11-10007

Public Utilities Commission of Nevada

Electronic Filing

Submitted: 12/2/2011 11:52:50 AM

Reference: fc9a28e9-754f-426d-b487-f58682054a25
Filed For: NPC and SPPC

In accordance with NRS Chapter 719,
this filing has been electronically signed and filed
by: /s Connie Silveira

By electronically filing the document(s),
the filer attests to the authenticity of the electronic signature(s) contained therein.

This filing has been electronically filed and deemed to be signed by an authorized agent or representative of the signer(s) and
NPC and SPPC

ATTACHMENT 2 – REPORT OF EXPONENT

TESTIMONY OF SHKOLNIKOV AND BAILEY

Q. What is Exponent's role in the December 6, 2011 workshop?

A. NV Energy asked Exponent to be a technical resource to the Commission and to the public on health and safety issues relating to radiofrequency (RF) fields.

Q. What is the purpose of your testimony?

A. The purpose of our testimony is to address issues that have been raised in relation to the operation of smart meters deployed in Nevada by providing: 1) a description of the devices of NV Energy AMI Network that involve communication by means of RF signals; 2) a comparison of these signals with the national standard in the United States for RF emissions as published by the Federal Communications Commission (FCC); 3) documentation of the status of scientific research on potential health risks and safety of RF exposure; and 4) responses to comments submitted to the Commission regarding RF health and safety issues.

WITNESS BACKGROUND AND EXPERIENCE

The witnesses from Exponent are Yakov Shkolnikov, Ph.D. and William H. Bailey, Ph.D. Their background and experience is summarized below.

Dr. Yakov Shkolnikov

Q. Please state your name and business address

A. My name is Yakov Shkolnikov. My business address is 420 Lexington Avenue, Suite 1740, New York, NY 10170.

Q. What is your occupation?

A. I am an Electrical Engineer.

Q. By whom are you employed?

A. I am a Managing Engineer at Exponent, an independent research and consulting company. I work in the Electrical & Semiconductors Practice, which assists clients in designing and evaluating electrically active devices and systems. As a Managing

Engineer, I frequently assist clients in evaluating RF exposure, electromagnetic interference, and the safety of medical and non-medical devices.

Q. What is your education background?

A. I earned my B.S. with *summa cum laude* in engineering physics from Cornell University in 1999. I then continued my studies as Gordon Wu Fellow at Princeton University and subsequently earned my M.A. and Ph.D. in Electrical Engineering from Princeton University in 2004 and 2005, respectively.

Q. Are you a member of any professional organizations?

A. Yes. I am a member of the American Physical Society and the IEEE. I'm also a member of The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety, Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 300 GHz)

Q. Are you a licensed engineer?

A. Yes. I have passed the Professional Engineering examination, and I am a licensed engineer in the State of New Jersey.

Q. What particular experience do you have regarding the RF signals from the Smart Meter?

A. During my undergraduate internships, I have evaluated the design of RF and optical network components. In my Ph.D. research, I have performed experimental studies on fundamental processes by which electromagnetic fields interact with matter. These research studies have resulted in over 20 peer-reviewed publications in leading physics journals, such as *Physical Review Letters* and *Applied Physics Letters*. A full list is shown on my CV, which is attached as **Exhibit YS-1**.

Since starting at Exponent in 2005, I have designed, evaluated, and tested systems that produce and communicate via RF signals. I have performed multiple evaluations of RF exposure, compatibility, and signal strength from devices as varied as *ad hoc* networks, radar installations, cell phone and AM radio towers, MRI machines, smart meter networks, consumer electronic devices, and medical device implants. I also evaluated and redesigned network communication installations, and as part of the design team for products to protect U.S. troops from improvised explosive devices, I have developed algorithms to process received RF signals as well as improved RF component designs. Additionally, as a visiting research faculty at the School of Biomedical Engineering at Drexel University, I have researched and published on the topics of electric shock and medical device implants. I have been invited and given guest lectures at Princeton University and Drexel University on the evaluation of risk in medical device design as well as the effect of electricity on the human body.

Dr. William H. Bailey

Q. Please state you name and business address.

A. My name is William H. Bailey, Ph.D. My business address is 17000 Science Drive, Suite 200, Bowie, MD 21705.

Q. What is your occupation?

A. I am a scientist and researcher in the Center for Exposure Assessment and Dose Reconstruction at Exponent. My work involves reviewing, analyzing, and conducting health research. Much of my work over the past 25 years relates to the exposures and potential biological, environmental, and health effects associated with electrical facilities and devices, including electric utility facilities, electrified railroad lines, industrial equipment, appliances, and medical devices that produce electromagnetic fields across a wide range of frequencies.

Q. What is the role of exposure assessment in public health?

A. Exposure assessment is a key element in a) the assessment of potential risks of chemicals and physical agents, and b) environmental epidemiology studies. The science of exposure assessment encompasses studies based on chemical, biological, and physical principles required to analyze human exposure from single and multiple routes; occupational exposure studies; and population-based studies. These studies are essential for the translation of toxicity data to assess the potential for risk to individuals and populations and to inform public health decisions.

Q. By whom are you employed?

A. I work in the Health Sciences Group within Exponent, an independent research and consulting company.

Q. What is your educational background?

A. I earned a Ph.D. in neuropsychology from the City University of New York. I received two additional years of training in neurochemistry at The Rockefeller University in New York City under a fellowship from the National Institutes of Health. My education includes a B.A. from Dartmouth College in 1966 and an MBA from the University of Chicago, awarded in 1969.

Q. Please briefly describe your professional experience.

A. Since 1986, I have been a visiting research scientist at the Cornell University Weill Medical College. I also have been a visiting lecturer at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health in the field of bioelectromagnetics. From 1983 through 1987, I was head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research. For the seven previous years, I was an Assistant Professor in Neurochemistry at The Rockefeller University.

Q. Are you a member of any professional organizations?

A. I am a member of The Rockefeller University Chapter of Sigma Xi, a national scientific honor society; the Health Physics Society; ICES, Subcommittees 3 and 4 – Safety Levels with Respect to Human Exposure to Fields; the Bioelectromagnetics

Society; the IEEE Engineering in Medicine and Biology Society; the Conseil International des Grands Reseaux Electriques; the American Association for the Advancement of Science; the New York Academy of Sciences; the Society for Neuroscience; the Air & Waste Management Association; the Society for Risk Analysis; and the International Society of Exposure Analysis.

Q. Have you authored any papers or journal articles?

A. I have published or presented more than 50 scientific papers on this and related subjects. My CV is attached as **Exhibit WHB-1**.

Q. What particular experience do you have regarding the RF signals from the Smart Meter and health?

A. I am an Associate Editor of *Health Physics*, with primary responsibility for the peer review of manuscripts describing the results of research on electromagnetic fields including both ELF and RF, a role that I also have filled as a reviewer of grant applications submitted to the National Institutes of Health for funding. I have been involved in performing human health risk assessments of RF exposures from military radar, industrial devices, and a variety of consumer appliances. I am a member of Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz) of ICES and served as an elected member of the Committee on Man and Radiation (COMAR) of the IEEE Engineering in Medicine and Biology Society, 1998–2001. In addition, I have served as an advisor to the Irish Government's Department of Communications on health issues relating to RF from mobile-telephone base station antennas. Because of my background and experience I have served as an advisor on risk assessment and public policy to various international scientific and health agencies on topics relating to electromagnetic fields, including RF.

THE NV ENERGY AMI NETWORK

Q. What is the purpose of the NV Energy AMI network?

A. The purpose of the NV Energy AMI network is to automatically transmit electricity and gas use from the customer back to NV Energy. The transmitters on customer's electric meters (smart meters) communicate to NV Energy by sending RF signals with frequencies between 896 megahertz (MHz) to 960 MHz.

Q. Are there other devices in the NV Energy AMI network that communicate by RF signals?

A. Yes. There are Tower Gateway Base (TGB) stations that collect information from the signals sent by smart meters at customers' locations. These TGBs also transmit signals back to the customers' smart meter to maintain accurate communications with customers' smart meters.

Q. **Is the NV Energy AMI network a mesh grid network?**

A. The NV Energy AMI network is a hybrid system. A majority of the smart meters, 99% in the current installation, operate in a point-to-point fashion. A tiny fraction, currently 1%, operate in a mix of a point-to-point and buddy mode (which allows for a single communication between meters on a licensed frequency should it be necessary).

Q. You have identified the devices of the NV Energy AMI network that are sources of RF fields. Are these devices also important sources of other frequencies of electromagnetic fields associated with the operation of other devices?

A. No. Specifically, they would not important sources of electric and magnetic fields (EMF) typically associated with power lines and home and office appliances, which are in the extremely low frequency (ELF) range (i.e., 1 Hertz (Hz) to 3kHz). Neither would they be sources of what has been described as 'dirty electricity.' According to engineers at Health Canada there is no engineering definition for this term. but in their investigation of exposures in homes they referenced voltages on household wiring that could be sources of electric fields in the range of 4 to 100 kHz (Gajda et al., 2010) as measured by a meter that is claimed to detect electrical transients and harmonics produced by wiring in homes.

NV ENERGY AMI NETWORK RF SIGNALS AND THE FCC NATIONAL STANDARDS

Q. What national standards must the NV Energy AMI network devices comply with to be licensed and deployed in the United States?

A. Devices that emit RF energy must meet levels published by the FCC. As part of its oversight functions, the FCC has published an RF exposure standard and approves devices that emit RF fields for sale after testing to meet FCC standards (FCC 2010a, 2010b, 2010c, 2010d).

Q. What is the history of the FCC exposure standard?

A. Scientists have been reviewing research with the goal of implementing and improving exposure standards for RF energy since the 1950s. A major step towards this goal was the formulation of the American National Standard Institute's (ANSI) Standard C95.1-1982. In parallel, the National Council on Radiation Protection & Measurements (NCRP) initiated a standard setting process that began with a summary of RF exposure parameters and mechanisms of interaction that was published as NCRP Report No. 67 "Radiofrequency Electromagnetic Fields—Properties, Quantities and Units, Biophysical Interaction, and Measurements" (NCRP, 1981). The NCRP is chartered by Congress and operates as a "nongovernmental, not-for-profit, public service organization whose mission is to formulate and widely disseminate information, guidance and recommendations on radiation protection and measurements which represent the consensus of leading scientific thinking."[1] The NCRP's 1981 report was followed in 1986 by a comprehensive review of RF research literature on biological effects and human studies and a proposed standard for RF exposure published in NCRP Report No. 86 "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields." In 1993, a large scientific task group was assembled by the World Health

[1] http://www.ncrponline.org/AboutNCRP/Our_Mission.html

Organization (WHO) to review research on the effects of electromagnetic fields in the frequency range of 300 Hz to 300 gigahertz (GHz) in an evaluation of human health risks (WHO, 1993).

In 1985, the FCC, based on advice from the Institute of Electrical and Electronics Engineers (IEEE) first adopted the ANSI standard (1982). The FCC modified and updated the standard in 1996, based on the ANSI and NCRP standards with input and advice from other agencies including ANSI, NCRP, the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and IEEE.

Q. What is the purpose of the FCC standard?

A. The purpose of the FCC standard, as for similar standards, is to prevent adverse biological effects from overexposure to RF fields. In the range of frequencies produced by NV Energy AMI network devices, the principal effect of overexposure is heating of tissues, which can accelerate biochemical reactions and affect homeostatic mechanisms. Warming of the body by a degree or so can be uncomfortable and detract from optimum performance, as we all have probably experienced on hot days. At higher temperatures, the effects become more severe, and in the extreme cause tissue damage, e.g., burns. [2] For devices like smart meters that operate at very low power, the RF levels are far too low to produce tissue heating as will be explained below.

Q. How were these adverse effects identified?

A. The steps that scientists follow in identifying adverse effects of RF exposure are the same steps followed to assess the risks of any exposure. Scientific and regulatory agencies worldwide use a standard scientific process for evaluating biomedical

---

[2] IEEE (1995) elaborates as follows: "At elevated body temperatures, increases in metabolism, heart and respiration rate, and nerve conduction velocity can occur. At temperatures above ~42 °C, central nervous system function can deteriorate and convulsions may occur. At this level protein denaturation may begin and cells may be damaged. Sustained exposure to this level in humans often leads to irreversible neurological and cardiac damage (Mambo et al. [R1011], Britt et al. [B18], and Hales et al. [B51]). Other consequences of severe and prolonged hyperthermia include confusion, unconsciousness, increased heart rate, lowered blood pressure (Gathiram et al. [R1110]), elevated enzyme activity, and damage to the heart and kidneys" (p.41).

research (USEPA, 2003 USEPA, 2005; DHHS, 2004; IARC, 2006) and this process has been recognized as applicable to the evaluation of exposures to RF fields. This process is called a weight-of-evidence review and entails looking at *all* the evidence on a particular issue in a systematic and thorough manner to see if the overall data presents a logically coherent and consistent picture. A weight-of-evidence review consists of three broad steps as follows.

1. **Conduct a systematic search of the scientific literature, typically using computer-based searches of biomedical research databases of published reports, to identify research studies.** This search of the international research literature should retrieve studies regarding RF exposure in relation to various health endpoints in the relevant lines of evidence, including:

    - epidemiologic studies of humans in their natural environment,
    - experimental studies in humans (usually short-term for minor effects) or in animals (*in vivo*), and
    - experimental studies in isolated cells and tissues (*in vitro*).

    The overall pattern of results from epidemiology and *in vivo* studies needs to be considered, because the information provided by these two study types is complementary; *in vivo* studies address the inherent limitations of epidemiology studies and *vice versa*. Epidemiology studies are non-experimental, meaning that researchers do not have precise control over the things to which people are exposed in the study. On the other hand, scientists tightly control all aspects of experimental studies in humans and animals and, therefore, have greater certainty that an observed effect is due to the exposure being studied and not some other factor. Experimental studies in animals have some limitations, however, because of the uncertainty of extrapolating findings in animals to humans. When we consider both of these study types together (in addition to *in vitro* studies), we get a better picture of the possible relationship between the exposure and the disease.

In vitro studies are widely used to investigate the mechanisms for effects that are observed in living organisms. The relative value of *in vitro* studies to a human health risk assessment, however, is much less than that of *in vivo* and epidemiology studies. Responses of cells and tissues outside the body may not reflect the response of those same cells if maintained in a living system, so their relevance cannot be assumed (IARC, 1992). It may, therefore, be difficult to extrapolate from simple cellular systems to complex, higher organisms to predict risk to health. In addition, the results of *in vitro* studies cannot be interpreted in terms of potential human health risks unless they are performed in a well-studied and validated test system. For these reasons, the IARC and other agencies treat data from *in vitro* studies as supplementary to data obtained from *in vivo* and epidemiology studies.

2. **Evaluate each study to determine its strengths and weaknesses, so that more weight can be given to studies of higher quality.** Epidemiology studies must be designed, conducted, and evaluated carefully to prevent bias and ensure validity—the more closely the study's results are believed to reflect the true association between the exposure and the disease under investigation, the more valid the study is and the more weight that is assigned to its findings in a weight-of-evidence evaluation.

3. **Use standard guidance to evaluate the entire body of evidence for the plausibility of a cause-and-effect relationship between a particular exposure and biological effect.** This guidance is usually patterned after Hill's criteria, an analytic framework used in the weight-of-evidence review process for epidemiologic studies (e.g., Hill, 1965; ICNIRP, 2002; DHHS, 2004). The criteria include strength of associations, evidence for a dose-response relationship, consistency within and across studies, and biological plausibility of the hypothesized causal link, among others. The more firmly the data are judged to meet these criteria, the more convincing the evidence for a causal relationship. Similar guidance that is more oriented towards

experimental studies is also applied in assessing potential risks (Repacholi and Cardis, 1997).

It should be clear from this process that all types of studies and all types of effects are evaluated in standard setting. After completing a weight-of-evidence review, the consensus of scientists assembled by national and international health and scientific agencies will determine the lowest level of exposure that produces adverse effects (i.e., the lowest observed adverse effect level [LOAEL]). In the case of exposure to RF fields, the LOAEL is exposure level in which a behavioral disruption occurs with a increase in body temperature. The FCC (1996), NCRP (1986), IEEE (1995), and ICNIRP (1998) all agree that this response occurs at a whole body dose identified as a specific absorption rate (SAR) of 4 Watts per kilogram (W/kg).

Q. How does the FCC standard protect public health?

A. The FCC standard does this by limiting the intensity and duration of exposure such that adverse effects are not expected even when taking into account variation in environmental conditions, e.g., higher ambient temperatures or sensitive populations such as children and the elderly. As illustrated in Figure 1, the FCC SAR limit for the exposure of workers is 10-fold lower than the LOAEL, i.e. 0.4 W/kg, and a further 5-fold reduction in the SAR limit is made for the general public. The same approach is followed by IEEE and ICNIRP. Thus, the exposure limits (i.e., the maximum permissible exposure [MPE]) for the general public is 50-fold lower (10 x 5) than an exposure level associated with an uncomfortable rise in body temperature. [3]

[3] The limits developed are based on the RF dose, also known as the SAR, which varies by frequency. The SAR, however, is not easy to estimate directly, so the standard provides limits on the RF levels in the environment that can be measured or calculated, as power density (power in watts per unit area). To assess compliance, power density is measured or predicted by engineering calculations for areas where people may come in contact with RF fields.

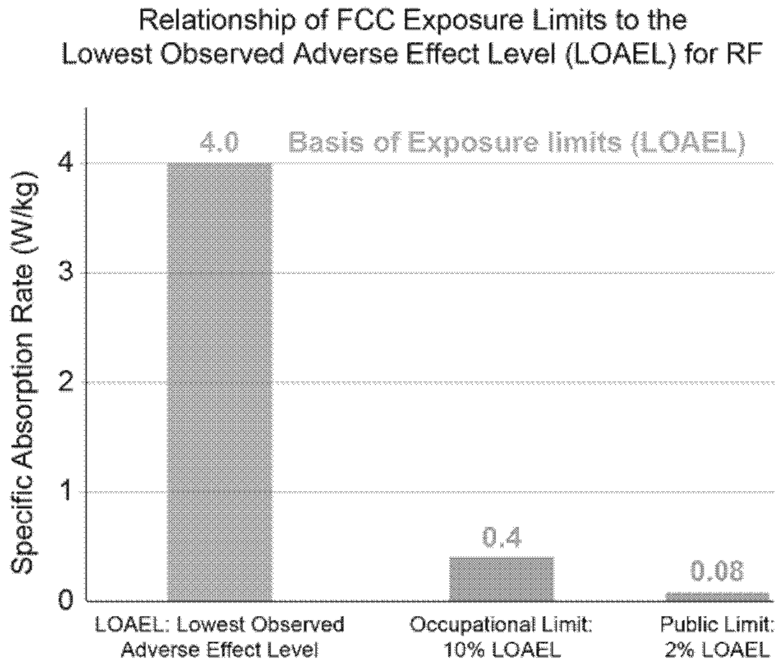

Figure 1. A representation of how biologically-based limits on the RF doses to tissue have been derived by the FCC, IEEE, and ICNIRP standards for persons in occupational environments and members of the general public.

