NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-HFM-073**

The Human Effects of Non-Lethal Technologies

(Impacts humain des technologies non létales)

The Final Report of NATO RTO HFM-073.

Published August 2006

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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Table of Contents

List of Figures/Tables

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The Human Effects of Non-Lethal Technologies

(RTO-TR-HFM-073)

Executive Summary

In 2000, the Defence Capabilities Initiative (DCI) issued a Non-Lethal Weapons (NLW) Road Map for the introduction of NLW into NATO and tasked RTO to form three Technical Groups. The Studies, Analysis and Simulation Panel (SAS) formed SAS-035, "NLW Effectiveness Assessment" and SAS-040 "Long-Term Scientific Study on NLW and Future Peace Enforcement Operations." The Human Factors and Medicine Panel (HFM) formed HFM-073 "The Human Effects of Non-Lethal Technologies (NLT)" and this Technical Report addresses the conclusions and recommendations of this group.

Human effects data are important to nearly every aspect of NLW effectiveness assessment, development, acceptability, and use, as well as to assuring human safety during development, testing, training, maintenance, and use. A summary of NLT technologies (Annex G) and a Glossary of terms (Annex H) are provided.

There is a great need for a database on the Human Effects of NLT. HFM-073 found that: (1) there was no existing suitable scheme for organizing data on the human effects of NLT; (2) much of the existing data was unavailable due to proprietary or national security interests; (3) developing such a database would be extremely expensive and time consuming; and. (4) there is yet very little relevant quality data available that would be useful for any particular NLT. HFM-073 developed an assessment of the nature of data required for such a database (Annex I) and recommends a multi-tiered approach to the database creation (Chapter 3).

The advent of NLW requires new medical considerations and preparation for training, treatment, and logistics, especially with regard to the possibility of new types of injuries from novel technologies and the increased number of some types of conventional injuries. There also should be preparation for adverse psychological effects, in the targets, bystanders, and the forces employing the NLW. A uniform procedure for documenting medical uses and gathering medical "lessons learned" from NLT encounters should be developed. A significant example of a situation where medical preparation could have made a major difference in the outcome of a rescue employing NLW was the so-called "Moscow Theatre Hostage Incident" (Annex M).

New forms of conflict and social violence demand an improvement and more systematic approach to training in controlling individuals and crowds. Techniques, procedures, policies, and rules will need to be developed and promulgated for when and how to employ NLW that are appropriate for all participating nations. There may be significant cultural and sociological issues raised for both the targets and operators of NLW. Training for both commanders and troops will involve a great deal more than how to physically operate the weapon.

Issues of policy, legality, ethics, and public acceptance of NLW are heavily influenced by human effects data and its communication and interpretation. Policy issues are especially difficult for novel weapons, such as those using RF energy or electricity. Legal conventions limit the use of chemical technologies and lasers, as well as the intentional use on non-combatants (e.g., during hostage rescue). Research on NLT

human effects raises ethical considerations of employing medical personnel in “weapons research” and in the use of human volunteers for testing the effectiveness and safety of proposed NLT.

While there are many specific conclusions to be drawn from this study (Chapter 7), the most significant finding is that Human Effects information, in all its dimensions, is critical for the success of NATO’s implementation of NLW. The HFM Panel is the only RTO organization able to support NATO in this area and both a Lecture Series on the findings of HFM-073 and a follow-on Technical Team are recommended.

Impacts humain des technologies non létales

(RTO-TR-HFM-073)

Synthèse

En 2000, l'Initiative des capacités de défense (DCI) a publié un calendrier relatif à l'introduction des armes non létales (Non-Lethal Weapons, ou NLW) dans l'OTAN, et a chargé la RTO de former trois groupes techniques. Le Panel d'étude, d'analyse et de simulation (SAS) a formé le SAS-035, « évaluation de l'efficacité des NLW », et le SAS-040, « étude scientifique à long terme sur les NLW et les futures opérations de maintien de la paix. » Le Panel sur les facteurs humains et la médecine (HFM) a formé le HFM-073, « l'impact humain des technologies non létales (Non-Lethal Technologies, ou NLT) », et ce rapport technique présente les conclusions et recommandations de ce groupe.

Les données sur les impacts humains sont importantes pour presque tous les aspects de l'évaluation de l'efficacité des NLW, de leur développement, de leur acceptabilité et de leur utilisation, ainsi que pour assurer la sécurité humaine au cours du développement, des essais, de la formation, de la maintenance et de l'utilisation. Un résumé des technologies NLT (annexe G) et un glossaire des termes utilisés (annexe H) sont fournis.

Il y a grand besoin d'une base de données sur l'impact humain des NLT. Le HFM-073 a constaté que : (1) il n'existait pas de système approprié pour l'organisation des données sur l'impact humain des NLT ; (2) une grande partie des données existantes était indisponible à cause d'intérêts de propriété ou de sécurité nationale ; (3) le développement d'une telle base de données serait extrêmement coûteux et demanderait énormément de temps ; et (4) il existe encore très peu de données de qualité disponibles sur ce sujet, qui pourraient être utiles à une NLT en particulier. Le HFM-073 a mis au point une évaluation de la nature des données requises pour une telle base de données (annexe I), et recommande une approche multi progressive pour la création de la base de données (chapitre 3).

L'introduction des NLW exige de nouvelles considérations médicales et une préparation à la formation, au traitement et à la logistique, notamment en ce qui concerne l'éventualité de nouveaux types de blessures dues aux nouvelles technologies, et l'augmentation du nombre de certains types de blessures conventionnelles. Il devrait également exister une préparation aux effets secondaires psychologiques pour les cibles, les spectateurs, et les forces utilisant les NLW. Une procédure uniformisée devrait être mise en place afin de documenter les usages médicaux et de centraliser les « leçons » médicales à tirer des confrontations impliquant des NLT. « L'incident de la prise d'otages du théâtre de Moscou » (annexe M), comme il fut appelé, est un exemple significatif d'une situation où une préparation médicale aurait pu faire une grande différence dans l'issue d'une opération de sauvetage faisant appel aux NLW.

Les nouvelles formes de conflits et de violence sociale nécessitent une amélioration et une approche plus systématique de la formation à la maîtrise des individus et des foules. Des techniques, des procédures, des politiques et des règles devront être définies et promulguées pour savoir quand et comment employer les NLW appropriées pour toutes les nations participantes. D'importants problèmes culturels et sociologiques pourraient se poser aussi bien en ce qui concerne les cibles que les opérateurs des NLW. La formation des officiers et des troupes devra inclure bien plus que le simple maniement physique de l'arme.

Les questions de politique, de légalité, d'éthique, et d'acceptation publique des NLW sont fortement influencées par les données sur les impacts humains, par leur communication et leur interprétation. Les questions de politique sont tout particulièrement épineuses pour les nouvelles armes, telles que celles faisant appel à l'énergie radioélectrique ou à l'électricité. Les conventions légales limitent l'usage des technologies chimiques et des lasers, de même que l'utilisation intentionnelle sur des non combattants (par exemple, au cours de libérations d'otages). La recherche sur l'impact humain des NLT soulève des considérations éthiques quant à l'emploi de personnel médical pour la « recherche sur les armements » et l'utilisation de volontaires humains pour les tests d'efficacité et de sécurité des NLT proposées.

Bien qu'il y ait de nombreuses conclusions spécifiques à tirer de cette étude (chapitre 7), la plus importante est que l'information sur l'impact humain, dans toutes ses dimensions, est indispensable au succès de la mise en œuvre de NLW par l'OTAN. La commission HFM est l'unique organisme de la RTO capable de soutenir l'OTAN dans ce domaine, et une série de conférences présentant les conclusions du HFM-073, ainsi que la mise en place d'une équipe technique de suivi, sont recommandées.

Chapter 1 – BACKGROUND TO NATO ACTIVITIES ON NON-LETHAL WEAPONS (NLW)

1.1 INITIAL NATO NLW ACTIVITY: 1994 – 1997

In 1994, the North Atlantic Treaty Organisation (NATO) Conference of National Armaments Directors (CNAD) tasked the Defence Research Group (DRG), one of the precursors to today's Research and Technology Organisation (RTO), to create a Specialist Team to study the possible contributions NLW could make to NATO crisis management, peacekeeping, and peace support operations. In March 1966, this DRG team issued its report to the CNAD [1.7.1]. In August 1966, the CNAD reported the findings [1.7.2] to the North Atlantic Council (NAC), the highest decision-making body of NATO, and forwarded them for comment to the Military Committee, a group parallel to the CNAD but consisting of high-ranking military personnel. On 27 September, the NAC agreed to consider the policy aspects of NLW, including the pertinent political, legal, ethical, and moral issues and formed the NLW Policy Team in August 1997.

On 19-20 September 1996, the DRG organized an international seminar in Pisa, Italy, titled "37th DRG Seminar on Non-Lethal Weapons" [1.7.3], which was NATO's first conference on NLW. The only presentation at this Seminar on the human effects of NLW was "Health and Safety Issues for Non-Lethal Technologies" by Michael R. Murphy.

1.2 NATO POLICY ON NLW: 1998 – 1999

The report of the NLW Policy Team [.17.4] and deliberations of the CNAD led to the issuance of a NATO Policy on NLW on 27 September 1999 1.7.5], three years to the day after the Team was authorized by the NAC. From the perspective of human effects, some salient points from this policy are:

- **Definition of NLW:** "Non-Lethal Weapons are weapons which are explicitly designed and developed to incapacitate or repel personnel, with a low probability of fatality or permanent injury, or to disable equipment with minimal undesired damage or impact on the environment."
- **Objectives for NLW Use:** "Non-Lethal Weapons should enhance the capability of NATO forces to achieve objectives such as (not necessarily in priority) to: (1) accomplish military missions and tasks in situations and conditions where the use of lethal force, although not prohibited, may not be necessary or desired; (2) discourage, delay, prevent, or respond to hostile activities; (3) limit or control escalation; (4) improve force protection; (5) repel or temporarily incapacitate personnel; (6) disable equipment or facilities; (7) help decrease the post-conflict costs of reconstruction."
- **Caveat on Non-Lethality:** "Non-Lethal Weapons shall not be required to have zero probability of causing fatalities or permanent injuries. However, while complete avoidance of these effects is not guaranteed or expected, Non-Lethal Weapons should significantly reduce such effects when compared with the employment of conventional lethal weapons under the same circumstances."
- **Direction to Planners:** "NATO planners shall ensure that the potential contribution of Non-Lethal Weapons is taken fully into account in the development of their plans."
- **Minimal Characteristic of NLW:** "They must achieve an appropriate balance between the competing goals of having a low probability of fatality or permanent injury, with minimal undesired damage, and a high probability of having the desired effects."

- **Compliance with Existing Regulations, etc.:** "The research and development, procurement and employment of Non-Lethal Weapons shall always remain consistent with applicable treaties, conventions and international law, particularly the Law of Armed conflict as well as national law and approved Rules of Engagement."

1.3 NATO ROADMAP FOR NLW: 1999 – 2000

At its April 1999 Washington Summit meeting, NATO approved a Strategic Concept to equip the Alliance for the security challenges and opportunities of the next century and to guide its future political and military development [1.7.6]. Among new focus areas were crisis management and peacekeeping activities. New threats included ethnic conflict, abuse of human rights, political instability, and terrorism. The strategy called for military capabilities that will be effective under the full range of foreseeable circumstances and specifically called out (1) ability to engage opposing forces effectively; (2) deployability and mobility; (3) survivability of forces and infrastructure; and (4) sustainability and interoperability. There is a clear potential for NLW to help address many of these goals and capabilities.

Also at the Washington Summit, NATO launched its Defence Capabilities Initiative (DCI) to help ensure the goals of the Strategic Concept. A High Level Steering Group (HLSG) was formed to oversee the program of the DCI. Two of the five focus areas of the DCI are especially relevant to NLW, namely (1) Effective Engagement – "i.e., the ability to successfully engage an adversary in all types of operations, from high to low intensity;" and (2) Survivability; "i.e., the ability to protect forces and infrastructure against current and future threats." The DCI requirement for promoting the development of a NATO NLW capability was documented in DCI item EE 2(i) and states [1.7.7]:

> *"The Alliance should complete work to ensure that NATO has sufficient range of capabilities for the full spectrum of crisis response operations, including: i/ work on a policy for the development and use of non-lethal weapons technology in accordance with national and international law; ii/ adapting weapons technologies for use in operations that have a particular emphasis on the requirement to minimize collateral damage."*

The lead for the DCI NLW item was assigned through the CNAD to the RTO, which had recently been formed as a combination of the old Advisory Group on Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). The RTO reports to both the CNAD and the Military Committee and is composed of a senior management body, the Research and Technology Board (RTB), and seven Technical Panels: (1) Studies, Analysis and Simulation (SAS); (2) Human Factors and Medicine (HFM); (3) Applied Vehicle Technology (AVT); (4) Information Systems Technology (IST); (5) Systems, Concepts and Integration (SCI); (6) Sensors and Electronics Technology (SET); and (7) the NATO Modelling and Simulation Group (NMSG). Each Technology Panel enables and referees multiple Exploratory Teams (ET) and Technical Teams (TT). The RTO provides the greatest international mechanism ever conceived for the advancement of defence Science and Technology [1.7.8].

The DCI item on the development and use of NLW and the development of a NATO NLW Roadmap was assigned to the SAS Panel [1.7.9]. In response, the SAS Panel established an Exploratory Team (ET) on NLW, designated SAS-E15, at its meeting in November 1999. SAS-E15 held its first meeting in April 2000 and completed and transmitted its report, through the CNAD, to the DCI HLSG by 8 November 2000 [1.7.10]. This report is an excellent review of NLW issues. The report concludes that because of the unconventional nature of NLW, issues relating to their employment, and the urgent requirement of the DCI, that the normal means by which NATO acquires equipment, the Conventional Armaments Planning System (CAPS), is inadequate to establish an initial NATO NLW capability. It highlights the importance of policy, especially

relating to incipient directed energy weapons. It also notes the importance of studying the target effects of NLW in order to establish the type, predictability, and severity of injury, both physiological and psychological, caused by an NLW. The report also endorses the work of three RTO-initiated Technical Teams (TT), one on measures of military effectiveness (SAS-035), one on human effects (HFM-073), and one on the long-term impact of emerging technologies (SAS-040), and includes them in its Roadmap (see Annex A).

Annex B of this report provides an Organization chart for the NATO components involved in the early efforts of NATO to achieve an NLW capability.

1.4 NATO TECHNICAL TEAMS ON NLW & NLT: 2000 – 2004

Before focusing on the activities of NATO RTO HFM-073, the Human Effects of Non-Lethal Technologies, it is informative to summarize the activities of all three NATO RTO TT on NLW, thereby placing HFM-073 in context. The work of both SAS-035 and SAS-040 has been completed and Final Reports have been submitted.

SAS-035, which is a successor to SAS-E15, has proposed a basic mathematical methodology for assessing the effectiveness of NLW in specific military scenarios. Inputs to the methodology include the physical characteristics of the weapon and the environment in which it is used, the level of a weapon's output that reaches a specific target, and the actual response of the target vis-à-vis the desired response and the military requirement. Effectiveness is calculated across seven dimensions: (1) mobility; (2) communications; (3) physical function; (4) sensation and interpretation; (5) group cohesion; (6) motivation; and (7) identification. The lack of adequate target response data was seen as a significant inhibitor to the implementation of the methodology developed by SAS-035. [1.7.11, 1.7.12]

SAS-040 held a multinational exercise to evaluate future technologies (out to the year 2020) that might be suited to address the whole spectrum of NATO peace support operations. The group identified five promising technologies and recommended accelerating research in these areas: (1) RF devices; (2) anti-traction approaches; (3) rapid barriers; (4) stun devices; and (5) nets. Its final report noted that NLW must satisfy national and international legal and political constraints and that doing so might become an issue between NATO countries; it recommended increasing activities to foster NATO acceptance of NLW. [1.7.13, 1.7.14]

HFM-073 addressed the human effects of non-lethal technologies from the perspective of both the target (effectiveness and non-lethality) and the operator/bystander (accident, fratricide, long-term health effects). The implications of NLWs on training and field medicine were reviewed. Special attention was directed to the issues involved in obtaining target response data of the type, quality, and quantity that would satisfy the methodology proposed by SAS-035.

Both HFM-073 and SAS-035 created glossaries for terms relating to NLW and proposed frameworks for developing a database for NLW. Both HFM-073 and SAS-040 reviewed the legal/political issues that might constrain the development of NLW.

1.5 THE HUMAN FACTORS AND MEDICINE PANEL

The HFM Panel was formed in 1998 following the creation of the RTO. It is, without question, the most appropriate NATO group to address human issues associated with the development and use of non-lethal weapons. The mission of the HFM Panel is to:

> *"Optimize performance, health, well being, & safety of the human in operational environments with consideration of affordability. This involves understanding & ensuring the physical, physiological, psychological, & cognitive compatibility among military personnel, technological systems, missions, & environments. This is accomplished by exchange of information, collaborative experiments, & shared field trials."*

In response to the tasking from RTA, the HFM panel sponsored an Exploratory Team (ET-4) titled "Physiological and Psychological Issues in Non-Lethal Technologies." The ET was chaired by the UK and met twice in 2000, once in Germany and once in the UK. The Technical Activity Proposal of ET-4 is presented in Annex C.

Upon reviewing the mission of the HFM Panel, the team immediately perceived a potential conflict between adhering strictly to the HFM Panel's mission and fully addressing the needs of other NATO groups on NLW. The HFM Panel is oriented toward operator/warfighter health & safety, not that of a potential target. The HFM Panel mission does not address weapon effectiveness, which is one reason the eventual HFM-073 addressed non-lethal "technologies," instead of "weapons." The fact that medical organizations and people in medical professions generally do not study better ways to incapacitate or repel people, reflects a general problem for studying the human effects of NLWs. In addition, most of the military expertise for such study lies in medically oriented organizations, which may be either prohibited or disinclined to address weapon effectiveness or non-treatment issues regarding targets.

This question was addressed to the HFM-Panel and the ET received verbal dispensation to depart from the strict HFM Panel mission and address all the human issues relevant to NLT. ET-4 recommended the formation of a TT to be named "The Human Effects of Non-Lethal Technologies. This TT, identified as HFM-073 and TG-012, held its first meeting in April 2001. The Terms of Reference for HFM-073 are presented in Annex C. The Members and meetings of HFM-073 are identified in Annex D.

The Goals of HFM-073: The newly formed HFM-073 agreed that Human effects information is essential to establishing the effectiveness, safety, and acceptability of NLT, yet the required data are lacking for many proposed technologies. The goals of HFM-073 were to develop data and processes to:

- Evaluate NLT effectiveness vis-à-vis the NATO definition of NLW;
- Minimize risk of injury to NATO forces and the public;
- Increase information exchange to facilitate understanding and interoperability;
- Guide/coordinate research efforts and reduce redundancy;
- Identify gaps in our knowledge and identify research needs;
- Facilitate public acceptability;
- Identify non-lethal weapons suitable for anti-terrorist activity; and
- Facilitate training, readiness, joint operations.

HFM-073 also placed its proposed activities in the context of the activities of the SAS-035 on "Measures of Effectiveness of NLWs" (see Annex F). This chart was presented during a joint meeting of the members of HFM-073 and SAS-035 held in Oslo, Norway, on 15 May 2002.

1.6 THE NATO SCIENCE COMMITTEE

The NATO Science Committee deals with issues of civilian science, in contrast with the NATO RTO, which is concerned with military science. The topic of NLW is clearly relevant to both aspects of science.

On 17-23 October 2004, the NATO Science Committee was the prime organizer of a NATO Advanced Research Workshop (ARW) titled "Integrating Human Effectiveness and Risk Characterizations of Non-Lethal Weapons (NLW) into Antiterrorism Civil Science Programs" in Prague, CZ, which included 45 participants. The Workshop started with two days of presentations on NATO, NLW, and risk assessment. Following the formal presentations, the Workshop continued with structured discussions and smaller working groups. A publication of the papers presented at the workshop is in progress.

The NATO Science Committee is open to supporting additional workshops on NLW and NLT and because of the dual applicability of NLW to both civilian and military science would be an excellent opportunity for coordination with the RTO.

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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).

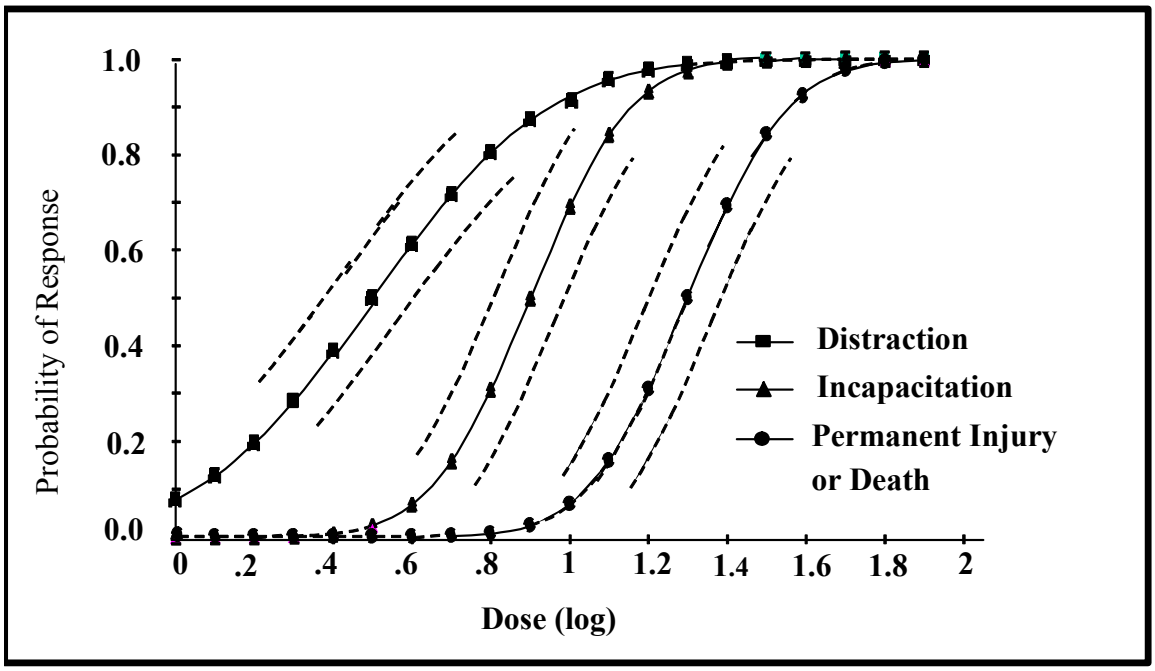

Figure 1: Idealized Dose-Response Curves for an NLT. Symbols identify curves for three types of responses. Solid curves apply to the probability of response from a population of individuals and the dashed lines to either side reflect confidence intervals. Such curves can illustrate the issues and goals 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.

Chapter 3 – DATABASE ISSUES FOR NLT

3.1 THE NEED FOR A DATABASE

While there are many areas of knowledge that bare on military and police technologies, the focus on NLT/NLW as a separate discipline is relatively new. As with any new field of study, the relevant information, facts, and opinions need to be assembled, organized, and stored in a manner that allows rapid search and retrieval. Collectively, this assembly of information and means of its management is referred to as a database. A database on NLT/NLW could be used, for example, to draw conclusions, make decisions, solve problems, make predictions, create and validate models, evaluate the sufficiency of data on a particular topic, provide design criteria for potential systems, and choose the best NLW for a particular military scenario. A well-developed database would also be useful to rapidly address questions that might arise during or immediately after the use of an NLW, including inquiries from the press and public. A database for NLT/NLW needs to be highly dynamic in order to best serve this rapidly developing field.

3.2 ISSUES IN DEVELOPING AN HFM-073 NLT DATABASE

At the beginning of the work of HFM-073, we planned to develop an actual NLT database for use by the Technical Team, the HFM Panel, and other NATO organizations. In particular, it was anticipated that the desired database would be transferred to SAS-035 to supply data for the model being developed by that team (see Section 1.4). We reviewed existing databases from several member countries, including Germany, the Netherlands, United Kingdom, and United States, and evaluated the requirements for developing a common HFM database. It was agreed that ideally a joint database should be developed through the contributions of many participating countries, thereby sharing the work and cost. However, this goal proved impractical. A summary of the issues that impeded the completion of this objective is provided below.

3.2.1 Choice of Computer Software

A contemporary database must be computer-based. It must be portable among user computer capabilities, or be exportable to other capabilities, or reside on a host computer that can be remotely accessed by everyone involved, probably via the Internet. Existing attempts to start NLT databases have used a mixture of custom (non-commercial) software or custom database formats based on Microsoft Access. Several members expressed dissatisfaction with the approach they were currently using. Some of the existing databases are little more than a collection of original papers and reports. It was obvious that a solution with much more sophisticated search capabilities would be needed. The database being developed by the United States Joint Non-Lethal Weapons Directorate Human Effects Centre of Excellence uses the commercial database program "AskSam." The host computer for this database is located at Brooks City-Base, TX, USA, and was readily demonstrated to HFM-073 over the Internet at the meeting in the Netherlands. This program appeared to have the features and search capabilities required for a useful database. However, other issues blocked the development of an HFM-073 database, so no software was officially selected by the Team.

3.2.2 Obtaining Sufficient Resources

After reviewing the requirements for an adequate database it became apparent that building one would be a very time consuming and expensive endeavour. There would be both start-up and continuing costs for software, hardware, communication links, and systems management. Data management and data entry

personnel would be required. The content of the database would need to be acquired and evaluated, requiring the considerable time of specialists in the relevant disciplines (e.g., science, engineering, medicine, political science, psychology). As none of the members of HFM-073 was able to provide either the financial, system, or human resources required, lack of resources was a significant impediment to developing an HFM-073 database.

3.2.3 Restricted Information

Another issue that complicated and impeded the development of a common HFM-073 database was the various restrictions that are placed on data sharing. This issue becomes greater as the information become more detailed, relevant, and recent and, therefore, useful. Some data are classified at various security levels, including "For Official Use Only", Restricted, Secret, and Top Secret. In addition, the compilation of unclassified data, as would be done in a database, may itself become classified. Data that are developed by for-profit industry often have proprietary or ownership issues. The team allowed that a database with different levels of access was possible, e.g., some data open to everyone and other data restricted to holders of a NATO clearance, but this approach would further complicate and increase the expense of the database. The existing databases were said to have a mixture of types of restricted and unrestricted information and separating them out for different audiences would require additional expense, time, and the judgement of trained security officials.

3.2.4 Data Availability

It was the Team's assessment that there was very little relevant data available on the human effects of NLT and that the data which were available were of varying quality and usefulness. The Team observed that the concept of "data" and "useful data" seemed to have vastly different meaning to different people and groups. Because of the importance of data and the common misunderstanding of its complexity, we developed a review of the fundamental nature of data to allow all parties involved to have a reference for a common understanding (Annex G).

3.3 A MULTI-TIERED DATABASE STRUCTURE

Because of the issues described earlier in this section, the Technical Team agreed that its database activity should be focused on general topics. Following considerable discussion, a conceptual process and approach for organizing a database for the Human Effects of NLT/NLW was developed by HFM-073. Our approach involves placing human effects information within the context of a total knowledge-base for NLT/NLW. A four-tiered structure is proposed, with the simplest tier on the bottom. In the proposed database scheme, Tier I is similar to a computer searchable list of published references. Tier II is matrix of data available for the various proposed non-lethal **technologies**. Tier III address the human effects data available, extrapolated, or modelled for specific non-lethal **weapons** that are currently in use or are under development. Tier IV is a high-level decision tool for commanders. With successive tiers, the information becomes more and more directly relevant to using specific non-lethal weapons in specific military operations. With successive tiers, more knowledge and experience is required for proper data evaluation and classification. The lower tiers are based more on scientific considerations, while the upper tiers are based more on considerations that are practical, weapon-oriented, and scenario-driven. Similarly, the higher tiers are much more likely to contain proprietary and classified data. An essential aspect of our concept is that the data in any upper tier can be traceable to the previous tiers. A diagram of the proposed database structure is shown in Figure 2.

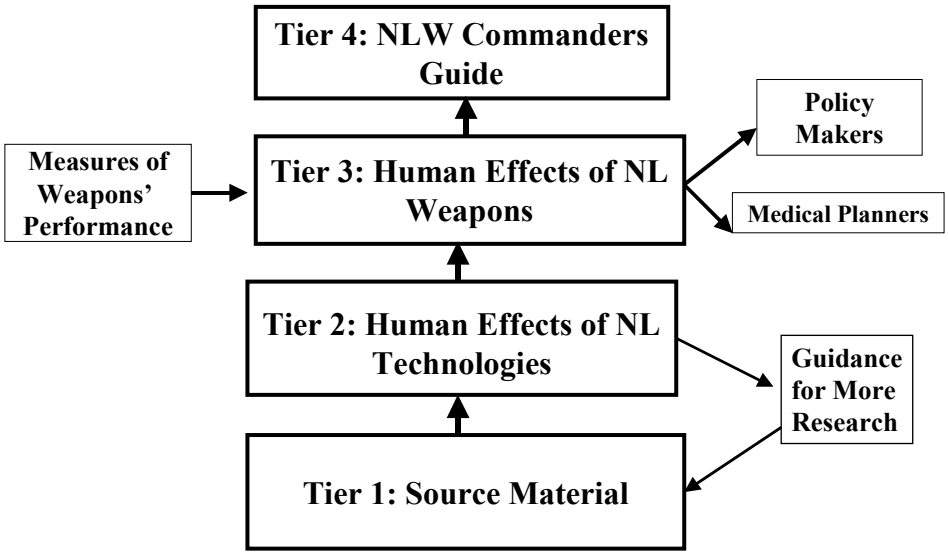

Figure 2: A Multi-Tiered Database for the Human Effects of NLW.

3.3.1 Tier 1 – Primary Source Material

Tier 1 is proposed as a searchable library of references, documents, and other recorded material relevant to the human effects of NLT. It could contain information in any form, including raw and processed data, text, pictures, animation, video, and audio. Ideally, the complete material would be searchable electronically, but, at a minimum, the title (or brief description), source, summary, and keywords would be coded. Intelligent coders and data entry personnel are required to create Tier 1. While Tier 1 could contain both restricted and unrestricted material, it is likely that most of the material will be unrestricted, making it available for academic, civilian, and multi-national use. It is envisioned that Tier 1 will not include much information on specific NLW. Tier 1 will be useful to those evaluating the basis for current beliefs (e.g., so called conventional wisdom), for authors writing summaries of the state-of-knowledge on a particular topic, and for experimentalists designing new research. It will provide the source data for developing Tier 2.

While Tier 1 is proposed to be fully searchable, the Technical Team discussed the types of data entry fields that might be useful. The primary classification should be by technology (see Annex H). The source of the data should be coded (e.g., animal experiments, human experiments, field report, accident, analysis of incidents, lessons learned, experiences, debriefings, modelling, anecdotes, theoretical, historical, opinion). The nature of the effects measured should be identified (e.g., environmental, biological, psychological, sociological, medical, physical). The nature of the data (e.g., quantitative vs. qualitative) should be noted, as described in Annex G.

3.3.2 Tier 2 – The Human Effects of Non-Lethal Technologies

Tier 2 will provide an evaluation and organization of the data found in Tier 1. Tier 2 might be thought of as a critical review of the existing data, organized in tables of numbers and text, or in figures, diagrams, and mathematical curves that can be conveniently searched and retrieved. It is basically a computerized "review article". Subject matter experts are required to organize and populate Tier 2, making it inherently more

difficult to create than Tier 1. In developing this database it will become apparent where data are lacking and where additional research is needed. Although incomplete without the existing classified information, Tier 2 will still be useful at the unclassified level. It will contain links to models that predict effects of NLT. The Tier 2 database is expected to be useful to experimenters, equipment designers, policy makers, and medical planners.

We suggest that a primary means of organization for Tier 2 be the NLT area (see Annex G) and intended and unintended effects. Beyond these classifications, the possible categorization schemes are unlimited. Desired effects include incapacitation, repel, immobilization, sensory loss or distortion, area denial, distraction, annoyance, reduced communication, warning, disorientation, etc. Metrics of these effects include level achieved, onset time, duration, and total recovery time. Possible unintended effects range from lethality to minor injury or psychological trauma. Such effects may recover quickly or last for a lifetime. The modification of potential effects by environmental (e.g., weather) or personal (e.g., drug use, clothing, special sensitivity) factors has enormous possibilities. The possible preventative and treatment medical issues are also extremely important for planning triage, treatment, and recovery actions for targets, operators, and bystanders exposed to NLT.

3.3.3 Tier 3 – The Human Effects of Non-Lethal Weapons

The difference between Tier 2 and Tier 3 is that Tier 3 is based on specific weapons systems. Tier 3 will require knowledge of the measures of performance (MOP – see Annex H) of existing or potential weapon systems, e.g. the type of energy, dispersion, range, incidental emissions. Much of the information for this database will be derived from extrapolations based on data included in Tier 2, but additional information on operational goals, rules of engagement, and policy will be required from planners, policy makers, and commanders. Through the use of models, such as the one developed by SAS-035, the information from Tier 3 will provide an assessment of the operational utility and effectiveness of specific or potential NLW systems. Such a database will assist planners in deciding the best course of action to achieve a particular objective.

3.3.4 Tier 4 – Commanders Aid

Tier 4 is envisioned as a high level decision tool for military commanders in choosing and establishing the rules of engagement for specific NLW in a specific operation. It is a distillation of information that is based on and is traceable to the data provided in the lower three Tiers. In addition to the expertise required to develop Tier 3, the completion of Tier 4 will require the input of experienced field commanders.

