NATO Intermediate Force Capabilities Concept Development and Experimentation

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Abstract

NATO and its members face increasing threats and challenges from adversaries undertaking acts of aggression that deliberately stay below the level that would trigger a conventional (i.e., lethal) response or where such a response would incur costs – undesired escalation, risks of collateral damage including civilian casualties (CIVCAS), or other adverse outcomes – to the Alliance. To deter and counter such threats and challenges, NATO has been developing an Intermediate Force Capabilities (IFC) Concept. IFC means include Non-Lethal Weapons (particularly Non-Lethal Directed Energy capabilities), Cyber, Electronic Warfare, Information Operations, and other appropriate means. These IFC means can actively *Detect, Contest, Deter and Counter across the competition continuum* (imposing direct costs, opportunity costs, and delays particularly for sub-threshold activities); *Increase Decision and Action Space* (gaining/ maintaining the initiative and expanding the engagement space), *Act Proactively and Seize Initiative while Minimizing Undesired Outcomes* (and adversaries' expected exploitation of incidents in Information Space) plus *Improve Control of Escalation/De-escalation* (winning engagements and the narrative). Experimentation – in the form of wargaming – has been the principal driver: generating insights for the concept, presenting comparisons with NATO addressing the same challenge using Baseline capabilities versus also having IFC available, and providing qualitative and quantitative evidence for the concept. This presentation would highlight aspects of the IFC Concept and specific wargame results and insights that pertain to countering small unmanned aircraft.

Keywords: Intermediate Force Capabilities, Concept Development and Experimentation, Wargaming, Non-Lethal Weapons, Cyber, Electronic Warfare, Information Operations

Characterizing the Impact of Non-Lethal Weapons

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ABSTRACT

Understanding the impact of non-lethal weapons (NLWs) is critical to making informed choices about their development, acquisition, employment, and integration with other systems. However, the fact that these systems are valued for their restrained effects makes measuring their impact inherently difficult. The authors developed a methodology for evaluating how the tactical, operational, and strategic impact of NLWs can be characterized by a logic model framework that links the activities they perform with direct outputs, higher-level outcomes, and ultimate strategic goals, both for the NATO Alliance and for the U.S. Department of Defense. The logic model designed for NATO includes integration of NLWs with electronic warfare, cyber operations, and information operations. The authors also identified metrics that facilitate data collection to further evaluate the impacts of these systems at multiple levels. Analyzing the logic models in the context of a series of vignettes revealed key outputs and outcomes to which NLWs contribute, as well as the fact that acoustic systems, laser dazzlers, and the millimeter-wave Active Denial System were particularly versatile. Outputs and outcomes that particularly contributed to strategic goals included enhancing perceptions, shaping gray-zone encounters, enabling effective action while mitigating risks, and creating additional options while constraining those of other parties. The authors also analyzed impediments to NLW integration with other systems and how best to integrate these capabilities into future wargames, models, and simulations.

Keywords: Impact, effectiveness, logic model, measuring, metrics

Industry challenges in front of heterogeneous regulations applicable to Less Lethal solutions in Europe

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ABSTRACT

Less lethal weapons have been introduced more than 50 years ago and used, mainly for polices forces to control aggressive crowd behavior. This category of non-firearms covers a range of products and regulations that are defined differently and sometimes at cross-purposes. The European Union has attempted to harmonize the conditions for the possession and use of such a category of weapons, which is also sometimes confusing. Today, there is still no universally agreed-upon definition of this class of weapons. The present article aims to underline the advantages of a common position on lethal products serving both commercial objectives for the arms industry and political objectives for each Member State.

Keywords:

Less lethal devices
Less lethal policy
European Union
Defense
Arms industry
FN Herstal

The use of Non-Lethal Weapons during the Yellow Vests Protests: a non-exhaustive census of the incidents reported by the Medias

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ABSTRACT
During the Yellow Vests Protests, a series of populist demonstrations that took place in France from November 17th, 2018 to the beginning of 2020, the police and gendarmerie forces used Non-Lethal Weapons (NLW) against violent protesters. This type of device (baton round, hand grenades, etc.) is used during protests because of its capacity to minimize the likelihood of casualties, but zero risk is impossible to reach. In fact, one death and over a hundred serious injuries linked to police action have been reported by the French press during the near two years of weekly demonstrations.
This presentation is a summary of the most serious types of incidents observed: the wound of a woman presumed hit in the face by a tear-gas grenade that led to her death; and injuries like facial trauma (jaws or brow bones), monocular blindness, or brain hemorrhage for examples. The aim of this study is to highlight the major risks of injury to determine new development focuses to improve the forces' non-lethal devices. Each incident is documented from the information given by French Medias, supplemented with additional indications when known.

Keywords: Yellow Vests Protests, Non-Lethal Weapons, Census, Injuries, Demonstrations

Literature review of case reports regarding NLW thoracic impacts

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ABSTRACT

During the last decades, there has been an increase in the development and use of kinetic energy projectiles, mainly because of their ability to neutralize without inflicting serious injuries. Even though these are intended to temporarily incapacitate individuals. It is often encountered that kinetic impact projectiles can cause penetration, severe injuries, permanent disabilities and even mortality. The injury level is highly related to the shot distance and the body region that is impacted. Because the thoracic region is the dominant impact region and because it hosts vital organs, it is considered to be one of the most sensitive areas of the human body. Therefore, all injuries to the chest should be regarded as potentially life threatening. The objective of this study is to review case reports and case studies of kinetic energy projectiles impacts on the thoracic region available in open literature. The ballistic and operational conditions, and also medical outcome of each case are described. The study is divided into penetrative and non-penetrative impacts of different kinds of projectiles (rubber bullet, plastic bullet, bean bag, flashball, FN303), in order to be able to comprehend the injury potential of these projectiles and to provide an insight on real shooting conditions.

