Annex G – NLT AND THEIR HUMAN EFFECTS

Annex G describes technologies that are being used or are being proposed for use for non-lethal applications. Specific weapon systems are not addressed, except for a few examples.

1) **Electromagnetic – Radio Frequency (RF):** Electromagnetic energy typically in the frequency range of 3 kHz to 300 GHz and is an emerging technology for NLW applications.

    a) **Anti-Electronic Electromagnetic Weapons:** Anti-materiel weapons utilizing high power microwave pulses or non-nuclear EMP to disable electronic equipment by jamming or burning out sensitive components. Such weapons could be employed, for example, to disrupt the electrical system of engines, disable communication or radar systems, or damage computing equipment. Both the operators of such weapons and humans near the targeted equipment could be incidentally exposed to RF energy, but at the levels anticipated, such exposure would be expected to have no deleterious direct effect on humans. Indirect effects, such as the disruption of medical equipment, could have severe human consequences.

    b) **Microwave Energy:** Radio Frequency electromagnetic energy typically in the frequency range from 100 MHz to 30 GHz. High Power Microwave (HPM) and ultrawideband (UWB) radiation usually refer to high peak power, low average power pulses used as anti-electronic weapons. The primary accepted effect of human exposure to high average power microwave energy is the heating of tissue. Depending on the frequency of the microwaves and other factors, the energy may be deposited deep into the body or primarily localized near the body surface.

    c) **Microwave Hearing:** A phenomenon in which microwave pulses of certain characteristics are heard as clicks or buzzes. The mechanism of this phenomenon is believed to be a thermoelastic transduction of the rapid temperature rise caused by the RF pulse into a mechanical wave in the head that is heard by the normal hearing apparatus. It is not believed to be harmful, but some consider that it might be annoying.

    d) **Millimetre Wave Energy:** Radio Frequency electromagnetic energy typically in the frequency range of 30 GHz to 300 GHz. Millimetre Wave Energy is an emerging technology for non-lethal weapon applications, in particular, the Active Denial System, which beams ~95 GHz millimetre waves at a distance to cause intolerable heating sensation that stops when no longer exposed to the energy. As this frequency of energy is deposited on the surface of the body, the first medical signs of excessive exposure would be skin burns or damage to the cornea.

    e) **RF Human Exposure Standards:** NATO and other international bodies have established health and safety recommendations for permissible exposure limits for human exposure to RFR energy. Such recommendations would doubtless apply to occupational exposures during development, training, and use of RF technologies for non-lethal applications. For NATO, the applicable standard is STANAG 2345 “Evaluation and Control of Personnel Exposure to Radio Frequency Fields – 3 kHz to 300 GHz.”

2) **Electromagnetic – Visible and Invisible Light and Lasers:** Most NLT concepts utilizing light are intended to temporarily disrupt vision. For these, the principal human effect of concern is damage to the eye. In particular, the ability of the eye to focus certain frequencies on the retina creates an increased risk of damage from these frequencies. Secondary effects due to visual impairment are also of concern.

Reflections from high-energy lasers used for anti-material applications might produce enough energy to damage the skin or eyes.

a) **Flashes and Flares:** Devices used to generate light in the visible spectrum, directionally or omni-directionally.

b) **Infrared Energy:** Electromagnetic radiation in the 1 to 100 micron wavelength range, with a majority of the devices using such energy operating between 1 and 10 microns.

c) **Isotropic Radiators:** Special munitions that illuminate or bloom with high intensity. The energy is generated by an explosive burst, which superheats gaseous plasma surrounding it, causing a bright flash.

d) **Laser Illuminators:** Devices that use low energy lasers operating in the visible spectrum in a variety of colours, intending to illuminate, intimidate, distract, and identify the target. Such devices are intended to be "eye-safe," however a major human effects issue with visible lasers has been concern over the possibility of retinal damage.

