

**Environmental Assessment  
From an EMF (Electromagnetic Field)  
Perspective**

In a  
Metro Taxi Cab

Performed for:  
Metro Cab Drivers

Work performed in  
2009  
With 2014 addenda

By  
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## Executive Summary

Individuals who drive Metro Cabs indicated that, due to recent changes in the fleet they lease from, they have been getting predictably recurring headaches during and long after their work shift, and been unable to sleep. They suspected it had something to do with the wireless features. While this was part of the picture, other contributors were found.

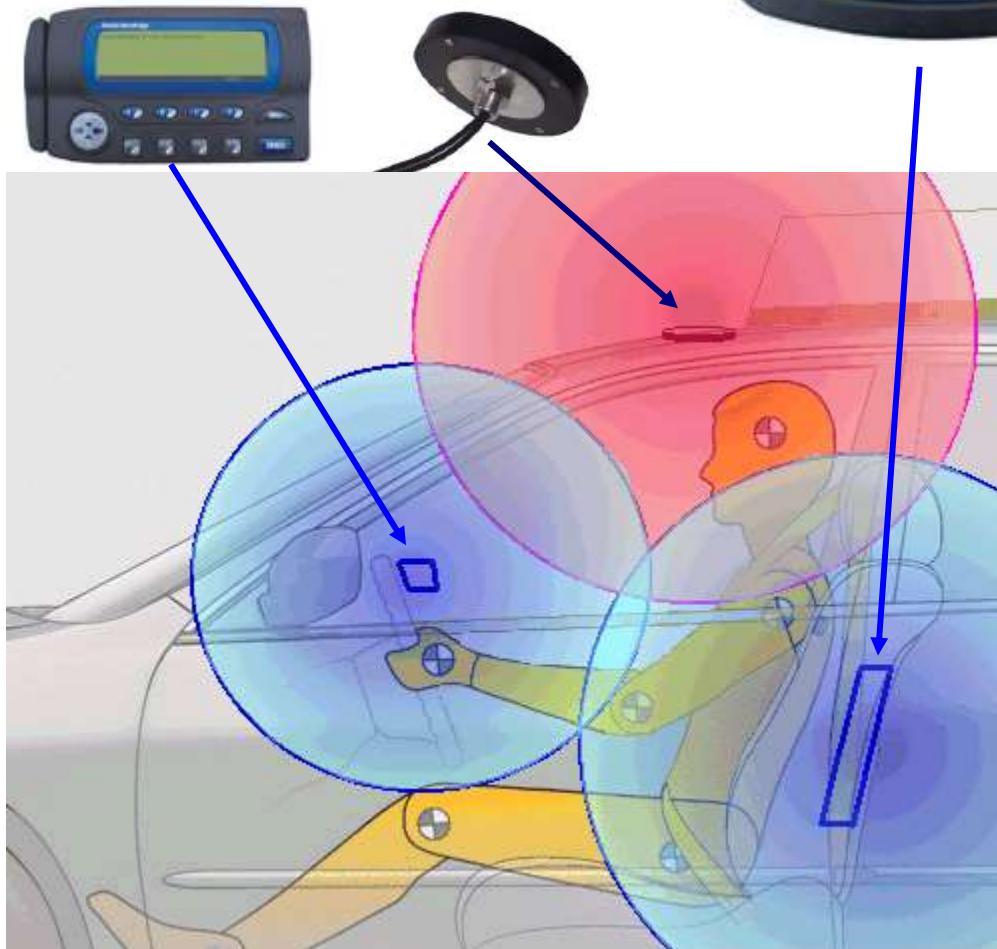
Passenger Information Monitor (PIM)

## Findings

Three new items (since 2007) contribute to personal exposure within the cab, in addition to standard electrical systems and wiring.

Below is a perspective of their approximate range of influence, and biological interest.