Keywords: kinetic energy non-lethal projectiles, literature review, case reports, penetrative and non-penetrative injuries, thoracic region

Abstract

NON-LETHAL WEAPONS WITHIN THE POLICE: LONG TERM ANALYSIS OF REAL CASES

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Abstract. The PAB or « Peloton Anti-Banditisme » was created in 1976 on the same model as the Los Angeles Police Department SWAT. The PAB is the local Special Police unit of the Liège Police Zone.
In term of less-lethal equipment, the unit is equipped with the FN303 rifle, OC spray, batons and TASER X2.
This article goal is to provide a presentation and then a crossed analysis of real cases where non-lethal weapons have been used. At the time of writing this abstract and since the last article in 2091, multiple TASER use has been recorded (for the first time in the series of articles) and new cases of FN303 use combined with baton and OC spray will be added to the database. With more than 30 different cases in total, some statistics and correlations can be built.

The article will also help to better define the potential limits (injuries) of the employed technologies and to check on the consistency with standardized laboratory tests and the effectiveness of these systems.

UK Physical Assessment of the TASER 7™ system

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ABSTRACT
The UK Home Office and National Police Chiefs' Council (NPCC) had a requirement for a Conducted Energy Device suitable for covert carriage to replace the TASER X26™. The TASER 7™ was identified by the NPCC as a potential candidate. Dstl were tasked by the Home Office Commissioning Hub to conduct an assessment of the TASER 7™ to evaluate the compliance of the TASER 7™ with the Police Operational Requirements to also include overt police roles.

The UK Code of Practice on Armed Policing and Police use of Less Lethal Weapons sets out the basic principles in relation to selection, evaluation and approval of less lethal weapons by the police. As part of the approval and evaluation process a technical assessment must be considered. Defence Science and Technology Laboratory (Dstl) conducted a physical assessment of the TASER 7™ that included a technical assessment and user handling performance. This presentation describes the assessment and findings that supported the Home Secretary's decision to authorise the TASER 7™ for use by the UK police.

Keywords: LLW, conducted energy device, TASER, technical assessment.

Operational Taser use in the UK

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ABSTRACT

The UK Government and those responsible for policing and law enforcement must ensure they fulfil the obligations set out in articles General Provisions 2 and 3 of the UN Basic Principles on the Use of Force and Firearms by Law Enforcement Officials which 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 for use in appropriate situations, with a view to increasingly restraining the application of means capable of causing death or injury to persons."

In 2004, this obligation resulted in the Home Secretary authorising the use of CEDs for police operations involving the deployment of authorised firearms officers (AFOs) as a less lethal option. In July 2007 this authorisation was extended to allow those officers to use CEDs in operations or incidents where the use of firearms was not authorised, but where they were facing violence or threats of violence and they would need to use force to protect the public, themselves, or the subject.

In 2008, CED use was extended to non-firearms officers facing similar violence or threats of violence. These officers are now referred to as Specially Trained Officers, or STOs. It is the responsibility of each Chief Constable to establish the operational requirements for STO capacity within their force based on their individual strategic threat and risk assessment.

In addition to the police forces across the UK; the British Transport Police, Ministry of Defence Police, the Civil Nuclear Constabulary, and the National Crime Agency also have personnel who are authorised to use CEDs. There are also authorised CED users in the police forces of Guernsey, Jersey, and the Isle of Man. All these authorised CED users are trained and accredited to deploy with CEDs in the same way.

Only CEDs that have been approved by the secretary of state, may be used by the UK police service. The evaluation and assessment processes for such weapons include, where appropriate:

- a needs analysis (based upon Strategic Threat and Risk assessment)
- determination of operational requirement
- independent (of the manufacturer) technical and medical assessment (to include capability, limitations, effect and lethality)
- operational performance trials

The process will take into account relevant strategic, ethical, operational and societal issues, including an assessment of environmental factors.

The CED forms parts of the less lethal weapon systems approach, and it is this 'system' which is evaluated on behalf of the secretary of state before the system is authorised for use. Typically, the system includes the CED, the sighting system, the cartridges, maintenance and storage instructions, Authorised Professional Practice and training standards.
Any significant change (technical, physical or usage) to an approved less lethal weapon system can have implications on the less lethal nature of the system and requires Home Office approval.

The rigorous assessment process by scientific and medical experts prior to Tasers being authorised for UK use along with the standards of training, policy and guidance is arguably one of the most robust in the world.

However, since its introduction the deployment and use of Taser by UK police has been contentious and emotive. It polarises public opinion and it is regularly debated and discussed in mainstream and social media. This abstract introduces a report by UK police on the latest guidance to forces regarding operational oversight and review.

Keywords: CED, Evaluation, Operational Use

The UK medical assessment of the TASER 7™

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ABSTRACT
The TASER 7™ is the latest generation of conducted energy device to be authorised by the Home Secretary for use by the police in the UK. The decision on whether to authorise the TASER 7™ system was informed, in part, by the findings from an independent medical assessment undertaken by the Scientific Advisory Committee on the Medical Implications of Less-Lethal weapons (SACMILL). This presentation will review the elements of the TASER 7™ system explored by SACMILL and present the committee's findings.

