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IMPLEMENTATION OF NON-LETHAL DEFENSE SYSTEMS ABOARD COMMERCIAL VESSELS FOR CLOSE COMBAT TERRORIST THREATS

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Abstract. *Implementation of non-lethal defense systems aboard commercial vessels for close combat terrorist threats is just an idea of protection against any threats that can jeopardize the ship, cargo or sailers.If the military can develop and use a non-lethal, directed-energy weaponthat isdesigned for area denial why not design a similar system, but for commercial vessels. Imagine that each ship could be equipped with a system based on millimeter-wave transmitter that could protect against possible attacks, putting an end to piracy. The impact of this system would not only eliminate close combat to defend the ship but even remove thecosts of protection paid whenships transit dangerous areas.Rapid heating of the target's skin followed by a rapid deviation from the original path of any potential risk is the effect that it will creat. Even if the system requires a larger investment, mitigating will be felt over time.Developing this system followed by applying some specific operating procedures would ensure a correct and legal use. The system works by firing a high-powered beam of 95 Ghz wave of heat, similar to the microwave oven, that excite the water and fat molecules from the skin.A smaller version of the army system would keep the commercial vessels safe from any attacks, a simple idea but with big consequences.*
Keywords: *non-lethal; defense systems; terrorist, commercial vessels*

INTRODUCTION

The Active Denial System (ADS) (figure 1) has been developed by the U.S. military in order to have minimal and non-lethal effects when used on people. This device is actually a directed-energy weapon that uses a strong millimeter-wave transmitter designed for area denial, permeter security and also crowd control.

Figure 1 – ADS on a armored vehicule(source: http://rossaprimavera.ru)

The "goodbye effect", "pain ray"or "heat ray" are some informall nicknames for this device, it uses a high power electro- magnetic transmitter and in some cases can also disable vehicles.
Raytheon company is marketing a reduced-range version of this technology, and after beeing deployed in the Iraq War with good results, the only question that we put ourselves is what if all the commercial ships would have such a device onboard.

Of course there should be some limitations, laws and regulations of use, but if we think about this ideea it could end the armed robbery or terrorism onboard any ship anywhere and with a small amount of acquisition followed by regular maintenance.

1. PRINCIPLE OF ACTIVE DENIAL SYSTEM

A high-powered beam of 95GHz wave is aimed at a target, which corresponds to a wavelength of 3,2 mm. The microwave oven has the same principle function as the ADS, exciting the water and fat molecules in the skin, instantly heating them via dielectric heating. The big difference is that a microwave oven uses the much lower frequency (and longer wavelength) of 2.45GHz.
The short millimeter waves used in ADS only penetrate the top layers of skin, most of the energy is being absorbed within 0.4mm (1/64"), whereas microwaves will penetrate into human tissue about 17mm (0.67").
The repel effect of ADS in humans (figure 2) occurs at slightly higher than 440C (1110F), though first-degree burns occur at about 510C (1240F), and second-degree burns occur at about 580C (1360F).
Pea-sized blisters have been observed in less than 0.1% of ADS exposures throughout testing, indicating that second degree surface burns have been caused by the device. The radiation burns caused are similar to microwave burns, but only on the skin surface due to the decreased penetration of shorter millimeter waves.

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As long as the beam is applied the surface temperature of a target will continue to rise at a rate dictated by the target's material and distance from the transmitter, along with the beam's frequency and power level set by the operator.

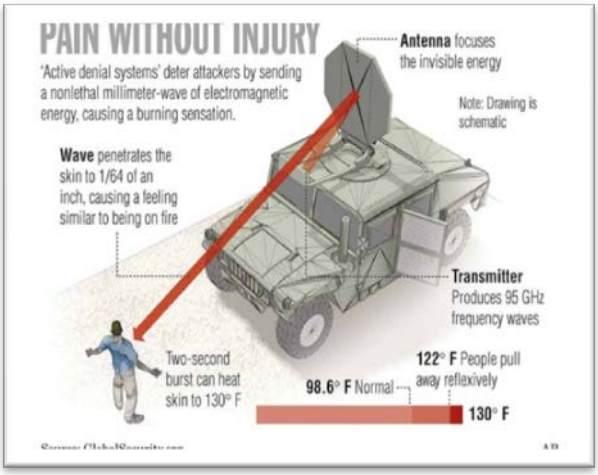

Figure 2 – Operating principle of ADS(source: https://defence.pk)

Most human test subjects reached their pain threshold within 3 seconds, and none could endure more than 5 seconds.