Q. What are the exposure limits set by the FCC for the frequencies produced by components of smart meters?

A. The FCC's RF standard provides MPEs for different sub-ranges within the RF frequency band. The standard has different MPEs for the general public than for those occupations where workers are trained to work in an RF environment. The MPEs for the general public are lower than those for occupational environments. To assess compliance, the MPE is measured (or predicted based on engineering calculations) for areas where people come in contact with RF fields, and averaged over 30 minutes. The MPE is expressed as RF strength, or "power density," which is power in watts over a specified area (i.e., watts per meter [W/m]).

Power density is analogous to the concentration of a chemical dissolved in water or to the brightness of a light focused on an area. Imagine a flashlight shining on a piece of paper held 1 foot away, compared to the dimmer light on a paper from a flashlight held 10 feet away. For practical purposes, the MPE is estimated at the closest point where a person could be exposed to the fields, because this would be the location of the highest exposure given that the strength, or power density, decreases with distance from the source. The MPE for the frequency of RF signals transmitted by a smart meter is 10 watts per square meter (W/m^2), or its equivalent, 1 milliwatt per square centimeter (mW/cm^2) at 2.45 GHz and 0.6 mW/cm^2 at 900 MHz for members of the public, averaged over 30 minutes (47CFR1.1310). For some RF devices the transmitter is not on continuously, but may transmit for shorter periods at levels above the MPE. The 30 minute averaging time[4] is included in the standard because the body can compensate for shorter high exposures to prevent any changes from occurring (homeostatic mechanisms). Smart meters and similar devices including wireless technology, however, can never reach the MPE, so averaging is not needed or applicable.

Q. You have mentioned RF exposure standards other than the FCC standard that applies within the United States. What are the other well-regarded national or international standards?

A. The main national and international scientific organizations that have recommended RF exposure limits include ICNIRP (ICNIRP, 2009) and the International Committee on Electromagnetic Safety (ICES) (IEEE, 2005). ICNIRP is a committee of independent scientific experts that disseminates information and advice on the potential health hazards of exposure to non-ionizing radiation. ICES is a committee within the IEEE; it is responsible for development of standards for the safe use of electromagnetic energy, including RF energy. While IEEE refers to its recommended exposure limits as standards, these and ICNIRP's exposure limit guidelines are recommendations that do not have the force of law unless adopted by a country, state, or other political entity. The World Health Organization (WHO)

---

[4] The FCC defines averaging time as the "appropriate time period over which exposure is averaged for purposes of determining compliance with RF exposure limits" (FCC Office of Engineering and Technology, Bulletin OET65).

recommends that countries adopt the ICNIRP guidelines.[5] Both these organizations have reviewed research published after the 1996 FCC regulation was enacted.

Q. Are the ICNIRP and ICES exposure limits similar to those of the FCC standard?

A. Yes. The exposure limits set by the FCC, ICNIRP, and ICES are similar in the frequency range applicable to the smart meter. Each recommends that exposure of the general public be limited to 10 watts per square meter, equivalent to 1 mW/cm^2 at 2.45 GHz. At 900 MHz, the ICNIRP limits the exposure to 0.45 mW/cm^2 while FCC limits the exposure to 0.6 mW/cm^2. There is also difference in averaging time for the FCC and IEEE standards is 30 minutes, and for the ICNIRP standard, the averaging time is 6 minutes.

Q. Have federal, state, and scientific agencies had the occasion to review RF health and safety issues as they pertain specifically to smart meters?

A. Yes, we are aware of reports issued by the FCC (Knapp, 2010) as well as the Monterey County Health Department (MCHD, 2011), the Maine Center for Disease Control and Prevention (MCDC), the Public Service Commission of California (PUCC, 2010), and the California Council on Science and Technology (CCST, 2011) that were prompted by the roll out of smart meters in different parts of the country. All of these agencies indicated from their expertise and research that the RF exposures from smart meters were exceeding low, compliant with FCC and other standards, and unlikely to pose any public health or safety risks.

---

5 http://www.who.int/peh-emf/en

Q. What is the difference between exposure and the exposure limit?

A. Exposure is a measurement of how much RF signal arrives at the body. Average power density is an example of exposure measure.

The dose is the rate at which the RF signal is absorbed by the body. The SAR is an example of dose measurement.

The exposure limit is the value, based on the governing standard, of how much exposure is permitted that does not cause the dose limit to the body to be exceeded.

As an analogy, exposure is the equivalent to measuring how fast the car is going and the exposure limit is equivalent to the speed limit (and, in this example, this limit is set below the speed at which accident and loss of vehicle control is likely to occur).

Q. How is the RF exposure measured/defined?

The exposure/dosage value can be further specified as local (affecting only part of the body) or whole body (assuming the whole body is exposed). Additionally, spatial averaging (over 10 grams of tissue, 1 gram of tissue) or time averaging (none, 6 minutes, 30 minutes, 24 hours) may be specified.

The specific exposure and dosage metric that is used depends on the standard adopted by the country and typically varies depending on the frequency of the RF signal, the distance of the transmitter to the body, and the hazard being evaluated.

Table 1: Typical Exposure and Dosage units

Typical exposure measure	Typical dosage measure
Power density: power received per unit area. Typical units of W/m^2, mW/cm^2, $\mu W/cm^2$ $10\ W/m^2 = 1\ mW/cm^2 = 1{,}000\ \mu W/cm^2$	Specific Absorption Rate (SAR), power absorbed per unit volume. Typical units of W/kg

Q. Is there relationship between exposure and dosage?

The relationship between exposure and dosage (SAR) is quite complicated and depends on the geometry, frequency, and multitude of other factors. There is no straightforward conversion between SAR and power density as they measure different quantities (incident versus absorbed power); however, exposure of 0.45

mW/cm^2 at 900 MHz and 1 mW/cm^2 at 2.45 GHz would ensure that the whole-body SAR is below 0.08 W/kg (IEEE C95.1-2005, p. 24).

Q. What are some examples of RF exposure standards in other countries?

Most of the RF safety standards in the world fall into two categories: In the United States, as well as many other countries (such as Japan), the standard is based on IEEE Standard C95.1. In Europe, the primary standard is based on ICNIRP's 1998 guideline (at lower frequencies below 100 kHz, other standards may apply). There are some countries whose national standards deviate from the ICNIRP 1998 standard and IEEE Standard C95.6, such as China, Russia, and other former eastern block countries such as Poland. For convenience, these standards at 900 MHz and 2.45 GHz are summarized in Table 2.

Table 2: National Exposure Standards[a]

Standard	Exposure limit	Notes
FCC 47CFR1.1310	0.6 mW/cm^2 at 900 MHz 1 mW/cm^2 at 2.45 GHz	Source-based (duty cycle) averaging over 30 minutes
ICNIRP 1998	0.45 mW/cm^2 at 900 MHz 1 mW/cm^2 at 2.45 GHz	Time averaging over 6 minutes, peak power density not to exceed 1,000 times the exposure limit
Russia (СанПиН 2.2.4/2.1.8.055-96)	0.01 mW/cm^2 at 900 MHz 0.01 mW/cm^2 at 2.45 GHz Note that the WHO database incorrectly lists the Russian exposure limit as 10 mW/cm^2	Average transmitter power (long duration averaging)
China (GB9175-88)	0.01 mW/cm^2 at 900 MHz 0.01 mW/cm^2 at 2.45 GHz	Average transmitter power

[a] For a summary of national standards, see http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Worldmap5.htm

Q. Do the RF signals from devices of NV Energy AMI network comply with the FCC standard?

A. The NV Energy AMI network devices that are sources of RF fields are listed in Table 3. These devices received a grant of equipment authorization from the FCC. The FCC ID for the grant of equipment authorization is also listed next to each device. As part of the grant process, these smart meters underwent an evaluation of their RF fields as they compare to MPE values.[6] The result of this evaluation is a guideline for installing this equipment such that the produced RF signal would not exceed these MPE values during deployment.

Table 3: Devices that are part of the NV Energy AMI network

Device	Location	FCC ID
Tower Gateway Base Station (TGB)	Outside	SDBTGB20
Electrical smart meter (ICON)	On the exterior of the building	SDBIDTB001
Electrical smart meter (Elster)	On the exterior of the building	SDBELS
Electrical smart meter (L & G)	On the exterior of the building	SDBFLEXLG100
Electrical smart meter ZigBee module	Inside the electrical smart meter	SDBZIGMOD10
Electrical smart meter ZigBee module	Inside the electrical smart meter	SDBZIGMOD20
Gas meter module	Inside the gas meter, exterior of the building	SDBGFL2
Gas meter module	Inside the gas meter, exterior of the building	SDBGFL2CI
Thermostat	Interior (optional device)	R33H1
Home energy interface device	Interior (optional device)	R33D1

Q. Some of the equipment installation guidelines require a minimum distance of 20 centimeters (cm). Does this mean that the FCC exposure limit will be exceeded at closer distances?

A. The 20 cm rule is a threshold for performing an SAR-based compliance assessment. As long as the equipment is intended to be used at a distance of greater than 20 cm to the user, this more detailed SAR-based exposure (47CFR2.1091 (c)) is not required. "This does not imply that FCC exposure will be exceeded at distances less than 20 cm" (Knapp , 2010).

[6] Devices currently in development will obtain the grant of equipment authorization prior to deployment.

Q. ZigBee modules operate in an unlicensed frequency band. Does that mean that the FCC does not regulate their exposure?

A. As indicated above, all NV Energy AMI network devices received a grant of equipment authorization from the FCC and underwent an evaluation of their RF exposure.

Licensed versus unlicensed frequency refers to the requirement that all RF installations operating outside a specific frequency range (unlicensed ISM bands) receive a license grant that preserves transmitter equipment exclusive (or sometimes semi-exclusive) access to a licensed frequency band.

Q. Why do published values for smart meters' exposure vary so much and why don't the exposures in this testimony match previously available numbers?

It is inappropriate to use the exposure values calculated for a specific smart meter network as an estimate for an exposure for another network. Other smart meter networks may result in RF exposures that are above or below exposure levels of the NV Energy AMI network. There are many different smart meter network designs; a single exposure value is not applicable to all of them. The exposure from the network may depend on the configuration of the network, frequency of readouts, housing density, total size of the network, frequency of operation, and a multitude of other factors.

In addition, many of these reports incorrectly summarize and combine measurements, or perform theoretical calculations to derive exposures that are not only wrong, but also patently absurd. Some exposure measurements reported on the Internet use measurement devices with dubious specifications, calibration factors, and averaging time constants, and frequently do not perform the analysis to isolate the signal from the smart meter from that caused by other RF generating devices.

There is also a variation in the published reports of how conservative the exposure estimates are. In this analysis, we have utilized a very conservative approach; the exposure values in this testimony very likely greatly overestimate the actual exposure.

Q. Will accounting for the reflection of RF signals, i.e., the reflection factor, increase the estimate of the exposure?

A reflection factor of 2.56 recommended in the FCC publication OET 65 was used for all the calculations to account for the effects of local enhancement of RF exposure (hot-spots) due to reflections from the ground, walls, wires, and other objects in the environment. There are theoretical papers that suggest much higher reflection factors may occur in a highly reflective environment such as a completely enclosed metal wall elevator. This research, however, neglects to take into account the absorption of the RF signal by a human body. Research that correctly takes this effect into account shows that even for a person inside an almost completely enclosed reflective room, the FCC reflection factor of 2.56 would overestimate the increase in absorbed RF power (Simba et al., 2009).

An additional factor to consider is that in the planned deployment, the smart meters are located outside the residence. A room fully enclosed by a very reflective metal would not permit the RF signal to even enter the residential area; it would reflect almost the entire RF signal back. So a very high reflection factor in a residential area would actually result in a reduction of the exposure.

Q. What information did you rely on to calculate RF exposures from the NV Energy AMI network ?

Exponent utilized the following information to perform the exposure calculation:

- Test reports filed for the equipment listed in Table 3[7]
- Number of messages per day and message length for different devices of the NV Energy AMI network provided by NV Energy
- TGB locations as provided by NV Energy

[7] Retrieved from the FCC database accessible at https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm

- Antenna patterns provided by NV Energy
- Typical installation scenarios as specified by NV energy
- Standard models for the RF signal propagation

Q. What typical smart meter installation did you consider?

A. A typical smart meter installation is shown in Figure 2. The electrical smart meter is installed on a panel that typically is recessed into the exterior wall of the residence (preferably garage walls). Gas smart meters are usually installed several inches away from the exterior wall. If such a gas smart meter is installed, a minimum separation of 18 inches is maintained between it and the electrical smart meter.

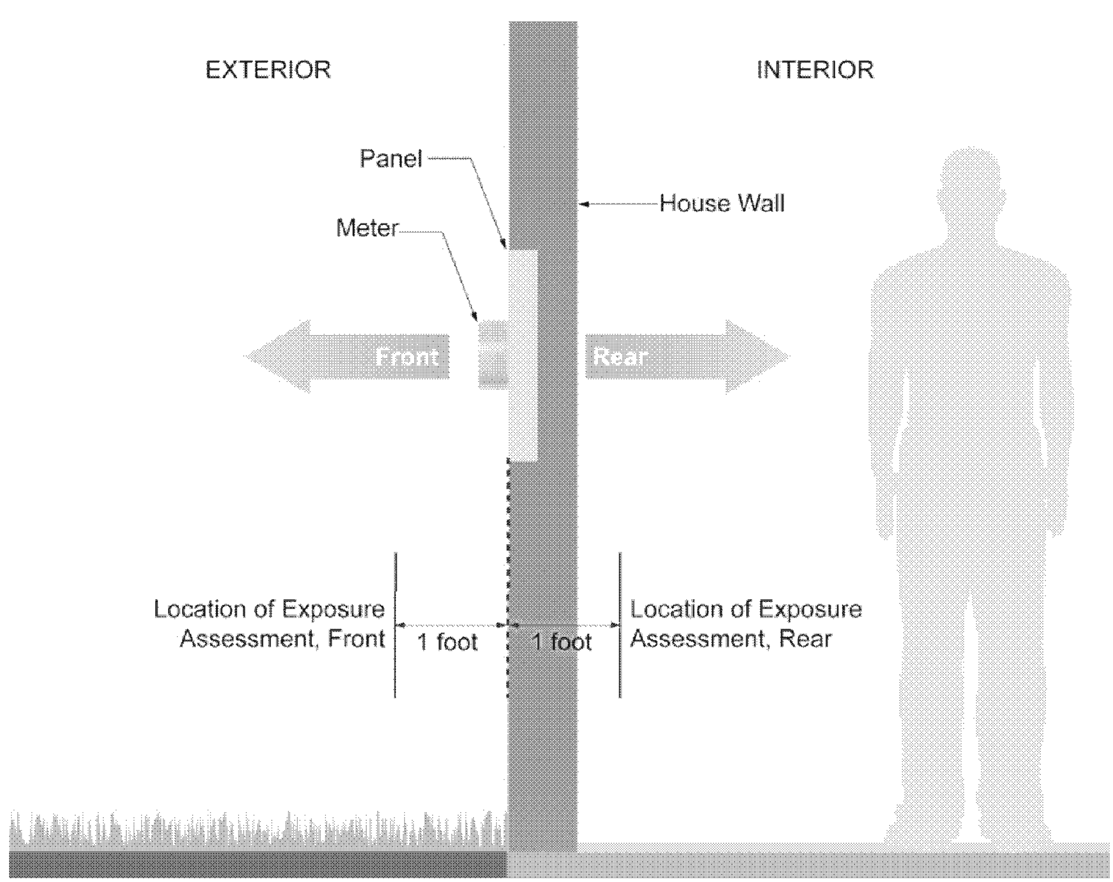

Figure 2. Typical Smart Meter Installation

Q. At what locations did you calculate the exposure?

A. We calculated the exposure at a distance of 1 foot away from the metering panel.

Q. What are the typical exposures from the electrical and gas smart meters?

A. The exposures from the smart meters are summarized below in Table 4.

Table 4: Smart Meter Exposure[a]

Device	Location	Exposure (mW/cm^2)	FCC MPE (mW/cm^2)
Electrical smart meter	1 foot front	0.000026	0.6
Electrical smart meter	1 foot rear	0.00000041	0.6
Gas meter	1 foot front	0.0000072	0.6
Gas meter	1 foot rear	0.00000041	0.6
ZigBee module in the electrical smart meter[b]	1 foot front	0.0000052	1.0
ZigBee module in the electrical smart meter[b]	1 foot rear	0.00000052	1.0

[a] Typically 1 foot rear of the smart meter is on the inside of the house, and 1 foot front of the smart meter is on the outside of the house.

[b] Without the customer-optional home area network (HAN). Since HAN will not be available for the majority of installations, and when available, will still be optional for the customer, it was not considered a typical exposure scenario.

Q. How were these exposures calculated?

A. These exposures were calculated from the product of the peak power density level and the duty cycle.

Table 5. Typical peak power densites and duty cycles[a]

Device	Location	Peak power density (mW/cm^2)	Fraction of time transmitting	Duty cycle based on 30 minute period
Electrical smart meter[b]	1 foot front	0.44	0.000035	0.000060
Electrical smart meter[b]	1 foot rear	0.0069	0.000035	0.000060
Gas smart meter[c]	1 foot front	0.12	0.0000087	0.000060
Gas smart meter[c]	1 foot rear	0.0069	0.0000087	0.000060
ZigBee module in the electrical smart meter	1 foot front	0.026	0.0002	0.0002
ZigBee module in the electrical smart meter	1 foot rear	0.0026	0.0002	0.0002

[a] Typically 1 foot rear of the smart meter is on the inside of the house, and 1 foot front of the smart meter is on the outside of the house.

[b] 95% of the electric meters currently installed operate at or less than 0.000035 of the time (0.0035% of the time). 100% of the electric meters currently installed operate at or less than 0.00048 of the time (0.048% of the time).

[c] 100% of the gas smart meters are expected to operate at or less than 0.0000087 of the time (0.00087% of the time).

On average, typically the smart meter (gas or electric) in the NE Energy AMI network sends less than one message per 30-minute period (averaging time per 47CFR1.1310). Because we performed a conservative exposure estimate, we assumed that at least one message was transmitted per 30 minutes. This resulted in a duty cycle that is greater than or equal to the fraction of time transmitting.

Q. Is it appropriate to utilize the duty cycle in exposure assessment?

A. Yes. FCC exposure limits are based on "source-based" (also known as duty-cycle) time-averaged values (Knopp letter, 2010).

Q. Why is there such a big exposure difference between the front and rear locations?

A. The metal panel (housing) on which the meter is mounted stops most of the RF signal from entering the interior of the house.

