European Working Group
Non-Lethal Weapons

10th European Symposium on Non-Lethal Weapons
May 20-23, 2019

Royal Military Academy, Brussels, Belgium

General Information
Conference Program & Paper Overview

www.non-lethal-weapons.org

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WELCOME

Non-Lethal Weapons are becoming more and more established within military and police operations reducing the risk of unnecessary fatalities and undesirable outcomes.

The bi-annual NLW Symposium which was first held in 2000 moved this year to the Royal Military Academy in Belgium. The Symposium has been, and is always an ideal forum to discuss ideas, advances, requirements in an interdisciplinary framework.
Developing NLW technologies and encouraging its safe and effective use by the military and law enforcement units is definitely an initiative that the European Working Group on NLW would like to fully support.

The 2019 Symposium will provide a valuable opportunity to hear from and discuss the many aspects of these subjects with scientists, operational practitioners and subject matter experts in very different fields.

It is a great opportunity to take stock of significant technical and societal developments in the NLW community, open the discussion and draw conclusions, after having received the point of view of different communities.

Please enjoy these moments as much as we will and, at the end of the symposium, take new ideas and discussion topics with you in order to feed the will to progress that has always been present in our domain.

Chairman of the Symposium
Alexandre Papy ir PhD
Associate Professor

Chairman of the EWG on NLW
Massimo Annati
Italian Navy (ret´d), Milano

ABOUT THE EWG-NLW

In 2019 the Biannual Symposium is being organised by the European Working Group on Non-Lethal Weapons for the 10th time. It is the longest running and only event where subject matter experts can come together and discuss the complex topics surrounding the development and deployment of Non-Lethal Weapons in both law enforcement and defence environments.

Over the past 20 years the Symposium has established itself as the main hub for networking and sharing the latest information in this important and often contentious area of work. The move of the symposium from its previous home in Ettlingen, Germany to the Belgian Royal Military Academy in Brussels giving us the opportunity to remember the core tenets of the Symposium:

• To promote research and development of Non-Lethal Weapon technologies to meet current and future operational requirements.
• To encourage the European defence and security industry to become more innovative and more competitive in designing, developing and validating new Non-Lethal Weapon technologies.
• To learn from international operational expertise of Non-Lethal Weapon technology, development and deployment.

With that in mind we invite you to submit abstracts to the committee from the following areas of expertise:

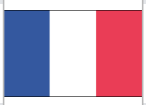
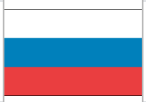
- Scientific and technical
- Operational
- Legal
- Medical
- Human effects
- Policy making
- Human rights

The above topics are only a guide and the organisers are willing to consider abstracts on all aspects of this wide subject area.

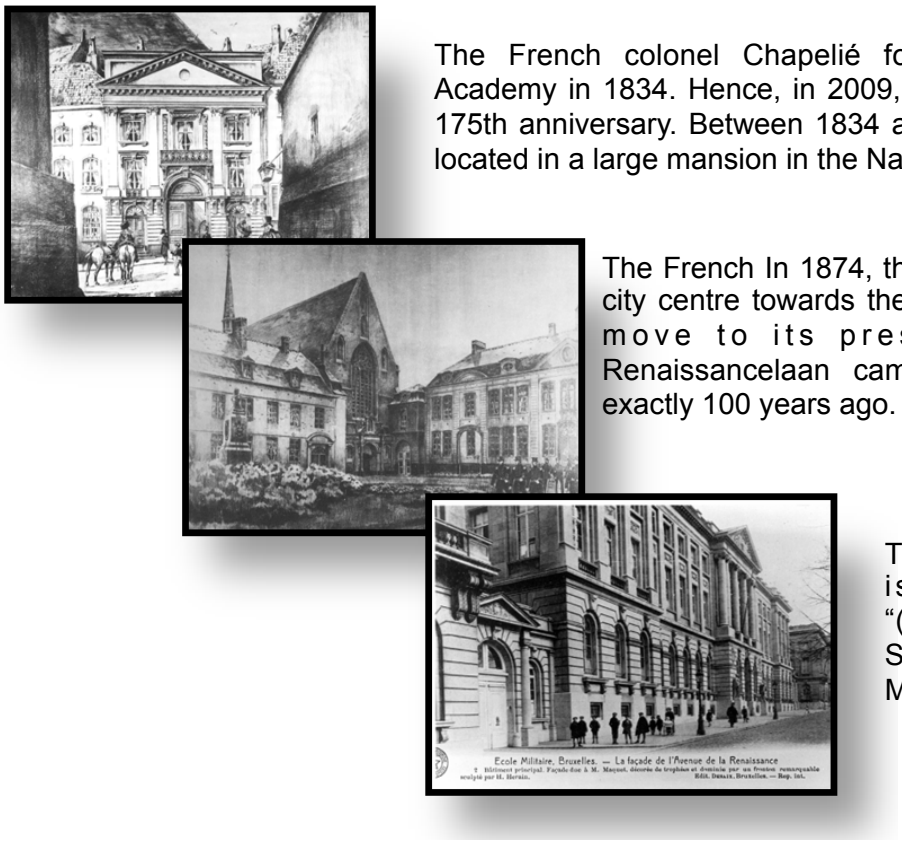
Brussels is home to the European Union, NATO and EDA and offers excellent transport connections within Europe and beyond. We look forward to receiving your submissions and meeting you in this new centrally located venue.

Chairman of the Symposium
Massimo Annati
Italian Navy (ret´d), Milano

EWG INTERNATIONAL COMMITTEE

Massimo	ANNATI	Chairperson		Europe, Italian Navy (ret'd)
Alexandre	PAPY	Deputy Chairperson		Belgium, Royal Military Academy
Becky	NEWMAN	Secretary general		United Kingdom, Strategic Engagement & Capabilities Team, Home Office Science – Centre for Applied Science & Technology
Stefano	BERGONZINI	Point of contact, Member of symposium committee		NATO, NATO Stability Policing Centre of Excellence
Milan	BEZDEK	Point of contact, Member of symposium committee		Czech Republic, Military Technical Institute (MTI, s.e.)
Marius Valeriu	CIRMACI-MATEI	Point of contact, Member of symposium committee		Romania, Military Technical Academy, Bucharest
Massimo	CRIVELLI	Point of contact, Member of symposium committee		Switzerland, Swiss Army
Thomas	ERIKSSON	Point of contact, Member of symposium committee		Sweden, Swedish Defence Research Agency, Tumba
Rüdiger	HAAS	Point of contact, Member of symposium committee		Austria, Bundesministerium für Landesverteidigung
Carlos Alberto Sousa	MAGALHAES	Point of contact, Member of symposium committee		Portugal, Special Unit Police
Sjef	ORBONS	Point of contact, Member of symposium committee		Netherlands
Reza	RAHIMI	Point of contact, Member of symposium committee		Norway, Norwegian Defence Research Establishment (FFI)
Anthony	RIESEMANN	Point of contact, Member of symposium committee		France, DGA, Bourges
Vincenzo	SANFILLIPPO	Point of contact, Member of symposium committee		Italy, Ministry of Defence, National Armament Directorate
Victor	SELIVANOV	Point of contact, Member of symposium committee		Russia, Baumann University
Graham	SMITH	Point of contact, Member of symposium committee		United Kingdom, Home Office Centre for Applied Science and Technology CAST

ABOUT THE ROYAL MILITARY ACADEMY (RMA)



The French colonel Chapelié founded the Royal Military Academy in 1834. Hence, in 2009, the Academy celebrates its 175th anniversary. Between 1834 and 1874, the Academy was located in a large mansion in the Naamsestraat – Brussels.

The French In 1874, the Academy moved from the city centre towards the abbey of Terkameren. The move to its present location at the Renaissancelaan campus took place in 1909, exactly 100 years ago.

The Royal Military Academy is a bilingual institute "(KMS=Koninklijke Militaire School: ERM=Ecole Royale Militaire).

GENERAL GUIDELINES

RULES OF THE HOUSE

The most important conference areas are indicated on the RMA orientation map.

The opening of the conference, all the oral presentations and poster sessions take place in the conference centre. The conference room is on the first floor of this building.

Please shut down your cellular phone while being in the conference room.

Once a conference session is in progress, we ask you not to enter the conference room by the first floor ; in that case, please use the entry on the second floor.

If you have to leave the conference room during a presentation, please use the exit at the back of the room.

The poster area and the coffee break area are situated on the first floor and the technical exhibition booths are located on floor 0 and floor 1. A lift is available for persons with reduced mobility.

The conference helpdesk is situated on the ground floor.

Toilets are located in the Conference Centre on the ground floor.

The lunch area is in a different building of the Academy. Please follow the signs (see also the RMA map).

Unguarded cloakrooms are at your disposal at the entrance of the conference area and at the entrance of the lunch area. We advise you not to leave any valuables there.

Unless you are guided by a member of the local staff, please do not enter buildings other than the Conference Centre and the lunch area.

CONFERENCE BADGES

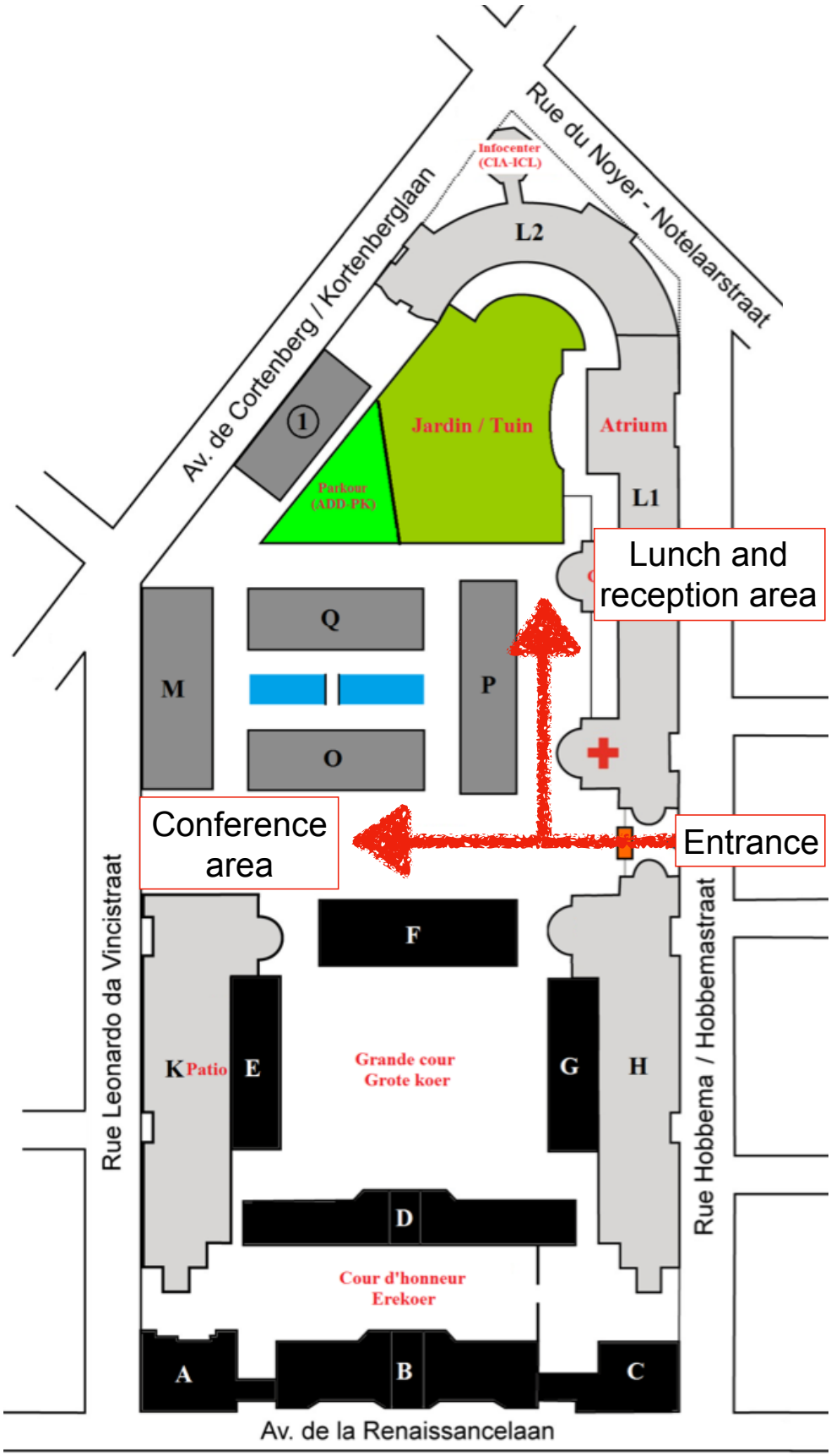
Upon check-in, you will receive a personal badge. Please wear your badge upon entering the Academy and at all times during your stay within the Academy.

