Mean Value	2.60

The coloured questions (italicized)are those that differ between the Cyprus and Bristol studies.

Further analysis of key variables

Although there are many findings of interest in the results from the adult questionnaire, perhaps of most importance are the results of migraine, headache, dizziness and depression where there are statistically significantly high levels amongst those living in Akrotiri.

Migraine

The relationship between migraine and village was referred to in Table 6. Given the highly statistically significant association between village and migraine ($p = 0.000$) it was decided to carry out a logistic regression with migraine as the outcome variable. The reference district was Pano Kyvides and odds ratios were calculated for both Akrotiri and Asomatos against the reference village. The results are shown in the table below. The odds ratio for Akrotiri was 2.73.

Table 13 Unadjusted odds ratio of experiencing a migraine

Village	Odds Ratio	95% CI	P
Pano Kyvides (reference)	1.0		
Akrotiri	2.73	1.828 to 4.091	0.0001
Asomatos	1.582	0.908 to 2.756	0.105

The reason that logistic regression was chosen for this stage of the analysis was twofold. Firstly the outcome variable migraine could be treated as a binary variable (migraine present/ migraine absent). Secondly regression analysis can help to identify confounding variables. These variables may appear to be important in explaining the presence or absence of migraine when looked at singly but their apparent effect may in fact be because they are associated with another variable that is itself influencing the outcome.

Migraine was then analysed with all other variables to see which responses were statistically significantly associated. There were significant differences across age groups (χ^2 = 30.095, df 4, p = 0.000). The increased odds of experiencing migraine were seen in the 51 – 65 years age group. On the other hand there was less migraine in the 41-50 age group and in those over 65. There is a gradient from Akrotiri, through Asomatos to Pano Kyvides for each of the age groups with respect to migraine. This is statistically significant in Akrotiri (p = 0.023) and in Pano Kyvides (p = 0.013).

A logistic regression for education with five categories showed that when compared with those who had a university education, all other educational levels exhibited increased odds of reporting migraine. This was significantly elevated in those who had received no schooling (p=0.031) and those whose education was limited to elementary up to 12 years (p=0.028). The differences between men and women were highly significant (p = 0.000). Of those with migraine 77.5% are women and 22.5% men. Of the male population, 7.7% have migraine compared with 24.7% of the female population. Amongst smokers 12.1% had migraine compared with 18.0% who were non smokers (p = 0.016). There were significant differences (p = 0.001) in migraine between those using a mobile phone (13.3%) and those not using a mobile phone (21.2%).

The development of the model

Initially the logistic regression model was developed by adding first one and then two independent variables. For example when gender and educational level were entered into the logistic regression model only gender and two of the educational categories were shown to be significant.

In developing the whole model the following variables were entered: village, age in five groups, educational level in five groups, gender, smoking, mobile phone use, median risk score. Variables were entered into the logistic model in a stepwise way. Variables were removed when they were shown not to contribute to the overall model. The results were as follows.

Table 14 Variables in the equation (migraine)

		B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
								Lower	Upper
Step 1(a)	HE2			8.931	4	.063			
	HE2(1)	.904	.535	2.855	1	.091	2.469	.865	7.045
	HE2(2)	1.228	.451	7.406	1	.007	3.413	1.410	8.264
	HE2(3)	.853	.472	3.267	1	.071	2.346	.931	5.914
	HE2(4)	.910	.371	6.004	1	.014	2.483	1.200	5.140
	XAGEGP2	-.123	.115	1.146	1	.284	.884	.705	1.108
	Q3_GENDE(1)	-1.629	.250	42.505	1	.000	.196	.120	.320
	Q10_SMOK(1)	.230	.271	.717	1	.397	1.258	.740	2.140
	Q11_MOBI(1)	-.034	.253	.018	1	.892	.966	.589	1.586
	VILLAGE_			29.192	2	.000			
	VILLAGE_(1)	1.165	.220	27.978	1	.000	3.207	2.082	4.938
	VILLAGE_(2)	.489	.301	2.631	1	.105	1.630	.903	2.943
	Constant	-2.296	.489	22.054	1	.000	.101		

a Variable(s) entered on step 1: HE2, XAGEGP2, Q3_GENDE, Q10_SMOK, Q11_MOBI, VILLAGE_.

In the final model it has been established that the variables village, (both Akrotiri and Pano Kyvides), university education (two of the five categories) and gender are all significant. The highest odds ratio of 3.207 relates to Akrotiri. The inference to be drawn from this analysis is that the most important risk factor in those who have reported migraine is being resident in Akrotiri.

Headache

A logistic regression was carried out with the odds of experiencing headache in villages one and two with village three. They demonstrated significantly greater odds of headache in Akrotiri and Asomatos.

Table 15 Odds ratio of experiencing a headache by village

Village	Odds Ratio	95.% C.I	P
Reference village Pano Kyvides	1.0		
Akrotiri	3.69	2.717 to 5.004	<0.0001
Asomatos	1.89	1.257 to 2.851	<0.002

Headache was then analysed to see which of the variables showed a significant association. These were entered into a logistic regression model. The following table presents the result of the stepwise logistic regression.

Table 16 Variables in the equation (headache)

		B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
								Lower	Upper
Step 1(a)	HE2			8.931	4	.063			
	HE2(1)	.904	.535	2.855	1	.091	2.469	.865	7.045
	HE2(2)	1.228	.451	7.406	1	.007	3.413	1.410	8.264
	HE2(3)	.853	.472	3.267	1	.071	2.346	.931	5.914
	HE2(4)	.910	.371	6.004	1	.014	2.483	1.200	5.140
	XAGEGP2	-.123	.115	1.146	1	.284	.884	.705	1.108
	Q3_GENDE(1)	-1.629	.250	42.505	1	.000	.196	.120	.320
	Q10_SMOK(1)	.230	.271	.717	1	.397	1.258	.740	2.140
	Q11_MOBI(1)	-.034	.253	.018	1	.892	.966	.589	1.586
	VILLAGE_			29.192	2	.000			
	VILLAGE_(1)	1.165	.220	27.978	1	.000	3.207	2.082	4.938
	VILLAGE_(2)	.489	.301	2.631	1	.105	1.630	.903	2.943
	Constant	-2.296	.489	22.054	1	.000	.101		

a Variable(s) entered on step 1: HE2, XAGEGP2, Q3_GENDE, Q10_SMOK, Q11_MOBI, VILLAGE_.

It can be seen from column Exp(B) that the significant odds ratios are village 1, Akrotiri; gender; and one of the educational levels. The variable with the highest odds ratio is gender (5.10) followed by living in Akrotiri (3.207). The odds ratio for gender in the table is shown as .196 but this would be the odds ratio for males and the reciprocal value of 5.10 would be the odds ratio for females.

It can be concluded therefore that the dominant factors in explaining the presence of headache, is that of gender and educational level.

Dizziness
The same approach was followed for dizziness with the following results: the odds ratios were significant for the following variables: gender (3.17); Akrotiri (5.7) and Asomatos (2.47).

Depression
The same approach was followed for depression with the following results. The odds ratios were significant for the gender (3.01), Akrotiri (2.95) and Asomatos (2.5).

Although gender was an important factor in reported dizziness and depression, residence was also highly significant with a trend from Akrotiri to Asomatos, and not Pano Kyvides.

5.3 Analysis of female questionnaires

83% of women completing this questionnaire reported at least one pregnancy in their lifetime, with: 29.1% reporting one or two pregnancies; 20.5% three pregnancies; 16.5% four pregnancies; and 34% more than four pregnancies. Approximately 35%

of women had experienced miscarriages; 64% had experienced a single miscarriage and 13.6% more than two. Approximately 17% of women had had a termination of pregnancy. In all the responses to this point there were no significant differences between villages.

The question on stillbirths produced a complex result that was of borderline significance. There were nine women who had had stillbirths in both Akrotiri and Kyvides and none in Asomatos. In percentage terms an average of 4.6% of women had experienced stillbirths. 12% of women had had an infant death but there were no significant differences between villages. The percentage of births weighing less than 2500 grams was 9.2% and the percentage of births that arrived more than three weeks early was 9.7%. There were no significant differences between villages. On average of 8.1% of respondents reported problems with conception and there were no significant differences between villages.

The general conclusion from the female questionnaire was that there were no significant differences between villages with regard to pregnancy and childbirth.

5.4 Analysis of child questionnaire

The male: female ratio was 48.7:51.3 and the differences between villages were not statistically significant. There were no differences in the ages of the children between villages.

Women were asked to answer the following question. Was your child born with any of the following? The following table gives the actual number of children born with any recorded abnormality. There were no significant differences between villages with regard to abnormalities at birth. Even if there were differences the number of abnormalities reported is too small to be able to draw any firm conclusions.

Table 17 Abnormalities at birth

Condition	Akrotiri	Asomatos	Kyvides
Down’s Syndrome	0	0	0
Spina bifida or other spinal defect	0	0	1
Cerebral palsy	0	0	1
Hole in the heart or other heart defect	0	1	1
Any birth defect of the digestive tract	0	1	0
Any kidney, bladder or genital anomaly	1	0	2
Any other condition	3	4	3
Total	4	6	8

The questionnaire then posed a series of questions on whether the child had experienced any of the following conditions.

Table 18 Conditions amongst the children

Condition	Akrotiri	Asomatos	Kyvides	Significance
Diabetes	0%	0%	0%	NS
Asthma	2.6%	3.4%	2.3%	NS
Other breathing/ lung problems	3.2%	0%	5.2%	NS
Epilepsy	0%	0%	0%	NS
Migraines	7.4%	1.8%	0%	.000
Headaches	12.9%	10.7%	2.8%	.001
Dizziness	7.1%	5.6%	1.9%	.045
Depression	0.6%	1.8%	0.5%	NS
Heart problems	0%	1.8%	1.4%	NS
Cancer	0%	0%	0%	NS

The percentages of children with migraine and headache were highly significantly different between villages and those with dizziness were of borderline significance. As the database is constructed it is not possible to cross correlate between family and child. However, observation suggests that there is a tendency for correspondence between adult and child members of the same family.

The next set of questions was concerned with the following infections.