Q. How will exposure change at greater distances?

A. At a distance of 1 yard, the calculated exposure values (and peak power density) will drop by a factor of 9 compared to a 1-foot distance. It will continue to drop rapidly as the distance is increased.

Q. Did you consider the effect of the wall material on the exposure?

A. Since we performed a conservative estimate of exposure, we did not take into the account the reduction of the exposure that would result from the absorption of the RF signal by the wall materials and the household furnishings.

Q. If customer utilizes the optional home area network (HAN), will the exposure increase?

A. When the customer chooses to utilize the optional HAN, there will be other devices (see Table 3) that will be provided to the customer by NV Energy. In this case, the RF exposure in the residence will increase, but if the guidelines for installing these devices are followed, the RF signal should not exceed MPE values during the optional HAN use.

Q. What is the typical RF exposure and peak power density from the TGB?

A. Typical RF exposure from the TGB is 0.00000000012 mW/cm^2 and the peak power density 0.000000000594 mW/cm^2. Since we performed a conservative estimate of exposure, we did not take into the account the reduction of the exposure that would result from the absorption of the RF signal by the wall materials and the household furnishings. By comparison, the MPE values at TGB frequencies of 896-960 MHz is 0.6 mW/cm^2.

Q. At what distance was the TGB exposure was calculated?

A. Most houses will be 1 km (0.62 miles) or greater from the TGB. This is the distance at which the TGB exposure was calculated.[8]

Q. Is the exposure from the NV Energy AMI network below the FCC MPE limits?

A. As part of the FCC equipment authorization grant process, FCC required that NV Energy AMI network devices comply with FCC MPE limits. Moreover, our

[8] Standard medium-size city Hata signal propagation model was utilized to calculate the signal drop as a function of distance. (for details of the model see Lee SJ and Miller LE. CDMA Systems Engineering Handbook. Boston: Artech House, 1998, pp. 188-189.)

exposure estimates show that typical exposure will actually be more than a factor of 15,000 below this limit.

Q. How does the exposure from the NV Energy AMI network compare to natural sources of RF exposure?

A. Both the Earth and the human body are sources of a natural RF signal. While the natural RF signal and the AMI network RF signals are not the same (most of the natural RF signals are between 80 GHz and 300 GHz compared to 900 MHz and 2.45 GHz from the AMI network), it is still informative to compare their exposures to gain understanding of their relative values. Figure 3 below illustrates these natural sources.

The whole-spectrum EMF exposure from the ground is 28 mW/cm^2.[9] The RF signal from the Earth is 0.00013 mW/cm^2 (ICNIRP, 2009a). The whole-spectrum EMF exposure from the body is 50 mW/cm^2 (Rogalski, 2000). The RF signal from the human body is 0.0003 mW/cm^2 (ICNIRP, 2009a).

---

[9] See e.g. http://0-climate.gsfc.nasa.gov.iii-server.ualr.edu/static/cahalan/Radiation/EarthRadVblackbody.html

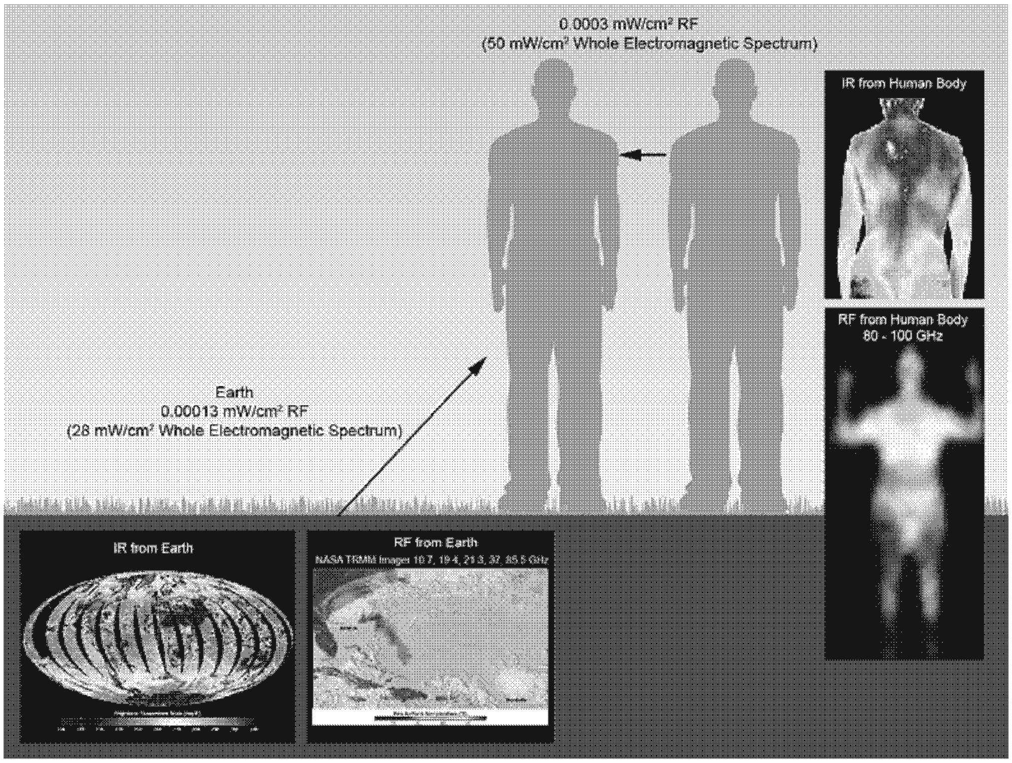

Figure 3. Whole electromagnetic spectrum exposure and RF signal exposure (3 kHz to 300 GHz) from natural sources. Maximum exposure frequency from natural sources is in the infrared (IR) frequency range, well above the RF, but there is still an exposure in the RF frequency band, predominantly in the 80 GHz and 100 GHz range.[10]

Typical exposures from the NV Energy AMI network in the house residential area will be more than a factor of 100 below the RF exposure from the Earth. The network exposure outside the residential areas exposure may be higher, but will still be a factor of 3 lower than the RF exposure from Earth even at 1 foot (and will rapidly drop as the distance increases.

Q. Are there other typical sources of RF exposure?

[10] Image sources: Earth Images: NASA (http://disc.sci.gsfc.nasa.gov/AIRS/additional/gallery/airs_isabel.shtml, http://trmm.gsfc.nasa.gov/overview_dir/tmi.html (technical details), and http://earthobservatory.nasa.gov/Features/HurricaneHeart/heart_5.php); Human Body images: technical details at (http://www.brijot.com/technology/our-technology), http://brijot.com/products/gen2, http://rst.gsfc.nasa.gov/Sect9/Sect9_9.html

A. There are several other sources common sources of RF background. Their exposure values are summarized in Table 6.

Table 6: Other Sources of RF Exposure under Typical Use.

Technology	Peak Power Density (mW/cm^2)	Exposure (mW/cm^2), based on 47CFR1.1310 averaging	Frequency
Mobile phone next to the head (1.81 minute call)[a]	1.5 – 12	0.09 – 0.19	450 MHz, 480 MHz, 850 MHz, 900 MHz, 1800 MHz, 1900 MHz,
Cordless phone next to the head (3 minute call)[b]	0.05 – 1.2	0.005 – 0.12	900 MHz, 1.9 GHz, 2.4 GHz
TV, Radio, Cell phone towers (urban environment)[c]		0.000045 - 0.00015	0.3 MHz to 3 GHz
Microwave oven (1 foot away, 1 minute heating at 100% setting every half hour)[d]	0.14	0.0047	2.4 GHz
WiFi (at least a yard away from transmitter)[e]	0.002	0.000000010 - 0.0010	2.4 GHz

[a] http://news.yahoo.com/s/ytech_gadg/20101007/tc_ytech_gadg/ytech_gadg_tc3837

[b] Based on Table 1-8 in Rohde UL and Newkirk DP. RF/microwave circuit design for wireless applications. John Wiley & Sons, 2000, p. 56; duration of call estimated based on VOIP call length in Guha S and Daswani N. An Experimental Study of the Skype Peer-to-Peer VoIP System (located at http://saikat.guha.cc/pub/iptps06-skype/)

[c] Based on field values in Valberg PA, Van Deventer TE, Repacholi MH. Workgroup report: base stations and wireless networks—radiofrequency (RF) exposures and health consequences. Environ Health Perspect 115:416, 2007.

[d] The FDA's Bureau of Radiological Health has set a limit of 5 mW/cm^2 for leakage from microwave ovens during normal use (21 CFR 1030.10). At 1 foot, the peak power density will drop to 0.14 mW/cm^2.

[e] Based on Foster KR. Radiofrequency exposure from wireless LANs utilizing Wi-Fi technology. Health Physics 92: 280-289, 2007.

A mobile phone produces both local and whole body exposure. Since a mobile phone is held so close to the body, it is the dominating local exposure that is estimated, but there is also whole body exposure for mobile phones, which includes a combination of local head/neck exposure and the exposure when the phone is near the rest of the body).

Q. How does the exposure from the NV Energy AMI network devices compare to the common RF exposure sources.

A. Figure 4 illustrates the relative exposure values:

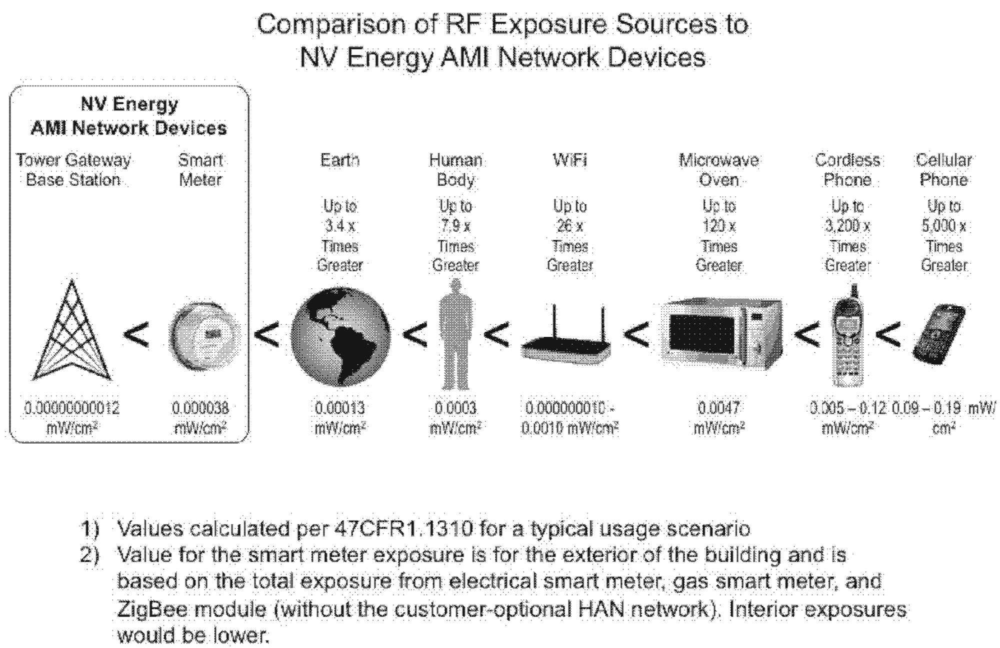

Figure 4: Comparison of common RF Exposure Sources to NV Energy AMI Network Devices

The NV Energy AMI network devices produce RF exposures that are lower than other common RF sources shown in Figure 4.

Q. With all this natural and man-made RF background, how can smart meters and the TGB detect the RF signals?

A. An individual smart meter and its corresponding TGB agree beforehand on what sequence of frequencies (in the 896 to 960 MHz range) they will communicate over. This allows them to track each other's transmission and reject the other sources of RF signal.

As an analogy, consider the task of meeting a friend in a very busy airport terminal. With thousands of people circulating in the terminal, it could be impossible to find your friend. If, however, you agree beforehand that you are going to meet at a specific location and then walk together through the terminal, thousands of people in the airport terminal are no longer interfering with your task.

Q. Will exposure be higher in the multi-tenant buildings where the meters are grouped and may even be located inside the building in electrical rooms?

A. Directly near the meter bank, the average power density will increase by approximately the amount that is equal to the number of meters in the bank. But typically, such installations will be located at a greater distance from the residential areas than a single meter installation. Since the exposure drops rapidly as a function of distance, it is unlikely that the exposure inside the building will exceed the values in Table 4**Error! Reference source not found.**. Moreover, all installations, including multiple units or banks of meters in the same location, must be compliant with public exposure limits (Knapp, 2010).

In addition, the need for orderly communication between multiple devices and TGBs impose practical limits on the number of smart meters that are sending messages at any given time. Finally, the distance between meters (as dictated by the size of the meter) effectively reduces exposure at a given point because exposure decreases significantly in relationship to the distance from the meter. Consequently, as Knapp notes, "Irrespective of duty cycle, based on the practical separation distance and the need for orderly communications among several devices, even multiple units or "banks" of meters in the same location will be compliant with the public exposure limits."

Q. If all the neighboring houses have smart meters, does that increase the exposure inside my residence?

A. Since the exposure drops rapidly as a function of distance from a transmitter, the smart meters mounted on neighboring houses do not add appreciably to the exposure values listed in Table 4.

Q. Do smart meters communicate using pulsed or pulse modulated RF signals?

A. Smart meters that are part of the NV Energy AMI network do not use pulsed or pulsed modulated signals. To transmit the utility-use information to NV Energy, the smart meter uses a message of approximately 107 milliseconds[11] (1 millisecond is 1/1,000 of a second). Electrical meters will typically transmit 28 messages a day.[12] Gas meters will typically transmit six messages a day.[13] This message is transmitted using a constant amplitude modulation method. That is, during the transmission, the RF signal oscillations have constant amplitude. When the message is completely transmitted, the RF signal oscillations cease. The smart meter's RF transmitter is turned off until the next message needs to be sent out. This type of transmission is considered to be a burst rather than a pulsed or pulse modulated communication.[14] The RF signal from transmitting smart meters, however, is always oscillating,[15] i.e., not generating pulses.[16]

This is exactly the same way that a microwave oven operates when set at less than 100%. For example, when set at 10%, a microwave oven will first use 100% power output, then switch to 0% output, then use 100% power output, and 0% again (and so on) maintaining an average output of 10%. These periodic changes as the microwave changes power output during cooking. While cooking, the power output varies between 100% power output and 0% power output. Thus, like the NV Energy AMI smart meter, it turns on and off.

Q. How many seconds total a day does the NV Energy AMI network smart meters transmit a day?

A. The NV Energy AMI network's electrical smart meter typically transmits a total of 3 seconds per day. Gas smart meters typically transmit a total of less than 1 second

[11] Maximum message length in the current installation is 215 milliseconds. 99% of the meters use message length that is less than or equal to 107.40 milliseconds.
[12] 95% of currently installed electrical smart meters send 28 or less messages a day. The maximum number of messages a day sent in the current installation is 194.
[13] All gas meters are expected to send less than seven messages a day.
[14] A burst is defined as a wave or waveform composed of a pulse train or repetitive waveform that starts as a prescribed time and/or amplitude, continues for a relatively short duration and / or number of cycles, and upon completion returns to the starting amplitude (IEEE:Standard Dictionary of Electrical and Electronics Terms 100. IEEE, 1988).
[15] Oscillation is defined as a Fluctuation or vibration on each side of a mean value or position (http://www.hq.nasa.gov/office/hqlibrary/aerospacedictionary/508/o.html)
[16] Pulse is defined as a variation of a quantity whose value is normally constant; this variation is characterized by a rise and a decay, and has a finite duration. http://www.hq.nasa.gov/office/hqlibrary/aerospacedictionary/508/p.html

per day. The ZigBee module inside the electric smart meter typically transmits less than 18 seconds a day.

Q. Do RF signals from Smart Meters pose a risk for people who have implanted medical devices such as pacemakers?

Medical device users should always follow the device manufacturer's and doctor's recommendations when they are in a vicinity of an RF transmitter, regardless of whether that transmitter is a smart meter, WiFi, cell phone, or cordless phone, or other device the emits RF fields (Knapp, 2010).

Typically, manufacturers of implanted cardiac devices and pacemakers and will recommend that a distance of 6 inches be maintained to a transmitter.[17]

For other medical devices, the information provided by the manufacturer should be the guideline. For example, Medtronic's InterStim Model 3023 Neurostimulator is accompanied by specific instructions (Figure 5)[18]

The following devices should **not** interfere with your InterStim System:

- Microwave ovens
- Televisions, AM/FM radios, stereos, cellular phones
- Tabletop appliances, such as toasters, blenders, electric can openers, food processors
- Hand-held items, such as hair dryers, shavers
- Appliances, such as washers, dryers, electric stoves
- Electric blankets and heating pads
- Vacuum cleaners, electric brooms
- Personal computers, electric typewriters, copiers, and fax machines

Figure 5. Example of medical device manufacturer's instructions

Q. Can RF signals from smart meters and NV Energy AMI network heat up medical implants?

[17] For a detailed discussion see OET 56-1999.

[18] Medtronic Inc., IntelliStim Therapy for Urinary Control Patient Manual, 1999.

A. The typical exposure from the smart meter is more than a factor of a 15,000 below the level that would be required to produce whole-body averaged SAR of 0.08 W/kg. By comparison, a typical limit on RF SAR recommended by medical device manufacturers is between 0.1 and 2 W/kg. [19]

Q. Do smart meters introduce noise into the power lines?

A. All smart meters listed in Table 3 passed a power line conducted emissions test (47CFR15.107) as part of the equipment authorization process. This test verifies compliance with a limit of the signal that a smart meter can introduce into the power lines. The detailed results for each meter can be located on the FCC website.

PERSPECTIVE ON GENERAL HEALTH CONCERNS

Q. Concerns have been raised in comments about a variety of symptoms and nervous system responses either experienced by a few commenters in the vicinity of smart meters or from information obtained from postings on internet websites. Is there a good scientific basis for the idea that RF fields from the NV Energy AMI network would be capable of eliciting such effects?

A. There has been a long history of biomedical research that has observed human and animal subjects as well as the responses of cells and tissues for varying periods of time, ranging from a few minutes or for most of a lifetime that provides us with considerable data to evaluate the possible scientific basis for such assertions.

Our response to comments filed with the Commission on this topic (Exponent, 2011) summarized the conclusions of five national and international health and scientific agencies. It is clear from the consistency of their conclusions that the weight of the evidence fails to support the assertions in the comments. The research supports the absence of adverse effects on the subjects of these studies over a wide range of RF exposure intensities. The very weak RF signals from the NV Energy AMI network further underscores the implausibility that any responses observed are due to exposure to RF signals.

---

[19] http://www.mrisafety.com/safety_article.asp?subject=139

Q. The topic of electromagnetic hypersensitivity was also raised by some persons who believe that health conditions or hypersensitivity to RF fields might make them especially vulnerable to aggravating influence of signals from the NV Energy AMI network. What can one conclude from scientific research on this topic?