A future solution to eradicate burns is by implementing some fine adjustments to the main control panel, in which distance of action, surface tipe and instensity of the beam could be seted to avoid injures.

Mechanism of Dielectric Heating Molecular rotation (figure 3) occurs in materials containing polar molecules having an electrical dipole moment, with the consequence that they will align themselves in an electromagnetic field. If the field isoscillating, as it is in an electromagnetic wave or in a rapidly oscillating electric field, these molecules rotate continuously aligning with it.

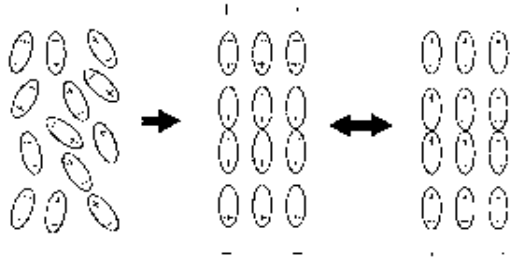

Figure 3 – Mechanism of dielectric deating molecular rotation(source: http://www.slideshare.net)

2. HUMAN TESTING

The Air Force Research Laboratory spokesman described this experience as a test subject for the system:

"For the first millisecond, it just felt like the skin was warming up. Then it got warmer and warmer and you felt like it was on fire. As soon as you're away from that beam your skin returns to normal and there is no pain."

On over 700 volunteers and over 10,000 exposures by ADS have been performed, and so Penn State Human Effects Advisory Panel (HEAP) concluded that ADS is a non-lethal weapon that has a high probability of effectiveness with a low probability of injury:

- no significant effects for wearers of contact lenses or other eyewear (including night vision goggles)
- normal skin applications, such as cosmetics, have little effect on ADS's interaction with skin
- no age-related differences in response to ADS exposures
- no effect on the male reproduction system
- the limit of damage was the occurrence of pea-sized blisters in less than 0.1% of the exposures (6 of 10,000 exposures).

Possible long-term effects

This matter is very important one because the effects on people reprezents the approvel of use. Many possible long-term effects have been studied, with the conclusion that no long-term effects are likely at the exposure levels studied.

However, overexposures of either operators or targets may cause long-term damage including cancer. According to an official military assessment, "In the event of an overexposure to a power density sufficient to produce thermal injury, there is anextremely low probability that scars derived from such injury might later become cancerous. Proper wound management further decreases this probability, as well as the probability of hypertrophic scarring or keloid formation."

- Cancer: A mouse cancer study was performed at two energy levels and exposures with a 94GHz transmitter: a single 10 second, 1 W/cm^2 exposure; and repeated 10 second exposures over 2 week period at 333 mW/cm^2. At both energy levels, no increase in skin cancers were observed. No studies of higher energy levels, or longer exposure times have been performed on millimeter wave systems.
- Cornea damage: tests on non-human primate eyes have observed no short-term or long-term damage as the blink reflex protects the eye from damage within 0.25 seconds.
- Birth defects: millimeter waves only penetrate 0.4 mm (1/64") into the skin,

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making direct damage to the testes or ovaries impossible.

- Blisters and scarring: pea-sized blistering due to second degree burns occurred in a very small minority (less than 0.1%) of tested exposures, which have a remote potential for scarring.

ADS operators would be exposed to more than the standard maximum permissible exposure (MPE) limits for RF energy, and military use requires an exception to these exposure limits.

3. LIMITATIONS

Like all focused energy, the beam will irradiate all matter in the targeted area, including everything beyond/behind it that is not shielded, with no possible discrimination between individuals, objects or materials.

Anyone incapable of leaving the target area (e.g., physically handicapped, infants, incapacitated, trapped, etc.) would continue to receive radiation until the operator turned off the beam. Reflective materials such as aluminium cooking foil should reflect this radiation and could be used to make clothing that would be protective against this radiation.