Table 19 Infectious diseases

Condition	Akrotiri	Asomatos	Kyvides	Significance
Head cold (including runny nose)	92.2%	94.6%	90.5%	NS
Measles	7.3%	*9.1%	^2.4%	.041
Rubella (German measles)	^6.7%	*21.1%	12.4%	.013
Chicken pox/ shingles	63.0%	63.8%	55.5%	NS
Mumps	^1.3%	*9.4%	4.4%	.029
Lung or chest infections	11.8%	*18.2%	^5.5%	.006
Pneumonia	3.9%	3.6%	2.4%	NS
Meningitis	0.6%	0.0%	0.9%	NS
Otitis (recurrent ear infections)	22.4%	25.4%	25.8%	NS
Tonsillitis	36.8%	*53.7%	^34.6%	.034
Skin infections	4.6%	8.8%	3.8%	NS
Urinary tract infections	3.9%	3.4%	4.3%	NS
High temperatures	*78.6%	^61.0%	65.7%	.009
Glandular fever	0.7%	0.0%	1.0%	NS

Table 20 Significant differences in infectious diseases between villages

Condition	Akrotiri	Asomatos	Kyvides	Significances
Measles	7.3%	*9.1%	^2.4%	.041
Rubella (German measles)	^6.7%	*21.1%	12.4%	.013
Mumps	^1.3%	*9.4%	4.4%	.029
Lung or chest infections	11.8%	*18.2%	^5.5%	.006
Tonsillitis	36.8%	*53.7%	^34.6%	.034
High temperatures	*78.6%	^61.0%	65.7%	.009

In five of the six infectious diseases where there are significant differences between villages Asomatos has the highest percentage. Akrotiri has the highest percentage for ‘high temperature’. It is difficult to explain the increased incidence of infectious disease in Asomatos. The literature of exposure to EM fields does not suggest that there is an association with infectious disease in children.

5.5 Open comments

All three of the questionnaires developed for use in this study included a section at the end for respondents to provide any additional comments. Data provided in this way can often provide a valuable insight and deeper understanding of the issues involved in the research. The comments recorded in all of the questionnaires were extracted and subjected to a thematic analysis, allowing the identification of ‘common themes’ in responses recorded.

Adult questionnaire

Respondents completing the adult questionnaire were offered the opportunity at the end of the document to record additional comments about health concerns they had for themselves or their family. 134 questionnaires contained additional comments (out of a sample of 1004). The vast majority of these comments were provided by the residents of Akrotiri (104), with Asomatos (19) and Pano Kyvides (11) making far smaller contributions.

The presence of the antennae dominates responses from Akrotiri. The overwhelming majority of comments provided made reference to the antennae and the ‘effect’ on health. The consensus of opinion recorded is that the antennae ‘damage’ health,

“We are extremely worried about our health and especially small children’s health because of the antennae in Akrotiri” Akrotiri resident.

“…the antennes will harm our health.” Akrotiri resident

A few respondents suggested what form this ‘damage’ might take, typically raising concerns about cancer.

A few respondents mention EM fields or radiation emitting from the antennae as the cause of health problems, but in general respondents believe that;

“The antennae cause damage to our health” Akrotiri resident.

One other recurring theme could be identified in responses from Akrotiri. Concern was expressed regarding noise and air pollution, and the potential this had to affect health.

“The sound of the aeroplanes and also the pollution of the environment from the aeroplanes cause me health problems.” Akrotiri resident.

“I am worried about the aeroplanes that fly above our houses (and) the sound and pollution they cause….” Akrotiri resident.

"We have got headaches caused from the noise of the aeroplanes" Akrotiri resident.

Responses provided by the residents of Asomatos showed a similar pattern of concern (albeit in lesser numbers). Respondents here were also concerned that their health was being damaged (in an unspecified) way by the antennae.

"I am scared for my health and my children's future due to the installation of the antennae" Asomatos Resident.

"We are very anxious about the military antennae because we are hearing continuously the different damages that may be caused to our communities. Because we are very close I believe that we are exposed in a greater degree." Asomatos Resident.

The responses from both Akrotiri and Asomatos when viewed together suggested that these communities firmly believe that their health was being damaged by the antennae. The worry and distress reported is an important consideration. Resident's perception of the risk involved is, in many ways, as important as the actual risk.

"It is definitely a great risk to live in Akrotiri nowadays. It's the aeroplanes which cause noise and pollution and on the other hand it's the antennae with radiation. I am not sure if it is harmful to our health but is definitely harmful to our psychological health because we live under fear". Akrotiri Resident.

Whilst the majority of respondents reported that the antennae were damaging their health, some did appeal for answers.

"We want confirmation from the specialists that the antennae will not harm our health. We are worried about our health" Akrotiri Resident.

This is important as this suggests that a scientifically validated, independent survey may prove useful in addressing the concerns of some residents.

Overall the concerns raised by the residents of Pano Kyvides reflected more general health issues in society such as ageing, diet and stress. However a few did express a level of awareness regarding the situation in Akrotiri and Asomatos.

"I would like to know in detail how harmful the antennae are and what they harm" Pano Kyvides Resident

Female questionnaire

Additional comments were provided by 29 (16 Akrotiri, 5 Asomatos, 8 Pano Kyvides) of the 514 women completing the female questionnaire. This questionnaire was concerned with reproductive health, and so it is perhaps unsurprising that the issues reported by women centre around pregnancy and gynaecological problems including early menopause and conception problems. A small number in all three villages also reported headaches, dizziness and nausea.

Analysis of the responses in this questionnaire revealed a major difference from the others. Women reporting symptoms or health concerns did not make any reference to the military antennae. In fact the antennae were not mentioned at all. This is very different from the other questionnaires which definitely associate health problems with exposure.

Child questionnaire

Parents or guardians completing a questionnaire for a child were offered the opportunity at the end of the document to record any additional comments they had about their child's health or concerns they had for them. 22 out of the 427 child questionnaires completed were found to contain additional comments. All these were provided from the 'exposed' sites of Akrotiri (17) or Asomatos (5). Respondents from Pano Kyvides made no further comments at all. The military antennae (perhaps unsurprisingly) were the concern of almost all of the respondents providing comments. There was anxiety that the antennae were damaging the future health of the children living in the villages.

"I'm very worried about my child's health and with the operation of the antennae it will definitely have consequences." Parent – Akrotiri.

Respondents in general appeared to believe that the presence of the antennae would have a detrimental effect on their children's health, as it was having on their health now. However a few did acknowledge such concerns whilst demanding answers;

"We want to know if there is any danger for the children's health because of the antennae." Parent – Akrotiri.

Overall, respondents concerns and comments for their children's health were dominated by the presence of the military antennae and the (perceived) damage to health that would occur from exposure. None of the respondents detailed what this 'damage' would be or offered any suggestions as to how they think it would manifest.

Summary

Additional comments were provided by far fewer respondents than were expected, especially in the exposed communities. The UK research team were informed of the high level of concern in Akrotiri and Asomatos. Typically in the UK those taking part in studies welcome the opportunity to make their point and raise concerns. This happened only to a limited extent. This may be due to cultural differences, in that the respondents did not feel the need to comment. The residents in the 'exposed' sites had far more to say than the unexposed, and their comments were mainly concerned with the antennae and the concept that they were 'damaging health', albeit in a largely unspecified manner.

5.6 Results of mortality study

Overall mortality and Standardised Mortality Ratios

The Ministry of Health has good information on age-specific death rates for all causes on a national basis. These are based on the 2001 population census. Death information is based on the three-year period from 2001 to 2003. The following table shows the national rates. This is the starting point for calculating the standardised mortality ratio (SMR).

Table 21 Cyprus national age specific death rates 2001

Age groups	Population from 2001 census	Deaths for three year period 2001-2003	Annualised age specific death rates per 1000
0-4	42,582	143	1.12
5-9	51,718	19	0.12
10-14	53,178	15	0.09
15-19	54,603	74	0.45
20-24	51,803	92	0.59
25-29	48,272	84	0.58
30-34	48,233	98	0.68
35-39	51,561	111	0.71
40-44	52,289	143	0.91
45-49	45,580	221	1.62
50-54	42,587	364	2.85
55-59	34,554	516	4.98
60-64	30,747	714	7.74
65-69	25,445	1,100	14.41
70-74	20,965	1,561	24.83
75-79	15,974	2,156	44.99
80 plus	18,089	6,733	124.07

Table 22 Akrotiri (Village 1)

Age groups	National age-specific death rates per 1000	Population census 2001	Expected deaths
0-4	1.12	28	0.03136
5-9	0.12	42	0.00504
10-14	0.09	56	0.00504
15-19	0.45	47	0.02115
20-24	0.59	39	0.02301
25-29	0.58	23	0.01334
30-34	0.68	29	0.01972
35-39	0.71	45	0.03195
40-44	0.91	64	0.05824
45-49	1.62	33	0.05346
50-54	2.85	27	0.07695
55-59	4.98	23	0.11454
60-64	7.74	42	0.32508
65-69	14.41	35	0.50435
70-74	24.83	39	0.96837
75-79	44.99	20	0.8998
80 plus	124.07	13	1.61291
All ages			**4.76431**

Table 23 Asomatos (Village 2)

Age groups	National age-specific death rates per 1000	Population census 2001	Expected deaths
0-4	1.12	9	0.01008
5-9	0.12	17	0.00204
10-14	0.09	22	0.00198
15-19	0.45	18	0.0081
20-24	0.59	15	0.00885
25-29	0.58	14	0.00812
30-34	0.68	6	0.00408
35-39	0.71	9	0.00639
40-44	0.91	25	0.02275
45-49	1.62	17	0.02754
50-54	2.85	12	0.0342
55-59	4.98	5	0.0249
60-64	7.74	11	0.08514
65-69	14.41	18	0.25938
70-74	24.83	14	0.34762
75-79	44.99	7	0.31493
80 plus	124.07	5	0.62035
All ages			**1.78645**

Table 24 Pano Kyvides (Village 3)

Age groups	National age-specific death rates per 1000	Population census 2001	Expected deaths
0-4	1.12	32	0.03584
5-9	0.12	51	0.00612
10-14	0.09	76	0.00684
15-19	0.45	67	0.03015
20-24	0.59	44	0.02596
25-29	0.58	21	0.01218
30-34	0.68	27	0.01836
35-39	0.71	44	0.03124
40-44	0.91	68	0.06188
45-49	1.62	42	0.06804
50-54	2.85	16	0.0456
55-59	4.98	32	0.15936
60-64	7.74	10	0.0774
65-69	14.41	27	0.38907
70-74	24.83	17	0.42211
75-79	44.99	15	0.67485
80 plus	124.07	15	1.86105
All ages			**3.92605**

The calculation of the SMR should be straightforward at this point providing one can obtain information on the actual number of deaths. As mentioned in Section 4 above there were several different ways of calculating ‘observed’ deaths.

Firstly, there was the mortality questionnaire. This gave 46 deaths for Akrotiri, 18 deaths in Asomatos and 59 deaths in Pano Kyvides over the last ten years. Using these figures as the basis for the SMR calculation would give an SMR for Akrotiri of 0.97 (4.6/4.76); for Asomatos 1.01 (1.8/1.79) and for Pano Kyvides 1.50 (5.9/3.93).

The mortality questionnaire required recall for the previous ten years and this may have been unreliable. The cemetery search for the same time period revealed the following information: In Akrotiri there were 65 deaths, 29 in Asomatos and 63 in Pano Kyvides. These would give SMRs of 1.37 (6.5/4.76) for Akrotiri, 1.53 for Asomatos (2.9/1.79) and 1.60 (6.3/3.93) for Pano Kyvides.