A. This notion has gained the attention of persons who are seeking an explanation for their symptoms or who are trying to avoid exposures that appear to be coincidental with symptoms. Our review of the research literature failed to provide persuasive support for a causal relationship between exposure to weak RF fields and a variety of subjective symptoms. This view is shared by the WHO and other agencies who recommend that such symptoms be termed idiopathic environmental intolerance (IEI) because there is no confirmed link to RF fields or other types of EMF.

We summarized the assessments of research by five national and international agencies in our response to comments filed with the Commission on this topic (Exponent, 2011). Altogether, all of these agencies concluded that the scientific evidence failed to support the existence of an effect of RF fields on self-reported symptoms. That does not mean that there is not some basis for the symptoms that some people experience; it just means that exposure to RF fields is not at all likely to be the cause.

This topic was also addressed by Dr. James Kornberg, M.D. and his report concludes that there is no convincing evidence for human hypersensitivity to electromagnetic fields in general and in particular to the RF fields with power densities and frequencies associated with NV Energy's AMI network (Kornberg, 2011). In addition, there is no recognized medical diagnostic category for a link to effects pf RF or EMF exposure.

QUALITY OF EVIDENCE SUPPORTING ASSERTIONS IN COMMENTS

Q. Would you please comment on the quality of the evidence that some commenters have relied upon as support for their assertions of likely harm from exposure to RF signals from the NV Energy AMI network?

A. Almost the entirety of the evidence provided in submissions relevant to RF health and safety issues consists of anecdotal observations, postings on internet sites, and opinions offered by a small group of scientists. Such data are wholly inadequate for assessing potential health risks of RF exposure. As mentioned above, the requirement for a scientific assessment of health risks that scientific and health agencies perform requires an examination of all the available high-quality data and an objective review process.

Q. Can you single out a source of information that informed a good number of comments filed with the Commission that does not pass scientific muster?

A. Many of the assertions and opinions relevant to the assessment of biological effects of RF fields cite a small group of scientists whose opinions have not been accepted by most experts. The wellspring for these opinions is an unpublished document that has been posted on the internet by its authors (the BioInitiative Report), which has not been peer reviewed by a scientific journal. The authors of the report most widely cited in comments include Cindy Sage, Dr. Johansson, Dr. Carpenter, and Martin Blank, Ph.D. Cindy Sage is also the author of a critique of RF health and safety issues that is posted on the Internet and also referenced in comments. The main conclusion of the BioInitiative Report is that existing standards for exposure to RF fields are insufficient because "effects are now widely reported to occur at exposure levels significantly below most current national and international limits."

Based on our own review of the scientific research on RF and the many reviews of that research conducted by credible scientific panels, the Bioinitiative Report is not an objective or reliable source for information about RF exposure. To be persuaded that any effect occurred below exposure limits, the research would need to show two things: 1) that the effects reported in well-designed single studies were replicated, and 2) that the reported effects were reliable indicators of adverse effects on the health or functional ability of an intact living organism. These requirements have not been fulfilled. Reviews from public health agencies and national and international scientific organizations in the United States, United Kingdom, and Europe offer conclusions that contrast starkly with the alarmist statements in the Bioinitiative Report about health risks of RF fields and the need for lower exposure limits.

Q. Yet some articles have appeared in a peer-reviewed journal by some of the authors of the Bioinitiative Report and others that do suggest that some laboratory and epidemiologic studies indicated that the risk to human health of exposure to RF fields is significant. What is your comment?

A. Based on our review of the papers in that issue of *Pathophysiology*, we have not found the material to be persuasive. These papers resemble that of the BioInitiative report; they essentially repeat the conclusions of that report, and still rely upon flawed methods for drawing conclusions. It should be noted that the Editor for the special issue of the journal *Pathophysiology* that published these papers was Dr. Blank, a contributor to the BioInitiative Report. As Editor of this special issue, he would have solicited authors to submit manuscripts, selected reviewers of the manuscripts, and signed off and approved all manuscripts.

Q. What are the flaws that affect the conclusions of the BioInitiative Report?

A. The authors of the BioInitiative Report have not followed the standard, scientific methods for developing exposure limits. Other organizations that have reviewed the RF research, or the research for many other exposures, follow a procedure that includes a systematic evaluation of the entire body of scientific evidence. This includes three areas of research: epidemiology studies, *in vivo* studies, and *in vitro* studies. After evaluating the quality of individual studies and consistency of results, exposure limits are developed to prevent exposures at intensities of RF fields where adverse health effects have been reliably reported.

In contrast, the conclusions in the BioInitiative Report are not based on this weight-of-evidence, multidisciplinary approach. The authors of the BioInitiative Report argue that this systematic approach should be replaced by a process that sets guidelines at exposure levels where biological effects have been reported in some studies, even if they have not been substantiated or linked to adverse health effects. Instead of a comprehensive review, the BioInitiative Report cites results from specific studies, but provides no rationale for their inclusion or an explanation why many other relevant, published studies were not considered. One striking omission is that the BioInitiative Report does not discuss the results from whole animal (*in vivo)* studies, which are considered an important indicator of the potential hazard from any exposure. Instead, the BioInitiative Report's approach gives disproportionate weight to the results of *in vitro* studies that report biological effects in isolated cells or tissues that have been selectively 'cherry-picked' from a much larger literature.

Q. Has the larger scientific community considered the BioInitiative Report?

A. Yes and their comments are not favorable. The scientific agencies that have prepared written reviews of the report commented that the BioInitiative Report did not follow the methods of a standard weight-of-evidence review and, for this reason, its conclusions and recommendations were not convincing (EC, 2007; HCN, 2008; ACRBR, 2009; COMAR, 2009). EMF-NET, a project funded by the European Commission[20] wrote, "There is a lack of balance in the report; no mention is made in fact of reports that do not concur with authors' statements and conclusions. The results and conclusions are very different from those of recent national and international reviews on this topic" (EC, 2007).[21] The Australian Centre for RF Bioeffects Research (ACRBR) wrote, "As it stands it merely provides a set of views that are not consistent with the consensus of science, and it does not provide an

[20] EMF-NET is a Coordination Action that aims to provide a framework for the coordination of the results of the research activities related to the biological effects of electromagnetic fields, considering also the potential risks related to exposure in the working environment (occupational exposure). http://web.jrc.ec.europa.eu/emf-net/aims.cfm

[21] http://emf-net.isib.cnr.it

analysis that is rigorous-enough to raise doubts about the scientific consensus" (ACRBR, 2009)

Q. The BioInitiative Report suggests that there are adverse biological effects at levels below current RF exposure limits set by national and international agencies. Such effects are alleged to occur at exposure levels that do not cause tissue heating, i.e., athermal effects.

. Yes. But to date, evaluations of the scientific evidence for biological effects at levels below those attributable to heating have not concluded that the data supporting such effects is persuasive, given the limited quantity, quality, and inconsistencies of the data, e.g., ICNIRP (2009), SCENIHR (2009). However, studies continue to be performed to test for possible effects at lower levels of exposure, and are periodically evaluated by agencies, given that the common exposures to RF fields all occur at levels well below recommended limits for public exposure. As part of the work towards evaluating and updating the ICNIRP standard, this agency invited scientists from around the world to participate in an international seminar on the topic of non-thermal RF electromagnetic fields (ICNIRP, 1997)

Evaluations of the scientific evidence for biological effects at levels below those attributable to heating, however, have not concluded that the data supporting such effects is persuasive, given the limited quality of some of the data, and inconsistencies within the data (e.g., ICNIRP, 2009; SCENIHR, 2009). But studies continue to be performed to test for possible effects at lower levels of exposure and are periodically evaluated by agencies because *the common public exposures to RF fields all occur at levels well below recommended limits for public exposure*. The International Commission for Non-Ionizing Radiation Protection (ICNIRP), for example, in its review of the research literature in 2009 concluded:

> It is the opinion of ICNIRP that the scientific literature published since the 1998 guidelines has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high

> frequency electromagnetic fields. The biological basis of such guidance remains the avoidance of adverse effects such as "work stoppage" caused by mild wholebody heat stress and/or tissue damage caused by excessive localized heating (D'Andrea et al. 2007). With regard to non-thermal interactions, it is in principle impossible to disprove their possible existence but the plausibility of the various non-thermal mechanisms that have been proposed is very low. In addition, the recent in vitro and animal genotoxicity and carcinogenicity studies are rather consistent overall and indicate that such effects are unlikely at low levels of exposure. Therefore, ICNIRP reconfirms the 1998 basic restrictions in the frequency range 100 kHz–300 GHz until further notice (p. 257).

Q. Do these standard-setting organizations deny that there are any athermal biological effects?

A. No, there are a variety of mechanisms by which RF fields have been demonstrated to affect components of biological tissues other than by frank heating. These include induced charge and dipole relaxation, pearl-chain formation (the linear rearrangement of molecules and cells into chains), changes in the shape and permeability of cells, and the "microwave hearing effect." All of these interactions can occur without appreciable tissue heating and so are athermal mechanisms (ICNIRP, 2009a). The latter is interesting because it occurs due to a rapid pressure wave within the inner ear which, like sound, moves hair cells to stimulate the perception of sound. The peak power density required to elicit this perception in the frequency range of signals transmitted by a smart meter is estimated to be 5-20 kilowatts per square meter (kW/m^2) (ICNIRP, 2009a), some 10,000,000 times greater than the typical exposure (and 1,000 times greater than even peak power density) produced by the NV Energy AMI network.

Thus, despite the athermal nature of these effects, they occur to a significant extent only at exposure intensities greater than those that produce tissue heating. Hence, there are confirmed athermal effects, but none that would be relevant to an explanation for biological responses at levels below that associated with adverse effects of RF heating, i.e., LOAEL.

Q. If the authors of the BioInitiative Report are not correct, then why is WHO still investigating RF? Doesn't this mean the public should be concerned?

A. No. The public should appreciate that the ongoing role of the WHO in "investigating" or monitoring and reviewing the research is a cautionary measure. The results of their activities can be found at the website of the International EMF Project that includes fact sheets for the public on RF andEMF.[22] Other WHO actions include the recommendation that all countries worldwide consider adopting the ICNIRP guidelines and their scheduled written review of the research to update their 1993 Environmental Criteria Document monograph (WHO, 1993). Because virtually everyone in developed countries has exposures to RF fields from different sources, it is important to make sure that even the slightest possibility of a risk has not been overlooked.

PERSPECTIVE ON HEALTH CONCERNS RAISED ABOUT CANCER

Q. Are you aware that the most common concern expressed in public comments about the smart meter was cancer and the press release by the WHO[23] about a report from the International Agency for Research on Cancer (IARC) that RF fields would fall into the category of a possible human carcinogen (2 B)?

A. Yes, we read of this concern in the comments submitted to the Commission and have provided the perspective of four international health and scientific agencies to address this concern. The consensus expressed in these reviews and evaluations of the scientific evidence in areas of human epidemiology, as well as experimental laboratory studies, is that evidence is limited that cancer develops from exposures to RF fields, and the indications of potential risk derive almost entirely from statistical

---

22 http://www.who.int/peh-emf/en/

23 The WHO is commonly cited in the media as the author of the report, but it was authored by the IARC. The WHO commissioned the IARC to evaluate the potential carcinogenic hazard of exposure to RF fields. So the report here is referred to as the IARC report and a summary of the report by Robert Baan and his colleagues at IARC written on behalf of the WHO is indicated by reference to Baan et al., 2011.

associations in some studies between the use of mobile phones and certain types of cancer. These associations are generally regarded as not being supported by the results of experimental laboratory studies of animals and cells.

In light of the comments to the Commission arising from the IARC's classification, it is important to give this special attention. Therefore, the following Q & A discussion will focus on the recent comprehensive review by ICNIRP (2009) and the IARC report in four specific areas:

1. Studies of cancer from RF sources other than mobile phones.

2. Studies of brain tumors and mobile phone use.

3. Studies addressing other cancers and mobile phoneuse.

4. A discussion of the IARC classification.

This summary of the IARC and ICNIRP reports together with the other current reviews of RF exposure and cancer and other potential effects provides a broad survey of current knowledge about RF exposure and health. In the case of the IARC report, the details supporting the main conclusions and evaluation have yet to be published, which is a limitation to the summary below.

Q. What research did the IARC review that may be most relevant to smart meters?

A. The studies described below cover a broad range of exposure levels. The highest exposures are typically found in experimental studies of laboratory animals; chronic bioassays expose animals at various RF levels (some at or above the effect level) for nearly their entire lifespan. Some laboratory studies look for effects in cells at low RF levels, as well. The highest RF exposure levels in human studies are those in epidemiology studies of either occupational exposure or mobile phone exposure. The lowest RF exposure levels are those epidemiology studies of community exposures to RF fields from radio and other transmitter antennas. Such studies involve exposures that are closer to that of smart meters than mobile phones

Data on laboratory animals has been reviewed by ICNIRP (2009) and most recently by the IARC (Baan et al., 2011). The 2009 ICNIRP review focused on papers published after 1993. Several cancers have been studied including brain tumors, lymphoma, mammary tumors, skin tumors, and colon tumors in a number of experimental models including rodent bioassays, studies using genetically predisposed animals, and co-carcinogenicity studies. ICNIRP concluded that the cellular and animal genotoxicity and carcinogenicity studies are consistent and indicate that cancer-related effects are unlikely at SAR levels up to 4 W/kg. The IARC summary report (Baan, et al., 2011) noted that none of the seven chronic bioassays showed an increased incidence of any tumor type in tissues and organs in animals exposed to RF-electric and magnetic fields (RF-EMF) for 2 years (Baan et al., 2011). In addition, increased cancer incidence in exposed animals was observed in 2 of 12 studies with tumor-prone animals and in 1 of 18 studies using initiation-promotion protocols.[24] Based on these data, the IARC concluded that there was "limited evidence" in experimental animals for the carcinogenicity of RF-EMF (Baan et al., 2011).

Data on occupational exposure and cancer has been reviewed by ICNIRP (2009) and also by the IARC (Baan et al., 2011). In most of the studies, exposure was assessed by using occupation or job title as a proxy for exposure. ICNIRP concluded that there was no cancer site for which there was consistent evidence that occupational exposure to RF fields affects the risk of cancer. The IARC summary report (Baan et al., 2011) noted that studies of occupational exposure have investigated brain tumors, leukemia, lymphoma, and other types of malignancy including uveal

[24] Initiation is the first stage in the development of cancer; initiation typically results from exposure to an agent that can cause mutations in a cell. Promotion is a later stage in cancer development, following initiation. If there is sufficient exposure to the agent, promoters increase the frequency of tumor formation that occurs after initiation.

melanoma and testicular, breast, lung, and skin cancers. The IARC noted that these studies had methodological limitations and the results were inconsistent (Baan et al., 2011).

Data on exposure from transmitters, including towers that transmit radio, television, microwave, and cellular telephone signals, were reviewed by ICNIRP (2009) and the IARC (Baan et al., 2011). Most of the studies reviewed have been geographic correlation studies with no individual exposure assessment, with the exception of two studies of childhood leukemia that assessed individual exposure using information from radio transmitters (ICNIRP 2009). ICNIRP concluded that the results of these studies based on community exposure have been inconsistent both within and between studies and do not show a relationship with RF exposure. The IARC Working Group reviewed studies that addressed environmental exposure to RF-EMF and cancer, but found the available evidence insufficient for any conclusion (Baan et al., 2011).

Q. Over more than a decade the media has reported on epidemiology studies of cancer in human populations in relation to the use of mobile phones. What do these studies report?

Numerous case-control studies and one cohort study have been conducted to investigate the risk of brain tumors from mobile phone use, including the large multi-site, multi-national project coordinated by the IARC. This project, referred to as the INTERPHONE study involves 13 case-control studies conducted in European countries, Japan, Israel, Canada, New Zealand, and Australia (Cardis et al., 2007). It includes epidemiologic studies on malignant brain tumors, focusing on glioma, and non-malignant brain tumors including meningioma and acoustic neuroma, as well as other cancer outcomes (e.g. salivary and parotid gland tumors) from a few of the studies. A majority of the published epidemiologic studies to date from the INTERPHONE study have not reported an increased risk of mobile phone use and brain tumors; however positive associations have been reported for some tumor types in several studies in subgroups defined by latency period or ipsilateral use (the side of head where the mobile phone is predominantly used, compared with the location of the tumor). Other than a recent Japanese study (Takebayashi et al., 2008), which incorporated estimates of SAR in their exposure protocols, all published epidemiologic studies to date have relied solely on self-reported estimates of the amount of time the mobile phone was used. A recent pooled analysis that included all glioma and meningioma cases reported an odds ratio (OR) below 1.0,[25] indicating no positive association, and also did not indicate an increase in risk for longer duration of phone use including duration of over 10 years (INTERPHONE, 2010). The only positive association was observed for the highest category of cumulative call time. The authors reported that limitations, including recall and selection bias, may have influence over the results. Recall bias was possible because the exposure to mobile phone use was self-reported and recall may have been more difficult for long duration users or use in the distant past. Nonparticipation was also suggested as a source of selection bias since participating controls had a higher percentage of mobile phone use compared to non-participating controls.

Several studies have also been published based on data from a Swedish case-control study population (Hardell et al., 2002a, 2002b, 2004b, 2005a, 2006a, 2006b, Mild et al., 2007; Hardell et al., 2011). Briefly, the study population included cases of malignant and benign brain tumors diagnosed between 1997 and 2003 from selected (not all) Swedish regional cancer registries matched to one control based on age, sex, and residence identified from the Swedish population registry. Use of mobile phones was obtained from a questionnaire with follow-up by telephone interview. The results from all the Swedish (non-INTERPHONE)[26] studies suggest an association of brain tumors with use of mobile phones, particularly among those in the longer latency groups. The authors noted that they have controlled for, or have no evidence of, recall bias given that they have observed various associations across

25 A pooled analysis combines individual-level data across many studies and analyzes the data together to get a summary estimate of the association between a particular exposure and disease. An odds ratio is a measure of association that describes the ratio of the odds of exposure among persons with a disease to the odds of exposure among persons without a disease.

26 These studies were not included data used in the INTERPHONE Group's studies.

different tumor types. This observation, however, is not sufficient to rule out the possibility of recall bias, and given the case-control study design and methods used for collecting exposure information, recall and reporting bias may still influence the results of these studies. These studies include multiple comparisons among the numerous variables, such that the elevated ORs must be considered in the context of extensive exploratory analyses. The results of these studies, which used a different methodology than the INTERPHONE study protocols, reported the highest ORs, and generally are not consistent with all other epidemiologic studies. It is important to note that other Swedish studies that have relied on standard scientific procedures to identify cases from Swedish cancer registry data have not reported such associations.