4. APPLICABILITY

a. Civilian Control

Riot shields and water cannon may soon be made obsolete by a revolutionary weapon that can stun a hostile crowd with invisible microwaves.

For this purpose the ADS can been mounted on the back of a tank, or jeep aside with a radar dish and it is known as Vehicle Mounted Active Denial System (VMADS)

Jane's Defence Weekly said recently the 'non-lethal' nature of some weapons 'might encourage military forces to use them directly against civilians and civilian targets'.

'It's part of this new political correctness on the battlefield,' said a spokesperson. 'The problem today in situations like Palestine is that you have adversaries mixing with innocent civilians. Forces now need a suite of weapons for different situations. You can score so many own goals by killing innocent civilians.'

Scientists have spent $40 million developing the weapon at the Air Force Research Laboratory, New Mexico. Demand for non-lethal weapons grew after the disastrous US military mission to Somalia in 1993, when marines died because they could not shoot back without hitting civilians.

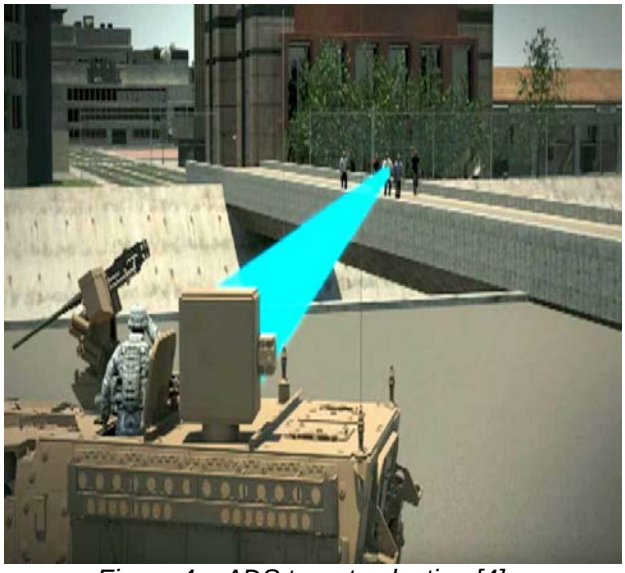

Figure 4 – ADS target selection [4] (source: http://i1.wp.com/www.moderntribune.info

The VMADS is the most sophisticated development in the search for the ultimate non-lethal weapon.

b. Counter-IED Operations

Heating an area with RF can cause plastic explosives to retain some energy which will allow them to be "viewed" via a thermal imaging system. RF energy may also disable detonation or timer electronics.

5. COMPONENTS OF ADS

The main components of an AID are:

- Electron Gun;
- Vacuum Chamber;
- Mirrors (generally concave);
- Low light video camera;
- Thermal imager;
- Antenna.

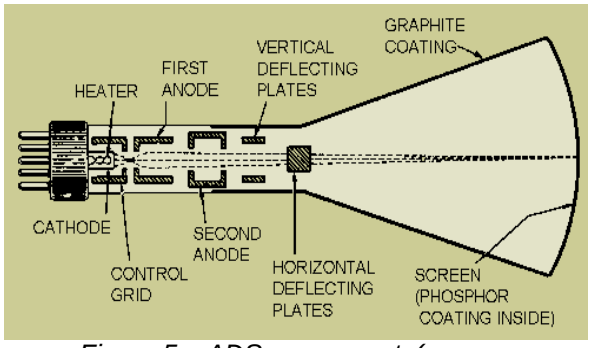

Figure 5 – ADS components(source: https://image.slidesharecdn.com/)

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Figure 6 – ADS Raytheon prototipe(source: https://share-ng.sandia.gov/news)

The two electronic scheme (figure 7 and 8) are representing the general condition for building a ADS, with all needed components and electronic circuits.