The third approach was to use the National Information on deaths. These records were available for the last five years. The numbers of deaths in Akrotiri was 30, Asomatos 18, Pano Kyvides 26. The corresponding SMRs would be 1.26 (Akrotiri); 2.01 (Asomatos) and 1.32 (Pano Kyvides). These different SMRs are shown below;

Table 25 SMRs using the different mortality data

	Akrotiri	Asomatos	Pano Kyvides
Questionnaire	0.97	1.01	1.50
Cemetery	1.37	1.53	1.60
National records	1.26	2.01	1.32

The discrepancy between the 3 methods of calculating the SMR suggests that we do not have a satisfactory method of determining the effect of any extraneous factor specific to location. This suggests in particular that the national records and the burial records are effectively over-reporting the deaths in respect of families actually living in the communities, in that they are including the extended family which is not resident. The questionnaire appears to possibly be the more accurate measure.

Specific cause mortality

There is a generalised problem in trying to establish whether there is an increase in specific causes of deaths when the disease in question is relatively uncommon. For the purposes of this study the causes of death of interest (as suggested by previous research on EMFs) were some specific cancers, in particular brain, and leukaemia. The approach that was taken was to use the questionnaire as the basis for investigating causes of death and to attempt to check the reliability against any hospital records, cancer registration records or records in the County Offices.

Preliminary results from the questionnaire suggested that over the last ten years there possibly 23 cancers or leukaemias in Akrotiri; 10 in Asomatos; and 18 in Pano Kyvides. It was possible to establish that there were 5 cases from Akrotiri, 3 from Asomatos and 3 from Pano Kyvides where the diagnosis was a brain tumour, leukaemia, Hodgkins or non Hodgkin’s lymphoma. These cases are being further investigated in an attempt to confirm the diagnosis.

The 5 cases reported from Akrotiri comprised of 2 brain tumours and 3 leukaemias. The 3 cases from Asomatos consisted of 2 leukaemias and 1 Hodgkins lymphoma. The 3 cases from Pano Kyvides included 2 leukaemias and 1 Hodgkins lymphoma.

The precise sub-type of leukaemia and whether the brain tumour was a primary brain tumour or a secondary with the primary source being elsewhere, for example the lung, needs to be confirmed. The national system of death registration is based on returns to the County Offices. Of the nine cases where there was a suspicion of either brain tumour of leukaemia **only one appeared on the national register**. In that particular case, (one of the leukaemia cases from Akrotiri), the cause of death on the national system was heart attack. If one expresses the number of tumours as a rate for the three different villages this gives an annual incidence rate of 0.625 per 1000 population for Akrotiri; 0.857 per 1000 population for Asomatos and 0.300 per 1000 population for Pano Kyvides.

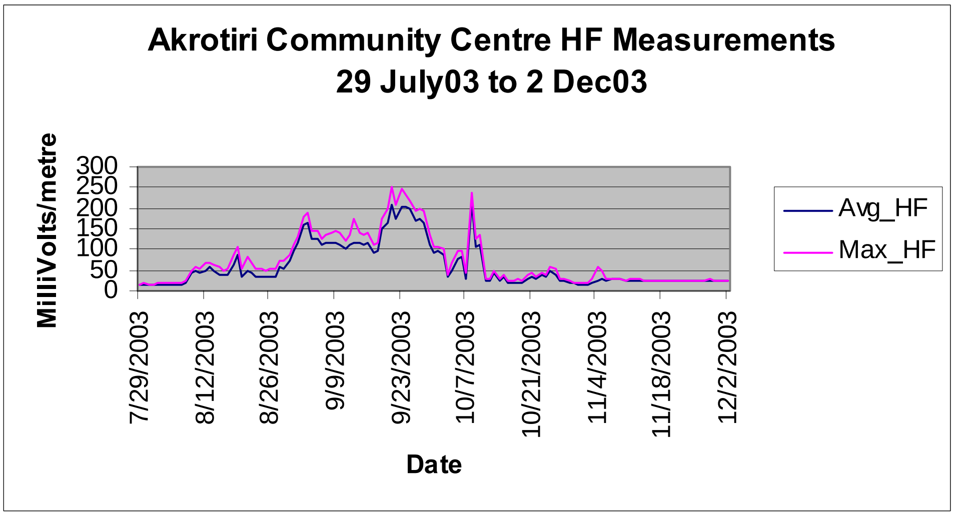
6. Measurement Results

As outlined in Section 4 both longitudinal and specific spot measurements were carried out according to the agreed protocol. The longitudinal studies in Akrotiri were continuous from 29th July 2003 until 15th April 2005, with samples taken every 10 minutes without interruption. These measurements contained recorded levels of up to 100 MHz (HF) and 100MHz and above (UHF). The possibility of undisclosed emissions from the antennae site was vanishingly small.

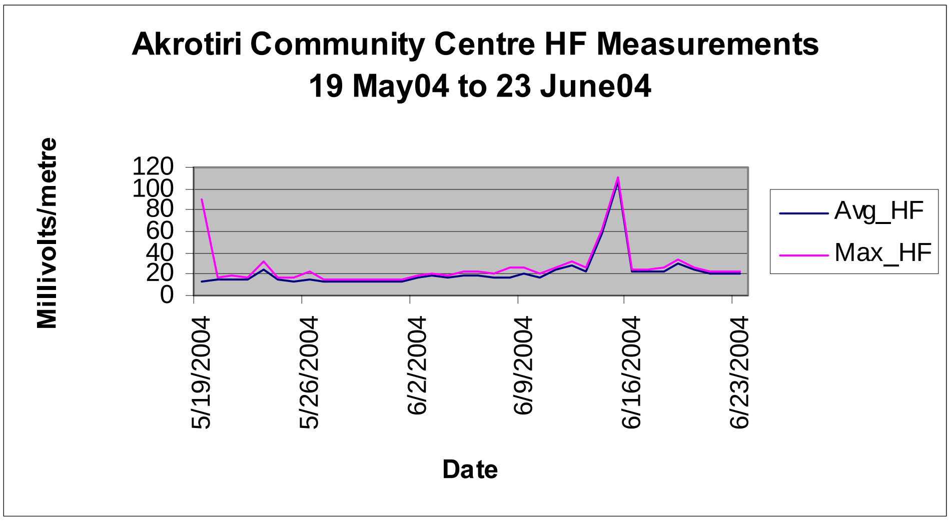
Longitudinal studies:
Since samples on six channels were collect every 10 minutes, this represents an unmanageably large set of data. The raw logger data are transformed into date and time stamped values in Microsoft Excel. Each 10 minute sample records the maximum value detected, the average value and the minimum recorded RF level. If the signal is constant wave (CW) then all three values are the same. Peak values are commonly generated by short term events. These are commonly static, switching transients on the power (mains) supply or mobile phones nearby which are "polling" the base station. The most representative measurement is the average value recorded in the sampling period. Even confining the data to this value still poses a problem since one data set of approximately 4 months still contains 13,000 data points. In order to simplify the display a Pivot Table in Excel has been created to produce a daily average. The table still holds all the measurements, but each daily point can be changed to the total count, average, standard deviation, peak or minimum. The illustrations below are displaying the average and maximum for the high frequency, and the average for the UHF (largely cell-phone) values. The original Excel file of all the data for all six channels is available, together with the Pivot table which can be used to extract other measurements. Each graph shows the days recorded on the "Y" axis and the field strength in millivolts per metre on the "X" axis.

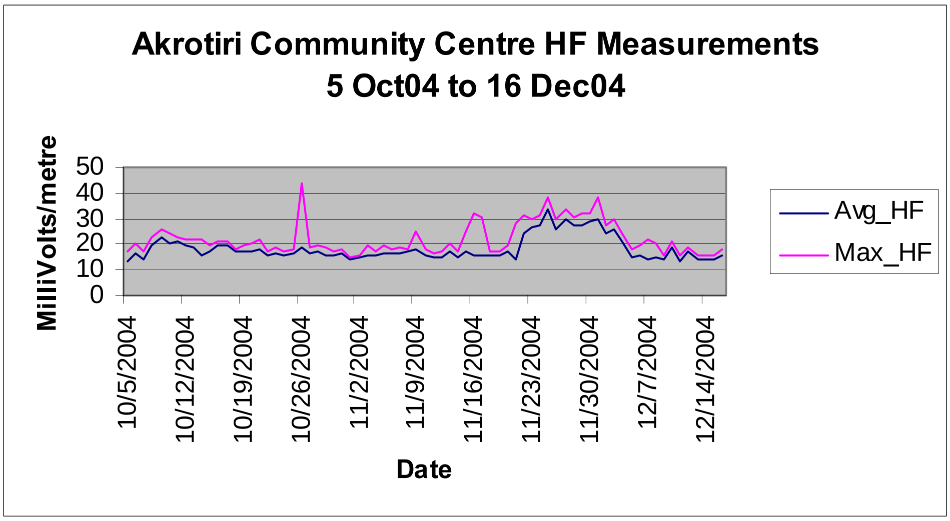
Akrotiri Bank

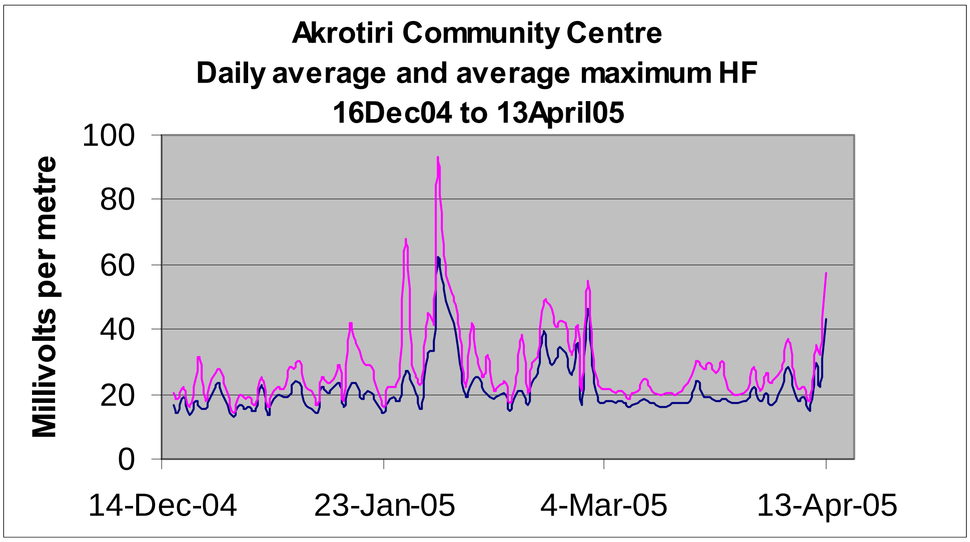
a. **High frequency measurements (10MHz to 100MHz approx**