To date there has only been one cohort study that has reported results of cancer risks among mobile phone users (Schuz et al., 2006). Most recently, results from this cohort have been published extending the follow-up period to 2007 (Frei et al., 2011). The authors analyzed the records of 420,095 mobile phone subscriptions in Denmark and compared them to the Danish Cancer Registry. In the most recent publication, the authors also linked their subscription and cancer data with a cohort study that included socioeconomic data such as education and income. Since this study was looking at subscriptions to mobile phone service as the indicator of mobile phone use exposure, it is not prone to recall bias that is potentially present in the case-control studies, which were based on self-reported exposure. Exposure could be misclassified, however, if the subscriber was not the primary user of the mobile phone or if there is substantial variation of phone use across the group labeled as subscribers. For example, users of mobile phones that were not listed as subscribers would not be identified and would be classified as unexposed in this cohort design. Overall, the authors concluded that no increased risk of brain tumors, acoustic neuromas, salivary gland tumors, eye tumors, leukemias, or overall cancer was observed in their large cohort study (Frei et al., 2011).

Another line of evidence should be considered. The incidence of brain tumors in the United States has appeared to stabilize or even decrease over time since the 1980s

(Deorah et al., 2006), and similarly Denmark, Finland, Norway, Sweden (Lonn et al., 2004; Deltour et al., 2009), Switzerland (Roosli et al., 2007), and New Zealand (Cook et al., 2003), during a period of substantially increased mobile phone use. If the increased risks suggested by the INTERPHONE Study and the Swedish case-control studies conducted by Hardell and associates were correct, we would expect to see an increase in the annual rates of brain cancer, particularly over the period of 10 years or more after mobile phone use became widespread. The data do not indicate that the occurrence of brain cancer has increased over time.

The majority of estimates of relative risk[27] results reported to date for mobile phone use and brain cancer are near 1.0 (i.e., no association) or lower. Based on the epidemiologic literature to date, these epidemiologic data have not established any consistent or strong association between mobile phone use and cancer.

Q. What is the evidence from epidemiology studies for a relationship between mobile phone use and other cancers?

A. The results of mobile phone use and risk of cancers other than brain tumors do not suggest a causal association. Conclusions based on the studies investigating other tumor sites such as parotid and salivary gland tumors (Hardell et al. 2004a; Lonn et al., 200; Sadetzki et al., 2008), non-Hodgkin's lymphoma (Hardell et al., 2005b; Linet et al., 2006), uveal melanoma (Stang et al., 2009), testicular cancer (Hardell et al., 2006c; 2007), and intratemporal facial nerve tumors (Warren et al., 2003) are limited by the small number of studies published, however, a majority indicate no associations with use of mobile phones. The study of parotid gland tumors in Israel (Sadetzki et al., 2008) reported increased risk with heavy and longer term use of mobile phones that was not consistent with the other two studies reporting no associations (citation).

27 Similar to an odds ratio, a relative risk is an estimate that compares the risk of disease among persons who are exposed to the risk of disease among persons who are unexposed. Relative risk estimates are reported in cohort studies, while odds ratios are reported in case-control studies.

In their assessment of EMF exposure, the European Health Risk Assessment Network on Electromagnetic Field Exposure (EFHRAN) concluded there was inadequate evidence to demonstrate risk of gliomas and meningiomas from mobile phone use (EFHRAN, 2010a). Their review included the recent pooled INTERPHONE study of gliomas and meningiomas (. There was not sufficient evidence for a causal association between exposure and the risk of disease for any of the diseases they reviewed. Based on a review of the epidemiological data available, ICNRIP concluded that despite the methodologic shortcomings and limited data on latency and long-term use, the available data do not suggest a causal association between mobile phone use and gliomas (ICNIRP, 2009).

Q. The status of research as summarized by the IARC panel of scientists seems rather consistent with that summarized by other panels of scientists, so please explain how the research was classified by IARC.

A. According to the preamble for IARC Monographs, the IARC Working Group gathers evidence from epidemiology, *in vivo*, and *in vitro* studies and evaluates the strength of the evidence for carcinogenicity. Based on their conclusions from the strength of the evidence, the Working Group assigns the agent, in this case RF energy, to a category ranging from 1 to 4, with 1 as the category for an agent classified as "carcinogenic to humans" and 4 as the category for an agent classified as "probably not carcinogenic to humans." A 2B classification of "possibly carcinogenic to humans" is defined by the IARC, as follows:

> This category is used for agents for which there is *limited evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals. It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances an agent for which there is *inadequate evidence of*

carcinogenicity in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data (emphasis added).

In a publication summarizing the classification of RF energy as 2B, Baan et al. (2011) indicate that the Working Group considered one cohort study and five case-control studies that were judged to provide useful information regarding gliomas and mobile phone use. Ultimately, the Working Group considered the recent results of the pooled INTERPHONE study (2010) and a recent analysis by the Swedish research group (Hardell et al 2011). The Working Group concluded that although both studies were susceptible to biases, the results suggesting the risk of gliomas after exposure for 7 or more years prior to diagnosis "could not be dismissed" and that a causal interpretation was possible (Baan et al 2011). The details of the review and conclusions by the Working Group are to be provided in a future Monograph by the IARC, yet to be published.

In a response to the classification of RF energy as 2B, the members ICNRIP again reviewed the epidemiologic data on brain tumors, gliomas and meningiomas, and the use of mobile phones (Swerdlow et al., 2011). Particular limitations noted by the authors were that the participation rates of INTERPHONE were low, suggesting the possibility of selection bias. In addition, the INTERPHONE study group has identified evidence of recall bias that has an influence over the results of the study. The authors note that the methodological deficits of the INTERPHONE study limit the conclusions that are drawn from the results. When the results of the INTERPHONE study are placed in the context of other epidemiologic, biological, and animal studies, this review concludes that there is unlikely to be an increase in the risk of brain tumors in adults from cell phones.

Q. How does this research affect our perspective on the very low exposures to RF signals that occur from the NV Energy AMI network?

A. While the results of two studies (pooled INTERPHONE 2010 and Hardell et al 2011) suggest a possible increased risk of gliomas with high mobile phone use, the epidemiologic data does not support the presence of a causal association between brain and other tumors and use of mobile phones, which is consistent with available evidence from animal and mechanistic research. Based on epidemiology studies in people who use mobile phones, that provided "limited evidence of carcinogenicity," the IARC Working Group classified RF energy in the category of "possibly carcinogenic to humans" (Group 2b) (Baan 2011). Other groups reviewing the same information have concluded that RF energy is not likely to cause cancer and that the addition of new data from INTERPHONE does not change their conclusion (EFHRAN 2010, ICNIRP 2009).

Q. What is your opinion regarding the health effects of the Smart Meter?

A. Our opinion is that to a reasonable degree of scientific certainty here is not a reliable scientific basis to conclude that the RF signals that are used to communicate between devices on the NV Energy AMI network will cause or contribute to adverse health effects in the population.

References

American National Standards Institute (ANSI). Safety levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz. Report No ANSI C95.1-1982. New York: ANSI, 1982.

Ahlbom A, Green A, Kheifets L, Savitz D, Swerdlow A. ICNIRP Standing Committee on Epidemiology. Epidemiology of health effects of radiofrequency exposure. Environ Health Perspect 112:1741-1754, 2004.

Ahlbom A, Feychting M, Green A, Kheifets L, Savitz DA, Swerdlow A, ICNIRP Standing Committee on Epidemiology. Epidemiologic evidence on mobile phones and tumor risk – a review. Epidemiology 20:1-14, 2009.

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

Aydin D, Feychting M, Schuz J, Tynes T, Andersen TV, et al. Mobile phone use and brain tumors in children and adolescents: A multicenter case-control study. J Natl Cancer Inst 203:1264-1276, 2011.

Baan R, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V. Benbrahim-Talla L, Guha N, Islami F, Galichert L, Straif K, WHO International Agency for Research on Cancer Working Group. Carcinogenicity of radiofrequency electromagnetic fields. Lancet Oncol 12:624-626, 2011.

Barth A, Ponocny I, Gnambs T, Winker R. No effects of short-term exposure to mobile phone electromagnetic fields on human cognitive performance: A meta-analysis. Bioelectromagnetics [E-pub ahead of print], 2011.

Bernhardt JH, Matthes R, Repacholi MH (eds) Non-thermal Effects of RF Electromagnetic Fields. Oberschleiβheim, Germany: ICNIRP, 1997.

Blackman CF, Benane SG, House DE, Joines WT. Effects of ELF (1-120 Hz) and modulated (50 Hz) RF fields on the efflux of calcium ions from brain tissue in vitro. Bioelectromagnetics 6:11, 1985.

California Council on Science and Technology (CCST). Health Impacts of Radio Frequency from Smart Meters. Sacramento, CA: CCST, 2011. http://www.ccst.us/publications/2011/2011smartA.pdf

Cardis E, Armstrong BK, Bowman JD, Giles GG, Hours M, Krewski D, McBride M, Parent ME, Sadetski S, Woodward A, Brown J, Chetrit A, Figuerola J, Hoffmann C, Jarus-Hakak A, Montestruq L, Nadon L, Richardson L, Veillegas R, Vrijheid M. Risk of brain tumors in relation to estimated RF dose from mobile phones: results from five Interphone countries. Occup Environ Med 68:631-640, 2011.

Christensen HC, Schuz J, Kosteljanetz M, Poulsen HS, Boice JD Jr., et al. Cellular telephones and risk for brain tumors: a population-based, incident case-control study. Neurology 64:1189-1195, 2005.

Cook A, Woodward A, Pearce N, Marshall C. Cellular telephone use and time trends for brain, head and neck tumours. N Z Med J 116:U457, 2003.

Cooke R, Laing S, Swerdlow AJ. A case-control study of risk of leukaemia in relation to mobile phone use. Br J Cancer 203:1729-1735, 2010.

Cooper D, Hemmings K, Saunders P. Re: "Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter; II. All high power transmitters." Am J Epidemiol 153:202-204, 2001.

D'Andrea et al. 2007

Danker-Hopfe H, Dom H, Bomkessel C, Sauter C. Do mobile phone base stations affect sleep of residents? Results from an experimental double-blind sham-controlled field study. Am J Hum Biol 22:613-618, 2010.

Danker-Hopfe H, Dorn H, Bahr A, Anderer P, Sauter C. Effects of electromagnetic field emitted by mobile phones (GSM 900 and WCDMA/UMTS) on the macrostructure of sleep. J Sleep Res 20:73-81, 2011.

Danker-Hopfe H, Dorn H, Bornkessel C, Sauter C. Do mobile phone base stations affect sleep of residents? Results from an experimental double-blind sham-controlled field study. Am J Hum Biol 22:613-618, 2010.

de Vocht F, Burstyn I, Cherrie JW. Time trends (1998-2007) in brain cancer incidence rates in relation to mobile phone use in England. Bioelectromagnetics 32:334-339, 2011

Deltour I, Johnasen C, Auvinen A, Feychting M, Klaeboe L, Shuz J. Time trends in brain tumor incidence rates in Denmark, Finland, Norway, and Sweden 1974-2003. J Natl Cancer Inst 101:1721-1724, 2009.

Deorah S, Lynch CF, Sibenaller ZA, Ryken TC. Trends in brain cancer incidence and survival in the United States: Surveillance, Epidemiology, and End Result Program, 1973-2001. Neurosur Focus 20:E1, 2006.

Department of Health and Human Services (DHHS). The Health Consequences of Smoking: A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. 2004.

Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliott P. Cancer incidence near radio and television transmitters in Great Britain, I. Sutton Coldfield transmitter. Am J Epidemiol 145:1-9, 1997a.

Dolk H, Elliot P, Shaddick G, Walls P, Grundy C, Thakrar B. Cancer incidence near radio and television transmitters in Great Britain, II. All high power transmitters. Am J Epidemiol 145:10-17, 1997b.

Eger H, Hagen KU, Lucas B, Vogel P, Voit H. The influence of being physically near to a cell phone transmission mast on the incidence of cancer. Umwelt Medizin Gessellschaft 17:1-7, 2004.

Elliott P, Toledano MB, Bennett J, Beale L, de Hoogh K, Best N, Briggs DJ. Mobile phone base stations and early childhood cancers: case-control study. BMJ 340:c3077. 2010.

Elwood JM. Causal relationships in medicine: a practical system for critical appraisal. Oxford: Oxford University Press, 1988.

Erdreich LS and Klauenberg BJ. Radio frequency radiation exposure standards: considerations for harmonization. Health Physics 80: 431-439, 2001.

European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN). Risk analysis of human exposure to electromagnetic fields. Report D2 of the EFHRAN project, July 2010a.

European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN). Report on the analysis of risks associated to exposure to EMF: *in vitro* and *in vivo* (animals) studies. Report D3 of the EFHRAN project, July 2010b.

Exponent. Technical Memorandum: Reply to Written Comments Raised by Customers on NV Energy's Advanced Service Delivery Program – Health and Safety of Exposure to Radiofrequency signals, December 1, 2011

Federal Communications Commission (FCC). Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be approved. 47 CFR § 1.1307:296-301, 2010a.

Federal Communications Commission (FCC). Radiofrequency radiation exposure limits. 47 CFR § 1.1310:302, 2010b.

Federal Communications Commission (FCC). Radiofrequency radiation exposure evaluation: mobile devices. 47 CFR § 2:1091:648-650, 2010c.

Federal Communications Commission (FCC). Radiofrequency radiation exposure evaluation: portable devices. 47 CFR § 2:1093:650, 2010d.

Federal Communications Commission Office of Engineering & Technology, OET Bulletin 56, "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields," 1999.

Feychting M. Mobile phones, radiofrequency fields, and health effects in children – Epidemiological studies. Prog Biophys Mol Biol 107:343-348, 2011.

Frei P, Poulsen AH, Johansen C, Steding-Jenssen M, Schuz J. Use of mobile phones and risk of brain tumours: update of Danish cohort study. BMJ 343:d6387, 2011.

Gajda G, Thansandote A, Lemay E, McNamee J, Bellier PV. Estimation of ambient electric fields generated by dirty electricity from compact fluorescent lamps. Ottawa: Health Canada, Consume and Clinical Radiation Protection Bureau, 2010.

Hardell L, Hallquist A, Mild KH, Carlberg M, Pahlson A, Lilja A. Cellular and cordless telephones and the risk for brain tumours. Eur J Cancer Prev 11:377-386, 2002a.

Hardell L, Mild KH, Carlberg M. Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours. Int J Radiat Biol 78:931-936, 2002b.

Hardell L, Mild KH, Carlberg M. Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours. Int J Radiat Biol 78:931-936, 2002b.

Hardell L, Eriksson M, Carlberg M, Sundstrom C, Mild KH. Use of cellular or cordless telephones and the risk for non-Hodgkin's lymphoma. Int Arch Occup Environ Health 78:625-632, 2005b.

Hardell L, Carlberg M, Hansson MK. Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997-2003. Int J Oncol 28:509-518, 2006a.

Hardell L, Carlberg M, Hansson MK. Pooled analysis of two case-control studies on use of cellular and cordless telephones and the risk for malignant brain tumours diagnosed in 1997-2003. Int Arch Occup Environ Health 79:630-639, 2006b.

Hardell L, Mild KH, Carlberg M, Soderqvist F. Tumour risk associated with use of cellular telephones or cordless desktop telephones. World J Surg Oncol 4:74, 2006c.

Hardell L, Carlberg M, Ohlson CG, Westerberg H, Eriksson M, Mild KH. Use of cellular and cordless telephones and risk of testicular cancer. Int J Androl 30:115-122, 2007.

Hardell L, Carlberg M, Mild KH. Pooled analysis of case-control studies on malignant brain tumours and the use of mobile phone and cordless phones including living and deceased subjects. Int J Oncol 38:1465-1474, 2011.

Heinrich S, Thomas S, Heumann C, von Kries R, Radon K. Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: a population based cross-sectional study. Environ Health 9:75, 2010.

Hennekens CH and Buring JE. Epidemiology in Medicine. Philadelphia, PA: Lippincott Williams & Wilkins, 1987.

Hill BA. The environment and disease: association or causation? Proc R Soc Med. 58:295–300, 1965.

International Agency for Research on Cancer (IARC). Mechanisms of carcinogenesis in risk identification. Introduction. Vainio H, Magee PN, McGregor DB, McMichael AJ (eds). IARC Sci Publ. No 116 pp. 1-5, 1992.

International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. Volume 80: static and extremely low-frequency (ELF) electric and magnetic fields. Lyon, France: IARC Press, 2002.

International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. Preamble. World Health Organization International Agency for Research on Cancer. Lyon, France. 2006.

IEEE. IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields 3 kHz to 300 GHz (Std C95.1-2005), 2005.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74:494-522, 1998.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). General approach to protection against non-ionizing radiation. Health Phys. 82:540-548, 2002.

International Commission on Non-ionizing Radiation Protection (ICNIRP). Draft Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Phys 96:504-514, 2009a.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Review of the scientific evidence on dosimetry, biological effects, epidemiological observations, and health consequences concerning exposure to high frequency electromagnetic fields (100 kHz to 300 GHz). Oberschleißheim, Germany: ICNIRP, 2009b. http://www.icnirp.de/documents/RFReview.pdf

The INTERPHONE Study Group. Brain tumor risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int J Epidmeiol 39: 675-694, 2010.

The INTERPHONE Study Group. Acoustic neuroma in relation to mobile telephone use: Results of the INTERPHONE international case-control study. Cancer Epidemiol, 2011. doi:10.1016/j.canep.2011.05.012.

The INTERPHONE Study Group. Brain tumor risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int J Epidmeiol 39: 675-694, 2010.

Knapp J. Letter from Julius P. Knapp, Chief, Office of Engineering and Technology, FCC to Cindy Sage, August 6, 2010.

Kornberg J. Letter to H.H. Shafferman, December 1, 2011.

Linet MS, Taggart T, Severson RK, Cerhan JR, Cozen W, Hartge P, Colt J. Cellular telephones and non-Hodgkin lymphoma. Int J Cancer 119:2382-2388, 2006.

Lönn S, Ahlbom A, Christensen HC, Johansen C, Schuz J, Edstrom S, Henriksson G, Kundren J, Wennerberg J, Feychting M. Mobile phone use and risk of parotoid gland tumor. Am J Epidemiol 164:637-643, 2006

Lönn S, Klaeboe L, Hall P, Mathiesen T, Auvinen A, Christensen HC, Johansen C, Salminen T, Tynes T, Feychting M. Incidence trands of adult primary intracerebral tumours in four Nordic countries. Int J Cancer 108:450-455, 2004.

Lönn S, Ahlbom A, Hall P, Feychting M, Swedish INTERPHONE Study Group. Long-term mobile phone use and brain tumor risk. Am J Epidemiol 161:526-535, 2005.

Lowden A, Torbjörn □, Ingre M, Wiholm C, Hellert L, Kuster N, Nilsson JP, Arnetz. Sleep after mobile phone-related symptoms. Bioelectromagnetics 32:4-14, 2011.