CMT's Driver Interactive Unit (DIU)



## Discussion and Recommendations

With the intent to “enhance the payment experience,” so that “Credit and debit card equipped taxicabs give passengers the same conveniences they already receive at the supermarket, gas pump, online and virtually everywhere,” and “The Passenger Information Monitor (PIM) provides the passenger with real-time mapping to track their journey,” “CMT has partnered with leaders in the media and entertainment industry to provide a unique blend of entertainment, news and advertising, via the PIM in the backseat of every FREEdom Solution taxicab.” In addition, “CMT's FREEdom solution includes access to FleetNet, CMT's web portal, which allows vehicle or fleet owners to manage and track their vehicle operations. FleetNet also provides the ability for the TLC or the fleet manager to send text messages to drivers' in-vehicle terminal.” This author contends that Creative Mobile Technologies (and imitators that may follow in their footsteps) outfitting cabs with these digital features is a bad idea.

Conventionally any gasoline-powered auto produces an Alternating Magnetic Field, whose frequency varies with the speed of the vehicle, from the Alternator, which is a three-phase generator, functionally just like every power company uses. Additional Pulsating Magnetic Fields are provided by DC Motors, when in use, due to make-and-break operation of the brushes, as well as from the cabling that feeds the ignition coil(s). Separately, Wideband Emissions (many frequencies simultaneously) are produced by the High Voltage Ignition (HVI) System. In and of themselves these may be bad enough. What have been added since about mid-2007, are a digital interactive display known as a Driver Interactive Unit and a digital interactive display known as a Passenger Information Monitor. Both are pictured in the previous page, and both are Wideband Harmonics sources, now brought within immediate proximity of the driver and passenger(s). The last item of interest is a multi-band Antenna that uses GPS to determine its position, and Cellular/PCS communications to constantly update its position in a Fleet Management System. The latter is located immediately above the driver's head on the exterior of the cab. While this was done for convenience of the installer, there are other serious considerations that make this specific location especially troublesome.

RF (Radio Frequency) transmitting antennas produce peculiar energetic behavior in their immediate proximity in order to force EM (Electromagnetic) energy to travel in free space. That is because the electronics' internal impedance (characteristically around 50 Ohms) is different that that of free space (377 Ohms). The impedance mismatch causes standing waves (*as in a small circular pond when a pebble is dropped in the middle*) immediately near the antenna for a distance of about two wavelengths from the antenna. This is known as the Near Region. Beyond this is the Far Region where EM/RF travels freely through space. Within the Near Region complex interactions occur between the Electric and Magnetic fields produced, and measurement is nearly impossible due to the convective currents produced in anything metallic, or conductive, associated with the measurement equipment, or the exposed structure under study, resulting in exposure to usually be a calculation estimate. These local echoes cause peaks and nulls that are not predictable, and change dynamically depending on the position of anything conductive and mobile within this region of influence, be it a human or other conductive structure. While human skin is generally a good insulator to Electric fields, it is not to Magnetic fields, so within the Near Region the interaction is not just superficial or reliably predictable. A portion of the energy echoing back and forth escapes the Near Region and begins to travel freely in free space in the Far Region. For everyone on the

planet the exposure is mostly in the Far Region. For those who use cellular or other transmitters near them there is the additional exposure in the Near Region. The regions are distinguished by the wavelength of the frequency in use. In the case of the CMT multi-band antenna, reception in the GPS frequencies occurs at  $1575.42 \pm 2$  MHz and is not a Near Region exposure concern from this antenna as it is receive only. For Cellular / PCS it is at 806-960 / 1710-2170 MHz. The wavelength for 1 GHz (1000 MHz) is about 1 foot (12 inches, or about 30 cm). Two wavelengths' radius would define a region within about two feet from the antenna as the Near Region. The wavelength for 2 GHz (2000 MHz) is about 6 inches (about 15 cm). Two wavelengths' radius at this frequency would define a region within about 12 inches from the antenna as the Near Region. The present installation of the antenna is directly above the driver's head. Although it is outside the cab, the window is transparent, placing the driver's head immediately within the Near Region. Realizing that the driver cannot be relocated, this is the worst possible placement for the antenna. This may be compounded by RF leakage from the electronics near the operator controls. A much better location would have been on the roof above the rear seat, on the passenger side. Drivers have already complained of recurring headaches, indicating that negative, and possibly damaging, biological interaction has been going on for some time. Their exposure is typically 8 to 12 hours.