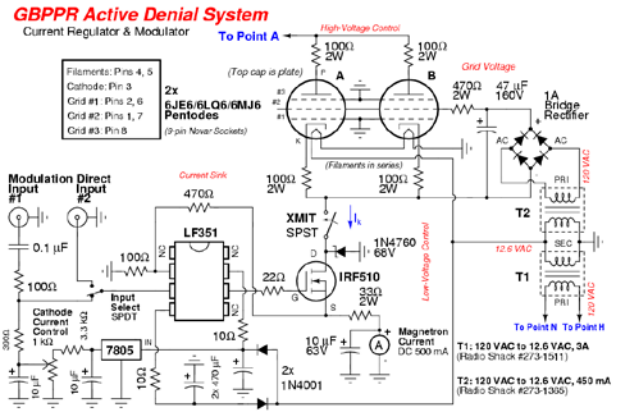

Figure 7 – ADS current regulator and modulator(source: https://s01.justpaste.it/)

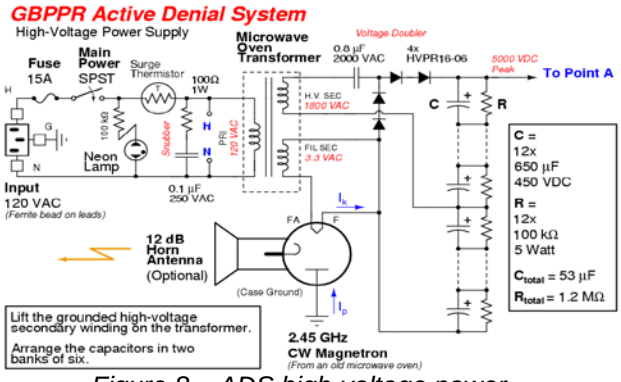

Figure 8 – ADS high-voltage power supply(source: https://s01.justpaste.it/)

6. IMPLEMENTING ADS ON BOARD MERCHANT SHIPS

For now ADS is tested and mounted on fixed and mobile platforms (figure 9). The mobile platforms are the armored vehicles to be used in areas with military conflicts in which civilians are involved.

Figure 9 – ADS mounted on armored vehicles(source: https://v.wpimg.pl)

This presentation aims to a posssible future of this device on board merchant vessels, so that implementation can save capital expenditure for major shipping companies used to guard and defense ships in danger zones known for terrorist or armed robbery activities.
Small platforms with reduced capabilities mounted on board should provide protection against this threats.

Figure 10 – ADS smaller exemple(source: https://assets.wired.com/, http://usuncut.com/)

From big to small, from the size of a truck to a smaller platform there is a enormous work, that Raytheon has accomplished, and a mass production for merchant ships should not be a problem, even setting it as a standard.

Figure 11 – ADS smaller platforms(source: https://www.wired.com/, http://www.mintpressnews.com/)

With increased accuracy and target identification provided by a video camera with adequate zoom placed in the center of the antenna (figure 12), the device can be used with a minimum of knowledge accumulated after a preparation certified by the company that will implement the ADS on merchant ships.
Automatic orientation of the antenna beam and also by simply handling a joystick and view target

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on a display device eases the way that the operator can remove the possible boats infringing upon the safety of the ship, crew and cargo also.

Figure 12 – ADS smaller platform mounted on a military vessel(source: https://i.ytimg.com)

7. BENEFITS

As always any system may have disadvantages, but the decision depends largely when balance is tilting to benefits.

The main benefits of the ADS are:

- **a.** Active Denial System is completely non-lethal,
- **b.** Does not cause long term health problems;
- **c.** Can be used from long range;
- **d.** Very mobile;
- **e.** Handheld version or can be mounted on various platforms;
- **f.** Very adaptable, can be used anywhere in any conditions, at any time;
- **g.** The acquisition cost is gradually reduced over time by limiting or the lack of force protection group on board.

8. DISADVANTAGES

Some disadvantages can influence the use on global scale of a new device, but is indicated that solutions for some problems should be known and applied to limit disadvanteges influence.

The main disadvantages of the ADS are:

- ✓ Could be used in inappropriate ways and used as a torture weapon;
- ✓ When used, could cause people to run away from the ray and trample or stampede others;
- ✓ If shot into a large group people may not be able to leave, even though they are trying.

Conclusion

Non-lethal weaponries especially ADS has proved to be more beneficial in terms of less causalities and collateral damages. Incapacitation of targets has become easier without causing loss of lives. There should be a more invest in non-lethal weaponries rather than lethal ammunitions for dealing with protests and other such matters. The idea of implementing them on board commercial vessels should be of interest for all the reasons especially piracy.

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