Chapter 2 – OVERVIEW OF THE HUMAN EFFECTS OF NLT

2.1 WHAT ARE HUMAN EFFECTS?

HFM-073 defined "Human Effects" very broadly as any effects on human beings, including physical, biological, physiological, psychological, and social effects. The study of the human effects of NLT includes anatomy, biology, medicine, psychology, sociology, and politics as applied to levels of life from cells to crowds to whole populations, as well as the models (animal, mechanical, and mathematical) used to represent, organize, explain, and predict the effects of NLT on humans. Table 1 diagrams some of the aspects of the study of human effects as applied to NLT.

The study of the human effects of NLT is interdisciplinary, requiring expertise in the specific technology, the metrics and dosimetry of the energy utilized, and the relevant effects.

Table 1: Purview of Research on the Human Effects of NLT

Level of Organization	Examples of Areas of Study	Examples of Possible NLT Effects or Impact	Pressing Issues for NLT
Cells	Toxicology, Cancer, Pathology	Chemicals used for NLT purposes could be carcinogenic; lasers might damage retinal cells	Long-term health effects, such as cancer, in particular for users of the NLT
Organs	Pathology, Anatomy	Blunt impact weapons could damage internal organs; RF weapons could burn the skin	Damage to organs of sight or hearing; crippling body damage
Whole Organisms	Physiology, Medicine	TASERS and other Electro-Muscular Devices can incapacitated the whole person; likewise some gases	Damage to CNS functions such as perception, memory, motor coordination
Individual Behaviour, Motivation	Psychology	Behaviour may be modified to avoid/reduce unpleasantness, pain, or the threat thereof.	What is meant by incapacitation
Crowd Behaviour	Psychology	NLT may cause complex responses in crowds, from resignation and compliance to fear and panic	Predictive models for crowd response to NLT; effects of culture expectation, motivation
Population Response; Attitudes; Protests; Voting Behaviour	Sociology, Politics	Groups may develop incorrect beliefs regarding NLW in general or specific NLT; acceptance could be threatened	Risk communication regarding the safety, value, and ethics of NLT

2.2 HUMAN EFFECTS OF NLT

The very definition of NLW (see Chapter 1) indicates the importance of human effects data to nearly every aspect of NLW effectiveness assessment, development, acceptability, and use. The goal of NLW to "incapacitate or repel personnel" establishes a clear human-centred requirement for measuring success of a particular NLW or NLT. The goal to have a "low probability of fatality or permanent injury" addresses another human-centred criterion for NLW.

In addition to these "target-oriented" aspects of NLW, an NLW, as with any other weapons, must be evaluated for human safety during development, testing, training, maintenance, and use. There is always a potential for accident as well as repeated or long-term human exposure. The possible human effects of NLT range from medical (e.g., cellular damage) to group psychology (crowd response) and from the acute (e.g., pain) to the long-term (e.g., cancer, PTSD). Depending on the circumstances, occupational health standards and accident reporting procedures may apply (see Table 2).

Table 2: Human Effects Implications of Non-Lethal Weapons

Human Population Affected	Situation	Desired Acute Effects	Possible Undesired Effects	Considerations
Targets	Operations	Distraction, Incapacitation, Repel	Lethality, Injury: temporary (e.g., a bruise) or permanent (e.g., blindness)	NLW definition; international law, treaties; Medical planning
Non-combatants; Bystanders	Operations	None	Same as target	Discriminating weapons needed; Medical planning
Friendly Forces	Accident, Training, Testing, Use, Maintenance, Friendly Fire	None	Lethality, Injury, long-term health compromise (e.g., cancer)	Occupational health exposure standards need to be validated; Medical planning

The human issues concerning NLW are not unlike those related to therapeutic drugs; there are desired effects (e.g., incapacitation vs. therapy), and undesired effects (e.g., permanent injury vs. side effects) and there is a useful dose region in between the two (e.g., operational versus therapeutic window). The population response for each is highly variable. The effects of both can be characterized by plotting the probability of response (desired or undesired) verses some measure of the strength of the weapon/drug applied, so called – dose-response curves (see Figure 1).

