

Detailed Examples of NLT: Radio Frequency Energy, Kinetic Energy and Electro-Muscular Devices

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GENERAL PROBLEMS IN RESEARCH ON MICROWAVES AND RF

The effects of human exposure to microwaves range from direct thermal effects causing pain to unknown effects of microwaves in anti-materiel systems. The possible medical effects induced by the use of microwaves in non-lethal weapon systems are difficult to evaluate. In spite of extensive research and wide use of cell phones and wireless phones, the available scientific evidence does not show that any health problems are associated with using wireless phones. There is no proof, however, that wireless phones are absolutely safe. Wireless phones emit low levels of radiofrequency energy (RF) in the microwave range while being used. They also emit very low levels of RF when in the stand-by mode. Whereas high levels of RF can produce health effects (by heating tissue), exposure to low-level RF that does not produce heating effects causes no known adverse health effects. Many studies of low-level RF exposures have not found any biological effects. Some studies have suggested that some biological effects may occur, but such findings have not been confirmed by additional research. In some cases, other researchers have had difficulty in reproducing those studies, or in determining the reasons for inconsistent results.

A few animal studies have suggested that low levels of RF could accelerate the development of cancer in laboratory animals. However, many of the studies that showed increased tumor development used animals that had been genetically engineered or treated with cancer-causing chemicals so as to be pre-disposed to develop cancer in the absence of RF exposure. Other studies exposed the animals to RF for up to 22 hours per day. These conditions are not similar to the conditions under which people use wireless phones, so we don't know with certainty what the results of such studies mean for human health.

Three large epidemiology studies on the health effects of RF have been published since December 2000. Between them, the studies investigated any possible association between the use of wireless phones and primary brain cancer, glioma, meningioma, or acoustic neuroma, tumors of the brain or salivary gland, leukemia, or other cancers. None of the studies demonstrated the existence of any harmful health effects from wireless phone RF exposures. However, none of the studies can answer questions about long-term exposures, as the average period of phone use in these studies was around three years. A combination of laboratory studies and epidemiological studies of people actually using wireless phones would provide some of the data that are needed. Lifetime animal exposure studies could be completed in a few years. However, very large numbers of animals would be needed to provide reliable proof of a cancer promoting effect if one exists. Epidemiological studies can provide data that is directly applicable to human populations, but 10 or more years' follow-up may be needed to provide answers about some health effects, such as cancer. This is because the interval between the time of exposure to a cancer-causing agent and the time tumors develop - if they do - may be many, many years. The interpretation of epidemiological studies is hampered by difficulties in measuring actual RF exposure during day-to-day use of wireless

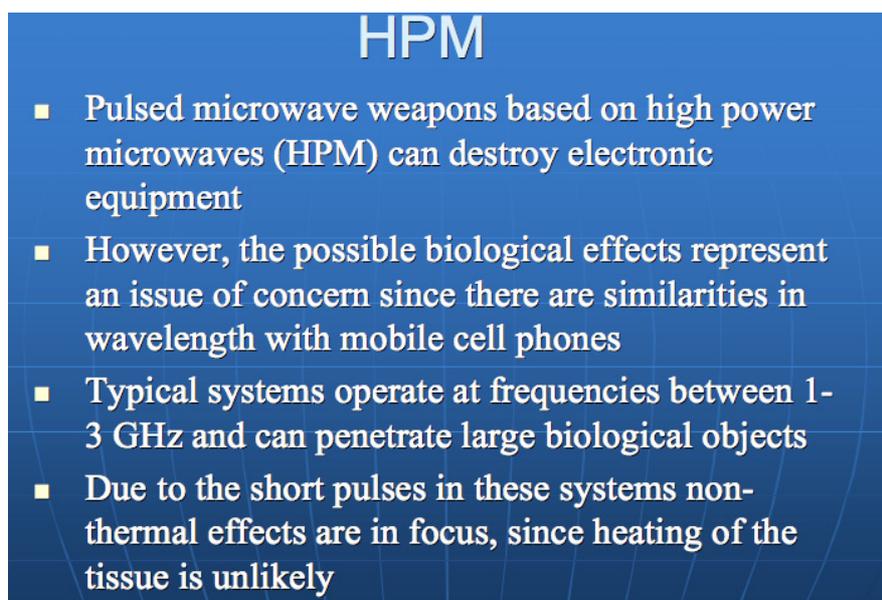
phones. Many factors affect this measurement, such as the angle at which the phone is held, or which model of phone is used. <http://www.fda.gov/cellphones/>.