e) **Laser Ionisers:** Postulated technology that would use laser energy to ionize the air molecules along a path, thereby enabling transmission of electromagnetic or electrical energy at long distances without conventional antennas or wires. Also see Electrical Stimulating Devices.

f) **Laser Light Bullets:** An emerging technology that purportedly produces a long bright pulse of focused laser light in a variety of colours. It is produced by rounds containing a tuned resonator chamber surrounding a lasing medium that is energized by the explosive charge.

g) **Laser Scattering Obscuration:** Visual obscuration or glare caused by aiming lasers at windows, vision ports, automobile windshields, or airplane canopies. Micro-abrasions in the glass scatter the light in such a way that visibility is greatly impaired.

h) **Pulsed-Energy Projectile (PEP):** A pulsed laser technology concept intended to produce a large flash, bang, and shock wave to temporarily disorient and incapacitate individuals.

i) **Ultraviolet Energy:** Electromagnetic energy typically of wavelengths ranging from about 1 nm to 400 nm.

j) **Visible Light:** Electromagnetic energy typically in the 400 – 700 nm wavelength range, which is detectable by the human eye. Such light is focused onto the retina by the lens of the eye, generally making it more potentially hazardous to vision than light at higher or lower wavelengths.

k) **Visible Light Strobes:** Visible lights that flash at a frequency near that of the human brain electrical waves (7 – 9 Hz). Such stimulation could possibly cause vertigo, disorientation, seizures, and vomiting in sensitive individuals. However, such effects are poorly documented and their potential utility for non-lethal applications has not been evaluated.

3) **Electrical Stimulation Devices:** Devices that produce and deliver a non-lethal electrical shock to a target, resulting in pain, involuntary muscle contraction, and incapacitation, depending on the device and its application. The shock can be produced by pulsed or direct electric current, affecting the target muscle signal paths and disturbing the body's nervous system. Conceivable undesired effects could include effects on the heart and interference with medical implants that utilize electricity, such as cardiac pacemakers. Electrical burns at the area of contact are possible.

a) **Electrical Fence:** A fence that delivers a non-lethal electrical shock. It can be employed as a barrier against intruders.

b) **Electrical Water Stream:** A proposed mobile unit that projects a water stream charged with high voltage, low amperage.

c) **Net Mines:** Emerging technologies which would use a target-activated mine to deploy a net that would deliver an electrical stimulation.

d) **Stun Gun:** A generic term often applied for electrical stimulating devices. The term "cattle prod" is also used.

e) **TASER:** A commercial electrical stimulation device with increasing use for law enforcement, security, and anti-terrorism. Such devices usually deliver electrical energy through pointed barbs that enter the skin. Depending on the location of entry, such barbs could cause undesired minor to severe injury. TASER is a registered trademark of a specific company, however the term TASER is often used generically to mean any hand held, gun-like electrical stimulating device.

f) **Wireless "TASER":** Postulated devices for delivering electrical energy to a target at a distance without a wire. There are many ideas but little success. One concept would deliver a shocking projectile that includes a source of stored electricity (e.g., a capacitor) and barbs that catch onto the target and discharge upon impact. Another proposal is to use an aerosol charge to produce a gas-dispersed conducting channel, down which an electrical shock could be delivered to the target.

4) **Projectile, Blunt Impact and other Kinetic Devices:** Devices intended to impart kinetic energy and cause temporary physical pain, resulting in deterrence, distraction, incapacitation, and a reduced motivation. Also, hollow projectiles can be filled with chemicals, dyes, or other substances that are released upon impact. Depending on energy, range, ricochet, bounce, location of impact, and the sensitivity of the individual, such devices can result in undesired injuries such as severe bruising, broken bones, contusion, concussion, and eye damage and are potentially lethal.