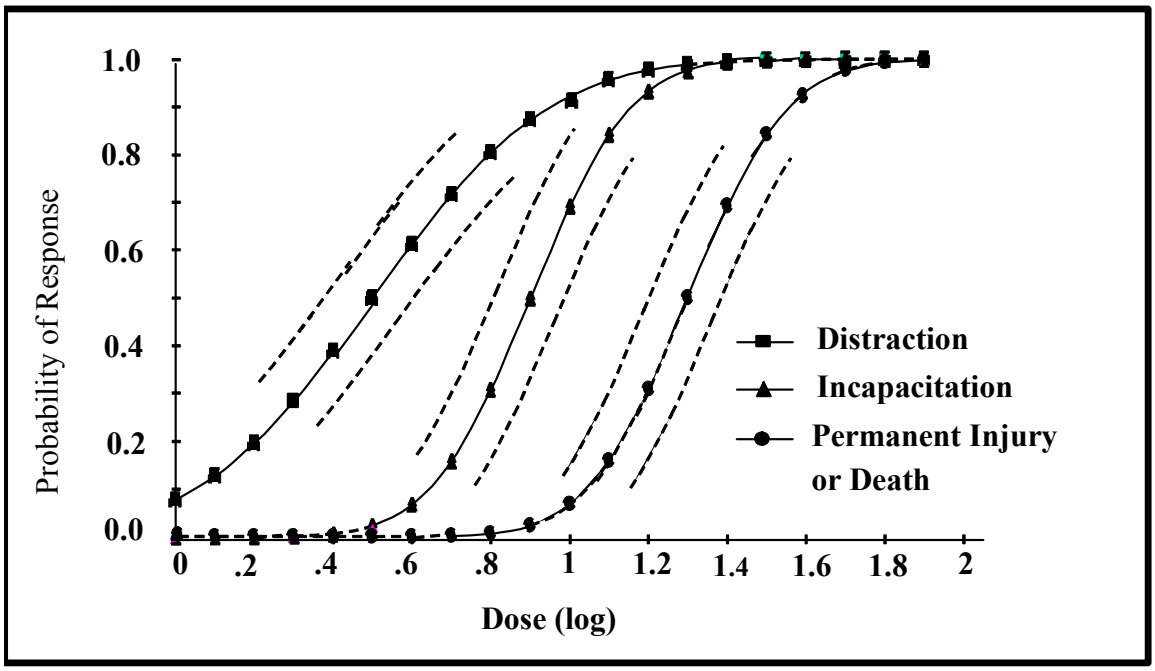

Figure 1: Idealized Dose-Response Curves for an NLT. Symbols identify curves for three types of responses. Solid curves apply to the probability of response from a population of individuals and the dashed lines to either side reflect confidence intervals. Such curves can illustrate the issues and goals of NLT. However, the data required to create real curves of this type are difficult and expensive to collect. Credible Dose Response curves exist for very few NLT, relevant populations, and appropriate scenarios of use.

2.3 IMPACT OF HUMAN EFFECTS DATA ON NLW

2.3.1 Evaluating Operational Utility

The NATO definition of NLW specifies that such weapons are designed to "incapacitate or repel." Human Effects data are necessary to evaluate the extent to which proposed NLT meet this requirement, but the requirement itself is vague with no suggestion of quantifiable metrics. For example, some might consider "incapacitation" to include a disinclination to perform task (like throw a rock or enter a forbidden area), whereas others may consider "incapacitation" to mean the impossibility of performing a task. Thus, in addition to achieving a non-lethal goal, i.e., incapacitation or repel, operational commanders are also interested in the parameters of the incapacitation. Some relevant parameters include: Dose for main desired effect; Can the effect be tuned; Time until initial effect; Duration of effect; Synergy with other factors; Reversibility versus irreversibility of effects; Side effects to Targets Undesired collateral effects; Environmental effects; and Susceptibility to countermeasures. Human effects analysis, by literature review, research, and modelling, is important to addressing all of these parameters.