Keywords: Conducted energy device, TASER, medical implications.

Comparative Effectiveness of a New Generation Conducted Electrical Weapon

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ABSTRACT
Conducted Electrical Weapons (CEWs) have been used by law enforcement agencies worldwide to control and restrain potentially violent persons. With a continuous improvement and development of these devices, effectiveness testing is required. A new generation TASER CEW (New CEW) is in development. It has a 10-dart multi-shot cartridge and applies redesigned electrical waveforms onto a subject intended to cause muscle incapacitation equivalent to or greater than prior CEW models. In this pilot study, we used our previously published, standardized methodology for measurement of CEW effectiveness on motivated human volunteers. Their task was to attempt to reach a suspended martial arts dummy 10ft (3.05m) away while being exposed to the electrical waveform of a TASER 7 CEW (TASER 7) or the New CEW. Several intervention groups were examined. The effectiveness of different dart placement of the New CEW was looked at, with comparison made to historic data. In one head-to-head comparison group, the TASER 7 and the New CEW were examined using each volunteer as their own control. The results demonstrate that the New CEW has the same/similar ability to induce neuromuscular incapacitation as the TASER 7. Additionally, the ability of the New CEW to place multiple darts on a specific target area to create the desired probe spread is a technological advantage over previous models, making it potentially more effective in the field.

Keywords: TASER, Conducted Electrical Weapon, New CEW, Darts, Incapacitation,

Cardiac safety using a swine surrogate model for a new concept conducted electrical weapon

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ABSTRACT

Axon Enterprise, Inc. has developed a new concept Conducted Electrical Weapon (CEW). Instead of the traditional high-voltage, electrically-paired 2 or 4 probes design, the new CEW uses a low-voltage, floating polarity, independently targeted 10 probe design. With this design, electrical connections can occur between any probes and with 10 probes independently targeted, field efficacy should be higher than the traditional designs. With the possibility of multiple probes on target (current design limits the total connections to 4), the possibility of anterior-posterior transthoracic connections, and with probes potentially rapidly alternating polarity, this presents new areas for safety study. The authors used their previously published swine safety surrogate model using hypotensive cardiac capture or ventricular fibrillation as the clinical endpoints to compare the new CEW to two previous CEW models, the T7 and X26E, specifically examining multiple probes, anterior-posterior connections, and rapid alternating polarities. The drop in mean arterial blood pressure (MAP) during exposures was the end point of interest. The exposure groups were 2 probes, 2 probes anterior-posterior, 3 probes, and 4 probes. There were a total of 265 thoracic exposures over 5 swine. A Kruskal-Wallis test assessing for differences in MAP change by weapon was p=0.35 and did not show any difference. There were no instances of ventricular fibrillation. Based on our study, there was not a statistical difference between the weapons.

Keywords: TASER, Conducted Electrical Weapon, Cardiac Safety, Swine Model, pacing, ventricular fibrillation

Human physiologic changes with exposure to a new concept conducted electrical weapon

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ABSTRACT

Axon Enterprise, Inc. has developed a new concept Conducted Electrical Weapon (CEW). Instead of the traditional high-voltage, electrically-paired 2 or 4 probe design, the new CEW uses a low-voltage, floating polarity, independently targeted 10 probe design. With this new design, electrical connections can occur between any probes and with 10 probes independently targeted, field efficacy should be higher than the traditional designs. With the possibility of multiple probes on a subject (current design limits total connections to 4) including anterior to posterior connections and with probes potentially rapidly alternating polarity, this presents new areas for safety study. The authors used their previously published human physiology methodology to study 8-second exposures using different numbers of probes (up to 6; maximum 4 connections) and connection locations. In our study, blood was drawn pre-exposure, immediately post-exposure, at 1 hour and at 24 hours. Blood variables studied included potassium, pH and lactate, troponin and CK. EKGs were done pre and post exposure and continuous spirometry was performed. There were 27 subjects in our study. There were no clinically significant blood changes except for modest changes in pH and lactate and catecholamines immediately post-exposure consistent with prior weapons, and rises in CK which were similar to prior multi-shot weapons. There were no dysrhythmias, ectopy or ischemic changes on any EKGs. The spirometry data had mixed results.

Keywords: TASER, Conducted Electrical Weapon, physiology, EKG, spirometry

Safety Profile of New TASER Conducted Electrical Weapon Darts

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ABSTRACT
A new generation TASER Conducted Electrical Weapon (New CEW) is being introduced in 2023. It's technology enhancement includes a multi-shot feature from a 10-dart cartridge. The darts are thin-diameter, low-profile projectiles launched by primer-ignited black-powder which classifies this New CEW as a "firearm". It is important to know the limits of the safety margin the New CEW darts operate within regarding their potential for "over-penetration" because of their thinner diameter design compared to older CEW darts and because of the firearm deployment platform. The current New CEW dart muzzle velocity is reliably 53.3 m/sec (175 ft/sec) ± 9.1 m/sec (30 ft/sec) when measured with a ballistic chronograph. We fired 48 New CEW darts into live human tissue at measured velocities between 55.8-75.6 m/sec (183-248 ft/sec). Target sites included the lower abdomen, mid-thigh and the buttocks. The New CEW darts were fired via adjustable velocity, compressed air cannon through a ballistic chronograph to record accurate projectile velocities. Even at the fastest velocities, no overpenetration of human tissue was noted. We conclude that the New CEW darts operate with a significant margin of safety in terms of muzzle velocity and risk of human tissue penetration when fired as intended into recommended target areas.