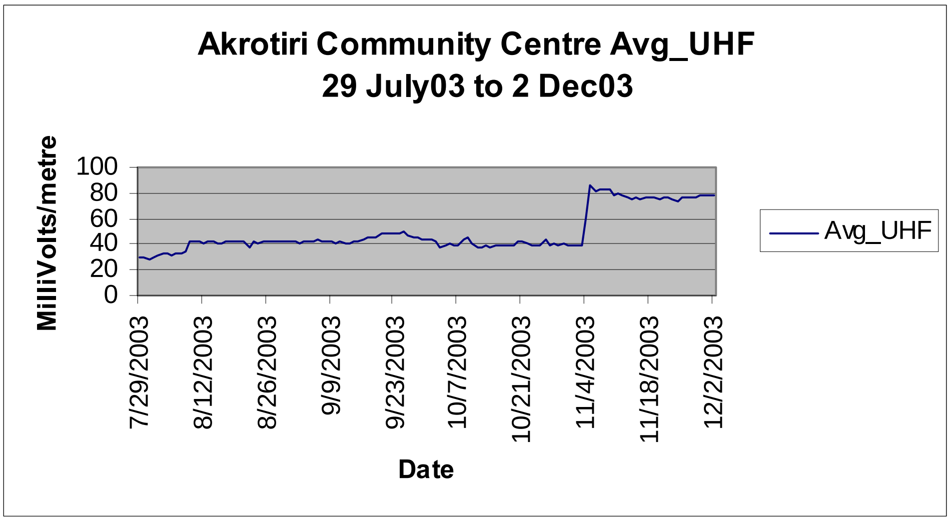
Note that in November, due to refurbishment of the Community Centre, the power source was disconnected and the logger was transferred to the Bank. This was returned to the Community Centre in May



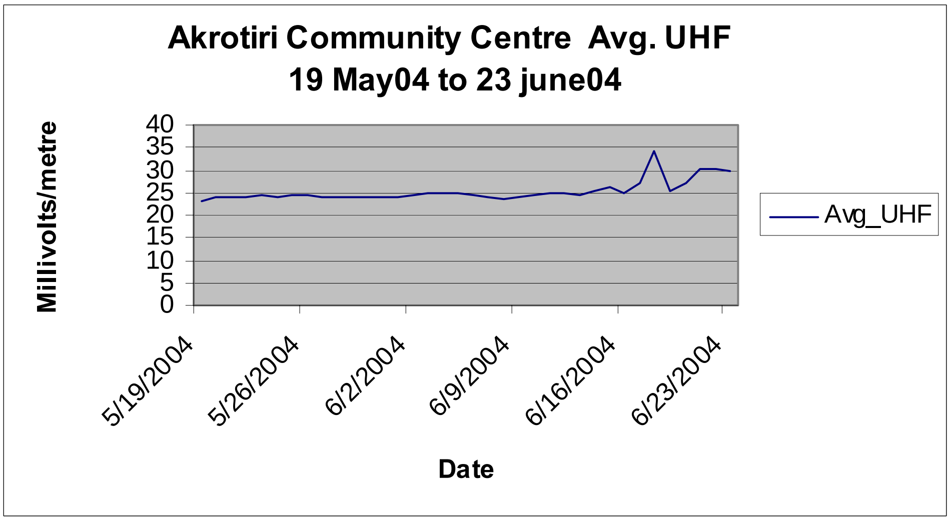


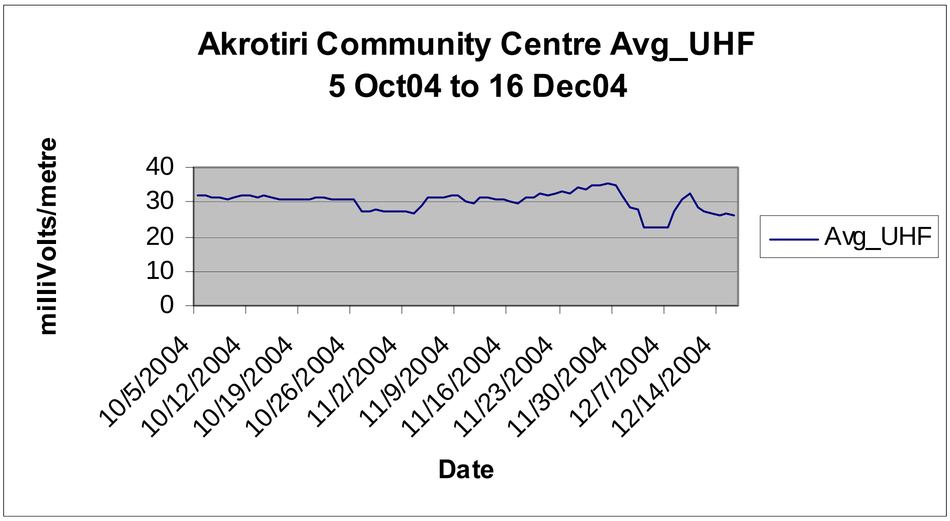


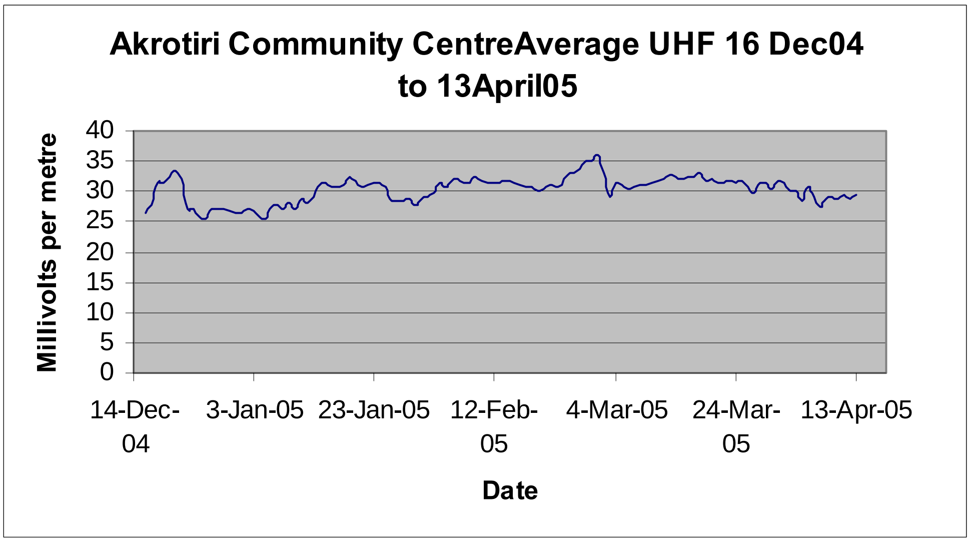
b. UHF Measurements (i.e. 100MHz to 2000MHz approx)



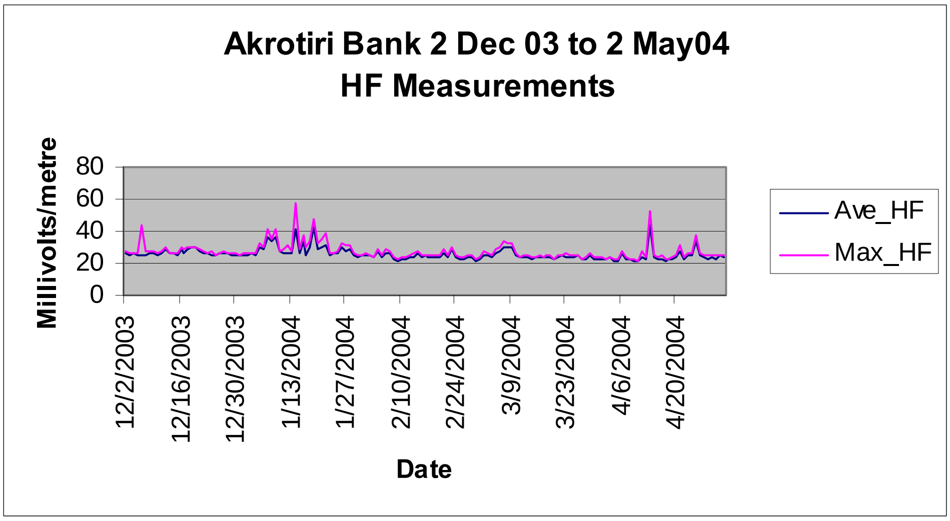
Note the sudden increase in UHF signal on transfer to the Bank. This is because the site was some 100 metres nearer the cell-phone mast.

