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Questions Linger About Health Effects Of DOD's 'Non-Lethal' Ray

When the Pentagon recently unveiled plans for a "non-lethal" gun capable of controlling crowds by heating people's skin with millimeter waves, Marine Corps and Air Force officials said the beam would be painful but "harmless." But questions remain about the biological effects of millimeter waves, even among scientists working on the non-lethal weapon. Further, aspects of the program are classified, making it impossible for the public to fully understand the technology research and the implicit assumptions upon which the Marine Corps and Air Force's conclusions are based.

About $40 million has been spent on this technology over the last decade, according to the Marine Corps, which is in charge of the Pentagon's non-lethal programs. The Pentagon's joint non-lethal weapons program and the Air Force Research Laboratory are funding the effort; proponents hope to get the necessary approval to build a prototype vehicle with a millimeter-wave emitter on its roof. That system, the Vehicle Mounted Active Denial System, could save lives by reducing fatalities among adversaries and innocent persons, proponents say. But is exposure to the technology completely safe, as the Marine Corps' press release on the technology suggests? In fact, recent Air Force research on the biological effects of millimeter waves (MMWs) concludes there are potential health concerns.

"As the use of MMWs increase, the possibility exists that personnel might be inadvertently exposed, perhaps leading to injury. Because of the shallow penetration depth of MMWs, thermal injury to the eye and the skin are most

likely," states the paper "Radio Frequency Radiation of Millimeter Wave Length: Potential Occupational Safety Issues Relating to Surface Heating," published in the February 2000 edition of Health Physics. The paper goes on to suggest claims of safety are based on the premise individuals will both sense and be able to physically move out of the way of the ray. Irradiation of both the eyes and the skin are "for the most part, self limiting in that the exposure will be sensed and avoided before thermal injury is incurred."

Further, the paper says it remains an open question whether exposure to millimeter waves might promote cancer.

"To date, there have been no laboratory studies that address the specific issue of whether MMW exposure might promote cancer development. Because applications of [radio frequency] energy are so novel, there is also no epidemiological work addressing this question. Because MMW energy is absorbed in the skin, it would be expected that any long-term detrimental health effects would most likely be manifest in the skin," states the paper. Inside the Navy has learned the Air Force has been studying the potential for millimeter waves to cause cancer and hopes to have the paper published this year, but the scientists are not permitted to discuss their research while it is being reviewed for publication. Even if the study concludes MMWs do not promote cancer, it will only be the first time that subject is addressed in published research, and only within the Air Force's own MMW research program, which is focused on developing the non-lethal weapon.

Further, some studies of MMWs have demonstrated the radiation can cause cataracts on the eyes of animals. Research published in 1998 reported thresholds for corneal damage at 94 GHz in rhesus monkeys. The energy necessary to produce a corneal lesion at 94 GHz was measured at 6 J cm-2 (three-second exposure to 2 W cm-2).

The Air Force will not discuss the power density of the non-lethal ray it is developing, though the service's program manager for radio frequency active denial technology, Kirk Hackett, said it is pulsed, not modulated, and operates at 95 GHz. It is pulsed on and off for relatively long periods of time, a few seconds at a time, he said.

A pulse refers to a single abrupt emission of radiation. Modulation refers to varying the amplitude, frequency, phase or intensity of a carrier wave in accordance with a sound wave or other signal.

In an interview last week, he also told ITN the power density of the non-lethal ray is high enough that it exceeds guidelines for millimeter wave exposure issued by the International Commission on Non-Ionizing Radiation. He said the exposure levels are safe and the international standards too conservative.

"In respect of adverse effects on human health, ICNIRP adopts the

[World
Health Organization] view of what constitutes health . . . and the induction of pain would be regarded by ICNIRP as an adverse effect," ICNIRP
Chairman Alastair McKinlay told ITN.

"We want to satisfy the press and the public that this is an acceptable thing to use on the battlefield but at the same time we're trying to protect the specifics so people can't duplicate it, can't develop countermeasures and things like that. It's very difficult," Hackett said.