ADS

An interesting example new NLT directed energy system is the development of the Active Denial System (ADS) or the millimeter wave weapon. This entirely new directed energy system can emit and converge 94 GHz waves on objects at a distance of several hundred metres and thereby induce heating of the skin of an exposed person. This type of waves cannot penetrate more than a few hundred microns into the body. The entire energy content is therefore delivered in the superficial layers of the skin and this results in a local heating that stimulates heat sensitive endings of local pain nerve fibers. The Air Force Research Laboratory (AFRL) at Brooks City Base in San Antonio played an important role in the medical research that was necessary to evaluate the effects and possible hazards. These studies included a lot of solid studies on dose-response relations and threshold effects (Mason et al., 2001; Millenbaugh et al., 2006; Nelson et al., 2003; Ryan et al., 2000; Walters et al., 2004). This appears to be a good example of how basic medical research can be used to increase safety in a new NLW system.

HPM

Pulsed microwave weapons based on high power microwaves (HPM) represent another example of directed energy non-lethal weapons. Such systems aim to interact with and destroy electronic equipment. However, the possible biological effects represent an issue of concern since there are similarities in wavelength with mobile cell phones. Typical systems operate at frequencies between 1-3 GHz and can penetrate large biological objects. Due to the short pulses in these systems non-thermal effects are in focus, since heating of the tissue is unlikely. Suggested effects of cell phones are assumed to be thermal, and therefore not relevant to HPM. Some groups have reported defects in the Blood-Brain Barrier and nerve cell death in rats exposed to GSM cell phones (Belyaev et al., 2006; Salford et al., 1994; Salford et al., 2003). These results are controversial and need to be verified by other groups.



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HPM sources do not seem to induce cell death or Blood-Brain Barrier defects. Changes in cytoskeleton proteins have been reported only after a number of pulses that are much higher than realistic for practical

use of HPM weapons (Risling et al., 2005; Risling et al., 2001). For technical reasons it is difficult to exclude thermal effects also in HPM experiments, due to for example artefacts induced by recording electrodes (de Pomerai et al., 2000; Tattersall et al., 2001; Walters et al., 1998). The former WEAG countries have defined Common European Priority Area for research. One of these projects is ERG101.006 RF Biological Effects Research with the aim to produce scientific evidence to advise safety standards for exposure of defence personnel to radio frequency (RF) fields. It focuses on non-thermal effects of novel pulsed military sources. This is a collaboration project between UK, Italy, Belgium, the Netherlands, Spain and Sweden. Pulsed microwave weapons based on high power microwaves (HPM) is one of the areas in the project and this research area is still active and possible biological effects are much more difficult to analyse for these complicated non-lethal weapons than for traditional systems such as kinetic impact.

KINETIC ENERGY

The security forces in Northern Ireland have used Baton Rounds since 1973 and they are intended to cause painful non-lethal injuries. The type of injury is, more or less, a blunt trauma with a superficial injury that is a roughly 4 cm in diameter circular abrasion and an area of surrounding contusion. However, they have the potential to cause serious injury and a number of lethal head or thoracic injuries were observed during the first years of use (Metress and Metress, 1987). Head and eye injuries as well as fatal thoracic injuries have also been reported from Israel and African countries (Balouris, 1990; Jaouni and O'Shea, 1997; Kalebi and Olumbe, 2005; Mahajna et al., 2002). The safety in use of Baton Rounds has significantly increased by a careful empirical medical evaluation that was performed on the initiative of the Home office and the Northern Ireland Office (NIO), leading to improved design (the attenuated energy projectile) and strict rules for training and use (Burrows, 2001; Hughes et al., 2005; Maguire et al., 2007). This work has drastically decreased the number of lethal head injuries and increased public acceptability.