3.4 THE FUTURE OF AN NLT/NLW HUMAN EFFECTS DATABASE

Establishing a database to cover all the technologies envisioned for NLW will be expensive and complicated, even if it were limited to existing data. However, we believe that there exist very few existing data of the type that would be suitable for Tier 2 of the proposed database or that could be used in the model developed by SAS-035. Any matrices developed for Tier 2 will have a lot of blank cells; there is far more to learn than is already known. The collection of good, dose-response data is accomplished one experiment and one datapoint at a time and is tedious and expensive. Thus, the completion of a complete Human Effects Database is likely to be very slow. The best we can propose is that a common structure for the rapid assimilation of new NLW human effects data be agreed upon among NATO nations and that the NLT/NLW database be built in this structure as data become available.

Chapter 4 – MEDICAL ISSUES FOR NLT

4.1 GENERAL CONSIDERATIONS

To date, non-lethal technologies have seen some, but limited, effective use. For example, pepper spray has been employed to disperse angry mobs in domestic riot situations and rubber baton rounds have been used in the Bosnian peacekeeping missions. Non-lethal technologies are often used by law enforcement and correctional agencies to end domestic violence conflicts, prevent suicides, and to intervene in other threatening situations. However, there is still a strong and growing demand for improved yet simple, effective technologies and weapons that provide a safe alternative to deadly force.

4.2 ENABLING A SPECTRUM OF RESPONSE

In a terrorist/hostage situation, it is conceivable that the use of riot control agents, directed energy, or flash-bang devices could quickly and temporarily disorient or disable all people in the crisis, allowing for the capture of the belligerents and safe recovery of hostages and innocents. Likewise, during a potential suicide crisis or threat, use of a blunt impact projectile or an electrical stun device could quickly and temporarily incapacitate the individual, preventing both the suicide and potential harm to law enforcement officers and bystanders.

A broad spectrum of non-lethal responses are needed for law enforcement, peacekeeping, counter-proliferation, anti-terrorism (both domestic and international), and the management of relations with rogue nations at all levels of conflict (http://www.unh.edu/ntic/).

The variety of situations in which NLW may be needed and the wide spectrum of techniques that may be used make it very difficult to predict all possible medical effects of the NLW systems. It seems fair to assume that medical effects of NLW in general must be mild compared to the lethal alternatives. However, it is possible that the threshold for use may be lower for NLW. For a safe use of NLW it is important to analyze the possible medical effects before the introduction of a new system. This ideal has not been achieved in most cases. The millimetre wave project of the US Air Force is an interesting exception to this role, since this system has been carefully evaluated in animal experiments and with human volunteers, and dose-response data provide a good background for safety-regulations.

Safety regulations: For other systems, predictions of medical effects can partly be made from case reports and experience with similar systems. Such data may also have been developed for setting safety-regulations. Safety-regulations are important to prevent a NLW from becoming a lethal weapon, e.g., as might occur with the inhalation of sedatives (see Annex M).

Reports on medical effects of NLW are hard to find in medical databases. A search of the website http://www.ncbi.nlm.nih.gov/PubMed/ on Nov 30, 2003 found 155 articles on blunt injury, 105 articles on weapons, and no articles on non-lethal weapons during the preceding 150 days.

4.3 SPECIAL ISSUES: MICROWAVE AND RADIO FREQUENCY (RF) SYSTEMS

The effects of human exposure to microwaves range from direct thermal effects causing pain to the untested possible effects of microwaves used in anti-materiel systems. The possible medical effects induced by the use

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 any health problems associated with using wireless phones, yet, as with the health effects of any agent, **absolute** safety can never be proven. 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. A more extensive discussion on possible effects of RF systems can be found in Annex J.

RF based non-lethal weapons include high power pulsed microwaves (HPM) and the 94GHz ADS system. The ADS system is based on biological thermal effects, while HPM systems have no known biological anti-personal effects. The ADS system has been extensively tested with regard to both desired and possible undesired effects. So far, no other weapon system has been tested with such a systematic approach in order to establish safety margins and rules for use.

HPM systems are being tested in several labs in different countries to identify possible biological side effects. No effects that could have health consequences have been revealed, so far, and the effects that have been claimed to occur at low levels (so-called non-thermal levels) have been difficult to replicate when adequate controls and accurate dosimetry are employed.

4.4 SPECIAL ISSUES: ELECTRICAL MUSCULAR DISRUPTION DEVICES (EMD)

Stun weapons from TASER Incorporated are used by a large number of police forces. A number of user reports have been published at the TASER website (www.taser.com). Currently, military use is not widespread. Medical risks include cardiovascular disturbances, penetration injuries (skin and eye), and fall injuries. Reported fatalities have been attributed to pre-existing drug abuse or cardiovascular illness. A few studies on experimental animals have been conducted. A more thorough consideration of the medical implications of EMD use for NLW is presented in Annex K.

4.5 SPECIAL ISSUES: BARRIER SYSTEMS

Barrier systems included Airbag Stoppers, Microwire Systems, Nets, Rapid Barriers, and Temporary Fences, and have proven very effective when emplaced at the right time. However, all barrier systems have the potential of confining movement in such a way that vehicles can crash into them, or people can be crushed between them and a moving crowd. Temporary barriers that are rapidly emplaced are a particular problem because people could be hit, thrown back, fall, or get entangled in them; such barriers can also appear in unexpected locations, making the issues of crowd pressure more likely.

4.6 SPECIAL ISSUES: ACOUSTIC SYSTEMS

Acoustic systems, known for centuries, have been analysed in detail and their effects described in narrative non-fiction and scientific literature. The human ear is sensitive between 20 – 20,000 Hz. Non-lethal actions using acoustics could range from loud sounds producing a temporary deafness to disagreeable sounds having a psychological effect. With low frequencies, additional effects can be obtained, in particular, loss of equilibrium. The aim of a directional multi-effects acoustic system is to generate different anti-personnel effects: targeted information/disinformation (psychological effect on selected people among a crowd),

continuous or interrupted unbearable acoustic stress (physical and psychological effects), loss of equilibrium by the use of low but audible frequencies (physiological effect on inner ear).

Most audible acoustic systems can be defeated with ear protection. When the effects of an NLW acoustic system depend on the loudness of the sound, there is usually a risk of permanent damage to hearing.

4.7 SPECIAL ISSUES: LASER SYSTEMS

Laser Systems are widely used in weapon systems for range finding, detecting, and pointing. Their frequencies are fixed and mostly well known, so that eye protection with special goggles is possible.

Laser weapons have been developed for use against sensor systems, anti-optical equipment and, at very high intensities, to burn metal structures and destroy weapon systems. They can easily affect the eyesight of persons. The need to pay attention to new laser weapons to be sure they do not violate international humanitarian law has already been codified in Article 36 of the 1977 First Additional Protocol to the 1949 Geneva Conventions. Current technology provides the possibility for small lightweight lasers that are dangerous for eyesight over distances of kilometres. Laser eye protection is frequency specific and because of easy to alter frequencies (tuneable lasers) there is no fully effective protection that soldiers could wear. It should be emphasized that with repetitively pulsed laser weapons there is a high probability of multiple lesions induced in the victim's eyes. With very short-pulsed lasers (nanoseconds or less), haemorrhages may be large and thus visually important even if impacts are in the periphery. Immediate blinding, forcing mission abortion, and permanent blindness may be the result. Blindness is exceptionally debilitating, even when compared with the worst of other injuries. No cure is possible and even long-term prognosis with improvements of ophthalmic surgery is very poor. The awareness of blindness-causing weapons would establish fear, anxiety, and extreme mental problems in soldiers on the battlefield. Sudden blindness, most likely with no other injury, will be psychologically very disturbing for the victim as well as for his fellows. The soldier's morale will be affected. Even the rumour of that laser weapons may be used may result in inactivity, mission abortion, or desertion; people will not knowingly risk their eyes.

Protection measures. The need for adequate vision in a life-threatening situation is, of course, vital to the soldier. Avoidance of looking into a laser is not possible for physiological reasons. If some kind of light or flash might be noticed in darkness, the eyes automatically will try to focus the source. Closing the eyelids is too late to avoid the laser energy from immediately damaging the retina, the papillo-macular bundle, or the *fovea centralis* (the central area of vision) without causing pain. Observation of enemy positions by periscopes or other optical systems will not protect against laser radiation – indeed, it may actually increase the energy received by the retina. Technical or electronic high-speed shutters are too slow for laser pulses. Eye-safe goggle systems for soldiers and aircrews are possible only against known, fixed-frequency laser systems with near-monochromatic bands. For protection purposes, specially designed bandstop filters may be used without degrading visual performance significantly, but to be effective the threat wavelengths would need to be determined. However, tuneable lasers can work at any wavelength and an effective filter would have no visible transmission and therefore completely impair vision.

4.8 SPECIAL ISSUES: BLUNT IMPACT (KINETIC) WEAPONS

There is little medical research on the human effects of blunt impact NLW. Some problems can be predicted from earlier experience and prevented by correct use. Data from studies on effects of Behind Armour Blunt Trauma (BABT) and in sports-incurred injuries may be relevant. Skin penetration, mild brain injury, eye

injuries, bleeding in internal organs, contusions, and shock can be anticipated, depending on the area and energy of the impact.

Unclear definitions make it difficult to compare effects of different types of non-lethal trauma. Repeated mild trauma is a current problem in several medical specialties, such as neurology and sports medicine. Some aspects of repeated mild trauma are discussed in Annex L. Additional information can be found in the report of HFM-024 (RTO-TM-022) "Blunt Trauma Induced by Non-Lethal Weapon Kinetic Projectiles" found through http://www.rta.nato.int/Pubs/RDP.

Descriptions of the experiences from use of kinetic weapons in riot control and law enforcement in Northern Ireland can be found at the Northern Ireland office web site. http://www.nio.gov.uk/. The North Ireland experience with impact weapons shows that it is possible to reduce the number of eye and head injuries with good training and well-defined safety regulations.

4.9 SPECIAL ISSUES: SEDATIVES

One of the most significant examples of the importance of medical issues for the use of non-lethal weapons is the 2002 hostage rescue from a Moscow theatre. This incident is fully discussed in Annex M.

4.10 COLLECTION OF AFTER-ACTION MEDICAL DATA

While laboratory data and models are useful in predicting the medical effects of NLT, there is no substitute for human effects data collected soon after an action in which NLT have been used. We suggest that NATO develop after-action data collection forms that are implemented along with new NLWs. After-action medical recording and reporting procedures should become an integral part of the fielding of any new NLW. Examples of After-Action medical forms for NLW operational use are provided in Annex N.

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Chapter 5 – TRAINING ISSUES FOR NLT

5.1 TOWARDS A POLICY WITH NEW OPTIONS

The continuous presence of the media in theatres of operation has the effect of disciplining the disproportionate use of deadly force because all excesses are immediately witnessed by television viewers around the globe, shocked by the sight of violent death, a "barbarian" concept. In addition, the nature of conflicts has also evolved: there are fewer wars between states in which citizen soldiers face each other and where the enemy soldier merely serves as an instrument in the strategy of a particular state; an instrument which it is legitimate to eliminate within the scope of international law. Modern wars tend to be intrastate affairs in which a minority is pitted against a ruling majority or one ethnic group against another.

In this type of conflict, the adversary is neither the enemy nor a friend, and it is more necessary than ever to avoid causing unnecessary suffering. If, in third generation conflicts, maximum lethality is sought in the employment of weapons, a scenario such as that in Bosnia is now difficult to imagine without the possibility of being able to dose lethality at will and without constant concerns about avoiding fatalities, destruction, or any other forms of unnecessary suffering. The presence of latent violence in zones of civilian and military action, as well as the related effects of strict rules of engagement and the constant presence of the media, imposes increasing constraints of stress and time on today's soldiers in the response that they can give to a given threat. The soldier is also obliged to think twice before responding. In fact, the mistake of a single person in assessing the situation or taking disproportionate action can result in consequences for the credibility of the troops as a whole and for the operation whatever that may be. Faced with situations that are less and less clear-cut, coupled with an uncertain threat, the soldier must be capable of delivering the right response, decisively and unambiguously. Furthermore, faced with this permanent concern of having to do the right thing, the soldier might see himself restricted to employing less than lethal means. Additional options are therefore needed to fill the void between inaction and the employment of lethal means.

The search for non-lethal means or with reduced lethality is taking the path of providing supplementary options to respond to uncertain problems. NLT are not a particularly new phenomenon: police forces have been using them for several decades, notably in the form of rubber bullets or irritant sprays. More recently, however, armed forces have begun to take a greater interest in them, as the scope of assignments carried out by military contingents has expanded to include policing missions.

With new options at his disposal, the soldier must be trained in a much more refined manner so that his response to a given situation is proportionate, and yet flexible to all kinds of problems. During training it is therefore necessary to ensure a degree of realism so that the soldier is confronted with situations that are as close to reality as possible. It is also essential that the soldier be able to master the diverse facets of the escalation of violence so as to be able to respond to it by using the most appropriate means. Finally, the constraints imposed by having to master additional equipment should be overcome through simple and effective instruction.

5.2 RULES OF ENGAGEMENT

The Rules of Engagement (ROE) provide armed forces involved in an operation with the rules essential for carrying out their task. They have taken on particular importance since the significant increase in the number of peace support missions because they set the limits, not least for the tactical levels, for the recourse to deadly

force. If the ROE are, in general, the legal consequence of political considerations motivating the operation, they are not able to take into account certain cases or cannot be adapted to the situation in the field, either because there is a lack or poor orientation of political will or because the situation on the ground has taken an unexpected turn.

During Military Operations Other Than War (MOOTW), the legal threshold for the lethal use of weapons is often set at that of legitimate self-defence or at situations in which it is impossible to accomplish the mission without resorting to arms. It is acknowledged that ROE also have to be established for the use of NLT so that they may be used in similar conditions to those of usual lethal weapons, that is to say in a well-defined legal framework.

Over the last fifty years, the nature of many military operations has changed radically. Military missions, especially peace support operations, have in their nature come to resemble policing missions. Furthermore, media and popular interest in military actions has also grown enormously. This is also the reason why unnecessary casualties or fatalities inflicted on combatants or enemy civilians are no longer tolerated and why the adoption of NLT is experiencing such growth.

Despite all of that, too many situations arise in which the use of deadly force is disproportionate in relation to the real threat. A crowd of demonstrators, even if it is acting aggressively, does not necessarily have to be dispersed using live rounds. NLT therefore increase the arsenal of possibilities available to the commander and his soldiers to respond to the threat in line with the principle of proportionality.

NLT are developed to enable the prevention of unnecessary fatalities, and that is also one of the aims of international humanitarian law. Setting the legal threshold for the use of NLT at a lower level than that set for lethal weapons would provide the soldier with additional options for his response: NLT provide the possibility of acting before the situation deteriorates; beyond that deadly force remains the only possible alternative. However that does not prevent ROE from being imposed that strictly determine the use of non-lethal force, in a way that is compatible with the principles of force protection and with international humanitarian law.

The principle of continuum in the employment of force is therefore merely a principle of proportionality: in order to prevent access to a military installation, a physical presence is sufficient in the vast majority of cases. If a suspect comes too close to this installation, a verbal warning may largely be sufficient. If the person attempts to get past the guard, use of the weapon without opening fire or neutralisation using an electrical discharge device would seem proportionate. Finally, if the person transforms into an aggressor and threatens the physical integrity of the guard or, despite warnings, attempts to force his way endangering the life of personnel, use of deadly force might be called for. The use of force is thus proportionate to the circumstances, as is illustrated in Figure 3.

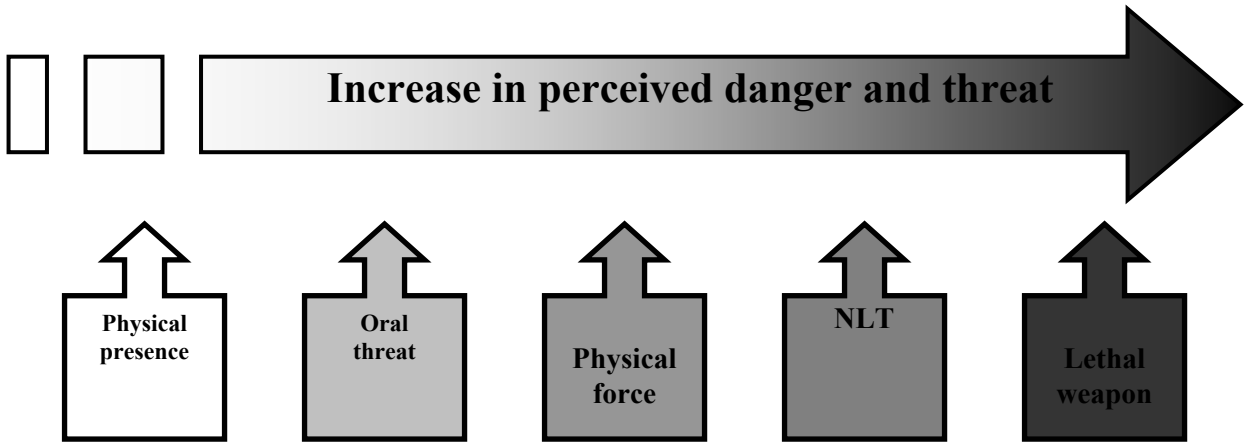

Figure 3: Increase in the Threat Perceived by the Soldier and the Proportionate Response. The intensity of shading indicates the danger posed.

It is of paramount importance that the soldier not only be instructed in ROE, but also, and above all, to understand and assimilate them. The ramifications and possible consequences of each action must be known and mastered. The continuum in the use of force must be mastered and be able to be applied in relation to the level of violence.

Developing ROE is never simple, and where the use of NLT is planned, it is even more complicated. Since the process for preparing the ROE for different types of operations is similar, the drafting of ROE for the use of NLT for a force will also be based on national policy, operational requirements, and the law.

It may seem like a cliché, but properly crafted ROE are essential to the success of all operations. When formulating the ROE for an operation (to include one which will involve the employment of NLT), the objective is to utilize the ROE cell or its equivalent to anticipate and brainstorm as many different foreseeable circumstances as possible and from this group interaction generate clear, unambiguous guidance for those military personnel who will be placed in harm's way. The two primary purposes for the ROE are to "provide implementation guidance on the inherent right and obligation of self-defence and the application of force for mission accomplishment." All commanders must understand these two purposes, and how to utilize the ROE as a risk management tool. A mistake often made by commanders involves blurring the distinction between mission accomplishment and self-defence. This can lead not only to confusion within the command but also place those executing mission taskings at greater risk.

Due to force protection questions, ROE have to be classified. ROE concerning unarmed crowds or unarmed hostile elements must not be know from the public especially if they limit the use of any kind of force to the troop.

Special attention has to be put on the understanding of the ROE both at commander and troop level. ROE must be clear, simple and not subject to interpretation.

5.3 NEED FOR INSTRUCTION

New forms of conflict and the increase in social violence of the last twenty to thirty years must lead, perhaps paradoxically, to an improvement and more systematic approach to training in controlling individuals and crowds as well as in the means to achieve it. The organisations mainly affected by these movements are the armed forces and police on the one hand, and civilian security organisations on the other.

The common denominator between all these organisations is that the work of security boils down to the level of those who execute it, and regardless of the context, to relations with the public, be it during vehicle searches, trivial encounters, guard duty or other types of patrol.

In a modern democratic society, any institution dealing with security is closely monitored by political authorities – and the media. This should have the effect of constantly spurring decision-makers in the direction of progress and of putting certainties in question.

In the future, instruction with NLT may be considered routine, but at this time it presents a unique challenge. A part of this challenge is reaching the same level of proficiency with NLT systems that exists for lethal weapon systems. To accomplish this training goal will be one of the commander's most difficult responsibilities. Proper instruction and practice are the cornerstones to operational success, and commanders must work their way through the training process. There is no short cut. Unit readiness requires the unit which will use a NLT to train with that system.

The training aspect of the NLT equation can be lengthy and costly. In most cases, both the military units and the instructors will have, at best, only limited experience with the system. Furthermore, developing the appropriate training package will take time. In fact, most training packages will be the result of trial and error to discover what works well and what does not. Commanders can expect the overall training time for their units to increase in direct proportion to the time needed to train for the use of the NLT system. This increase simply reflects the reality that the unit must go through the standard lethal weapon system training as well as the new NLT system training.

5.4 CODIFICATION OF VIOLENCE AND PROPORTIONALITY

One legend firmly rooted in the field of those with recourse to the use of arms is fortunately starting to disappear: that of a "bolt of lightening out of the blue". In this figurative case, the basic soldier suddenly finds himself in a life threatening situation in which an on the spot decision to fire a shot or use an instantaneous defensive technique makes the difference between life and death. However, reality shows that confrontations do not generally arise in an instant, just as they do not come to an end immediately after the application of a means of defence, but instead they ensue from a process, from a continuum of communication between the intervener and the suspect, between the soldier and his "adversary".

In other words, it is a matter of finding a system which permits proportional interaction and continues from the highest to the lowest level of the suspect's or adversary's resistance. This should lead to the creation of a so-called table "of proportionality", where each action by the suspect corresponds to a reaction on the part of the soldier. This system codifies the suspect's levels of resistance, and the main fluid levels of response, adapted to the situation and offers numerous possibilities for de-escalation.

5.5 KEEP IT SIMPLE

The need to create a range of response options must, paradoxically, lead to a simplification and a complementarity of various techniques. Basic conditions for effective instruction in this field are as follows:

- **Respect for the laws**, procedures, principle of proportionality and minimum use of force.
- **Adaptation to adults**: the technique must be convincing, based on the experiences of the students, and is justifiable.
- **Simplicity of learning**, for reasons of time, cost and subsequent training. It is basically unrealistic to use techniques that require more than several minutes instruction because they will be forgotten. Instead it is preferable to insist on complementarity.
- **Realism**: the techniques must work quickly and well so as to avoid aggravating the situation.
- **Coherence**: each technique should be seen as a block aimed at erecting a wall of defence around the user. If the blocks are cracked (not realistic) or do not fit, there is a risk that the instruction will not make sense: the different instructors of the various means of defence (lethal and non-lethal) must teach exactly the same principles from the point of view, for example, of safety distances, of ROE or of proportionality.

It clearly seems that demands placed on the instructors with this method are considerable, but as an experienced instructor noted “the time when one learned how to shoot but not when have passed.”

5.6 GENERALIST INSTRUCTORS

The global approach to the problem of training in NLT has in recent years led certain organisations to create posts as instructors in defence techniques, or even, in techniques to control aggressive behaviour, capable of instructing the full range of behaviour and above all the appropriate responses to deal with it.

Such instructors are exceptional because the need for realism necessary in their training requires a certain degree of specialisation. The minimum requirement, in our opinion, is that each instructor be able to teach two main fields, and be trained as an advanced user in the others so as to guarantee the comprehension and coherence of instruction.

In the case of small organisations (less than 100 persons), it is still possible to operate a more traditional system based around pedagogical capacities of a limited number of instructors.

5.7 VARIOUS PHASES OF LEARNING

The problem becomes more pronounced in larger organisations such as an army, where the turnover of personnel is greater and where it is more difficult to keep an overview.

It is also crucial to understand, in a big organisation like an army, that not everybody needs the same level of training with NLT. According to the complexity of the apparatus or simply to the kind of mission, an operator or a troop will need more instruction on a certain type of NLT. This has to be accessed.

The training program for each NLT should consist of two parts, one part for general training matters (such as important safety information, including any special first aid or emergency medical care for accidents

involving the relevant NLT) for all members of the troop and the second part for the specific members who will employ the system. The instruction contained within this second part should include the following:

- The function and inner workings of NLT;
- Tactics, techniques and planning considerations for NLT;
- Special equipment, transportation or support required for its use;
- Training directed toward a specific mission capability;
- Actual practice using the NLT;
- The normal malfunctions or break points for the NLT; and
- Maintenance, repair procedures for the NLT.

For the second part of the training, as the table below shows, the first didactic phases of learning these techniques are possible in groups in a decentralised manner, and relatively inexpensively once the initial investment has been made.

Table 4: The Phases of Learning as Applied to NLW

Didactic phase	Stimulation	Aim	Instruction
Learning	Artificial/command	No time limits, no faults	Group
Training	Simple situation, known in advance	Intensive work, memorisation	Group
Drill	Simple situation, unknown	Mastering technique	Group and/or Individual
Application	Simulator	Select level of response suited to the situation	Group and/or Individual
Integration	"Real" through role play	Control ability to resist stress	Individual

Didactic phase	Non-verbal communication	Verbal communication	Techniques of defence	Non-lethal weapon	Lethal weapon
Learning	Body positions	Learning set phrases	Elementary drills	Manipulations	Standard behaviour
Training	Utilisation	Questions/ responses	Application with means of simulation	Application with means of simulation	Figures/colours/ Cut-outs→ reflection
Drill	Utilisation		Utilisation with means of protection and/or simulation		Humanoid graphic targets
Application	Interactivity with instructor			Simulation (laser)	Simulation (laser)
Integration	Role play with protection and means of simulation				

If we take the example of shooting, the learning phase involves performance norms and standard behaviour when confronted with one or several targets, presenting weapons from the starting position, changing the magazine, etc. They are nevertheless trained by simulating reality as far as possible, even when faced with paper targets. The stimulus to open fire is artificial (whistle or command).

After this phase, a memorisation test is conducted in which students are made to shoot after reflection at numbered targets, or according to a colour code, or geometric shapes, or even a combination of all three. The idea is to force the marksman to make a decision before opening fire. The end of this phase of instruction can be marked by spraying the shapes of inoffensive objects or weapons on the target with the aid of outlines to get him used to identifying threats and looking at the suspect's hands. In order to arrange a surprise effect, the marksman or marksmen turn their backs to the targets, which will already have been shuffled.

The following phase requires the use of realistic graphic humanoid targets in order to train the marksman to identify the content of the suspect's hands. A certain degree of additional realism can be achieved by making the targets "talk" through the instructor. It does not take the marksmen long to recognise all of the possible target combinations and be able to predict the exercises due to the layout of the shooting facility.

It is therefore time to progress to the next level which aims at training the full range of possible reactions based on the use of target simulators.

The first generation, of the diaporama or video projector type that stop on the image the moment the shot is fired have the advantage of allowing a number of people to be trained quickly, while still subjecting the marksman to an appreciable level of stress. However, they are not truly interactive, and tend to reduce scenarios to "ambushes" (typically, a young man approaches to show his papers and rapidly draws … his wallet) thereby drilling an overreaction.

On the other hand, the activities that immediately follow the shot, such as taking cover, communicating with the suspect, colleagues or reinforcements are difficult to act out after the image has been stopped.

The alternative that has been used for a long time is the role play. The recent emergence of equipment able to absorb baton blows (ASP, PR-24, etc.), freshly accepted defence techniques, as well as the development of guns that can fire cartridges made from soap (Simunition FX) in service weapons has made it possible to integrate the full range of possible reactions. We consider this form of training to bear the closest resemblance to reality, and this is not only because the blows and impacts generate a certain amount of pain, and have the effect of providing instantaneous recognition of poor performance. There is no better teacher than experience.

5.8 CREATING REALISM IN THE SCENARIOS

The major problem with role plays is that the learning effect depends on the quality of the instructor. The danger lies in seeking to convince the students of their poor standards by making them fail in unsurvivable scenarios, which greatly reduces the didactic effect.

Moreover, return on investment is also a major problem with this method. Not only is it necessary to have the time required playing out a scenario with a hundred students, but above all it is difficult for the instructor to act out a given role in a perfectly identical way more than a dozen times. These two constraints alone in practice limit the use of role plays to the training of small groups of specialists, where the instructor/student ratio is more favourable.

For more important stages of training, an intermediate solution (not intended to replace role plays), that creates a bridge between technical drill and decision-making drill is obtained through a simulator (e.g. simulator of the type "Range 2000", see http://www.caswells.com/range2000.html). This tool is based on three elements:

- A laser simulator inserted in the barrel of the service weapon;
- A PC loaded with the software connected to a projector; and
- An ordinary screen.

The principle is simple. The shooting instructor creates a scenario containing all the possible issues and films it using an ordinary video camera. The sequence filmed is then cut according to the scenario, assigning zones of effectiveness following the impact of projectiles (laser simulator) or the employment of NLT (weapons with laser simulator or other simulation system) with the help of a few mouse clicks. Each of the possible cases is assigned a connection, for example with an impact to the leg: fall to your knee, etc. It is thus possible to create complete and precise scenarios, and respect the organisation's doctrine of engagement and /or ROE. It is of course possible to establish a manual connection according to the reactions of the person trained. The student is confronted with a scenario that he can resolve as he sees fit. The wealth of connections is limited only by the imagination of the instructor and the time available to prepare the situations. Connection to a database allows the results and behaviour of the student to be recorded. The advantage of the system is that it allows identical training to be carried out with a large number of people using the full range of possible reactions from the table of proportionality, and not just involving shooting.

5.9 CONTINUAL TRAINING IS ESSENTIAL

The modern instructor therefore no longer has to be a specialist in a particular materiel or technique, but instead needs to be more of a generalist. If the majority of confrontations in the real world are – fortunately – able to be resolved without the need to open fire, training should reflect this reality. The development of modern techniques in instruction and in the simulation of confrontations is an important step in this direction. From this perspective, it is in our view essential for all professionals and people concerned to attend a course offering basic training of this type.

It is easy to understand from reading this that what is primarily at stake is the concept of training instructors. As a general rule, the training of users and instructors is an internal matter for the organisation. However, it is advisable to confer the running of training and refresher courses for instructors to a third party with a view to broadening their field of vision.

If the field of vision is not broadened, this could lead to the emergence of a "submarine effect". That is to say that an instructor no longer has contact with other systems or other forms of training. This can lead to absurd deviances arising in training that loses sight of its real objective.

"Mixed" courses made up of various bodies (armed forces, police, etc.) are extremely beneficial so as to avoid ill-fated effects. Moreover, the function of instructor/supervisor should be limited in time. A "burn-out" effect generally becomes noticeable after five or six years. Development as an instructor, or basically the learning of a specialisation is beneficial for sustaining motivation and developing synergies.

In addition, a constant update should be established during training by creating a list of "lessons learned" so as to ensure that the structure learns from its own experiences.

5.10 NEED TO RETAIN LESSONS

After each training sessions and/or each involvement of a NLT, lessons learned have to be retained in order to implement continuous improvement. Lessons learned meetings and database have to be implemented in order to be sure that all crucial criteria are detected and retained.

Lessons learned meetings give everyone a chance to freely discuss the good and bad aspects of the training session, material, procedures, etc., so that good practices are repeated and bad practices are eliminated.

Lessons learned database should be based on an "after-action report" model taking into account important parameters such as environmental circumstances, sequence of actions, latency time between engagement and effect and/or zone of impact.

5.11 SUMMARY

The presence of latent violence in zones of civilian and military action, as well as the related effects of strict rules of engagement and the constant presence of the media, imposes increasing constraints of stress and time on today's soldiers in the response that they can give to a given threat.

The search for non-lethal means or with reduced lethality is therefore important to provide supplementary options to respond to uncertain problems.

A special attention has to be put on the development and understanding of ROE both at commander and troop level. ROE must be clear, simple and not subject to interpretation.

Instruction with NLT may be considered routine, but at this time it presents a unique challenge: reaching the same level of proficiency with NLT systems that exists for lethal weapon systems. Proper instruction and practice are the cornerstones to operational success, and commanders must work their way through the training process.

The global approach to the problem of training in NLT requires creating posts as instructors in defence techniques, or even, in techniques to control aggressive behaviour, capable of instructing the full range of behaviour and above all the appropriate responses to deal with it.

It is crucial to understand, in a big organisation like an army, that not everybody needs the same level of training with NLT.

After each training sessions and/or each involvement of a NLT, lessons learned have to be retained in order to implement continuous improvement.

Chapter 6 – HUMAN EFFECTS ISSUES AFFECTING NLW DEVELOPMENT, TESTING AND ACCEPTANCE

6.1 INTRODUCTION

Armed Forces must have the doctrine, ethos, organisation, and weapons to defeat their opponents and achieve mission success. Throughout the Cold War, the armed forces of the West prepared for conventional, inter-state war. Within the past decade, the use of military force has not been principally state against state, but more typically exercised in regional engagements in peace keeping, peace enforcement, and humanitarian aid. Military sources refer to such scenarios as OOTW, Operations Other Than War.

Such scenarios are fraught with novel complications compared to conventional warfare. Troops deployed on peace keeping, policing, or humanitarian operations equipped with firearms are confronted and outnumbered by unarmed civilians including the elderly, infirm, women, and children. An excessive response can worsen the operational situation and can frequently include the "CNN factor", i.e., selective news reports reaching the home audience in real time. A nil response or back-down by the troops undermines their peace keeping credibility with the consequence of no improvement in the overall situation. In the worse case, back-down may encourage the indigenous population to further action. In addition, a military commander may be faced with the moral dilemma of having to destroy a target with the risk of killing non-combatants or of trying to deter with a show of force, potentially placing his own troops in what some might consider to be unnecessary danger.

In these circumstances, commanders have found military worth in having both lethal and non-lethal options. Non-lethal capabilities expand the number of options available to commanders confronting situations in which the use of deadly force is not preferred. Additionally, non-lethal capabilities increase the engagement space and time, thus allowing a commander to reflect and act, as opposed to having to react.

Weapons useable in such scenarios are visualised as being non-lethal with a high effectiveness in role and employed as politically appropriate to the situation. The human effects of NLT development deployment, factors that can affect injury and death rates, as well as mission success, are examined in this section.

6.2 MILITARY NEEDS

The decision to use a lethal or non-lethal capability will depend on the effect to be achieved and the tactical or operational objective. Non-lethal capabilities include anti-personnel, anti-material, and anti-capability. Non-lethal capabilities may contribute to the following military need:

- Protection of military personnel, vehicles, depots, and installations to enhance force protection;
- Control of the movement or actions of people;
- Control or neutralisation of vehicles and weapon platforms;
- Protection of key assets, such as infrastructure (transport, power, water);
- Disarming people with low probability of fatal injury and minimal collateral damage;
- Neutralisation of Weapons of Mass Destruction and ballistic missiles without risk of payload release;

- Suppression of enemy weapon systems with minimum collateral damage; and
- Protection of friendly forces, including Non-Governmental Organisations (NGOs).