In order to be optimally useful, Human Effects Researchers need to have close contact with operational needs for which the NLT is being considered. SAS-035 has developed an excellent scheme for assessing the operational utility of NLW based on a review of several real-world scenarios in which NLW might be used. Human Effects research on the effectiveness of NLT should focus on developing the type of data that will be useful for this approach.

2.3.2 Technical Feasibility and Weapons Design

Technical feasibility means that the science, engineering, and manufacturing capability exist to build a desired non-lethal system. Issues of cost, size, weight, logistics, and maintenance are important. Human Effects data are involved in providing the requirement parameters for the system. In an orderly process, bioeffects review and research would: (1) determine areas of human vulnerability; (2) develop biological criteria for biological effect on the target, recovery of the target, and long-term medical impact on targets, operators, and bystanders; and (3) provide data to the engineers so that a system can be built to optimally expose the target and limit collateral damage. Too often, the process is anything but orderly, and NLW systems are built on the minimally supported belief or hope that if you make it hard enough, bright enough, loud enough, smelly enough, etc., it must do something. As the study of non-lethal weapons matures, the impact of snake-oil salesmen is declining, but it is still wise to beware and demand to see the actual data upon which claims are being made.

2.3.3 Policy Acceptability

Policy acceptability is an extremely complicated topic in which bioeffects have two major roles. For anti-personnel NLWs, the policy that NLWs should "minimize permanent injury" is primarily a human effects issue. The immediate effects of an NLW are part of its evaluation as having operational utility. The time to and extent of recovery from the weapon's effects are important criteria to determine policy acceptability.

The second role of human effects in NLW policy setting, concerns the long-term medical consequences of exposure to the NLWs for everyone exposed, including the operator, the target, and bystanders. Possible delayed effects, such as cancer, behavioural, or reproductive consequences need to be considered, if we are to minimize future litigation and public outrage. These concerns are relevant to anti-material technologies as well as anti-personnel application of NLWs.

2.3.4 Developing Health and Safety Human Exposure Standards

Human effects biological data are the primary basis for setting health and safety standards for environmental agents, including those that may be encountered as the result of exposure to a NLT. If occupational exposure standards exist for the particular agent being used, as they do for many types of noise, radiation, and chemicals, then these standards should be followed when possible. If the exposures are sufficiently novel that no health standards exist, for example certain types of directed energy, then standards need to be developed.

Occupational standards would be irrelevant with respect use of the agent against a target, as other criteria, set forth in NLW policy, would apply. Similarly, such standards, which are usually highly conservative with large safety factors, would generally not be expected to apply to fighting forces during an operation. However an issue arises with respect to the applicability of such standards during training and test and evaluation, when it may be desirable to expose allied forces to the NLT. The importance of realistic training for NLW is discussed in Chapter 5.

Human exposure standards form a stable base for the safe exploitation of technologies for potential use as NLW. Such standards are based on data available at the time the standards are set and the exposure limits for parameters for which there are no data may be extrapolated form existing data, often with added, very conservative, safety factors. The reason that no data exist for some parameters is that these parameters were either technologically difficult to produce or were basically moot because there was little to no possibility of human exposure. When such parameters become relevant, the standards must be either established de novo or

the existing standards may need to be reconsidered and revised. There may be a complex conflict between the requirement to adhere to existing exposure standards and the need to optimize test and evaluation and training. This situation is a particular issue for directed energy (RF and lasers), where particular hazards and health effects are often dependent on frequency, pulse characteristics, and other physical factors. Although it is often expensive and takes considerable time, the most satisfactory solution to this conflict is to conduct human effects research to set or revaluate the standard appropriately.