Early stages of disease can manifest themselves as irritation that persists during exposure to an irritant. Moving away from the irritant, discomfort stops and the body is able to recover. If the body cannot recover (sufficiently) during the time away, then additional and similar irritants may be present, and /or a trigger mechanism may be established that can cause irreversible damage.

One of the functions of the central nervous system occurs with EM messaging named "Action Potential". This is a pulse train that travels to and from organs and appendages for indication and control. Interference with this type of messaging can bring on discomfort or pain. Wideband Emissions and Harmonics can mimic these signals and cause irritation that may be local or systemic, depending on the frequencies, the extent of exposure, and the strength of the emissions. A casual sweep near the Passenger Information Monitor and the Driver Interactive Unit indicated them both to be wideband emitters. These emissions have sharp rise and fall times, allowing them to easily penetrate the skin boundary and propagate through the central nervous system using the same concept utilized in TENS (Transcutaneous Electrical Nerve Stimulation) and TASER units (*the former used by athletes and sports medicine doctors to alleviate pain, and the latter by law enforcement units to inflict pain or immobilize individuals, respectively, the difference simply being intensity*). While a controlled use such as in a TENS unit can alleviate pain, uncontrolled exposure such as that from the cabs' newest electronics fall within the description of TASER exposure.

The exposure level of the RF emissions was below the Thermal guidelines used by the FCC, which "limits, and the NCRP and ANSI/IEEE limits on which they are based, are derived from exposure criteria quantified in terms of SAR (Specific Absorption Rate). The basis for these limits is a whole-body averaged SAR threshold level of 4 watts per kilogram (4 W/kg), as averaged over the entire mass of the body, above which expert organizations have determined that potentially hazardous exposures may occur." [oet65, p8]

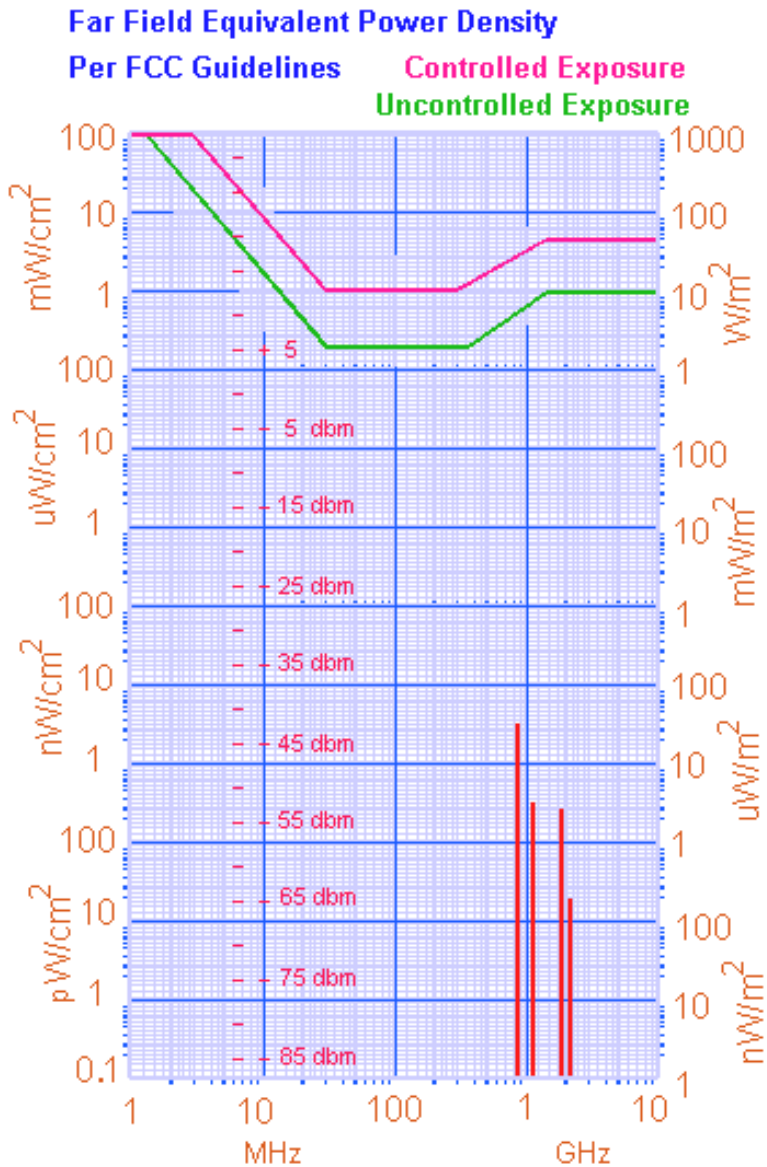
"Another feature of the exposure guidelines is that exposures . . . may be averaged over time with the average not to exceed the limit for continuous exposure." [oet65, p10]