The speakers will receive a blue badge, the poster presenters a green badge and the EWG members a red badge. You will identify the local staff by their yellow badge, the IT responsible by his orange badge and the photographer by his purple badge.

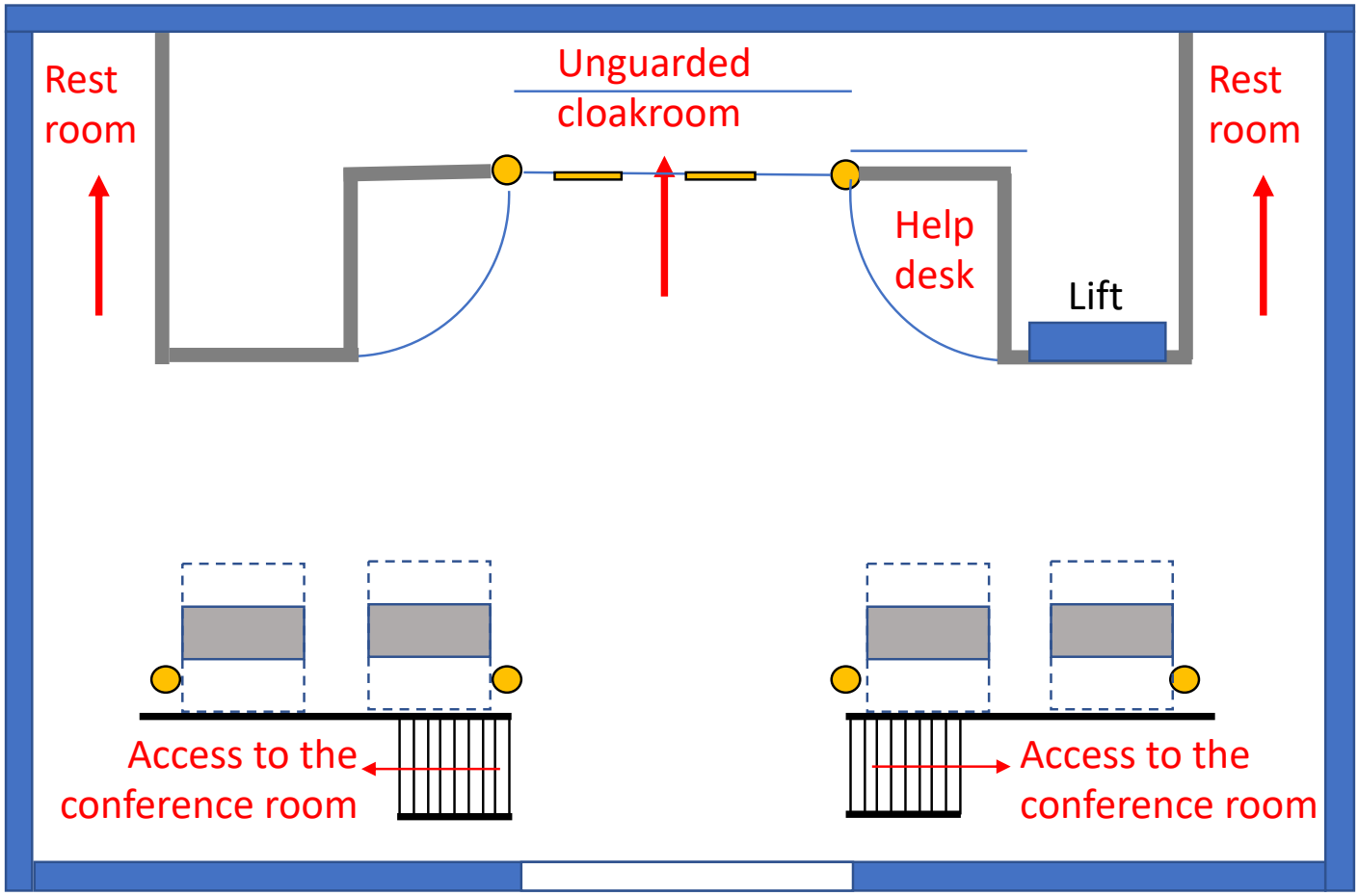
HELPDESK

For questions or problems, please contact the help-desk situated in the conference building on ground floor. The help-desk is open throughout the conference.

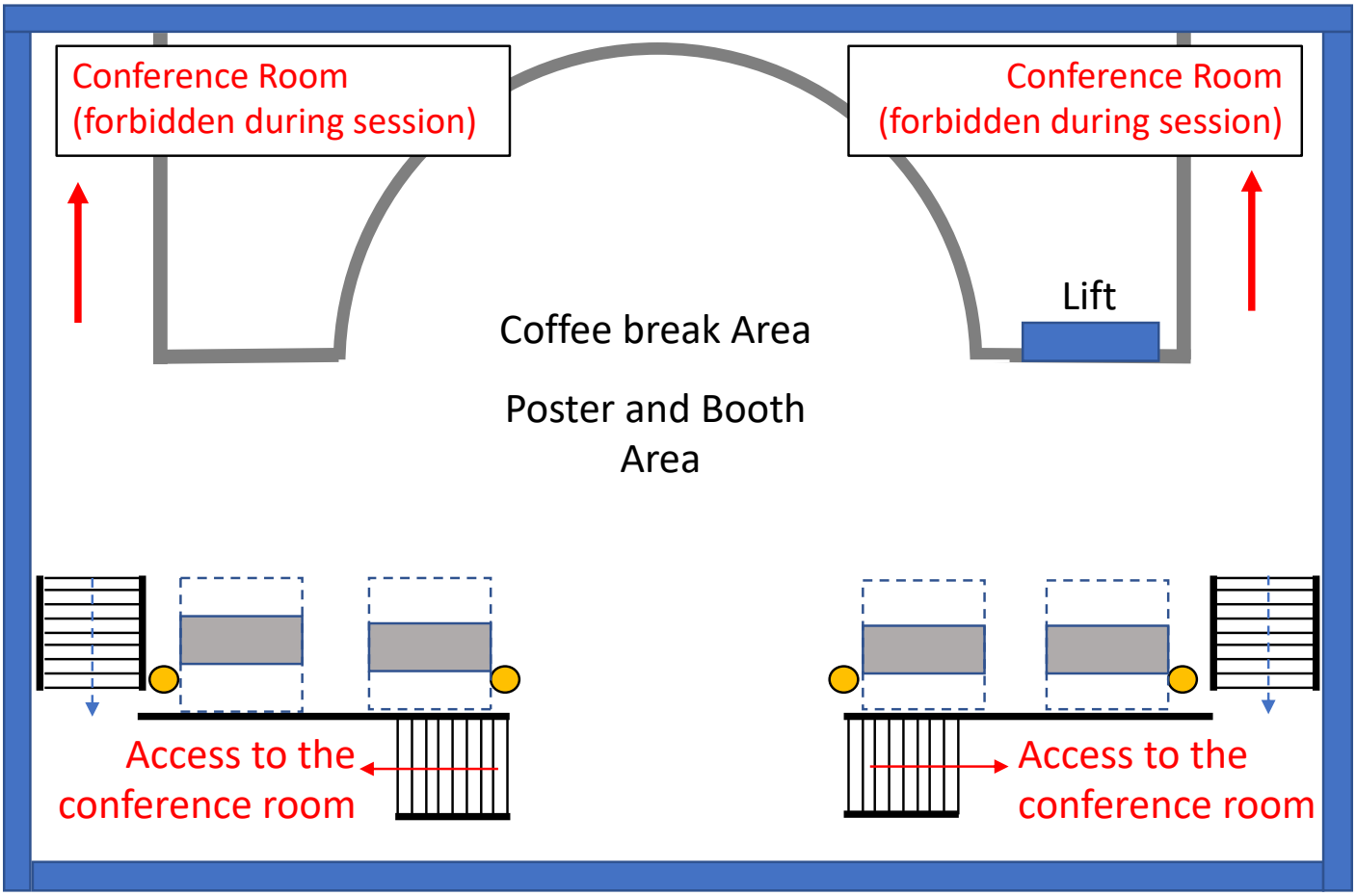
PRACTICAL INFORMATION - RMA ORIENTATION MAP



FLOOR 0


Rest room
Unguarded cloakroom
Rest room
Help desk
Lift
Access to the conference room
Access to the conference room

FLOOR 1


Conference Room
(forbidden during session)
Conference Room
(forbidden during session)
Lift
Coffee break Area
Poster and Booth
Area
Access to the
conference room
Access to the
conference room

PRACTICAL INFORMATION - CONFERENCE BUILDING

ORAL PRESENTATIONS

For last minute instructions, we ask all speakers as well as the session chairmen to join the IT responsible (**Mr. Tom Vancaeyzeele**) in the conference room 20 minutes prior to the start of their session.

POSTER SESSIONS

All poster sessions run during the coffee-breaks. Specific **poster in the spotlight** sessions are organized thorough the week. Poster presenters are also asked to contact the IT responsible (**Mr. Tom Vancaeyzeele**) 20 minutes prior to the start of their session. They are required to stand in front of their posters during the following coffee-break.

Authors are invited to remove their posters before Thursday 18.00 Hr.

TECHNICAL EXHIBITION

The technical exhibition runs during the entire week.

INTERNET

The Academy offers wireless internet connection in the conference building.You can connect your device using the following credentials.

SSID : Research Net
Login : ResearchNet
Password : R3s3@rchN3T

REGISTRATION AND RECEPTIONS

The registration is open on Monday May 20th 2019 from 18h00 to 20h00 and will take place in the Conference Building. There will be a « **welcome drink** » at the same time on the first floor of the same building.

On Tuesday May 21st 2019, a « **welcome reception** » will be held in the lunch and reception area from 18h00 to 20h00.