But some scientists say the actual effects of the non-lethal weapon will
remain mysterious unless the Air Force provides additional information.

"Your problem here is basically they are giving you conclusions. What do
the data look like that they base the conclusions on? What is the data analysis, the statistical analysis which they applied and was it appropriate and do their conclusions follow from that analysis?" said biologist Allan Frey, who has broad research experience in biology and physics and has at times served as a consultant to the Defense Department.

"Probably most important of all is what were the implicit assumptions they
made before they even started the experiment, upon which the data rests?"
said Frey. "More often than not, in scientific research conclusions that
you read are not necessarily valid and this is because all experiments have
implicit assumptions that are made before the experiment even starts which
determine what's done, what's looked at, what's assumed to be relevant, what's even measured and so forth. Depending on those implicit assumptions
which are typically not verbalized, that affects what you get as a result
and whether it can be generalized to anything."

According to the Health Physics paper, the focus of the Air Force's research in biological effects of millimeter waves has been on thermal receptors in the skin that can detect increases in temperature. The paper
asks what degree of overexposure to MMWs would be necessary to elicit blistering and local inflammation responses, but says there is no literature on the threshold for skin damage in response to MMWs.

"In order to answer this question, we must therefore make assumptions that
the basic effect of MMW exposure is to increase the skin temperature and
that such exposure will produce conventional burning. In light of the shallow penetration depth of MMWs, these appear to be reasonable conjectures," states the paper. Many scientists say millimeter waves, a form of non-ionizing radiation, are absorbed in the skin, as opposed to more powerful X-rays and other ionizing radiation that penetrate deeper into the body.

But there is no consensus among scientists that thermal effects are the only biological effects this kind of non-ionizing radiation can produce.
Hackett said it is unclear whether millimeter waves cause non-thermal effects.

"There's controversy in the scientific community whether what are called non-thermal effects exist in response to energy of this type. I'm just a physicist but I'm not convinced they exist. And so it should be regarded as an open question," said Hackett. "As far as we know, and we have not seen any other effects other than thermal with this energy."

But some scientists question whether the Air Force's focus on thermal receptors might lead researchers to overlook other kinds of less-obvious effects millimeter waves might have on the body.

"Skin is an interesting organ. It's a pretty complex one. Actually, you have all sorts of sensory mechanisms in there, various kinds of sensors," said Frey. If a researcher is interested in the thermal receptors and is studying them, there is a possibility other receptors are being affected but not being measured and there could be changes in them that have other potentially irreversible consequences, Frey explained.

"You can be making a difference. For example, the immune system: that is significant in terms of suppressing cancer. You have cells always dividing," said Frey. Even though MMW radiation is non-ionizing and said not to be capable of breaking chemical bonds or causing mutations, there is still a question of whether MMWs could impair the human body's ability to kill off mutations that arise from other causes, Frey said.

"You have mistakes made in the DNA. You have three billion base pairs and when they replicate, whenever cells are divided which happens a lot in the skin, errors are made, there are mutations, so there's always essentially the potential for cancer occurring everyday in everybody. But we have all kinds of mechanisms to suppress that or turn it off or rectify that, some of which involve the immune system," said Frey. "You know, you've got immune system bodies in the skin and what are you doing to them and is it of any consequence from a health standpoint?"

Hackett acknowledged MMWs could have effects the Air Force is not yet aware of, but still argues the technology is safe.

"We won't claim that we have complete knowledge of the effects," said Hackett. "But we will claim we know enough to go forward with the development of the technology and to assure the safety of the human volunteers for the thing."

The Air Force's own scientific research documents just how little is understood about some of the strange effects associated with exposure to millimeter waves. The Russians, in fact, have for years used the non-ionizing radiation of millimeter waves to address health problems.