The attenuated energy projectile has a comparatively soft end that reduces the risk for fatal head injuries, but transmits energy rather effectively to soft body regions. Training in the Northern Ireland police is rigorous and restricted to relatively few policemen.

ELECTRO-MUSCULAR DEVICES

This group of NLT includes stun guns that are used in direct contact with the object and variants of the Taser electroshock gun that can be used at a distance up to 7 meters with good effect and accuracy. The Taser induces an instant, but transient, muscular paralysis. It is an important NLT for the police in several countries. It is also the most debated of modern non-lethal weapons. This may be partly dependent on the fact that the exact mechanisms for effect of the Taser, the widespread uncontrollable muscular contractions, still are partly unknown. The muscular and possible cardiovascular effects of exposure to Taser have been examined in experimental animals (Jauchem et al., 2006; Lakkireddy et al., 2006) and observations in numerous human volunteers (Ho et al., 2006). There are a lot of data from the use of the advanced Taser in many countries. Perforating ocular injuries have been described (Chen et al., 2006). The Taser M26 and X26 systems have been carefully evaluated by authorities in many countries. Such information has been compiled on the ILEF NLW database. Some features in the Tasers provide protection against possible misuse. The Taser can disperse confetti with serial numbers when it is fired. This links the specific Taser to the scene where it is used. The X26 can be employed with the Taser Cam, a videocamera system that can be used to document deployment of the gun.

Tests: Taser gun not factor in death of homeless man
 BY VICKI ADAMS
 HOLLYWOOD, Calif. (AP) — A study by the University of Southern California said it found at least one death from the original Taser device, whose technology is the basis for the newer stun gun used by Hollywood police and others. The study, published in a peer-reviewed journal, said the man died from cardiac arrest, and no deaths have been linked to its products. For a Taser to be deadly, it must deliver a certain amount of voltage and current long enough to damage, said Laurel. He added that the man's heart condition was not related to his death.

Cocaine, not stun gun, faulted death of homeless man, 31
 HOLLYWOOD, Calif. (AP) — A study by the University of Southern California said it found at least one death from the original Taser device, whose technology is the basis for the newer stun gun used by Hollywood police and others. The study, published in a peer-reviewed journal, said the man died from cardiac arrest, and no deaths have been linked to its products. For a Taser to be deadly, it must deliver a certain amount of voltage and current long enough to damage, said Laurel. He added that the man's heart condition was not related to his death.

Miramar officer won't face charges
 MIRAMAR, Calif. (AP) — A Miramar police officer who shot a man with a Taser gun in 2005 will not face charges, a prosecutor said. The man died from cardiac arrest, and no deaths have been linked to its products. For a Taser to be deadly, it must deliver a certain amount of voltage and current long enough to damage, said Laurel. He added that the man's heart condition was not related to his death.

Taser gun cleared in man's death
 HOLLYWOOD, Calif. (AP) — A study by the University of Southern California said it found at least one death from the original Taser device, whose technology is the basis for the newer stun gun used by Hollywood police and others. The study, published in a peer-reviewed journal, said the man died from cardiac arrest, and no deaths have been linked to its products. For a Taser to be deadly, it must deliver a certain amount of voltage and current long enough to damage, said Laurel. He added that the man's heart condition was not related to his death.