a) **Batons:** Projectiles, usually cylindrical, fired at a human target from a riot gun. They vary in hardness and elasticity. They may be made of wood or rubber. The wooden version is also known as a "broomstick round." They are usually aimed at the legs or at the ground for ricochet effect into a crowd. The "Soft Baton" is a pliable variant that changes its shape after impact to form a pancake. Direct fire at close or point blank range of any projectile can cause serious or fatal injuries.

b) **Bean Bag:** Fabric sacks filled with lead shot usually weighing from 40 to 150 grams, designed to be fired from shotguns and other launchers. The bags conform to the shape of the target on impact, producing less damage than a solid hard projectile.

c) **Ring Vortex Projectile:** A concept of creating a stable gas vortex to cause kinetic impact and/or deliver chemicals at a distance.

d) **Rubber Balls:** Hard rubber balls, usually 8 – 16 mm in diameter, fired from a shotgun. They have maximum effect when fired in confined spaces, where multiple bounces augment the number of impacts on the target with sufficient force to sting rather than hurt. The small size and velocity of the balls may create a significant ocular hazard.

e) **Sponge Grenade:** Projectile made out of spongy material. These can either be used as a kinetic weapon or with the inclusion of CS to produce skin/eye irritation or a dye to mark the target.

f) **Water Cannon:** A mobile unit that projects a bolus or stream of water at an individual or crowd for riot control purposes. Injuries from falling are possible.

5) **Acoustic Devices:** Weapons utilizing acoustic energy to induce human effects through the sense of hearing or through the direct impact of pressure waves on other parts of the human body. A large variety of acoustic devices have been proposed for non-lethal applications. Most are of uncertain effectiveness and many could damage hearing.

a) **Audible Acoustic Weapons:** Weapons utilizing acoustic energy that can be heard by the human target and have their effect through the sense of hearing. Some intended effects of such weapons are to irritate, distract, divert, repel, disperse, and general sensory overload. Such weapons may also be used to communicate, inform, or confuse an adversary as well as to disrupt communication. Other effects that have been claimed include the induction of giddiness, nausea, fainting, and loss of equilibrium. Acoustic energy may be combined with other stimuli to enhance the effects of both. Examples include "flash bang weapons," in which an acoustic stimulus is combined with light, and the "whistling baton" in which a wooden round is designed to produce a loud whistling sound in addition to a kinetic impact. Methods have been proposed that may allow the delivery of acoustic energy to highly specific locations. A possible undesired effect of loud acoustic weapons is damage to the sense of hearing.

b) **Inaudible Acoustic Weapons:** Acoustic weapons that cannot be heard, but have their impact through direct coupling of the acoustic energy pressure waves with the human body. Generally, these fall into two categories, infrasound and ultrasound.

c) **Infrasound:** Very low-frequency sound that can travel a long distance and easily penetrate most buildings and vehicles. There have been claims that infrasound can create such human effects as nausea, loss of bowel control, disorientation, vomiting, internal organ damage, and even death. Experimental research has not confirmed such effects at intensities that practical to use for use in non-lethal applications.

d) **Ultrasound:** Acoustic energy at frequencies above the audible range for human hearing, nominally above 20 kilohertz. There have been proposals that two ultrasonic beams could be combined to produce audible frequencies and that other directed energy sources could be used to produce ultrasound at the surface of the body, perhaps inducing discomfort or pain.

e) **Infrapulse Generator (Vortex Generator):** A device under development that produces an acoustic noise, pulsing shock waves and vortices, and may be used as carriers for irritants. Current devices produce a vortex that travels at approximately 30 to 50m per second with an effective range is about 60m. It is proposed for crowd control.