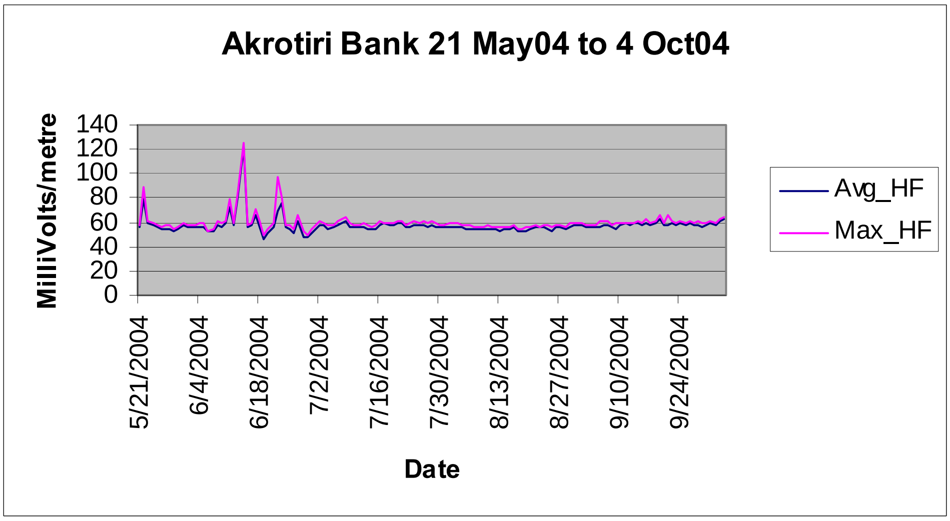


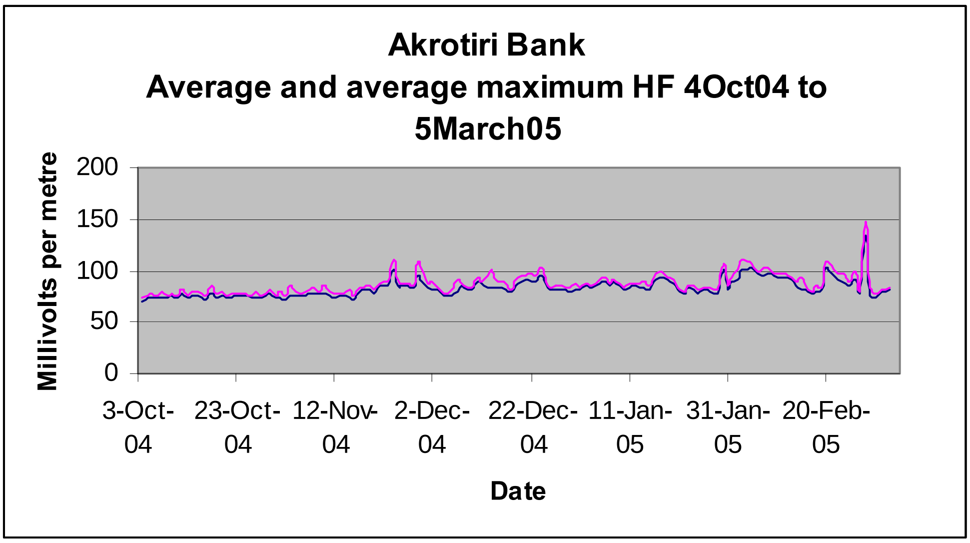




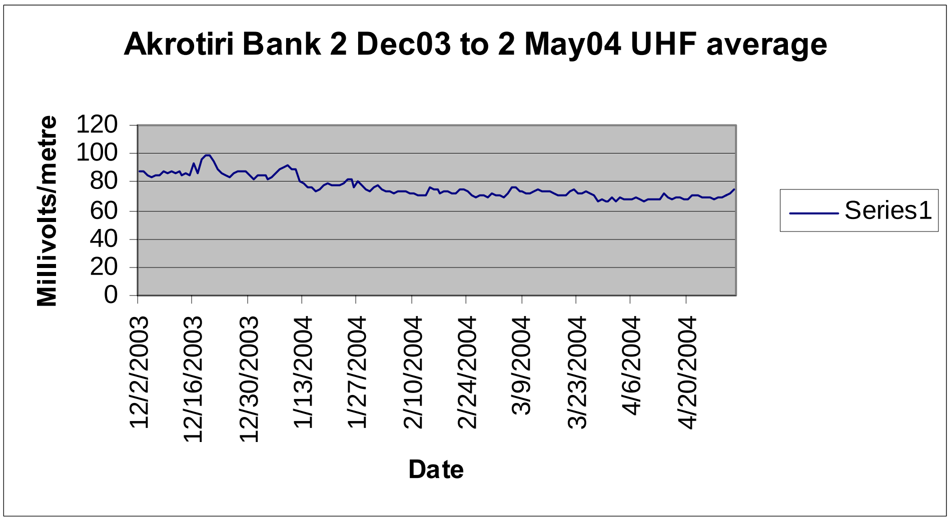
c. HF Measurements at Akrotiri Bank



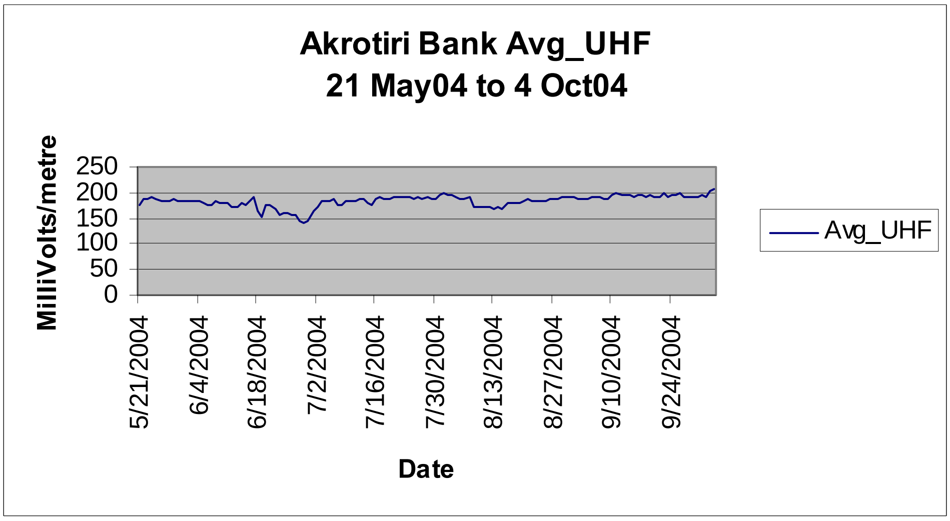




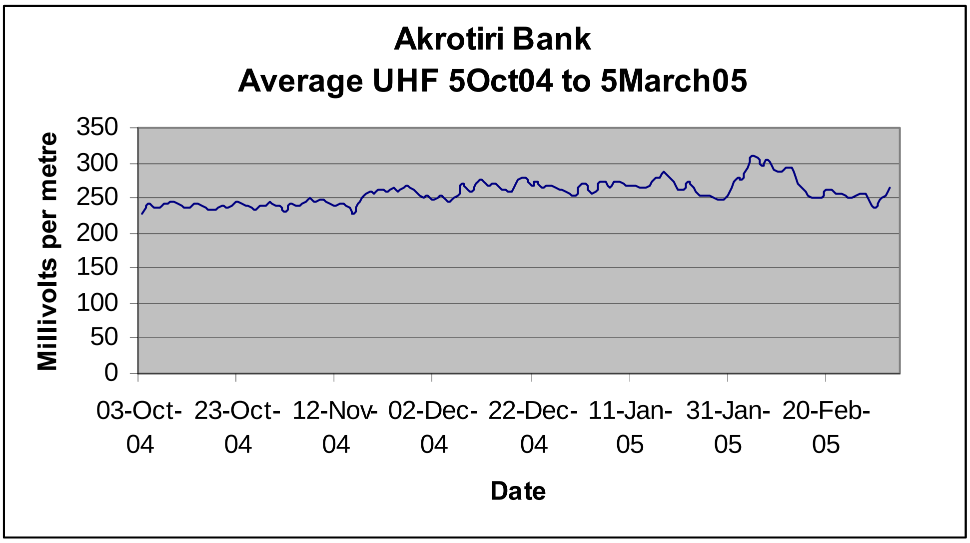
Akrotiri Bank
Average and average maximum HF 4Oct04 to 5March05
Millivolts per metre
200
150
100
50
0
3-Oct-04
23-Oct-04
12-Nov-04
2-Dec-04
22-Dec-04
11-Jan-05
31-Jan-05
20-Feb-05
Date



Akrotiri Bank 2 Dec03 to 2 May04 UHF average
Millivolts/metre
120
100
80
60
40
20
0
12/2/2003
12/16/2003
12/30/2003
1/13/2004
1/27/2004
2/10/2004
2/24/2004
3/9/2004
3/23/2004
4/6/2004
4/20/2004
Date
Series1

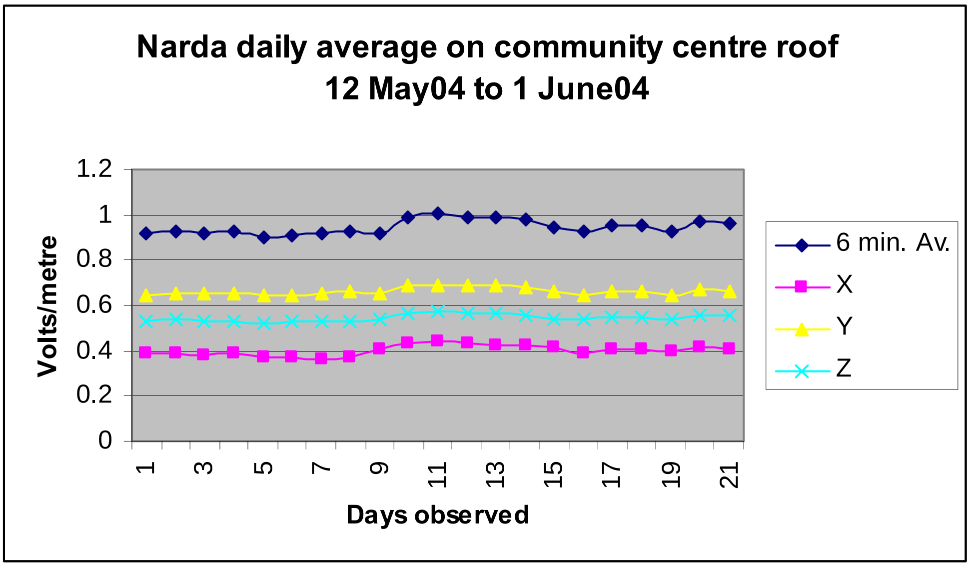


Akrotiri Bank Avg_UHF
21 May04 to 4 Oct04
MilliVolts/metre
250
200
150
100
50
0
5/21/2004
6/4/2004
6/18/2004
7/2/2004
7/16/2004
7/30/2004
8/13/2004
8/27/2004
9/10/2004
9/24/2004
Date
Avg_UHF



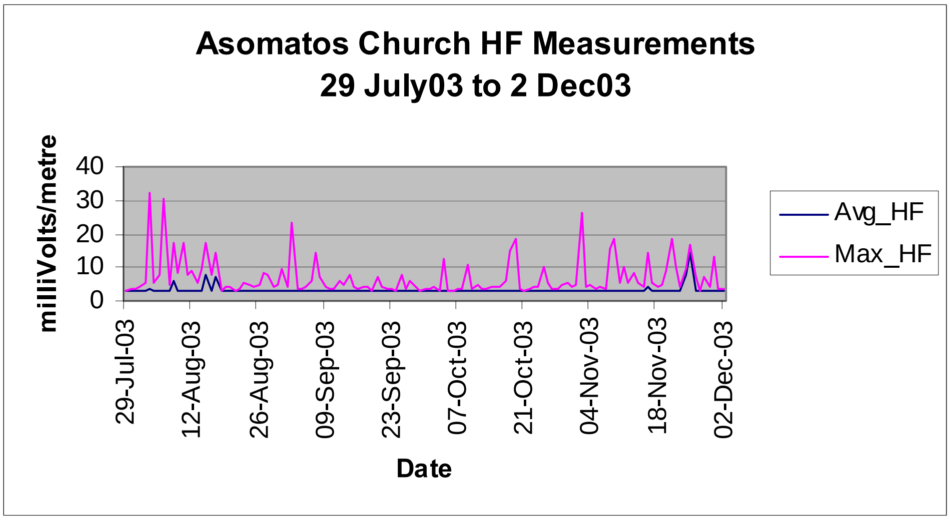
Conclusion for the logger measurements in Akrotiri