The question of in-custody death

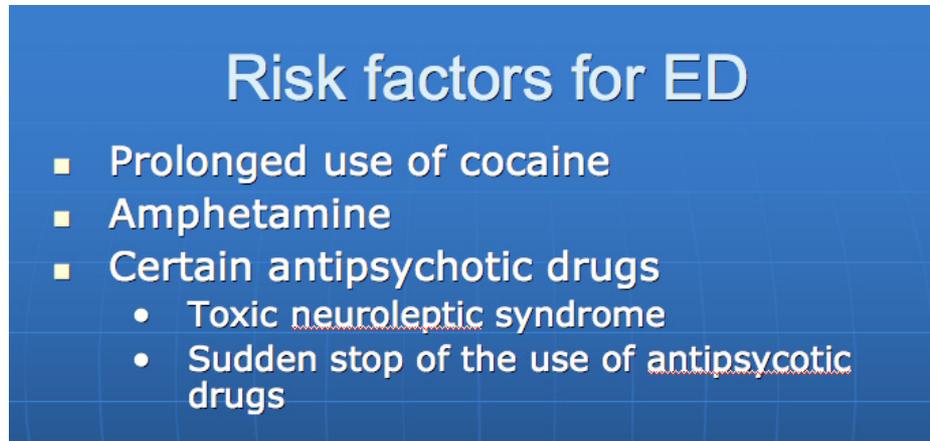
STUN GUN FALLACY: HOW THE LACK OF TASER REGULATION ENDANGERS LIVES

AMERICAN CIVIL LIBERTIES UNION OF NORTHERN CALIFORNIA
 SEPTEMBER 2005

TASER STUDY

The most debated issue with the Taser gun is the possible relation to in custody deaths. A number of deaths in people with a recent history of Taser exposure have received a lot of attention. The typical case is a death a few hours after exposure, which seems to exclude acute direct electrical effects on the heart. In a recent review of 75 cases (Strote and Range Hutson, 2006), it was found that there was a history of drug abuse in more than 85% of these examined cases. More than 50% had signs of cardiovascular pathology that could have contributed to death. 75% had developed a condition called Excited Delirium (ED). The ED patients are by definition violent and combative (Di Maio and Di Maio, 2006). They have an increased body temperature and may develop muscular breakdown (rhabdomyolysis) (Ruttenber et al., 1999). They can also attain a serious heart muscle rhythm disturbance, a prolongation of the QT interval that may lead

to the fatal torsades de pointes (Brice et al., 2003). A similar rhythm disturbance has been observed in a limited number of psychiatric patients treated with combinations of neuroleptics (antipsychotic drugs), or in patients that suddenly finish their medication with neuroleptics (Morrison and Sadler, 2001).



Risk factors for ED

- Prolonged use of cocaine
- Amphetamine
- Certain antipsychotic drugs
 - Toxic neuroleptic syndrome
 - Sudden stop of the use of antipsychotic drugs

Cocaine abuse is a major factor for the development of ED (Blaho et al., 2000). Drugs like cocaine induce a number of serious changes in the body of the abusers like effects on the transport of dopamine and serotonin (transmitter substances) in the brain (Mash et al., 2003; Mash et al., 2002; Mash et al., 2000). These changes at the chemical level in the brain seem to increase the risk for ED development. Other cocaine-induced chronic effects are cardiac hypertrophy and cardiomyopathy, which seem to increase the risk for fatal heart arrhythmias such as torsades de pointes. Thus, a cocaine abuser which turns into an ED patient has a significant risk for sudden death. A prolonged combat-like situation preceding restraint may elevate the likelihood for in custody death for the cocaine abuser (Brice et al., 2003; Stratton et al., 2001). Excited, aggressive and confused cocaine abusers and psychiatric patients in an acute confusional state have a high probability for being exposed to a Taser. Today, it is getting more and more obvious that such ED patients should be subjected to a careful medical examination after restraint, regardless if they have been exposed to Taser or not. However, a continuous development of new Taser systems and the uncertainty concerning the mechanisms for the muscular effects of the gun obviously necessitates further medical evaluation. The question of safety and sudden death is currently addressed in a number of ongoing studies. Thus, it is possible that the issue of ED and in custody deaths is not specific for the Taser gun. Anecdotic reports on occurrence of sudden deaths after exposure to pepper spray could indicate that this outcome should be considered in all situations of restraint with drug addicts. However, not all drugs seem to increase the risk for ED. Central stimulants such as cocaine and amphetamine appear to have a higher ED risk profile than the opioids. It may be of importance to analyze the drug abuse pattern in different cultures and countries. A number of US police departments develop strict rules for medical examination of people exposed to Taser. It is suggested that similar rules should be adopted if Tasers are employed for use in police-like actions during international military missions.