PROGRAMME

Monday 20/05/19 Afternoon		
Time from	**Time to**	**Activity**
Optional Seminar		
13 h 00	**17 h 30**	***Optional Seminar (registration required)***
13 h 00	14 h 15	Introduction on Non-Lethal-Weapon and Risk assessment of Kinetic Energy Non-lethal Impacts ***Cyril Robbe, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
14 h 15	14 h 30	***Short break***
14 h 30	15 h 45	Taser and FN 303 : operational aspects from the users point of view ***O. Paelinck, former member of Peloton Anti-Banditisme, Special Unit Liege police, Belgium***
15 h 45	16 h 15	Live demo in the ABAL ballistic laboratory ***Cdt Jurgen Grossens, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
16 h 15	17 h 30	Medical aspects linked to the use of Conducted Energy NLW ***Eric Lemaire, University Hospital Center of Liège, Belgium***
Registration and Welcome drink		
18 h 00	**20 h 00**	Registration, poster installation, oral presentation upload **Registration drink**

PROGRAMME

Tuesday 21/05/19 Morning		
Time from	**Time to**	**Activity**
7 h 45	8 h 15	Doors and registration desk are open
Welcome and Keynote Session		*Chair : Alexandre Papy*
8 h 15	8 h 30	Opening and Welcome ***Major General Lutgardis Claes, Commander of the Royal Military Academy***
8 h 30	8 h 45	Welcome from the European Working Group ***Rear Admiral Massimo Annati, Chairman of the European Working Group***
8 h 45	9 h 10	Keynote speech ***Lieutenant General Rudy Debaene, Director General Material Resources and National Armament Director of the Belgian Army***
Human rights, legal aspects and interational organizations session I		*Chair : Sjef Orbons*
9 h 10	9 h 40	Developing international Guidance on Less-Lethal Weapons and Related Equipment in Law Enforcement (2019): A step towards transferable standards ***Stuart Malsen, Centre for Human Rights, University of Pretoria, South Africa***
9 h 40	10 h 10	Update on Current and Planned NATO NLW Activities ***John Nelson, American Systems Corporation in support of U.S. Joint Non-Lethal Weapons Directorate, USA***
Coffee break		
10 h 10	10 h 40	Coffee break
Conducted Energy Weapons session		*Chair : Graham Smith*
10 h 40	11 h 10	Benefits vs. Real and Perceived Risks of Handheld Electrical Weapons ***M.W. Kroll, University of Minnesota, USA***
11 h 10	11 h 40	UK management of the in-service technical performance and manufacturers changes to the TASER® X2™ system. ***Graham Dean , Defence Science and Technology Laboratory (Dstl), UK***
11 h 40	12 h 10	The Latest Generation Conducted Electrical Weapon: Evaluation of Safety and Effectiveness ***Donald Dawes, Lompoc Valley Medical Center, USA***
Lunch break		
12 h 10	13 h 40	**Lunch**

PROGRAMME

Tuesday 21/05/19 Afternoon		
Time from	**Time to**	**Activity**
Technical evaluation I		Chair : Ulf Arborelius
13 h 40	14 h 10	Rubber batons and ricochets: a case report ***Fayçal Chidiac, French Gendarmerie Forensic Sciences Institute, Cergy-Pontoise, France***
14 h 10	14 h 40	An Experimental versus Numerical method to assess head injuries of Non-lethal projectile impacts ***Cyril Robbe, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
Business session		*Chair : Ulf Arborelius*
14 h 40	15 h 10	Non-Lethal Boat Stopping System ***Andrew Howell, BCB International Ltd, Cardiff, UK***
Posters in the spotlight - Poster session & coffee break		
15 h 10	15 h 25	Posters 1-2
15 h 25	16 h 00	Coffee & poster session
Operations I session		*Chair : Rüdiger Haas*
16 h 00	16 h 30	Developing Use of Force Reporting: A Case Study from England and Wales. ***A. Dymond, Sociology, Philosophy and Anthropology, Amory Building, University of Exeter, UK***
16 h 30	17 h 00	A Technology Assessment approach of NLW for police and defence forces: lessons learned from the Taser X2 trial of the Dutch National Police ***Sjef Orbons, OSDAR, Eindhoven, The Netherlands***
17 h 00	17 h 30	The United Kingdom operational experience of the TASER® X2™ ***R.D. Sheridan, Defence Science and Technology Laboratory (Dstl), Salisbury, UK***
17 h 30	18 h 00	Police use of non-lethal weapons: analysis of real cases ***A. Papy, Royal Military Academy, Department of Weapon Systems and Ballistics, Eric Lemaire, University Hospital Center of Liège, Belgium***
Welcome Reception		
18 h 00	20 h 00	**Welcome reception**

PROGRAMME

Wednesday 22/05/19 Morning		
Time from	**Time to**	**Activity**
8 h 30	9 h 00	Doors and desk are open
9 h 00	9 h 05	Administrative remarks (organizers)
Operations II session		*Chair : Rebekah Newmann*
9 h 05	9 h 35	The Attenuating Energy Projectile: an update on effectiveness and safety from operational data. ***G Smith, Defence Science and Technology Laboratory, St Albans UK***
9 h 35	10 h 05	A prospective Police Technology Assessment study of the use of non-penetrating projectiles for public order maintenance ***O.M.J. Adang, Academy of the Netherlands and University of Groningen (the Netherlands)***
Posters in the spotlight - Poster session & coffee break		
10 h 05	10 h 20	Posters 3-4
10 h 20	10 h 55	Coffee & poster session
Modelling I session		*Chair : Sofia Hedensternia*
10 h 55	11 h 25	Numerical recreation of field cases on a biofidelic human FE model involving deformable less-lethal projectiles model involving deformable less-lethal projectiles ***A. Bracq, Laboratory LAMIH UMR CNRS 8201, University of Valenciennes, France***
11 h 25	11 h 55	Improved simulation of a human thorax subjected to ballistic impact ***Lionel Gilson, Royal Military Academy – Department of Construction, Brussels, Belgium***
Lunch break		
11 h 55	13 h 25	**Lunch**

PROGRAMME

Wednesday 22/05/19 Afternoon		
Time from	**Time to**	**Activity**
Modelling I session (follow on)		*Chair : Sofia Hedensternia*
13 h 25	13 h 55	The validation of a finite element head model for the non-lethal impacts ***A. Oukara, Ecole Militaire Polytechnique, Algiers, Algeria***
13 h 55	14 h 25	Impact of soft projectiles on rigid targets: modelling and impact pressure measurement attempt ***Michel Arrigoni, ENSTA Bretagne, France***
Posters in the spotlight - Poster session & coffee break		
14 h 25	14 h 35	Posters 5-6
14 h 35	15 h 10	Coffee & poster session
Human Effects session		*Chair : Alexandre Papy*
15 h 10	15 h 40	Estimation of Laser Dazzle Effects on Shooting Performance ***M. Vandewal, Royal Military Academy, CISS Department, Brussels, Belgium,***
15 h 40	16 h 10	The usability of the FN 303 in operational conditions: Nonlethal, less-lethal, or somewhat too lethal after all? ***J. Taverniers , The Human Factors Lab, Tervuren, Belgium.***
16 h 10	16 h 40	Trauma evaluation after using double tap marking FX®-cartridge for Force-on-Force military training. ***JC. de Schoutheete, Queen Astrid Military Hospital, Brussels, Belgium***

PROGRAMME

Thursday 23/05/19 Morning		
Time from	**Time to**	**Activity**
8 h 30	9 h 00	Doors and desk are open
9 h 00	9 h 05	Administrative remarks (organizers)
Innovation and design session		*Chair : Florian Audigier*
9 h 05	9 h 35	Toward Bullet Simulating Non-Lethal Projectiles ***Cyril Robbe, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
9 h 35	10 h 05	On the mechanical and chemical characterizations of foams used for non-lethal projectiles ***A. Boudiaf, Ecole Militaire Polytechnique, Algiers, Algeria***
10 h 05	10 h 35	Error budget of non-lethal projectiles using stochastic simulations ***I.Ndindabahizi, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
Posters in the spotlight - Poster session & coffee break		
10 h 35	10 h 45	Posters 7
10 h 45	11 h 25	Coffee & poster session
Technical evaluation II session		*Chair : Graham Smith*
11 h 25	11 h 55	Optimizing a skin penetration model to assess kinetic energy non-lethal weapons ***Fayçal Chidiac, French Gendarmerie Forensic Sciences Institute, Cergy-Pontoise, France***
11 h 55	12 h 25	In-situ Prediction of the Acoustic Impact of Stun Grenades ***C. Amon, JOANNEUM RESEARCH Forschungsgesellschaft mbH – DIGITAL, Graz, Austria***
Lunch Break		
12 h 25	13 h 40	**Lunch**

PROGRAMME

Thursday 23/05/19 Afternoon		
Time from	**Time to**	**Activity**
Human rights, legal aspects and interational organizations session II		*Chair : Graham Smith*
13 h 40	14 h 10	Non-Lethal Weapons Through the Lens of State Responsibility ***Paul Behrens, University of Edinburgh. School of Law, University of Edinburgh, Old College, South Bridge, United Kingdom***
Modelling II session		*Chair : Marijke Vandewal*
14 h 10	14 h 40	Laser dazzling of CMOS imaging sensors ***C. N. Santos, CISS Department, Royal Military Academy, Brussels, Belgium***
14 h 40	15 h 10	Active Denial Technology Computational Human Effects End-to-End Hypermodel For Effectiveness ***Shelley Cazares, Institute for Defense Analyses, USA***
15 h 10	15 h 40	Biological risks of acute and chronic 94 GHz exposures ***F. Del Vecchio, Institut de Recherches Biomédicales du Service de Santé des Armées, Brétigny sur Orge, France***
Best presentation and poster awards		
15 h 40	16 h 00	**Deliberation + announcement best presentation / best poster awards**
Closing		
16 h 00	16 h 15	Closing ***Rear Admiral Massimo Annati, Chairman of the European Working Group***
Closing coffee		
16 h 15	16 h 45	Closing Coffee

POSTERS

Posters	
1	Methodology for the creation of an anthropometric 3D finite-element model of the human head for blunt impacts simulation ***Nestor Nsiampa, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
2	*Aerodynamical CFD Study of a non-lethal 12-gauge fin-stabilized projectile* ***Véronique de Briey, Royal Military Academy – Department of Weapons Systems and Ballistics, Brussels, Belgium***
3	A global survey of less lethal weapons manufacture and use – human rights and trade control implications. ***Helen Close, Omega Research Foundation, Manchester, UK***
4	Contemporary development, trade and use of "remote control" riot control agent delivery mechanisms: challenges for effective State regulation ***Helen Close, Omega Research Foundation, Manchester, UK***
5	In-band laser damage to an uncooled thermal infrared imager. ***Gareth Lewis, CISS Department, Royal Military Academy, Brussels, Belgium***
6	Evaluation of Natural Capsaicin pepper spray by GC-FID-MS, NMR and HPLC: an alternative to the use of Oleoresin Capsicum. ***Nilton Olivera Junior, Condor Non-Lethal Technology, Rio de Janeiro, Brazil***
7	Effects associated with the pulsed current of electroshock devices ***Tatiana Fomina, SRC-FMBC, 123182, Zhivopisnaya 46, Moscow, Russia***

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Non-Lethal Weapons Through the Lens of State Responsibility

P. Behrens

The principle of humanity and the need to mitigate the consequences of warfare have been fundamental tenets of international humanitarian law from the beginning. The prioritisation of non-lethal over lethal weapons appears to be well in line with these efforts. Modern rules of international law, however, often stipulate prohibitions on specific weapons categories without reflecting on underlying principles, frequently resulting in restrictive consequences for non-lethal weapons. The use of tear gas, for instance, runs counter to the ban on riot control agents under the Chemical Weapons Convention, the development of bacteria which degrade fuel is likely to violate the Biological Weapons Convention. At the same time, the overarching principle of 'humanity' was at no time abandoned and is emphasised even in contemporary instruments of international law.