6) **Multi-Sensory Devices:** Devices that affect more than one sensory modality simultaneously, e.g., the visual and auditory senses. There is an expectation that the effects will be at least additive and, perhaps, synergistic. Sensory overload is a possibility, leading to confusion and indecisiveness.

a) **Flash Bang Grenade:** An acoustic and optical diversionary device, usually hand thrown, that emits a loud bang and a dazzling light when activated. The device is designed to create a sensory overload, which temporarily causes confusion, distraction, and an inability to effectively respond to a tactical team's actions.

b) **Multi-Sensory Distraction Device:** A device that contains a combination of payloads, including audible sounds, bright strobe lights, and malodorants.

c) **Thermobaric Compounds:** Compounds that are characterized as having a single-event chemical explosion requiring no external atmosphere. Thermobaric compounds could potentially be tailored for a specific energetic release for a desired non-lethal effect. The energy release is expected to last longer than that from a typical flash-bang.

7) **Chemicals for Anti-Personnel Applications:** Pharmaceuticals, irritants, and lubricants, have been proposed for a variety of anti-personnel applications. Possibilities for undesired human effects are significant and depend on the amount of exposure (dose) of the agent, its means of entry into the body (e.g., skin for liquids, respiratory for gasses), and access to sensitive organs (e.g., the eye). While some of these compounds are used by domestic police, their use by multinational forces and in warfare is limited by laws and treaties.

a) **Calmatives:** Sedatives or sleep-inducing agents intended to incapacitate personnel or render them less aggressive.

b) **Markers:** Materials, dyes, and paints, usually in a dust or liquid form, used to mark the clothes or skin of individuals or groups. A marking substance may be clearly visible, or may be relatively or totally invisible until detected using special tools or equipment. One concept envisions a fluorescent powder sprayed into crowds from pressurized containers; particles adhering to clothing would only be visible under ultraviolet light. Another concept envisions sponge grenades or projectiles impregnated with infrared dye. Potential medical issues include adverse reactions on the skin and eyes, the delivery device of such markers, and the energy used to detect invisible agents.

c) **Malodorants:** Foul smelling gases or sprays, such as scatole and mercaptans, that cause temporary distraction and potential repulsion of individuals by revolting olfactory saturation.

d) **Obscurants:** Chemical agents used to obscure vision. Concepts include chemicals that create smoke screens and liquids that harden and obscure vision ports or optics.

e) **Riot Control Agents:** A chemical that can produce physical discomfort, incapacitation, or area denial. They generally work by irritation of eyes or respiratory tract. Effects reverse within a short time following termination of exposure. They can be deliver as a power, spray, in an aerosol, or as the payload of a projectile (e.g., Pepper Ball). Some potentially useful agents are prohibited by the Chemical Weapons Convention.

i) **Dibenz (b,f) – 1:4-oxazepine (CR):** An effective riot control agent with immediate effects similar to CS, but more potent and less toxic than CS. It causes immediate eye pain, blepharospasm and lacrimation, which persist for 15 to 30 minutes. It causes almost no effects in the lower airways and lungs and has no persistent eye and skin effects. It does not degrade in water, but resists weathering and is also very persistent in the environment.

ii) **Chloroacetophenone (CN):** A riot control agent no longer in common use because it is more toxic than CS, OC, or CR. It was sold under the trade name “Mace.”

iii) **Oleoresin Capsicum (OC):** A food product obtained from chilli peppers that are dried and ground into a fine powder. When mixed with an emulsifier such as mineral,

vegetable, soy oil or water, it may be sprayed from a variety of dispensers and used as an irritant for safely controlling violent persons or vicious animals. OC is the primary active component of "pepper spray."

iv) **Ortho-chlorobenzalmalononitrile (CS):** An effective riot control agent that usually incapacitates within 5 to 10 minutes. Effects linger for about an hour. Decontamination and cross-contamination is a considerable problem in urban environments. Can cause erythemia and delayed blistering after contact with the skin.

v) **Pelargonic Acid Vanillyamide (PAVA):** A synthetic chemical agent with effects similar to OC.