The military perceive non-lethal weapons as offering additional options in their response to OOTW compared to all out war. A survey undertaken by Deas et al [6.11.1] amongst serving officers of Captain to Colonel rank (75% response rate) with command or staff operational experience found that 92% of respondents advocated the use of NLT. NLT was envisaged as an intermediate stage in escalation, a means of delaying the use of lethal force; in other words NLT is seen as an addition to, not a replacement for conventional weapons. Eighteen scenarios were identified, for which the NLT solution was regarded as exclusively anti-personnel in 10 cases, anti-personnel and anti-equipment in a further 4 cases, and exclusively anti-equipment in the remaining 4. The identification of the intended purpose of the NLT has important implications on the characteristics of NLT, as intrinsic safety against personnel is obviously a very high priority.

The emphasis is very much on very low injury rates although the risk of injury may be allowed to increase as the situation nears use of lethal force, i.e. the least lethal or injurious alternative compatible with keeping order. Such intent is very difficult to weigh qualitatively and ultimately will rest with the commander in the field operating within guidelines and appropriate training.

Ideally, NLT allows the actions of peacekeepers to be graded to the scenario, avoiding excessive and escalating action, i.e. avoiding a disproportionate response. The numbers of casualties and the type of injuries, together with collateral damage, can be minimised to acceptable moral and political levels. Use may reduce the actions of a belligerent local population and consequently lower their morale, which along with prolonging the situation at low casualty levels would increase the opportunity of a political settlement being reached.

However, if belligerents perceive the NLT as an escalation or weakness, the situation will progress toward use of lethal force. The effectiveness and limitations of the particular NLT needs to be fully understood by the commander in the field to avoid indecision and inappropriate use. Appropriate deployment and training in tactics is as important as the actual NLT used.

The intention of the deployment on an NLT should be to reach a political settlement with minimal long-term rancour, both internally and internationally. It is important that the new equilibrium is maintained thus allowing the affected state to function in a peaceful and civilised manner. The alternative is decay into civil strife that is expensive in human and financial terms to all parties. To achieve this outcome the military operations need to be proportionate with maintaining order; excessive and brutal force is hardly likely to be conducive to reach a satisfactory settlement.

6.3 RULES OF ENGAGEMENT

Rules of engagement (ROE) are addressed in Section 5.2 from the point of view of military employment of NLT. By their very nature ROE have the potential to affect casualty rates and severity of injury for both the deployed force and the population. They therefore have direct links to the human consequences of using NLT (see Reference 6.11.2).

An emphasis on minimising casualties is illustrated by UK ROE paraphrased below for operations other than war. For War fighting the Geneva Convention is followed.

> *For OOTW: – UK Armed Forces will only open fire if their life, those of their comrades or civilians is at imminent risk from death or serious injury from the actions of another person and*

that there is no other way to prevent this danger. If opening fire, this must be at minimum force required to contain the situation and the number of rounds must be kept to a minimum to achieve the desired end state. Attacks on buildings or property does not constitute licence to open fire as this is against UK National Law unless the aggressor's attack is likely to cause imminent death or serious injury to those inside or adjacent to the building.

It is important to note that ROE are not intended to put the deployed soldier at a disadvantage in the face of threat of use of lethal force. All US ROE cards state "NOTHING IN THESE RULES LIMITS YOUR RIGHT TO EXERCISE YOUR INHERENT RIGHT OF SELF-DEFENCE." The right of self-defence contains the caveats of necessity and proportionality. The US regards necessity when a hostile act has been committed or hostile intent is exhibited. UK ROE tend to be more proscriptive and generally allow action in response to the existing threat of force rather than immediately following a hostile act. Proportionality requires that any necessary use of force be reasonable in intensity, duration, and magnitude, based on all facts known to the commander at the time. As noted earlier, ROE also restricts the operational concepts of retaliation and pursuit. In other words, the use of force must be immediate, discriminatory, of short duration, and proportional to the threat.

The US Joint Chiefs of Staff Standing ROE (JCS SROE) directs U.S. forces to exercise force consistent with the U.N. Charter and customary international law. ROE are the means by which national authorities and operational commanders regulate the use of armed force in any given military operation. However, they also serve three more specific purposes.

Politically, ROE prevent military operations from expanding beyond political objectives.

Militarily, ROE represent limitations the on-scene commander may take in achieving mission accomplishment. The conduct of operations in OOTW always involves a balance of threat and counter threat by both sides. In this instance, ROE serve to ensure this balance is not upset, thus resulting in escalation of the crisis.

Legally, ROE represent operational guidance, including that required for self-defence, ensuring a commander's actions stay within the bounds of national and international law.

It should be noted that ROE are approved by legal representatives, e.g. UK Army Legal Department.

Utilising non-lethal capabilities requires a careful balance between using too much force – which may turn lethal – or too little, thus failing to induce the desired target response. The principal criterion for the employment of any non-lethal capability should be an assessment of its effectiveness against a target. Understanding such as a "risk" assessment, non-lethal capabilities clearly fill the gap between the negotiation and the bullet and provide options that allow commanders to choose from a broader range of options.

6.4 LEGAL ISSUES

The constraints of domestic and international law apply to the conduct of operations and to weapons and their use. These include treaty provisions containing prohibitions on specific weapons (such as the Ottawa Treaty and the Chemical Weapons Convention), restrictions on the use of weapons, prohibitions on causing superfluous injury or unnecessary suffering, protection for the environment, and requirements for discrimination (targeting). Additional constraints stem from the principles of proportionality and military necessity. All weapon systems and instructions for use (Guidance for Use & ROE) should undergo a legal

review prior to development and employment. Other elements to be considered include domestic law, national policy, diplomacy, and operational concerns. It is impossible to itemise domestic law for each individual NATO nation in this context in this chapter. In addition, the legal parameters are constantly evolving making it essential to obtain current legal opinion whenever NLT is considered for development or deployment.

The legality of the weapons themselves will be the basis for the legal review. If there is a body of data showing that under specified conditions of use, the non-lethal criteria are met, one can justify that effort has been made to reduce casualties. A "zero probability of producing casualties" cannot be expected. NLT has certain conditions for use where it can be expected that lethality and injury can be confidently expected to be minimal. The military personnel need to be trained in the use of the NLT to achieve this objective. However, it is possible that the military operator could employ the NLT in a manner outside the non-lethal envelope, for example firing baton rounds directly at the head (instead of the body) at close range. The issue, depending on ones perspective, could be considered less an issue of legality than an issue of proper training and proper rules of engagement.

An important part of the legal consideration is that of intent. As such, the tactics, procedures, policy of deployment, and use are an integral part of any discussion of the weapon systems per se. An understanding of what the military commander or force is trying to achieve is linked to the intent and, when used, the proportionality of response becomes an important consideration.

Implicit in all applications of force is the potential for injury, and indeed lethality. The design of the equipment and the way in which it is used can substantially reduce this risk. The extent to which the risk becomes acceptable depends on the situation in which the weapon or system is used. For example, if NLT is being deployed as an alternative to a conventional firearm, de-escalation of force is achieved. Other issues relating to acceptability are discussed elsewhere in this section.

The semantics of terminology applied to non-lethal weapons can carry legal implications and much effort has been devoted by various organisations to define the terminology for a particular context of use. It is important to note that the potential exists for US domestic law being applied to US deployed forces operating in OOTW. At the time of writing, a similar situation exists in the UK where UK law may be used for an incident in Iraq. It is thus worth noting the various descriptors within civilian as well as military spheres. Terminology options have referred to "non-lethal", "less than lethal", or "less-lethal". These first two terms imply that death will not result following the use of these weapons but plainly, this is not always the case in spite of the reassuring connotation. The term "non-lethal weapon" is an oxymoron and although the choice of words to describe alternatives to lethal force may initially appear trite, for law-enforcement officers called to describe their actions in court, a death attributed to a "non-lethal" system would invoke legal challenge and undermine a policy designed to reduce the recourse to lethal force. The issue of what to call these new types of military weapons is moot with respect to NATO, which has selected to call them "non-lethal weapons" (see Section 1.2), however it is still noteworthy that the choice of this terminology is not without implications.

For civilian law-enforcement, the term "less-lethal weapon" (LLW) is normally used to describe such equipment (and other capabilities). The United States National Institute of Justice (NIJ) uses the following definition for this type of equipment: "Devices or agents used to induce compliance with law-enforcement personnel without substantial risk of permanent injury or death to the subject." This definition addresses weapon systems, but injury and death are human effects.

Using the NIJ definition as a basis, the Association of Chief Police Officers (ACPO) in the UK broadens the description to include tactics and describes less-lethal capabilities thus: "Weapons, devices or tactics designed

and intended to induce compliance without substantial risk of serious or permanent injury or death. The aim will be to control and neutralise a threat without recourse to lethal force. The outcome may occasionally be lethal but this is less likely than the result of the use of firearms."

The military forces of the North Atlantic Treaty Organisation (NATO) use the descriptor "non-lethal". This term in the military context does not imply nil casualties or damage, but is a statement of intent to achieve the lowest achievable probability of casualties and physical damage. The term has often been challenged as being inappropriate, but an alternative descriptor that can provide a better interpretation has yet to be widely adopted within international circles. "Non-lethal" merely emphasises one effect amongst a range of effects required for military operations. NATO defines non-lethal weapons (NLW) as: "… weapons which are explicitly designed and developed to incapacitate or repel personnel, with a low probability of fatality or permanent injury, or to disable equipment, with minimal undesired damage or impact on the environment."

The US Department of Defence has issued a policy for NLW that includes an explicit contrast of NLW to conventional blast, penetration and fragmentation "lethal weapons", and a recognition that their effects are can be "relatively reversible": "Weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel, whilst minimizing fatalities, permanent injury to personnel and undesired damage to property and the environment".

In the UK, the development of less-lethal approaches and minimal force options should ensure compliance with European Human Rights Legislation (broadly equivalent to US Civil Rights legislation).

Discrimination of effects is important. Article 2 of the "UN Basic Principles on the use of Force and Firearms by Law-enforcement Officials" states that: "Governments and law-enforcement agencies should develop a range of means as broad as possible and equip law-enforcement officials with various types of weapons and ammunition that would allow for a differentiated use of force and firearms. These should include the development of non-lethal incapacitating weapons…".

6.5 DESIGN AND DEVELOPMENT OF NLT

Unlike conventional lethal weapons that destroy their targets principally through blast, penetration, and fragmentation, non-lethal weapons employ means other then gross physical destruction to prevent the target from functioning. Non-lethal weapons are intended to have one, or both, of the following characteristics:

- They have relatively reversible effects on personnel or materiel; and
- They affect objects differently within their area of influence.

It is within this context that benefit for the political and military leader is best realised. A combination of lethal and non-lethal capabilities provides the military commander with a broader range of means to accomplish a mission, particularly in the presence of civilian non-combatants and their property. It should be noted that the NATO and US DOD Directive definitions encompass the environmental impact of non-lethal weapons, and the capability to disable equipment. These additional roles reflect the broader requirements of the military use: countermeasures to sophisticated enemy technology or well-armed belligerents, and the ability to apply force over large geographical areas, frequently within other sovereign states. It must also be recognised that military forces may also be required to support or indeed replace law-enforcement officers and therefore require the equipment, tactics, and policy to tackle, for example, public-order disturbances.

In general, non-lethal/less-lethal capabilities must provide an adaptable and reliable means to influence the tactical, operational, and strategic situations and enhance the police or military commander's ability to

accomplish assigned missions. The underpinning requirement is that commanders need a broad range of options, normally supported by lethal force, to reduce the frequency (compared to conventional weapons) of death and permanent injury to targeted personnel, without exposing their own personnel to unacceptable risks.

6.5.1 Hazard and Risk

Foremost of the general medical and biophysical principles that underlie the use of NLT against personnel, should be the recognition that any application of energy (whether kinetic, electrical, electromagnetic, or chemical) to the human body is potentially harmful. The acceptability of specific injuries may be defined both in terms of clinical criteria (threat to life; long-term complications; disability; poor clinical outcome), and political/operational criteria.

Hazard is the capability of a system to cause harm. Injury potential ("risk") is related to the nature and severity of injury given an interaction, and the probability of an interaction occurring. The injuries, given an impact or other type of interaction (e.g. electric shock, chemical), depend on the vulnerability of the specific contact area to that form of energy; this vulnerability will be different for the various body regions. There will also be variations in response amongst individuals. For each type of energy application, the vulnerable areas should be identified. The probability of impact on the intended location is a function of accuracy of the technology, and therefore components such as internal (weapon), external (e.g. flight) ballistics and the skills and training of the user have important medical implications – accuracy and consistency are key medical issues.

The design of NLT that is effective whilst maintaining low lethality and minimal risk of medium and long-term injury, inevitably implies the use of medical researchers. This necessity evokes an ethical paradox to the researcher – the design of weaponry on one hand, set against the desire to minimise casualties caused by disorder in the longer term. The ethical conflict may be further exacerbated by the need to study effects in human volunteers: should the risk of NLT be understood through such research as opposed to no such research being undertaken.

6.6 NLT GENERAL CONCEPT

The key to the NLT concept is non-lethality, that is to say, the safety factor in that context of use. Any NLT or concept carries a certain degree of risk in its use, either in the perception by the hostile recipient or its intrinsic safety to humans. The former may be envisaged as escalation by the recipient and this is possibly but not necessarily linked to the intrinsic safety factor. The safety factor may be assessed in a number of ways, with a simple approach being the number of deaths or serious injuries per number of times used. However, this approach to risk depends exclusively on operational experiences with fielded NLWs and does nothing to help access the potential risks of new systems. New approaches for assessing risk using such information as (1) dose response injury data on a number of undesirable endpoints, (2) the probability of the nature of the location and coupling of the energy employed, and (3) recovery assessment of injuries of varying severity and being developed to create a science of non-lethal weapons risk assessment. Some day, non-weapons, used according to specified conditions or ROE, may be assigned a "non-lethal index" similar to the safety index used for therapeutic drugs.

Regardless of the terminology and means and metrics for estimating risk, it is still correct to assume any NLT used for a non-lethal weapon must have a very low risk of causing permanent injury or death.

Factors to consider during the development phase should include:

- **Training**. The overall accuracy of the system is in the hands of an individual; effective training not only to ensure discriminatory and appropriate response but also to reduce the incidence of inadvertent and inappropriate use (see Chapter 5).
- **Quality control of weapons and ammunition**. This factor will affect accuracy, dispersion, and weapon output such as minimum and maximum velocity, contaminants in irritants etc. The fact that defective weapons can cause serious and unplanned injury will be no less true for non-lethal weapons that for traditional weapons.
- **Reports on use (After-Action Reports)**. Users must be responsive to medical issues that may arise in operational use. It is essential that those responsible for policy and audit of use, receive feedback – this may enable changes in procedure that minimise unexpected injuries (type and severity) whilst maintaining operational effectiveness (see Chapter 4 and Annex N).
- **Equipment/user support**. Small changes in the design of an existing weapon system or in the guidance for its use may have profound medical consequences. For example, a change in the source of propellant for the cartridge of a kinetic energy system could reduce the consistency of the burn process, and consequently the velocity, accuracy, and consistency of the system. Quality control ensures that systems are safe (to the user) and are suitable for effective deployment also have direct impact on their human effects.

For some forms of energy transfer such as kinetic energy (impact), the biophysical interactions and pathophysiological consequences are relatively well understood and can be predicted with models. For others (such as electrical incapacitation devices), the mechanisms are not well understood and predictive models are currently unavailable.

Absolute prediction of injury is difficult, even when the biophysical principles are understood. Inherent human variability and limitations in the predictive models (which may be based on animal experimentation[1], work on human cadavers[2], or fundamental studies on the material properties of the body) necessitate caution in extrapolation to absolute injury in living humans. Confidence may be acquired in the veracity of opinion by comparing with similar systems where there is information from operational use, and where the existing system may be used as a benchmark. However, there always remains an element of subjectivity in interpretation.

Experimental or modelling data may allow a comparison of the injury potential of a new NLT system with that on one deployed historically, but laboratory studies cannot model true operational use; it is desirable that retrospective and prospective casualty data be acquired and reviewed to gain further confidence in the laboratory work (see Annex N).

It is also desirable to engage a broader focus beyond biophysical interactions and the direct consequences of energy transfer operationally:

- The outcome of unintended serious injury is also dependent on the timeliness and quality of available medical care; in an operational setting these may not be optimal (see Chapter 4).
- Although it is natural to focus an assessment of the NLT on physical injury – both acute and long-term – the psychological impact of injury or even non-injurious exposure is also important to consider.

[1] Subject to national policy on such research.

[2] Subject to national policy on such research.

A model is a representation of the necessary (in the opinion of the modeller) characteristics of an object or event in the real world. A model in the context of injury prediction is a tool that describes a biophysical process. The tool can be used to predict how changes in the input to the body or body part (e.g. energy, contact area, etc.) would affect the potentially injurious output (e.g. pressure in the body, damage to a material). A model may be physical or mathematical, or a combination of the two. Any model is only as good as the data and presumed relationships used to develop it. A common error with the use of models is use outside the boundaries of the assumptions and data that supports them (e.g. using a model developed using low-speed impact data to predict effects from high-speed impacts). Treated with skepticism, models are useful for "what-if" studies to determine the consequences of changing input parameters, e.g. contact diameter, or the stiffness of projectiles. However, all models are necessarily incomplete and have limitations; their use to predict specific injuries to personnel requires informed judgement (preferably reinforced by validation from human exposure), not blind faith. Models are not literal mimics of human response.

6.7 CONVENTIONS

Chemicals have a strong historical background as riot control agents (RCA). The change to NLT from RCA is an alteration in scenario and it is essential that guidance be obtained in view of the high profile legal, ethical, and political issues involved.

Most if not all NATO member countries are a State Party to the Chemical Weapons Convention (CWC), the Convention on the Prohibition of the Development Production, Stockpiling and Use of Chemical Weapons and on their Destruction [6.11.3], and also to the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (Geneva 1925) [6.11.4], as well as the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, referred to as the BWC [6.11.5].

What is a Chemical Weapon? The CWC defines chemical weapons (CW) as toxic chemicals and their precursors, except where intended for purposes not prohibited under the convention, as long as the types and quantities of the chemicals are consistent with such purposes.

What is a Toxic Chemical? The CWC defines a toxic chemical as any chemical that through its chemical action on life processes can cause death, temporary incapacitation, or permanent harm to humans or animals. To help implement the convention, chemicals identified for the application of verification procedures are listed in schedules. It is important to note the wording "any chemical which through its chemical action can cause.... temporary incapacitation". This definition certainly overlaps with any envisaged role of a chemical NLT; indeed, the CWC defines a riot control agent as any chemical not listed in a schedule that can produce sensory irritation rapidly in humans or disabling physical effects that disappear within a short time following termination of exposure.

How Incapacitating and how Temporary the Effect? Although a chemical may have a very low likelihood of loss of life or serious injury, this does not mean it is exempt from the CWC. Chemicals cannot be used as a method of warfare. The CWC does not define warfare but strictly defines legitimate chemical use, including, "Military purposes not connected with the use of chemical weapons and not dependent on the use of the toxic properties of chemicals as a method of warfare, e.g., screening smokes and chemicals used for explosive properties" and "Law enforcement including domestic riot control purposes".

What is Law Enforcement? Chemicals can be used in law enforcement but not in warfare, but what is the definition of a law enforcement operation; is it one conducted specifically within a nation undertaken by that

nation's police and military forces, e.g., the conflicts in Northern Ireland. Should riot control operations undertaken by an invited foreign power be viewed as law enforcement? Are international peacekeeping operations a law enforcement operation? It is possible that what starts out has a policing action with limited terms of engagement may change into similar to limited warfare, with terms of engagement to match. It is conceivable that riot control agents may be justified as non-lethal weapons in low-key law enforcement operations, but violate the CWC if the operations become more aggressive. The definition of whether law enforcement equates to peacekeeping is a crucial grey area requiring international clarification if chemicals are to be considered as NLT.

Chemical Weapon Convention Limitations: Article X of the convention "Assistance and protection against chemical weapons", states that each State Party has the right to request and receive assistance and protection against the use or threat of use of chemical weapons", conditional on:

- Chemical weapons have been used against it;
- Riot control agents have been used against it as a method of warfare; or
- It is threatened by actions or activities of any state that are prohibited by Article 1.

Article 1 "General Obligations" states that each State Party undertakes never under any circumstances to:

- Develop, produce, otherwise acquire or retain chemical weapons, or to transfer, directly or indirectly, chemical weapons to anyone;
- Use chemical weapons;
- Engage in any military preparations to use chemical weapons;
- Assist, encourage or induce in any way, anyone to engage in any activity to a State Party under this convention; and
- Each State Party undertakes not to use riot control agents as a method of warfare.

This set of prohibitions places a number of potential limitations upon chemical NLT. Any use, or threat to use chemical NLT as an antiriot agent, could be challenged as use as a method of warfare. Any NLT chemical, not regarded as an antiriot agent could be viewed as a chemical weapon and therefore a contravention of the Convention. Any chemical NLT programme would require a development programme, which would need to be distinguishable in character from that required for a chemical weapons programme, which is forbidden by the CWC. Attempts to justify chemical NLT development could create opportunities for CW proliferators to justify their actions and make the task of implementing the CWC virtually impossible.

Finally, the employment of chemicals as NLT has to be compatible with use, thus demonstrating intent. For example, whereas CS in hand or baton round sized canisters would be considered legitimate law enforcement equipment, 155mm shells filled with CS would clearly be considered as preparation to use riot control agent in waging war, prohibited under the CWC.

Research & development of novel incapacitants could be open to misinterpretation under the CWC. Non-lethal incapacitating chemicals for riot control are legitimate whereas those for military purposes are not. It is significant that use of chemical incapacitants in hostage rescue situations appears to be acceptable, but only when there is a potential lethal threat to the hostages and the situation is very limited in time, location, and number of people involved.

Super caustics, corrosives, depolymerisers, and embrittlement agents are not prohibited by the CWC; any toxic effect would be a by-product of their intended primary purpose. Any use of these substances directly

against humans or animals is prohibited under the convention. Use of this class of chemicals should be considered within the context of the environment. Broadly speaking persistent widely dispersed, and economically damaging chemicals would fail to comply with various international conventions.

All biological materials are prohibited unless they are for permitted purposes under the BWC. Biodeterioration chemicals would be permissible for break down of hydrocarbons as part of pollution control but would not be permissible as a means of economic warfare.

The human effects issues raised by the use of anaesthetic drugs are considered in Annex M. However, in our opinion, the potential use of chemicals as non-lethal warfare weapons is fraught with legal and political difficulties. The receipt of an accusation of contravention of the Convention would be embarrassing for any Government or organisation: consequently, deployment of such NLT would need to be extremely carefully considered.

6.8 INHUMANE WEAPONS

In 1995, a United Nations review conference was held in Vienna to examine the provisions of the 1980 Weapons Convention. In essence this comprised a review of "inhuman" weapons". In some respects, all weapons can be regarded as inhuman, hence it is necessary to examine the background to the original request for a review to understand the context and thinking behind the conference and the Weapons Convention.

The 1980 Convention was adopted by the United Nations conference by consensus, with three protocols, Protocol 1, non-detectable fragments, Protocol II mines & booby traps, and Protocol III incendiary weapons. A committee was set up to deal with restrictions on conventional weapons (i.e. not nuclear, chemical, or biological) by the 1974 – 1977 Diplomatic Conference. There is thus a considerable drive toward humanising weaponry [6.11.6].

The International Committee of the Red Cross (ICRC) has held a number of meetings to consider the subject of laser weapons. This culminated in the Vienna session of the Review Conference of the 1980 United Nations Convention on Certain Conventional Weapons in 1995 [6.11.7] Blinding is considered to be a superfluous injury and to cause unnecessary suffering. The IV Protocol was adopted in Vienna and applies to international conflicts, although the intention of future provisions is to extend the Protocol IV to internal conflicts. The Fourth Protocol prohibits the use and transfer of laser weapons specifically designed to cause permanent blindness as one of their functions. Additionally the state must take all feasible precautions to avoid permanent blinding through the legitimate use of lasers for other purposes, including training. ICRC points out that this is the first time that use and transfer of a weapon has been entirely prohibited under international humanitarian law [6.11.8].

An extrapolation that can be made from the prohibitions of the IV Protocol is that reversibility of a serious effect is an essential criterion for any NLT and that accidental serious injury needs to be very unlikely. In the opinion of many workers in the NLT field, even small numbers of injuries or fatalities would be difficult to defend. Dazzle does not appear to fall within the IV Protocol and at the opposite end of the effect spectrum, it should be noted that blinding by lasers used for anti-equipment purposes (e.g. against optical sights) has been stated by some parties as being not applicable.

An important question to answer is – can reasonable estimations of future bans be made in relation to non-lethal weapons? NLTs have already been discussed in ICRC documents as possibly inhumane weapons.

6.9 PUBLIC AND POLITICAL ATTITUDES AND EXPECTATIONS

Current military operations are increasingly complex, characterised by a high degree of unpredictability, and this trend is likely to continue. Military operations other than war (OOTW) will almost certainly continue to be the most frequent. Adversaries will focus on vulnerabilities, such as sensitivity to casualties, legitimacy, reliance on technology, Rules of Engagement, and media impact. Minimising the consequences of such interventions is an important factor in any rapid return to normality, including the maintenance of public support. There is also a growing public expectation, fuelled by the promise of technology, that somehow conflicts involving the West can be resolved successfully and swiftly with few or no casualties and minimal collateral damage. Military operations are under the scrutiny of the world media and mistakes or successes attract immediate attention. As such, today's forces may not yet be fully equipped to meet the demands imposed by peacekeeping, peace enforcement, and humanitarian operations. Non-lethal capabilities – fielded and under development – will help alleviate such operational deficiencies. It should be noted that the NL concept envisages that NLT will always be underpinned by lethal force and should provide the commander in the field with a greater range of options. A scale of lethality is envisaged in which NLT forms the lower part of the scale with lethal force at the top end of the scale.

Acceptability: After ensuring the legality of a weapon's development and use, it is important to address other elements of public awareness and acceptability. Belligerents may exploit perceived inadequacies, whether these are true or not, in the safety of the NLT system. Unacceptable facts or publicity can affect the public, politicians and the military user and quite possibly can affect the success of the mission. It is thus important to have effective testing of the system prior to deployment coupler with appropriate ROE and training. Security considerations may affect the types of information that can be made available for the sake of public information prior to a weapon's deployment. Policies will ultimately have to account for all elements of public awareness and acceptability.

Public Perceptions: Public expectation of the country supplying the military force will differ from that of the public of the country receiving the aid. Recent such deployments, e.g. Kosovo, Somalia, have involved elements of peace keeping, policing, and humanitarian operations. The political decision taken by the country supplying the military force is in response to a desire for an improvement in reduction in violence, implementation of order, and/or implementation of food and medical aid.

The domestic population supplying the troops is not directly affected and has a stand off perspective; the majority of that population is almost certainly prepared to accept a higher number of consequential casualties compared to the population of the affected country. However, if the number of overall casualties increases, the majority of the domestic population supporting the deployment will start to decrease and will eventually reach a point where the domestic population will cease to support the deployment. It should be emphasised that the demographics of this response have not been modelled as far as the author is aware and almost certainly varies with the nationality and the particular scenario. Long-term deployments are common, e.g. Kosovo, and are linked with a perception that the deployed forces are "doing a good job", with low casualties and a noticeable improvement in the situation.

The affected country however may not be so tolerant of any casualties and may regard the helping military force as an additional burden to their plight. It is important that the deployed forces are seen to be improving the situation and the converse does not occur. The deployed forces must not be seen or perceived to change from a neutral stance to one of supporting one faction. Casualties and attitude changes can be manipulated by internal factions to their own ends, which can lead to escalation.

Misuse of NLT could result in bullying or torture, or at least the appearance or claim thereof. NLT, by definition of its reversibility, leaves little or no evidence of use on the victim. It is therefore extremely difficult to refute use of NLT for torture of captives unless sound procedures are in place.

Public and or press may perceive that a particular NLT was inhumane. The only counter to such accusation is to demonstrate the very low likelihood of injury, especially in comparison with alternative courses of action.

Military: It is important to note that the military require public and political support, and that the military expect, eventually, to leave the affected country, preferably in a better state than when they arrived. Lack of any of these expectations can affect morale, not only of the deployed force, but that of the force as a whole, and eventually affect recruitment and retention. A reduction of morale carries the risk of discipline impairment and weapon misuse.

Political: The politician has three pressures, from the domestic population (the points outlined above), the military, and other countries. From the principles above and legal judgements, the UK has developed an auditing framework for evaluating potential less-lethal options. This "acceptability matrix" for the technology has four headings; examples of the issues addressed are given:

- **Strategic** – Does it meet legal requirements? Is deployment nationally being considered? Does it meet the stated Operational Requirements?
- **Ethical** – Has a medical assessment been undertaken? Does it meet health and safety requirements? Are there ethical/cultural issues?
- **Operational** – What are the training requirements? Is a community impact assessment required? What monitoring of the technology will take place?
- **Societal** – What public consultation is appropriate? What is the public liability? What is the justification for adopting the technology?

The use of NLT as an alternative to lethal force does not absolve the authorities from demonstrating accountability, and engendering public and political support for their policies, tactics and technology.

6.10 SUMMARY

There is general acceptance by both military and civilian individuals and bodies that deployment and use of NLT is a positive move to reduce both casualty numbers and severity of injury whilst still maintaining order.

Many factors interlink to provide casualty reduction whilst maintaining or improving NLT effectiveness. These factors are weapon design, manufacturing to quality standard, training and use, and ROE. Any defect in any one of these factors can increase casualty numbers and severity.

Beside NLT effectiveness in role, the ethics, legality and perception of NLT can potentially affect deployment and use. Such issues can rapidly become political, potentially constraining use of an otherwise effective NLT, with an adverse outcome on the particular scenario, in terms of objective and casualties.

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Chapter 7 – CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

NATO operations will benefit by having an NLW capability.

Information on the human effects of the technologies used or proposed for NLW is critical to all aspects of an NLW capability, from concept, to development, to evaluation, to testing, policy approval, acquisition, deployment, and rules of engagement.

While there are very few adequate human effects data on any proposed NLT, there is a particular need for acquiring data on promising, novel technologies, such as those using electromagnetic or electrical stimulation.

Human effects specialists should be involved at all stages of the development of a NATO NLW capability. The RTO HFM Panel is the premiere NATO resource for providing this assistance.

7.2 RECOMMENDATIONS

Public and Military Acceptance: In order to garner acceptance of NLW use, both by the military members who will use them and the general public, it is essential to provide information and to give opportunities for debate. The general concept of the value of NLW should be addressed as well as the nature of specific weapon systems and technologies that are planned or already in use. Information on human effects will be of major importance. The HFM Panel should enable a RTO Lecture Series on the Human Effects of Non-Lethal Technologies (see Annex O).

Directed Energy and other Novel NLT Concepts: Conventional NLT that have been used for many years by police, e.g., baton rounds, flash-bangs, pepper spray, will be easier for NATO to adopt and the public to accept because they have a long track record of successful and relatively safe use. Novel NLT, such as radio frequency, laser, and electro-muscular devices, have a tremendous potential for effectiveness, but are difficult to test because of medical ethics and the requirement for limiting human exposure to that allowed by highly conservative occupational health and safety standards. The health and safety of long-term exposure to electromagnetic emissions is still debated. The HFM Panel should enable a new Exploratory Team on the Human Effects of Emerging Non-Lethal Technologies (see Annex O).

Legal and Political Issues: Inside NATO-Nations different law is applied on different situations in certain scenarios in police or military operations. For multinational and joint operations the Law of Armed Conflict should be identical for each participating nation. Because of the multi-national nature of NATO operations, there will be a need to develop a common NATO standard for the use of NLW and training of personnel. This might also imply changes in the domestic law of some NATO member states.

Medical Preparation: The tragic outcome of the Moscow Theatre Hostage Rescue (see Annex M) illustrates the important role of medical preparation in planning for NLW deployment. Tactical medical planning for immediate rescue activities and therapeutic strategy is essential in an overall operative environment. It is obvious that medical protection and treatment of NATO allied forces is as important as ever, but, for NLW, the treatment and recovery of the opposition forces becomes a new high priority. The aim could be a NATO certificate for NLT. The initiative for developing a STANAG on NLT / NLW should be launched.