However, a continuous development of new Taser systems and the uncertainty concerning the mechanisms for the muscular effects of the gun obviously necessitates further medical evaluation. The question of safety and sudden death is being addressed in a number of ongoing studies.

REFERENCES

- Balouris CA. 1990. Rubber and plastic bullet eye injuries in Palestine. *Lancet* 335(8686):415.
- Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, W HS, Salford LG, Persson BR. 2006. Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double stranded DNA breaks or effects on chromatin conformation. *Bioelectromagnetics* 27(4):295-306.
- Blaho K, Winbery S, Park L, Logan B, Karch SB, Barker LA. 2000. Cocaine metabolism in hyperthermic patients

- with excited delirium. *J Clin Forensic Med* 7(2):71-76.
- Brice JH, Pirrallo RG, Racht E, Zachariah BS, Krohmer J. 2003. Management of the violent patient. *Prehosp Emerg Care* 7(1):48-55.
- Burrows C. 2001. Operationalizing non-lethality: a Northern Ireland perspective. *Medicine, conflict, and survival* 17(3):260-271.
- Chen SL, Richard CK, Murthy RC, Lauer AK. 2006. Perforating ocular injury by Taser. *Clinical & experimental ophthalmology* 34(4):378-380.
- de Pomerai D, Daniells C, David H, Allan J, Duce I, Mutwakil M, Thomas D, Sewell P, Tattersall J, Jones D, Candido P. 2000. Non-thermal heat-shock response to microwaves. *Nature* 405(6785):417-418.
- Di Maio TG, Di Maio VJM. 2006. *The Excited Delirium Syndrome. Cause of Death and Prevention*. Taylor & Francis, CRC Boca Raton, London, New York.
- Ho JD, Miner JR, Lakireddy DR, Bultman LL, Heegaard WG. 2006. Cardiovascular and physiologic effects of conducted electrical weapon discharge in resting adults. *Acad Emerg Med* 13(6):589-595.
- Hughes D, Maguire K, Dunn F, Fitzpatrick S, Rocke LG. 2005. Plastic baton round injuries. *Emerg Med J* 22(2):111-112.
- Jaouni ZM, O'Shea JG. 1997. Surgical management of ophthalmic trauma due to the Palestinian Intifada. *Eye (London, England)* 11 (Pt 3):392-397.
- Jauchem JR, Sherry CJ, Fines DA, Cook MC. 2006. Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of *Sus scrofa* following repeated TASER exposures. *Forensic science international* 161(1):20-30.
- Kalebi A, Olumbe AK. 2005. Death following rubber bullet wounds to the chest: case report. *East African medical journal* 82(7):382-384.
- Lakkireddy D, Wallick D, Ryschon K, Chung MK, Butany J, Martin D, Saliba W, Kowalewski W, Natale A, Tchou PJ. 2006. Effects of cocaine intoxication on the threshold for stun gun induction of ventricular fibrillation. *Journal of the American College of Cardiology* 48(4):805-811.
- Maguire K, Hughes DM, Fitzpatrick MS, Dunn F, Rocke LG, Baird CJ. 2007. Injuries caused by the attenuated energy projectile: the latest less lethal option. *Emerg Med J* 24(2):103-105.
- Mahajna A, Aboud N, Harbaji I, Agbaria A, Lankovsky Z, Michaelson M, Fisher D, Krausz MM. 2002. Blunt and penetrating injuries caused by rubber bullets during the Israeli-Arab conflict in October, 2000: a retrospective study. *Lancet* 359(9320):1795-1800.
- Mash DC, Ouyang Q, Pablo J, Basile M, Izenwasser S, Lieberman A, Perrin RJ. 2003. Cocaine abusers have an overexpression of alpha-synuclein in dopamine neurons. *J Neurosci* 23(7):2564-2571.
- Mash DC, Pablo J, Ouyang Q, Hearn WL, Izenwasser S. 2002. Dopamine transport function is elevated in cocaine users. *Journal of neurochemistry* 81(2):292-300.
- Mash DC, Staley JK, Izenwasser S, Basile M, Rutenber AJ. 2000. Serotonin transporters upregulate with chronic cocaine use. *J Chem Neuroanat* 20(3-4):271-280.
- Mason PA, Walters TJ, DiGiovanni J, Beason CW, Jauchem JR, Dick EJ, Jr., Mahajan K, Dusch SJ, Shields BA, Merritt JH, Murphy MR, Ryan KL. 2001. Lack of effect of 94 GHz radio frequency radiation exposure in an animal model of skin carcinogenesis. *Carcinogenesis* 22(10):1701-1708.
- Metress EK, Metress SP. 1987. The anatomy of plastic bullet damage and crowd control. *Int J Health Serv* 17(2):333-342.
- Millenbaugh NJ, Kiel JL, Ryan KL, Blystone RV, Kalns JE, Brott BJ, Cerna CZ, Lawrence WS, Soza LL, Mason PA. 2006. Comparison of blood pressure and thermal responses in rats exposed to millimeter wave energy or environmental heat. *Shock (Augusta, Ga)* 25(6):625-632.
- Morrison A, Sadler D. 2001. Death of a psychiatric patient during physical restraint. Excited delirium--a case report. *Medicine, science, and the law* 41(1):46-50.
- Nelson DA, Walters TJ, Ryan KL, Emerton KB, Hurt WD, Ziriach JM, Johnson LR, Mason PA. 2003. Inter-species extrapolation of skin heating resulting from millimeter wave irradiation: modeling and experimental results. *Health physics* 84(5):608-615.
- Risling M, Sköld M, Malm E, Sondén A, Larsson I-L, Angeria M, Malmgren L. 2005. Observations on changes in the content of tubulin and VEGF protein in cell cultures exposed to High Power Microwaves, in vitro. In *Non-lethal options enhancing security and stability* Fraunhofer institut Chemische Technologie, DWS Werbeagentur und Verlag GmbH, Karlsruhe:18-11 – 18-11.
- Risling M, Suneson A, Meier M, Malmgren L. 2001. Studies on the possible effects of high power microwaves on the central nervous system. In *NonLethal Weapons* Fraunhofer institut Chemische Technologie, DWS Werbeagentur und Verlag GmbH, Karlsruhe:10-11 – 10-19.
- Rutenber AJ, McAnally HB, Wetli CV. 1999. Cocaine-associated rhabdomyolysis and excited delirium: different