2.4 EXISTING AND PROPOSED TECHNOLOGIES FOR NLW

Many technologies are being used or suggested for non-lethal applications. HFM-073 has modified the taxonomy originally developed by the U. S. Joint Non-Lethal Weapons Program and added comments on the expected desired and possible undesired human effects of these technologies. A full discussion of NLT and their human effects is provided in Annex G. Table 3 summarizes this information.

2.5 A GLOSSARY OF NLW TERMS

There are an enormous number of terms relating to human effects from different perspectives, e.g., medical, biological, physiological, psychological, sociological, psychiatric, legal, pathological, and so forth. In Annex H, HFM-073 defines some of the terms that are most relevant to the human effects of non-lethal weapons so that NATO HFM and RTO will have a common reference. Our selection criteria for terms to include were: (1) Terms unique (or nearly unique) to the human effects of NLTs; (2) Common terms that are used in an unusual way in the context of NLT human effects; and (3) Common terms that are used with their usual meaning, but are very important to the human effects of NLT.

2.6 SCIENTIFIC WORKSHOPS INCLUDING HUMAN EFFECTS OF NLW

2.6.1 European Symposia on Non-Lethal Weapons

During the tenure of HFM-073, there have been three “European Symposium on Non-Lethal Weapons”, all held at Stadthalle Ettlingen, Germany:

- New Options Facing the Future, 24-26 September 2001;
- Non-Lethal Capabilities Facing Emerging Threats, 13-14 May 2003; and
- Non-Lethal Options Enhancing Security and Stability, 10-12 May, 2005.

The activities of NATO on NLW were reported in the 2005 meeting by Dr. Murphy, Chair HFM-073, NATO Studies on “Non-Lethal Weapons: Effectiveness, Future Technologies, and Human Effects”. http://www.non-lethal-weapons.com/index.html

The organizer of all 3 meetings was Dr. Klaus Dieter Thiel of the Fraunhofer Institute, ICT, Pfinztal/ Germany, who is also a member of HFM-073.

Table 3: NLW Technologies and their Desired and Possible Undesired Human Effects

Technology or System	Proposed Desired Effects	Possible Undesired Effects	Comments/Issues
Electromagnetic: Radio Frequency (RF)	Anti-electronic; heat induced pain	RF burns; electronic interference	Safety standards may be exceeded; public concern on RF effects
Electromagnetic: Light/Lasers	Distraction, decreased/temporary visual ability	Eye damage, blindness, skin burns	Prohibition of "Blinding Lasers"
Electrical Stimulation Devices	Muscle contractions, pain	Electrical burns, cardiac issues, penetration injury from contacts	Need additional data on safety & mechanism
Kinetic Devices	Pain, deterrence, distraction, incapacitation	Bruises, organ damage, fractures, concussion, lethality	Much experience with use, but little experimental data
Acoustic Devices	Annoyance, incapacitation, repel	Hearing damage	Many claims of effectiveness have been exaggerated
Multi-Sensory Devices (flash/bang)	Distraction, sensory impairment	Eye/ear damage	Indirect effects due to startle reaction
Chemical	Calmatives, skin/eye irritation, marking	Hypersensitivity/ idiosyncratic; organ toxicity (e.g. lungs, liver, kidney)	International chemical weapons conventions/treaties
Physical Devices	Impair movement, restraint	Cuts, scrapes, abrasions, e.g., when trying to defeat	Secondary effects could be severe (e.g., crushed by a crowd)
Animals	Intimidation, capture	Unpredictable; public sensibility	Not commonly noted as a NLT

ICT and Dr. Thiel have also initiated the International Virtual Non-Lethal Weapons Platform, as a forum for exchange of scientific information on Non-Lethal Weapons and a network of excellence for dealing with NLT issues. The platform is realized on a web site at ICT and is expected to complete its organization phase by the end of 2006. Participation is voluntary and may be initiated at the web site: http://www.ict.fhg.de/english/gefe/vslr/vnlwp.html