Keywords: TASER, Conducted Electrical Weapon, Darts, Ballistics,

FN Herstal's vision for next-generation Less Lethal weapons

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ABSTRACTS FN HERSTAL

The basics of Less Lethality (safety, efficiency and accuracy) have always been at the heart of FN Herstal's less lethal weapon development. Thanks to major advances in image recognition technology, a major step has recently been achieved in further minimizing the risk of inadvertently hitting the head (forbidden zone), when a less lethal action is intended.
This new concept, called **FN Smart ProtectoR®-303 Tactical**, is a portable and compact kinetic energy solution to de-escalate a threat at any distance from 0m up to 30 m, with an innovative safety assistance system. This concept is composed of a shoulder launcher platform (FN 303® Tactical), and by a hi-tech image recognition system (FN VictoR®-SP). On the one hand there is the *FN 303® Tactical*, which is the most advanced platform compliant with the basics of less lethality. On the other hand, the *FN VictoR®-SP*, which is a device able to capture and analyse video stream in real-time to recognize human forms, and specifically the head to prevent headshots leading to permanent injury. When a restricted zone is predicted to be impacted, the *FN VictoR®-SP* transmits in real time a no-go signal to the *FN 303® Tactical* platform.
By working on this patented concept, FN Herstal aims to provide police forces and security agencies with a solution complying with the basics of less lethality combined with a high-tech shoot / don't shoot assistance to minimize the risk associated with a badly placed impact.

Keywords : FN Herstal, FN 303® Tactical , FN VictoR®-SP, FN Smart ProtectoR®-303T, Less Lethal devices

SMARTSHOOTER - Real time Fire Control Systems

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SMARTSHOOTER - Real time Fire Control Systems
SMASH is a revolutionary fire control system for small arms. By using advanced sensors and tracking technology, targets can be quickly and accurately acquired and engaged. SMASH calculates the point of aim of stationary and moving targets in real-time and releases the trigger at the moment of highest hit probability. Fielded and operationally proven, it is a cost-effective solution that brings all shooters to an expert level
The SMASH family is built on an open architecture platform, enabling easy integration, add on & updates. Examples for added applications are the less lethal mode as well as the counter drone mode.

Keywords: Fire Control System, C-sUAS, Less Lethal, small arms

Assessment of counter drones in the UK

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National Police Chiefs Council, Strategic manager for less lethal weapons and counter drones

ABSTRACT

In December 2018 a Drone flying over Gatwick airport caused significant and lasting disruption for 3 days; c1,000 of flights were cancelled and c140,000 passengers affected. It was the biggest disruption since its closure in 2010 from the Icelandic volcano eruption.

This paper explores the incident and capability improvement including:

1. Creation of NPCC National Team - National Counter Drones 'Hub'.
2. Developed greater collaboration between forces developing an inclusive network of experts.
3. Development and delivery of a National capability of Detect, Track, Identify and Effector systems.
4. Helped develop new legislation to support Officers across the UK in combatting threat from drones.
5. Supported HMG, in creation of a Counter Drone coordinated cross Government response.

Keywords: Counter Drone

Towards standardized test methods for assessing the performance of counter-drone solutions

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ABSTRACT
The proliferation of drone technology and the increased threat related to these systems has given rise to the development of hundreds of counter-drone solutions. However, assessing the effectiveness of each solution for a given use case is no easy task. Therefore, the European Commission has decided to fund the COURAGEOUS project, which aims to facilitate the development of a common baseline understanding amongst authorities concerning the effectiveness of different technical systems intended for use in specifically the detection, tracking and identification of non-cooperative drones. In doing so, the project aims to support decision-making at national level regarding the development, procurement and/or operational deployment of different commercially available counter-drone systems, most of which are very expensive.
In a first phase, COURAGEOUS will focus on the development of a standardised counter-drone systems testing methodology that will be used for testing both individual sensors & integrated systems. In a second phase, COURAGEOUS will execute four different test campaigns across Europe, where commercially available C-UAS systems will be evaluated following the developed test methods, in order to validate the methodology and to provide a baseline dataset.

Keywords: Counter-drone; counter-uav; standardization; drone detection.

Human collateral damage assessment of a pellet C-UAS system using a gelatine based standardized surrogate

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ABSTRACT
Unmanned Aerial Vehicles can be deemed a threat for a wide range of disastrous scenarios in urban contexts, regarding critical infrastructures or in civilized environments. Various countermeasures exist, based on different technologies. One of the possibilities is a cloud of pellets that has a relatively short range of impact. The objective of this approach is to maximize the covered area in order to increase the probability to hit the target. A specific pellet based C-UAS system has been identified for the scope of this study. Present work assesses the risk of a pellet regarding collateral damage. It is achieved with the determination of a specific ballistic limit. In particular, the velocity at which 50 percent of pellets perforate the test object of interest. It will allow to determine what the range of risk is regarding collateral damage. This limit is determined by following a NATO standard assessment of skin penetration of non-lethal projectiles on a gelatine skin surrogate. Previously published work has modeled the trajectory of the dedicated Counter-UAS projectile and has determined the ballistic limit for the intended target. With the addition of present work, it allows to define a value for range of risk in the trajectory model. Additionally, the obtained ballistic limits and inferred energy densities are contrasted to ballistic limits from comparable research campaigns by use of sectional densities.