This implies that momentary exposure, as from digital emissions, can be substantially higher than the exposure guidelines, as long as the average is below them.

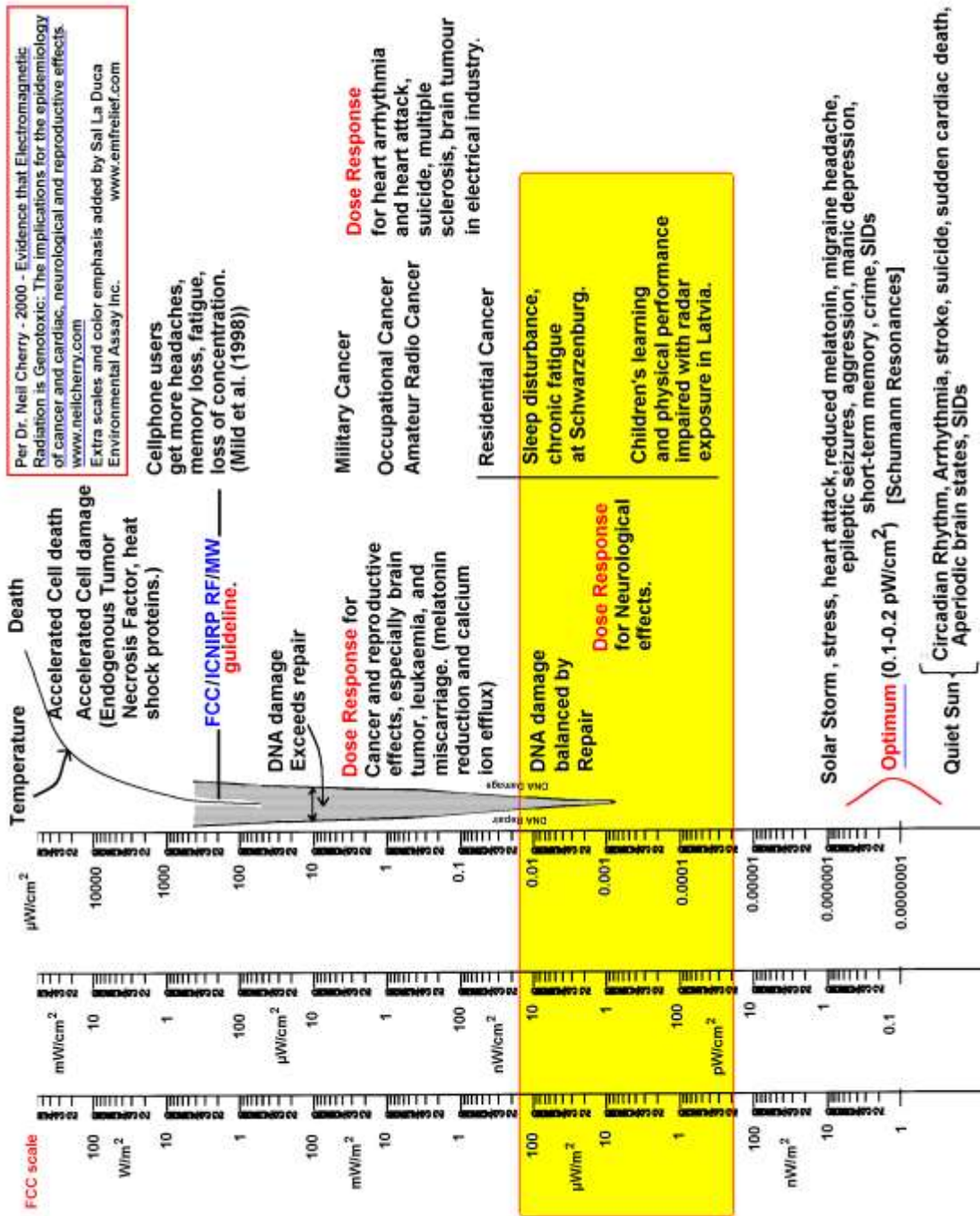
Both of the above criteria are based on short-term effects.