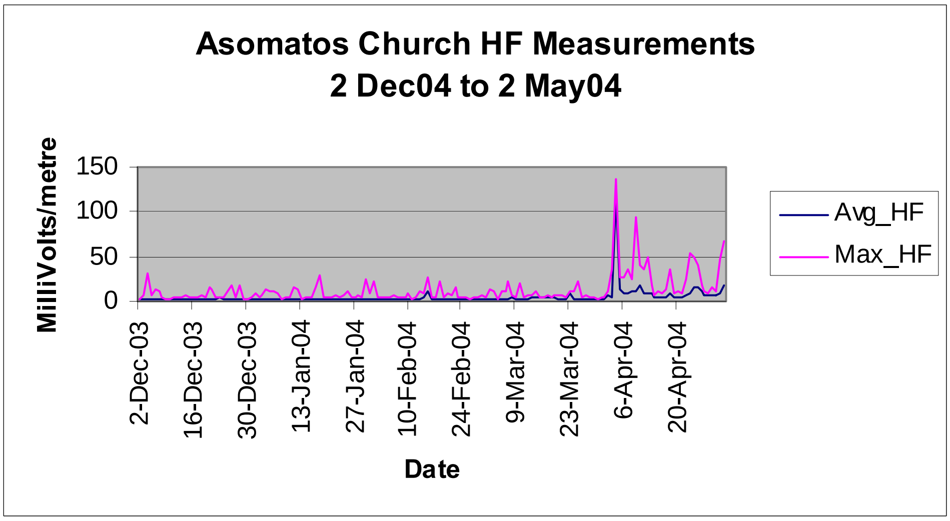
The field strength at the Community Centre is higher than at the Bank, but only for the HF measurements. At the Bank, the UHF values are higher. All the fields within the buildings are less than 1 Volt per metre. The attenuation due to the walls and windows is difficult to estimate. Some observations on the balcony of the Community Centre indicated that these outside measures might be twice the indoor value, which is confirmed by the Narda logger placed on the roof. Importantly the highest HF value recorded at the Community Centre was about 0.35 Volts/metre. The average and peak values declined towards the end of 2003 and in spite of re-siting the replacement equipment in the same spot, the subsequent readings have all been very much lower. In mid 2004 there was construction work at the antenna site, but even on resumption of activity the levels of 2003 have not since been recorded.



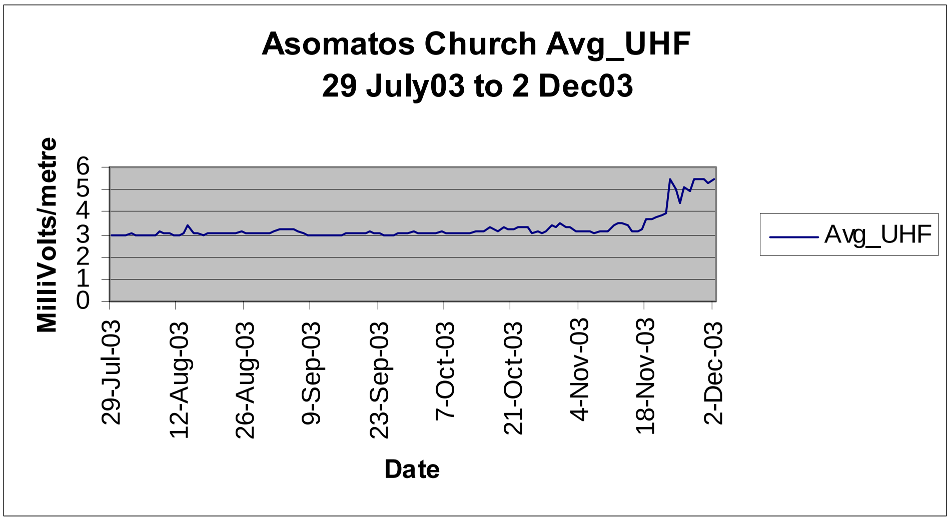
Measurements at Asomatos Church

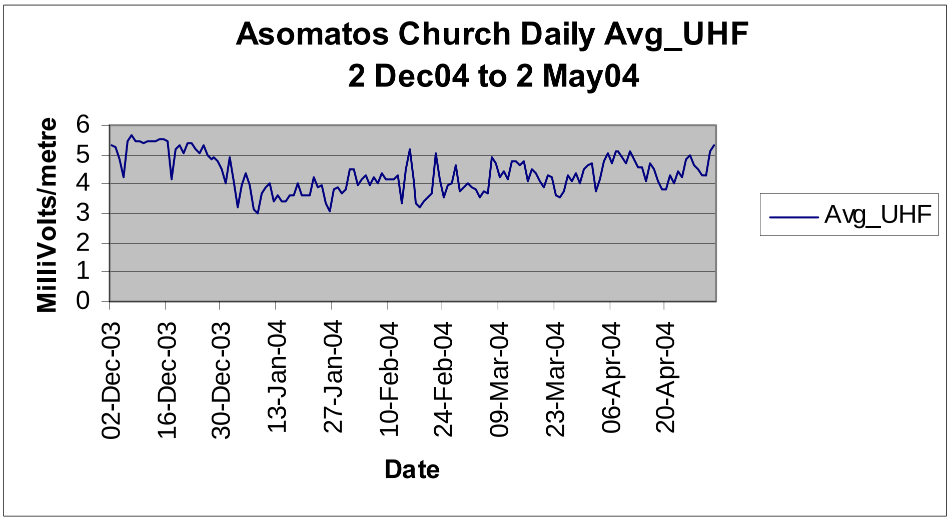
a. **High Frequency**





b. UHF measurements



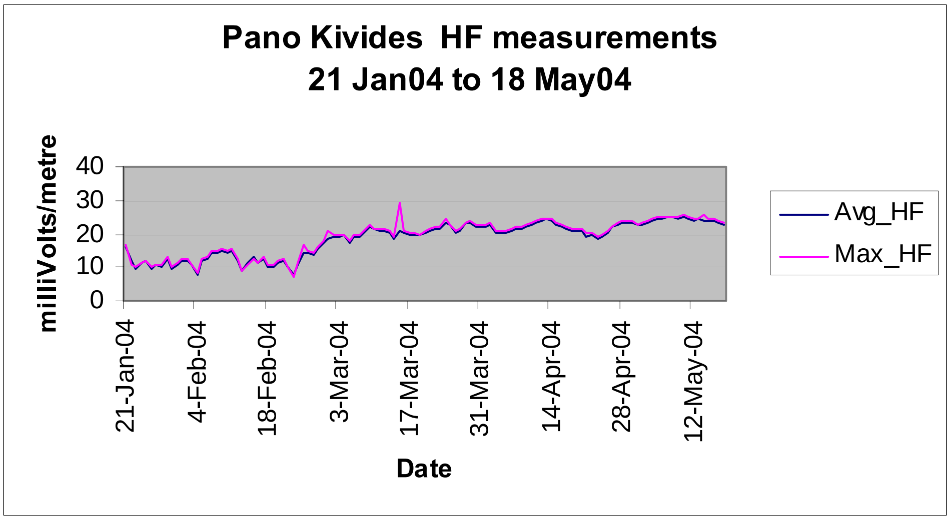


Conclusions for Asomatos

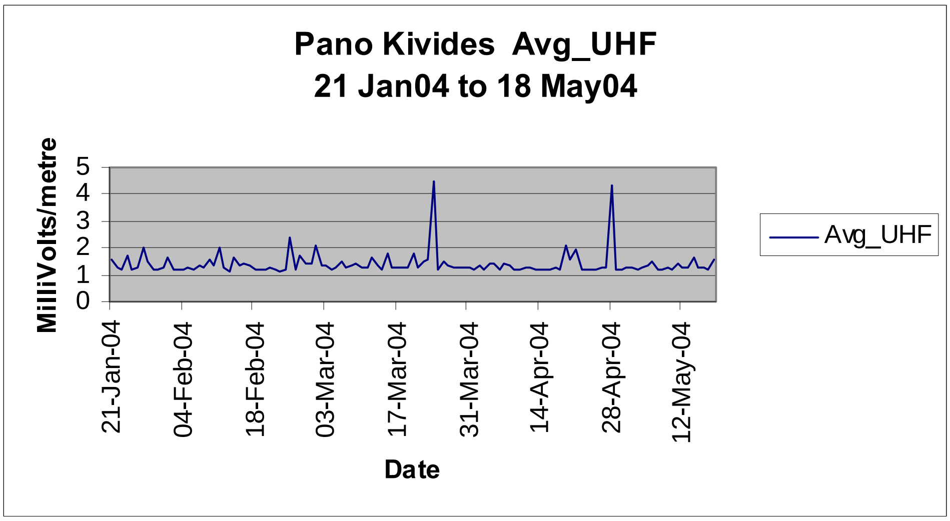
The HF and UHF measurements are much smaller than at Akrotiri, consistent with much lower outdoor values. The HF values increased in April 2004 for short time but were not above 0.15 Volts/metre, otherwise no periods of untoward activity were detected, although the UHF readings increased marginally towards the end of 2003 – possibly as a result of cell-phone mast changes (these are present also in Akrotiri). Sometimes the readings are barely above the noise floor of the logger, though the equipment did detect transient increases consistent with cell-phones being brought into the church, and the occasional taxi transmitting outside. These events are too short to appear in the daily average but are captured in the uncondensed data. No readings over about 0.1 Volts/metre we detected except for the cell-phones (these can be up to 10 Volts/metre very close to the source).

Measurements at Pano Kyvides

a. **HF Measurements 21 Jan04 to 18 May04**



b. b. UHF Measurements



Conclusions for Pano Kyvides

The radiofrequency values for Pano Kyvides were exceedingly low both inside and outside the medical centre. Occasional values were consistent with the use of cell-phones, but otherwise most readings were close to the noise floor of the meter.

Field Surveys

Signals for measurement were provided after the close-down of normal operations. Continuous operation at maximum power was considered undesirable since it was possible to relate the measured field strength E at any determined power to the maximum values with the relationship:

$$\sqrt{\frac{P_{Max}}{P_{Measurement}}}$$

In the case of the studies in Akrotiri and Asomatos the measurements were carried out at 100 kWatt constant wave on a fixed frequency in the centre of the operating frequency range. This could be related to the maximum rated power of the antenna of 500 kWatt by the relationship:

$$E_{Max} = 2.236.E_{Measured}$$

This relates to the power density as:

$$\text{Power density (Wm}^{-2}\text{)} = E^2 / Z_0$$

Where Z_0 = impedance of free space (i.e.377 ohms) and E is in Volts per metre.