Keywords: Terminal Ballistics, Unmanned Aerial Vehicles, Counter-UAS, Multi-Projectile, 12 Gauge

Abstract

Are dedicated C-(s)UAS effective enough against realistic threats ?

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Abstract. The '*Comparative Analysis of lethal / low-collateral damage effectors against LSS* UAS' is a 4- year project organized in the framework of the NATO 'Defense Against Terrorism' Programme of Work (DAT PoW). The project capstone activity is called NNTEX-22C (NATO Non-lethal Technology Exercise 2022 Counter-UAS) and is a NATO endorsed military utility assessment exercise that has been organized in 2022.

NNTEX-22C purpose is to bring together stakeholders and warfighters to execute scenarios employing low-collateral damage C-UAS technologies. The activity focuses on the engagement part of the kill chain (Detect, Track, Identify, and Neutralize).
Dedicated technologies are compared to previous tests which assessed the C-UAS capability of a Belgian Air Force 'Force Protection' squad performing AAAD (All Arms Air Defence) using their organic weapons (NNTEX-20C).

The proposed article will report facts about the activity and gives keys to determine the level of effectiveness and suitability for each participating C-UAS technology during realistic and relevant scenarios.

NATO standardized method for assessing the thoracic impact of Kinetic Energy Non-Lethal Weapons

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ABSTRACT
Kinetic energy non-lethal weapons (KENLW) systems remain one of the most widespread type of non-lethal weapons on the field. NATO has released four standardized documents in order to assess the injury potential of such projectiles. These documents have been written by an international team of experts in the field of non-lethal weapons. Particularly, the AEP 99 from the STANREC 4744 focuses on the evaluation of non-penetrative thoracic impacts. It is based on PMHS tests. The topic of this article consists in describing the standardized document in the form of a scientific article. Firstly, KENLWs and the resulting injuries are described through a literature study. Secondly, the assessment methodology and its scientific rationale is explained in detail. Thirdly, implementations of the AEP 99, using different means of evaluation, are presented. After that, the evaluation of commercially available KENLW is performed and results are compared with the literature. Finally limitations and way ahead are identified and discussed.

Keywords: Non-lethal weapons, impact projectile, standardization, skin penetration, ballistic simulant

NATO standardized method for assessing the skin penetration of Kinetic Energy Non-Lethal Weapons

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ABSTRACT

Kinetic energy non-lethal weapons (KENLW) systems remain one of the most widespread type of non-lethal weapons on the field.

NATO has released four standardized documents in order to assess the injury potential of such projectiles. These documents have been written by an international team of experts in the field of non-lethal weapons. Particularly, the AEP 94 from the STANREC 4744 focuses on the evaluation of the skin penetration of non-lethal projectiles based on a specific test. The proposed methodology is to shoot a projectile on a surrogate composed of three layers (chamois skin layer, a specific closed-cell foam and ballistic gelatine). The surrogate is validated using Post Mortem Human Subjects (PMHS) tests.

The topic of this article consists in describing the standardized document in the form of a scientific article. Firstly, KENLWs and the resulting injuries are described through a literature study. Secondly, the assessment methodology and its scientific rationale is explained in detail. Thirdly, interlaboratory tests are conducted for validating the procedure, and ultimately AEP 94 implementations are presented. After that, the evaluation of commercially available KENLW is performed and results are compared to case reports from the literature. While correspondence is achieved, limitations and way ahead are identified and discussed.

Keywords: Non-lethal weapons, impact projectile, standardization, skin penetration, ballistic simulant

Blind test of the AEP-94 Skin penetration assessment of non-lethal projectiles (according to NATO STANREC 4744)

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Abstract

The WTD 52 is responsible for the development and testing of non-lethal weapons (NLW) in Germany. In this context, it is necessary to address the risks involved in the use of NLW. To this end, WTD 52 works very closely in multilateral working groups such as the NATO JNLWCG and the EWG together with other partners on methods and procedures dedicated to risk analysis. The results of this effort include the publication of standardization documents such as NATO standardization recommendation (STANREC) 4744. These NATO standardization recommendation (STANREC) incudes ALLIED ENGINEERING PUBLICATIONs (AEPs) which are listing recommended practices regarding test methodology to assess the risk of using kinetic NLW. One criteria to quantify the risk of lethality of non-lethal projectiles is the occurrence of skin penetration. The penetration criterion comes from non-lethal projectile impacts on Post Mortem Human Subject (PMHS).

Even though the methods described here represent the latest state of the art, it is necessary to check the practical implementation. After all, it should be possible for the described procedure to be carried out by test institutions from all NATO countries and achieve equivalent results.

The blind test described in this article and conducted by WTD 52 is intended to provide precisely this verification and lead to improvements (in the written formulation and technical realisation) of the AEPs.