8) **Chemicals for Anti-Materiel Applications:** Chemicals intended primarily to disable or degrade materiel. They may have an impact on humans who are incidentally exposed to them during handling or use.

a) **Anti-Traction Agents:** Polymers and other chemical compounds that can reduce the coefficient of friction of surfaces thereby creating a slippery surface that is impassable to personnel or vehicles. Humans attempting to traverse such surfaces generally fall down and are unable to stand back up. These agents are also known as low-friction polymers, slick'ems, "Instant Banana Peel," and super-lubricants. Although intended for anti-material applications, contact with these agents could cause skin and eye irritation.

b) **Depolymerisers:** Chemical compounds that induce the breakdown of chemical bonds in polymers, which could cause the breakdown in rubber-based materials such as tires and other plastics.

c) **Embrittlers:** Compounds that operate by altering the molecular structure of base metals or alloys, causing metal structures to become brittle and irreversibly lose their structural strength.

d) **Emulsifiers:** Chemicals contained in a mixture of mutually insoluble liquids that when dispersed over the ground can create a quicksand-like surface that can inhibit foot or vehicle travel. Also known as soil destabilizers.

e) **Foams:** Chemical compounds mixed with air to form foams with various properties, e.g., rigid foams are made from epoxies and other organic chemical compounds to immobilize material components thereby rendering them inoperative. Foams tend to be made of volatile chemical that can be harmful when breathed or can irritate the skin.

f) **Fuel Contaminants:** Chemical additives to fuel intended to degrade standard engine performance by altering combustion proprieties or increasing viscosity.

g) **Lubricant Contaminants:** Chemicals intended to destroy the lubricating property of lubricants.

h) **Supercorrosives:** Highly corrosive acid compounds that can dissolve most noble metals, such as gold and platinum, and organic compounds. They could be used to attack structures, vehicles, tires, roads, rooftops, and optical systems. They could be hazardous to humans as well.

9) **Animals:** Both contemporaneously and historically, animals have been used in combat and law enforcement. Dogs and dolphins are well known examples. In the future, other species may be employed for non-lethal applications. Insects (e.g., bees) have been proposed. The variable sensitivity of the human population to insect stings could be a medical issue.

10) **Physical Devices:** Barriers (e.g. fences), entanglement material (e.g., nets), restraints (e.g., handcuffs) designed to deny access, restrict human movement, or prevent escape. Such devices may have a number of secondary undesired effects, such as people being trampled or crushed against a fence by an advancing crowd, or being forced into a position that is incompatible with adequate breathing (positional asphyxia).

    a) **Caltrops:** A vehicular barrier device with four projecting spikes so arranged that when three of the spikes are on the ground, the fourth one points upward. Caltrops were used by the ancient Romans to thwart the advance of cavalry.

    b) **Entanglements:** Net or rope containing devices intended to impede or stop vehicles or vessels by entangling the wheels or running gear. They can be deployed by a launcher or by other explosive devices.

    c) **Microwire Obstacles:** Thin steel wires compacted under tension. When deployed the wires expand to assume predetermined geometric shapes formed from a tangle of the wire itself. Expansion ratios of 1:6000 are achievable. The devices could be used to prevent access by vehicles or by personnel to designated areas. Micro wires represent a means of erecting an impenetrable barrier to deny access to an area or building. Sharp edges could lead to cuts.

    d) **Portable Vehicle Arresting Barrier:** A device with a pop-up net deployed across a road that can stop a heavy, rapidly travelling vehicle within a short distance. Human safety issues include the effects of rapid deceleration.

    e) **Instant Barriers:** Rapidly deployed barriers, e.g., pre-emplaced nets, fences, or gates that emerge, rise, or descend when needed. Conceivably, automobile air bag technology could be extended to produce a barrier for persons or vehicles.

    f) **Spiked Strip Barrier:** A flat strip that resembles a fire hose, with retractable hollow spikes that are designed to flatten the tires of a target automobile. When the strip is activated, hollow spikes extend vertically and puncture the tires as they roll over the strip.