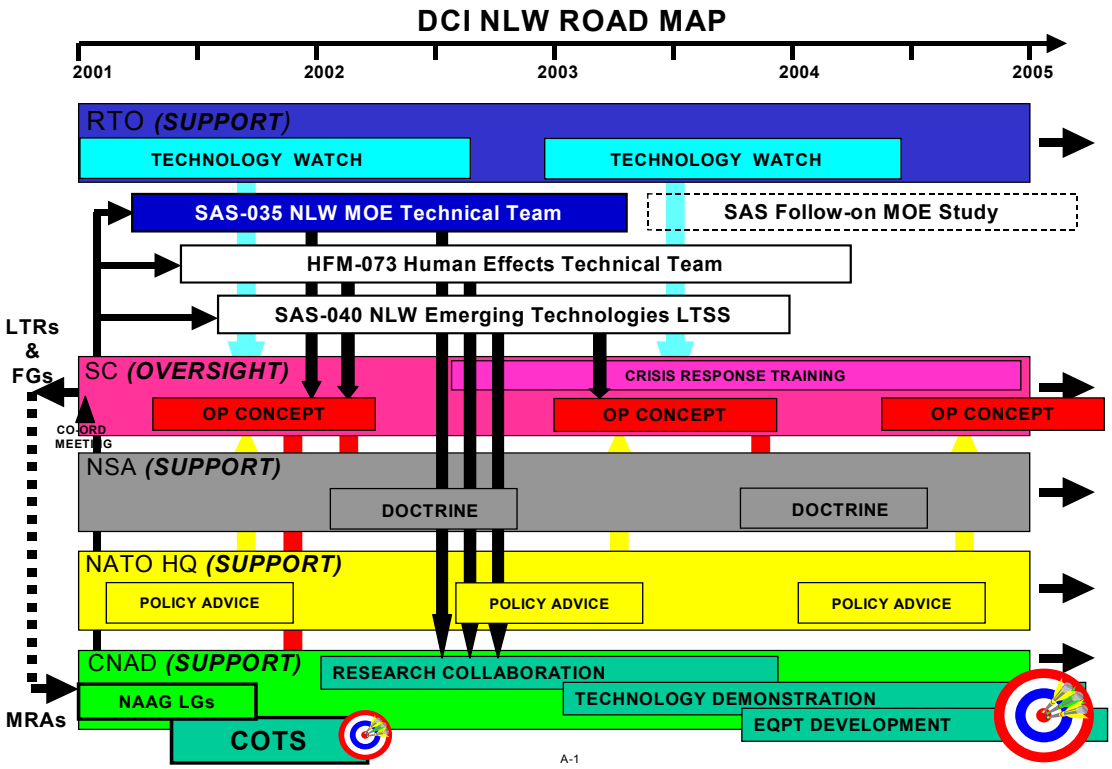
Training: The issue of training how and when to use NLW deserves further consideration by specialists in military and police training. An "after-action" or "lessons-learned" format should be developed and deployed to report and evaluate the outcomes of NLW use. These examples would be useful when training troops to be able to deal with all the full spectrum of options, from doing nothing to applying lethal force.

Continued Research: Military-funded Human Effects Research in NLT is urgently needed to evaluate both their effectiveness and risks. Research in this area should be encouraged and supported, including collaborative experiments enabled by the HFM Panel.

Discussion and Information Exchange: The HFM Panel should continue to work to break down the barriers that limit multi-national sharing of critical human effects data on NLT. The HFM Panel should evaluate organizing a symposium on NLT/NLW, possibly in collaboration with the SAS Panel and the NATO Science Committee.

Annex A – NATO ROADMAP FOR DEVELOPING A NLW CAPABILITY

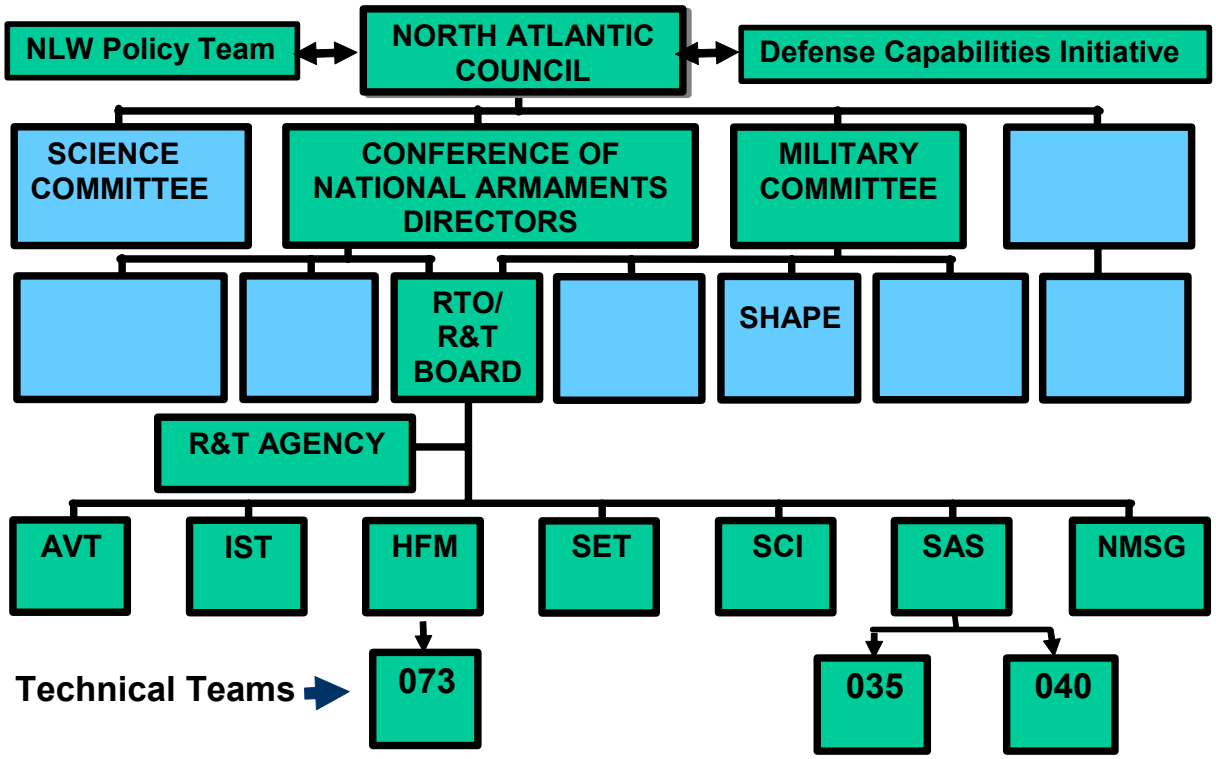
The NATO Defence Capabilities Initiative (DCI) NLW Roadmap developed by the Research and Technology Organization (RTO), Systems, Analysis and Simulation Panel (SAS-E15) November 2000, as updated 2004 in Final Report SAS-035.



A.1 ABBREVIATIONS

CNAD	Conference of National Armaments Directors
COTS	Commercial off the Shelf
FGs	Force Goals
HFM	Human Factors and Medicine Panel
LTRs	Long Term Requirements
LTSS	Long Term Scientific Study
MOE	Measures of Effectiveness
MRAs	Military Requirements (Armaments)
NAAG LGs	NATO Army Armaments Group – Land Groups
NSA	NATO Standardization Agency
OP	Operations
SC	Strategic Command

Annex B – NATO ORGANISATIONS ACTIVE IN PLANNING NLW CAPABILITY



B.1 ABBREVIATIONS

HFM-073	Human Effects of Non-Lethal Technologies
R&T	Research and Technology
RTO	Research and Technology OrganiSation
SAS-035	Non-Lethal Weapons Effectiveness Assessment
SAS-040	Long-Term Scientific Study on Non-Lethal Weapons & Future Peace Enforcement Operations
SHAPE	Supreme Headquarters Allied Powers Europe

Annex C – TAP AND TOR FOR HFM-073

C.1 TAP FOR HFM-073 (TG-12)

ACTIVITY	Technical Team – RTO Task Group	Human Effects of Non-Lethal Technologies											TBA	
PRIORITY	Medium												04 / 2001	
PRINCIPAL MILITARY REQUIREMENTS		3	4	5						NU (occ NS)			03 / 2004	
MILITARY FUNCTIONS		4	6	11	12	14								
PANEL AND COORDINATION		HFM; Human Factors and Medicine								SAS				
LOCATION AND DATES		various; semi-annual, with a symposium at end of year 3											P-I	
PUBLICATION DATA		TR or MP							06 / 2004		40			
KEYWORDS	Non-Lethal	Weapons					OOTW				Peace-keeping			
Psychology		Physiology					Protection				Technology			

C.1.1 Theme

Non-Lethal Technologies (NLTs) have, in such forms as baton rounds and irritant gases, been widely used in cases of civil unrest. The increasing use of military forces in peace-keeping operations and Operations Other Than War (OOTW) has led to an increasing emphasis on the use of NLT in the control of materiel and personnel in situations where the use of lethal weapons is not acceptable, together with a proliferation of suggestions on the forms such NLT might take.

While the use of NLTs raises many concerns, this Technical Team is concerned specifically with Human Effects issues, both physiological and psychological. Such effects include: (a) effects on operators, allied forces, and target populations; (b) protection against accidental exposure or by exposure by opposing forces; (c) effectiveness and means of action; and health and safety issues. A large number of technologies have been proposed, including kinetic energy, sticky or slippery foams, barriers, acoustics, light (dazzle), odours, and nets, so that the number of human effects issues that are raised by the use of NLTs is correspondingly large. One area of especial concern is the effect on motivation of large groups of people, which may be very different from the effects on individuals.

C.1.2 Justification

NLTs are the subject of a voluminous literature, but much of it is of poor quality and fails to address fundamental issues. Moreover, technical assessments and experimental work could clearly benefit from international discussion and scrutiny. For NLTs already in general use, such as baton rounds and irritant gases,

there is a considerable body of experience, but in other cases it is difficult to say in what circumstances an untried NLT might best be used, whether it would be effective at all, or what degree of risk is likely for users, target populations or bystanders. These questions need to be addressed, but this needs to be done on an international basis to share experience in situations where NLTs might have been used; and also to make best use of different levels of funding and methods of approach, which differ substantially between NATO member nations.

Experimental work on NLTs is likely to be very expensive. The need for, and nature of, the experimental work required should be discussed within an international forum to make best use of available funds.

Much information, especially on safety issues, is available in contexts other than specifically NLT, but the relevance of this is again best discussed within an international forum.

C.1.3 Topics to be Covered

- Effects of NLTs on individuals and populations.
- Medical, Health, and safety issues in the use of NLTs, including effects on targeted populations and bystanders.
- Terminology for the NL technologies and human effects.
- Effects of NLTs on motivation and actions of large groups of individuals; to include models of crowd behaviour in different scenarios.
- Protection of the soldier.
- Data collection issues and database development for the human effects of NLTs.
- Training issues for the use of NLTs.

C.1.4 Chairman

US.

C.1.5 Members

FR; GE; NE; PL; UK; US.

C.1.6 National Resources Available

TBD

C.2 TERMS OF REFERENCE (TOR) FOR HFM-073 (TG-012)

C.2.1 Origin

C.2.1.1 Background

Non-Lethal Technologies (NLTs) have been widely used in cases of civil unrest and will be used in future NATO operations other than war (OOTW). Although there is a substantial literature on the physical

characteristics of many proposed NLTs, the human effects (psychological/physiological and short/long term) on the users and putative targets of such technologies and are largely unknown.

C.2.1.2 Justification

This activity is needed to facilitate training, readiness, and joint operations utilizing NLTs; to reduce duplication of research effort; to facilitate acceptance of NLTs; and to minimize risk of injury to NATO forces and to members of the public. Identification of requirements for human effects data will provide the armaments community with criteria for minimizing the risk of injury resulting from use of NLTs.

C.2.2 Objectives

This technical group will address the human effects of NLTs (physiological & psychological) to:

- Assess the consequences of NLTs for health and safety;
- Increase information exchange to facilitate understanding & reduce redundancy;
- Identify gaps in our knowledge and identify research needs;
- Supply relevant information to commanders/warfighters and suppliers;
- Facilitate public acceptability; and
- Identify non-lethal weapons suitable for anti-terrorist activity especially when non-combatants or innocent bystanders are involved, with special attention given to safety margins.

Duration of the TG will be three years

C.2.3 Products

The proposed products of the TG are:

- A common database for NLT Human Effects;
- A common glossary for NLT Human Effects;
- Prioritized recommendations for needed human effects data;
- Yearly progress report and final report;
- A Workshop and possibly a Symposium; and
- Publications, e.g., proceedings, AGARDograph.

C.2.4 Resources

C.2.4.1 Membership

The membership will be composes of experts in fields relating to the human effects of non-lethal technologies, including medical doctors, psychologists, physiologists, and engineers, from governmental agencies, industry, and academia.

Participating nations at this time: CZ, ES, FR, GE, NL, PL, SE, UK, US.

Lead Nation: US.

Chairman: Dr. Michael R. Murphy.

C.2.4.2 National and/or NATO Resources Needed

National resources: Man power and travel funding by the nations.

NATO resources: Publication (AGARDograph?), others TBD.

C.2.4.3 RTA Resources Needed

Two key note speakers at the symposium under the Consultant and Exchange program: TBD.

C.2.5 Security Classification Level

NATO unclassified, open for PfP, except for single events.

C.2.6 Participation by Partner Nations

All NATO member nations and Partners for Peace are welcome to participate.

C.2.7 Liaison

The Technical Team will liaise and coordinate its activities with other RTO activities concerned with non-lethal weapons, especially the SAS Panel's study on Non-Lethal Weapons. This goal will be realized by double membership, by exchange of documents, and perhaps by an official liaison relationship.

Liaison with TTCP, as well as with the European Working Group on Non-Lethal Weapons, and the US Joint Non-Lethal Weapons Human Effects Centre of Excellence is sought.

Annex D – MEMBERS AND MEETINGS OF HFM-073

D.1 CONTRIBUTING MEMBERS OF HFM-073

Country	Member	Status
Czech Republic	Jiri Chaloupka	Active
France	Michel Hugon	Active until October 2003
Germany	Dieter Reimann	Active
	Klaus-Dieter Thiel	Active
The Netherlands	Tony Gaillard	Active
Norway	Per Kristian Opstad	Active
Sweden	Mårten Risling	Active
	Ulf Sundberg	Active
Switzerland	David Humair	Active
United Kingdom	Mike Forrest	Active until September 2002
	John Florio	Active until November 2002
	Robert Inns	Active
United States	Noel Montgomery	Active until May 2002
	Mark Wrobel	Active

D.2 MEETINGS OF HFM-073

France, Paris	26 – 27 April 2001
The Netherlands, Soesterberg	4 – 6 December 2001
Norway, Oslo	4 – 16 May 2002
United States, San Antonio	13 – 15 November 2002
Sweden, Stockholm	2 – 4 June 2003
United Kingdom, Porton Down	2 – 4 December 2003
Czech Republic, Hradec Králové & Prague	25 – 27 May 2004
Switzerland, Bern	25 – 27 October 2004

Annex E – STATEMENTS FROM PARTICIPANTS IN HFM-073

The following statements are the opinions of the individual participants and should not necessarily be viewed as the opinions of the organization or the nation that supported their participation in HFM-073.

E.1 CZECH REPUBLIC (PROVIDED BY JIRI CHALOUPKA)

The Czech Republic has been a member of NATO for 5 years. By admission to this organization one of the main strategic tasks of our foreign policy has been fulfilled. Building up qualitatively new contacts with NATO allies represents one of the main conditions for security enhancement and stability enlargement. At present the Czech policy towards NATO is characterized by active participation of the Czech Republic in implementation of NATO security policy. Czech Army integration and interoperability process is ensured by links of Czech Armed Forces structures and capabilities with NATO principles and standards. Within the Non-Lethal Technologies research program the Czech Armed Forces encourage cooperation and coordination between NATO and PfP country's research workers in the Research and Technology Organization and by this they contribute to interoperability of newly developed technologies.

The Czech Armed Forces are engaged in NATO and UN multinational peacekeeping operations. Because of the need of alternative weapons that may be widely used in cases of civil unrest, they have decided to participate in research cooperation in the field of Non-Lethal Technologies (NLTs) development. These alternative weapons can be probably used in future military operations other than war (MOOTW). The task of these technologies – to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesirable damage to property and the environment – is in accordance with our foreign policy in all areas of the world.

The research into NLTs in our country is primarily for security forces – police, military police or civil security agencies. The use of NLTs in military operations has been proposed in order to maintain crowd control and to break the resistance of the population as a way of minimizing enemies (e.g., during the defence of one's own troops against rioting of crowds, during peacekeeping or peacemaking operations). Special police forces or armed forces may plan to use them during antiterrorist operations and activities.

Research and developmental activities in the Czech Armed Forces are coordinated at the level of the Ministry of Defence Department of Research and Development Control. The technical part of this research and potential NLTs development is the responsibility of the Ground Forces Military Technical Institute. At present this Institute is carrying out a project concerning the development of explosives with rubber projectiles. This project will be finished in 2005.

Police and civil security agencies are interested in purchasing commercially available NLTs from foreign importers. We do not know anything about possible research and development efforts by the organizations.

Other research and developmental activities have also been carried out at the Purkyne Military Medical Academy in Hradec Králové. The aim of these activities has been to find new and efficient ways for the protection of soldiers against harmful factors, including mechanical, physical, chemical, biological, or environmental factors. In the field of NLTs, the experiments concerning the auricular and extra-auricular systemic effects of noise, low-frequency noise, and infrasonic noise have been conducted and means for providing soldiers with protection have been found. Animal research on the biological effects of physical factors that might be used in NLTs, using histochemical and protein analysis, is just beginning. The aim of

this research is to determine the protective characteristics of various materials and to prevent injuries of our own troops in case of the use of new military technologies.

The Ground Forces Military Training Base is used for training for many missions, including those possibly involving NLTs. Training effectiveness is achieved by applying the principles of protective equipment development, human organism adaptation, psychological and military training procedures, and the development of an extended individual training program.

Research on the development of drug combinations that can be used for anaesthesia, analgesia, and psychological status improvement, in order to control the panic reactions of individuals or a crowd, has been conducted during the last few years.

Another project of the Ground Forces Military Technical Institute is designed to find the effective and humane substitution for anti-personnel mines with the use of non-lethal technologies. This project consists of finding a technical solution for appropriate weapons and analyzing the latest non-lethal technologies. An MCG generator with an output current of approx. 22 kA, which is able to supply a vircator as a source of HPM, has been developed and tested as a first step.

E.2 FRANCE (NONE PROVIDED)

E.3 GERMANY (PROVIDED BY DIETER REIMANN)

E.3.1 Why Germany participated? Background

The primary reason why Germany participated in HFM-073 was to support the Occupational Medicine and Occupational Health Service of the German Armed Forces. Medical health protection at work is based on Article 2 of the Basic Law of the Federal Republic of Germany. Occupational safety and health legislation is designed to protect people from hazards and health damage at work. The bases for these laws go back to social legislation in 1871 by Reichskanzler Bismarck.

The legally established executive authority for administration and implementation of Article 2 is based on Article 21, paragraph 5, p. 4, Occupational Safety and Health Act (Arbeitsschutzgesetz) of 1996 (this is an adaptation of the legislation in the European Community) Article 114, paragraph 1, sub–paragraph 3, and Article 115, paragraph 5, p. 3, Code of Social Law (Sozialgesetzbuch – SGB VII). The objective of thus legislation is occupational health and environmental medicine coverage of all Bundeswehr personnel, including, but not limited to, the investigation of the causes of occupational hazards within the scope of the preventive functions the government has to discharge in its capacity as the social injury carrier in accordance with Article 14, SGB VII.

The supreme federal authority, pursuant to Article 1, Industrial Safety Act of 1973 (Arbeitssicherheitsgesetz), and in conjunction with the guidelines of the Federal Ministry of the Interior, sees to it that occupational health officers performing tasks pursuant to Article 3, ASiG, are appointed in organizations.

The Surgeon General of the Armed Forces at the Federal Ministry of Defence (FüSan I 2) is the office of primary responsibility for coordinating all occupational and environmental medicine activities within the scope of public-law supervision and functional control. Occupational safety and health and environmental protection activities comprise all legal, administrative, occupational medicine, and environmental medicine measures designed to protect Bundeswehr personnel from operational hazards at home and abroad.

E.3.2 Why Germany participated? Inducement

In March 2000 the Chief of Staff Federal German Armed Forces decided to promote research on NLT and to hurry to provide German Forces in Kosovo with adequate Non-Lethal Weapons because of critical events in the liberation action of personnel of the German Embassy off Tirana, Albania, and in an aggressive crowd in Mitrovica, Kosovo.

The Surgeon General of the ARMY ordered a medical officer as consultant for the German Bundeswehr to the NATO RTO HFM 073 "NLW in Peace Support Operations. Medical Aspects and Human Effects of Non-Lethal Technologies".

Of special interest are the efforts of the Armed Forces Medical Service for protection of the own Forces when employing NLT/NLW. In Germany for historical ethical reasons trials with humans or even animals are strictly limited. So it was expected to collect international knowledge and experience on human effects in the use of NLT from nations using NLT already.

By definition the main interest for the HFM panel is protecting the soldier. If we concentrate on the effect on the opponent it's for predicting medical effects, crowd behaviour or preparation of medical support and therapy. By learning about the effects we can prove that the specific NLT will act less than lethal.

Task Group 12 worked on Taxonomy and Glossary of NLT related medical terms and thus produced distinctness in thinking. Visits of specialised laboratories and lectures of scientific co-workers increased knowledge and raised experience.

When the Task Group was initiated in 2000, level of authority was German ARMY Support Command, Surgeon General of the ARMY, Koblenz. Now – by change of structure – Medical Office, Muenchen is in charge.

E.3.3 German Focus Areas for NLT

There is activity on NLTs in the German MoD. Studies and papers on scenarios and in which NLWs might be used have been prepared. The 40 mm impact foam grenade is the only NLW currently in use by the German forces. New activity was initiated following the March 2004 riots in Kosovo. An update on NLT activities in German Forces is given below:

E.3.3.1 Acoustics

Loudspeaker-Vans have been in use for decades for information and irritation purposes.

Directional multi-effects acoustic systems using controlled phased arrays an undergoing trials. These systems acoustically target selected people within a crowd with low audible frequencies to cause unbearable acoustic stress, targeted information/disinformation, and loss of equilibrium.

Infrapulse-Generator technology is in research and development.

E.3.3.2 Animals

Special trained dogs (German Shepherd) for different purposes (watchdog, search and rescue, explosives and mine tracing, drug sniffing, etc.) have been stationed with the troops with their individual sentries for several years. They are integrated in the parachute forces too. Veterinary care is available at all times.

E.3.3.3 Barriers

A Multipurpose launcher, a Bazooka-like 90 mm tube (Panzerfaust) using compressed air, in under trial for delivering payloads up to 1.5 kg up to a range of 300 m. Payloads could include, for example, fog, flash bangs, markers, entanglers, nets (range limiting, 9 m in diameter), or HPM-jammers.

Micro wire obstacles consisting of steel wires compacted under tension, have been developed. When deployed the wires expand to assume pre-determined geometric shapes formed from a tangle of the wire itself. Expansion ratios of 1:6000 are achievable. Micro-wires could be used as impenetrable barriers to prevent access by vehicles and personnel to designated areas. They could also be deployed to prevent egress of hostile groups from designated areas. The technology could be extended to provide propeller entanglement to stop small boats and patrol craft, if the system could be deployed just below the surface. Micro-wires could ensnare the propellers of fixed wing aircrafts and rotors of helicopters on the ground.

Airbag Stopper technology and means of erecting Rapid Barriers are in research and development.

E.3.3.4 Chemical Agents

Chemical agents such as CN, CS, even Pepper Spray or other preparations of OC are not allowed in military operations because of the Chemical Weapons Convention (CWC) and, furthermore, there are detailed national German restrictions on the use of chemicals, which refer especially to Peace Enforcement and Peace Keeping military operations. Decision for implementing OC was taken in September 2004.

The goal of NLT is to incapacitate people or equipment while minimizing unintended fatalities and damage. However, Jean Pascal Zanders from Stockholm International Peace Research Institute has pointed out: “The Chemical Warfare Convention doesn’t ban chemicals, it bans purposes under which those chemicals are applied.” [1]

The situation has changed since the World Wars, Cold War, and even since 1993, when the CWC was agreed upon, to a new emphasis on Crowd Control, Law Enforcement, Embassy Protection, Rescue Missions, Peace Keeping Missions, and Counter-terrorism. However, we are still depending on old law. There is an urgent need for rethinking and rewriting the existing laws with respect to the implementation of NLTs using chemicals. International legal experts should reconsider the old laws in the light of new security imperatives and the development of new NLTs. Especially after the riots in Kosovo in March 2004, when it was reported that 28 people died and 800 were injured and 15 churches and about 110 houses were destroyed, we should consider relaxing restrictions on the use of “chemicals” in certain situations. Such exceptions could be limited to Operations Other Than War (OOTW) or for discrimination between rioters, combatants, and civilians in a hostage or human-shield situation. Multinational exercises should be conducted to identify situations when the use of specific NLTs would be fully justified; scenarios should include consideration of unexpected or even “unthinkable” situations.

The German MoD and Ministry of Foreign Affairs has been expanding its consideration of the use of certain NLTs by the military in peace keeping and peace enforcement operations. Decision for the use of “Reizstoffe” and pepper spray for escalation purposes instead of lethal force passed legislation in September 2004 [2]. Only products already in use in the police forces and declared to the CWC-Organisation in The Hague, NL, will be implemented.

E.3.3.5 Directed Energy

Radio Frequency and High Power Microwave systems are being considered to stop ground or aerial vehicles and missiles and to jam radio communications and information technology. The frequency spectrum that can be used varies from VHF to millimetre waves. The emitted energy can have various characteristics: continuous or pulsed, specific peak power, specific mean power, specific pulse duration and frequency (there may be only one pulse), sharply focused or wide spread. For protection against electromagnetic fields see STANAG 2345 [3].

E.3.3.6 Electro-Incapacitating Devices; Electro-shockers

The Air TASER M26 was tested at a German Army proving ground and was found to be not accurate enough in function. Malfunction and electric shortcuts by sparks to the trigger hand in high humidity weather may endanger your own personnel.

Some Police forces in Germany have tentatively begun using M26 TASERS. The effects are impressive, but there is still concern that the physiological and neurological effects of the TASER are still poorly understood.

A Plasma Electro incapacitating device is under going research and development.

E.3.3.7 Impulse Weapons

40 mm sponge grenades [4] and a 40 mm impulse grenade with marker substance and their launchers have been delivered to special troops since 2002. Reports about training experience or use in action have demonstrated that these weapons pose no occupational threats to our own forces. There is no information available yet about their effects on targets.

40 mm launchers have been adapted to a number of G36 guns for mutual use.

A Vortex-Generator is undergoing research and development.

Water cannons, both traditional and sophisticated, using High Pressure Pulsed Water, are under going trials.

E.3.3.8 Other Focus areas

Work is being conducted on a Broadcasting Station and on Newspapers for spreading information to both illiterate and literate inhabitants of a country.

Unmanned Aerial Vehicles (UAV) with non-lethal payloads is undergoing research and development.

Specialized Training Procedures have been developed for dogs and their individual sentries. Also, specialized Training Procedures have been developed for the use of the 40 mm impulse grenade, the 40 mm launcher, and the G 36 adapted version.

In 2001, 2003, and 2005, in Ettlingen, Germany, European Symposia on NLW were well attended by scientists and policy makers from all over Europe and North America. A broad spectrum of topics were presented and the proceedings were published in a book. These are considered among the best symposia on NLTs in the world.

E.3.4 Conclusions and Recommendations

Even though there is very high interest in peaceful operations and a good rapport with people in the countries in which the German military is deployed, the effective use of explosives by adversaries and terrorists is compromising the opinion of NLT. Unless it can be demonstrated that the intelligent use of NLT, at the right time in the right places, produces better outcomes than traditional means of warfare, there will be little push to deploy NLW.

E.3.4.1 NLT Awareness

Military decision makers should be kept aware of new information on the use and validation of existing NLWs as well as new findings on NLTs undergoing trials and advanced development. If such awareness is maintained, NLWs and NLTs may be considered for use in specific emergency situation. A high-level, table-top type of document, including various NLT, operational, and logistical requirements, with examples of specific scenarios and rules of engagement in which such options have been or might be employed, would serve the purpose.

E.3.4.2 Public Acceptance

In order to garner public acceptance for the use of NLWs, it is essential to provide information and to give opportunities for debate. In particular, NLT other than kinetic or pyrotechnic devices will have to be assessed carefully with regard to their effects on human health in order to inform the public that they do not produce new unknown effects, including long-term effects.

E.3.4.3 Legal and Political Issues

Inside NATO-Nations different law is applied on different situations in certain scenarios in police or military operations. For multinational and joint operations, the Law of Armed Conflict should be identical for each participating nation. Because of the multinational nature of NATO operations, common NATO standards for the use of NLWs and the training of personnel will need to be developed. Developing this common standard might also lead to changes in the domestic law of some NATO member states.

E.3.4.4 Medical Preparation

When a chemical incapacitant was used at the Moscow theatre hostage incident, tragic outcome, mostly due to poor preparation for rescue and therapy, shoed how important tactical medical planning is in an overall operational use. Every non-lethal technology has to be evaluated for medical aspects during its conception, development, training, and application. Even if the technology is designed for anti-materiel applications, human or humanitarian aspects might become involved during application. Each NLT has to prove its non-lethality by definition and be tested for effects on human health and the environment. Methods for protection of own forces and therapeutic strategies for both our own forces and the adversary need to be developed. The goal could be establishing a process for NATO certification of each NLT before it is approved for operational use. Such a process could be documented in a NATO STANAG on NLWs, and we recommend that this effort be stated as soon as possible.

E.3.4.5 Training

As with training on traditional weapon systems, training for use of NLWs will be aided by computer simulations in virtual reality situations. As such simulations need to be based on experience, a process for completing, collecting, and analysing “after-action” or “lessons-learned” reports following actual NLW use.

E.3.4.6 Continued Activities of the HFM Panel on NLW

The aim of HFM-073 to create a medical NLW databank, including psychological and pharmacological aspects, to be implemented later on into a technical and operational databank should be followed in the future. Valuable medical data are of fundamental importance for the above mentioned certification process. MoD-funded Human Science Research in NLW is urgently needed to prove advantages and public acceptance.

E.4 THE NETHERLANDS (PROVIDED BY ANTHONY W.K. GAILLARD)

From 1999 until the end of 2003 a large research program (~2.4 million euros) on non-lethal weapons (NLW) was conducted by TNO Defence, Security, and Safety. The objective of the program was to investigate the suitability for the Royal Netherlands armed forces of a number of NLW concepts by the determination of their technical performance, weapon effectiveness, and operational value, within the context of a number of scenarios.

The research focused on the following NLWs: Microwaves, Calmatives, Flash-bang hand grenades, Infrasound, Barriers, Entanglements, Blunt impact devices, and Psychological Operations.

These NLWs were evaluated on the basis of the judgments of military experts, in perspective of a number of military scenarios. Aspects considered were: effectiveness, usability, acceptability, and maturity. The study showed that for almost each situation a useful NLW can be found. The challenge is to find an NLW-system that is appropriate for many tasks or situations, and fulfils the global military requirements.

Finally the following five NLW concepts were selected as being suitable for the Netherlands armed forces: High Power Micro Waves (HPM), Combined flash-bang hand grenades, Non-penetrating projectiles (NPP), Pepper spray, and Psychological Operations (PsyOps).

Since NLWs become more and more important in NATO as well as in the other European countries, a new NLW program is currently prepared. Currently the Ministry of Defence is preparing a new policy with regard to the use of NLWs in the Armed Forces. A new program on HPM threat and protection started in 2003 and will last until August 2007 (budget 1.4 ME), whereas the research on Crowd Riot Control and Psychological Operations continues in other research programs.

Besides HFM-073 the Netherlands participated in several international groups: NATO SAS-035, NATO SAS-040, and EWG-NLW, and presented several papers at the 1st, 2nd, and 3rd European Symposiums on NLW (2001, 2003, 2005), at the ICEAA (2001), and at the NATO-ARW on Anti-terrorism (2004). The Netherlands will also participate in the new NATO Task group SAS-060 on “Non-Lethal Weapons Effectiveness Assessment, Development and Verification”, and in the exploratory group for “The Human Effects of Emerging Technologies for Non-Lethal Operations”.

E.5 NORWAY (PROVIDED BY PER KRISTIAN OPSTAD)

Until recently only Norwegian police forces has been equipped with non-lethal weapons in the form of CS sensory irritants for crowd and riot control, baton rounds and distraction grenades. The Norwegian Police Directorate, which is organized directly under the Ministry of Justice, do not have their own research establishment, but a computer and materiel service which is responsible for selection and testing of materials and weapons.

Although Norway has a long tradition for significant contributing to UN operations in different countries, non-lethal technologies have not been included during these operations.

Norwegian Armed Forces are increasingly deployed in areas and situations where the objective of their mission is incompatible with the use of lethal military force. They often have to take the role both as military forces and as police forces. In addition there is in the western countries an increasing intolerance not only to suffer own casualties but also casualties among bystanders, civilians and even enemies. The Norwegian forces in Afghanistan are the first to be equipped with non-lethal weapons such as paintballs, rubber bullets, and CS sensory irritants.

The Norwegian Defence Research Establishment has started for 3 – 4 years ago a research program on non-lethal weapons. The main purpose of this program is quality assurance, efficiency, procedures for employment, security for users and international law to avoid breaching BTWC or CWC or any other international legal obligations. Although this program should have been a joint program for the Ministry of Defence and the Ministry of Justice it is entirely financed by the Ministry of Defence. In the future we will be interested in taking more advantage of non lethal technologies in military operations to avoid unnecessary suffering and damage to personnel. We will be interested in information about the bio medical effects of such weapons and promote research in collaboration with our NATO partners.

E.6 SWEDEN (PROVIDED BY ULF SUNDBERG)

In 1994, the Swedish Defence Research Agency (FOI) began considering “Non-Lethal Technologies” (NLTs) for possible support of units in international missions. FOI first developed a catalogue of scenarios and then analyzed the applicability of various conventional and alternative techniques to address each scenario. These scenarios, built on Swedish experiences from early FN missions, have also been used in the work of NATO LG3 ToE NLW/MOUT and SAS-040, in which Sweden participated.

The FOI NLT project took a holistic approach, but it was obvious from the beginning that Human Effects are critical for a complete understanding of the mechanisms of action and the outcomes of the use of NLT.

Technology projects have included (a) the use of high power microwave (HPM) as an auto stopper, which was tested 1994, and (b) an experimental development for generating infrasound (“Vortex generator”), which was later presented at a German-Swedish Workshop on NLW 1995 (Euskirchen). Both projects are currently inactive.

The possible impact of HFM on human health and safety, is being studied by Mårten Risling, FOI Department of Weapons Traumatology.

