TETRA Industry Group

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TETRA Industry Group Seminar – 24 April 2007 at Design Business Centre
Summary of Presentations

Prof Lawrie Challis

Prof Challis began by explaining briefly how TETRA works, in trunked and direct mode operation, and said that the RF from handsets is pulsed, whereas, although the modulation stops now and then, RF from base stations is not pulsed. He summarised the time-slot sharing that causes the pulsing in handsets and enables a single base station to communicate with up to 16 handsets, thereby reducing the number of base stations required.

He described the maximum power of handsets (1W) and vehicle radios (3W), but said that average power was much lower – around one quarter of the peak signal. He also described adaptive power control, which means that the handset uses the lowest power possible to maintain contact with the base station, to preserve battery life, which can drop the average power by a factor of 30.

He showed a table comparing the power output of analogue radios, TETRA and GSM which showed that output from TETRA radios was comparable with GSM 1800 and lower than GSM 900 and analogue.

Prof Challis explained how RF is absorbed a few cm into body tissue and explained how SARs are calculated using a fluid filled phantom head. He stressed that the only known biological effect of RF exposure is a heating effect, and that SAR values were required to be within safety guidelines.

Prof Challis went on to say that the intensity (power density) a person would receive from a base station was of the order of 1000 times lower than that from a handset, and that public concern about base stations was therefore misplaced, as any effects would be extremely small compared with those from handsets/phones.

Discussing the heating effects, Prof Challis explained that the temperature of a small part of the head could be raised at most by around 0.05 degrees Centigrade if the transmission lasted as long as 6 minutes, which was unlikely, and the handset was being used a long way from a base station or inside a building. The natural variation in body temperature over a day is around 1.0 degree C.

Prof Challis went on to discuss whether there were non-thermal mechanisms which could produce a biological effect. He suggested that nearly all likely mechanisms that produce an effect on cells are small in comparison with the thermal noise caused by cells being in constant motion. He explained that there were two mechanisms which *might* give rise to a small but detectable biological effect and there may be unlikely mechanisms that no-one has yet thought of.

Prof Challis went on to draw a distinction between a biological and a health effect. He explained that we rely on biological effects to function (eg the action of light striking the retina enables sight) and that there was not necessarily a health risk associated with a biological effect.

Referring to the Stewart Report published in May 2000, Prof Challis recalled the conclusion which was that the balance of evidence to date suggests that RF exposure below guideline levels does not cause adverse health effects for the general population. He explained that published research has its limitations, and that mobile phones have been in use for a relatively short period of time and that further research was needed. It has only been fairly recently that funding has been attracted to enable good quality scientists to design and conduct good quality studies.

Moving on to TETRA specific health issues, Prof Challis recognised that the Stewart recommendation that signal coding that pulses close to 16Hz should be avoided had caused some difficulties for the TETRA community and for the government. He explained that the origin of this had been some research carried out in the 1970s – 1980s which had suggested that 16Hz pulsing caused calcium, which is an important element of the nervous system, to leach out of cells. However, a 1993 international review report had concluded that this effect did not exist.

Nevertheless, the Stewart committee had to report on the matter, since it was documented in the scientific literature. Some people had suggested that the number of published papers on both sides of the argument should be considered in making a judgement, but there are associated problems given that a single laboratory may publish several papers all based on the same errors, and scientists attempting to replicate results but finding no effects will not continue to repeat the studies.

The Home Office recommended a TETRA specific review which was conducted by AGNIR in 2001, and further research was recommended in several areas:

- 2 studies on calcium efflux (DSTL and Cambridge)
- 6 volunteer studies at DSTL and Imperial (cognitive studies, Sheffield (blood pressure), Bristol (electrical brain activity), King's College ('unpleasant symptoms') and Essex (hyper-sensitivity to base stations)
- 1 study on demodulation (if humans cannot demodulate the signal, why should pulsed RF have an effect) at Bradford/HPA/Maryland
- Long term health monitoring programme (Imperial)
- 3 dosimetry (SAR) studies (HPA and MCL)

Prof Challis said there was no epidemiological work available on TETRA but there is some on GSM phones – studies of brain tumours (gliomas and acoustic neuromas). Below 10 years there was no association of increased risk with exposure, but above 10 years, there seemed to be some evidence of an increased risk. Further work would be needed to see if this was a real effect or experimental bias, given that numbers of people in the study who had used GSM phones for longer than 10 years had been small, and the study relied on the recall of the facts by people who were experiencing symptoms. It was difficult to say though why any bias should be apparent with longer term but not shorter term use. So there is a hint of a potential problem with longer term use, but it is only a hint and people should not get too excited about it, pending some bias-free longer term research. Prof Challis pointed out that

most detectable cancer symptoms do take 10 – 15 years or more to appear, and as yet few people have used mobile phones for that period of time. So cohort studies need to continue.