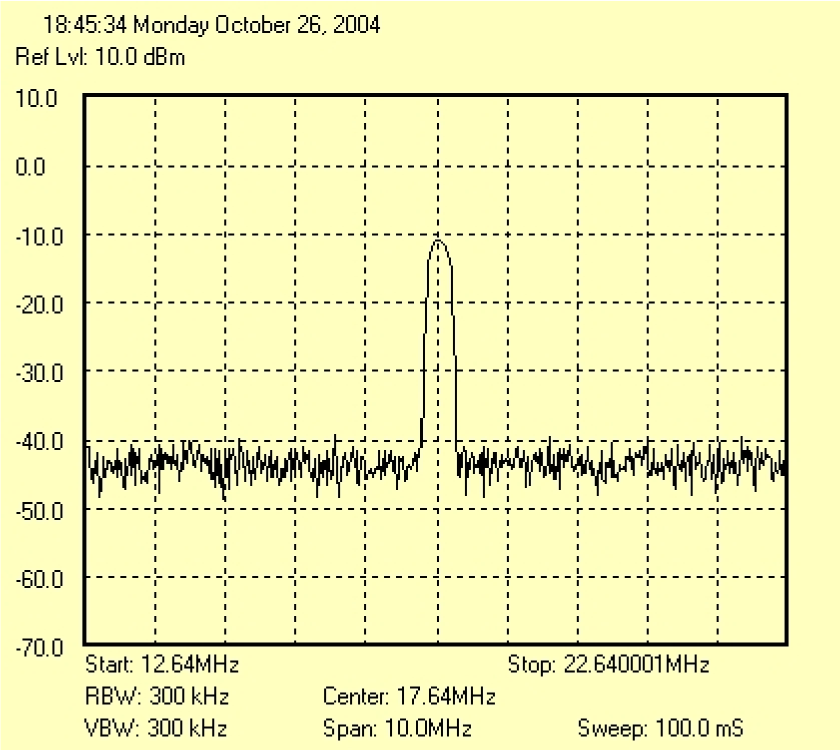
The first survey was able to complete the Akrotiri area, but the spectrum analyser failed at the start of the Asomatos survey. Equipment was returned to the manufacturer for repair (damage during transport by air) and recalibration. A new survey was undertaken which was able to complete the two areas. Asomatos was completed first at a number of pre-selected sites. The operating procedure used was to set up the equipment in the vehicle with the analyser preset to the chosen frequency, and linked to a computer. The antenna was mounted on a suction device at the rear of the vehicle. A call to the base by telephone allowed operation to start with the beam slew set to the northernmost setting used in operation. As a precaution all mobile phones were switched off. At each location the vehicle was stopped, and the analyser set to scan a narrow frequency band. The visual display was dumped into the computer together with a numeric readout of the display. Simultaneously the Narda isotropic E-field meter was set to record the average maximum e-field and this was held at arm’s length above and at the front of the vehicle. At the same time a GPS operating through Microsoft Autoroute gave a readout of the Easting and Northing of the measurement location.

Once fourteen locations had been measured, covering the residential area of Asomatos, a call to the base allowed the beam direction to be moved to the south towards Akrotiri. Some additional measurements were taken close to the Pluto antenna to provide an approximate antenna factor at the operating frequency. This was confirmed by a recalibration in the UK.

The measurement procedures were repeated at Akrotiri, covering the area from the main road near the bakery, up to the entrance to the RAF base to the east. In this case eleven locations were used with a repeat measurement at the bakery. Effort was made to avoid overhead wires, though at some locations this was not possible.

Fig 3. Equipment in place during calibration of the system

Fig 4. Typical spectrum analyser display during calibration



Calibration of Antenna/vehicle/spectrum analyser assembly

metres	Field Strength (V/m)	Analyser dBm	Volts	Calibration Factor
3	5.237	-1.50	0.19	27.561
6	3.207	-5.64	0.12	26.722
9	2.607	-8.38	0.085	30.667
12	1.897	-10.88	0.064	29.635
15	1.313	-13.23	0.0485	27.079
18	1.100	-13.62	0.047	23.404
21	0.973	-15.88	0.0355	27.418
24	0.833	-17.29	0.0305	27.322
27	0.780	-18.31	0.027	28.889
30	0.655			
33	0.630	-19.87	0.0225	28.000
				average =27.670

Results

a) Measurements in Asomatos

Location	Easting	Northing	Narda V/m	Analyser V/m	*Assuming 500kW*
Church	3295992	3463899	**0.34**	**0.028**	***0.062***
Charalampou Evagolau (8)	3295956	3465010	**0.28**	**0.024**	***0.054***
Cemetery	3296073	3464313	**0.58**	**0.012**	***0.026***
School	3296119	3463835	**1.38**	**0.049**	***0.110***
Asomatos exit sign	3296196	3463909	**0.59**	**0.055**	***0.124***
End of Ag. Nicolaos	3296175	3463703	**0.53**	**0.042**	***0.093***
Muhktar's House	3296078	3463304	**0.34**	**0.050**	***0.111***
Christou Andrea	3296041	3463407	**0.26**	**0.055**	***0.124***
Main road	3295880	3463445	**0.28**	**0.064**	***0.142***
Building site	3295831	3463564	**0.37**	**0.058**	***0.130***
Old church	3296012	3463807	**0.8**	**0.064**	***0.142***
Arch. Michael	3295913	3463773	**0.1**	**0.044**	***0.099***
Corner of Ermou	3295723	3463799	**0.22**	**0.062**	***0.139***
Asomatos Welcome sign	3295430	3463702	**0.45**	**0.015**	***0.035***
Edge Pluto Antenna on road*	N/A	N/A	**4.6**	**1.959**	***4.380***
Average value in Volts/metre			**0.46**	**0.04**	**0.1**
Measured at 100 kW Antenna factor used 27.67					

* Junction of the road to Akrotiri and Twitchers Path

b) Measurements in Akrotiri

Location	Easting	Northing	Narda V/m	Spectrum anal. V/m	*Assuming 500kW*
Church (Car park)	3295355	3460231	**0.78**	**0.091**	***0.204***
Bakery	3299194	3460453	**0.67**	**0.291**	***0.650***
Sylvana Restaurant	3295948	3460453	**0.47**	**0.072**	***0.161***
Base gate	3296271	3459729	**1.04**	**0.064**	***0.142***
"Perfect Pizza"	3295891	3460081	**0.41**	**0.124**	***0.277***
Community Centre	3295701	3460117	**0.44**	**0.100**	***0.224***
Bank	3295521	3460176	**0.29**	**0.002**	***0.005***
End of Acropolis St	3295380	3460089	**0.19**	**0.044**	***0.098***
Start of School area	3295371	3460161	**0.89**	**0.069**	***0.155***
End of school area	3295247	3460159	**0.52**	**0.116**	***0.260***
New house over bakery	3295262	3460257	**0.58**	**0.108**	***0.241***
Bakery at end	3295181	3460451	**0.58**	**0.291**	***0.650***
Mean value in Volts/metre			**0.57**	**0.11**	**0.26**
Measured at 100 kW CW. Antenna factor used 27.67					

Survey of road along Lady's Mile Beach (December 15th 2004)

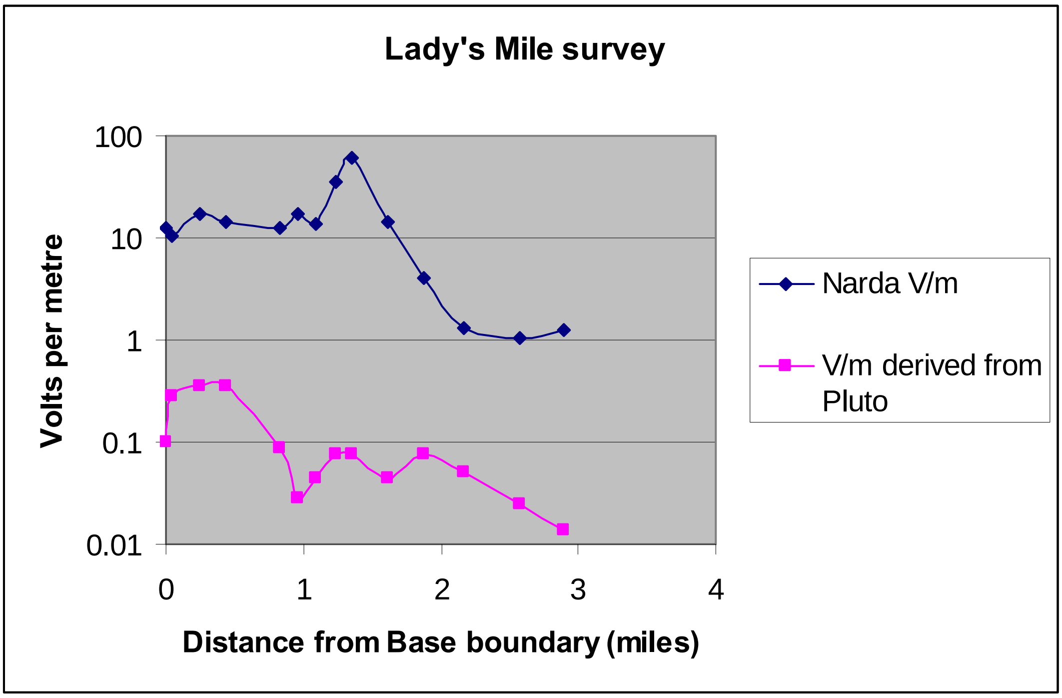
A survey using two measurement systems was undertaken along Lady's Mile from the Akrotiri Base Boundary whilst 100kW transmission at 17 MHz was being provided with the beam "steered" as far to the South (i.e towards Akrotiri) as normally permitted. The field was measured with the spectrum analyser system used for the village surveys simultaneously with broadband three axis measurements above the vehicle using a Narda EMR 21C with a type 18 probe (100kHz-3GHz). Assistance with measurements was given by the research assistant Antigoni Menelaou who also was present at the base when the system arrangements were made and under the observation of Dr A G Georgiou who was present in the vehicle throughout the study.

The results are expressed as measured volts per metre at the Pluto transmission frequency and broadband "Narda" volts per metre enclosing all sources from 100 kHz to 3 GHz.

Table 25. Location and fields along access road to Lady's Mile Beach (South to North)

Location	Easting	Northing	Dist. from Origin (miles)	Narda V/m	V/m derived from Pluto	Assuming 500KW
End of Ladies Mile	3299626	3460338	0	12.79	0.10	0.22
Lady's mile café	3300627	3460133	0.04	10.58	0.28	0.62
0.25 mile point	3300501	3460512	0.25	17.11	0.35	0.78
Beach gate (0.43m)	3300431	3460765	0.43	14.42	0.35	0.78
Lady's Smile café	3300514	3461351	0.83	12.53	0.09	0.20
0.96 mile point	3300521	3461536	0.96	17.03	0.03	0.06
Captain's cabin	3300526	3461735	1.09	13.56	0.04	0.10
1.24 mile point	3300540	3461967	1.24	**35.48**	0.08	0.17
Golden Beach café	3300557	3462107	1.35	**60.78**	0.08	0.17
Glaros 1.61	3300595	3462476	1.61	14.5	0.04	0.10
1.87 mile point	3300656	3462860	1.87	4.03	0.08	0.17
2.16 mile point	3300757	3463301	2.16	1.34	0.05	0.11
Oasis Tavern	3300910	3463906	2.58	1.04	0.02	0.06
Tarmac Start	3300366	3464319	2.89	1.26	0.01	0.03

Field versus distance plots (on Logarithmic scale)



Conclusions

The fields derived from Pluto are consistent with the measurements at Akrotiri and are of similar magnitude. This also shows the antenna beam pattern (approx 10:1 voltage ratio, 100:1 power ratio). Measurements are approximately 6,400 times lower on a power ratio than ICNIRP standards or 300 times lower power than the suggested Swiss and Italian limits of 3 or 6 Volts/metre.
The broadband measurements are dominated by other sources which are in the medium wave band (following verification measurements on 12 April 2005) but

nevertheless include some of the access road which lies between the towers on the eastern end of the salt flats and the beach. As a result of these observations additional measurements were undertaken by the SBAA which confirmed these are indeed medium wave sources of main frequency 723 kHz where the Reference Level for general public exposure (ICNIRP) is 87 Volts/metre.