Development of a skin surrogate using additive manufacturing for investigation using non-lethal agents in the form of kinetic projectiles

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ABSTRACT

Validated and scientifically statements on the effects of non-lethal projectiles on the human body are hardly available. This is essential to ensure that no serious or fatal injuries can occur when using non-lethal projectiles. Therefore, the ability to predict the effects of non-lethal projectiles needs to be developed. In this context, there is a lack of testing and validation capabilities that enable the services of the German Armed Forces to ensure that non-lethal projectiles meet the complex and multi-criteria requirements. For this purpose, bone and organ surrogates can be used, which imitate both the shape and the physical properties of tissue and bone. The procurement or production of surrogates that meet the requirements is currently difficult to realise. Due to the lack of reliable surrogates, the aim of this work is the substitution of human skin with a surrogate that has approximately the same mechanical properties and can be used for the investigation of the effects of non-lethal projectiles. Therefore, this paper deals with serval mechanical tests such as tensile and pressure that were performed on elastomer-based materials. The results are then compared to tests of human skin with similar setups, to indicate a suitable material. The indicated material is used to manufacture a surrogate for investigating the effects of non-lethal projectiles. Furthermore, a test setup will be discussed to validate the new developed surrogate.

Keywords: Skin surrogate, additive manufacturing, mechanical tests, elastomer-based materials

A new biomechanical physical surrogate for thoracic blunt impact

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ABSTRACT
In biomechanics, due to strict ethical rules, experimental setups on cadavers are complex to conduct. These rules can be overcome using physical or numerical surrogates. In the precise framework of blunt ballistics, the use of numerical surrogates has shown wide interest. The difficulty of such development remains in the characterization and modeling of body armor. In this case, a physical biofidelic instrumented surrogate can allow conducting physical experimentations. This study proposed to describe the creation of a physical human thorax surrogate dedicated to blunt ballistic impacts called SurHUByx (Surrogate HUByx). The geometry of this new surrogate is based on an existing numerical finite element model, named HUByx (Hermaphrodite Universal Body xy), which consists in a biofidelic 50th percentile human torso. In order to build the physical dummy and to choose appropriate materials for anatomical structures able to reproduce correctly the human behavior, a reverse engineering procedure was applied: material properties of the numerical model were simplified in order to match properties of manufacturable materials. This new "simplified" biomechanical model was also developed numerically (named SurHUByx FEM) and was used to replicate experimental reference cases conducted on Post Mortem Human Subjects. Results were consistent with the biomechanical corridors. The model being numerically validated, the construction of the physical dummy began. The new physical dummy was also submitted to the impact cases performed by Bir et al. (2003). The whole procedure allowed creating a biofidelic dummy with manufacturable materials, which can be used for ballistic accident reconstruction.

Keywords: Human torso, Blunt trauma, Ballistic impact, Surrogate

Evaluation of Lemongrass Irritant

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ABSTRACT

The use of Oleoresin Capsicum (OC) irritant, commonly known as pepper spray, as a force option to incapacitate an aggressive subject is common across Law Enforcement Agencies (LEAs) all over the world. Lemongrass as an irritant is a relatively new and unfamiliar to most LEAs. Though it is less potent than OC, it has three advantages over OC as an irritant. Firstly, OC irritant triggers nasal discharges when a subject has been exposed to the irritant and this is not desirable in the Covid-19 pandemic or other communicable diseases. Secondly, the use of OC irritant contaminates the location and may require a temporary de-cant. Thirdly, Lemongrass irritant enables an exposed subject to recover quicker as compared to OC irritants. The evaluation will verify the range and observe the trajectory of the liquid stream. The evaluation will also focus on the effectiveness of the Lemongrass irritant to incapacitate a subject, the presence of nasal discourages, the time taken for decontamination and recovery. Lastly, the evaluation will determine the efficacy of the irritant spray after one year of storage and the proposed operational applications of the Lemongrass irritant.

Keywords: Irritant, Lemongrass, Oleoresin Capsicum (OC), Pepper Spray, Covid-19.

Exposure to reaction products of pyrotechnic ammunition using the example of flash-bang irritants

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Abstract

The development and testing of non-lethal active agents (NLW) have been the focus of various research projects since the 1960s and have been pursued with increased efforts since 1990. The aim was and is to enable the security forces to react appropriately to the respective situation with non-lethal agents. The safety, environmental and health aspects associated with the use of such agents are usually not sufficiently known, especially for new active agents. In addition, there are no established test regulations for analysis and evaluation of such agents.

The aim of this work is to develop a methodology that enables the testing and evaluation of the reaction products that arise when using irritants or stun grenades. The knowledge gained in this way should be able to be used for the assessment of the health load for people in different scenarios, e.g. during exercises or when used in buildings.

For this purpose, different types of sound and flash grenades were examined with regard to their reaction products and the spread of their vapours and gases in an open-air test site. After the reaction of a grenade, the gaseous and solid reaction products were analysed in a closed pressure vessel using gas chromatography, laser diffraction, X-ray diffractometry and scanning electron microscopy. In the open-air test site experiments, it was also possible to determine the initial volume and the speed of propagation of the vapours and gases generated by a grenade. The experimental results, together with a given spatial geometry, formed the input data for simulation calculations. These were implemented in a spatially resolved CFD model (Computer Fluid Dynamic) to calculate the spread and exposure of airborne hazardous substances. The simulation results show the local and temporal exposure to aerosols, particles and gases after the initiation of one or more sound and flash grenades under different spatial conditions and turbulence conditions. In comparison with known exposure limits, their exceedance can be shown. The presented system can also be applied to any other pyrotechnic ammunition or weapon system, e.g. to analyse and evaluate the load on the shooter when firing.