Shown to the right are the approximate Frequencies (*horizontal axis*) and intensities (*vertical axis, with different units on right and left for ease of conversion*) detected. They are well below the MPE (Maximum Permissible Exposures) shown near the top of the graph. There is a good chance of significant RF leakage from the operator controls, as measurement inside and outside the cab did not vary in intensity.

Based on these recommendations there is no exposure concern, because flesh does not get warm beyond the body's ability to control temperature. Since it doesn't "cook," everything's OK . . .



However, behavioral responses occur well below the Thermal guidelines, although these are not technically defined as bad, nor actionable. Below is a sketch with the general area of detected emissions highlighted in yellow.





The exposure concerns for wideband emissions are much more difficult to quantify. That is because most exposure criteria are based on emissions of single frequency, constant level / intensity, or both. Wideband emissions or Harmonics do not fit either category, and subsequently there are no exposure guidelines. That is, for humans. While generally actionable threshold criteria exist for Harmonics for AC power systems, they differ automotive systems, and there are none for humans.

Wideband Emissions or Harmonics sweep through a portion of the frequency spectrum generating many discrete frequencies simultaneously. Lightning is a typical example. High Voltage Ignition Systems is another, on a smaller scale. Dimmers, Fluorescent lighting, and Digital systems are yet another, on a smaller scale still. [The observed effects of RF radiation on biological systems seem to depend more on a differential rate of energy deposition than is the case with ionizing radiation where biological effects are related more to energy and integral (time independent) quantities, such as absorbed dose [NCRP report# 67, 3-1981 - intro, p2]. The sharper the digital “edge” (rise or fall time), the higher the differential rate of energy deposition (this author’s comment). With a simple AM radio you can detect the crackle during lightning. If the AM radio could be made to listen to all frequencies simultaneously, then it could be noted that there are emissions at most frequencies throughout the portion of the spectrum that the unit can detect. Digital displays of any type will emit energies at many frequencies simultaneously similar to Lightning or HVI systems, but on a much smaller scale. The exposure then depends on the size of the display, the vintage of the associated electronics, and the proximity of the display to the user. A typical digital display as used for a computer is typically two feet (60 cm) distant from the user. The digital displays as used in the metro cabs are within 6 inches of the driver, 8 to 12 hours a day. If there is central nervous system irritation, as the cabbies affirm, then the extended length of exposure is bound to cause effects that may linger for some time after exposure stops. The cab drivers testified to this, having noted their trouble sleeping, hours after their work shift.