This paper explores the question in how far international law itself, through the system of State responsibility, offers a way to reconcile these potentially divergent interests. The Draft Articles on State Responsibility, adopted by the International Law Commission in 2001, deal with the structure that applies when rules of international law (including the law of armed conflict) have been violated, but they also allow for certain exceptions to the wrongfulness of an act, if specific parameters apply. These situations are very narrowly defined, and there are good reasons to interpret them strictly. However, once their conditions exist, the rules of State responsibility may well mitigate between divergent interests of international law and avoid the emergence of results which run counter to the mandates of humanity which, from its earliest days, were meant to inform the system of the law of armed conflict.

Paul Behrens, PhD, LLM, is Reader (Associate Professor) in Law at the University of Edinburgh. He has taught in the past at the University of Leicester, is a member of the Surrey International Law Centre, Associate of the Stanley Burton Centre for Holocaust and Genocide Studies and member of the Scottish Centre for International Law. He has been Visiting Lecturer / Visiting Researcher at Uppsala (Sweden), Stockholm (Sweden), Kiel (Germany) and other universities.

Dr Behrens is co-author of *Elements of Genocide* (Routledge 2012)) and *The Criminal Law of Genocide* (Ashgate 2007) and has written articles and papers on topics of international humanitarian law and international criminal law. He has also published in the field of diplomatic law, including the books *Diplomatic Interference and the Law* (Hart Publishing 2016) and (as editor) *Diplomatic Law in a New Millennium* (Oxford University Press 2017).

Dr Behrens teaches international law at the University of Edinburgh, including LLM courses on International Criminal Law and Diplomatic Law. He also contributes regularly to newspapers (including *Guardian, Scotsman, Süddeutsche Zeitung*) on issues of international law and constitutional law and has given media interviews on these topics.

Notes

‘Developing international Guidance on Less-Lethal Weapons and Related Equipment in Law Enforcement (2019): A step towards transferable standards’

C. Heyns,[1] S. Casey-Maslen[2] and T. Probert[3]

[1] Member of the UN Human Rights Committee, Professor of Human Rights Law, Institute for International and Comparative Law, University of Pretoria, Pretoria Private Bag X20, South Africa Christof.Heyns@up.ac.za[2] Honorary Professor in the Centre for Human Rights at the University of Pretoria, and former Head of Research at the Geneva Academy of International Humanitarian Law and Human Rights

[3] Extraordinary Lecturer in the Centre for Human Rights at the University of Pretoria, and a Research Associate of the Centre of Governance and Human Rights at the University of *Cambridge*

While the development and equipping of law enforcement officials with “less-lethal” weapons has long been encouraged by international human rights law, there has been a dearth of clear international standards against which to measure their lawful and responsible design, production, procurement, testing, training, transfer, deployment, and use. Over the past year the authors, as members of an international Academic Working Group convened in Geneva, and in collaboration with the UN Office of the High Commissioner for Human Rights (OHCHR), have been involved in the development of Guidance on Less-Lethal Weapons and Related Equipment in Law Enforcement. The objective of the Guidance is to assist States, their law enforcement agencies, manufacturers, human rights bodies and mechanisms, private security companies, and police oversight bodies, as well as civil society in complying with international rules governing the use of force in law enforcement. The Guidance first explains the general principles of law governing use of force in law enforcement, then addresses general considerations pertaining to less-lethal weapons, including their design and production, legal review, testing and procurement, monitoring of use, transparency, training and transfer. Particular guidance is then offered on the use of less-lethal weapons in specific situations (arrest, the management of assemblies, and in custodial settings). A number of less-lethal weapons that serve no legitimate law enforcement objective are then listed. Finally, more detailed guidance is provided on specific categories of less-lethal weapons: police batons, hand-held chemical irritants, chemical irritants dispersed at a distance, conducted electrical weapons, kinetic impact projectiles, dazzling weapons, water cannon, and acoustic weapons. This paper will introduce the Guidance and process that led to their development, including the role of law enforcement agencies and less-lethal weapon manufacturers, as well as discuss the importance of sensitising all relevant stakeholders to their content in order that they develop appropriate protocols.

Christof Heyns is a Member of the UN Human Rights Committee, one of the UN’s pre-eminent human rights mechanisms, charged with reviewing implementation of the International Covenant on Civil and Political Rights (ICCPR). Before this, in 2010–16, he was the UN Special Rapporteur on extrajudicial, summary or arbitrary executions. Also in 2016, he headed up the UN Independent Investigation on Burundi. In all three roles he has engaged with the subject of less-lethal weapons, and highlighted the need for more developed international considerations of their use in law enforcement. Prof Maslen and Dr Probert have worked closely with Prof. Heyns and other partners as part of the Academic Working Group that has drafted the new Guidance that will be published by the UN in 2019.

Notes

Update on Current and Planned NATO NLW Activities

J. Nelson[1]

[1]*American Systems Corporation in support of U.S. Joint Non-Lethal Weapons Directorate 3097 Range Rd, Quantico, VA 22134, USA*
john.nelson@americansystems.com and john.j.nelson.ctr@usmc.mil

Driven by operational experience as well as threats likely to be seen in the future security environment, NATO has been active in working on NLW issues. There are ongoing activities within the Science & Technology Organisation, in the Defence Against Terrorism (DAT) Programme, and in the NATO Army Armaments Group's Joint Non-Lethal Weapons Capabilities Group (JNLWCG). This presentation will provide an overview of work to identify and address challenges to NLW development, acquisition, and employment (and plans to conduct a Stakeholders Event to pursue solution implementation); an initial demonstration examining non-lethal effectors to counter small unmanned aircraft systems (and planned future assessment exercises of NLW in C-sUAS); and work to promote NLW standardisation and better inclusion in NATO and National concepts and doctrine.

John Nelson, an international defence analyst with 30 years' experience, has led many high-level planning and analytical efforts. Several examples include analysis and re-design of I Marine Expeditionary Force's (I MEF's) Planning/Decision/Execution/Assessment process, significantly increasing I MEF's planning horizon; development and analysis of the first in a series of interagency exercises on Peace Support Operations; development of theatre-level contingency plans and organizational assessments for the Implementation Force/Stabilization Force (IFOR/SFOR) in Bosnia; leadership of a multifaceted study analysing the insurgency in Iraq's Anbar Province; and leading roles in multiple NATO studies, including the NLW Effectiveness Assessment (SAS-060) that won a 2008 NATO Scientific Achievement Award, a Capabilities-Based Assessment (SAS-078), which received Bi-Strategic Command endorsement, and NLW in NATO and National Concepts (SAS-094) that received the NATO Scientific Achievement Award in 2018.

Notes

Benefits vs. Real and Perceived Risks of Handheld Electrical Weapons

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Handheld conducted electrical weapons (CEWs) have been used 3.9 million times in the field in 107 countries. Prospective studies (including over 40k uses of force) find a 65% reduction in subject injuries versus batons, manual control, and “pepper” spray. There is a 2/3 reduction in fatal shootings when CEW usage is not overly restricted. USA-derived data suggest that the temporal subject fatality rate with resistant arrest is ≈ 1:1000 without a CEW and ≈ 1:3000 with the CEW. UK data suggest 85% compliance with simply the threat of a CEW.

There have been 18 deaths from falls (16 brain injuries and 2 cervical fractures) and 8 deaths from fume ignition. These 26 deaths provide a fatality risk of 6.7 per million [95% CI: 4.5-9.8]. There are 20 cases of unilateral blindness from a probe eye penetration. There were also 4 cases of non-fatal major burns and 1 of permanent brain damage from a fall. These 25 injuries provide a risk of 6.4 per million [(95% CI: 4.3-9.5].

The risk of electrocution is very low since present CEWs satisfy the IEC 60335 electric-fence limit of 2.5 W and the ANSI-CPLSO-17 limits of 125 μC per pulse with a normalized aggregate current of 2.2 mA. Arrest-related- death anecdotes alleging an electrocution all fail several diagnostic tests for an electrocution.

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Notes

UK management of the in-service technical performance and manufacturers changes to the TASER® X2TM system

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In 2016 the Home Office Centre for Applied Science and Technology (CAST) completed a technical evaluation of the TASER® X2TM Conducted Energy Device (CED) against the UK Police operational requirements. The Home Office published the report and the then Home Secretary authorised the TASER® X2TM for operational use by UK police in March 2017. The TASER® X2TM came into operational service in August 2017 with the first operational use in September 2017. A mechanism is in place to allow a police user of the TASER® X2TM to report any technical faults, problems or issues experienced with the TASER® X2TM system during training or in operational use. The police send reports to the Defence Science and Technology Laboratory (Dstl) so any trends or patterns in faults can be identified and highlighted to Axon. Fifty-seven reports have been received by Dstl. The first report was received in November 2017 and a breakdown of faults has been collated up to January 2019. Over this period there have been nearly 8000 uses of the TASER® X2TM in the UK. This paper highlights an example of a commonly reported fault and one that impacted officer safety and explains the follow up action that has been taken. This includes guidance material published by Axon. Dstl works with Axon to assess any changes to the TASER® X2TM system. The UK manages any changes to the TASER® X2TM system and the new design of TASER® hook and loop training (HALT) cartridges have been evaluated to verify that the performance meets the police requirements.

Graham Dean, Dstl

Notes

A model for conducted electrical weapon safety and effectiveness evaluation – the TASER 7

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Axon has released its third generation conducted electrical weapon (CEW) called the T7 that has numerous advantages over prior generation weapons. Through a decade-long collaboration with external medical consultants, Axon has developed a three-phase final safety/efficacy pathway for all substantially new weapons. In the three-phase safety/efficacy testing, the T7 was non-inferior to the “gold standard” X26E; and, from a cardiac safety standpoint, had a “safety profile” more similar to the X2, and, from an efficacy standpoint, had an efficacy more similar to the X26E. This would represent an improvement in the evolution of the weapons. The authors recommend all new CEWs be subjected to a similar pathway and that the data be published through the peer review process to allow public scrutiny. We believe this represents the current industry standard for due diligence.

Donald Dawes,

Notes

PacSci EMC's Non-Lethal Vehicle Stopping Device: *ArrestNet*™ - Countering an Increasing Terror Trend: Vehicles as Weapons at Public Events

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There is a clear and growing trend around the world in which cars and trucks have been used as lethal weapons, with devastating effect. Terrorist attacks at temporary public events at the Nice Bastille Day firework display and the Berlin Christmas Market led to nearly a hundred deaths with many more injured. Whilst high-profile buildings can be protected with hard barrier systems, temporary public events and festivals that attract thousands of visitors represent an easy target to the determined terrorist. So, there is a clear capability gap in lightweight, mobile solutions to effectively stop hostile vehicles that do not comply with access-point entry control, solutions that can be easily moved from event to event. The paper considers available solutions and shortfalls, and describes PacSci EMC's development history of ArrestNet™ including the application of ultra-strong and lightweight net entanglement solutions to defeat hostile vehicles, non-lethally. Design approach and concepts, state-of-the-art UHMWPE, knotless netting technology, Military v Civilian applications and drivers are considered. Furthermore, non-lethal solutions are considered in the context of real-word application at temporary events and civilian operator effectiveness. The potential for automatic activation (e.g. over-speed sensor, triggered by infringement of red traffic lights) that non-lethal effects allow, improving reliability and saving manpower costs is highlighted. Vehicle entry point design as a means to reduce speed and penetration is considered, as are the limitations of non-lethal effect versus hard kill lethal solutions. However, it is concluded with the multitude of temporary events, and the growing threat trend, that stopping vehicles with moderate penetration is better than the current reality of no protection at all.