Following a study in 2002, the Swedish Defence Forces International Centre (SWEDINT) recommended the acquisition of NLT for International use, based on a definition and Policy applicable for Swedish units. These recommendations were accepted by the Defence Forces Headquarters (16 November 2004). The Policy excludes Information Operations and Electronic Warfare.

In 2005, the FOI NLW Project became part of a larger project aimed at acquiring an Armed Forces capability to be able to respond to any targets with an adapted scalable effect.

E.7 SWITZERLAND (PROVIDED BY DAVID HUMAIR)

According to their missions and changes in the security environment, the Swiss Armed Forces will increasingly be involved in situations where the use of lethal force is inappropriate or even counter-productive. Under such conditions, the enlargement of the range of options at a soldier's disposal must be assured and monitored.

As a member of the PfP programme, Switzerland took up the opportunity offered by the RTA of NATO to participate in the HFM-073 group on NLW in June 2002. Participation in the group was assured by a member of the Armed Forces Planning Staff, who contributed to different discussions, particularly the section on training, and organised a meeting for the HFM-073 group in Bern in November 2004. This involvement in the NATO discussion on NLW provided Switzerland with a great opportunity to develop a network of experts in the field.

As part of standard guard duty training, every soldier in the Swiss Armed Forces is instructed in the rules of proportionality, and the concept of the continuum of force (namely from a physical presence to the involvement of fire arms) forms an integral part of this training. A discussion is conducted to introduce non-lethal responses/means to all troops involved in armed guard duty.

Different non-lethal means are already in use within specialised troops of the Swiss Armed Forces. These means include the use of batons and pepper spray. Tests were launched with a view to producing non-lethal rounds for the 40 mm grenade launcher, but these have recently been stopped.

Switzerland fully supports this report and is interested in participating in future working groups on the subject of NLW.

E.8 UNITED KINGDOM (PROVIDED BY ROBERT INNS)

UK Armed Forces are increasingly deployed in situations where achievement of their objectives is not compatible with the full use of lethal military force; for example in peacekeeping and peace implementation situations. In parallel with this situation, there is an increasing public intolerance, not only of casualties suffered by UK forces, but also of casualties among the opposition and bystanders in the civilian population.

The UK MoD is concerned to keep abreast of Non-Lethal Weapon (NLW) developments, which according to the NATO definition, are explicitly designed and employed so as to incapacitate personnel or equipment with a very low probability of death or serious injury and with minimal collateral damage or impact on the environment".

NLW currently in service are CS sensory irritant (used for law enforcement applications only due to CWC constraints), distraction grenades, and baton rounds. With regard to the latter, there is a continuing programme of research, by Dstl, in hand to look at ways to reduce the risk of injury. This research is undertaken for the Northern Ireland Office (NIO), Home Office/ACPO, and MoD to meet the requirements of the Patten report on policing in Northern Ireland (NI) (and implicitly military operations in NI), and ACPO's desires to have a broader range of options in conflict management – public order and alternatives to conventional firearms. DSTL are contributing to this programme, largely in terms of providing independent medical opinion on the risks from commercial devices such as TASERS (electrical incapacitation devices) and water cannon. DSTL has also been asked by NIO to develop concepts for baton rounds with even less risk of injury, and projectiles to deliver effective quantities of CS on individuals. Full and up to date details of the programme can be found at www.nio.gov.uk.

In addition to the above, on MoD's behalf, Dstl conducts and co-ordinates a small programme of research into some of the novel technologies. It is also responsible for the UK's International Research Collaboration in this area. Research has been conducted into non-lethal barrier technologies such as foams and nets, traction inhibiting adhesives, electrical shorting compounds employing metal fibres and dusts, and underwater acoustic devices.

More recent research includes computer studies of the Vortex Ring gun and the uses of optical dazzle and microwave devices. All research that is undertaken is consistent with the fact that the UK has no plans to develop or promote NLW that would breach the BTWC or CWC or any other international legal obligations. The 1995 Protocol IV to the 1980 Convention on Certain Conventional Weapons prohibited the development of laser weapons designed to permanently blind the unaided eye. However, optical systems (including lasers) that temporarily dazzle are considered as possible military options. An integral part of any research of this nature is the study of human physiological and psychological effects caused by optical dazzle devices.

As with any weapon system, normal legal reviews will be conducted before any such weapon enters service. The NLW application of High Powered Microwave (HPM) and Radio Frequency (RF) devices has been a research programme conducted by the UK since the mid 1980s. This programme has investigated the enabling technologies, target interaction processes, military utility and protection techniques appropriate to the development of, and threat from, RF-Directed Energy Weapons (DEW) and integrated hazards based on the RF, HPM and mmW wave parts of the EM spectrum. Potential generic applications include information operations, platform and installation protection, Command and Control Warfare (C2W), novel warheads, and "soft-kill" munitions, which achieve their effect by inducing disruptive electrical processes in the sub-components of target systems rather than gross blast effects from an explosive. The programme also monitors emerging NLW anti-personnel concepts such as the US VMADS system to provide awareness of such systems and to understand our vulnerability to them.

E.9 UNITED STATES OF AMERICA (PROVIDED BY MICHAEL R. MURPHY)

The U. S. Joint Non-Lethal Weapons Program (JNLWP) (http://www.jnlwd.usmc.mil/) was established 09 Jul 96, under DoD Directive 3000.3. The directive established joint service organizational responsibilities and provided guidelines for the development and employment of non-lethal weapons. The directive designated the Commandant of the US Marine Corps as Executive Agent (EA) for the JNLWP. Under DoD Directive 3000.3, NLWs are defined as "weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment."

The JNLWP seeks to find solutions to capabilities deficits and quickly deliver technically mature and militarily useful non-lethal weapons and capabilities for the warfighters. The strategic direction for the JNLWP is to support and fund the research, development, testing, and evaluation of non-lethal weapons, concepts, and capabilities that have clear applications and unique contributions in support of the force protection, dominant manoeuvre, and precision engagement joint operating concepts. These efforts work to improve existing non-lethal weapons, provide standoff capability to deliver non-lethal capabilities beyond small arms range, and find transformational non-lethal technologies and concepts that offer advantages and solutions at all levels in the spectrum of threats and crises.

A Joint Service representative body, the Joint NLW Integrated Product Team (JIPT), establishes and directs DoD NLW programs for joint doctrine, professional training, materiel requirements, research and

development and acquisition-related activities. The JIPT has functions and responsibilities to support the execution of EA responsibilities. The JIPT, chaired by the Deputy Chief of Staff, Plans, Policies and Operations, Headquarters Marine Corps (PP&O), is the final arbiter for the consolidated DoD NLW RDT&E program.

The Joint Coordination and Integrated Group (JCIG) acts in an oversight capacity, reviewing and recommending approval to the JIPT for new starts or the termination of unsuccessful efforts. The JCIG coordinates and integrate NLW programs supported by the JNLWP. The JCIG catalogs and tracks progress of independent and Joint NLW programs, looking for efficiencies and leveraging opportunities.

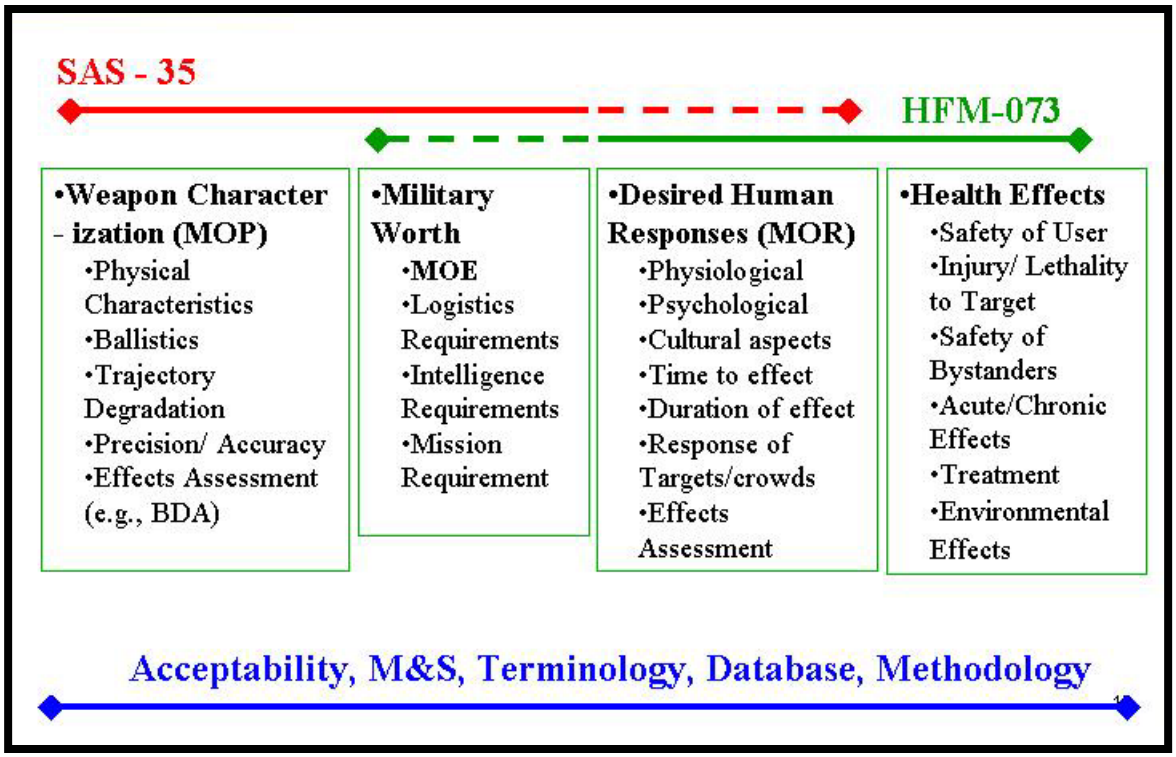
The Joint Non-Lethal Weapons Directorate (JNLWD) is responsible for the centralized coordination and integration of NLW technologies and systems that support the Services and Combatant Commanders. The Directorate was established to execute and manage the JNLWP in its day-to-day activities and provide support to the JIPT. The Director acts on behalf of the EA and the JIPT in accordance with actions approved by the JIPT Chair. The Director chairs the JCIG. The JNLWD ensures that funding efficiencies are in place and approaches among the divisions are coordinated and maintained. The Directorate represents the EA throughout a wide range of venues and audiences. The JNLWD combines military, civil service, and support personnel tasked to implement and maintain an aggressive, energetic, and forward-looking NLW program. The Directorate's responsibilities also include serving as the DoD NLW single point of contact for liaison with foreign entities on matters of mutual interest concerning NLWs.

The human effects of non-lethal weapons are managed directly by the JNLWD through a series of organizations. The Joint Non-Lethal Weapons Centre of Excellence, operated by the Air Force Research Laboratory at Books City-Base, Texas, was established in 2001 to provide scientific, fair evaluation of existing human effects information and develop strategies to collect the required information if it does not exist (http://www.afrlhorizons.com/Briefs/Sept02/HE0209.html).

The JNLWP also established the Human Effects Advisory Panel (HEAP), under contract with the Marine Corps Research University at Pennsylvania State University, which serves as an independent technical advisor on matters pertaining to the human effects on non-lethal weapons. The JNLWD also supports significant human effects analysis and research through the Non-Lethal Technology Innovation Centre (NTIC), located at the University of New Hampshire. NTIC organizes the annual non-lethal conference "Non-Lethal Technology and Academic Research (NTAR) Symposium" and manages research projects on behalf of the JNLWD (http://www.unh.edu/ntic/index.html).

Annex F – PURVIEW OF HFM-073 COMPARED WITH SAS-035

The relationship between NATO RTO Panels "Measures of the Effectiveness of Non-Lethal Weapons" (SAS-035) and "The Human Effects of Non-Lethal Weapons" (HFM-073 as proposed by HFM-073. As defined by SAS-035, MOP = Measures of Performance; MOE = Measures of Effectiveness; and MOR = Measures of Response. M&S = Modelling and Simulation.



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.

Annex H – GLOSSARY OF TERMS IMPORTANT TO THE HUMAN EFFECTS OF NON-LETHAL TECHNOLOGIES

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. This Glossary attempts to define 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. There is a special focus on terms that are used in minutes of the meetings of HFM-073 and in the body of the HFM-073 Final Report. Criteria for including words were: (a) Terms unique to the human effects of NLTs; (b) Common terms that are used in an unusual way in the context of NLT human effects; (c) Common terms that are used with their usual meaning, but are very important to the human effects of NLTs.

3-Rib Chest Structure: A mechanical model used to measure chest compression and thoracic response (chest wall velocity) from ballistic impacts.

Accreditation: The official certification that a model or simulation or process is acceptable for use for a specific purpose. Also see Validation and Verification.

Acceptability: The complex determination of whether the contemplated use of a non-lethal technology is (1) worth the cost in manpower, material, and time involved; (2) is consistent with the law of war; and (3) is militarily and politically supportable.

Acute Effects: An immediate physiological, behavioural, or psychological effect occurring as a result of the stimulus from an NLT. Examples of acute desired effects include pain from a kinetic impact, distraction from a flash-bang, and irritation of the eyes and lungs from Oleoresin Capsicum.

After-Action Review (AAR): A professional discussion of an event that enables soldiers to discover for themselves what happened, why it happened, and how to sustain strengths and improve on weaknesses. It is a tool that leaders, trainers, and units use to get maximum benefit from every mission or task. It could be used to assess the operational performance of NLT.

Asphyxia: Decreased oxygenation of the blood, often due to the inability to breathe due to airway obstruction or irritation.

Asphyxia, Positional: Asphyxia caused by restricting a human in a position in which breathing is inhibited.

Basis Responses: A set of abilities defined by SAS-035 as the smallest set of descriptors that form the basis from which all the desired target responses necessary to accomplish anti-personnel and anti-materiel assigned mission tasks can be generated. These Basis Responses describe the Required Responses and Measures of Response in a simple and common manner such that they can be mathematically compared in order to compute the Measures of Effectiveness. They are a means of reducing complex information to a minimum ordered set of actions to allow the Measures of System Effectiveness to be mathematically calculated. The following seven Basis Responses were listed:

- Physical Function;
- Mobility;
- Communication;

- Sense and Interpret;
- Group Cohesion; and
- Identification.

Battle Stress: A temporary disorder of psychological function and performance experienced by some individuals during combat. Battle Stress cases are considered as Battle Casualties, but the majority of these casualties do not become patients and most can be handled outside of the medical support system.

Behavioural Effect: An effect on the behaviour or performance of a person.

Biological Effect (Bioeffect): Any effect of an internal or external stimulus on part or all of a biological organism.

Blunt Trauma: Change of body structure caused by imparted kinetic energy.

Bystander: A person located near the target of a NLW who is not an adversary and is not the intended target of the NLW. Similar to the term "non-combatant." The safety of bystanders will be an important issue for the use of NLTs.

Chronic and Long-Term Effects: Effects of a NLT that could affect health over a long period of time, even years. The potential effects most often cited are the induction or promotion of cancer, the reduction of fertility and/or the increase of birth defects, and facilitation of a variety of physiological disorders and diseases. Concern applies both to the user, who may experience repeated low-level exposure and to the targets, who may experience multiple acute high-level exposures. Such effects may take many years to appear.

Commotio Cerebri: Shock to the brain causing unconsciousness. This condition is especially relevant to kinetic NLT.

Commotio Cordis: A ventricular fibrillation induced by impacts to the front chest, particularly near the front left ventricle, during repolarization.

Communication: Capability of exchanging information with other persons via verbal or non-verbal means. The goal of some NLTs is to disrupt this capability.

Compliance: The act of submitting to the will, control, or orders of another person.

Confuse: To disrupt thinking with clarity or acting with intelligence and understanding.

Concussion: An injury to the brain produced by a violent blow and followed by temporary or prolonged loss of function and consciousness.

Constraints to NLTs: Limiting factors that influence development, testing, training, and deployment of NLTs. For example, certain conventions, laws, & treaties restrict the use of chemicals in combat; standards that set limits on human exposure to electromagnetic fields, lasers, or acoustics may limit testing and training on some NLTs. The claim or perception that some NLT effects are tantamount to torture could limit their use.

Control Force: Police or military personnel attempting to restore civil order. Also see "crowd control" and "riot control."

Contusion: An injury to an organ or tissue that is caused without breaking the skin, e.g., a bruise.

Countermeasure: A means via actions or equipment by targets to defeat the goals of a NLT.

Crowd Control: The goal to effect the gathering, unified action, or dispersal of a crowd in a desired manner.

Cultural Background: Characterization of human groups by such factors as ethnicity, religious beliefs, and education. It is believed that cultural background will affect human response to some NLT, especially those relating to psychological effects.

Dazzle: Temporary loss of vision or temporary reduction in visual acuity. Also see "Glare."

Damage Assessment: The evaluation of the effect of NLTs on targets.

Deception: Measures designed to mislead the enemy by manipulation, distortion, or falsification of information in order to influence his course of action.

Delayed Effect: Physiological (e.g., health), behavioural, or psychological effect of a NLT that appears some time after the original stimulus, e.g. a delayed toxic effect.

Denial Measure: An action to hinder or deny the enemy the use of space, personnel, or facilities. Threats, barriers, and the induction of pain are examples of denial measures.

Desired Effects: The objective for using the NLT, e.g., distraction, incapacitation, repel. Also see "undesired effects."

Deter: To prevent or discourage from acting by imposing fear or doubt regarding the consequences of the action or by creating a physical obstacle.

Disable: To deprive targets of capability and effectiveness, often by impairing their physical abilities.

Disorient: To impair targets sense of spatial or temporal relationship with their surroundings or goals.

Disperse: To decrease the density of a group of people, e.g., breaking up a crowd.

Distract: To cause to turn away from the original focus of attention or interest.

Dose-Response: The relationship between the intensity of a stimulus (dose) and its effects. For any specified effect, a dose-response curve can be created. The separation between the dose-response curves for desired and undesired effects of a non-lethal technology defines its margin of safety and its operating envelope.

Duration of Effect: The time course of recovery from an effect produced by NLT. The duration of the effect of a NLT is important in assessing its effectiveness and in planning its use. It is also important for planning the interrogation of a captured target and in assessing medical management of an injured target. Also see "Time of Effect".

Effect: Change produced by an action or stimulus.

Effectiveness: A measure of the success of a NLT in meeting its objectives. From an operational perspective, it is a measure of the ability of a specific NLW when employed in a given scenario to allow achievement of mission objectives by an employing force.

Energy Coupling: The efficiency of transfer of energy from one medium to another. For the human effects of NLT, the issue is usually how well energy couples with the human body. For example, infrasound delivered in air couples poorly with the human body, whereas infrasound delivered in water couples well with the human body. Energy that strikes a human that is not coupled well, is usually either reflected by the body or passes through the body.

Environmental Effects: Effects of NLTs on fauna or flora. The goal to preventing undesirable environmental effects is codified in the definition of non-lethal weapons. The issue of environmental effects is especially important for chemically based NLT, the residue of which could remain for a considerable time.

Exposure Standards: Health and Safety standards developed to protect the general public and operators from exposure to potentially harmful physical or chemical stimuli. These standards are generally very conservative, employing a large safety factor. They do not apply to the use of such stimuli in NLTs against a target and are generally relaxed during warfare. However, they apply during the development and testing of NLTs and in training and exercise scenarios. In military operations, they usually apply to weapon's operators and other personnel. In NATO, such standards are codified as Standardization Agreements (STANAGS), e.g., STANAG 2345 for exposure to radio frequency radiation.

Extrapolation: Using specific, limited observations and data (e.g., from an animal, physical, or computer model, from a small subset of the human population, or using sub-optimal levels of an NLT) to predict the effects of NLTs on humans in an operational situation. Also called generalization.

Flash-Blindness: The temporary loss of vision following exposure to a bright light.

Glare: Loss of visual performance (veiling glare) or annoyance or discomfort (discomfort glare) produced by light greater in intensity than that to which the eyes are adapted. Diminished vision can also be produced from light reflecting or scattering from surfaces, such as windshields, water surfaces, or VDTs (reflection glare).

Group Cohesion: The level of organization, cooperation, and density of a group or crowd of individuals.

Head Injury Criterion (HIC): A measure developed by the U. S. National Highway Traffic Safety Administration to indicate the probability and severity of skull fracture.

Human Effects: Effects on a human being, including physical, biological, physiological, psychological, and social effects. Knowledge about human effects can be obtained by observation, experimentation, and modelling. Data can be collected from animal models and directly from humans in both laboratory and field conditions. Knowledge about the human effects of non-lethal weapons is essential to assure operational utility, technological feasibility, and policy acceptability.

Immobilize: To stop, restrict, or hinder movement.

Imparted Energy: The total energy transferred from a kinetic device to the human body. Also see "energy coupling."

Incapacitate: To deprive the target of strength or ability, temporarily inducing a state where no effective action can be performed.

Indecisiveness: Reduced ability to plan or make a decision and act effectively.

Injury Criteria: The critical levels of various damaging effects, such as blast pressure and thermal radiation, required to achieve specified levels of damage. Also see "dose-response."

Interim Total Body Model (ITBM): A compilation of various thoracic, abdominal, and head injury models, most often based on a biomechanical lumped parameter representation of anatomical behaviour. The ITBM is being used to model the effects of blunt impact NLT.

Lobdell's Model: A lumped parameter biomechanical model of how the thorax will respond to high mass, low velocity impacts. Developed to support injury assessment for the automotive industry, now used to model the effects of blunt impact NLT.

Margin of Safety: A term borrowed from pharmacology that indicates the separation between an effective dose and a toxic dose of a drug for a specified population of users. For non-lethal technologies, the margin of safety defines the operating environment between operational effectiveness of a NLT and the occurrence of undesirable effects. The margin of safety is often expressed as a ratio of the threshold value for damage divided by the threshold for effectiveness. It can be readily visualized by plotting dose response curves for desired and undesired effects on the same graph. The margin of safety can be highly affected by the variability of the relevant population of targets. A technology with a large margin of safety is preferred.

Measures of Effectiveness (MOE): Defined by NATO RTO SAS-035 as a quantitative or qualitative measure that indicates the degree to which a military objective can be achieved by using one or more systems (lethal/non-lethal) in an operational context, e.g., probability of damage, etc.

Measures of Operational Effectiveness (MoOEs): Defined by NATO RTO SAS-035 as a quantitative or qualitative measure of the impact of the use of NLTs to the overall success of an operation.

Measures of Performance (MOP): Defined by NATO RTO SAS-035 as a measure of the intrinsic quality of the system under consideration (taking into account environmental conditions). Examples are speed, payload, range, time on station, frequency, or other distinctly quantifiable performance features.

Measures of Response (MOR): Defined by SAS-035 as a measure of how a target reacts (desired/undesired) to a system that is applied (i.e., taking into account countermeasures).

Measures of System Effectiveness (MoSEs): Defined by SAS-035 as an overall measure of the effectives of a system employing NLTs. It is a combination of the Measures of Response, the Target Response Characteristics, and the Required Responses.

Medical Response: Agents and procedures to treat the acute and delayed effects of NLTs to facilitate the reversal of acute effects and the prevention of delayed effects, based on medical need. Particularly for novel NLT, preparation for medical treatment will help reduce casualties and undesired effects. Medical responders should be prepared to treat operators, targets, and bystanders who may intentionally or accidentally be exposed to NLT.

Mobility: The capability of individuals or groups of people to move from one location to another, characterized by speed and direction.

Model: A physical or mathematical representation the real world, simplified by ignoring certain details. Models allow complex systems and situations to be understood and their outcomes predicted within the scope of the model, but may give incorrect descriptions and predictions for situations outside the realm of their intended use. Also see "extrapolation" and "dose-response."

Motivate: To provide with an incentive; to move to action; impel.

Motivation: From the perspective of NLTs, the strength of the targets' desire to achieve their goal, or conversely, the strength of the targets' ability to resist the application of an NLT. Although this is an easily understood term, there are few objective metrics for assessing motivation with respect to a given NLT. In many cases, motivation is directly proportional to the effective dose of an NLT.

Non-Lethal Effect (NLE): An effect that incapacitates or repels personnel, with a low probability of fatality or permanent injury, or disables equipment, with minimal undesired damage or impact on the environment.

Non-Lethal Technologies (NLTs): Technologies being considered or utilized for non-lethal weapons.

Non-Lethal Weapons (NLWs): Weapons that are explicitly designed to incapacitate and repel personnel, with a low probability of fatality and permanent injury, or to disable equipment, with minimal undesired damage or impact on the environment. (NATO NLWs Policy)

Operating Envelope: The range of applications (dose, level) of a NLT in which desired effects are maximized and undesired effects are minimized. Also see "dose response" and "margin of safety."

Operator: With respect to NLWs, the person responsible for firing, launching, or otherwise delivering a NLT to a target. For many NLT, operators may experience repeated low-level exposure and run the risk of accidental high-level exposures. Also see "Safety Standards."

Pain: An unpleasant sensation occurring in varying degrees of severity as a consequence of injury or exposure to intense stimuli likely to cause injury, disease, or emotional disorder. The most basic form of pain is assumed to help prevent injury. Humans usually seek to reduce or avoid pain. The induction of pain to compel adversary compliance is common to many existing and proposed NLW.

Pain Compliance: The use of pain to exert control over a target. Also see "compliance."

Performance: The efficiency and quality of a purposeful action. One goal of NLTs is to disrupt the performance of targets. Means of assessing changes in performance caused by NLTs could be an in important issue for the NATO RTO Human Factors and Medicine Panel.

Personal Protection: Protective clothing or other means used by an operator or user to prevent potentially hazardous exposure to an NLT. Also see "countermeasure."

Physical Restraint: The control of the capacity or mobility of targeted individuals or groups by physical means (e.g., handcuffs).

Physiological Effect: An effect on the anatomy or functioning of the human body.

Pre-empt: To act to gain time and space in order to forestall the activities of an adversary in order to maintain freedom of action.

Probability of Damage: Defined by NATO RTO SAS-035 as the probability that damage will occur to a target expressed as a percentage or as a decimal.

Probability of Detection: Defined by NATO RTO SAS-035 as the probability that a person, object or phenomenon will be detected, expressed as a percentage or as a decimal.

Probability of Unintended Effects Given a Hit (P_{HL}): Defined by NATO RTO SAS-035 as conditional probability of injury or lethality given a hit. This probability is specified as a function of dose and may vary according to population and individual variables such as age, gender, sensitivity, clothing, and motivation level.

Probability of Intended Effect Given a Hit (P_{HE}): Defined by NATO RTO SAS-035 as the conditional probability of achieving the task objective. This probability is specified as a function of dose and may vary according to population and individual variables such as age, gender, sensitivity, clothing state, and motivation level.

Probability of Hit (P_H): Defined by NATO RTO SAS-035 as a term used by the modelling community to describe the probability that a target will be hit by a given release of a munition, expressed as a percentage or as a decimal.

Probability of Kill (Pk): Defined by NATO RTO SAS-035 as a term used by the modelling community to describe the probability of stopping specific functions of a target if that target is hit.

Psychological Effect: An effect on the mind (e.g., thinking, attitude, motivation, etc.) of a person. It is often considered as an intermediate to a behavioural effect. Undesired psychological effects of non-lethal technologies on the target, bystanders, and operators could also be an issue and should be evaluated in any complete risk analysis.

Psychological Operations: Military operations designed to have an effect on the mind (e.g., thinking, motivation, attitude, etc.) of a person.

Reostatic Weapons: With respect to NLW, the ability of a single weapon or technology to produce a spectrum of desired effects merely by adjusting the level of exposure or some other parameter. For example, the same weapon might be adjusted to produce annoying effects at lower levels, incapacitation at higher levels, and lethality at even higher levels. Also called tunable or scalable weapons.

Repel: To ward off or keep away; drive back.

Riot Control: The management of a large group of people engaged in unrestrained civil disobedience. Also see "Crowd Control."

Risk Characterization: The formal process by which desired (i.e., intended) and undesired (i.e., unintended) effects of NLTs are identified, examined, and evaluated to determine the technology's effectiveness and safety.

Rules of Engagement (ROE): Directives issued by competent military authority that delineate the circumstances and limitations under which forces may initiate and/or continue combat engagement with other forces encountered. Standing ROE refer to those generally intended for all situations, but tailored ROEs for specific situations may augment those standing rules. Knowledge of the human effects of NLTs will be extremely important for specifying appropriate ROE for NLWs.

Secondary Injures: Injuries that are not due to the primary intent or effect of the non-lethal weapons, but occur as an unanticipated or unavoidable sequelae. For example, an anti-electronic weapon could disrupt life-sustaining medical equipment leading to death. Any NLW that induces momentary loss of equilibrium could inadvertently lead to injuries from falling.

Simulation: An attempt to predict aspects of the behaviour of some system by creating an approximate (mathematical) model of it. This can be done by physical modelling or by writing a special-purpose computer program. The use of simulations allows many iterations of proposed scenarios with different assumptions.

Spasm: An involuntary and unnatural contraction of one or more muscles or muscular fibres. Spasms are usually either clonic or tonic. In clonic spasms, the muscles or muscular fibres contract and relax alternately in very quick succession. In tonic spasm, the contraction is steady and uniform, and continues for a comparatively long time. Also see "tetanus."

Spoof: Mislead, often through the use of faked or altered communications.

Startle: A reaction to a sudden noise, impact, or flash that causes an involuntary response such as stiffening of the body, flexion of the arms, a verbal response, or fall to the ground. Flash-Bang devices often produce a startle response.

Stun: Condition of complete inability to act purposely. When applied to an individual, it implies inability to attack or defend or even move.

Target: Person at whom a NLT is directed. Also see "bystander."

Tetanus: A state of continuous muscular contraction, especially when induced artificially by rapidly repeated stimuli. Electrical stimulation can result in tetanus.

Threshold Effect: An effect for which a threshold dose must be exceeded before the effect is observed. Because of the variability of human response, thresholds are often expressed probabilistically as the dose that elicits the subject response in 50% of the population; this metric is called the Effective Dose 50 (ED50). Also known as the "minimal effective dose."

Time to Effect: The time between exposure to a NLT and the desired effect. This time may be immediate (e.g., kinetic weapons), take a few seconds to occur (e.g., millimetre wave heating), or take many seconds (e.g., calmatives). Also see "Duration of Effect".

Trauma: Any injury, either physical or psychological.

Undesired Effects: Effects of a NLT that do not support the goals of its use. Lethality and permanent injury clearly are undesired effects of NLT. These are sometimes referred to as "side effects" or "unintended effects."

User: The operator of an NLT. Acute and long-term safety of the user will be important to the policy acceptability of NLT.

Validation and Verification (V&V): A process whereby a device, procedure, simulation, model or other product is tested for meeting its design requirements and specifications. Validation assesses the relevance of the product to its stated purpose. Verification assesses the degree of accuracy and reliability of the product.

Vertigo: A feeling of dizziness or loss of equilibrium that may lead to falling down.

Viscous Criterion: An empirically derived injury criterion developed for the automobile industry for low velocity, high mass impacts to the chest. Equivalent to the maximum product of chest wall velocity and compression (VC_{max}).

Visual Obscuration: Temporary impairment of vision, e.g., with a bright light or certain lasers. May also be called “temporary blindness.”

Vulnerability: Susceptibility to an effect (e.g., incapacitation, injury). The variability of the vulnerability of different individuals in a target population is a major challenge for the evaluation and use of NLWs.

Annex I – THE NATURE OF DATA

I.1 INTRODUCTION

The term "data" is used here in the broadest possible sense. Data are mere basic observations, which are real, not assumed or hypothesized. Data should neither be underrated nor overrated in their importance. They should certainly never be confused with the concept of absolute truth. Data can be thought of as the foundation of an epistemological system that includes information, knowledge, truth, and wisdom. This Annex discusses some of the common classifications of types of data and their treatment; for a more thorough treatment the reader should consult textbooks and other scholarly works on epistemology and statistics.

I.2 BASIC TERMINOLOGY

The word "data" is plural**;** the singular form is "**datum,**" but the terms "**point data**" or "**datapoint**" or "**observation**" are often used with the same meaning, e.g., a single number or observation. The term "**dataset**" is a grouping of related data "**Raw data**" are the initial form of the data, as collected, before any statistical analysis, enumeration, etc. is done. An "**observation period**" is the time during which data are collected. Collected data are considered to be "**samples**" of a larger underlying "**population**" of similar data. "Sample size" is the number of samples in a particular dataset.

I.2.1 Quantitative Data

Data that are related in an ordered or numeric scale. (Also called numeric data.)

- **Rank Data**: The simplest type of quantitative data, needing only to be capable of being sequentially ordered, e.g., one datum is equal or bigger, or better, or more effective, etc., than each other in the set; for convenience, such data may be numerically ranked starting with a value of 1 at one end of the scale. The area of mathematics known as non-parametric statistics is used to describe, summarize, compare, and analyze such data.
- **Measurement Data**: Data collected using a measuring instrument (e.g., a thermometer, force meter, stop watch). Such data are often immediately transduced and digitized for computer analysis.
- **Frequency Data**: Data obtained by counting the number of times an event occurs. If the total number of observed events is known, frequency data may be expressed as a proportion or percentage. If the duration of the observation period is known, such data may be expressed as a rate (e.g., events per hour).
- **Duration Data**: Data obtained by measuring the amount of time that a process was occurring. If the duration of the observation period is known, such data may be expressed as a proportion or percentage.
- **Latency Data**: The time between a designated start of an observation period to the occurrence of a particular event.
- **Interval Data**: The time between two events within an observation period.
- **Dose Response Data**: Data that correlate "dose" to "response." The dose may be any appropriate measure of the amount of non-lethal technology (e.g., joules of energy, watts of electricity, density of a chemical) applied and the response be any conceivable, quantifiable effect of that technology,

including intended and unintended effects. Such data are often illustrated in "dose-response curves" in which dose (low to high) is plotted on the x- axis and response (low to high) is plotted on the y-axis. As the points in such curves usually represent measures of central tendency (e.g., means) of a set of like data, dose-response curves often display an indication of variability or confidence, as well. The medians of such curves, in which 50% of the datapoints fall above and 50% fall below, are often used as a shorthand summary of an effective dose (called "Effective Dose 50", or ED_{50}). Such summary measures may then be compared for intended versus unintended effects to compute a margin of safety or safety factor. While well-established dose-response curves for multiple effects of the same technology is considered ideal, such data currently exist in only a few cases.