A non-ionising radiation application to numerically calculate an anatomical model's safe distance from multiple mixed frequency sources based on the requirements of various standards and guidelines.

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ABSTRACT

Rapidly calculating the human factors safe distance from multiple mixed frequency non-ionizing radiation sources and their interaction with surrounding medium, such as buildings and vehicles, is an important consideration, especially in time critical urban deployments. Typically, calculations take specialists weeks to obtain. To reduce turnaround times and allow non-specialists to obtain results rapidly, a RADHAZ application has been developed. The work presents the mathematical framework for solving an anatomical model's safe distance based on frequency dependent threshold exposure levels, averaging times, averaging areas and anatomical regions for an IEEE Standard[1], ICNIRP Guideline[2] and UK statutory requirement[3]. Currently the application utilizes the finite element method (FEM), a propagation model and optimization routines to find the safe distance from a single radiofrequency (RF) source, using drop-down options for 1) standard required [1-3], 2) RF options including, power, directional gain and polarization, and 3) human factors, including anatomical model, position, orientation, and ground level properties. The application has pre-set RF options, allowing the application to be tailored to specific contractor hardware and/or user profiles, depending on clearance levels, knowledge, and capabilities. The application has been designed to solve a full anatomical model exposed to a mixed frequency source (modulated pulse) with a center frequency of 5GHz on low-end hardware, as a standalone executable. The mathematical framework allows for the implementation of multiple mixed frequency sources, and additional surrounding medium. Future developments will utilize hybrid numerical methods to significantly reduce solution times, while increasing the size and complexity of the anatomical model's surroundings.

Keywords: Application, safe-distance, non-ionizing radiation, multi-source

Human effects of laser dazzling investigated in a shooting simulator

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ABSTRACT
Currently there is an already good understanding of the extent of visual obscuration caused by laser eye dazzle of humans. The experienced extent of visual obscuration depends mainly on the laser irradiance at the eye, the ambient light level, the wavelength of the laser and the contrast level of the target.
However, laser dazzling even at exposure levels below the obscuration limits has a significant and quantifiable effect on human performance. To investigate these effects, we set up a shooting simulator in a dark tunnel with a 532nm green dazzling laser. Trained shooters volunteered to participate in the trial. On a sound signal they tried to hit a bullseye target appearing on the projection screen. Shooting scores and delays to shoot were registered for each shot.
The results from the trials are compared with results obtained during a measurement campaign conducted previously at an indoor shooting range. In addition to the different offset angles of the target from the laser, observations at different experimental conditions, including different target contrasts and background luminance levels will be presented at the conference.

Keywords: Laser dazzling, shooting simulator, task performance, eye dazzling, human effects

Terminal outcomes of using an improvised 12-gauge non-lethal ammunition

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ABSTRACT

This paper aims on evaluating the terminal effects and outcomes related to the use of some improvised non-lethal ammunition consisting of regular 12-gauge shot ammunition for which the shots were replaced with a certain amount of rubber spheres that equip the HDS airsoft shotgun variants. Since the rubber spheres are available for online acquisition and they come in three different gauges (.43, .50 and .68 inches), trials were conducted with three different configurations for the 12-gauge non-lethal cartridge. Experimental testing environments were represented by a force wall and a ballistic gelatine rig, according to the STANREC 4744 procedures. Furthermore, a numerical evaluation was made in order to identify the bahavior of the rubber sphere - gelatin interface. Even though the making of such non-lethal cartridges is relatively simple and does not require special purpose equipment, the results confirm that this improvised approach does not lead to a safe and reliable non-lethal kinetic ammunition and its terminal effects might inflict severe damage to the persons engaged from a short distance.

Keywords: Improvised non-lethal ammunition, force wall, lethality assessment, rubber projectiles

A review of existing low, slow, and small UAS counter-measures

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ABSTRACT
Being able to reliably deal with rogue low, small, and slow UASs is paramount to ensure safety of Private, Public, and State institutions. Various happenings, both in peace and war times, such as the numerous airspace intrusions in airports worldwide, or the current ongoing events in Ukraine, illustrate the critical aspect of the threat posed by those UASs. As of today, some discrepancy between the performances announced by commercially-available counter-UAS technologies and results of in-field experiments might exist. Various factors, such as lack of extensive testing (on the system's parameters and/or the effect of the environment), or no testing at all, could explain those differences. In this review, a compilation of existing counter-UAS systems, combining both sensors and (low collateral damage) effectors, is presented, and comparison between real-world experience and expected technology outcomes is provided, whenever possible. From this statement of fact, the potential cause(s) of such discrepancy is/are deduced, and suggestions to narrow down the mismatches are proposed.

Keywords: Review, LSS, UAS, CUAS, Sensor, Effector

Preliminary Results on Designing a (PO)MDP to Determine Configuration-Specific Engagement Strategies for Countering Multiple UAS.

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ABSTRACT

As unmanned systems become an increasing threat to protected areas and installations, so does the threat of saturating protection systems with multiple of these relatively low-cost threats. An additional future challenge might come from adding swarm capabilities to these systems, where they could employ different strategies based on their mission and the situations they encounter. To find good engagement strategies for the defender, it would be interesting to convert the situation to a Partially Observable Markov Decision Process (POMDP) and have an agent search for good defensive strategies. The agent might have one defensive measure at its disposal or several. The number of threats might be changed to reflect the expected number of independent threats active in the area of responsibility or the number of elements in the swarm also taking their behaviour into consideration. Using the Partial Observability, the uncertainty of measurements and the limits of the sensors can be introduced in the simulations. Different classic policies can be evaluated to determine their effectiveness at handling the proposed threat and dealing with the risk of failure these threats present. The objective is to identify policies leading to better results.