Neal Kerr. Sr. Director, Product Line Management Law Enforcement Products at PacSci EMC, Over 23 years' experience in the Defence Industry in various roles including Project Management, Business Development and Contract Negotiations.

Philip John Dandy. Chartered Mechanical Engineer, MBA in Project Management. 35 years' experience in the Defence and Security Industry. Technical Management, Project Management, Business Development Roles in military vehicles, robotics and non-lethal vehicle stopping systems. Named on several patents. Consults for PacSci EMC on their non-lethal vehicle stopping programme.

Notes

Non-Lethal Boat Stopping System

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BCB has developed a range of non-lethal Boat Stopping Systems for use by naval, police and private security forces. The range utilises a compressed air pneumatic launcher that fires an arrester line across the bow of a suspect or intruding vessel. On each end of the line is a sea anchor which provides a few tons of drag to halt any vessel with a rudder or propeller shaft safely. Maritime Law Enforcement Agencies have seen the potential for these systems in Littoral Waters, Inland Waterways and harbours where choke points can be easily identified, manageable patrol areas can be established, and routes of escape can be denied. It is also very effective to use the systems on the high seas as part of a layered defensive measure against terrorism, piracy and sabotage. There are three launcher systems in the range: Barracuda – A small hand held/fired pneumatic launcher that fires a munition comprised of a Dyneema line and two inflatable drogues. Its effective range is approximately 40 meters. Buccaneer – A medium sized mobile launcher that is ideally tripod mounted on a patrol vessel. Its effective range is 100 meters. Sea Stinger- A large shore mounted or ship mounted launcher. It has an effective range of up to 200 meters and is ideally for harbours or inland waterway choke points. Munitions – Each system fires a floating Dyneema line with a sea anchor at both ends. The Sea Stinger can also fire a meshed net which is capable of stopping larger heavier vessels. The BSS does not necessarily have to entangle the propeller, unlike other systems. Hence our BSS has proved to be 100% reliable to stop every boat we have been tried against. Recently repeat order delivered for 4k navy ships.

Andrew Howell. After University (Accounting & Financial Management Degree) Andrew started the business BCB International Ltd in 1979. As Managing Director Andrew is responsible for all aspects of management, product development, sales, finance and operations. Andrew is actively involved in new product development. Andrew frequently field tests new and existing camping and survival items made and distributed by the company.

Notes

Use of Force Reporting: A Case Study from England and Wales.

A. Dymond

Use of force, including the use of less lethal weapons, is a power central to policing, and one with far reaching implications for officers, members of the public and police-community relations alike. All too often, however, incidents involving less lethal weapons are not systematically reported, or are captured only for the most serious of incidents, if at all. It is crucial that police use of force is reported and analysed effectively, so that lessons can be learnt and harm to officers, members of the public and society as a whole can be reduced. This paper discusses one recent national attempt to address the issue of use of force reporting via the introduction of a new reporting system for English and Welsh police forces in April 2017, drawing on the author's direct involvement with the review. Good practices, lessons learnt and broader implications from the English and Welsh experience for other countries will be discussed.

Dr. **Abi Dymond** is Lecturer in Criminology and ESRC Future Research Leaders Scholar at the University of Exeter, where she works on issues around use of force by police and correctional officials, with a particular focus on projectile electric-shock weapons. She is the winner of the 2018 ESRC Celebrating Impact (Outstanding Early Career Impact) for her work in this area, has conducted research to help inform the Use of Force Reporting Review in England and Wales and is also a member of the Programme Board for the Review. Prior to taking a full-time post in academia, Dr. Dymond gained over a decade's experience working on policy and research for various civil society organisations, most recently at UK NGO the Omega Research Foundation, where she worked on a range of human rights issues involving the use of less lethal weapons.

Notes

A Technology Assessment approach of NLW for Police and Defence forces: Lessons learned from the Taser X2 trial of the Dutch National Police

S. Orbons

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A Defence Technology Assessment (DTA) is a qualitative research method that has been developed and applied to assess the military utility of Non-Lethal Weapons (NLW). It has been demonstrated that NLW performance is real world situations is dependent on the operational context of its use. Application of DTA on NLW for domestic policing in The Netherlands (Police TA or PTA) focused on the utility of Conducted Energy Devices (CED), namely the Taser X26 and Taser X2, for Dutch police officers tasked with street surveillance. After an initial prospective PTA of the Taser X26, a retrospective PTA has been performed to evaluate a one year Taser X2 trial by the Dutch National Police. Data were collected through evaluation forms completed by police officers who used the Taser X2, as well as from interviews with stakeholders, police officers and targeted suspects. This paper sets out how the collected data were processed to feed into the PTA to produce the findings of the evaluation. It reviews the predictive potential of the PTA by comparing the findings resulting from the Taser X2 trial with those from the prospective Taser X26. It also discusses the evolution of the PTA method itself drawing from the experiences gained in the analysis process of the Taser X2.

Sjef Orbons has been in the Ministry of Defence of the Netherlands between 1989 and 2014. In his latest MOD position he was a senior researcher at the Netherlands Defence Academy, with a special focus on the topic of Non-Lethality in the military domain. In that capacity, he published on the military applicability of Non-Lethal Weapons, and received his PhD in 2013. Previous staff positions include the Department of Defence Concepts in the Defence Staff and the NATO Defense College in Rome. He is a member of the European Working Group on Non-Lethal Weapons. His latest assignment was with the Police Academy of The Netherlands to conduct a research programme exploring and evaluating the feasibility of current and future Less than Lethal Weapons for the National Police. He received his Master of Science from Eindhoven University of Technology.

Notes

The United Kingdom operational experience of the TASER® X2TM

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Conducted energy devices (CEDs) have been incorporated into UK policing as a less-lethal option for more than 15 years, with the TASER® M26TM CED being introduced in 2003 followed by the TASER® X26TM CED in 2005. The next generation TASER® X2TM CED was authorised for use in the UK in 2017, with its first operational use in September of that year. Every time a TASER® X2TM CED is used, the police officer is required to provide a detailed report on the circumstances of that use. Under UK guidelines, a 'use' is not only defined as discharge of the device, but also when the device is drawn or aimed, when a warning arc is displayed, or when a red laser dot is projected onto the subject. Each of these represents a 'use of force' and this allows for a more nuanced interpretation of the effectiveness and safety of the TASER® X2TM CED under operational conditions. This presentation is based upon an analysis of nearly 8,000 TASER® X2TM usage reports and provides insights into the operational performance of TASER® X2TM CED when used by UK police officers trained under the nationally approved CED training programme designed and administered by the UK College of Policing. Due to time constraints, the UK TASER® X2TM Use Form database had not been validated in its entirety before the deadline for submission of this manuscript. This means that some of the detailed data presented here may change, although the broad conclusions will remain the same.

Bob Sheridan is a life scientist with a background in physiology and pharmacology. After working in academia and the pharmaceutical industry, Bob joined Dstl, which is part of the UK Ministry of Defence. Bob's work involves understanding the human effects of less-lethal technologies, and he has been involved in research on conducted energy devices (also known as conducted electrical weapons) since 2001.

Notes

Police use of non-lethal weapons: analysis of real cases

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The PAB or « Peloton Anti-Banditisme » has been 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 non-lethal equipment, the unit is equipped with the FN303 rifle, OC spray, batons.
This article provides a comprehensive presentation of case-reports where non-lethal weapons have been used. 18 cases of FN303 uses (more than 200 impacts) combined with baton and OC spray populates the database today. These cases are described, ballistically defined and a medical outcome is given.
The article helps to better define the potential limits (injuries) of non-lethal impacts. It gives some insights about the consistency between standardized laboratory tests and the real-world experience. Ultimately the effectiveness of these systems is portrayed and discussed.

Prof **Alexandre Papy** (ir PhD) has a master in engineering and a PhD where he specialized in weapon systems and ballistics. After working as officer in an artillery unit he chose the academic way as an assistant and then an associate professor in the department of weapons systems and ballistics of the Royal Military Academy in Brussels, Belgium. He is member of the most important international working groups talking about non-lethal weapons at NATO and European level. He is the custodian of the STANREC 4744 dealing with the risk assessment of non-lethal impacts. He has been recently elected chairman of the Joint Non-Lethal Weapons Capability Group which is the focal point of all non-lethal activities at NATO level.

Notes

Rubber batons and ricochets: a case report

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This paper is actually a case report from an "accident" during SWAT team training, resulting in injuries by Fiocchi Rubber Baton bullets. Two people were injured in this incident, one suffering multiple finger bone fractures and the other had a 3cm wide and 3cm deep open wound in the inner thigh, with kind of distant traumas around this wound. Two versions of the incident were in dispute. The prosecutor hypothesis supposed direct shots on the victims from a distance between 5 and 10 meters. The defendant version claimed that injuries resulted from uncontrolled ricochets on a concrete floor at a distance between 3 and 5 meters from the victims. We had then to assess the behavior of such bullets after ricochets (angles of departure and stability after ricochet, kinetic energy retained), and the wounding ability of such bullets. Our protocol included high-speed video tracking, test shots on simulants and Doppler radar tracking. The results showed clear support to the prosecutor version, since after a ricochet, the angle of departure never exceeded 5°, the mean loss of velocity was 39 m/s and the flight was clearly unstable for at least 3 meters. Direct shots on simulants appeared positively correlated to the wound, even though this model showed limits in its validity. This case may then be of interest for professionals in the non-lethal weapons area, and those involved in Army or Law enforcement doctrine conception.

Cedric SAUTIER is a major from French Gendarmerie, and Head of the Ballistics Department in French Gendarmerie Forensic Sciences Institute. He graduated in Engineering MSc from *Ecole Speciale Militaire de Saint-Cyr*, the French Army officers' academy. He then joined the National Gendarmerie, serving in Strasburg as head of homicide and organized crime investigation unit for Alsace. The Forensic Sciences Institute hired him in 2013, as deputy head of the Ballistics Department. In parallel he graduated a MSc in applied mathematics in 2016 from *Ecole Normale Supérieure de Cachan* and Paris Dauphine University. His main task is to provide judges and investigators with forensic expertise regarding firearms and ballistics, and his current research topics are firearms identification, crime scene reconstruction and wound ballistics.

Notes

The Attenuating Energy Projectile: An analysis of operational firings

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The UK police deploy a bespoke blunt impact round known as the Attenuating Energy Projectile (AEP) as a less lethal support to firearms operations. This paper describes the development, attributes and standard operating procedures for the use of the AEP and also collates the information gathered from the data collection forms that are completed each time an AEP is used operationally. The information covers the use of the round from its introduction in 2005 to January 2019. The information presented enhances that presented previously by forming a more objective assessment of the effectiveness of the round against the subject and undertaking an investigation into the correlation of effectiveness to clothing worn, moderators and impact point.

Graham is a chartered physicist and has worked for UK Government since 1987, until recently for the Home Office but now for the Defence Science and technology laboratory. Since 2000 his main area of expertise has been centered on the technical aspects less lethal weapons and protective equipment for the UK police.