These two exposures (RF and Wideband) work in tandem to provide the perceived effects, so it is difficult to say with certainty that the RF is the problem, or the Wideband Emissions are the problem, but what is certain is that their combined presence since shortly after their mid-2007 installation has provided irritating biological effects.

If the experienced irritation transitions to illness, then the claimed “improvement in services to the passengers” is a hollow improvement at the cost of the cab drivers’ health. Indubitably CMT will deny any responsibility. Guiding agencies will deny any cause and effect. Meanwhile cab drivers’ health will be affected negatively, and it will be up to them to bypass the “junk science” that the guiding agencies rely on, and either change jobs, or use their collective bargaining efforts through unions or otherwise to demand that the devices be removed from the cabs. Granted, progress may be inevitable. However, when that progress is at the cost of the health of those involved, the progress is not forward, but backwards.

The “improvements” have already been installed in many of New York City, Chicago, and Boston’s cabs. Others may very well follow, unless the cabbies unite, and through their collective efforts take measures to protect their health.

## 2014 Addendum

Automotive electrical systems used to consist of necessary lighting and ignition systems. To provide the needed power, there was a battery, and an alternator. This simple arrangement provided an Alternating Magnetic field from the Alternator functioning, and a pulsating magnetic field from the current to the ignition coil.

Somewhere in the late 70s / early 80s, computerization came of age, and began to be employed in automobiles. This consisted of fuel mixture monitoring and control, as well as maintenance and trouble alerting systems. These had memory, requiring dedicated connectors for access, distancing the user from being able to inherently maintain their vehicle. This also brought on digital systems and switching power systems' Harmonics related to their electronics.

Somewhere around 2010 automobile electric systems began employing flat panel displays for driver information, as well as fully integrated wireless communications systems.

The net impact of all of these has been a widening presence of a greater span of frequencies due to the necessary electronics. These end up permeating the passenger cabin, causing the driver and passengers to be victim receivers. Were they electrical machines, EMI (Electromagnetic Interference) considerations would come into play. Ironically, humans employ so many electrically-based internal communications and control systems, that they may as well be labeled as electrical machines. But that is against the ongoing philosophy that humans are impervious to EMI from encroaching EMF components. Peculiarly, the medical profession is fully aware that exposure to certain fields and frequencies causes health improvement. So controlled exposure can be healing, but uncontrolled exposure causes no effect. Some of these "professionals," depending on which lot one is speaking of, are truly balmy.

In this mix of automobiles are Diesel-powered cars. They do not have an ignition system, and can function entirely mechanically once started. Their electromagnetic fields are minimal.

Another trend has been to integrate entirely battery-powered drive systems to supplement or outright substitute the fuel-fed drivetrain.

Owing to different designers, and different designs, some systems use three-phase motors, and necessary three-phase inverters. Some use variable frequency drives. Some use a combination of both. Those units that are entirely electric do not need an alternator, and thus do not have the alternating magnetic field associated with it. But they may have alternating fields or Harmonics at different frequencies from their other varied systems. It is a mistake for the casual investigator to use a field meter designed for 50 / 60 Hz systems, as it may not respond to the frequencies present in an automotive system.



## Very Limited Glossary

Electron – The fundamental unit of charge. It's associated with an Electric Field.

Voltage – Electrical difference between two points, or surfaces, because of differing concentration of electrons.

Current – Flow of charge (electrons) past a given point over a unit of time. It is measured as Amperes (Amps) and will cause a Magnetic Field.

Watt – Unit of power caused by an interaction of a certain amount of Voltage and a certain amount of Current. In static systems: Voltage x Current = Power (in Watts)

Alternating – Periodically changing polarity and strength.