- **Threshold Data:** Threshold data are a measure of the minimum dose required to produce some level of an effect in an individual or a population. There are several mathematical approaches to estimating threshold, but the most complete is the use of dose-response data, as described above. Threshold data are usually accompanied by a measure of variability or uncertainty with respect to the population response that is being estimated. The concept of threshold is usually tied to the percentage of a population that displays a particular effect at the threshold dose. For occupational health and safety standards, the threshold dose for an undesired effect may be based on a very small percentage of the population being affected; for such standards, the permissible limit is often much lower than the threshold dose, in order to provide an additional safety factor.
- **Binary Data (or Digital Data):** Binary data are quantitative data represented by a series of the digits "1" and "0," called bits. Ultimately, most quantitative data are converted to binary when processed by a computer. The number of bits used to represent a quantitative datum determines the possible resolution (bit depth) of the measurements; for example, if 8 bits are used, the maximum resolution of the measurement is 2^8, or 256 different levels.

I.2.2 Qualitative Data

Qualitative data include descriptions and classifications of events without reference to any calibrated scale. They are often subjective and/or opinionated. Numbers are arbitrary identifiers of qualitative data and might as well be substituted with words or other symbols. For example, the observation by a battle participant that a particular non-lethal weapon was effective in a particular military operation is an example of qualitative data. There are procedures for maximizing information from qualitative data. Qualitative data are often valued for their usefulness in developing hypotheses that can be tested using experimental, quantitative methods.

I.3 DATA QUALITY – THE COLLECTION OF DATA

All data are not collected equal. Particular data may be described with various qualifying terms, such as good, bad, reliable, biased, etc. The principles of data quality may be derived from common usage. Good data are **not** data that agree with the experimenter's cherished theory. They are merely data that have been collected in a reliable, reproducible manner, with opportunities for error and bias minimized as much as possible. Any data can be biased or outright falsified. However, as the quality of the data increases, the potential for falsification and bias becomes easier to detect, control, and avoid. Hearsay and other verbal report, given long after an incident and by an observer with a clear vested interest in the use of the data, has the highest potential for bias and inaccuracy. Standardized procedures for data collection (e.g., entry forms, time limits, structured questionnaires, written classification criteria, multiple observers, etc.) can increase the quality of data. Poor measurement devices (e.g., biased, unreliable, or uncalibrated) can result in both increased variability and systematic error. The gold standard for high quality data is that obtained from a well-designed, controlled experiment using a calibrated measuring instrument and skilled observers who have little knowledge of the

hypothesis being tested or of which treatments are administered to which groups (often called a "blind" observer). The insistence on such procedures does not impugn the honesty or trustworthiness of the observer; research has shown that experimental bias can occur unconsciously in even the most honourable and well-intentioned observers. Even qualitative data may be judged according to the known accuracy and expertise of the observer. Thus a qualitative observation from an experienced and trusted individual may be more relevant and valuable than any number of datapoints or amount of statistical analysis. However, data quality should not be equated to data relevance, as rarefied experimental data may or may not provide valid predictions of effects in the real world.

I.4 STATISTICAL ANALYSIS OF DATA

Raw data provide little information without further processing. Statistics is the discipline that uses mathematics and probability theory to process raw data into various types of information. Statistics is both a well established and evolving discipline and only the barest introduction is attempted here.

- **Descriptive Statistics**: Descriptions associated with central tendency (mean, mode, medium) or variability (e.g., range, standard deviation) of a dataset.
- **Estimating Populations Parameters**: Statistical procedures used to estimate the parameters (e.g., central tendency, confidence levels) of an underlying population based on the data obtained from samples from that population.
- **Hypothesis Testing**: Statistical procedures used to draw conclusions from data, for example to decide if two or more sets of data have been drawn from the same or different populations, i.e., to estimate if they are statistically significantly different from one another?
- **Statistical Significance**: Using calculations of size, central tendency, and variability of the samples, and assumptions regarding independence or dependence of the samples, the predicted direction of the difference, the sampling method used, and the distribution of the underlying populations, measures of statistical significance estimate the probability that observed data and datasets are related by chance or otherwise. The most common question is whether two or more datasets come from the same or different underlying populations. An example question for non-lethal weapons is whether or not a particular exposure, e.g., to a putative acoustic weapon, has had an effect on task performance. The experimenter collects quantitative data under the conditions of exposure and no exposure and compares the results using an appropriate statistical test. The result of the test indicates the probability (p) that the samples differ by chance. By convention, the probability level of 0.05 is accepted as being "statistically significant." The label "$p < 0.05$" indicates that "the probability that the apparent relationships between these datasets will appear by chance is less than .05 (i.e., one time in 20). It is important that interpreters of statistical results realize that if a probability level of 0.05 is used as the criterion, results labelled as being "statistically significant" will have a purely chance relationship 5% of the time.
- **Using Appropriate Statistics**: Statistical tests make assumptions regarding the mathematical nature of the sampled data and the underlying population from which the sampled data are collected. These include assumptions about the type of data (see discussion above in 1.2.1) and the distribution of data within the underlying population. The statistical approach selected must match the nature of the data being analyzed. There is no more common error in data analysis than the inappropriate use of parametric statistics on non-parametric data, with the use of the mean as a measure of the central tendency of ranked data being an egregious example.

I.5 CHALLENGES FOR NLW HUMAN EFFECTS DATA COLLECTION

Researchers on the human effects of NLW face a difficult challenge in that they need to collect data on human subjects, yet current regulations for human experimentation do not adequately address the types of experiments they need to perform. Most regulations for human use are oriented toward improving medical treatment or elucidating fundamental knowledge about human physiology or behaviour. Measuring the risks or effectiveness of a weapon system, albeit a non-lethal weapons, is not a familiar justification for permitting human experimentation. Existing regulation, ethical considerations, risk-benefit calculations, available alternatives, and the need for reliable applicable data all affect this complicated issue, which can only be noted in this paper.

I.6 DATA AND MATHEMATICAL MODELS: GARBAGE IN – GARBAGE OUT

Raw data, analysed data, and the relationships supported by the results of statistical comparison are often used to create mathematical models that describe these relationships in a form that can be readily graphed, simulated, and more easily understood; such models are called "**descriptive models."** When such models are used to predict relationships and outcomes that have not actually been used to create the model, they become **"predictive models."** Accurate predictive models are extremely useful, however their accuracy must be validated by additional data collection before they can be relied upon. An issue that sometimes arises in non-lethal weapon testing is the claim or assumption that a descriptive model is also an accurate predictive model, without the validating step of demonstrating that the model can accurately predict new data. Models are often based on very limited observations made in highly controlled, unrealistic situations using numerous untested assumptions. Worse is when models are initially based on poor quality data analysed within inappropriate statistics. The most excellent model cannot make up for bad data. Models can be used to guide the collection of additional data and new data can be used to improve the models; however, models do not eliminate the need to collect new data.

Annex J – HUMAN EFFECTS OF RF ENERGY

1) Most studies on low-level (so-called "non-thermal") RF exposures have not found any biological effects. A few studies have suggested that some biological effects may occur, but such findings have not been confirmed by additional research. In many cases, other researchers have had difficulty in reproducing those studies, or in determining the reasons for inconsistent results.

2) 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 tumour development used animals that had been genetically engineered or treated with cancer-causing chemicals so as to be pre-disposed them to develop cancer in the absence of RF exposure. Other studies exposed the animals to RF for up to 22 hours per day. Such exposures are very different from those people might receive while using a wireless phone or while employing an RF-based NLW, so the results are difficult to interpret in terms of human health, even if the findings are valid.

3) Three large epidemiological studies on the health effects of RF have been published since December 2000 and several more are in progress. Between them, the studies investigated any possible association between the use of wireless phones and primary brain cancer, glioma, meningioma, or acoustic neuroma, tumours of the brain or salivary gland, leukaemia, 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 (see Lonn (Lonn et al. 2004)).

4) A combination of laboratory studies and epidemiological studies of people actually using wireless phones would provide some of the data that are needed to assess the potential health effects of low-level RF. 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. The reason for needing such a long study is that the interval between the time of exposure to a cancer-causing agent and the time tumours would develop – if they do – could 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/. Assessment of the human effects of exposure RF used for NLW would face even greater problems because of the relatively small exposed population compared to that using wireless phones.

5) A recent special issue of the premier scientific journal on RF health effects (Bioelectromagnetics Supplement 6, pp. 1-213, 2003) published 14 detailed review papers on the potential harm of exposure to RF. A paper by D'Andrea, Chou, Johnston, and Adair, (D'Andrea et al. 2003b) reported that studies have evaluated the electroencephalography (EEG) of humans and laboratory animals during and after Radiofrequency (RF) exposures. Effects of RF exposure on the blood-brain barrier (BBB) have been generally accepted for exposures that are thermal zing. Low-level exposures that report alterations of the BBB remain controversial. Exposure to high levels of RF energy can damage the structure and function of the nervous system. Much research has focused on the neurochemistry of the brain and the reported effects of RF exposure. Research with isolated brain tissue has provided new results that do not seem to rely on thermal mechanisms. Studies of individuals who are reported to be sensitive to electric and

magnetic fields are discussed. In this review of the literature, it is difficult to draw conclusions concerning hazards to human health. The many exposure parameters such as frequency, orientation, modulation, power density, and duration of exposure make direct comparison of many experiments difficult. At high exposure power densities, thermal effects are prevalent and can lead to adverse consequences. At lower levels of exposure biological effects may still occur but thermal mechanisms are not ruled out. It is concluded that the diverse methods and experimental designs as well as lack of replication of many seemingly important studies prevents formation of definite conclusions concerning hazardous nervous system health effects from RF exposure. The only firm conclusion that may be drawn is that high power RF exposure could be hazardous to humans; however, in practice, such high level exposures are extremely rare.

6) Another review paper in the recent special issue of Bioelectromagnetics (D'Andrea et al. 2003a) presents an overview of the recent behavioural literature concerning microwave exposure and discusses behavioural effects that have supported past exposure standards. Other effects, which are based on lower levels of exposure, are discussed as well, relative to setting exposure standards. The paper begins with a brief discussion of the ways in which behavioural end points are investigated in the laboratory, together with some of the methodological considerations pertinent to such studies when radio frequency (RF) exposure is involved. It has been pointed out by several sources that exposure to RF radiation can lead to changes in the behaviour of humans and laboratory animals that can range from the perceptions of warmth and sound "microwave hearing" to lethal body temperatures. Behaviour of laboratory animals can be perturbed and, under certain other conditions, animals will escape and subsequently avoid RF fields; but they will also work to obtain a burst of RF energy when they are cold. Changes of cognitive function (memory and learning) following RF exposure in humans and laboratory animals have been reported in the scientific literature. Mostly, these are thermally mediated effects, but other low level effects are not so easily explained by thermal mechanisms. The phenomenon of behavioural disruption by microwave exposure, an operationally defined rate decrease (or rate increase), has served as the basis for human exposure guidelines since the early 1980s and still appears to be a very sensitive RF bioeffect. Nearly all evidence relates this phenomenon to the generation of heat in the tissues and reinforces the conclusion that behavioural changes observed in RF exposed animals are thermally mediated. Such behavioural alteration has been demonstrated in a variety of animal species and under several different conditions of RF exposure. Thermally based effects can clearly be hazardous to the organism and continue to be the best predictor of hazard for humans. Nevertheless, similar research with man has not been conducted. Although some studies on human perception of RF exist, these should be expanded to include a variety of RF parameters.

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Annex K – HUMAN EFFECTS OF ELECTRO-MUSCULAR DEVICES (EMD)

K.1 ELECTRICAL FENCE HISTORY

The Underwriter Lab Investigation [1] of electrical fences extended over three years and included a survey of medical electric shock research, special shock tests, and field investigations of the use of fences and accidental contacts. As a result, electrified fences were approved as safe provided they operated in bounds of current level and time duration specified for both continuous and pulsed modes. The levels specified are comparable in value to the TASER® output for the pulsed mode but of lower frequency so that a person making accidental contact can free himself between pulses.

K.2 ELECTRONIC GUN INJURIES

In a study titled "Electronic Gun (Taser) Injuries" 218 patients who had been "tasered" by the police were compared with 22 shot with conventional handguns [2]. The long-term morbidity rate was significantly less for tasered individuals (0 %) that for those with bullet wounds (50 %) ($P < .05$). The mortality rate was also significantly lower for tasered persons (1.4 %) that for gunshot wound victims (50 %) ($P < .05$). Possible complications associated with Taser wounds included contusions, abrasions, and lacerations (38 %), mild rhabdomyolysis (1 %), and testicular torsion (0.5 %).

K.3 CARDIAC SAFETY OF HIGH VOLTAGE TASER X26 WAVEFORM

This section is based on a report by Max Nerheim, Robert Stratbucker, M.D., Ph.D., & P.E., as modified by Dr. Dieter Reimann.

K.3.1 Introduction

The use of any device as a less-lethal weapon carries with it some degree of risk to the subject being controlled. This risk, however, must be compared to the risk associated with the use of traditional weapons including firearms, batons, impact weapons, chemical sprays, and physical restraint techniques. With the application of an electrical incapacitation weapon, the principal risk had been thought to be the induction of ventricular fibrillation in the subject [3]. In this study, the authors purposely attempted to create the highest risk scenarios they could envision in real-life field settings and still failed to induce ventricular fibrillation with the external application of high voltage emissions in experimental animals of body habitus comparable to adult humans with stimulating waveforms up to 15x the intensity of the commercial TASER X26.

K.3.2 Methodology

Following approval of the Animal Use Committee, ten domestic swine of several breeds and both sexes, were randomly selected from a much larger pool to span a spectrum of weights (30 and 117 Kg, (66 to 258 pounds)) and ages (9 months to 5 years). Unassisted endotracheal ventilation under 2% Halothane anaesthesia was supplemented with 3 litre/minute oxygen. Most pigs occupied a full day of testing.

The high voltage pulses were administered using carefully controlled "maximum susceptibility" experimental scenarios in every animal. To accomplish this goal, the pulse delivery probes were placed on the previously identified sensitive areas of the thorax.

K.3.3 Ohmic vs. Arcing Contact with the Skin

In the measurements, they found that the peak currents in arcing mode were not substantially higher than in direct contact. In fact, the measurements showed that the total charge per pulse delivered in arcing mode was less than the charge per pulse using direct contact. Specifically, they found no significant difference in cardiac electric *safety margin* between arcing (plasma coupling) and non-arcing (ohmic coupling) cutaneous contact conditions. In order to quantify a *safety margin*, the stimulation waveform was adjusted to 100% of the electrical output of the standard, commercially available TASER X26.

K.3.4 Application

During the application of the TASER X26 waveform in the standardized electrode configuration the heart rate and blood pressure remain unaffected.

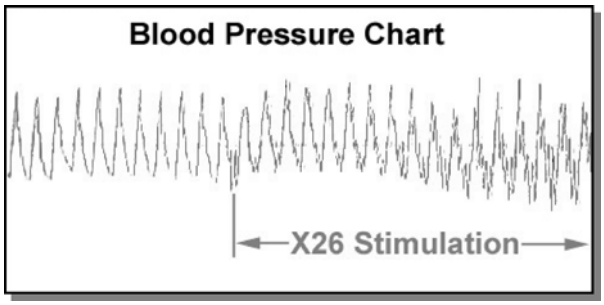

Figure K-1: Blood Pressure following X26 TASER Stimulation.

From the recording, it can be seen that the heartbeat continues completely unchanged during the stimulation. The tiny, hash-like fluctuations in the reading of the blood pressure that abruptly appear with the activation of the high voltage excitation are caused by the mechanical contractions of the skeletal muscles, reinforcing that the high voltage pulses from the TASER X26 were indeed emitting supra-threshold neuromuscular stimuli. Proof is provided that the stimulation intensity is below that of the ventricular fibrillation threshold. Moreover, the TASER X26 stimulation intensity is below the pacing threshold level. Supra-threshold pacing pulses would likely evoke an occasional paced beat of the heart.

Other physiologic variables being equivalent, paced beats have a significantly lower stimulus threshold than does the induction of ventricular fibrillation.

K.3.5 Fibrillation Threshold

To find the actual fibrillation threshold of pulses similar to the TASER X26® pulse, the stimulation intensity of the TASER test pulses was then increased step-wise from 2x (two times) to a maximum of 48x of the baseline until fibrillation was induced. The tests were run with a 5-second duration of 19 pulses per second discharge across the chest.

The safety margin was calculated using the threshold measurement methodology of Werner Irnich [4], namely the threshold was calculated using the arithmetically averaged value of the lowest fibrillatory and the highest non-fibrillatory pulse. The safety margin is expressed as a multiple of the standard TASER X26 stimulation in terms of the value of the stimulating capacitors. Hence, a 42x safety margin indicates a threshold of

fibrillation was found at 42 times the simulating capacitance of the standard TASER X26. There was a consistent increase in safety margin associated with increased body mass (Figure K-2).

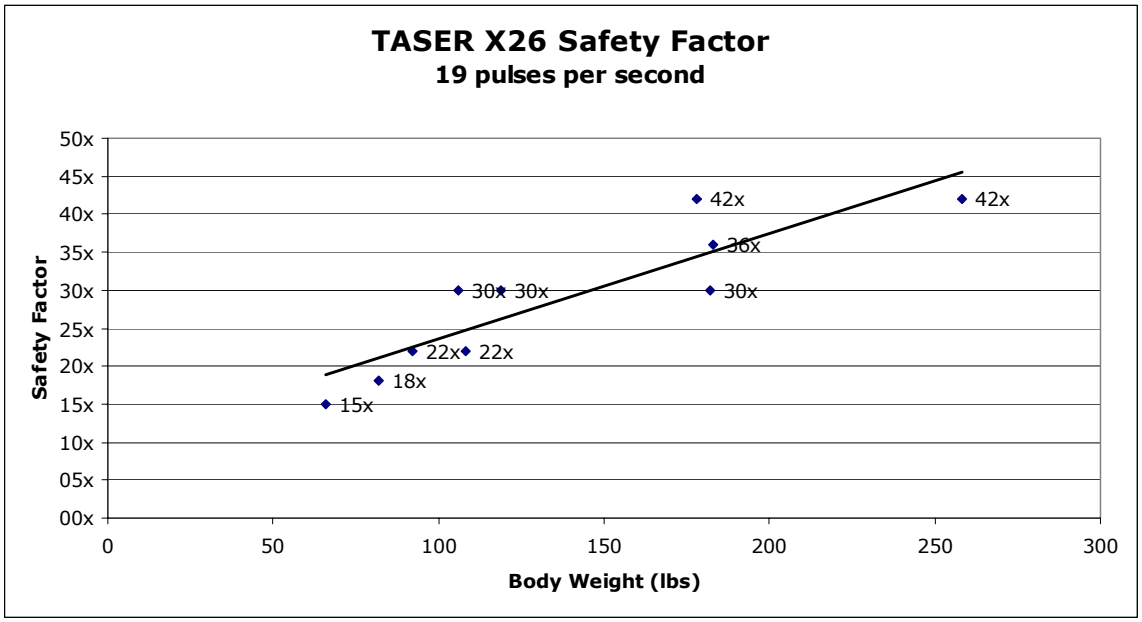

Figure K-2: Safety Factor of TASER X25 Related to Body Weight of Subject.

Recalling that the electrodes were always placed in the "most sensitive" positioning for cardiac stimulation, a safety margin of 20x would therefore exist for normal human adults of bodyweight greater than 100 pounds. The safety margin appears to be even greater than 20x for field applications because the "most sensitive" precordial electrode positioning would be extremely unlikely to occur as an accident of usage**.**

K.3.6 Safety Margin

As noted, the stimulation rate used in the cardiac safety margin experiments employed a constant pulse rate of 19 pulses per second. We were subsequently able to establish that decreasing the pulse rate further increased the safety margin as shown in Table K-1.

Table K-1: Safety Margin vs. Pulse Rate per Second (pps) in Pigs

Body Weight [lbs]	**19 pps** Safety Margin	**15 pps** Safety Margin	**10 pps** Safety Margin
66	15x	34x	
82	18x	52x	
92	22x	32x	95x
106	30x		80x
108	22x	26x	66x
119	30x		53x

The commercial version of the X26 generates a variable pulse rate that drops from 19 to 15 pulses per second after 2 seconds of operation, a design feature that promises to further increase the TASER X26 safety margin for routine field use.

Finally, the pulse characteristics of the TASER X26 were compared to those of the ADVANCED TASER M26, a popular unit currently in use at over 3,000 police agencies. The output current comparison in Table K-2 shows the TASER X26 output current is significantly less than the ADVANCED TASER M26.

Table K-2: Current Output Characteristics of X26 vs. M26

	Current per Pulse [microcoulombs]	Typical Pulse Frequency [pulses/second]	Average Current [milliamps]
ADVANCED TASER M26	182	20	3.6
TASER X26	112	19	2.1

K.3.7 Conclusion

An animal model for assessing the cardiac safety factor of an emerging class of high voltage, short duration, pulse train transcutaneous stimulators as incapacitation weapon has been developed and tested using pulse train induced ventricular fibrillation as the critical end point.

Of the various technical factors associated with electrical pulse train characteristics and their physiological consequences in a reasonable humanesque porcine surrogate model, the factors having the most critical influence on the initiation of a potentially lethal outcome of the application of such electrical pulse train to an anaesthetised animal are the pulse waveform intensity and pulse repetition rate.

By judicious selection of the electronic circuits and the various parameters controlling such circuits, it is possible to maximize a numeric safety factor for the use of such devices in beneficial ways and at the same time ensure that the *safety margin* is not less than that of other acceptable risks. In the analysis of the data from these experiments, the *safety margin* exceeds 20x for a normal human adult. Further, a safety margin of 15x was found for subjects with body weights similar to children and adolescents.

The risk of inducing ventricular fibrillation by the surface application of a TASER X26® to a human subject is highly improbable.

K.3.8 Some Remarks

In a ©1999 TASER® International folder the table of specifications name for the M26, Model No. 44000 an Amperage of 162 mA and a Pulse Energy of 1.76 J. Compared with Table K-2 above the value "162 [mA]" compares better with 182 [micro coulombs] Current per Pulse. But what about the Average Current of 3.6 mA? So presentation and interpretation of data and effects is confusing and difficult.

"The Air TASER® has the highest, measurable, real voltage of any stun device on the market, 50.000 Volts. Voltage tells how far the spark will jump and how much clothing the stun device can penetrate, if the spark must jump through fabric. This is the only true benefit from high voltage. Amperage and power determine how strong the pulse feels." Power in this text is used for "voltage"!

In order to measure the peak voltage of a stun device, simply measure the distance that the spark jumps when you activate the stun gun into the air. The thumb rule is 30.000 volts per inch. For example, the distance is 0.3 inches, so the maximum voltage is 0.3 inches x 30.000 Volts = 9.000 Volts. The Air TASER® actual peak voltage is given with 50.000 Volts, so the spark will jump over a distance of 1.66 inches (4.2 cm).

"The intrinsic pulse repetition rate was fixed at 19 pulses per second for all experiments. This is for the critical reason that our earlier muscle tension efficiency tests repeatedly showed the TASER X26® waveform achieving complete tetanus of pig skeletal muscle at repetition rates as low as 19 pulses per second. In other words, little was to be gained in strength of contraction, and something could be lost in cardiac safety margin when using pulse repetition rates in excess of 20 pps."

"Some older TASER® model was programmed with a pre-programmed timing cycle in light of the potential for respiratory interruption. The unit automatically provides four one second pauses during each 30 second discharge to allow the subject to breathe. Hence, the four one second breaks allow the target to take four full breaths every 30 seconds, minimizing the risk of anoxia. However, interruption of respiration for a full 30 seconds poses little health risk."

The new TASER® models are programmed with a pre-programmed timing cycle limited to 5 seconds each. The trigger has to be down again for another cycle.

Huge amounts of subcutaneous fatty tissue may deter the electric impact of the incapacitating device on the neuro-muscular groups of a body, even if the probes have made proper contact on the thorax and the trigger is pulled for 30 seconds. This could result in failure of complete incapacitation [5]. Subject may be affected, but still able to stand and move.

K.3.9 Suicide Bombers

The growing frequency of suicide bomb attacks not only in the Middle East raises the question, how explosives would react when exposed to an electro-incapacitating device. This might be the desirable weapon,

especially in crowded areas like market places, bus stops, cafés, or inside tubular structures such as aircraft, trains, or buses, where handguns cannot be fired without endangering bystanders or the vehicle. Explosives are often concealed in hand-tailored vests, prostheses, or carried in handbags or backpacks. Because of self-protection purposes it is important for police and military personnel to know, how the explosives carried by suicide bombers will react when tasered.

The following information was developed by Setracon Inc. [6] and presented at the 2003 TASER Tactical Conference, Orlando, May 10 & 11. Before applying the M26 Taser in this mode agencies and individuals should conduct their own testing to confirm this results. The paper intends to demonstrate the effect of the M26 Law Enforcement Taser when utilized against a person carrying explosives for malevolent purposes such as suicide bombers. This research is intended to substantiate that an M26 Taser can be used successfully against an individual packing explosives. Other explosive situations where a Taser may be utilized are limitless, however, they will result from First Responder reactions to a situation where utilization of a firearm may cause detonation, for example the inability of the First Responder to place a precision shot eliminating the ability of a terrorist to depress an actuator or inadvertently setting off the explosive through the shock of bullet impact. A suspected belt bomber will use commercial or military explosives for reasons of explosive stability with an electric initiation system. The Taser M26 will always produce 50,000 volts, 26 watts, at 162 milliamps if it is functioning correctly.

The author has proven with his video-taped experiments that tasering commercial explosives probably used by suicide bombers with the M26 Taser is possible without endangering the police or military user or the bystanders.

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Annex L – HUMAN EFFECTS OF MILD, NON-LETHAL TRAUMA

1) The importance of defining terms when assessing the effects of mild trauma is illustrated in an article by Elliot J. Pellman (Pellman 2003). Dr. Pellman wrote:

"In 1994, as the associate team physician and internist for the New York Jets, I was responsible for the diagnosis and treatment of concussions. I had been with the New York Jets since 1987, having trained as an internist and rheumatologist. Although published information existed, most of what I, like other team physicians, knew about concussions was from on-field anecdotes passed on from other team physicians and athletic trainers who had been treating professional football players for many years. During my years of medical school, internal medicine training (including an extra year as chief medical resident), and fellowship, from 1975 to 1986, I had never received a single lecture on concussions. As I learned later, this was typical of physician training for what was then an often under-diagnosed and little-understood clinical condition.

Al Toon, a Pro Bowl receiver for the New York Jets, had been with the team since 1985, after playing college football at the University of Wisconsin. As a player for the New York Jets, Mr. Toon was recognized as one of the finest receivers in the National Football League. From the beginning of his professional career, Mr. Toon began to incur what we now recognize as concussions. These dings, as they were referred to then, were minor, often causing no more than mild headaches and some dizziness. Unrecognized by everyone, including me, these concussions began to worsen in the later years of his career. Mr. Toon began to experience severe headaches, malaise, intolerance of loud noises, depression, and emotional labiality after what were viewed as mild, inconsequential blows to the head. Mr. Toon was experiencing what we now call post-concussion syndrome, which would eventually lead to the premature retirement of this great athlete in 1992. He was the first documented NFL player that I know of to retire as a result of this problem.

Mr. Toon's retirement, which received some attention in the public news media but none in the medical world, was overshadowed by the injury to Dennis Byrd, a defensive lineman who sustained a fracture of the cervical spine while also playing for the Jets. It was not until the following year, when another NFL player, Merrill Hoge, a player for the Pittsburgh Steelers, was also forced to retire because of post-concussion syndrome, that both medical personnel and football executives took notice. Shortly after the retirement of Mr. Hoge, NFL Commissioner Paul Tagliabue began to inquire about this medical issue. On the basis of my experience with Mr. Toon, I was invited to the Commissioner's office to offer my limited insight into this problem. The Commissioner and I realized that we had many, many more questions than answers. Was this a new problem or just an often misdiagnosed or unrecognized one? Was the premature retirement of these men a statistical anomaly or the beginning of an epidemic? I was asked to mount an effort to answer these questions.

During my treatment of Mr. Toon, I quickly realized how few experts and how little prospective, scientific medical information were available regarding concussions. I decided that a novel approach would be necessary to gather information, particularly for a professional sports league, and with the encouragement and support of Commissioner Tagliabue, in 1994 I formed the NFL Committee on Mild Traumatic Brain Injury. This committee was composed of experts from inside and outside the NFL, consisting of team physicians, team athletic trainers, a team

equipment manager, a neurologist who had considerable previous clinical experience with boxers, a neurosurgeon who had experience in treating NASCAR drivers, a neuropsychologist who was a pioneer in using neuropsychological testing to evaluate athletes, a biomechanical engineer to help us understand safety equipment, and an epidemiologist.

It became apparent to the committee that there was no single accepted definition of concussion and that, if we were to begin asking questions regarding the problem, we would need a single definition that would be used league-wide by the medical staffs of all the teams. The first several months of meetings were dedicated to defining concussion, or as we quickly decided, the more academically appropriate term, mild traumatic brain injury, which is more commonly referred to as MTBI. After a great deal of discussion, we decided that our definition would be broad, realizing that we would rather over-identify injuries than potentially exclude milder ones. A reportable MTBI was defined as a traumatically induced alteration in brain function that is manifested by 1) alteration of awareness or consciousness, including but not limited to loss of consciousness, ding, sensation of being dazed or stunned, sensation of wooziness or fogginess, seizure, or amnesic period; and 2) signs and symptoms commonly associated with post-concussion syndrome, including persistent headaches, vertigo, light-headedness, loss of balance, unsteadiness, syncope, near-syncope, cognitive dysfunction, memory disturbance, hearing loss, tinnitus, blurred vision, diplopic, visual loss, personality change, drowsiness, lethargy, fatigue, and inability to perform usual daily activities.

Once there was agreement on the definition of MTBI, we quickly realized that the first order of business was to gather information, in the knowledge that this would need to be a meticulous and lengthy process, and to educate and sensitize the League's medical and coaching staff to this medical problem. With the help of the epidemiologist on the committee, we devised a questionnaire that team physicians and trainers would be required to fill out after a player sustained an MTBI. A memo was sent to the physicians, athletic trainers, and team executives by the Commissioner emphasizing the importance of this information and mandating compliance in filling out these detailed forms.

After there was agreement on the form and a basis for collecting MTBI data, the committee decided to begin to examine the available safety equipment. Many team physicians had similar experiences with regard to the sales personnel of helmet manufacturers, who made claims about helmets and their potential to decrease the risk of MTBI. Players and medical staff were told to increase the air in the inflatable bladders in the helmets or to change the type of helmet to reduce the risk of MTBI. When manufacturers were invited to present the scientific data to support these claims, it became apparent to the committee members that these claims were not based on scientific data but rather were sales pitches made by over zealous salespeople.

Contacts with representatives and biomechanical engineers of the National Operating Committee on Standards for Athletic Equipment additionally made it obvious to the committee that the testing methods used to quantify football helmet head protection were unable to predict the amount of protection afforded to prevent MTBI. Furthermore, this lack of understanding of the physics and biomechanics of the injury was retarding helmet manufacturers from making changes to helmets that could lead to greater MTBI protection.

After lengthy discussion and many committee meetings, it was decided that the committee would recommend to Commissioner Tagliabue that the NFL should independently fund scientific

research that would enable scientists to better understand the cause(s) of MTBI; that this research should be funded to independent scientific researchers; and that the NFL Mild Traumatic Brain Injury Committee should be charged with oversight of the project. It was also decided that all research results would be given to the National Operating Committee on Standards for Athletic Equipment, to helmet manufacturers, and to as many researchers and clinicians as possible in an attempt to promote a better understanding of MTBI and methods that might, directly and indirectly, prevent and treat these injuries.

From the current perspective, the enormous investment in research on MTBI is paying dividends in an improved understanding of the causes and prevention of the injury. Although much more research is needed, the results of the committee's research thus far will be presented as a series of articles in Neurosurgery. The intention is now, as it was originally, to contribute scientific articles on the NFL's research on the biomechanics of concussion, the epidemiology of the injury, its symptoms and treatment, neuropsychological evaluations, and other aspects of MTBI. Thanks to the support of the NFL, NFL Charities, owners, executives, team medical staffs, players, and committee members, the NFL's approach to funding scientific research on the problem is a model for the approach needed by other sport leagues when medical issues of player health and safety emerge."

2) It is important to consider the psychological response to NLTs as well as the physiological and physical response. Three articles are reprinted to provide a background for psychological response to trauma. The first is titled "Common Reactions to Trauma," by Edna B. Foa, Elizabeth A. Hembree, David Riggs, Sheila Rauch, and Martin Franklin, of the Center for the Treatment and Study of Anxiety, Department of Psychiatry, University of Pennsylvania. They write:

"A traumatic experience produces emotional shock and may cause many emotional problems. This handout describes some of the common reactions people have after a trauma. Because everyone responds differently to traumatic events, you may have some of these reactions more than others, and some you may not have at all. Remember, many changes after a trauma are normal. In fact, most people who directly experience a major trauma have severe problems in the immediate aftermath. Many people then feel much better within three months after the event, but others recover more slowly, and some do not recover enough without help. Becoming more aware of the changes you've undergone since your trauma is the first step toward recovery. Some of the most common problems after a trauma are described below:

Fear and anxiety. *Anxiety is a common and natural response to a dangerous situation. For many it lasts long after the trauma ended. This happens when views of the world and a sense of safety have changed. You may become anxious when you remember the trauma. But sometimes anxiety may come from out of the blue. Triggers or cues that can cause anxiety may include places, times of day, certain smells or noises, or any situation that reminds you of the trauma. As you begin to pay more attention to the times you feel afraid you can discover the triggers for your anxiety. In this way, you may learn that some of the out-of-the-blue anxiety is really triggered by things that remind you of your trauma.*

Re-experiencing of the trauma. People who have been traumatized often re-experience the traumatic event. For example, you may have unwanted thoughts of the trauma, and find yourself unable to get rid of them. Some people have flashbacks, or very vivid images, as if the trauma is occurring again. Nightmares are also common. These symptoms occur because a traumatic experience is so shocking and so different from everyday experiences that you can't fit it into

what you know about the world. So in order to understand what happened, your mind keeps bringing the memory back, as if to better digest it and fit it in.