Notes

A prospective Police Technology Assessment of the use of non- penetrating projectiles for public order maintenance and riot control

Otto M.J. Adang

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At the request of the Dutch Police, a prospective Police Technology Assessment was performed to assess the feasibility of non- penetrating projectiles (both single- and multi-pellet) for public order maintenance. Data were gathered via a literature study, expert interviews and focus groups to analyse human factors involving both police officers and targeted individuals in the operational contexts police officers face during public order situations. There appeared to be little need for additional weapons for public order maintenance: the weapons already available (in addition to the long baton), such as tear gas and water cannon are seldom used, public order situations where police officers resorted to their firearm were exceedingly rare. Whereas single pellet projectiles are designed to target individual perpetrators within a crowd, multi pellet projectiles are meant to assist in dispersing a crowd. Looking at the operational contexts in which these weapons are to be used, it appears that accurate targeting of individuals is difficult, even for experienced shooters and there is considerable risk of severe injury. A problem with multi-pellet projectiles is both that differentiated use is not possible, as it is not possible to predict where the projectiles will end up, and that it is relatively easy for targeted individuals to take counter measures. Both types of projectiles can only be deployed responsibly in very specific large scale public order disturbances where a more or less homogenous group perpetrators use potentially life-threatening violence. The conclusion of the assessment is that implementation of non-penetrating projectiles for public order maintenance or riot control does not provide a realistic or effective potential use in line with the public order management concept in use in the Netherlands, whereas use of such projectiles would carry great risks, which include risks to the societal support for the way the police maintains public order.

Otto M.J. Adang, is Chair, Public Order Management and Academic Dean MSc Policing at the Police Academy of the Netherlands as well as Professor by special appointment in Security and Collective Behaviour at the University of Groningen (the Netherlands). He is a behavioural scientist interested in aggression, reconciliation and collective behaviour, specifically in the way in which individuals regulate conflicts and social tension. He has published in the following fields: social psychology, investigative psychology, social simulation, criminal justice, criminology, police studies, human rights, sports studies, ethology, primatology. He has done a number of studies on police use of force in general and police use of firearms, pepper spray and conductive electrical weapons in particular.

Notes

Numerical recreation of field cases on a biofidelic human FE model involving deformable less-lethal projectiles

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Since the 1970s there has been an increase interest in the use and development of less-lethal kinetic energy (LLKE) projectiles. These weapons are mainly used by law enforcement officers worldwide in cases of riot and crowd control. Even if such projectiles are designed to incapacitate an individual with a low risk of serious injuries, the literature indicates a risk of thorax injuries like rib fractures, lung and heart contusion when a projectile strikes the body. Among published articles discussing the wounding potential of LLKE projectiles, two are particularly well documented describing two field cases involving deformable projectiles (eXact iMpactTM and Flash-Ball®). However one question remains: how properly exploit field cases in order to find both injury thresholds and guidelines for the design of LLKE projectiles? Hence, the authors focus their research on the use of numerical tools as the finite element (FE) method to recreate the real impact conditions on a biofidelic human torso FE model. It requires the accurate modeling of the deformable projectiles at dynamic strain rates. To address that issue, the study begins by several ballistic experiments on a rigid wall equipped with a load sensor and a high-speed camera. The impact force measured and high-speed images are directly used in an inverse procedure to optimize model parameters of the concerned projectile to correlate impact experiments and modeling. Finally, this is followed by the impact modeling on the human torso FE model and the identification of model-dependent numerical metrics for injury thresholds related to lung and heart contusions. While efforts need to be pursued, this present research provides an interesting step towards designing effective and reliable LLKE projectiles.

Dr. **Anthony Bracq** is currently a post-doc research engineer at the laboratory LAMIH of the University Polytechnique Hauts-de-France in Valenciennes where he works in the mechanical department. His research focuses on the biomechanical consequences of non-penetrating ballistic impacts on the human torso. That aims to assess soft body armors and less-lethal weapons. His skills cover various fields like experimental mechanics and constitutive modeling related to soft materials as well as the finite element method for impact modeling. His Ph.D topic was: “Towards the prediction of thoracic injuries during ballistic impacts through experimental and modeling approaches”, defended in 2018, in partnership with the French Ministry of the Interior and the University of Technology of Belfort Montbéliard. He graduated with a MSc in mechanical engineering from the French engineering school ENSIAME with a specialty in material behavior characterization and numerical modeling. He has authored and co-authored 5 referred international journal papers and presented 3 papers in international conferences and one paper in national conference.

Notes

A Simple Model for Estimating Probability of Blunt Impact Skull Fractures

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We use open-literature test data on human skull impacts by rigid projectiles to estimate parameters of a skull/skin impact model. The model comprises a mass and three-parameter spring/dashpot system. We solve the equation of motion after impact analytically and determine the model parameters by minimizing errors between the experimental data and model predictions. Next, we consider a SIR-X projectile; we model it as a mass with a nonlinear spring in front and determine the spring parameters by utilizing the available SIR-X rigid wall impact data. We then calculate maximum impact force as a function of SIR-X impact velocity and show how the nonlinear spring properties of the projectile nose material could be modified to minimize the peak impact force. Under the common assumption that the probability of fracture depends on the peak impact force, we show the effect of the material optimization of the spring parameters on the reduction of probability of skull fracture. Finally, we note that the logistic-regression curve for correlating impact force with probability of fracture has relatively large confidence intervals. Consequently, we estimate that possible model errors in predicting peak impact forces provide a minor contribution to the overall uncertainty in predicting probability of fracture.

Corinne Kramer received her PhD from Johns Hopkins in the Department of Physics and Astronomy where her research focused on cytoskeletal mechanics and cellular mechanotransduction. Since coming to IDA, Corinne has developed expertise in injury modeling. She oversees several programs for the human effects division of the Joint Nonlethal Weapons Directorate including finite element model development and validation and uncertainty quantification efforts for multiple injury scenarios.

Notes

Validation of a finite element head model for the non-lethal impact

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The injury risk assessment of non-lethal projectile impacts should be a prior step before the use of such ammunitions in the operational field. The head impacts are considered among the most severe ones regarding the injury level that can be inflicted to the targeted persons. In fact, many studies have highlighted the vulnerability of the human head when undergoing non-lethal impacts. Therefore, there is a necessity to evaluate the injury risk on the head following the use of the non-lethal projectiles. Different methods have been proposed by researchers in order to deal with this issue. Both experimental and numerical investigations are considered. The assessment studies are mainly based on biomechanical surrogates and numerical finite element models. Numerical investigations offer more research capabilities being able to provide the possibility to predict more than one parameter. Therefore, it would be interesting to propose other numerical tools in order to achieve this task. The main objective of the present article is to propose a numerical model for the assessment of the non-lethal projectile head impacts. In this study, the validation of the model for the non-lethal impact using the XM1006 projectile is proposed. The methodology of the numerical simulations is detailed. The results are compared to those obtained from the aforementioned tools regarding the head force and show that the proposed model predicts the same head force levels. Finally, numerical simulations of different projectiles are proposed in order to consolidate the XM1006 projectile results.

Dr**. Amar OUKARA** was born in Algeria (Tizi-ouzou) on October 14th, 1985. He got his engineering degree in Mechanics at Ecole Militaire Polytechnique (EMP, Algeria) in 2010. He did his PhD thesis at Royal Military Academy (RMA, Belgium) between 2011 and 2015 and was a full time researcher at the Department of Weapon Systems and Ballistics (RMA). The undertaken researches in the framework of his PhD thesis concern the development of different methods for the assessment of non-lethal projectile head impacts. Three different methods have been proposed in order to achieve the injury risk assessment of such impacts. A finite element model of the head and a biomechanical surrogate have been validated for non-lethal impacts and proposed as tools for such tasks. Furthermore, he contributed in the construction of a methodology for the development of finite element non-lethal projectiles. Nowadays, he is researcher and lecturer at the EMP. The current research activities concern the development of experimental setup for ballistic tests, the numerical assessment of ballistic helmet blunt trauma (BHBT) and the validation of numerical and biomechanical tools for blunt impacts.

Notes

Impact of soft projectiles on rigid targets: modelling and impact pressure measurement attempt

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Impact engineering has been extensively investigated through numerous studies about terminal ballistic of metallic projectiles (bullets, fragments) on solid targets. It iconizes the fight between the sword and the shield. However, more and more attention is paid to soft targets and soft projectiles. On the one hand, military medicine has been focused on the wounds and lethal effects of metallic projectiles on soft targets. On the other hand, anti-riot forces have expressed the need for non-lethal projectiles. Under mechanical considerations, non-lethal projectiles made of elastomers are similar to a bird strike on a plate: they can be considered as soft bodies impacting semi rigid surfaces. This situation still meets some issues when predictive models are required. The prediction of the mechanical behavior of soft bodies at high strain rate remains indeed a challenge in mechanical engineering. Therefore, in order to evaluate the mechanical effects during soft impacts, experiments have been carried out at ENSTA Bretagne, using a soft projectile, ballasted with polymer in order to increase its kinetic energy. The projectile was accelerated by a Taylor gun and thrown onto a rigid steel target instrumented by a piezoelectric gauge made of PolyVinyliDine di Fluoride (PVDF polymer) to measure the impact pressure. The impact process was recorded with a rapid camera. Results are presented and show some advances in the practice of soft impact experiments.

Notes

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The human eye is an indispensable sensor for the execution of many military tasks and a degraded vision would undoubtedly affect operator task performance. Dazzling the eye with a visible light source is for that reason an obvious countermeasure when trying to affect human vision and possibly degrade human performance. The effects are most often translated into a decrease of the field-of-view of the eye but the question remains how this translates into human task performance degradation and secondly how accurate this degradation can be predicted. This study will try to quantify the performance degradation of a shooting task in a land environment when being dazzled by a green portable laser system. A measurement campaign has been organized to answer this question; every participant of the test group, composed of 14 persons, was asked to fire five shots in the direction of a competition-type target straight ahead, with and without dazzle. The registered time and scoring of the specific tests have been statistically analyzed to determine the significant effects and the outcome has been compared with a predicted dazzle impact. The results of the shooting test show that the used laser dazzle prediction models quite well the human performance degradation, and at the same time that there is a need for a specific test protocol to find the correct compromise between environmental validity of a trial and the number of independent variables that can be controlled.

Marijke Vandewal graduated in 1996 from the Royal Military Academy, division Polytechnics, as an engineer, specialty Telecommunications. After a specialised avionics Air Force training, she was assigned to the Flight Avionics in Kleine Brogel (Belgium), an F-16 Air Force Base. After that, she was transferred to Brussels as a software engineer on C-130 transport aircraft. In mid 2000 she became an assistant-professor at the Royal Military Academy, in Optronics, radar and microwave techniques. In cooperation with DLR (DEU) she obtained her Ph.D. degree in engineering sciences with a thesis entitled “Performance Analysis and Optimisation of High Resolution SAR systems on UAV platforms”. Since 2008 she has been working as a professor at the Department CISS (Communication, Information, Systems and Sensors) of the RMA and has been managing international as well as national research projects. Her main research domains are currently performance evaluation of passive optronics sensors and the use of lasers on the modern battlefield.

Notes

The usability of the FN 303 in operational conditions: Nonlethal, less-lethal, or somewhat too lethal after all?