Impedance – The dynamic electrical resistance that a structure offers to an Alternating signal.

Frequency – number of Alternations per unit time, such as Cycles per Second (a.k.a. Hertz (Hz)).

EMF (Electromagnetic Field) – Energy field that is propagated through conductive material such as wires, or free space, depending on frequency, caused by interaction of Voltage and Current.

RF (Radio Frequency) – Electromagnetic energy faster than about 30 million Cycles per Second (Hertz) or 30 Megahertz (MHz).

Near-field – The region nearest an EM source (Near region) where there are unusual electric and magnetic field interactions due to impedance mismatch between the antenna and free space.

Far-field – The region in space where the EM wave has adjusted to the impedance of free space (Far region) and travels unobstructed until it encounters something partially or fully conductive.

Inverse Square law – Reduction relationship where the field strength at a point twice as far as another point from an antenna is  $\frac{1}{4}$  that of the other. Most un-focused sources exhibit this relationship in the Far-field.

SAR (Specific Absorption Ratio) – The Rate at which Electromagnetic energy is deposited onto a solid surface. It is equal to the product of Voltage times Current and is divided by the surface area the energy is spread out over.

Attenuation – Reduction in strength due to either shielding (fully or partially conductive material) or distance (such that the emitted energy gets substantially spread out). Depending on the electrical conductivity, and the frequency(ies) involved, some shielding requires grounding.

## **La Duca Bio in Brief**

**Sal La Duca, Principal - Environmental Assay Inc. / Indoor Environmental Consultant /**  
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Sal is an Environmental Consultant specializing in the built environment, with about 40 years' experience in instrumentation and controls. After receiving two years training in the physical sciences, Sal performed as a Nuclear Reactor Operator / Reactor Technician (*Instrumentation and Control Technician - Nuclear*) on the USS Mississippi, CGN40, and participated in its initial construction, initial criticality, Commissioning (1978), initial sea trials and shakedown operations. During this time he also acquired a First Class FCC License with Radar Endorsement. After an Honorable Discharge, he was offered employment by Jersey Central Power and Light to help build a Radiological Survey instrument repair facility at the Oyster Creek Nuclear Plant in Forked River, NJ. After having done so, and trained sufficient employees to man the facility, he migrated to the Communications department, where he performed installation, calibration, and repairs of various generations of remote-control supervisory equipment for power system control, as well as work on fixed and mobile Radio Frequency equipment. After three years of this work he migrated to the Dispatch Center and performed as a Power System Load Dispatcher for six years, performing all operations of system control, and restoration, from 4,800 V to 500,000 V. He then had an opportunity to return to the Communications department where he performed as an Instrumentation and Control Technician.

In 1994 Sal incorporated and began offering Electromagnetic Field services. In 1999 he sought and acquired additional training, and expanded service offerings to include Indoor Air Quality. In 2003 he sought and acquired Certified Indoor Environmentalist (CIE) status with the Indoor Air Quality Association, which was later upgraded to Council-Certified Indoor Environmental Consultant (CIEC). He holds a Bachelor of Science from the University of Phoenix, AZ.

### **Training and Expertise**

1975 – 1977 Fundamentals and applications for operating a Nuclear Power Plant, as well as calibrating and repairing its control systems

1977 – 1981 Nuclear Reactor Operator / Instrumentation and Control Tech – Nuclear

1981 – FCC First Class License with Radar Endorsement

1982 – 1984 Fundamentals and applications for operating a Bulk Power Transmission and Distribution System, as well as calibrating and repairing its control systems

1985 – 1991 Power System Operator

1991 – Instrumentation and Control Tech

1994 – EMF (Electromagnetic Field) Consultant

2003 – Indoor Environmental Consultant – IAQA

2009 – Radio Frequency Safety Officer – NARDA Microwave