# Annex J – HUMAN EFFECTS OF RF ENERGY

1) Most studies on low-level (so-called "non-thermal") RF exposures have not found any biological effects. A few studies have suggested that some biological effects may occur, but such findings have not been confirmed by additional research. In many cases, other researchers have had difficulty in reproducing those studies, or in determining the reasons for inconsistent results.

2) A few animal studies have suggested that low levels of RF could accelerate the development of cancer in laboratory animals. However, many of the studies that showed increased tumour development used animals that had been genetically engineered or treated with cancer-causing chemicals so as to be pre-disposed them to develop cancer in the absence of RF exposure. Other studies exposed the animals to RF for up to 22 hours per day. Such exposures are very different from those people might receive while using a wireless phone or while employing an RF-based NLW, so the results are difficult to interpret in terms of human health, even if the findings are valid.

3) Three large epidemiological studies on the health effects of RF have been published since December 2000 and several more are in progress. Between them, the studies investigated any possible association between the use of wireless phones and primary brain cancer, glioma, meningioma, or acoustic neuroma, tumours of the brain or salivary gland, leukaemia, or other cancers. None of the studies demonstrated the existence of any harmful health effects from wireless phone RF exposures. However, none of the studies can answer questions about long-term exposures, as the average period of phone use in these studies was around three years (see Lonn (Lonn et al. 2004)).

4) A combination of laboratory studies and epidemiological studies of people actually using wireless phones would provide some of the data that are needed to assess the potential health effects of low-level RF. Lifetime animal exposure studies could be completed in a few years. However, very large numbers of animals would be needed to provide reliable proof of a cancer promoting effect if one exists. Epidemiological studies can provide data that is directly applicable to human populations, but 10 or more years' follow-up may be needed to provide answers about some health effects, such as cancer. The reason for needing such a long study is that the interval between the time of exposure to a cancer-causing agent and the time tumours would develop – if they do – could be many, many years. The interpretation of epidemiological studies is hampered by difficulties in measuring actual RF exposure during day-to-day use of wireless phones. Many factors affect this measurement, such as the angle at which the phone is held, or which model of phone is used. http://www.fda.gov/cellphones/. Assessment of the human effects of exposure RF used for NLW would face even greater problems because of the relatively small exposed population compared to that using wireless phones.

5) A recent special issue of the premier scientific journal on RF health effects (Bioelectromagnetics Supplement 6, pp. 1-213, 2003) published 14 detailed review papers on the potential harm of exposure to RF. A paper by D'Andrea, Chou, Johnston, and Adair, (D'Andrea et al. 2003b) reported that studies have evaluated the electroencephalography (EEG) of humans and laboratory animals during and after Radiofrequency (RF) exposures. Effects of RF exposure on the blood-brain barrier (BBB) have been generally accepted for exposures that are thermal zing. Low-level exposures that report alterations of the BBB remain controversial. Exposure to high levels of RF energy can damage the structure and function of the nervous system. Much research has focused on the neurochemistry of the brain and the reported effects of RF exposure. Research with isolated brain tissue has provided new results that do not seem to rely on thermal mechanisms. Studies of individuals who are reported to be sensitive to electric and

magnetic fields are discussed. In this review of the literature, it is difficult to draw conclusions concerning hazards to human health. The many exposure parameters such as frequency, orientation, modulation, power density, and duration of exposure make direct comparison of many experiments difficult. At high exposure power densities, thermal effects are prevalent and can lead to adverse consequences. At lower levels of exposure biological effects may still occur but thermal mechanisms are not ruled out. It is concluded that the diverse methods and experimental designs as well as lack of replication of many seemingly important studies prevents formation of definite conclusions concerning hazardous nervous system health effects from RF exposure. The only firm conclusion that may be drawn is that high power RF exposure could be hazardous to humans; however, in practice, such high level exposures are extremely rare.

6) Another review paper in the recent special issue of Bioelectromagnetics (D'Andrea et al. 2003a) presents an overview of the recent behavioural literature concerning microwave exposure and discusses behavioural effects that have supported past exposure standards. Other effects, which are based on lower levels of exposure, are discussed as well, relative to setting exposure standards. The paper begins with a brief discussion of the ways in which behavioural end points are investigated in the laboratory, together with some of the methodological considerations pertinent to such studies when radio frequency (RF) exposure is involved. It has been pointed out by several sources that exposure to RF radiation can lead to changes in the behaviour of humans and laboratory animals that can range from the perceptions of warmth and sound "microwave hearing" to lethal body temperatures. Behaviour of laboratory animals can be perturbed and, under certain other conditions, animals will escape and subsequently avoid RF fields; but they will also work to obtain a burst of RF energy when they are cold. Changes of cognitive function (memory and learning) following RF exposure in humans and laboratory animals have been reported in the scientific literature. Mostly, these are thermally mediated effects, but other low level effects are not so easily explained by thermal mechanisms. The phenomenon of behavioural disruption by microwave exposure, an operationally defined rate decrease (or rate increase), has served as the basis for human exposure guidelines since the early 1980s and still appears to be a very sensitive RF bioeffect. Nearly all evidence relates this phenomenon to the generation of heat in the tissues and reinforces the conclusion that behavioural changes observed in RF exposed animals are thermally mediated. Such behavioural alteration has been demonstrated in a variety of animal species and under several different conditions of RF exposure. Thermally based effects can clearly be hazardous to the organism and continue to be the best predictor of hazard for humans. Nevertheless, similar research with man has not been conducted. Although some studies on human perception of RF exist, these should be expanded to include a variety of RF parameters.

## J.1 REFERENCES

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