- stages of the same syndrome. *Am J Forensic Med Pathol* 20(2):120-127.
- Ryan KL, D'Andrea JA, Jauchem JR, Mason PA. 2000. Radio frequency radiation of millimeter wave length: potential occupational safety issues relating to surface heating. *Health physics* 78(2):170-181.
- Salford LG, Brun A, Sturesson K, Eberhardt JL, Persson BR. 1994. Permeability of the blood-brain barrier induced by 915 MHz electromagnetic radiation, continuous wave and modulated at 8, 16, 50, and 200 Hz. *Microscopy research and technique* 27(6):535-542.
- Salford LG, Brun AE, Eberhardt JL, Malmgren L, Persson BR. 2003. Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones. *Environmental health perspectives* 111(7):881-883; discussion A408.
- Stratton SJ, Rogers C, Brickett K, Gruzinski G. 2001. Factors associated with sudden death of individuals requiring restraint for excited delirium. *The American journal of emergency medicine* 19(3):187-191.
- Strote J, Range Hutson H. 2006. Taser use in restraint-related deaths. *Prehosp Emerg Care* 10(4):447-450.
- Tattersall JE, Scott IR, Wood SJ, Nettell JJ, Bevir MK, Wang Z, Somasiri NP, Chen X. 2001. Effects of low intensity radiofrequency electromagnetic fields on electrical activity in rat hippocampal slices. *Brain research* 904(1):43-53.
- Walters TJ, Ryan KL, Nelson DA, Blick DW, Mason PA. 2004. Effects of blood flow on skin heating induced by millimeter wave irradiation in humans. *Health physics* 86(2):115-120.
- Walters TJ, Ryan KL, Tehrany MR, Jones MB, Paulus LA, Mason PA. 1998. HSP70 expression in the CNS in response to exercise and heat stress in rats. *J Appl Physiol* 84(4):1269-1277.