Maine Center for Disease Control and Prevention (MCDC). Maine CDC Executive Summary of Review of Health Issues Related to Smart Meters. Augusta, ME: MCDC, November 8, 2010.
http://www.maine.gov/dhhs/boh/documents/Smart_Meters_Maine_CDC_Executive_Summary_11_08_10.pdf

Mild KH, Hardell L, Carlberg M. Pooled analysis of two Swedish case-control studies on the use of mobile and cordless telephones and the risk of brain tumours diagnosed during 1997-2003. Int J Occup Saf Ergon 13:63-71, 2007.

Monterey County Health Department (MCHD). Review of Health Issues Related to Smart Meters. Monterey County Health Department, Public Health Bureau, Epidemiology and Evaluation, March 2011.
http://publicagendas.co.monterey.ca.us/MG97205/AS97224/AS97230/AI99413/DO99416/DO_99416.pdf

National Council of Radiation Protection & Measurement (NCRP). NCRP Report No. 67, Radiofrequency Electromagnetic Fields—Properties, Quantities and Units, Biophysical Interaction, and Measurements. Bethesda, MD: NCRP, 1981.

National Council of Radiation Protection & Measurement (NCRP). NCRP Report No. 86, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields. Bethesda, MD: NCRP, 1986.

National Radiological Protection Board (NRPB). Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz). National Radiological Protection Board (NRPB). Volume 15, No 3, 2004.

Nieto-Hernandez R, Williams J, Cleare AJ, Landau S, Wessely S, Rubin GJ. Can exposure to terrestrial trunked radio (TETRA)-like signal cause symptoms? A randomised double-blind provocation study. Occup Environ Med 68:339-344, 2011.

Public Service Commission of California. 2010.

Repacholi MH and Cardis E. Criteria for Health Risk Assessment. Radiat Prot Dosim 72(3-4); 1997.

Röösli M, Lörtscher M, Egger M, Pfluger D, Schreirer N, Emanuel L, Locher P, Spoerri A, Minder C. Leukaemia, brain tumours and exposure to extremely low frequency magnetic fields: cohort study of Swiss railway employees. Occup Environ Med 64:553-9, 2007.

Röösli M, Frei P, Mohler E, Hug K. Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations. Bull World Health Org 88:887-896F, 2010.

Roöösli M and Hug K. Wireless communication fields and non-specific symptoms of ill health: a literature review. Wien Med Wochenschr 161:240-250, 2011.

Rubin GJ, Hillert L, Nieto-Hernandez R, van Rongen E, Oftedal G. Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields: A systematic review of provocation studies. Bioelectromagnetics 32:593-609, 2011.

Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, Zultan A. Novikov I, Freedman L, Wolf M. Cellular phone use and risk of beign and malignant parotid gland tumors–a nationwide case-control study. Am J Epidemiol 167:457-467, 2008.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) for the Directorate-General for Health & Consumers of the European Commission. Health Effects of Exposure to EMF. January 2009.

Schmiedel S, Brüggemeyer H, Philipp J, Wendler J, Merzenich H, Schüz J. An evaluation of exposure metrics in epidemiologic study on radio and television broadcast transmitters and the risk of childhood leukemia. Bioelectromagnetics 30:81-91, 2009.

Schoemaker MJ, Swerdlow AJ, Ahlbom A, Auvinen A, Blaasaas KG, Cardis E, et al. Mobile phone use and risk of acoustic neuroma: results of the Inter-phone case–control study in five North European countries. Br J Cancer 93:842–848, 2005.

Schüz J, Jacobsen R, Olsen JF, Boice JD Jr, McLaughlin JK, Johansen C. Cellular telephone use and cancer risk: update of a nationwide Danish cohort. J Natl Cancer Inst 98:1707-1713, 2006.

Simba AY, Hikage T, Watanabe S, Nojima T. Specific Absorption Rates of Anatomically Realistic Human Models Exposed to RF Electromagnetic Fields From Mobile Phones Used in Elevators. IEEE Transactions on Microwave Theory and Techniques, 57(5-1): 1250-1259, 2009. http://hdl.handle.net/2115/38548

Stang A, Schmidt-Pokrzywniak A. Lash TL, Lommatzsch PK, Taubert G, Bornfeld N, Jockel KH. Mobile phone use and risk of uveal melanoma: results of the risk factors for uveal melanoma case-control study. J Natl Canc Inst 101:120-123, 2009.

Swerdlow AJ, Feychting M, Green AC, Kheifets L, Savitz DA. Mobile phones, brain tumours and the Interphone study: Where are we now? Environ Health Perspect Online 1 July 2011.
http://dx.doi.org/10.1289/ehp.1103693

Swedish Radiation Safety Authority (SSM). Recent Research on EMF and Health Risks: Sixth annual report from SSMs independent Expert Group on Electromagnetic Fields 2009. Report number: 2009:36, December 2009.

Swedish Radiation Safety Authority (SSM). Recent Research on EMF and Health Risks: Seventh annual report from SSMs independent Expert Group on Electromagnetic Fields 2010. Report number: 2010:44, December 2010.

Szmigielski S. Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. Sci Total Environ 180:9-17, 1996.

Takebayashi T, Varsier N, Kikuchi Y, Wake K, Taki M, Watanabe S, Akiba S, Yamaguchi N. Mobile phone use, exposure to radiofrequency electromagnetic field, and brain tumour: a case-control study. Br J Cancer 98:652-659, 2008.

US Environmental Protection Agency (USEPA). A review of the reference dose and reference concentration process. EPA/630/P-02/002F, 2002.

US Environmental Protection Agency (USEPA). Fact sheet: EPA's guidelines for carcinogen risk assessment – what are they?, what do they say?, and how are they used? U.S. Environmental Protection Agency (USEPA) Fact sheet. March 3, 2003.

US Environmental Protection Agency (USEPA). Guidelines for carcinogen risk assessment and supplemental guidance for assessing susceptibility from early-life exposure to carcinogens. EPA/630/P-03/001F, 2005.

Warren HG, Prevatt AA, Daly KA, Antonelli PJ. Cellular telephone use and risk of intratemporal facial nerve tumor. Laryngoscope 113:663-667, 2003.

World Health Organization (WHO). International programme on chemical safety (IPCS). Environmental health criteria 170; assessing human health risks of chemicals: derivation of guidance values for health-based exposure limits. World Health Organization, 1994.

World Health Organization (WHO). Electromagnetic fields and public health: mobile phones Fact sheet N°193, June 2011

Wolf R and Wolf D. Increased incidence of cancer near a cell-phone transmitter station. Int J Cancer Prevention 1:123-128, 2004.

Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S. Deeble R, Fox E. Do TETRA (Airwave) base station signals have a short-term impact on health and well-being? A randomized double-blind provocation study. Environ Health Perspect 118, 735-741, 2010.

World Health Organization (WHO). Electromagnetic Fields (300 Hz to 300 GHz). Environmental Health Criteria 137. Geneva: WHO, 1993.

World Health Organization (WHO). Electromagnetic fields and public health: Electromagnetic Hypersensitivity. Fact sheet N°296 December 2005. http://www.who.int/mediacentre/factsheets/fs296/en/index.html.

World Health Organization (WHO). Environmental Health Criteria 238: Extremely Low Frequency (ELF) Fields. Geneva, Switzerland: World Health Organization, 2007.

Exponent®
Failure Analysis Associates®

Exponent
420 Lexington Avenue
Suite 1740
New York, NY 10170

telephone 212-895-8100
facsimile 212-895-8199
www.exponent.com

Yakov P. Shkolnikov, Ph.D., P.E.
Managing Engineer

Professional Profile

Dr. Yakov Shkolnikov has expertise in the development and analysis of high performance electronic devices and systems. With this expertise, he is able to advise clients on matters related to reliability and intellectual property issues.

As the head of the software task force at Exponent, Dr. Shkolnikov has assisted clients in software and algorithm development, software reliability analysis, and intellectual property evaluations. Dr. Shkolnikov has extensive experience in algorithm design and has developed methods and software in such diverse areas as analysis of radiological imaging data, computer vision and learning, statistical data processing, mechanical testing of medical implants, instrumentation of diagnostic systems, internet-protocol (IP) based communication, and analysis of ground penetrating radar data.

He has performed reliability and functional analysis of software used in medical, automotive, desktop, and embedded applications, and has experience with C, LabVIEW, MATLAB, and several other script, and controller languages, as well as with auto-documenting software and static verifiers such as PolySpace.

Dr. Shkolnikov has assisted clients in technical analyses supporting complex litigation cases such as class action lawsuits, and patent and trade secret litigation. He has performed infringement, obviousness, and validity analysis of patents for consumer electronic devices and software; assisted clients in locating prior-art and prior-use examples; and overseen large document reviews inherent to such cases.

His medical-devices project and research experience include the technical analysis of implantable cardioverter defibrillators (ICD), pacemakers, implantable pulse generators (IPGs), orthopedic implants, blood flow meters, electrosurgical and robotic equipment used in electro stimulation, and electro pathology. He also has experience in electromagnetic finite element analysis (AC/DC and RF), low electrical noise systems, cryogenic and high magnetic field measurements, data acquisition analysis and visualization, fiber optic systems, and electronic-device packaging.

Dr. Shkolnikov has published over 25 peer-reviewed papers on electrical engineering topics such as semiconductor physics and electrical-safety and has participated in numerous technical conferences on medical device analysis and semiconductors. He has a patent on the security of RFID cards, and has filed several provisional patents filings on cell phone power management, RFID technology, and mechanical strain sensing. Dr. Shkolnikov holds a research faculty appointment at School of Biomedical Engineering, Science and Health Systems at Drexel University, and is a guest lecturer at Princeton University, Department of Mechanical & Aerospace Engineering. He was also a referee for *Physical Review Letters* from 2006–2011 and is currently a referee for Health Physics.

Academic Credentials and Professional Honors

Ph.D., Electrical Engineering (minor in Mechanical Engineering), Princeton University, 2005
M.A., Electrical Engineering, Princeton University, 2004
B.S., Engineering Physics, Cornell University (*summa cum laude*), 1999

Graduated ranked 1st in School of Engineering, Summa Cum Laude, Cornell University; Gordon Wu Fellow, Princeton University; Merrill Presidential Scholar, Cornell University; Tau Beta Pi

2010 IEEE Region 1 Award, Category 3B : Technological Innovation (Industry or Government), For the Development of Mathematical Methods for Computing Ground-Penetrating Radar to Detect Land Mines

The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety, Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz)

Licenses and Registrations

Licensed Professional Engineer, New Jersey, #GE47825

Patents

US Patent No. 7,936,274: Shield for Radio Frequency ID Tag or Contactless Smart Card, filed May 3, 2011 (Shkolnikov Y, Du Y, McGoran B).

Publications

Shkolnikov YP, Bowden A, MacDonald D, Kurtz SM. Wear pattern observations from TDR retrievals using autoregistration of voxel data. J Biomedical Mater Res Part B: Appl Biomaterials, 2010, in press. Epub ahead of print.

Kurtz SM, Ochoa JA, Lau E, Shkolnikov Y, Pavri BB, Frisch D, Greenspon AJ. Implantation trends and patient profiles for pacemakers and implantable cardioverter defibrillators in the United States: 1993–2006. PACE 2009. doi: 10.1111/j.1540-8159.2009.02670.

Gokmen T, Padmanabhan M, Gunawan O, Shkolnikov YP, Vakili K, De Poortere EP, Shayegan M. Parallel magnetic-field tuning of valley splitting in AlAs two-dimensional electrons. Phys Rev B 2008; 78(23):233306.

Bishop NC, Padmanabhan M, Gunawan O, Gokmen T, De Poortere EP, Shkolnikov YP, Tutuc E, Vakili K, Shayegan M. Valley susceptibility of interacting electrons and composite fermions. Physica E-Low-Dimensional Systems and Nanostructures 2008; 4(5):986–989.

McGowan JC, Shkolnikov YP, Sala JB, Ray RM. Diffuse electrical injury: A questionable phenomenon. Biomedical Engineering Recent Developments, Nazeran H, Goldman M, Schoephoerster R (eds), Medical and Engineering Publishers, Inc., ISBN 978-1-930636-06-4, 2008.

McGowan JC, Shkolnikov YP, Sala JB, Ray RM. Diffuse electrical injury: Questioning the scientific basis. Proceedings, IEEE CCECE Conference, Niagara Falls, Ontario, Canada, 2008.

Gunawan O, Gokmen T, Shkolnikov YP, De Poortere EP, Shayegan M. Anomalous giant piezoresistance in AlAs 2D electron systems with antidot lattices. Physical Review Letters 2008; 100:036602.

Bishop NC, Padmanabhan M, Vakili K, Shkolnikov YP, De Poortere EP, Shayegan M. Valley polarization and susceptibility of composite fermions around a filling factor ν=3/2. Physical Review Letters 2007; 98:266–404.

Shayegan M, De Poortere EP, Gunawan O, Shkolnikov YP, Tutuc E, Vakili K. Quantum Hall effect in a multi-valley two-dimensional electron system. IJMPB 2007; 21:1388–1397.

Shayegan M, De Poortere EP, Gunawan O, Shkolnikov YP, Tutuc E, Vakili K. Two-dimensional electrons occupying multiple valleys. AlAs Physica Status Solidi (b) 2006; 243(14):3629–3642, November.

Gunawan O, Shkolnikov YP, Vakili K, Gokmen T, De Poortere EP, Shayegan M. Valley susceptibility of an interacting two-dimensional electron system. Physical Review Letters 2006; 97:186404.

Vakili K, Shkolnikov YP, Tutuc E, De Poortere EP, Padmanabhan M, Shayegan M. High-aobility AlAs quantum wells with out-of-plane valley occupation. Applied Physics Letters 2006; 89:172118.

Vakili K, Shkolnikov YP, Tutuc E, Bishop NC, De Poortere EP, Shayegan M. Spin-dependent resistivity and quantum Hall ferromagnetism in two-dimensional electrons confined to AlAs quantum wells. Physica E 2006; 34:89.

Vakili K, Gokmen T, Gunawan O, Shkolnikov YP, De Poortere EP, Shayegan M. Dependence of persistent gaps at Landau level crossings on relative spin. Physical Review Letter 2006; 97:116803.

Shkolnikov YP, Misra S, Bishop NC, De Poortere EP, Shayegan M. Observation of quantum Hall valley skyrmions. Physical Review Letters 2005; 95:066809.

Vakili K, Shkolnikov YP, Tutuc E, Bishop NC, De Poortere EP, Shayegan M. Spin-dependent resistivity at transitions between integer quantum Hall states. Physical Review Letters 2005; 94:176402.

Gunawan O, Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Ballistic electron transport in AlAs quantum wells. Physical Review Letters 2004; 93:246603.

Shkolnikov YP, Vakili K, De Poortere EP, Shayegan M. Giant low-temperature piezoresistance effect in AlAs two-dimensional electrons. Applied Physics Letters 2004; 85:3766.

Shkolnikov YP, Vakili K, De Poortere EP, Shayegan M. Dependence of spin susceptibility of a two-dimensional electron system on the valley degree of freedom. Physical Review Letters 2004; 92:246804.

Vakili K, Shkolnikov YP, Tutuc E, De Poortere EP, Shayegan M. Spin susceptibility of two-dimensional electrons in narrow AlAs quantum wells. Physical Review Letters 2004; 92:226401.

Vakili K, Shkolnikov YP, Tutuc E, De Poortere EP, Shayegan M. Realization of an interacting two-valley AlAs bilayer system. Physical Review Letters 2004; 92:186404.

Shayegan M, Karrai K, Shkolnikov YP, Vakili K, De Poortere EP, Manus S. Low-temperature, in situ tunable, uniaxial stress measurements in semiconductors using a piezoelectric actuator. Applied Physics Letters 2003; 83:5235.

De Poortere EP, Shkolnikov YP, Shayegan M. Field-effect persistent photoconductivity in AlAs and GaAs quantum wells with AlGaAs barriers. Physical Review B 2003; 67:153303.

Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Valley splitting of AlAs two-dimensional electrons in a perpendicular magnetic field. Physical Review Letters 2002; 89:226805.

De Poortere EP, Tutuc E, Shkolnikov YP, Vakili K, Shayegan M. Magnetic-field-induced spin polarization of AlAs two-dimensional electrons. Physical Review 2002; B 66:161308.

De Poortere EP, Shkolnikov YP, Shayegan M. High-mobility electrons in modulation-doped AlAs quantum wells. Physica E 2002; 13:646.

De Poortere EP, Tutuc E, Shkolnikov YP, Vakili K, Shayegan M, Palm E, Murphy T. Quantum Hall effect in AlAs 2D electron system. International Journal of Modern Physics B 2002; 16:2917.

De Poortere EP, Shkolnikov YP, Tutuc E, Papadakis SJ, Shayegan M, Palm E, Murphy T. Enhanced electron mobility and high order fractional quantum Hall states in AlAs quantum wells. Applied Physics Letters 2002; 80:1583.

Selected Conference Presentations

Shkolnikov YP, Bailey WH. Electromagnetic interference and exposure from household wireless. IEEE Symposium on Product Compliance Engineering, San Diego, CA, October 11, 2011.

Swart J, Shkolnikov YP. Electrical shock and the electric powered vehicles – An introduction forensics. IEEE Symposium on Product Compliance Engineering, San Diego, CA, October 11, 2011.

Hanzlik JA, Patel JD, JA Ochoa, Shkolnikov YP, Horn QC, Pavri BB, Greenspon AJ, Kurtz SM. Why are implantable cardioverter-defibrillators and pacemakers being revised today? Materials and Processes for Medical Devices Conference and Exposition, Minneapolis, MN, August 8–10, 2011.

Shkolnikov Y, Restrepo C, Parvizi J, Hozack W, Garino J, Suggs J, Kurtz S. Clinical validation of a squeakometer for characterization of acoustic emissions in arthroplasty patients. ORS 55th Annual Meeting, Las Vegas, NV, February 23, 2009.

McGowan JC, Shkolnikov YP, Sala JB, Ray RM. Diffuse electrical injury: Questioning the scientific basis. IEEE Canadian Conference on Electrical and Computer Engineering, Niagara Falls, Ontario, Canada, May 6, 2008.

McGowan JC, Shkolnikov YP, Sala JB, Ray RM. Diffuse electrical injury: A questionable phenomenon. 24th Southern Biomedical Engineering Conference, El Paso, TX, April 19, 2008.

Bowden AE, Shkolnikov YP, MacDonald D, Kurtz SM. Automated microCT-based damage maps of explanted polymeric TDR components. North American Spine Society 22nd Annual Meeting, Austin, TX, October 22–27, 2007.

Bowden AE, Shkolnikov YP, MacDonald D, Kurtz S. Development and validation of an automated MicroCT-based technique for mapping damage of explanted polymeric components for TDR. Spine Arthroplasty Society, Berlin, Germany, 2007.

Padmanabhan M, Bishop N, Shkolnikov YP, De Poortere EP, Shayegan M. Gap and mass measurements of composite fermions at nu=5/3 in a 2D electron system with tunable valley occupation. APS March Meeting, Denver, CO, 2007.