Prof Challis went on to describe the second phase of the MTHR programme which would include:

- Bias free epidemiological cohort study
- Studies of children
- Two TETRA-specific volunteer studies, one related to handsets and the other to base stations

To conclude, Prof Challlis said that the media sometimes publishes nonsense, giving as an example the recent coverage of an alleged cancer cluster around seven particular mobile phone masts. There are 47,000 masts in the UK, so why would a cluster be expected only close to that one if there was an RF effect? It is more likely to be pure chance. He advocated addressing the issue in a serious and realistic way, talking about the good science, and trying to eliminate from the equation the 'noise and fluff' in the media.

Dr John Tattersall

Dr Tattersall began by explaining that the studies on calcium efflux in the 1970s had claimed to see an effect, both at 16Hz and at other 'power windows' and that there had been serious flaws in the methodology and the results had not been replicated by other laboratories. He explained that the tissue that had been used in these studies was dead, and that poisoning with cyanide had not stopped the effect occurring.

Dr Tattersall went on to describe the DSTL study which was not to attempt to replicate directly the 1970s work, but to test the results. Real-time imaging of calcium in living cells had been used, with both brain neurones and heart cells being studied. A fluorescent dye had been used which changes colour in the presence of calcium. The analysis had been carried out blind to avoid the possibility of bias.

Looking first at the brain cell study, the resting levels of calcium in the cells exposed to a TETRA signal (400mW/kg) and sham exposed had been no different. Then the cells had been stimulated with potassium and their behaviour observed again, with TETRA and sham exposures. Again there was no significant difference.

Dr Tattersall described how the study looked at various levels of power, stepping up the signal power in 4 steps of 5, 10, 20 and 50 mW/Kg, which covered the range of power variations of adaptive power control, and the 1970s-reported 'power windows'. Again there was no significant difference between TETRA and sham exposure.

The results were checked using a different dye that was not dependent on UV light in case that was having an impact, again with negative results. Dr Tattersall explained that this part of the study had concluded that exposure to a TETRA signal had no impact on calcium in nerve cells.

Dr Tattersall went on to describe the study using heart cells, in which calcium rises transiently during each beat. Where pre-exposure, during exposure, and post-exposure measurements were taken, using 30 second recording periods, with additional recording at the point the signal was turned on and off.

When the heart cell beat frequency was tested there was no difference between the results for sham exposure and TETRA signal exposure, although acetyl choline (a chemical; that slows the heart) did produce the expected measurable response as did salbutamol (a proxy for adrenaline which speeds up the heart).

There was slight difference at the point when the signal was turned on, but this was not statistically significant, and proved to be an artefact of the way the data had been normalised.

The study went on to look at the strength (amplitude) of the calcium rise during each beat. Again there was no difference between sham and TETRA exposure, no effect of acetyl choline (as expected as although it slows the heart it has no impact on strength of the heart beat) but an increase in the strength of the beat with salbutamol, as expected.

During each heartbeat the decay rate of calcium was recorded and there was no significance difference between the decay rate with sham and TETRA signal exposures.

Dr Tattersall concluded his explanation of this part of the study by saying 'nothing really happened'. The results have been published in the International Journal of Radiation Biology (Dec 2005).

Dr Tattersall then described some work on hippo-campal rat brain slices, chosen as they are easy to keep alive, and are involved with learning, memory, spatial awareness and implicated in epilepsy. The study has stimulated the brain slices using a metal electrode and used a glass recording electrode to read the response. It was found that the electrodes were causing an artefact in the results, as they were getting hot, conducting heat into the tissue and effectively killing it. This had been unexpected, but was confirmed using a thermal imaging camera. Once a new measurement system had been developed to eliminate this heating, no effects on the cells were observed.

Sarah Smith

Sarah Smith presented the DSTL studies that had investigated the effects of radiofrequency on cognitive performance. She began by explaining how the team had ensured the design of the studies was statistically sound and the formal ethical review process they had been through before starting the studies. She also described the battery of tests that volunteers had completed– including simple and choice reaction time, sustained attention and working memory tests.

Confidence in the statistical reliability and study power was important as previous research had delivered results that were inconsistent, and the design had been criticised – eg carried out under single not double blind conditions.

The tests had been administered over a period of around 1.5 hours with the order of tests within subject blocks the same for each volunteer, but the order of the blocks themselves varied to eliminate the effects of fatigue. Measures of mood, anxiety and reported symptoms had also been taken before and after the cognitive tests.