Keywords: POMDP, Markov Process, C-UAS, Swarm, strategy, decision-making, MCTS

Non-Lethal 12-gauge ammunition Blunt Trauma Assessment: A case study from AM-403P Brazilian ammunition.

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The non-lethal 12-gauge AM-403P ammunition has been presented and some aspects of its terminal ballistics have been evaluated. Specific technical bases to evaluate its impact energy by BTTR (Biokinetics) have been pointed out and the correlation with classical techniques has been reported. The Back Face Signature pattern has been compared with the BTTR result and the convergence points were pointed out. The energy absorption by the elastic deflections of the projectile has been discussed by the estimative of the difference between the actual energy delivered to the target and the calculated kinetic energy of the projectile. The AM-403P security parameter has been established and reported. In addition, operational safety, tactical doctrine, and related concepts applied by the Brazilian security forces have been discussed with focus on AM-403P.

Keywords: non-Lethal-weapon, kinetic energy, blunt trauma, ballistics, rubber projectile.

An evaluation of precision and impact-energy aspects of 12-gauge AM-403P non-lethal ammunition.

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Condor, a Brazilian non-lethal technology company, has been designing and supplying the AM-403P ammunition for 10 years, providing a highly efficient non-lethal resource that protects life. Its precision and impact energy characteristics have been evaluated, and the precision parameters were the main points shown in this work. The dispersion of shots at different distances from the target was quantified by traditional concepts and compared with a new calculation, therefore introducing a Maximum Envelop Circle (MEC) parameter concept. The energy delivered to the body is mandatory to assess injury risks, and some aspects of the AM-403P impact energy have been discussed. The result of the dispersion calculations has been compared with other previously published results. The measured MEC radius was less than 10 cm at 20 m from the target. It has been observed that 20 m from the target is the optimal distance to achieve sufficient (effectiveness) with exceptional precision.

Keywords: non-Lethal-weapon, ammunition precision, energy, kinetic energy, rubber projectile.

An Analysis about Condor Drop: a system for remote launching of non-lethal ammunition by UAV.

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ABSTRACT

The professional employment of Unmanned Aerial Vehicle (UAV) in different tasks is a reality in the world. In the public security per example, some usual activities developed with UAV are people rescue and monitoring protests and roads. But it is just the beginning, proof of this are the new proposals recently presented by companies in the security area. Condor Non-Lethal Technologies presented recently a solution called Condor Drop that combines the displacement capacity, precision and stability offered by the UAV with a sequential electronic launcher for multiples ammunitions. This paper addresses the features of this type of technology and points the benefits and risks to use in operational situation. It presents unmet gaps by conventional launchers and ammunition and discusses about advantage and disadvantage of Condor Drop in these scenarios. It performs tests around Condor Drop performance and analyses parameters: accuracy, trigger delay and operational range. This paper intends to contribute with employment techniques of this solution in operational situations and to present pioneer tactics in development for to use UAV and non-lethal ammunitions.

Keywords: Condor Drop, UAV, Non-Lethal Ammunitions, Launcher.

Review of Literature : Behind Helmet Blunt Trauma mechanisms

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Combat helmets are meant to protect military personnel during impact events by defeating the incoming threats (blunt, ballistic or blast threats) without causing severe or fatal injury to the head. Unlike the older generation of helmets made of metallic materials, the development of a new generation of helmets made of composite material types of high ballistic performance and reduced weight like UHMWPE has enhanced the ballistic protection of the soldier and improved the ergonomic aspects of the helmets. Nevertheless, one drawback with these light helmets is the increase of the back face deformation (BFD) of the helmet shell, increasing likewise the risk of blunt trauma namely Behind Helmet Blunt Trauma (BHBT). BHBT is a non-penetrating injury type resulting from the BFD that might impair the performance of the soldier and even endanger his life. Therefore, it is important to investigate the origins of BHBT and to develop suitable mitigation strategies for implementation in future ballistic helmet designs. Unlike the different fields like automotive crash tests for pedestrians protection, automotive sport or construction industries where a long experience on the blunt trauma impact assessment and mitigation exists, the BHBT is a more recent discipline where there is still a lack of standardized procedures concerning testing methods, clear injury criteria and tolerance level for injury assessment.
Nevertheless, it is likely that the underlying injury mechanisms due to non-lethal impacts and BHBT or Behind Armour Blunt Trauma (BABT) in general. Hisley et al. [1] confirmed using the DIC technique of impacts of 9 mm on composite helmets that helmet dynamic BFD mechanically loads the skull similar to a direct impact from a non-lethal projectile or blunt object impact. Likewise, using a Blunt Trauma Torso Rig (BTTR) impacted by BABT impacts of 9mm parabellum projectiles and 7.62x51mm NATO projectiles impacting adequate body armour, Robbe et al. [2] performed a quantitative comparison between non-lethal impact dynamics and the behind armour blunt trauma (BABT) solicitations. They found a similitude between the two types of solicitations.
The goal of this paper is to provide a review of the literature on the different mechanisms of blunt head injuries especially BHBT in the effort to improve or to design better protection systems to mitigate these injuries.

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