Bishop N, Padmanabhan M, Vakili K, Shkolnikov YP, De Poortere EP, Shayegan M. Valley susceptibility measurements of composite fermions around filling factor nu = 3/2. APS March Meeting, Denver, CO, 2007.

Shkolnikov YP, Gunawan O, Vakili K, Gokmen T, De Poortere E, Shayegan M. Valley susceptibility of an interacting two-dimensional electron system. APS March Meeting, Baltimore, MD, 2006.

Padmanabhan M, Vakili K, Shkolnikov YP, Gunawan O, Gokmen T, Tutuc E, De Poortere EP, Shayegan M. Selective occupation of conduction band valleys in AlAs quantum wells. APS March Meeting, Baltimore, MD, 2006.

Gunawan O, Shkolnikov YP, Vakili K, De Poortere EP, Shayegan M. Giant piezoresistance in AlAs 2D electron systems with antidot lattice. APS March Meeting, Baltimore, MD, 2006.

Vakili K, Gokmen T, Padmanabhan M, Gunawan O, Shkolnikov YP, Tutuc E, Shayegan M. Landau level crossings in imbalanced, two-valley two-dimensional electron systems. APS March Meeting, Baltimore, MD, 2006.

Gunawan O, Shkolnikov YP, Tutuc E, Vakili K, Shayegan M. Antidot lattice in AlAs 2D electron system: Electron pinball with elliptical Fermi contours. APS March Meeting, Los Angeles, CA, 2006.

Vakili K, Y. Shkolnikov, Tutuc E, Bishop N, De Poortere EP, Shayegan M. Spin-dependent resistivity at transitions between integer quantum Hall states. APS March Meeting, Los Angeles, CA, 2006.

Vakili K, De Poortere EP, Shayegan M. Spin susceptibility of two-dimensional electrons in AlAs. PCCM Workshop on Correlated Electronic Materials, Princeton, NJ, 2005.

Shkolnikov YP, Vakili K, De Poortere EP, Shayegan M. Dependence of spin susceptibility of a two-dimensional electron system on valley degree of freedom. 16th International Conference on High Magnetic Fields in Semiconductor Physics, Tallahassee, FL, 2004.

Shkolnikov YP, Tutuc E, Vakili K, Gunawan O, Shayegan M. Physics and technology of AlAs semiconductor devices. Corporate Affiliates Program Meeting, Princeton NJ, 2004.

Shkolnikov YP, Vakili K, Shayegan M. Strain dependence of spin and valley polarization in AlAs 2D electrons. APS March Meeting, Montreal, Canada, 2004.

Gunawan O, Shkolnikov YP, Tutuc E, Shayegan M, De Poortere EP. Valley-resolved ballistic transport in a two-dimensional electron system. APS March Meeting, Montreal, Canada, 2004.

Vakili K, Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Spin polarization of 2D electrons in Narrow AlAs quantum wells. APS March Meeting, Montreal, Canada, 2004.

Shkolnikov YP, De Poortere EP, Vakili K, Tutuc E, Shayegan M, Karrai K, Palm E, Murphy T. stress-induced modification of electronic properties in AlAs 2D electrons. Corporate Affiliates Program Meeting, Princeton, NJ, 2003.

De Poortere EP, Shkolnikov YP, Shayegan M. Field-effect persistent photoconductivity in GaAs/AlAs-based structures. APS March Meeting, Austin, TX, 2003.

Gunawan O, De Poortere EP, Shkolnikov YP, Vakili K, Tutuc E, Shayegan M, Yau JB. Ballistic transport in AlAs 2D electrons. APS March Meeting, Austin, TX, 2003.

Vakili K, Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Magnetoresistance measurements in wide and narrow AlAs quantum wells. APS March Meeting, Austin, TX, 2003.

Shkolnikov YP, De Poortere EP, Vakili K, Tutuc E, Shayegan M. Lifting of the valley degeneracy in AlAs 2D electrons. APS March Meeting, Austin, TX, 2003.

Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M, Palm E, Murphy T. Magnetic field dependence of valley splitting in AlAs 2D electrons. 15th International Conference on High Magnetic Fields in Semiconductor Physics, Oxford, UK, 2002.

Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Evidence of multi-valley fermi surface in AlAs 2D electrons. APS March meeting, Seattle, WA, 2001.

Skinner CH, Stotler DP, Bell RE, Pitcher CS, Terry JL, Shkolnikov Y. High resolution spectroscopy at Alcator C-mod using a Fabry Perot interferometer. APS, 41st Annual Meeting of the Division of Plasma Physics, Seattle, WA, 1999.

Guest Lectures

Shkolnikov YP. Electricity and the human body. Mechanical Engineering, Princeton University, Princeton, NJ, April 8, 2010.

Shkolnikov YP. Got risk? Managing risk and reliability in modern technology. Cornell Club of Central New Jersey, Princeton, NJ, December 4, 2009.

Villarraga M, Shkolnikov YP. Medical device failure analysis during the design process. Department of Biomedical Engineering, Drexel University, Philadelphia, PA, May 6, 2009.

Shkolnikov YP. Electricity and the human body. Mechanical Engineering, Princeton University, Princeton, NJ, April 9, 2009.

Shkolnikov YP. Medical device design. North Jersey Section Engineering in Medicine and Biology IEEE Chapter, Clifton, NJ, August 4, 2008.

Villarraga M, Shkolnikov M. FMEA: Risk management and prioritization in medical device design. Thompson Interactive, July 17, 2008.

Shkolnikov YP. Failure analysis during the design process of medical devices. Department of Biomedical Engineering, Drexel University, Philadelphia, PA, 2008.

Shkolnikov YP, Villarraga M. Introduction to electrophysiology. Mechanical Engineering, Princeton University, Princeton, NJ, 2007.

Shkolnikov YP, Villarraga M. Failure analysis during the design process of medical devices. Compliance Online, 2007.

Shkolnikov YP. Electricity and the human body. Mechanical Engineering, Princeton University, Princeton, NJ, 2007.

Shkolnikov YP, Villarraga M. Medical device failure analysis during the design process. Department of Biomedical Engineering, Drexel University, Philadelphia, PA, 2007.

Academic Appointments

Visiting Research Professor, School of Biomedical Engineering, Drexel University, 2005–2011

Peer Review

- Referee for *Health Physics*
- Past Referee for *Physical Review Letters,* 2006–2011

Professional Affiliations

- Institute of Electrical and Electronics Engineers
- American Physical Society

Project Experience

Computer Architecture and Networks

- Analysis of computer networks including Internet, WAN, LAN, and smart meter networks
- Analysis of shared memory architecture for mobile computer devices
- Analysis of interrupt handling scheme in mobile processors.
- Software source code analysis (C, C++, Assembly) to identify vulnerabilities and errors in code
- Shielding and interference from RFID and related devices
- Intellectual property/patent investigations semiconductors, software, internet and telephony equipment
- Scalability analysis and improvement of IPTV systems
- Prior art and prior use searches for video game, consumer products, testing equipment and other electronic products
- Patent portfolio review and technical due diligence
- Memory technology analysis and reverse engineering
- Reconstruction of physical geometry and zone mapping of hard drives

Computer Graphics

- Design of 2D/3D image processing and machine learning algorithms
- Detection algorithms

- GPGPU software development
- Computer graphics software use and algorithm development
- Analysis of GPU hardware reliability
- Analysis of patent infringement in computer graphics, image processing, and hardware design

Health, Safety, and Medical Products

- Compliance assessment per 47CFR1.1307, 47CFR1.1310, IEEE C95.1, IEEE C95.6, IEC 60601-1-2, IEC 60479-1, ICNIRP 1998, ICNIRP 2010, and other RF and electrical health and safety standards
- Electric Shock & Electrocution investigations
- Software and methodology development for analysis of FTIR, small punch, tensile testing, tissue property testing, radiological images, and field-testing data
- Assistance in technology transfer product development for biological weapons detection

- Design development, review, and analysis for medic diagnostic equipment companies
- Source code review and modeling to identify failure mode in medical device software
- Failure analysis in medical products including diagnostic equipment, surgical equipment, and implants
- EMI and EMC evaluation of medical products
- Magnetic and electric field exposure and heating from transmission and distribution lines
- Medical products intellectual property analysis
- Risk assessment and FMEA analysis
- Reverse engineering analysis of diagnostic equipment

Computer Forensics and Security

- Verification of integrity of the produced digital images: Metadata analysis, image content analysis, photogrammetric analysis
- Enhancement, recovery, and analysis of video surveillance data
- Recovery and analysis of EPROM memory data relating to construction accident
- Data snooping and interception
- Development of automated text and document analysis tools
- Development of technology to secure contents of smart cards
- Security analysis of payment card shipment method
- Security analysis of a data storage and review facility
- Security product performance evaluation
- Validation of hard-drive data sanitization procedure
- Restoring damaged data
- Analysis of wireless transmission systems including encryption, anti-jamming, and error correction

Reliability

- Hardware in the loop testing and probing of microprocessor to identify malfunction
- Electromagnetic finite element analysis (FEA) of components, products, machines, and installations for RF exposure, electric shock hazard, reliability, electrostatic discharge, and effects of defects in manufacture and materials
- Electromagnetic interference with the function of GPS systems
- Shielding and interference from RFID and related devices
- Analysis of software and hardware component reliability of automotive products
- Analysis of RF emissions for purposes of a recall decision
- Product misuse investigations

Acoustic Analysis

- Forensic analysis of acoustic data, speech enhancement and other audio data processing, audio acquisition system design and evaluation, waveform/spectral based hearing damage assessment

Semiconductors

- Solid-state sensor design
- Semiconductor packaging design, processing, and failure analysis
- Semiconductor physics
- Intellectual property analysis of fabrication processes, semiconductor materials and devices

Cryogenics, Vacuum, and Magnetic Systems

- Operation and design of cryogenic systems
- Operation, control and design of electromagnetic and permanent magnet systems
- Operation and service of high and ultra high vacuum equipment, systems, and pumps

Exponent
17000 Science Drive
Suite 200
Bowie, Maryland 20715

telephone 301-291-2500
facsimile 301-291-2599
www.exponent.com

William H. Bailey, Ph.D.
Principal Scientist

Professional Profile

Dr. William H. Bailey is a Principal Scientist in Exponent's Health Sciences practice. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental and occupational health issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey has investigated exposures to alternating current, direct current, and radiofrequency electromagnetic fields, 'stray voltage', and electrical shock, as well as to a variety of chemical agents and air pollutants. He is particularly well known for his research on potential health effects of electromagnetic fields and has served as an advisor to numerous state, federal, and international agencies. Currently, he is involved in research on exposures to marine life from submarine cables and respiratory exposures to ultrafine- and nanoparticles. Dr. Bailey is a visiting scientist at the Cornell University Medical College and has lectured at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

Academic Credentials and Professional Honors

Ph.D., Neuropsychology, City University of New York, 1975
M.B.A., University of Chicago, 1969
B.A., Dartmouth College, 1966

Sigma Xi; The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety (Subcommitee 3, Safety Levels with Respect to Human Exposure to Fields (0 to –3 kHz) and Subcommitte 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz); Elected member of the Committee on Man and Radiation (COMAR) of the IEEE Engineering in Medicine and Biology Society, 1998–2001

Publications

Bailey WH, Johnson GB, Bishop J, Hetrick T, Su S. Measurements of charged aerosols near ±500 kV DC transmission lines and in other environments. IEEE Transactions on Power Delivery, in press.

Kavet R, Bailey WH, Bracken TD, Patterson RM. Recent advances in research relevant to electric and magnetic field exposure guidelines. Bioelectromagnetics 2008; 29:499–526.

Bailey WH, Wagner M. IARC evaluation of ELF magnetic fields: Public understanding of the 0.4μT exposure metric. Journal of Exposure Science and Environmental Epidemiology 2008; 18:233–235.

Bailey WH, Erdreich L. Accounting for human variability and sensitivity in setting standards for electromagnetic fields. Health Physics 2007; 92:649–657.

Bailey WH, Nyenhuis JA. Thresholds for 60-Hz magnetic field stimulation of peripheral nerves in human subjects. Bioelectromagnetics 2005; 26:462–468.

Bracken TD, Senior RS, Bailey WH. DC electric fields from corona-generated space charge near AC transmission lines. IEEE Transactions on Power Delivery 2005; 20:1692–1702.

Bailey WH. Dealing with uncertainty in formulating occupational and public exposure limits. Health Physics 2002; 83:402–408.

Bailey WH. Health effects relevant to the setting of EMF exposure limits. Health Physics 2002; 83:376–386.

Kavet R, Stuchly MA, Bailey WH, Bracken TD. Evaluation of biological effects, dosimetric models, and exposure assessment related to ELF electric- and magnetic-field guidelines. Applied Occupational and Environmental Hygiene 2001; 16:1118–1138.

Bailey WH. ICNIRP recommendation for limiting public exposure to 4 Hz–1 kHz electric and magnetic fields. Health Physics1999; 77:97–98.

Bailey WH. Principles of risk assessment with application to current EMF risk communication issues. In: EMF Risk Perception and Communication. Repacholi MH, Muc AM (eds), World Health Organization, Geneva, 1999.

De Santo RS, Bailey WH. Environmental justice tools and assessment practices. Proceedings, American Public Transit Association, 1999.

Bailey WH, Su SH, Bracken TD. Probabilistic approach to ranking sources of uncertainty in ELF magnetic field exposure limits. Health Physics 1999; 77:282–290.

Bailey WH. Field parameters. Proceedings, EMF Engineering Review Symposium, Status and Summary of EMF Engineering Research. Bracken TD and Montgomery JH (eds), Oak Ridge National Laboratory, Oak Ridge, TN, April 28–29, 1998.

Bailey WH. Policy implications. Proceedings, EMF Engineering Review Symposium, Status and Summary of EMF Engineering Research. Bracken TD and Montgomery JH (eds), Oak Ridge National Laboratory, Oak Ridge, TN, April 28–29, 1998.

Bailey WH. Probabilistic approaches to deriving risk-based exposure guidelines: Application to extremely low frequency magnetic fields. In: Non-Ionising Radiation. Dennis JA and Stather JW (eds), Special Issue of Radiation Protection Dosimetry 1997; 72:327–336.

Bailey WH, Su SH, Bracken TD, Kavet R. Summary and evaluation of guidelines for occupational exposure to power frequency electric and magnetic fields. Health Physics 1997; 73:433–453.

Bracken TD, Senior RS, Rankin RF, Bailey WH, Kavet R. Magnetic field exposures in the electric utility industry relevant to occupational guideline levels. Applied Occupational and Environmental Hygiene 1997; 12:756–768.

Blondin J-P, Nguyen D-H, Sbeghen J, Goulet D, Cardinal C, Maruvada P-S, Plante M, and Bailey WH. Human perception of electric fields and ion currents associated with high voltage DC transmission lines. Bioelectromagnetics 1996; 17:230–241.

Bailey WH, Charry JM. Acute exposure of rats to air ions: Effects on the regional concentration and utilization of serotonin in brain. Bioelectromagnetics 1987; 8:173–181.

Bailey WH, Charry JM. Measurement of neurotransmitter release and utilization in selected brain regions of rats exposed to dc electric fields and atmospheric space charge. Proceedings, 23rd Hanford Life Sciences Symposium, Interaction of Biological Systems with Static and ELF Electric and Magnetic Fields, 1987.

Pavildes C, Aoki C, Chen J-S, Bailey WH, Winson J. Differential glucose utilization in the parafascicular region during slow-wave sleep, the still-alert state and locomotion. Brain Research 1987; 423:399–402.

Bailey WH, Charry JM. Behavioral monitoring of rats during exposure to air ions and DC electric fields. Bioelectromagnetics 1986; 7:329–339.

Charry JM, Shapiro MH, Bailey WH, Weiss JM. Ion-exposure chambers for small animals. Bioelectromagnetics 1986; 7:1–11.

Charry JM, Bailey WH. Regional turnover of norepinephrine and dopamine in rat brain following acute exposure to air ions. Bioelectromagnetics 1985; 6:415–425.

Bracken TD, Bailey WH, Charry JM. Evaluation of the DC electrical environment in proximity to VDTs. Journal of Environmental Science and Health Part A 1985; 20:745–780.

Gross SS, Levi R, Bailey WH, Chenouda AA. Histamine modulation of cardiac sympathetic responses: A physiological role. Federation Proceedings 1984; 43:458.

Gross SS, Guo ZG, Levi R, Bailey WH, Chenouda AA. 1984. Release of histamine by sympathetic nerve stimulation in the guinea pig heart and modulation of adrenergic responses. Circulation Research 1984; 54:516–526.

Dahl D, Bailey WH, Winson J. Effect of norepinephrine depletion of hippocampus on neuronal transmission from perforant pathway through dentate gyrus. Journal of Neurophysiology 1983; 49:123–135.

Guo ZG, Gross SS, Levi R, Bailey WH. Histamine: Modulation of norepinephrine release from sympathetic nerves in guinea pig heart. Federation Proceedings 1983; 42:907.

Bailey WH. Biological effects of air ions on serotonin metabolism: Fact and fancy. pp. 90–120. In: Conference on Environmental Ions and Related Biological Effects. Charry JM (ed), American Institute of Medical Climatology, Philadelphia, PA, 1982.

Weiss JM, Goodman PA, Losito BG, Corrigan S, Charry JM, Bailey WH. Behavioral depression produced by an uncontrollable stressor: Relationship to norepinephrine, dopamine, and serotonin levels in various regions of rat brain. Brain Research Reviews 1981; 3:167–205.

Bailey WH. Ion-exchange chromatography of creatine kinase isoenzymes: A method with improved specificity and sensitivity. Biochemical Medicine 1980; 24:300–313.

Bailey WH, Weiss JM. Evaluation of a 'memory deficit' in vasopressin-deficient rats. Brain Research 1979; 162:174–178.

Bailey WH, Weiss JM. Effect of ACTH 4-10 on passive avoidance of rats lacking vasopressin (Brattleboro strain). Hormones and Behavior 1978; 10:22–29.

Pohorecky LA, Newman B, Sun J, Bailey WH. Acute and chronic ethanol injection and serotonin metabolism in rat brain. Journal of Pharmacology and Experimental Therapeutics 1978; 204:424–432.

Koh SD, Vernon M, Bailey WH. Free-recall learning of word lists by prelingual deaf subjects. Journal of Verbal Learning and Verbal Behavior 1971; 10:542–574.

Book Chapters

Bailey WH. Principles of risk assessment and their limitations. In: Risk Perception, Risk Communication and its Application to EMF Exposure. Matthes R, Bernhardt JH, Repacholi MH (eds), International Commission on Non-Ionizing Radiation Protection, Oberschleißheim, Germany, 1998.

Bailey WH. Biological responses to air ions: Is there a role for serotonin? pp. 151–160. In: Air Ions: Physical and Biological Aspects. Charry JM and Kavet R (eds), CRC Press, Boca Raton, FL, 1987.