Sarah Smith went on to describe the studies looking at a variety of different RF signals the military use. The test environment had been carefully designed, and neither volunteers nor

test administrators knew whether the RF signal was on or not. The dosimetry had demonstrated SARs well within the exposure guidelines.

The results showed no significant effects of the RF signals on cognition on 20 of the 22 tasks for the first study, and no significant effects on any of the 22 tasks for the second study, there were also no significant effects on subjective measures of mood and anxiety nor reported symptoms.

Once the results had been adjusted for the multiple comparisons made, the 2 effects seen in the first study are no longer significant.

Sarah Smith concluded that the military RF signals investigated had no robust effects on cognition.

She went on to describe the TETRA-specific study, which had been conducted using a 381MHz UHF signal, modulated at around 17.6 Hz. The study had compared right and left hand side exposure to both a TETRA signal and a sham signal. The study had been conducted double blind and with a good study power. The volunteers had all been male, in the age range 18 – 45, right handed and with normal colour vision.

The study had been conducted in a laboratory environment, with controlled temperature and lighting, and the tests had started at the same time of day for all the volunteers. The handset used had been powered by an external power source to ensure constant power, and had been head-mounted to keep it in a constant position.

Sarah Smith summarised the results as follows:

- There had been no significant difference between TETRA and sham exposure on 20 of the 22 tasks
- There did appear to be some difference between TETRA and sham exposure on a word recognition task
- There also appeared to be a difference between TETRA and sham exposure on a verbal working memory task.

Once the error calculation had been taken into account the only significant difference remaining was on the word recognition task.

There were no effects observed on mood or anxiety measures nor reported symptoms.

Sarah Smith concluded that the single positive result ought to be treated with caution as it had not yet been replicated. DSTL was submitting two papers for publication to the Bio-electromagnetics Journal, and it was hoped that the work would be published shortly. In the meantime, information is available on the Home Office website.

Dr Phil Chadwick

Dr Chadwick talked about his work at MCL measuring SARs in situations where TETRA radios were used in cars or on motor-cycles and where there were combinations of hand held and vehicle-mounted radios, to see whether there was additivity or whether the vehicle structure had an effect.

He stressed that these were measures of exposure not of putative health effects.

Dr Chadwick reviewed the exposure guidelines which were:

	General Public	Occupational Exposure
Local	2W per Kg (10g of tissue)	10W per Kg (10g of tissue)
Whole body	0.08 W per Kg	0.4W per Kg

He explained that these are lower by a factor of 10 than the point at which heating effects would be observed, and that the general public guideline is lower by a further factor of 5.

Dr Chadwick went on to explain how the phantom head and torso used in the work had been designed and constructed. The fluid used in the hollow phantom was slightly more conductive than human tissue to ensure that the results measured were conservative.

A motorised robot probe was used to conduct the measurements and this was mounted inside the torso to scan and measure the relevant exposed areas.

The measurements were cross referenced with those predicted through computational computer modelling with agreement within 20%.

SAR measurements were taken and compared with those predicted from computer modelling; there was pretty good agreement except at very low levels where the limits of the capability of the probe were reached.

Various permutations were used for the measurements – between 1 and 4 officers in a car, each having a 1W radio lapel or belt mounted, and each wearing or not wearing a stab proof vest. The vehicle-mounted radio had a maximum power of 3.3W

The measurements showed that:

- operation of the vehicle radio did not give rise to significant RF exposure for occupants of the vehicle
- when stab proof vests were worn, the SAR for a belt-worn radio reduced by a factor of 4 (less than predicted) and a lapel SAR reduced by a factor of 2 (more than predicted probably due to the bulk of the vest moving the radio antenna away from the body)
- RF peaks were in the necks of car passengers and close to the knee of the driver but these were still extremely small levels of RF
- For the motor-cycle the peak was in the small of the back, and behind the knee (probably due to resonance with the bike structure)
- For an officer using a personal radio, there was no additivity observed if there were other personal radios in use close by with operation of the vehicle radio
- There was no difference in measured SARs if the radios were belt rather than lapel worn
- SARs were not affected by the vehicle structure; measures were similar to those taken outside the vehicle and were as predicted.
- The measure at the small of the back on a motor-cycle was studied with the antenna in a range 1cm to 10cm away. At 2cm the SAR measured was 0.4W per Kg localised, closer than that the antenna de-tuned, at 10 cm away (and in the real world the antenna is at least this distance away from the rider's back) the SAR was pretty negligible.

Dr Chadwick summarised his conclusions which were:

- Measured and predicted SARs showed a good level of agreement
- The impact of the vehicle antenna was negligible for occupants
- The only significant SAR inside a vehicle was from the officer's own radio
- Measures were essentially the same as those made outside a vehicle

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