Conclusions of the spot and longitudinal measurements

There are considerable variations from place to place in the measured e-field whether focussed on a single frequency from the Pluto antenna, or using a broadband safety survey instrument. However at no time have any of the fields exceeded 1 Volt per metre measured at the villages. Levels can obviously exceed this close to the antenna, but are still in that case well within the ICNIRP limits of 28 Volts per metre for public exposure. The measurements at Akrotiri and Asomatos are also consistent with the Sofrecom broad-band integrated fields of 0.038 V/m at Asomatos Church to about 0.157 V/m at Ryan's Pub Akrotiri Volts/metre. Our measurements at the Twitchers track were 2 V/m (4.4 at maximum theoretical power), those of Sofrecom were 6.2 V/m – differences easily accounted for by slight differences in location. This close to the antenna there may be a significant near field component.

Particularly in the lower part of Akrotiri, it is the GSM mast that dominates the exposure, but it is the school on a level with the top of the mast that is in a field of 0.9 V/m i.e about 2 milliwatts per square metre. A similar field was found in the location of the Asomatos school, but that did not come from Pluto, and was not due to a cell-phone mast. This may have been an unidentified burglar alarm or similar device. At the community centre in Akrotiri, the SBAA-provided Narda field meter consistently reads about 1 V/m, a signal dominated by the cell-phone mast and little affected by Pluto operation (particularly recorded during one of our measurement sessions).

On one of the visits to Nicosia a check was made of the ambient e-field in the town. This was of a similar order to the levels in Akrotiri, indeed the Ministry of Health roof yielded 2 Volts/metre. These values are entirely similar to those found in any large town in the UK. In summary, there are many sources of radiofrequency fields in the salt-lake area, but the contribution of the Pluto antenna is small, and the overall levels are consistent with those experienced in most urban areas.

The additional studies on Ladies Mile highlighted additional sources that were still within ICNIRP levels but which may well contribute to the broadband levels we identified.

7. Discussion & conclusion

The study design required the inclusion of exposed (Akrotiri and Asomatos) and unexposed sites (Pano Kyvides). Akrotiri was selected because of its proximity to the antennae and levels of public concern. Asomatos was also chosen because of its location. The inclusion of both villages provided a larger sample size. Pano Kyvides was identified as a suitable control village. Its location was suitably distant from the antennae and the population demographics were believed to be similar. The analysis has shown that the three villages were in fact well matched and provided a good basis for the comparison of exposed and unexposed populations. The overall response rate of 87% was remarkably good for a study of this kind and we can be confident that the results were representative of the population as a whole.

In analysing the data from the questionnaires a number of important issues have become apparent. Firstly the responses to the adult health questionnaire provided significant differences between the villages (and not just between exposed and unexposed). In Akrotiri there was an increased reporting of migraine, headache, dizziness and depression. A similar trend was noted in Asomatos although at lower levels. What was also observed in Asomatos was a significant increase in reported asthma and heart problems.

In reviewing these findings in relation to the published literature there is no evidence of an association between asthma and heart problems and exposure to electromagnetic fields. On the other hand there is a consistent literature that cognitive and neurological effects are associated with electromagnetic field exposure. However, this is normally found at higher levels and higher frequencies and associated with mobile phone use as covered in detail in the Stewart Report. There are no reports of similar effects at lower levels, such as associated with mast exposure, except one report of cognitive and well-being effects at exposures of 1 volt per metre. The measurement study here confirmed an average value of 0.57 volts per metre in Akrotiri and 0.46 in Asomatos. In Pano Kyvides the levels were less than 0.001 volts per metre. It is worth noting that the Pluto Antenna contributed 10% of exposure in Asomatos and about 20% in Akrotiri. The other sources are various broadcast antennae in particular the cell phone mast in Akrotiri. It seems unlikely that the EM level is contributing to the neurological symptoms reported by those living close to the antenna.

The adult questionnaire was designed to explore general physical and mental health using a standard validated instrument (SF36) and risk perception. The results showed a distinct pattern with a gradient from Pano Kyvides, Asomatos to Akrotiri. The villagers in Akrotiri reported a more negative view of their health than those from the other two villages. Akrotiri reported a higher degree of physical limitation, emotional distress and pain. In addition the risk perception sections of the questionnaire shows that Akrotiri respondents had a higher level of perceived risk than the other two villages. For example they showed a high level of concern for external and physical factors including noise and electromagnetic pollution. It is possible to compare the results from this antenna study with other values from studies in Greece. One of these studies was in hospital staff, a healthy working population by Tountas et al in 2003[58]. The values for that study were as follows. The figures in brackets are the results from Akrotiri: physical functioning 84.2 (75.7); role physical 75.7 (71.4); bodily pain 74.4

(72.1), general health 69.0 (55.2); vitality 63.5 (56.7); social functioning 69.5 (72.3); role emotional 74.1 (74.2) and mental health 66.6 (64.6). This perceived low health status may well be causing distress and anxiety, which may in part explain the reported neurological symptoms, and, in addition, the very high risk perception scores recorded, especially for Akrotiri. In particular, the scoring of risk perception in S4Q17 of Table 10 was 4.85 for living near a military antenna which is equal with S4Q9 for living near a nuclear power plant. Despite the fact that similar studies in the UK have produced lower scores for all the 22 variables (as shown in Table 12), it can be concluded that the scoring of S4Q17 of Table 10 is ranked (proportionally) as the highest after S4Q11 of radioactive fallout from nuclear plant. Whilst scientifically it is not possible to compare the score between one question and another, this does indicate a particular bias in risk perception for Akrotiri compared even with Asomatos. This is surprising as Akrotiri and Asomatos are equidistant from the antennae. However this result may also in part explain the observed symptoms. In comparison with the results found in the UK, all 3 villages scored highly reflecting a national difference.

Furthermore the analysis of the open comments provided in all three questionnaires demonstrates a heightened state of anxiety concerning the presence of the antennae. The antennae dominated responses from Akrotiri, with the overwhelming majority of comments making reference to the antennae and the perceived “effect” on health. The consensus of opinion recorded is that the antennae “damage health”, albeit in an unspecified manner.

Hypersensitivity to electromagnetic fields has reportedly been associated with a general increase in sensitivity and anxiety, even though provocation experiments with EM fields have not been able to demonstrate an objective association.

Given the importance of the high levels of neurological symptoms reported in Akrotiri the information provided by the adult questionnaire gave the opportunity to analyse the relative importance of location (i.e. village) in explaining this outcome. The logistic regression analysis confirmed the importance of village, but also the contribution made by several other key factors including gender and education.

The visibility of the antennae from each village appears to be positively related to increased reporting health problems or illnesses (ie. migraine, headache, dizziness) and higher perceived risk scoring, with Akrotiri having the highest figures and Pano Kyvides having the lowest figures.

The findings from female questionnaires do not provide evidence of any differences between exposed and unexposed sites in gynaecological and obstetric history. Of particular interest, there was an absence of any difference in reported levels of miscarriage. Miscarriage has been associated with exposure to high levels of EMF in previous studies; however, this has not been found in this research.

No evidence of birth abnormalities was found in the child questionnaire, although suggested by the wider literature. There were, however, significant differences in the reporting of migraine, headache, dizziness and depression, with exposed sites reporting increased incidence. In relation to infectious diseases there were six conditions where increased levels were reported, five of these in Asomatos and one in Akrotiri.

The mortality studies produced results that were difficult to interpret. Although attempts were made to check the reliability of reporting systems, one against another, this was not entirely satisfactory. The SMRs were substantially different depending on which method was used. One of the specific objectives was to establish whether there was an excess of brain tumours and leukaemias from Akrotiri. This did not appear to be the case but with such small numbers over a ten-year period the absence of evidence does not imply that there is no association, but it would be impossible for this study to come to any definitive conclusions using data covering the period of operation for the antennae.

These results are in accordance with a recently concluded study in the USA on PAVE PAWS radar on Cape Cod. The local inhabitants were anxious about the health effects from the UHF radar system which although in a higher frequency range than PLUTO and of higher power density, had many similarities in being a phased array and beamed at a low angle. A study carried out by the US National Academy of Sciences concluded that there was no evidence of a health hazard, in particular no increase in cancer risk. However a recommendation of continued epidemiological studies has been made[59].

8. Recommendations

- The SBAA and military authorities should continue to have an open and honest dialogue with the residents of Akrotiri and Asomatos.
- Routine field monitoring should continue.
- Field monitoring should separate the cell-phone signal from other sources.
- The villages should be made aware that the health effects recorded in this study are most probably associated with anxiety, and that the levels of EM fields recorded are not sufficient to account for these observations.
- The villages should be made aware that no long-term deleterious effects on pregnancy and childhood have been recorded.
- The SBAA and Ministry of Health should consider investigating the other reported sources of anxiety and concern (such as low-level flying and sudden aircraft noise).
- A system of routine health monitoring should be devised (using the local medical systems) to observe the health of the communities next to the military antennae. This should include comprehensive morbidity and mortality data recording using the existing systems (rural health centres, hospital admissions, and cancer and regional registries).

Additional comments from Dr AG Georgiou, Chief Medical Officer

The Ministry of Health of the Republic of Cyprus is willing to mediate as an impartial authority in the dialogue between the residents of Akrotiri and Asomatos and the SBAA

The Ministry of Health of the Republic of Cyprus is willing to provide the necessary expertise in the interpretation of the results of the study to the residents of Akrotiri and Asomatos and to any other person which is directly or indirectly affected by the results.

A follow-up health study in 2008 (namely five years after the commencement of this study) is highly recommended in order to examine any differentiation in the pattern of gradient of symptoms and perceived risk in the residents of Akrotiri and Asomatos. The results of the routine health monitoring will be simultaneously evaluated within the context of the follow-up health study.

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