Weiss JM, Bailey WH, Goodman PA, Hoffman LJ, Ambrose MJ, Salman S, Charry JM. A model for neurochemical study of depression. pp. 195–223. In: Behavioral Models and the Analysis of Drug Action. Spiegelstein MY, Levy A (eds), Elsevier Scientific, Amsterdam, 1982.

Bailey WH. Mnemonic significance of neurohypophyseal peptides. pp. 787–804. In: Changing Concepts of the Nervous System. Morrison AR, Strick PL (eds), Academic Press, New York, NY, 1981.

Bailey WH, Weiss, JM. Avoidance conditioning and endocrine function in Brattleboro rats. Pp 371–395. In: Endogenous Peptides and Learning and Memory Process. Martinez JL, Jensen RA, Messing RB, Rigter H, McGaugh JL (eds), Academic Press, New York, NY, 1981.

Weiss JM, Glazer H, Pohorecky LA, Bailey WH, Schneider L. Coping behavior and stress-induced behavioral depression: Studies of the role of brain catecholamines. pp. 125–160. In: The Psychobiology of the Depressive Disorders: Implications for the Effects of Stress. Depue R (ed), Academic Press, New York, NY, 1979.

Technical Reports

Jardini JA, et al. Electric field and ion current environment of HVDC overhead transmission lines. Report of Joint Working Group B4/C3/B2.50, CIGRĖ, August 2011.

Johnson GB, Bracken TD, Bailey WH. Charging and transport of aerosols near AC transmission lines: A literature review. EPRI, Palo Alto, CA, 2003.

Bailey WH. Probabilistic approach to ranking sources of uncertainty in ELF magnetic-field exposure limits. In: Evaluation of Occupational Magnetic Exposure Guidelines, Interim Report, EPRI Report TR-111501, 1998.

Bracken TD, Bailey WH, Su SH, Senior RS, Rankin RF. Evaluation of occupational magnetic-field exposure guidelines; Interim Report. EPRI Report TR-108113, 1997.

Bailey WH, Weil DE, Stewart JR. HVDC Power Transmission Environmental Issues Review. Oak Ridge National Laboratory, Oak Ridge, TN, 1996.

Bailey WH. Melatonin responses to EMF. Proceedings, Health Implications of EMF Neural Effects Workshop, Report TR-104327s, EPRI, 1994.

Bailey WH. Recent neurobiological and behavioral research: Overview of the New York State powerlines project. In: Power-Frequency Electric and Magnetic Field Research, EPRI, 1989.

Bailey WH, Bissell M, Dorn CR, Hoppel WA, Sheppard AR, Stebbings, JH. Comments of the MEQB Science Advisors on Electrical Environment Outside the Right of Way of CU-TR-1, Report 5. Science Advisor Reports to the Minnesota Environmental Quality Board, 1986.

Bailey WH, Bissell M, Brambl RM, Dorn CR, Hoppel WA, Sheppard AR, Stebbings JH. A health and safety evaluation of the +/- 400 KV powerline. Science Advisor's Report to the Minnesota Environmental Quality Board, 1982.

Charry JM, Bailey WH, Weiss JM. Critical annotated bibliographical review of air ion effects on biology and behavior. Rockefeller University, New York, NY, 1982.

Bailey WH. Avoidance behavior in rats with hereditary hypothalamic diabetes insipidus. Dissertation, City University of New York, 1975.

Selected Invited Presentations

Bailey WH, Erdreich LS. Human sensitivity and variability in response to electromagnetic fields: Implications for standard setting. International Workshop on EMF Dosimetry and Biophysical Aspects Relevant to Setting Exposure Guidelines. International Commission on Non-Ionizing Radiation Protection, Berlin, March 2006.

Bailey WH. Research-based approach to setting electric and magnetic field exposure guidelines (0-3000 Hz). IEEE Committee on Electromagnetic Safety, December 2005.

Bailey WH. Conference Keynote Presentation. Research supporting 50/60 Hz electric and magnetic field exposure guidelines. Canadian Radiation Protection Association, Annual Conference, Winnipeg, June 2005.

Bailey WH. Scientific methodology for assessing public health issues: A case study of EMF. Canadian Radiation Protection Association, Annual Conference, Public Information for Teachers, Winnipeg, June 2005.

Bailey WH. Assessment of potential environmental effects of electromagnetic fields from submarine cables. Connecticut Academy of Science and Engineering, Long Island Sound Bottomlands Symposium: Study of Benthic Habitats, July 2004.

De Santo RS, Coe M, Bailey WH. Environmental justice assessment and the use of GIS tools and methods. National Association of Environmental Professionals, 27th Annual Conference, Dearborn, MI, June 2002.

Bailey WH. Applications to enhance safety: Research to understand and control potential risks. Human Factors and Safety Research, Volpe National Transportation Systems Center/Dutch Ministry of Transport, Cambridge, MA, November 2000.

Bailey WH. EMF health effects review. EMF Exposure Guideline Workshop, Brussels Belgium, June 2000.

Bailey WH. Dealing with uncertainty when formulating guidelines. EMF Exposure Guideline Workshop, Brussels Belgium, June 2000.

Bailey WH. Field parameters: Policy implications. EMF Engineering Review Symposium, Status and Summary of EMF Engineering Research, Charleston, SC, April 1998.

Bailey WH. Principles of risk assessment: Application to current issues. Symposium on EMF Risk Perception and Communication, World Health Organization, Ottawa, Canada, August 1998.

Bailey WH. Current guidelines for occupational exposure to power frequency magnetic fields. EPRI EMF Seminar, New Research Horizons, March 1997.

Bailey WH. Methods to assess potential health risks of cell telephone electromagnetic fields. IBC Conference—Cell Telephones: Is there a Health Risk? Washington, DC, June 1997.

Bailey WH. Principles of risk assessment and their limitations. Symposium on Risk Perception, Risk Communication and its Application to EMF Exposure, International Commission on Non-Ionizing Radiation Protection, Vienna, Austria, October 1997.

Bailey WH. Probabilistic approach for setting guidelines to limit induction effects. IEEE Standards Coordinating Committee 28: Non-Ionizing Radiation, Subcommittee 3 (0–3 kHz), June 1997.

Bailey WH. Power frequency field exposure guidelines. IEEE Standards Coordinating Committee 28: Non-Ionizing Radiation, Subcommittee 3 (0–3 kHz), June 1996.

Bailey WH. Epidemiology and experimental studies. American Industrial Hygiene Conference, Washington, DC, May 1996.

Bailey WH. Review of 60 Hz epidemiology studies. EMF Workshop, Canadian Radiation Protection Association, Ontario, Canada, June 1993.

Bailey WH. Biological and health research on electric and magnetic fields. American Industrial Hygiene Association, Fredrickton, New Brunswick, Canada, October 1992.

Bailey WH. Electromagnetic fields and health. Institute of Electrical and Electronics Engineers, Bethlehem, PA, January 1992.

Bailey WH, Weiss JM. Psychological factors in experimental heart pathology. Visiting Scholar Presentation, National Heart Lung and Blood Institute, March 1977.

Presentations

Shkolnikov Y, Bailey WH. Electromagnetic interference and exposure from household wireless networks. Product Safety Engineering Society Meeting, San Diego, CA October 2011.

Nestler E, Trichas T, Pembroke A, Bailey W. Will undersea power cables from offshore wind projects affect sharks? North American Offshore Wind Conference & Exhibition, Atlantic City, NJ, October 2010.

Nestler E, Pembroke A, Bailey W. Effects of EMFs from undersea power lines on marine species. Energy Ocean International, Ft. Lauderdale, FL, June 2010.

Pembroke A, Bailey W. Effects of EMFs from undersea power cables on elasmobranchs and other marine species. Windpower 2010 Conference and Exhibition, Dallas, TX, 2010.

Bailey WH. Clarifying the neurological basis for ELF guidelines. Workshop on Practical Implementation of ELF and RF Guidelines. The Bioelectromagnetics Society 29th Annual Meeting, Kanazawa, Japan, June 2007.

Sun B, Urban B, Bailey W. AERMOD simulation of near-field dispersion of natural gas plume from accidental pipeline rupture. Air and Waste Management Association: Health Environments: Rebirth and Renewal, New Orleans, LA, June 2006.

Bailey WH, Johnson G, Bracken TD. Method for measuring charge on aerosol particles near AC transmission lines. Joint Meeting of The Biolectromagnetics Society and The European BioElectromagnetics Association, Dublin Ireland, June 2005.

Bailey WH, Bracken TD, Senior RS. Long-term monitoring of static electric field and space charge near AC transmission Lines. The Bioelectromagnetics Society, 26th Annual Meeting, Washington, DC, June 2004.

Bailey WH, Erdreich L, Waller L, Mariano K. Childhood leukemia in relation to 25-Hz and 60-Hz magnetic fields along the Washington DC—Boston rail line. Society for Epidemiologic Research, 35th Annual Meeting, Palm Desert CA, June 2002. American Journal of Epidemiology 2002; 155:S38.

Erdreich L, Klauenberg BJ, Bailey WH, Murphy MR. Comparing radiofrequency standards around the world. Health Physics Society 43rd Annual Meeting, Minneapolis, MN, July 1998.

Bracken TD, Senior RS, Rankin RF, Bailey WH, Kavet R. Relevance of occupational guidelines to utility worker magnetic-field exposures. Second World Congress for Electricity and Magnetism in Biology and Medicine, Bologna, Italy, June 1997.

Weil DE, Erdreich LS, Bailey WH. Are 60-Hz magnetic fields cancer causing agents? Mechanisms and Prevention of Environmentally Caused Cancers, The Lovelace Institutes 1995 Annual Symposium, La Fonda, Santa Fe, NM, October 1995.

Bailey WH. Neurobiological research on extremely-low-frequency electric and magnetic fields: A review to guide future research. Sixteenth Annual Meeting of the Bioelectromagnetics Society, Copenhagen, Denmark, June 1994.

Blondin J-P, Nguyen D-H, Sbeghen J, Maruvada PS, Plante M, Bailey WH, Goulet D. The perception of DC electric fields and ion currents in human observers. Annual Meeting of the Canadian Psychological Association, Penticton, British Columbia, Canada, June 1994.

Erdreich LS, Bailey WH, Weil DE. Science, standards and public policy challenges for ELF fields. American Public Health Association 122nd Annual Meeting, Washington, DC, October 1994.

Bailey WH, Charry JM. Particle deposition on simulated VDT operators: Influence of DC electric fields. 10th Annual Meeting of the Bioelectromagnetics Society, June 1988.

Charry JM, Bailey WH. Contribution of charge on VDTs and simulated VDT operators to DC electric fields at facial surfaces. 10th Annual Meeting of the Bioelectromagnetics Society, June 1988.

Bailey WH, Charry, JM. Dosimetric response of rats to small air ions: Importance of relative humidity. EPRI/DOE Contractors Review, November 1986. Charry JM, Bailey WH, Bracken TD (eds). DC electric fields, air ions and respirable particulate levels in proximity to VDTs. International Conference on VDTs and Health, Stockholm, Sweden, June 12–15 1986.

Charry JM, Bailey WH. Air ion and DC field strengths at 10^4 ions/cm^3 in the Rockefeller University Small Animal Exposure Chambers. EPRI/DOE Contractors Review, November 1985.

Charry JM, Bailey WH. DC Electrical environment in proximity to VDTs. 7th Annual Meeting of the Bioelectromagnetics Society, June 1985.

Bailey WH, Collins RL, Lahita RG. Cerebral lateralization: Association with serum antibodies to DNA in selected bred mouse lines. Society for Neuroscience, 1985.

Kavet R, Bailey WH, Charry JM. Respiratory neuroendocrine cells: A plausible site for air ion effects. Seventh Annual Meeting of The Bioelectromagnetics Society, June 1985.

Bailey WH, Charry JM. Measurement of neurotransmitter release and utilization in selected brain regions of rats exposed to DC electric fields and atmospheric space charge. 23rd Hanford Life Sciences Symposium, Richland, WA, October 1984.

Bailey WH, Charry JM, Weiss JM, Cardle K, Shapiro M. Regional analysis of biogenic amine turnover in rat brain after exposure to electrically charged air molecules (air ions). Society for Neuroscience, 1983.

Bailey WH. Biological effects of air ions: Fact and fancy. American Institute of Medical Climatology Conference on Environmental Ions and Related Biological Effects, October 1982.

Goodman PA, Weiss JM, Hoffman LJ, Ambrose MJ, Bailey WH, Charry, JM. Reversal of behavioral depression by infusion of an A2 adrenergic agonist into the locus coeruleus. Society for Neuroscience, November 1982.

Charry JM, Bailey WH. Biochemical and behavioral effects of small air ions. Electric Power Research Institute Workshop, April 1981.

Bailey WH, Alsonso DR, Weiss JM, Chin S. Predictability: A psychologic/ behavioral variable affecting stress-induced myocardial pathology in the rat. Society for Neuroscience, November 1980.

Salman SL, Weiss JM, Bailey WH, Joh TH. Relationship between endogenous brain tyrosine hydroxylase and social behavior of rats. Society of Neuroscience, November 1980.

Bailey WH, Maclusky S. Appearance of creatine kinase isoenzymes in rat plasma following myocardial injury produced by isoproterenol. Fed Assoc Soc Exp Biol, April 1978.

Bailey WH, Maclusky S. Appearance of creatine kinase isoenzymes in rat plasma following myocardial injury by isoproterenol. Fed Proc 1978; 37:889.

Bailey WH, Weiss JM. Effect of ACTH 4-10 on passive avoidance of rats lacking vasopressin (Brattleboro strain). Eastern Psychological Association, April 1976.

Prior Experience

President, Bailey Research Associates, Inc., 1991–2000
Vice President, Environmental Research Information, Inc., 1987–1990
Head of Laboratory of Environmental Toxicology and Neuropharmacology, New York State Institute for Basic Research, 1983–1987
Assistant Professor, The Rockefeller University, 1976–1983

Academic Appointment

- Visiting Fellow, Department of Pharmacology, Cornell University Medical College, New York, NY, 1986–present

Prior Academic Appointments

- Visiting Scientist, The Jackson Laboratory, Bar Harbor, ME, 1984–1985
- Head, Laboratory of Neuropharmacology and Environmental Toxicology, NYS Institute for Basic Research in Developmental Disabilities, Staten Island, NY, 1983–1987
- Assistant Professor, The Rockefeller University, New York, NY, 1976–1983
- Postdoctoral Fellow, Neurochemistry, The Rockefeller University, New York, NY, 1974–1976
- Dissertation Research, The Rockefeller University, New York, NY, 1972–1974
- CUNY Research Fellow, Dept. of Psychology, Queens College, City University of New York, Flushing, NY, 1969–1971
- Clinical Research Assistant, Department of Psychiatry, University of Chicago; Psychiatric Psychosomatic Inst., Michael Reese Hospital, and Illinois State Psychiatric Inst, Chicago, IL, 1968–1969

Teaching Appointments

- Lecturer, University of Texas Health Science Center, Center for Environmental Radiation Toxicology, San Antonio, TX, 1998
- Lecturer, Harvard School of Public Health, Office of Continuing Education, Boston, MA, 1995, 1997
- Lecturer, Rutgers University, Office of Continuing Education, New Brunswick, NJ, 1991–1995
- Adjunct Assistant Professor, Queens College, CUNY, Flushing, NY, 1978
- Lecturer, Queens College, CUNY, Flushing, NY, 1969–1974

Editorship

- Associate Editor, Non-Ionizing Radiation, *Health Physics*, 1996–present

Advisory Positions

- US Bureau of Ocean Energy Management, Regulation and Enforcement, 2009–2010
- Canadian National Collaborating Centre for Environmental Health, reviewer of Centre reports, 2008
- Island Regulatory and Appeals Commission, province of Prince Edward Island, Canada, 2008
- ZonMw – Netherlands Organization for Health Research and Development, 2007-2008, reviewer for National Programme on EMF and Health

- National Institute of Environmental Health Sciences/ National Institutes of Health, Review Committee, Neurotoxicology, Superfund Hazardous Substances Basic Research and Training Program, 2004
- National Institute of Environmental Health Sciences, Review Committee Role of Air Pollutants in Cardiovascular Disease, 2004
- Working Group on Non-Ionizing Radiation, Static and Extremely Low-Frequency Electromagnetic Fields, International Agency for Research on Cancer, 2000–2002
- Working Group, EMF Risk Perception and Communication, World Health Organization, 1998–2005
- Member, International Committee on Electromagnetic Safety, Subcommittee 3 - Safety Levels with Respect to Human Exposure to Fields (0 to 3 kHz) and Subcommitee 4 - Safety Levels with Respect to Human Exposure (3kHz to 3GHz) Institute of Electrical and Electronics Engineers (IEEE), 1996–present
- Invited participant, National Institute of Environmental Health Sciences EMF Science Review Symposium: Clinical and In Vivo Laboratory Findings, 1998
- Working Group, EMF Risk Perception and Communication, International Commission on Non-Ionizing Radiation Protection, 1997
- U.S. Department of Energy, RAPID EMF Engineering Review, 1997
- Oak Ridge National Laboratory, 1996
- American Arbitration Association International Center for Dispute Resolution, 1995–1996
- U.S. Department of Energy, 1995
- National Institute for Occupational Safety and Health, 1994–1995
- Federal Rail Administration, 1993–1996
- U.S. Forest Service, 1993
- New York State Department of Environmental Conservation, 1993
- National Science Foundation
- National Institutes of Health, Special Study Section—Electromagnetics, 1991–1993
- Maryland Public Service Commission and Maryland Department of Natural Resources, Scientific Advisor on health issues pertaining to HVAC Transmission Lines, 1988–1989
- Scientific advisor on biological aspects of electromagnetic fields, Electric Power Research Institute, Palo Alto, CA, 1985–1989
- U.S. Public Health Service, NIMH: Psychopharmacology and Neuropsychology Review Committee, 1984
- Consultant on biochemical analysis, Colgan Institute of Nutritional Science, Carlsbad, CA, 1982–1983
- Behavioral Medicine Abstracts, Editor, animal behavior and physiology, 1981–1983
- Consultant on biological and behavioral effects of high-voltage DC transmission lines, Vermont Department of Public Service, Montpelier, VT, 1981–1982

- Scientific advisory committee on health and safety effects of a high-voltage DC transmission line, Minnesota Environmental Quality Board, St. Paul, MN, 1981–1982
- Consultant on biochemical diagnostics, Biokinetix Corp., Stamford, CT, 1978–1980

Professional Affiliations

- The Health Physics Society (Affiliate of the International Radiation Protection Society)
- Society for Risk Analysis
- International Society of Exposure Analysis
- New York Academy of Sciences
- American Association for the Advancement of Science
- Air and Waste Management Association
- Society for Neuroscience/International Brain Research Organization
- Bioelectromagnetics Society
- The Institute of Electrical and Electronics Engineers/Engineering in Medicine and Biology Society
- Conseil International des Grands Reseaux Electriques