"In light of the shallow penetration depth of MMWs, it is interesting

to note that this therapy is apparently efficacious at diseased organs that are distal from the site of irradiation. This raises an important question: How does MMW therapy act to alleviate gastric ulcers, for example, when the energy does not penetrate past the level of the skin? A number of mechanisms have been proposed to explain such events (e.g., "resonance" phenomena, irradiation of acupuncture points, stimulation of peripheral receptors, humoral events), but there is little experimental evidence offered to substantiate these postulates," states the February 2000 paper.
"Until a physiologically feasible mechanism is characterized and established empirically, Western medicine must react skeptically and treat such claims of improvement at distal sites as a phenomenon rather than a scientifically-based therapy," the paper continues.

Though U.S. military proponents of the non-lethal ray say they worry the public will get the wrong idea about the technology, the Air Force's own "New World Vistas" report, published in the mid 1990s, actually describes goals of using electromagnetic radiation for what sounds like mind control.

"It would also appear possible to create high fidelity speech in the human.
body, raising the possibility of covert suggestion and psychological direction. When a high power microwave pulse in the gigahertz range strikes the human body, a very small temperature perturbation occurs. This is associated with a sudden expansion of the slightly heated tissue," states the report. "This expansion is fast enough to produce an acoustic wave. If a pulse stream is used, it should be possible to create an internal acoustic field in the 5-15 kilohertz range, which is audible. Thus it may be possible to 'talk' to selected adversaries in a fashion that would be most disturbing to them." This appears to be a reference to the "microwave hearing effect," a scientific phenomena Frey is credited with discovering in the 1960s.

Hackett said the non-lethal MMW ray project is not seeking to create that kind of talking effect in people's heads.

In fact, Frey and Hackett said the microwave hearing effect does not occur with millimeter waves (which range from 3 to 300 GHz).

"On the other hand, if your millimeter waves have enough energy density, are powerful enough, there are other phenomena where you could cause sort of a concussion kind of effect which could conceivably be heard by bone conduction. It would transfer through skin to bone and bone into the inner ear," Frey said. He said it might be possible to modulate such energy to

create the perception of some intelligible sounds. "But off hand, I can't tell you what kind of power levels you might need to do that," he said. Hackett dismissed the idea of transmitting intelligible sounds to the head with MMWs as pure speculation.

Officials Say 'Non-Lethal' Ray Not Intended For Surveillance

The millimeter-wave radiation technology the Air Force and Marine Corps are exploring for use as a "non-lethal" weapon may have surveillance applications but those in charge of the project say those applications are not part of the plan.

John Pike, director of GlobalSecurity.org, told Inside the Navy the non-lethal ray concept sounds like "half of a radar," which might have information-gathering applications if equipment to receive and process radar pulses was included in the project. Perhaps, the U.S. military would develop an alternate version of the system for that purpose, suggested Pike, a defense expert.

Millimeter waves are non-ionizing electromagnetic radiation located between the microwave and infrared portions of the spectrum. MMW technology is marketed commercially for sensors.

"Because they are capable of 'seeing through' most packaging, clothing, and many wall materials, while still providing sufficiently detailed images, millimeter waves are ideally suited for use in security and emergency applications," according to the web site of the company Millivision, which markets MMW technology.

Marine Corps Col. George Fenton, head of the Pentagon's non-lethal weapons directorate, said the only purpose of the ray being developed by the Air Force and Marine Corps is to create a non-lethal weapon the U.S. military could use in dangerous situations. Kirk Hackett, the Air Force's program manager for radio frequency active denial technology, agreed with Fenton.

"We haven't considered any of those kind of applications. You know a radar consists of something that transmits a pulse of energy out usually and then a receiver that receives and analyzes that pulse of energy to tell where objects are. Some microwaves or energy may be able to go through walls but we only have the transmitter part," said Hackett. "It's really not ideally suited for the kind of application you're describing because we're putting a lot of energy out, we can't pulse it on and off very fast, so that application wouldn't be a good match for the technology we have."

-- Christopher J. Castelli