Increased arousal is also a common response to trauma. *This includes feeling jumpy, jittery, shaky, being easily startled, and having trouble concentrating or sleeping. Continuous arousal can lead to impatience and irritability, especially if you're not getting enough sleep. The arousal reactions are due to the fight or flight response in your body. The fight or flight response is the way we protect ourselves against danger, and it occurs also in animals. When we protect ourselves from danger by fighting or running away, we need a lot more energy than usual, so our bodies pump out extra adrenaline to help us get the extra energy we need to survive. People who have been traumatized often see the world as filled with danger, so their bodies are on constant alert, always ready to respond immediately to any attack. The problem is that increased arousal is useful in truly dangerous situations, such as if we find ourselves facing a tiger. But alertness becomes very uncomfortable when it continues for a long time even in safe situations. Another reaction to danger is to freeze, like the deer in the headlights, and this reaction can also occur during a trauma.*

Avoidance is a common way of managing trauma-related pain. *The most common is avoiding situations that remind you of the trauma, such as the place where it happened. Often situations that are less directly related to the trauma are also avoided, such as going out in the evening if the trauma occurred at night. Another way to reduce discomfort is trying to push away painful thoughts and feelings. This can lead to feelings of numbness, where you find it difficult to have both fearful and pleasant or loving feelings. Sometimes the painful thoughts or feelings may be so intense that your mind just blocks them out altogether, and you may not remember parts of the trauma.*

Many people who have been traumatized feel angry and irritable. If you are not used to feeling angry this may seem scary as well. It may be especially confusing to feel angry at those who are closest to you. Sometimes people feel angry because of feeling irritable so often. Anger can also arise from a feeling that the world is not fair.

Trauma often leads to feelings of guilt and shame. Many people blame themselves for things they did or didn't do to survive. For example, some assault survivors believe that they should have fought off an assailant, and blame themselves for the attack. Others feel that if they had not fought back they wouldn't have gotten hurt. You may feel ashamed because during the trauma you acted in ways that you would not otherwise have done. Sometimes, other people may blame you for the trauma. Feeling guilty about the trauma means that you are taking responsibility for what occurred. While this may make you feel somewhat more in control, it can also lead to feelings of helplessness and depression.

Grief and depression are also common reactions to trauma. This can include feeling down, sad, hopeless or despairing. You may cry more often. You may lose interest in people and activities you used to enjoy. You may also feel that plans you had for the future don't seem to matter anymore, or that life isn't worth living. These feelings can lead to thoughts of wishing you were dead, or doing something to hurt or kill yourself. Because the trauma has changed so much of how you see the world and yourself, it makes sense to feel sad and to grieve for what you lost because of the trauma.

Self-image and views of the world often become more negative after a trauma. You may tell yourself, "If I hadn't been so weak or stupid this wouldn't have happened to me." Many people see themselves as more negative overall after the trauma ("I am a bad person and deserved this."). It is also very common to see others more negatively, and to feel that you can't trust anyone. If you used to think about the world as a safe place, the trauma may suddenly make you think that the world is very dangerous. If you had previous bad experiences, the trauma convinces you that the world is dangerous and others aren't to be trusted. These negative thoughts often make people feel they have been changed completely by the trauma. Relationships with others can become tense and it is difficult to become intimate with people as your trust decreases.

Sexual relationships may also suffer after a traumatic experience. Many people find it difficult to feel sexual or have sexual relationships. This is especially true for those who have been sexually assaulted, since in addition to the lack of trust, sex itself is a reminder of the assault.

Some people increase their use of alcohol or other substances after a trauma. There is nothing wrong with responsible drinking, but if your use of alcohol or drugs changed as a result of your traumatic experience, it can slow down your recovery and cause problems of its own.

Many of the reactions to trauma are connected to one another. For example, a flashback may make you feel out of control, and will therefore produce fear and arousal. Many people think that their common reactions to the trauma mean that they are "going crazy" or "losing it." These thoughts can make them even more fearful. Again, as you become aware of the changes you have gone through since the trauma, and as you process these experiences during treatment, the symptoms should become less distressing.

3) The second example of the psychological response to trauma is by Jessica Hamblen, Ph.D. and is titled "The Oklahoma City Bombing." See (Hamblen 2003) and references therein. She writes:

"Almost half of the survivors directly exposed to the blast reported developing problems with anxiety, depression, and alcohol, and over one third of these survivors reported Posttraumatic Stress Disorder (PTSD). People who reported trying to avoid reminders of the bombing and who felt numb afterwards were more likely to develop PTSD and other disorders than people who did not avoid and were able to experience a range of emotions. Predictors of PTSD, anxiety, and depression included more severe exposure, female gender, and having a psychiatric disorder before the bombing (North et al. 1999)).

Over a year after the bombing, Oklahomans reported increased rates of alcohol use, smoking, stress, and PTSD symptoms as compared to citizens of another metropolitan city (Smith, Christiansen, Vincent, & Hann, 1999).

In a group of adults who sought mental-health services, being nervous and being upset by how other people acted when the bombing occurred were predictive of PTSD (Tucker et al. 1997)).

Children who lost an immediate family member, friend, or relative were more likely to report immediate symptoms of PTSD than children who had not lost a loved one (Pfefferbaum et al. 1999)).

Two years after the bombing, 16% of children and adolescents who lived approximately 100 miles from Oklahoma City reported significant PTSD symptoms related to the event (Pfefferbaum et al, 2000). This is an important finding because these youths were not directly exposed to the trauma and were not related to victims who had been killed or injured. PTSD symptomatology was greater in those with more media exposure and in those with indirect interpersonal exposure, such as having a friend who knew someone who was killed or injured (Pfefferbaum et al. 2000)).

4) The third example of how NLTs may affect is a fact sheet by (Monson 2003) can be found at as A National Center for PTSD Fact Sheet at. Dr. Morgan writes:

"Veterans, like other individuals, respond to traumatic situations in a variety of ways. Veterans are responding to the recent terroristic disaster in a manner similar to all Americans. They feel concern, anger, fear, and helplessness, which are all normal responses to an abnormal event. However, research indicates that people who have previously survived traumatic events may be particularly sensitive to the effects of later traumatic events such as terroristic acts and war. In general these events can cause a range of symptoms from general distress to an increase in PTSD symptoms, irritability, anger, alcohol and substance use, sensitivity to military stimuli, sleep disturbance, and avoidant/phobic reactions. Some individuals might anticipate and prepare for the worst possible future circumstances so they are not retraumatized by a subsequent shock. Studies of a recent American terroristic situation and of a recent military situation have provided information about some of the effects such events have on veterans.

Following the Oklahoma City bombing, some veterans of World War II, the Korean War, and some of those in the war during the Vietnam era reacted by experiencing the following more than they had before the bombing: (1) More frequent military and homecoming memories; (2) Depressed mood; (3) General distress; and (4) Posttraumatic Stress Disorder (PTSD) symptoms.

Veterans with PTSD may be particularly susceptible to reactivation or a worsening of their PTSD symptoms if re-exposed to military situations.

During the Gulf War: Vietnam veterans followed media coverage of the Gulf War closely and reported that the coverage brought back thoughts and feelings of Vietnam.

The reactivation or worsening of PTSD symptoms experienced by some veterans may have been related to similarities in the traumatic experiences (e.g., planes were a major part of both events). Situations that have high emotional or symbolic value, such as veteran gatherings or American symbols, also can reactivate or worsen PTSD symptoms."

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Annex M – MEDICAL ASPECTS OF THE MOSCOW THEATRE HOSTAGE INCIDENT

M.1 INTRODUCTION TO THE MOSCOW THEATRE HOSTAGE INCIDENT

In Moscow on **Wednesday** October 23, 2002, at about 21:00 more than 800 people were taken captive by some 50 Chechen rebels in the 1,100 seat "North-East"[1]-musical theatre. Only a few actors and theatre workers managed to escape. Dressed in camouflage and equipped with firearms, the rebels drove up with three cars, entered the theatre during the second intermission, and proceeded to the stage shouting: "We are Chechens, we are at war here!" They called themselves the "29. Suicide Division".

All but the commander, Movsar Barajew, wore black masks, had handguns, and wires and switches to large quantities of explosives around their waists. Thirty-two men and eighteen women hurried to deposit about thirty packages of explosives at the pillars and in the middle of Row 15 inside the theatre. The rebels threatened to kill everyone inside the theatre unless Russia ended the war in Chechnya. A female musician down in the orchestra, who argued, was executed immediately. Although the Chechen militants agreed to release some of the hostages (children under age 13, foreigners, and a pregnant woman) during the first couple of days, there were no attempts at negotiation by the Russian authorities.

Thursday, October 24, Al Dshasira broadcasted a typical "confessor video" of the hostage takers, which gave President Putin the possibility, to declare them "international terrorists".[2] The occupiers carried a mobile TV and a Laptop, so they had access to news reporting and other information from outside the theatre.

On Friday, October 25, U.S. President George W. Bush, in the company of a host of foreign leaders, offered firm support to Vladimir Putin during the hostage crisis. Bush telephoned Putin and offered unspecified help in freeing the hostages.[3] On that same day, representatives of the U.S. special services met with a deputy director of the FSB to discuss the situation. Representatives of the special services of Great Britain, Germany, Turkey, France, Switzerland, and Japan also attended this meeting[4]. At 10:40 p.m. that same evening, "the head of the MVD of Russia, Boris Gryzlov, and the director of the FBI, Robert Muller, agreed to work together under a regime of constant communication. Muller proposed to send to Moscow American specialists on antiterrorist activity and specialists in the sphere of using special technical means"[5].

M.1.1 The Rescue Begins

On Saturday, October 26, at 5:20, 40 minutes before expiration of their last ultimatum, the terrorists began to shoot more hostages[6].

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[1] "North-East" is a romantic musical playing during Soviet days, the theater is situated in Dubrovka, suburb of Moscow, 5 km from the Kremlin.

[2] ARD-Studio Moskau 2002.

[3] Chechnia Weekly, Vol. 3, Issue 32, October 28, 2002.

[4] Polit.ru, October 26, 2002.

[5] Newsru.com, October 26, 2002.

[6] Theater of War: Yuri Zarakhovich/Moscow ©TIME: August 25, 2003: Olga Chernyak, a journalist who was among the hostages.

Just after 5:30 a.m., Anya Andrianova first noticed the strange smell inside the theatre. Like most of the other hostages and many of the Chechen terrorists holding them captive, she was sprawled across an auditorium seat trying to get some sleep. Alarmed by the odour, she spotted gas, eerily visible as it seeped through the air-conditioning vents and rose from the floor. Terrified that the assault on the theatre had begun, Andrianova's friend used her mobile phone to call Ekho Moskvy's early morning radio show. "They are gassing us!" she screamed, her voice shrill with panic. "All the people are sitting in the hall. We beg not to be gassed!" Taking the phone from her friend, Andrianova pleaded with the host "We see it, we feel it, we are breathing through our clothes. Please give us a chance. If you can do anything, please do." A moment later radio listeners heard gunshots, and then Andrianova screamed: "That's it! We are all going to be blown up. Our government has decided no one should leave here alive."[7]

Another hostage later gave evidence that she saw "a terrorist sitting on the stage jumping up and trying to put on an NBC mask. He cramped, fainted and went down".[8] "Than I noticed that everybody around me relaxed and started snoring."

An unidentified anaesthetic "gas" was used and the hostage takers inside the hall were unable to act or to ignite their explosives. Another lucky reason for the failure of the terrorists to act might be that 5 of the leaders at that moment were in the first-floor stage-control-room watching the video recorded by the permanent camera in the theatre of their hostage taking on Wednesday. So, perhaps, nobody was in the hall to give orders to ignite the explosives.[9] The "North-East"-Musical Director said the terrorists liked the musical; maybe he talked them into watching it on video.

At 6:23 a.m., uniformed forces smashed through the theatre's glass front, stormed the theatre without wearing NBC masks, and began igniting flash-bang grenades[10]. In the Newspapers and media, different groups were named: ALPHA Antiterrorist Specialists[11], Russian Special Forces[12], Russian Special Police Units[13], nd Spetsnaz-Soldiers[14]. (Identification of those involved is important for legal reasons.)

Within 7 minutes, the rescuers shot most of the terrorists who had not been affected by the gas, including their 27-year-old commander, Movsar Barayev, and those were anaesthetized; only 3 terrorists lived to be arrested[15].

About thirty explosives, among these a 50 kg TNT bomb, were found in row 15 in the middle of the hall. Later it was stated that the terrorists had brought in over two tons of various explosives, but there is no firm evidence that the packages were indeed loaded with explosives at all.

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[7] Theater of War: Anya Andrianova and her girlfriend called the Moscow breakfast-radio Ekho Moskvy. ©TIME: August 25, 2003.

[8] Der Spiegel, 26.10.2002: Sturm auf das Moskauer Theater.

[9] ARD-Studio Moskau 2002.

[10] arte, 30.09.03, 20:45 – 21:35: "Es waren mehrere Explosionen zu hören."

[11] Der Spiegel, 26.10.2002.

[12] The Pharmaceutical Journal, Vol. 269, 723-724, November 16, 2002.

[13] Center for Nonproliferation Studies (CNS): Moscow Theater Hostage Crisis, November 4, 2002.

[14] Chechnia Weekly, Vol. 3, Issue 32, October 28, 2002 and
Oct. 28, 2002: http://www.timeeurope.com/magazine/2002/1104/cover/story.html

[15] Der Spiegel, 26.10.2002 and ©TIME: Theater of War. August 25, 2003.

M.2 MEDICAL ASPECTS OF THE RESCUE

First impression reports indicated that during their days (58 hrs) of captivity, the hostages were in constant fear for their life, without food or beverages, and in the odour of their own excrement, which had to be deposited in the orchestra pit. After the rescue, a few hostages stumbled out of the building on their own, but most had to be carried out. Unconscious hostages were carried unprofessionally by policemen or soldiers by their hands and feet or like pig-halves over the shoulders or lying on their backs on litters. No resuscitation or intubations were sighted. Many unconscious hostages were deposited without any assistance on the pavement in front of the theatre in the cold and rain, bodies one over another.

Doctors and medics arriving at the scene were not told that the hostages had been gassed, but were not provided with any antidote. The order for ambulances to proceed to the theatre came 45 minutes after the beginning of the operation, the result being that many hostages had to be taken to hospitals in buses, microbuses, or cars. Once loaded, some buses remained in place for over an hour before leaving for medical facilities; no patient assistance was provided during this time. In one case, thirty hostages were put in a twelve-seat military microbus, and a 13 year-old girl was crushed under other bodies in the aisle and died en route. Some 450 of the rescued were sent to 8 different hospitals across the Russian capital and treated.

Few expected the siege to end through diplomacy; the rebels had shown no interest in negotiating, and Putin would not capitulate. The attack on the theatre had all the hallmarks of a typical Chechen operation: daring, ruthlessness, ambitious and totally lacking an exit strategy. The Special Forces had done their work. The theatre was shielded by police and no information was given to the hospitals, to the relatives, or to the public. President Putin was seen on TV in a white smock in a hospital and showed his emotion.

Not only the refusal to negotiate but the nature of the rescue effort suggested that the storming of the theatre was undertaken to destroy the terrorists for political reasons, and that saving the lives of the hostages had a low priority. Although the Moscow health authorities had days to prepare for the aftermath of the rescue, over one hundred persons who died from “gas poisoning” or other causes could have been saved if the rescue effort had been properly organized.[16]

First Aid and rescue chain Problems: Primary care, resuscitation, ventilation, infusions, administration of antidotes, transportation, and intensive care seem to have been excluded from operational planning. The traditional “casualty categories,” could have adapted and used. he sequence is normally (1) Determine Priority of Treatment; (2) Triage; and (3) Transportation. Especially in a Mass Casualty Scenario, triage and actual stating the Priority of Treatment on site are fundamental procedures and have to be carried out by the most experienced physician on site. A mass casualty situation may be defined as a situation in which the number of casualties presenting cannot be managed by normal methods and facilities. As a consequence, medical triage is done to ensure that “as many patients as possible will get the treatment as needed in time, and at the right place”. The agreed NATO categorisation of casualties is (according to STANAG 2879):

- Group 1: Immediate Treatment: Provide acute emergency life saving therapy; overcome respiratory obstruction; ventilate; restore heart action; give i.v. infusion; place in stabilized resting position.
- Group 2: Delayed Treatment: For those who can tolerate it, delay special treatment such as time-consuming major surgery; stabilize respiration and heart action; stop haemorrhaging; administer i.v. fluids; splint; provide pain relief; provide transportation to an adequate treatment facility.

[16] David Satter: Center for Citizen Initiatives: A Letter from Moscow, Summer 2003.

- Group 3: Minimal Treatment: For those with relatively minor injuries who can effectively care for themselves or who can be helped by untrained personnel; carry to waiting area; provide calming reassurance.
- Proper preparations for the rescue (Mass Casualty Management) should have been done according to the preview of the possible scenarios within the tactical plan. Preparation of medical rescuers and medical teams with suitable supplies of antidotes is essential. The Medical Services of the Forces and their logisticians, could have organised the necessary medical facilities nearby the theatre. Hundreds of physicians and qualified medical assistants could have been readied, and if deemed safe, rushed into the theatre for first aid and resuscitation, at least two per person in the auditorium.

In case of explosions and damage to the theatre, transportation lines had to be cleared. Special search and rescue teams with trained dogs and electronic devices should have been in close vicinity. Mobile intensive care facilities should have been arranged nearby in a protected area with hundreds of places prepared for qualified antidote therapy, resuscitation, and first surgical treatment.

Facing an emergency situation involving more than 800 persons would have needed an intensive preplanning and the will to put it in action.

In Moscow there was no rescue chain organized. Many of the unconscious hostages could have been saved by restoring respiration and putting them into a stabilized resting position. Artificial ventilation could have reduced the effect of the inhaled anaesthetic (see below for further discussion of this point).

M.3 WHAT KIND OF "INCAPACITANT" WAS USED?

M.3.1 Capability

Russian Authorities have declined to identify the substance used in the rescue, so we have had to use the available evidence to deduce the answer. At first common and cheap substances were suspected, knowing about the lack of aesthetic pain relief medication in Russia. So, Nitrous oxide N_2O, Ethylene ($H_2C=CH_2$), Acetylene Narcylen HC≡CH, Cyclopropane (Trimethylene), CO, Aliphatic Halogens and, possibly Cyanide were prime candidates. Nitrous oxide is available in every hospital and most of the other substances are used in industry in Russia. "BZ", 3-quinuclidinyl benzylate, a Belladonna-Alkaloid, could also be a possibility as this substance is a Central Nerve System depressant that appeared to be available on both sides of the iron curtain in the 1950s; however, BZ takes hours to act and, results in delirium for days, and neither of these situations was reported in the Moscow theatre incident.

M.3.2 Eyewitness-Reports and Expert Opinions

Der Spiegel, 26.10.2002, Sturm auf das Moskauer Theatre: Correspondents of French Press Agency AFP: "When we smelled it we lay down on the floor". The "gas" spread over the hall like a fog. "I inhaled through my comforter, fainted for several times and woke up again, as if I had drunken a ton of vodka".

A teacher advised her pupils to inhale through wetted handkerchiefs before she fainted herself.

Kieler Nachrichten (KN) Monday, 28.10.02: 540 hostages suffering from "gas Poisoning" are hospitalised, 329 of them in Hospital Nr. 13.

KN Tuesday, 29.10.02: Vladimir Ryabinin, a physician from the Moscow Sklifosovsky Hospital, confessed[17], that 42 hostages were still treated in intensive care units in danger to life from gas poisoning, but that they really didn't know, what had caused the poisoning. Officially they heard about "sleeping gas," "special gas," or a "substance from the pool of incapacitants."

The Moscow newspaper Komersan suggested the substance could be a product of Cold War times.

KN Tu, 29.10.02, Page 3: Anna Politkowskaja, an observer of the Moscow newspaper The Novaya Gazeta, a specialist on Chechnya, speculated that a High Power Microwave weapon could have been used by the storming forces to disrupt the cell phone, internet connections, and other electrical device of the terrorists.

Der Spiegel, Tu, 29.10.02: Moskauer Geisel-Drama: "Policeman arrested for giving actual information from outside to the Chechens." Police later announced that they had also detained thirty "accomplices" in the area around the theatre and in other parts of the city.

Der Spiegel, 29.10.02: Moskauer Geisel-Drama: US Officials hinted, that "gas" was an opiate.

Die Welt, We, 30.10.02: The Russian Minister of Health, Juri Schewtschenko, released: "To overcome the terrorists a mixture of Fentanyl derivates was used."

Ärzte Zeitung, 30.10.02: In Moskau spricht alles für gängiges Narkosegas: Prof. Thomas Zilker gave the opinion that a common aesthetic had been used. His study of two German hostages found no evidence of cholinesterase inhibition, counter-indicating the use of a nerve agent. Both had recognized a light sweet smell and taste and immediately had fallen in a deep coma and woke up later in a Moscow Hospital.

According to press reports, some hostages in the theatre had died from gas exposure. One source close to the Kremlin said the amount of sleeping agent used was five times the normal dose.

Deutsches Ärzteblatt, 44, 1.11.2003: German expert on terrorism David Schiller estimates it could have been the chemical warfare agent BZ.[18]

Dr. Peter Hutton (The British Association of Anaesthesiologists) says, he doesn't know an anaesthetic that acts like the Moscow substance. "It's for sure a substance developed for military use only."

Western Secret Services too suggest that the Russian special services used a totally new substance that acts within seconds and is not detectable.

arte, 30.09.2003, 20:45 – 21:35: "All people around me fell asleep and started snoring at once."

Der Spiegel, Sa, 26.10.02 Sturm auf das Moskauer Theater: Toxicologists suggest that the "sleeping gas" was made of Valium.[19]

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[17] Kieler Nachrichten Tu, 29.10.02 and Time Europe Monday, August 25, 2003: Theater of War: The Chechens who dared seize a theater in Russia's capital are put down, but their cause is on center stage. BY JOHANNA MCGEARY AND PAUL QUINN-JUDGE/MOSCOW. With reporting by Yuri Zarakhovich/Moscow.

[18] arte (French/German TV), 30.09.03, 20:45 – 21:35: Eyewitness reports the aerosol had a smoky smell. BZ has to be carbonized!

[19] Valium has a much better therapeutic index than Opiate: Schiermeier, Q.: Hostage deaths put gas weapons in spotlight. Nature 2002; 420:7. Nov. 7 2002.

On Sunday, Oct. 27, reports stated it was likely an aesthetic gas, but the physicians in Moscow hospitals suspected chemical warfare agents and administered the common antidotes as used in the army.

Ken Alibek, former soviet expert on chemical warfare: Nobody really believes that Russia destroyed substances that were developed and produced in several chemical warfare programs for military purposes.

Prof. Joel Donchin, Hadassah Ein Karem University Hospital, Jerusalem: "None of the commonly used anaesthetics could have such an effect. A normal anaesthetic never could have been sufficient for such a large number of people in a tall theatre." The use of nerve gas could help to explain the bad condition and outcome of patients.

Leonid Idelmann, Head of the Israeli Association of Anaesthesiologists, assumed a chemical warfare agent too. "From my opinion the gas was based on Acetone." "This could be pointed out by the fact that the hostages immediately lost their consciousness, when the gas entered through the ventilation outlets."

Dr. Thomas Zilker, toxicologist in Munich supposed the gas was Nitrous oxide. "It has to be administered in large amounts to establish high enough concentration in the inner of the hall to cause people to fall into anaesthesia." This opinion matched well with vomiting and relatively quick wake up and relief.

Jan van Aken, Biological and chemical weapons expert in Hamburg, cellular biologist, and founder of the Sunshine-Project thinks none of the deadly well known military nerve gases were used; however, in could have been a new type of military gas. Common medical anaesthetics would have a major dosage problem.

Hansruedi Indermühle, AC Laboratory Spiez, Kanton Bern, Switzerland, thinks it was an aesthetic gas: "Hostages were told to have smelled the gas, and anaesthetic gas smells."

A German NBC expert suspected it was an old warfare agent like a Sarin derivative because many of the hostages were disrobed and recently showered, perhaps for decontamination.

Words of Russian Minister of Health Juri Schewtschenko 4 days after the event, printed in Die Welt Oct. 30, 2002, opened new perspectives: "A Fentanyl derivate was used to neutralize the terrorists." The gas used is a common anaesthetic used worldwide and "cannot by itself be called lethal."[20]

A source close to the Kremlin said the amount of agent used was 5 times the normal dose. "They're not saying what kind of gas they used, but they do say that they used too much of it to be safe."[21]

M.3.3 Conclusions Based on Eyewitness Reports and Expert Opinion

Diffusion (specific weight): "like a fog", "rising from the floor."

Odour, Taste: "light sweet smell and taste, "smoky smell"

Convulsions: were noticed in a terrorist on the stage.

[20] Russia comes clean over gas, demands extradition of Chechen envoy. Centre for Defence Information Web site. October 31, 2002. Available at: http://www.cdi.org/russia/229-1.cfm. Accessed January 3, 2003.

[21] Time Europe Monday, August 25, 2003: Theatre of War: The Chechens who dared seize a theater in Russia's capital are put down, but their cause is on center stage. BY JOHANNA MCGEARY AND PAUL QUINN-JUDGE/MOSCOW. With reporting by Yuri Zarakhovich/Moscow.

Nausea and Vomiting: were reported (but these symptoms are very common with poisonings (~13%) and following anaesthesia.

Anaesthesia / Signs of Poisoning: tipsiness, loss of consciousness, sound sleep, and death.

M.3.4 Discussion of Possible Substances Used in the Moscow Theatre Incident

M.3.4.1 Fentanyl

Fentanyl is a synthetic Opioid and, as an analgesic, its potency is 80 times that of Morphine. Profound analgesia and unconsciousness are induced by slow intravenous administration of adequate doses (50 to 100 µg/kg body weight) of Fentanyl. Respiratory depression is shorter than by Morphine. Following intravenous administration of fentanyl, the onset of action is within one circulation time. The duration of action is approximately 30 minutes.

Fentanyl is always applied intravenously (i.v.). We found no information of its use by inhalation.

High doses induce respiratory depression and respiratory arrest, which is why controlled artificial ventilation has to be prepared and ready for use when working with Fentanyl.

The narcotizing effects of morphine derivates can be antagonized by titration with naloxone (Narcan) and Naltrexone); however, renarcotization is quite common. Given the high lipophilicity of fentanyl derivatives, redistribution from tissue stores to the central compartment may explain the recurrent opioid effect. Those effects may be potentiated by acidosis, hypothermia, and rewarming,[22] so patients have to be monitored closely for some time following anaesthesia with fentanyl.

M.3.4.2 Neuroleptics and Opioid Combinations

Neuroleptic compounds, such as the butyrophenone derivate droperidol, Dehydrobenzperidol (DHB), produce a state of quiescence with reduced motor activity, reduced anxiety, and indifference to the surroundings. Sleep is not necessarily induced. In addition to inducing neurolepsis, droperidol has antiemetic actions and enhances the effects of other CNS depressants. In case of hypovolemia it causes heavy depression of blood pressure, which must be overcome by i.v. infusions.

Neuroleptic analgesia can be converted to neuroleptic anaesthesia by the concurrent administration of 65 % nitrous oxide in oxygen.

M.3.4.3 Dissociative Anaesthetics

Some arylcycloalkylamines may induce a state of sedation, immobility, amnesia, and marked analgesia. The name dissociative anaesthesia derives from the strong feeling of dissociation from the environment that is experienced by the subject to whom such an agent is administered. Ketamine hydrochloride is supplied in solution for intravenous or intramuscular use. For the introduction of dissociative anaesthesia in an adult, Ketamine hydrochloride is administered in a dose of 1 to 2 mg/kg intravenously over a period of one minute, which equals the intramuscular injection of 6 to 13 mg/kg. A sensation of dissociation is noticed within 15 seconds and unconsciousness becomes apparent within another 30 seconds. Following a single dose,

[22] Caspi J, Klausner JM, Safadi T, et al.: Delayed respiratory depression following fentanyl anesthesia for cardiac surgery. Crit Care Med. 1988;16:238-240.

unconsciousness lasts for 10 to 15 minutes and analgesia persists for some 40 minutes. In combination with nitrous oxide, Ketamine hydrochloride can be employed for induction of anaesthesia or to produce adequate general anaesthesia.

M.3.4.4 Nitrous Oxide (N_2O)

Nitrous oxide is a colourless gas without appreciable odour or taste. It is marketed in steel cylinders as a colourless liquid under pressure and in equilibrium with its gas phase. As it is released from the cylinder, some of the liquid nitrous oxide returns to the gaseous state; the pressure in the tank thus remains nearly constant until all the liquid has evaporated. The heat required for its evaporation is obtained from the walls of the cylinder and surrounding air, with the result that the tank becomes cold. Nitrous oxide is heavier than air. (Remember the statements of the hostages: "visible Vapour", "like a fog," "rising from the floor.")

Nitrous oxide is currently used as an adjuvant during most procedures in which general anaesthesia is employed. Analgesia equivalent to that produced by morphine follows the inspiration of 20% nitrous oxide; some patients loose consciousness when breathing 30% nitrous oxide, and most will become unconscious with 80%. A concentration of not less than 30% of oxygen is wise, and therefore, not more then 70% nitrous oxygen should be employed. There is very rapid onset of and recovery from effects. Also, Nitrous oxide frequently is used as a carrier for potent, non-flammable volatile anaesthetics such as halothane.

M.3.4.5 Halothane (Fluothane)

In combination with nitrous oxide, Halothane dose can be reduced compared to Halothane alone. The myocardial depressive effect of Halothane thereby is reduced.[23] Halothane is a clear liquid, its odour similar to Chloroform. It's a very potent anaesthetic but with only a low therapeutic index. When a person is overdosed, cardiac and respiratory arrest occurs simultaneously. That is why a special vaporizer is absolutely necessary for adequate dosage. Halothane uptake into the body is slow and only reaches desired effect after several minutes, which is the reason it is combined with nitrous oxide for initiating narcosis.

Fentanyl and Halothane in combination add in their respiratory and depressive action. A high-dose combination of both compounds might be considered a serious misjudgement[24]. It was curious that traces of halothane were found in the blood and urine specimens of two German hostages two days after their liberation, but no fentanyl or evidence of nerve agents was found.[25] However, halothane derivatives are in wide use in contemporary medicine for anaesthesia. Perhaps what was detected was a "Flurans", such as "Sevofluran" in nitrous oxide.

M.3.4.6 Fentanyl Derivates

There is abundant evidence in the literature on animal medicine of the development of fentanyl derivates for narcoses of large animals like bears, chimpanzees, domestic horses, elks, elephants, grey seals, grey wolves, gorillas, rhinoceroses and wood bison[26] (see Table M-1).

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[23] Stöcker, L.: Narkose. S. 30. Georg Thieme Verlag, 1969.

[24] Van Damme, B.: Moscow Theatre Siege. The Pharmacological Journal, Vol. 269, Nov. 16, 2002, 723-724.

[25] Schiermeier, Q.: Hostage deaths put gas weapons in spotlight. Nature 2002; 420: 7, Nov. 7 2002.

[26] WAX, Paul M., BECKER, Charles E. and Steven C. CURRY, MDs: Annals of Emergency Medicine, May 2003; Volume 41, Number 5, 700-705. See their Literature 19-24 & Stanley, T.: Human immobilisation. Europ. J. Anaesthesiol. 2003; 20: 427-428.

Table M-1: Characteristics of Opioids, Including Fentanyl Derivatives. (25)[27]****

	Relative Potency Compared to that of Morphine	Lipid Solubility*	Therapeutic Index**
Morphine	1	1,4	70
Meperidine	0.5	40	5
Methadone	4	120	12
Fentanyl	300	800	300
Sufentanil	4500	1800	25000
Alfentanil	75	150	1100
Remifentanil	220	18	33000
Carfentanil***	10000		10600

* Lipid solubility = octanol/water distribution coefficient.

** Therapeutic index = median lethal dose (LD50) / lowest median effective dose (ED50). WAX, Paul M., BECKER, Charles E. and Steven C. CURRY, MDs: Annals of Emergency Medicine, May 2003 Volume 41 Number 5, 700-705

*** Carfentanyl, known as Wildnil®, is the only opioid approved in the United States for animal use. A typical dose to immobilize seals is 10 µg/kg. It may be administered intravenously, but also with the same effect transmucosally or orally.[28]

**** The animal numbers from Table M-1 (1976) may not easily extrapolate to humans.

Sufentanyl is ten times more potent than fentanyl, is shorter acting even in high doses, and is available as a nasal spray. Its lipid solubility is much greater than fentanyl or morphine. In adequate doses it produces profound analgesia and narcosis. The stability of cardiac action under sufentanyl is impressive.

Carfentanyl is again 30 to 80 to 100 times as potent as fentanyl and has a therapeutic index 30 times higher, which means that narcotic activity will start at once with only a drop of the substance near a human, and that it is very well tolerated as long as the airways are kept open and adequate amounts of oxygen are in the breathing gas.

