Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communications Devices

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I write this report as a private citizen to urge three avenues of investigation concerning potential biological or adverse health effects of wireless communication devices. I recommend:

(a) Full and careful treatment of electromagnetic transient phenomena in tissue.

(b) Collection of appropriate human data concerning effects resulting from using wireless communication devices, such a phones or wireless computer systems, and concerning living near radiating sources of communication signals.

(c) Detailed consideration of the quality of existing and ongoing research.

Electromagnetic transient phenomena in tissue

It has been long known that *every* electromagnetic pulse is associated with non-steady responses or transients. Julius Adams Stratton in his classic text, Electromagnetic Theory, 1941, provides a clear discussion. Stratton distinguishes forced vibrations of material charges that have the same frequency as the impinging wave train, from free vibrations "damped in time as a result of the damping forces acting on the oscillating ions and their frequency is determined by the elastic binding forces (page 337)." The free vibrations are the transients.

These transients exist at all depths in the medium. The transients are most apparent in a field recording after the main frequency of the pulse has been absorbed. These so-called asymptotic responses have been the careful study of Professor Kurt Oughstun at the University of Vermont (Oughstun and Sherman, Electromagnetic Pulse Propagation in Causal Dielectrics, Springer-Verlag, 1994). However, as is clear from Stratton's presentation, these transients are present at all depths, a scientific fact that was missed in the evaluation of electromagnetic transients in the NAS study of the PAVE PAWS radar.

Consider a plane wave impinging orthogonally on a half space of water-based tissue. Let the plane wave be modulated by a one microsecond long square wave modulated pulse of frequency 2.1 gigahertz, and have amplitude 1 volt per meter. At one centimeter depth the transient has an approximate Gaussian functional shape with width at half maximum of 0.08 nanoseconds and amplitude of approximately 0.18 volts per meter. At five centimeter depth in tissue, the transient again has a Gaussian functional shape with width at half maximum being 1.5 nanoseconds and amplitude 0.20 volts per meter. These Gaussian-shaped pulses are unipolar: they represent a local, transient DC

level which is unmatched by a signal of opposite polarity until the end of the parent pulse.

The work of Rogers and colleagues has shown that short duration pulses, such as the transients described above, can change tissue physiological state (Rogers and colleagues, "Strength-duration curve for an electrically excitable tissue extended down to near 1 nanosecond", IEEE transactions on plasma science, 2004, vol 32, pp 1587-1599). Rogers was able to stimulate contraction in frog muscle using ultra-short pulses at very high voltages. The claim that tissue is immune to short pulses cannot be sustained. The Rogers work indicates that the Blair curve, related to the Hodgkin-Huxley model, holds down to nanosecond regime pulses. Additional research questions include whether short pulses at low amplitudes depolarize membranes or have other effects, and the effects of pulse trains.

In a complex environment with several emitters, pulses can arrive at the exposed human being in an overlapping manner. Interference between signals can produce a sequence of transient pulses within tissue, and these pulse sequences may have long term health consequences beyond the effects of single transients, since a prolonged low-level, local-in-time DC level can be produced.

This concern for transient sequences indicates how important it is to characterize the composite signals that actually impinge on human beings.

Collection of appropriate human data

Unlike ionizing radiation biology, the study of non-ionizing radiation biology has not yet been marked by especially strong statistical methods and critical thinking. The final arbiter of claims of safety is good quality data from human populations that have been properly analyzed and reported. *p*-values have been far too often incorrectly used for inference: the confidence interval is preferred and encloses *all* hypotheses that are compatible with the data. Statements that effects observed could have been due to chance are misleading at best. What properly serves the consuming public, which we as scientists are required to protect, are statements that adverse effects, if they are occurring, are occurring below a threshold *the public understands and can agree to.*

The quality of existing and ongoing research

Davidson has reported that 89% of industry supported clinical trials had positive outcomes (favoring the industry) while 61% of non-industry supported clinical trials were positive (Davidson, "Source of funding and outcome of clinical trials," J. Gen Int Med, 1986, pp 155-158). These and several other studies indicate that industry sponsored research can be biased toward industry interests.

The issue of potential bias should be considered as a science question in the pursuit of understanding the health and safety aspects of non-ionizing radiation. Studies sponsored by industry and government agencies with an interest in exploiting spectrum

should be compared with studies performed by scientists using National Science Foundation sponsorship or fully independent funding sources. If bias is observed, as has been noted in clinical studies, steps to limit conflict of interest should be taken. Until studies are completed, it would be prudent to assume that bias exists in studies performed by industry and government agencies with interest in exploiting spectrum.

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