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The recent French 'flash-ball' row over riot-gun injuries involving the 'Gilets Jaunes' protesters, has caused a heated, nation-wide debate over the use of the Lanceur De Bals (LDB40) less-lethal launcher. The issue had far reaching societal consequences, which have affected the manufacturers (of the LDB40 and the projectile ammunition), politicians, law enforcement policy makers, and police offers on the field. Such problematic situations are not new, however, as less-lethal launchers – and the use thereof – have been criticized before. As such, there was the infamous 2004 Boston Police incident, involving the FN 303® (hereafter FN 303). Here, a bystander was struck in the eye, causing lethal damage. Subsequently – following a $ 15M wrongful death lawsuit – the Boston City Council ordered the destruction of all remaining FN 303 – arguing they were more powerful and lethal than had been anticipated. More recently, the FN 303 drew a bad press when a Belgian police intervention in a youth institution and currently there is the French 'flash-ball' row over severe injuries involving the LDB40, inciting even supra-national organizations to intervene.
The present study aimed to study the usability of a less-lethal launcher from an end-user's perspective. For that purpose, in a first empirical leg, a within-subjects field experiment (N = 26) was organized to test the FN 303 in a lab condition, enabling optimal firing conditions, and in a high-pressure simulated operational stress condition. The FN 303 was chosen because the weapon has been specifically designed as a less-lethal weapon, is suitable for crowd control operations, and is arguably one of the more accurate less-lethal launchers available. Results showed that the simulated operational stress condition – consisting of both psychological and physiological challenges – had a significant deleterious effect on participants' shooting accuracy at a static target, even at 30 m. Moreover, as might be expected, accuracy was affected primarily in the hazardous vertical plane (i.e., according to the y-axis). Importantly, the high-pressure operational stress condition also resulted in a substantial change in participants' perceived usability of the FN 303: the less-lethal launcher was assessed, independently, to be less effective, less efficient, and less satisfying-in-use when working in a high-pressure operational context.
The second, phenomenological, leg of this study involves an in-depth exploration of the perceptions, concerns, and experiences of FN 303 end-users and has been completed through open-source desk research and face-to-face interviews. The explorative desk research revealed interesting ideas, comments, and genuine concerns of widely varying 'end-users': a blog developed by a member the general public and an official Comité P report – Comité P is the official Belgian Police watchdog. The interview section of the phenomenological research involved three police officers with substantial field experience with the FN 303 less-lethal launcher and an experienced prison guard with interesting information derived from prisoners themselves. Although the phenomenological study is considered an ongoing project, interesting results have already emerged. Quite surprisingly, some of these results broadened the standard operational range of the FN 303, while others narrowed it down. This manuscript reports the findings as they stand at this point.
To date, to the best of the authors' knowledge, no research has tested less-lethal launchers from an end-user's perspective and has done so in a realistic high-pressure environment or by introducing in-depth phenomenological findings from people in the field. Recommendations are presented in regard to human factors research, operator selection and training, operators' physical and skill maintenance, and user-centered design.

Throughout an accomplished protean career track in Belgian Defense (1981-2015) as both a Para-Commando officer and an academic, **John Taverniers** earned degrees in Industrial Sciences and Technology (MSc), Industrial/Organizational Psychology and Social and Military Sciences (PhD, bi-doctorate), and Ergonomics (MSc, postgraduate). During his tenure as professor and head of chair of psychology at the Belgian Military Academy, John established a record of innovative research on the intersection between work psychology, psychoneuroendocrinology, and human factors & ergonomics. A multitalented professional with extensive research, managerial, and operational experience, John currently engages in consultancy and contract research in the broad domain of Safety & Security. As such, he specializes in tailor-made programs in human factors engineering, human-machine interfaces, training & selection programs, cognitive reliability analyses, and user-centered design.

Notes

de Schoutheete JC [1,3], Papy A [2], Taverniers J [4], Van Puyvelde M [2], Nijs S [3], Pattyn N [2], Robbe C [2]

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Military training should be as close as possible to reality. However, a big gap exists in shooting practice between blank training and combat shooting, and this in every country in the world. Shooting training system with marking ammunitions from the type of FX®-cartridge – called “Small Arms Marking Ammunition System” (SAMAS) in Belgium – can bridge the gap but has not been studied yet. Double tap shooting using SAMAS was performed on a two-meter distance on 27 healthy individuals, divided in a study group and a control group. Different parameters were followed: blood pressure as well as heart rate, stress from a questionnaire and pain using a Pain Matcher ® (PM) and a virtual analogic scale (VAS). No skin laceration was observed. However, three months later, a scar was still visible in 59% of the volunteers. The pain perceived was higher than expected. The VAS defined by shooting was higher than the one correlated with the pain indicated as maximal level of tolerance by PM at D-day-5 ($p < .01$). Stress rose during experimentation significantly ($p = .001$). From this first multidisciplinary analysis on SAMAS in the literature, we observed that stress is not a limitation factor for using this ammunition. However, pain and wounds are more important than expected, bringing about some reluctance from volunteers. The latest should improve the quality of acquisition of tactics, techniques and procedures regarding combat training. Nevertheless, better protection strategies are required from the military regulation to allow broad use of this ammunition in combat training.

Jean-Charles de Schoutheete is a 33-year old military surgeon working at the Queen Astrid Military Hospital, and as fellow in trauma surgery at University Hospitals Leuven. He has been deployed two times with the Belgian special operations surgical team. He is married and he has a little daughter.

Notes

Toward Bullet Simulating Non-Lethal Projectiles

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Kinetic energy non-lethal weapon (KENLW) systems remain one of the most widespread type of non-lethal weapons on the field.
NATO has recently published four standardized documents in order to assess the injury potential of such projectiles. The area of interest of this article are the documents standardizing the thoracic and the head non-penetrative impacts (STANREC 4744: AEP 99 and AEP 103). The proposed process is to shoot the projectile on a target and dynamically measure physical parameters, linked to level of injuries. They give the user the choice of the appropriate target, as soon as the response of the system, impacted by a specific non-lethal projectile, remains in a specified range. So far, this process is performed using a commercially available projectile. This solution has two main drawbacks. On the one hand, the projectiles are rather expensive and expandable. On the other hand, the community has no control on the mechanical properties and behavior of the projectile. If the manufacturer modifies some characteristics of its projectile, the effect on the reproducibility of the test will be dramatic.
The objective of this study is to propose an alternate projectile, easy to develop, called “Bullet Simulating Non-Lethal Projectiles” (BSNLP), which purpose is to replace the reference projectile in the standard. This projectile must be representative of the projectiles on the market, easy to produce with off-the-shelf components, and fully characterized, in order to allow the user to choose its own way to implement it.
This article is focused on 40 mm projectiles. Components, characteristics and building methodologies are presented. Then, an experimental setup is proposed and results are presented in order to compare them to other KENLW projectiles. Finally, conclusions and way ahead are presented.

Cyril ROBBE
- 5-years Master Degree in mechanical engineering in the Catholic University of Louvain (UCL) in Belgium (2002-2007).
- 1-year complementary master in management in the UCL (2007-2008).
- Working as a researcher in Ballistics in the Royal Military Academy (RMA) in Belgium since 2009. The field of study is the experimental evaluation of kinetic energy non-lethal weapons.
-Part time associate professor in Ballistics in the Royal Military Academy (RMA) in Belgium since 2015.
- PhD: “the experimental evaluation of the thoracic impact of non-lethal projectile”, 2013, RMA, in partnership with the University of Liege (ULg) in Belgium.
- Thoracic topic leader of the NATO standardization group: Joint Non-Lethal Weapon Capability Group – Non-Lethal Kinetic Energy – Team of Expert (JNLW CG / NLKE ToE).

Notes

On the mechanical and chemical characterizations of foams used for non-lethal projectiles

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The Kinetic Energy Non-Lethal Weapons are used to repel or neutralize a dangerous person with a low probability of permanent or fatal injuries. Nevertheless, the use of such weapons is not without risk. Many real cases show that the non-lethal projectiles can lead to severe lesions and sometimes to the death. Consequently, there is a necessity to develop and control the manufacturing of the projectile materials in order to ensure a good effectiveness with a lower injury level. In the present article, a methodology of elaboration and characterization of polyurethane foams is proposed. The proposed methodology tends to control the development of the microstructure leading to a final product with desired properties for non-lethal application. The mechanical characterization was carried out using both quasi-static and dynamic tests. A homemade pneumatic launcher and a rigid wall are used for the dynamic characterization. Moreover, a physicochemical characterization of the developed foams was carried out: spectroscopy and DRX analysis, in order to highlight the opened-cell morphology and chemical irregularities, respectively.

BOUMDOUHA Noureddine was born the 29th of December 1990 in Algeria (M'sila). He obtained a Master degree in Materials and component at the University of Science and Technology Houari Boumediane – USTHB- (Bab ezzouar, Algiers). He is now a second year PhD student at Ecole Militaire Polytechnique –EMP- . His thesis is entitled: "Development and Dynamic Characterization of Polymeric Foams: Application to Non-Lethal Projectiles". The main objective of this work is to improve the physicochemical and mechanical properties of polymeric foams with the intent to use them as materials for non-lethal projectiles.

Notes

Error budget of non-lethal projectiles using stochas- tic simulations

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The maximum range of non-lethal weapons is often limited by the projectile dispersion. Indeed, beyond a given distance, the observed dispersion of pro- jectile on the target becomes too important. Consequently, the increased risk to miss the thorax and hit the head is deemed inadmissible. Therefore, in the development of long range non-lethal projectiles, it is of importance to identify the primary sources of delivery errors. In this paper, Monte-Carlo simulations are used to predict the projectile dispersion. These simulations are based on ballistic models developed for non-lethal weapons. The quantification of the propagation of uncertainties across the complete ballistic cycle allows for the identification of the parameters which influence the accuracy of non-lethal weapons.

Mrs **Irene Ndindabahizi** is a doctoral candidate at the Royal Military Academy in Belgium. She holds a masters degree in Aerospace engineering. Her research interests are in the field of Vulnerability and Lethality.

Notes

Optimizing A Skin Penetration Model To Assess Kinetic Energy Non-Lethal Weapons

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Kinetic Energy Non-Lethal Weapons (KENLW) are designed and mainly employed by law enforcement and military to incapacitate people or repel people while minimizing fatalities and permanent injury. Specifically, KENLW, when being employed, should absolutely avoid human skin penetration.
A surrogate method, defined in a NATO framework, is currently in use to assess the skin penetration injury risk.
This surrogate, which is validated against post-mortem human subjects experiments, presents some drawbacks mainly due to the employed materials.
The goal of this study is to assess the feasibility and, if possible, to find use conditions for a synthetic gel as an alternative to ballistics gelatin which is the reference simulant for soft tissues.
The secondary goal is to develop a new calibration method fitting the use of the simulant.
Experimental tests are performed and consequent statistical metrics are computed in order to quantify the influence of a set of parameters on the gel behavior.
The results highlight the strong advantages provided by the use of the synthetic gel, especially with regards to repeatability.
These results show the high potential of this material and consequently make it a solid candidate to replace ballistic gelatin.
The proposed calibration method leads to encouraging results.

Faycal CHIDIAC is a captain from French Gendarmerie, and deputy head of the Ballistics Department in French Gendarmerie Forensic Sciences Institute. He graduated in Engineering Msc and worked as an engineer then joined the National Gendarmerie. After the French Gendarmerie Officers School, he joined the Forensic Sciences Institute in 2014. In parallel he graduated with a MSc in Physics in 2018 from Cergy-Pontoise University, involving an internship at the Royal Military Academy in Bruxelles where he studied KENLW skin penetration injury risk. His main task is to provide judges and investigators with forensic expertise regarding firearms and ballistics.

Notes

In-situ Prediction of the Acoustic Impact of Stun Grenades

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This work presents a tool for the prediction of the acoustical impact of stun grenades for use during an ongoing operation. The aim is to provide in-situ special forces with the necessary resources to better fulfill the principle of proportionality in the use of stun grenades. To this aim, a standardized measuring procedure was developed to measure the acoustic parameters of stun grenades. In a data acquisition phase, the impacts of different types of stun grenades used by Austrian special forces were recorded and evaluated. In the next step, a mathematical model for the simulation of the sound pressure level caused by stun grenades within rooms was investigated. This model considers parameters for the sound pressure level such as the volume of the room, the equipment in the room, the type of grenade and their distance to a human being. To enable a realistic evaluation scenario, an Android-based demonstrator application with a graphical user interface was developed.