[27] Van Bever WF, Niemegeers CJ, Schellekens KH, et al. N-4-Substituted 1-(2-arylethyl)-4-piperidinyl-N-phenylpropanamides, a novel series of extremely potent analgesics with unusually high safety margin. Arzneimittel-Forschung. **1976**;26:1548-1551. in WAX, P. M., BECKER, C.E. and Curry, S.C. CURRY, MDs: Annals of Emergency Medicine, May 2003 Volume 41: 5, 700-705.

® = Registered Trademark.

[28] WAX, Paul M., BECKER, Charles E. and Steven C. CURRY, MDs: Annals of Emergency Medicine, May 2003 Volume 41 Number 5, 700-705.

Table M-2: Possible Substances Used in the Moscow Theatre

• Nitrous Oxide N_2O
• Ethylene ($H_2C=CH_2$)
• Acetylene
• Narcylen HC≡CH
• Cyclopropane (Trimethylen)
• CO
• Aliphatic Halogens
• "BZ", 3-Quinuclidinyl Benzylate,
• "Nerve Agents"
• Fentanyl
• Neuroleptics
• Dissoziative Anaesthetics
• Halothane
• Fentanyl Derivates

M.4 TECHNICAL MEANS FOR ADMINISTERING CHEMICAL NLW

The ideal effective NLW agent would be characterised by 4 properties:

Dynamic Parameters:

- Time of onset of effect: immediate.
- Duration of effect: sufficient for the specific operation.
- Recovery time: rapid.
- Reversibility: total.

Therapeutic Index (ratio of lethal dose to effective dose LD_{50}/ED_{50}): high.

Physical Parameters: easy to store, easy to handle, liquid or gas as required.

Sensory Quality: invisible, odourless, tasteless, neutral in temperature.

In the Moscow Theatre scenario, the incapacitant had to be injected into the large hall of the theatre via the ventilation system as a gas or an aerosolised liquid. This process had to be noiseless, invisible, and very fast, but without changing the preset ventilation flow rate. Under these circumstances it was a problem to build up the required level of concentration of the active agent in the hall. This could only be achieved by simultaneously flooding the ventilation system from many sources at different areas. In Moscow a group of experts evaluated the hostage crisis and offered a possible solution from scientific information available to the Ministry of Health. They applied available models and software for aerosol dispersion[29], which have been

[29] Baranov, V.N., V.V. Lazariev, V.V. Selivanov: System of special Means of Non-Lethal Effect to be applied by Police troops of Ministry of Internal Affairs, Russia, and Experience of their Application. Ministry of Internal Affairs, Moscow, RUSSIA, Bauman Moscow State Technical University, Moscow, RUSSIA. Ettlingen: 2. European Symposium 13.-14. May 2003, V13.

Minashkin, V.M.: Some Aspects of Application of the Aerosol "Non-Lethal" Weapon. Karpov Institute of Physical Chemistry, Moscow, RUSSIA. Ettlingen: 2. European Symposium 13.-14. May 2003, P48.

developed for calculation of fire fighting systems in compartments of engine rooms of naval vessels and industrial halls. The hall of the "North-East"-Theatre may be calculated as 50 x 100 x 12 Meters = 60.000 cubic meters. To fill the volume of the musical hall with an adequate concentration of the incapacitant per person, in a rough estimate, 19.5 kg of fentanyl were needed, for Sufentanil about 1.3 kg and for Carfentanil 0.65 kg[30]. The smaller the quantity required, the more difficult it would be to gain a homogenous spatial distribution in the musical hall.

Figure M-1 illustrates the effect of a non-lethal agent on human organisms according to the medical concept[31]. The curve on the left shows the dependence of the probability of the desired effect of a NLW on the human population depending on the strength of impact, in this case "dose". When the dose increases, undesired consequences, including fatalities, will appear, as shown by the curve on the right.

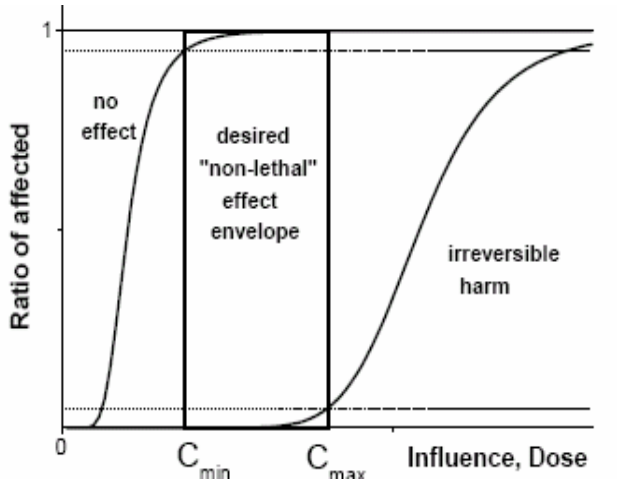

Figure M-1: Idealized Curves and Theoretical Useful "Envelope" for the Action of a Hypothetical NLW. The abscissa represents the ratio of affected persons out of the total population exposed, with "0" indicating that no person was affected and "100" indicating that all persons were affected. The ordinate indicates the relative "influence or dose" of the NLW used. Useful NLWs should occupy an operating envelope between having almost no effect, represented by the dose "Cmin" and with only a few persons with undesirable effects, represented by the dose "Cmax." (Also see Chapter 1.)

Typically the acceptable interval between desired and undesired effects, is that from 95 – 97% showing the desired effect to 3 – 5% showing an undesired effect, including damage or death. Minimal and maximal dose of this "desired operating envelope" often differ no more than 2 – 3 times.

At the first glance it looks simple to calculate the necessary dose and to apply the required amount of NL calmative somewhere in the middle of this envelope to guarantee success of operation, when terrorists are incapacitated and hostages are safely rescued.

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[30] Horizon: The Moscow Theatre Siege. BBC 2 (UK Television), Thursday January 15, 2004, 9 p.m., Transcript available http://www.bbc.co.uk/science/horizon/2004/moscowtheatretrans.html

[31] Klochikhin V.L.*, V.S.Pirumov**, A.V.Putilov*, V.V.Selivanov***: The Complex Forecast of Perspectives of NLW for European Application. *L.Ya.Karpov Institute of Physical Chemistry, 10, Vorontsovo pole, 103064 Moscow. **Russian Academy of Natural Sciences, 8, Warshavskoe shosse, 113105 Moscow. ***Bauman Moscow State Technical University, 5, Baumanskaya str., 105005 Moscow. 2nd European Symposium on NLW, May 13-14, 2003, Ettlingen, Germany, 16-15 & 16-16.

However the curve in Figure M-1 oversimplifies two facts of any comparable real situation. Firstly, this is an idealized curve for some average human. In reality, there is considerable variability is the dose-response of different human types (e.g., age and size) in different situations (e.g., degrees of stress, hunger, sleep). Furthermore the table assumes some instantaneous and specific dose, but in reality it is the dose-rate and accumulated dose that matter for the effect, and, this "time of exposure" can vary greatly, as well, from 10 min necessary for fighting operation in a big defended building to 30 min necessary to fulfil hostage evacuation from the affected area and for first medical aid.

In the Moscow Theatre situation, it took perhaps 40 – 60 minutes to fill the theatre hall with an effective concentration of gas, subdue the terrorists, and begin to evacuate the hostages. In this case the "desired operating envelope" simply disappeared. If the level of 95 % efficiency is absolutely required to neutralize terrorists and to prevent total mass destruction, there is no chance of eliminating some severe consequences and fatalities.[32]

M.5 ADDITIONAL DISCUSSION OF MOSCOW THEATRE INCIDENT

Four days after the event, the Russian Health Minister stated that the gas "cannot by itself be called lethal".[33] Despite this claim, 129 (16%) of the 800 hostages in the theatre died, and more than 650 of the survivors required hospitalisation. The Russian Health Minister attributed the deaths of the hostages to their poor condition from limited food and water and immobility during 3 days of captivity. By 12 days after the rescue, 67 hostages and 9 rescuers still remained hospitalised, 5 in critical condition.

From this statement we may conclude that the high numbers of dead and additional hostages with severe hypoxic defects and other injuries in consequence had not been expected. Some possible reasons for the deviation from theory might bee offered:

- The concentration of the incapacitant had to be very high to be effective in the large hall.
- Several sources were needed to blow the aerosol into the hall, so hostages were exposed to different concentrations at different places.
- The different weight of the aerosol compounds towards air might have provoked different concentrations of different substances at different places.
- Large volumes of the aerosol might have pushed away the air. Low oxygen concentration might have resulted in asphyxia.
- The hostages differed with respect to age, sex, weight, body-mass index, state of general health, fatigue, dehydration, and panic or fatalism, which influences the respiratory rate.
- The early German analytic data showed evidence of halothane, plus the Russian admission to using a fentanyl derivative suggests that more than one agent was used. This may also explain the failure to fully obtain reversal with naloxone in some cases, although hypoxic brain injury also may have contributed.

[32] Ibidem.

[33] Quoted from Wax: 8. Brown D, Baker P. Moscow gas likely a potent narcotic: drug normally used to subdue big game. Washington Post. November 9, 2002: A12. in WAX, Paul M., BECKER, Charles E. and Steven C. CURRY, MDs: Annals of Emergency Medicine, May 2003 Volume 41 Number 5, 700-705.

The most probable cause of death is that the hostages fainted in their seats to profound unconsciousness. In consequence, their airways were blocked and hypoxia developed with irreversible brain damage after about 6 minutes. From blowing aerosol into the hall to the beginning of the liberation action, 60 minutes elapsed. Even if the anaesthetic activity had been very short, the effects of hypoxia are sufficient to cause death.

The need to find and neutralize the widely spread ordnance may have been why there was a delay in starting the rescue, however there were no preparations for rescue! There were no rescuers organized, no first aid personnel, no physicians, and no ambulances. Ironically, opioid intoxication is a relatively simple poisoning to treat. Preparation of rescuers and medical teams with suitable stores of effective antidotes, such as naloxone, is essential. Antidotes to overcome an opiate poisoning were not sufficient, only a small number of syringes, no resuscitators, and only a few litters were seen[34]. Even from the official side, there were claims that not enough physicians were available to administer the antidotes.[35] In fact any helper could have injected naloxone into the muscles. There was no medical assistance seen being given to the hostages, no infusions, and no artificial ventilation. It is expected that several of the surviving hostages, who were delivered to the hospitals, will suffer from hypoxic lesions and brain damage.

M.6 CONCLUSIONS FROM THE MOSCOW THEATRE INCIDENT

More than 800 people were taken hostage in a Moscow theatre in October 2002 by armed Chechen rebels and were about to be killed. Given the large number of explosives in the hands of the hostage takers, a conventional assault or the use of more toxic chemical agents would probably have significantly increased the number of casualties in a destroyed theatre.

In an attempt to subdue the rebels and to rescue the hostages, the Russian authorities inserted an "incapacitant". The intent was likely to win control of the theatre with as little loss of life as possible. **This was achieved!** Although it may seem excessive that 16% of the 800 hostages died from the "gas" exposure, still **84% survived**. We do not know that a different tactic would have provided a better outcome. The use of a "sleeping gas" or "calmative" or "incapacitant" agent in this setting is a novel courageous attempt at saving the most lives. This counterterrorist action showed on the other hand that chemical "non-lethal" weapons are not always non-lethal. The variability of the situation (e.g., where one was located within the theatre) combined with the variable sensitivity of the population of individuals in the theatre (e.g., age, body size), combined with the disastrous consequences of failure, created a situation where non-lethality could not be guaranteed.

The planning and execution of medical attention to the hostages seems to have been scanty. The tragic outcome due to poor preparation of the rescue activities and therapeutic strategy shows how important tactical medical planning is in an overall operative environment[36].

M.7 SUPPLEMENT

The Moscow Dubrovka Theatre was reopened in February 2003[37]. More than 1000 auditors, amongst them several of the survivors, joined the first night of the "North-East Musical".

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[34] Van Damme, B.: Moscow Theatre Siege. The Pharmacological Journal, Vol. 269, Nov. 16, 2002, 723-724.

[35] arte, 30.09.03, 20:45 – 21:35.

[36] Hilflose Retter: Der Spiegel 45, S. 128 vom 04.11.2002.

No information is yet available about the outcome of the hundreds of patients treated in 8 hospitals all over the Moscow area. To seriously calculate the values and risks of the use of "non-lethal" agents it should be published some time.

After Moscow, we have to rethink the medical implications of all non-lethal agents, given the impossibility of getting an appropriate dose to all individuals in a large crowd[38].

Ongoing international scientific research is focussed on achieving broader therapeutic indexes and increased drug safety. Combinations of specific drugs, with different times of onset, different times to maximum effect, and with specific antagonists administered at the same time are under evaluation.

[37] KN 10.02.2003.

[38] Jan van Aken, toxicologist, head of the Hamburg-based office of the Sunshine Project.

Annex N – AFTER-ACTION MEDICAL REPORTING

N.1 MEDICAL EXAMINATION AFTER-ACTION REPORT (EXAMPLE)

NLW AFTER ACTION MEDICAL REPORT – Page 1

Report Number: _____ Date: _____
Name of Individual Examined:_____
Name of Reporting Official:_____
Nature of Incident:_____
Suggested Area of Injury:_____
Date and Time of – Incident: _____ Examination:_____

Note: For each relevant topic, make comments and/or rate symptoms from 1 (barely detectable) to 10 (severe); blank or "N/A" indicates no examination performed

Cerebral or neural symptoms

Warmth/burn:
Weakness
Headache:
Fasciculation /tremor:
Balance disturbance:
Nausea:
Vomiting:
Fatigue
Consciousness
Mental performance
Emotion: Anxious, Angry
Paralysed
Confused or Disoriented:
Deep tendon reflexes
Babinski
Motor coordination
Muscle weakness
EEG

Ophthalmologic examination

Conjunctiva/Cornea lesions/burns:				
Visual acuity without correction:	Right:	/10	Left:	/10
Visual acuity with correction:	Right:	/10	Left:	/10
Visual acuity before current incidennt:				
Lenses and retina (fundi after dilation)				
Nystagmus:				
Convergence:				
Pupils: Size:			Reaction to Light:	
Field of vision:				

NLW AFTER ACTION MEDICAL REPORT – Page 2

Report Number: _____ Date: _____

Additional physical examination:

Ears:
Tympanic membrane
Blood in the auditory canal?
Mouth and throat:
Heart:
Blood pressure:
Cardiac frequency:
Cardiac rhythm:
Chest pain:
ECG
Respiratory:
Respiration frequency:
Respiration difficulties or pain:
Coughing: Dry? Productive?
Abdomen:
Abdominal pain:
Diarrhoea
Dyspepsia
Skin:
Rash or eruption
Colour
Sweating
Injuries
Burns
Urine analysis:
Blood analysis:

Additional comments:

Annex O – TAP AND TOR FOR PROPOSED FOLLOW-ON ACTIVITIES TO HFM-073

O.1 TAP FOR PROPOSED FOLLOW-ON TO HFM-073

ACTIVITY	Exploratory Team	Human Effects of Emerging Non-Lethal Technologies											TBA	
PRIORITY	High												05/2005	
PRINCIPAL MILITARY REQUIREMENTS		3	4	5									05/ 2006	
MILITARY FUNCTIONS		4	6	11	12	13	14							
PANEL AND COORDINATION		Human Factors and Medicine (HFM)								SAS-060; HFM				
LOCATION AND DATES		Various; Semi-annual												
PUBLICATION DATA		TR or MP						06 / 2004		40				
KEYWORDS	Non-Lethal	Weapons				OOTW				Peace-keeping				
Biological Effects		Medical				Protection				Technology				
Directed Energy		Stun Devices				Radio Frequency				Lasers				

O.1.1 Theme

There is a great need for NATO to develop a Non-Lethal Weapon (NLW) capability and human effects issues are critical to meeting this need. Of particular importance, are issues raised by emerging technologies, such as RF and stun devices. NATO has been progressing toward acquiring a NLW capability since 1994. In 1999, the NATO NAC issued a Policy on NLW, which included the following definition: "NLW are weapons which are explicitly designed and developed to incapacitate or repel personnel, with a low probability of fatality or permanent injury, or to disable equipment with minimal undesired damage or impact on the environment." The Policy also gave the following direction, "NATO planners shall ensure that the potential contribution of Non-Lethal Weapons is taken fully into account in the development of their plans." At the April 1999 Washington Summit, NATO approved a Strategic Concept to equip the Alliance for the challenges of the next century and launched its Defence Capabilities Initiative (DCI) to implement this goal. DCI item EE 2(i) addressed the need to develop capabilities across the full spectrum of crisis response operations, including NLW. The lead for the DCI tasking went to the RTO, under which the SAS Panel developed a NATO RTO Roadmap. This roadmap endorsed three Technical Teams, one of which became HFM-073 (TG-12). This TAP is for an Exploratory Team to consider a follow-on effort to HFM-073, which completes its work in Dec. 2004.

O.1.2 Justification

The SAS-035 TT "Non-Lethal Weapons Effectiveness Assessment" has proposed a basic mathematical methodology for assessing the effectiveness of non-lethal weapons in a specific scenario. Inputs to the methodology include the physical characteristics of the weapon and the environment in which it is used, the level of a weapon's output that reaches a specific target, and the actual response of the target vis-à-vis the desired response and the military requirement. In their final report, the group recognized that the lack of adequate target response data is a significant inhibitor to the implementation of its methodology. The SAS-040 TT on a "Long-Term Scientific Study on Non-Lethal Weapons and Future Peace Enforcement Operations" held a multinational exercise to evaluate future technologies that might be suited to address the whole spectrum of NATO peace support operations. Five promising technologies were identified: RF devices, anti-traction approaches, rapid barriers, stun devices, and nets. The HFM-073 TT "The Human Effects of Non-Lethal Technologies" addressed the human effects of NLT from the perspective of both the target (effectiveness and non-lethality) and the operator/bystander (fratricide, long-term health effects). The implications of NLWs on training and field medicine were reviewed. Special attention was directed to the issues involved in obtaining target response data of the type, quality, and quantity that would satisfy the methodology proposed by SAS-035.

The proposed Exploratory Team will build on the work of SAS-035, SAS-040, and HFM-073, specifically addressing the medical and policy implications, data available, data needed, and processes for collecting data, focusing on the future technologies identified by SAS-040. We believe that it is critical to keep expertise in human factors and medicine involved in the effort to provide NATO an effective and acceptable NLW capability.

O.1.3 Topics to be Covered

The promise of emerging NLT for meeting the human aspects of NATO's NLW needs.

Health and safety issues raised by emerging NLT.

Medical issues raised by emerging NLT.

Data requirements for evaluating emerging NLT.

Protection issues raised by emerging NLT.

O.1.4 Chairman

USA.

O.1.5 Members

CHE, CZE, DEU, FRA, GBR, NOR, SWE, USA, others TBD (DEN, ESP, NLD, POL).

National Resources Available: TBD.

O.2 TERMS OF REFERENCE (TOR) FOR PROPOSED FOLLOW-ON TO HFM-073

TERMS OF REFERENCE – Exploratory Team (HFM ET -xx)

Human Effects of Emerging Non-Lethal Technologies

O.2.1 Origin

Background

There is a great need for NATO to develop a Non-Lethal Weapon (NLW) capability and human effects issues are critical to meeting this need. Of particular importance, are issues raised by emerging technologies, such as RF and stun devices. NATO has been progressing toward acquiring a NLW capability since 1994. In 1999, the NATO NAC issued a Policy on NLW, which included the following definition: "NLW are weapons which are explicitly designed and developed to incapacitate or repel personnel, with a low probability of fatality or permanent injury, or to disable equipment with minimal undesired damage or impact on the environment." The Policy also gave the following direction, "NATO planners shall ensure that the potential contribution of Non-Lethal Weapons is taken fully into account in the development of their plans." At the April 1999 Washington Summit, NATO approved a Strategic Concept to equip the Alliance for the challenges of the next century and launched its Defense Capabilities Initiative (DCI) to implement this goal. DCI item EE 2(i) addressed the need to develop capabilities across the full spectrum of crisis response operations, including NLW. The lead for the DCI tasking went to the RTO, under which the SAS Panel developed a NATO RTO Roadmap. This roadmap endorsed three Technical Teams, one of which became HFM-073 (TG-12). This TAP is for an Exploratory Team to consider a follow-on effort to HFM-073, which completes its work in Dec. 2004.

Justification

The SAS-035 TT "Non-Lethal Weapons Effectiveness Assessment" has proposed a basic mathematical methodology for assessing the effectiveness of non-lethal weapons in a specific scenario. Inputs to the methodology include the physical characteristics of the weapon and the environment in which it is used, the level of a weapon's output that reaches a specific target, and the actual response of the target vis-à-vis the desired response and the military requirement. In their final report, the group recognized that the lack of adequate target response data is a significant inhibitor to the implementation of its methodology. The SAS-040 TT on a "Long-Term Scientific Study on Non-Lethal Weapons and Future Peace Enforcement Operations" held a multinational exercise to evaluate future technologies that might be suited to address the whole spectrum of NATO peace support operations. Five promising technologies were identified: RF devices, anti-traction approaches, rapid barriers, stun devices, and nets. The HFM-073 TT "The Human Effects of Non-Lethal Technologies" addressed the human effects of NLT from the perspective of both the target (effectiveness and non-lethality) and the operator/bystander (fratricide, long-term health effects). The implications of NLWs on training and field medicine were reviewed. Special attention was directed to the issues involved in obtaining target response data of the type, quality, and quantity that would satisfy the methodology proposed by SAS-035.

The proposed Exploratory Team will build on the work of SAS-035, SAS-040, and HFM-073, specifically addressing the medical and policy implications, data available, data needed, and processes for collecting data, focusing on the future technologies identified by SAS-040. We believe that it is critical to keep expertise in

human factors and medicine involved in the effort to provide NATO an effective and acceptable NLW capability.

O.2.2 Objectives

This technical group will address the human effects of select Emerging NLTs, including RF and stun devices in order to:

- Assess their potential value for addressing NATO's desire for an NLW capability;
- Assess their impact on health and safety of personnel;
- Evaluate any untoward medical issues and facilitate medical planning;
- Determine the new data requirements; and
- Review the need for novel protection procedures and equipment.

Duration of the ET will be 1 year.

O.2.3 Products

The proposed products of the TG are:

- Recommendation on a new Technical Team on the Human Effects of Emerging NLT;
- Draft TAP, TOR, and POW for new Technical Team, if justified; and
- A final report.

O.2.4 Resources

Membership

The membership will be composes of experts in fields relating to the human effects of non-lethal technologies, including medical doctors, psychologists, physiologists, and engineers, from governmental agencies, industry, and academia. All members from HFM-073 will be invited. A new call for members from all nations participating in the HFM and SAS Panels will be conducted.

Participating nations at this time: CHE, DEU, FRA, GBR, NLD, NOR, SWE, USA.

Lead Nation: TBD.

Chairman: TBD.

(The lead nation (USA) for HFM-073 will plan the first meeting.)

National and/or NATO resources needed

National resources: Man power and travel funding by the nations.

NATO resources: TBD.

RTA Resources Needed

TBD.

O.2.5 Security Classification Level

NATO unclassified, open for PfP, except for single events.

O.2.6 Participation by Partner Nations

All NATO member nations, Partners for Peace, and members of the Mediterranean Dialog are welcome to participate.

O.2.7 Liaison

The Exploratory Team will liaise and coordinate its activities with other RTO activities concerned with non-lethal weapons, especially the SAS Panel's study on Non-Lethal Weapons (SAS-060). This goal will be realized by double membership, by exchange of documents, and perhaps by an official liaison relationship.

Liaison with TTCP, as well as with the European Working Group on Non-Lethal Weapons, and the US Joint Non-Lethal Weapons Human Effects Center of Excellence is sought.

O.3 TECHNICAL ACTIVITY PROPOSAL (TAP) FOR LECTURE SERIES

ACTIVITY	RLS	Human Effects of Non-Lethal Technologies												TBA by RTB Spring 2006	
Activity REF. Number	**HFM-145/RLS**													01/2007	
PRINCIPAL MILITARY REQUIREMENTS		1	3	4	5					NU				12/2007	
MILITARY FUNCTIONS		1	4	6	11	12									
PANEL AND COORDINATION		HFM								SAS					
LOCATION AND DATES		USA, WEU, New member state, TBD												P-I	
PUBLICATION DATA		EN						01/2008		TBD				NU	
KEYWORDS	Non-Lethal	Weapons				OOTW				Peace-keeping					
Biological Effects		Medical				Protection				Technology					
Directed Energy		Stun Devices				Radio Frequency				Lasers					

O.3.1 Background and Justification (Relevance to NATO)

Non-Lethal Weapons (NLW) are explicitly designed and developed to incapacitate or repel personnel, with a low probability of fatality or permanent injury. They should enhance the capability of NATO forces to achieve objectives such as to accomplish military missions and tasks in situations and conditions where the use of lethal force may not desired. In addition to preparation for the physical and physiological aspects of NLW use, there should be preparation for psychological effects, both for the target, bystanders, and the forces employing the NLW. While the effects of some non-lethal technologies (NLT) will be self-reversing, other effects may benefit by medical intervention to limit lethality and long-term effects. The availability of rapid medical treatment may be essential for enlarging the margin of safety and gaining the policy approval of some NLT. The SAS-035 TT has proposed a basic mathematical methodology for assessing the effectiveness of NLW in a specific scenario. The SAS-040 TT held a multinational exercise to evaluate future technologies that might be suited to address the whole spectrum of NATO peace support operations. The HFM-073 TT addressed the human effects of NLW from the perspective of both the target (effectiveness and non-lethality) and the operator/bystander (fratricide, long-term health effects). In order that the Alliance can develop and use these types of weapons, the scientific advances in this area must be communicated to the line medical officers and the challenges must be understood by field commanders and headquarters.

O.3.2 Objective(s)

This LS will aim to bring this knowledge to practicing military medical personnel and to inform military operational personnel of the realities of these types of operations. Education, emphasizing the new developments, will improve the effectiveness of NLT use and reduce the number of potential undesired effects. By understanding the consequences on human beings, participants will be able to determine the true NLW capabilities.

O.3.3 Topics to be Covered

Overview of NATO Activities on Non-Lethal Weapons, Human Effects of Non-Lethal Technologies, Medical Issues for NLT, Training in NLW, Use of Non Lethal Weapons in Military Operations Other Than War, NLW Strategies to Combating Terrorism, Cost-effectiveness of NLW use.

O.3.4 Deliverable (e.g. S/W Engage Model, Database, …) and/or End Product (e.g. Final Report)

Educational Notes, Meeting Proceedings.

O.3.5 Technical Team Leader and Lead Nation

Dr. M. Murphy, USAF/AFRL/HED, USA.

O.3.6 Nations Willing/Invited to Participate

CAN, CHE, CZE, DEU, FRA, GBR, NLD, NOR, SWE, USA, others TBD.

O.3.7 National and/or NATO Resources Needed (Physical and Non-Physical Assets)

Participation of speakers and meeting facilities in countries hosting the Lecture Series.

O.3.8 RTA Resources Needed (e.g. Consultant Funding)

Consultant funding for Lecture Series speakers.

Annex P – ABBREVIATIONS AND ACRONYMS

AAR	After-Action Review
ACE	Allied Command Europe
ACO	Allied Command Operations
ACP	Allied Communication Publication
ACPO	UK Association of Chief Police Officers
ACT	Allied Command for Transformation (new)
ADS	Area Denial System
AFV	Armoured Fighting Vehicle
AGARD	Advisory Group for Aerospace Research and Development
AJP	Allied Joint Publication
ALP	Allied Logistic Publication
AMedP	Allied Medical Publication
APAM	Anti Personal Anti Material
APP	Allied Procedures Publication
ATP	Allied Tactical Publication
AVT	Applied Vehicle Technology Panel
BABT	Behind Armour Blunt Trauma
BTWC	Biological and Toxic Weapons Convention
CA	Canada
CH	Switzerland
CN	1-Chloroacetophenone (Riot Control Agent)
CNAD	Conference of National Armaments Directors
CNN	Cable Network News (independent international newsgathering organisation)
COTS	Commercially off the Shelf
CR	Dibenz (b,f) – 1:4-oxazepine (Riot Control Agent)
CS	Ortho-chlorobenzalmalononitrile (Riot Control Agent, sensory irritant)
CW	Chemical Weapons
CWC	Chemical Weapons Convention
C2W	Command and Control Warfare
CZ	Czech Republic
DA	Denmark
DCI	Defence Capability Initiative
DEW	Directed Energy Weapons
DoD	US Department of Defence
DRG	Defence Research Group
Dstl	Defence Scientific and Technological Laboratories, UK
ED50	Effective Dose 50 %
EMD	Electrical Muscular Disruption Devices
EMP	Electromagnetic Pulse
EQPT	Equipment

ET	Exploratory Team
EWG NLW	European Working Group on Non-Lethal Weapons
FG	Force Goals
FR	France
GE	Germany
HEAP	Human Effects Advisory Panel
HFM-073	NATO RTO Human Factors and Medicine Panel, Working Group 073: "Human Effects of Non-Lethal Technologies"
HIC	Head Injury Criterion (U. S. National Highway Traffic Safety Administration)
HLSG	High Level Steering Group
HPM	High Powered Microwave
HQ	Headquarters
Hz, GHz	Hertz, Gigahertz = 10^9 Hertz
ICRC	International Committee of the Red Cross
IST	Information Systems Technology Panel
IT	Italy
ITBM	Interim Total Body Model
JCS	Joint Chiefs of Staff
JIPT	Joint NLW Integrated Product Team
JNLWD	Joint Non-Lethal Weapons Directorate
JNLW HECOE	Joint Non-Lethal Weapons Human Effects Centre of Excellence (US)
JNLWP	Joint Non-Lethal Weapons Program (US)
LD_{50}	Lethal Dose 50 %
LG	Land Group
LLW	"less-lethal" weapon
LTRs	Long Term Requirements
LTSS	Long Term Scientific Study
mmW	Millimetre Wave
MoD	Ministry of Defence
MOE	Measures of Effectiveness
MOP	Measures of Performance
MOR	Measures of Response
MRA	Military Requirements (Armaments)
NAAG	NATO Army Armaments Group
NAC	North Atlantic Council
NGOs	Non-Governmental Organisations
NI	North Ireland
NIJ	United States National Institute of Justice
NL	Netherlands

NLC	Non-Lethal Capability
NLE	Non-Lethal Effect
NLT	Non-Lethal Technology
NLW	Non-Lethal Weapon
NMSG	NATO Modelling and Simulation Group
NO	Norway
NSA	NATO Standardization Agency
NTAR	Non-lethal Technology and Academic Research
NTIC	Non-lethal Technology Innovation Center
nm	Nanometre = 10^{-9} m
OC	Oleoresin Capsicum (Riot Control Agent)
OOTW	Operations other than War
OP	Operations
PfP	NATO, Partnership for Peace
P_H	Probability of Hit
P_{HEHEH}	Probability of Intended Effect Given a Hit
P_{HLHEH}	Probability of Unintended Effects Given a Hit
Pk	Probability of Kill
POW	Programme of Work
PP&O	Plans, Policies and Operations
PTSD	Post Traumatic Stress Disorder
PTSS	Post Traumatic Stress Syndrome
RCA	Riot Control Agents
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
RF	Radio Frequency
RFR	Radio Frequency Radiation
RIB	Research and Technology Board
ROE	Rules of Engagement
RTA	NATO Research and Technology Agency
RTO	NATO Research and Technology Organisation
SAS	NATO RTO Studies, Analysis and Simulation Panel
SC	Strategic Command
SCI	Systems Concepts and Integration Panel
SE	Sweden
SET	Sensors and Electronics Technology Panel
SHAPE	Supreme Headquarters Allied Powers Europe (old)
SP	Spain
STANAG	Standardisation Agreement
TAP	Technical Activity Proposal
TBD	To be decided
TG	NATO RTO Technical Group

TOR	Terms of Reference
TT	Technical Team
TTCP	The Technology Cooperation Panel
U	Unclassified
UK	United Kingdom
UN	United Nations
US	United States of America
UWB	Ultrawideband radiation
V&V	Validation and Verification
VMADS	Vehicle Mounted Active Denial System
WMD	Weapons of Mass Destruction

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13. Keywords/Descriptors

Alternative technology	Military operations	Projectiles
Antipersonnel weapons	Mission profiles	Requirements
Contingency	Non-lethal weapons	Reviewing
Effectiveness	Operational effectiveness	Scenarios
International cooperation	Operations research	Standardization
Military equipment	Peacekeeping	Weapons effects

14. Abstract

Human effects considerations and data are important to nearly every aspect of Non-Lethal Weapon (NLW) development, effectiveness assessment, and deployment, as well as to assuring human health and safety during NLW evaluation, testing, training, use, and maintenance. In response to NATO RTO tasking, based on the recommendations of the 2000 Defence Capabilities Initiative, to support preparations for a NATO NLW capability, the Human Factors and Medicine Panel (HFM) formed HFM-073 "The Human Effects of Non-Lethal Technologies (NLT);" this Technical Report addresses the conclusions and recommendations of HFM-073. HFM-073 addressed the human effects of NLTs from the perspective of both the target (effectiveness and non-lethality) and the operator/bystander (fratricide, injury, long-term health effects). A summary of NLT technologies and a Glossary of terms important to the human effects of NLT are included in the Report. The complicated issue of policy approval for new NLWs is addressed and the implications of NLWs on training and field medicine are reviewed. Special attention is directed to the issues involved in obtaining target response data of the type, quality, and quantity that would satisfy the methodology and models being developed by another NATO RTO Panel, SAS-035 "Non-Lethal Weapons Effectiveness Assessment." Human Effects information, in all its dimensions, is critical for the success of NATO's implementation of a NLW capability. The HFM Panel is the only RTO organization able to support NATO in this area.

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