2.6.2 The NLT Technical and Academic Research Symposia (NTARS)

The Non-Lethal Technology Innovation Center was created by a grant from the Joint Non-Lethal Weapons Directorate and held the following meetings during the course of HFM-073:

- NTAR III, 7-9 Nov 2001 in Portsmouth, New Hampshire;
- NTAR Symposium IV, 19-21 November 2002, La Jolla, CA, USA;
- NTAR Symposium V, 5-6 Nov 2003, Arlington, VA, US; and
- NTAR VI, 15-17 November 2004, Winston-Salem, NC, USA.

The activities of NATO RTO activities on NLW were reported at NTAR VI by Dr. Murphy, Chair HFM-073, in a talk titled "NATO Studies on Non-Lethal Weapons (NLW): Effectiveness, Human Effects, and Future Technologies." http://www.unh.edu/ntic/

2.6.3 Jane's Meeting on Non-Lethal Weapons

- 5th Annual Jane's Conference "Non-Lethal Weapon," 17-18 September, Manchester UK.
- Jane's Less Lethal Weapons Conference "Critical Incident Intervention including Less-Lethal Weapons in War and Peace," 19-20 October 2004, Dublin, Ireland. http://www.janes.com/security/conference/llw2004/overview.shtml

2.6.4 National Defence Industrial Association (NDIA) Conferences

- Non-Lethal Defence V is scheduled for 25-28 March 2002 at the Hyatt Regency Reston, in Reston, VA.
- Non-Lethal Defence VI – 14-16 March 2005, Hyatt Regency Reston VA. http://register.ndia.org/interview/register.ndia

2.6.5 Organized by the Institute of Defence and Government Advancement (DGA)

- Non-Lethal Weapons: Exploring Technologies, Capabilities, Doctrine & Strategy: Using Directed Energy Weapons and Other Non-Lethals to Suppress the Enemy, 24-26 February 2003, Alexandria, VA, US.

2.6.6 Organized by NATO Science Program

- Integrating Human Effectiveness and Risk Characterizations of Non-Lethal Weapons into Antiterrorism Civil Science Programs." NATO ARW, 19-22 October 2004, Prague, CZ.

The activities of NATO RTO HFM-073 activities on NLW were reported by Dr. Murphy, Chair, in a talk titled "Human Effects of Non-Lethal Technologies: Activities of NATO RTO HFM-073".

2.7 CLOSING COMMENTS

The importance of human effects research and data to nearly all aspects of NLT and NLW effectiveness, acceptability, and policy approval is acknowledged and usually accepted. However, there is still considerable discussion regarding the timeliness and cost and even the possibility of obtaining data that would add significant value to the decisions required for acquiring an appropriate NLW capability and actually using it in a specific conflict scenario.

NLT also raise the usual issues of soldier health and safety, training for operational use, preparations for medical triage and treatment, and planning for possible post-conflict, long term medical and psychological consequences. While many of these issues may be familiar and already addressed under current medical/occupational health procedures, some novel issues may emerge related to new types of NLT exposures, e.g., directed energy, stun devices, calmatives).

It is difficult enough to develop human effects data for a single type of NLT on a uniform population of exposed persons, but the possible interactions between different simultaneously applied NLT, conventional weapons, human factors (e.g., age, frailty, drugs, stress, etc.), and environmental conditions increases the challenge enormously. If we are to begin to address this problem and build a useful database for NLT, it is important for allies to cooperate and share information. The NATO RTO is an excellent forum for this effort.

NATO's activities in defence and crisis management will benefit from the availability of NLWs and NATO is taking steps to acquire and prepare for its use of NLWs. Analyses and decisions made by NATO will no doubt contribute to the international discussion on the policy and technical aspects of NLW.