DI **Clemens Amon,** born in 1985, completed his studies in electrical engineering - sound engineering at the Graz University of Technology and the Graz University of Music and performing Arts in 2014 with his master thesis titled “Electrolarynx Control using Electromyographic Signals“ at the Signal Processing and Speech Communication Laboratory (SPSC). In this work he developed a system for the automatic control of an electro larynx, a device which offers people the possibility to re-obtain speech when their larynx is surgically removed or damaged. During his studies he was involved in many projects in the field of audio signal processing and embedded systems and worked at Klangerfinder GmbH und Co KG in Frankfurt. Since 2013 he is researcher in the „Intelligent acoustic solutions“-group at the JOANNEUM RESEARCH in Graz.

Notes

The United Kingdom Evaluation of an Overt GPS Tracking System – StarChase ™

R Newman,

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Pursuit activity and use of pursuit tactics place members of the public and police officers under a significant degree of risk. Wherever possible, trying to prevent a pursuit from taking place must be a primary consideration. More injuries and deaths are caused by police pursuits than by police use of firearms in the UK (28 people died during pursuits in 2016/7 compared with 8 deaths from police use of firearms). Preventative tactics are those which can be used to prevent a pursuit from taking place. Where preventative or pre-emptive actions are clearly proportionate to the intelligence available, their use is preferable to pursuit. The StarChase™ system is a capability that has the potential to add a further tactic to the current UK Agreed Professional Practice suite allowing for pre-emptive GPS tagging of a vehicle prior to officers making a request to the driver to stop. If the driver were to fail to concede to the request, police may be able to track the vehicle without immediately following it and consider other tactics for bringing the vehicle to a halt without the need to actively pursue. This presentation will be about the review of the technical specifications against the UK police operational requirement of the StarChase™ system by Dstl.

Chief Inspector **Rebekah Newman** is serving UK police officer with Sussex Police currently seconded to the Home Office Commissioning Hub as a Police Adviser to Dstl for Lethal and Less Lethal Weapons, Personal Protective Equipment and Road Policing.

Notes

An Experimental versus Numerical method to assess head injuries of Non-lethal projectile impacts

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Over last four decades, among all the conventional military technologies, non-lethal projectiles (NLP) emerge a new form of warfare for security strategy. Currently the use of NLP is common to control uncivil behavior of crowd during peacekeeping operation, armed conflicts, riot control, hostage situation and law enforcement task to neutralize the subject with low probability of permanent impairment. The main objective of this study is to develop a methodology to assess the head injury risk involved by a NLP impact based on experimental tests versus numerical predictive head injury simulations. Sixteen NLP impacts were conducted on rigid force plate at three different ranges of impact velocity (120, 72 and 55 m/s) and force/deformation–time data were used for the validation of NLP finite element model (FEM). A state-of-the art FE head model with specific head injury criteria was used for numerical computation of NLP impacts. Frontal and lateral FE NLP impacts to the head model at different velocities were performed and axonal strain has been computed to predict diffuse axonal injury (DAI) for 32 impact scenarios. Results show that temporo-parietal impacts (TPI) are more vulnerable to risk of DAI for higher velocity impacts. In frontal impacts the max risk of DAI is 1%, while in the case of TPI the min-max risk of DAI is 0-86%. With a velocity above 99.2 m/s there is greater than 50% risk of DAI for TPI. All the medium- and high-velocity impacts are susceptible to skull fracture, with a percentage risk higher than 90%. This study proposes tool for a realistic injury (DAI and skull fracture) assessment during NLP impacts to the human head.

I obtained my Ph.D Thesis in biomechanics in 2004 and a research manager habilitation in 2014. Since 2004 I have a permanent research position in Biomechanics at Strasbourg University. I'm specialized in finite element modelling of the human head, head trauma numerical accident reconstruction and head injury criteria development as well as head protective system evaluation and optimization. Main result of my research was the development of a predictive finite element head model which is able to predict skull fracture as well as loss of consciousness by calculating axonal strain during an impact. This was achieved by implementing anisotropic visco-hyperelastic material and new brain images data (DTI) to the brain material model and modeling the skull with a three layer composite model with damage prediction capability. From 2010 I have extended my interest to defence domain especially in blast investigation (experimental and numerical understanding) which lead me to initiate a new understanding of lung injury coming from this threat. I am in charge on several projects (French and European projects, industrial contracts…). A part of the proposed study was funding by the project HNBi N°3.8 Interreg V Rhin Supérieur project – FEDER.

Notes

Laser Dazzling of CMOS imaging sensors

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The advances in microelectronics over the past decades are intrinsically related to silicon and CMOS (complementary metal-oxide semiconductor) technologies, which enabled compact and low-cost microcircuits and imaging systems. The imaging sensors are very sensitive to intense light fluxes, especially coming from coherent light sources such as lasers. Consequently, laser dazzling of electro-optical (EO) devices has emerged in the last years as a powerful optronics countermeasure (OCM), leading to a temporarily disruption of image acquisition or object recognition in a landscape. At high power levels, laser light can even permanently damage the imaging sensor. In the present work, laser dazzling of CMOS cameras both in the visible and near-infrared (NIR) spectral regions was studied as an effective OCM. In addition, laser dazzling of a camera equipped with a fisheye lens, which is commonly present in micro-unmanned aerial vehicles (micro-UAVs), providing a wide field of view imaging system, is demonstrated. The influence of different parameters such as ambient illuminance, laser wavelength and irradiance were analyzed. During laser irradiation, different physical phenomena appear, such as diffraction, multiple reflections and light scattering. Camera parameters such as exposure time play an important role on the resulting blurred images. The diameter of the dazzled area increases with increasing laser irradiance, and the dazzle is effective at irradiance levels around a few mW/cm^2.

Cristiane N. Santos is currently working as a researcher at the Royal Military Academy in Brussels, Belgium. Her main research activities focus on lasers and optronics. She has been active in the field of condensed matter physics, developing research in optical and vibrational spectroscopies. She received her PhD degree in Applied Physics from the University of São Paulo (Brazil) and Joseph Fourier University (France) in 2007.

Notes

Active Denial Technology Computational Human Effects End-To-End Hypermodel for Effectiveness (ADT CHEETEH-E)

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We developed a computational model to simulate the response of a human target to Active Denial Technology (ADT), including estimates of ADT's physical, physiological, cognitive, *and* behavioral effects. The ADT system is a counter-personnel non-lethal weapon for crowd control, convoy protection, and perimeter security. The target is subjected to pulses of focused 95 GHz electromagnetic energy. The energy diffuses approximately 400 microns into the target's skin, producing no skin damage. However, the target may still perceive a burning sensation strong enough to repel (i.e., compel the target to immediately move away). The ADT system differs from traditional, lethal weaponry. The goal of a lethal weapon is to permanently destroy the target—therefore, models of lethal weaponry must simply estimate the weapon's physical and physiological effects. In contrast, the goal of the ADT system is to temporarily repel the target—therefore, ADT models must also estimate the ADT's cognitive and behavioral effects. We use validated physical models to estimate the output of the ADT system, coupled with additional models to estimate the ADT's effect on the target's physiology, cognition, and behavior. Our model begins with ADT beam formation and concludes with the estimated time at which the target is repelled. This end-to-end approach quantifies both the ADT system's main measure of effectiveness (the probability of repel) as well as its intermediate measures of performance (dose on target, temperature in skin, perceived pain level, etc.) These comprehensive model results may feed into force-on-force simulations to provide educated estimates of ADT effectiveness in military scenarios.

Dr. **Shelley Cazares** ties machine learning with physics, physiology, and cognitive science.

Since 2007, she has been a Research Staff Member at the Institute for Defense Analyses (IDA), providing scientific consultation to the U.S. government on national security issues. Her research focuses on modeling and simulation of next-generation non-lethal weapons.

Most recently, she served for a year at the Pentagon, developing its strategic overview of Artificial Intelligence. She also served as human test subject in NASA's Human Exploration Research Analog, living and working in a 55-square-meter mock spacecraft with three other crew members for 23 days straight.

From 2003 to 2007, Dr. Cazares was a Research Scientist at Boston Scientific Corporation, designing algorithms for implantable medical devices to diagnose and treat cardiac dysfunction. Over 30 of her inventions have been patented.

Dr. Cazares earned her S.B. in Electrical Engineering & Computer Science at the Massachusetts Institute of Technology with minors in Biomedical Engineering and Spanish. As a Marshall Scholar, she earned her D.Phil. at the University of Oxford, specializing in Signal Processing and Neural Networks. She studied Arabic at several locations in the Washington, DC area and Spanish at the Universidad de Salamanca in Salamanca, Spain.

Notes

Biological risks of acute and chronic 94 GHz exposures

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Among the extensive Non-lethal weapons development, anti-denial systems (ADS) have been used for crowd control [1].
ADS operate by emitting electromagnetic radiation (EMR) in millimeter band at 94 GHz inducing an intense burn sensation. The studies on biological effects of these systems are still limited.
The aim of this study was to identify the biological risks associated with acute and chronic exposures to the ADS.
Acute and chronic exposures, corresponding to the “operational” (crowd dispersion, 3s to 10000 W/m2, rising skin temperature to 53°C) and occupational conditions (4 hours a day, 5 days a week, 6 months to 100 W/m2) were performed on hairless male rats (16 weeks old), model close to human skin.
The power density (W/m2) was evaluated through a numerical calculation and confirmed by the superficial thermal elevation recorded by an infrared thermal camera.
Animals were exposed to EMR (n=36) or capsaicin (n=36, positive control, 2 mg/cm2, 30 minutes occlusive patch), activator of thermal pain receptors. Skin biopsies were taken after 3, 6 and 24h on anesthetized animals (n=6 rats for each biopsies collection time).
Histological analysis (hematoxylin phloxine saffron staining of biopsies included in paraffin) and inflammatory gene expression tests (PCR, Micro-array) have been done on skin biopsies.
The 94 GHz acute exposure provoked the disappearance of the epidermis upper corneal layers and the increase of the inflammatory gene expression SOCS-3 after 3h. Neither histological nor genetic expression modification could be observed after chronic 94 GHz exposure and after an acute and chronic capsaicin exposure.

Notes

U.S. AFRL Program for Behavioral Effects of Non-Lethal Weapons

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The U.S. Air Force Research Laboratory (AFRL) conducts ongoing research on the physiological and psychological effects of scalable and non-lethal weapons (NLW). This research includes characterizing and cataloging target behavior resulting from application across a broad spectrum of NLW technologies, singular or in combination, in operational scenarios. Reported here are the results of a multi-year investigation in which human subjects were exposed to a variety of NLW technologies (distracting noise, flashing broadband light, smoke, malodorant, and concussion devices) while performing tasks that indexed operational behaviors (gross motor & fine motor manipulations, and attention & executive control of working memory). Moreover, the motivational levels of the subjects were manipulated to investigate the relative effects of NLW technologies on different target populations. Different NLW technologies evoked different levels of avoidance and different levels of performance degradation. Further, manipulating subject motivation also evoked different levels of avoidance. The results are interpreted in a theoretical framework that incorporates decision theory (cold cognition) and emotion theory (hot cognition). The data are currently being incorporated into an existing AFRL agent-based modeling program (SARDEAN: Simulating Agent Response to Directed Energy Applications and New Technology) that allows operators to develop operationally accurate scenarios and test behavioral responses to any scalable or NLW technology that can be behaviorally characterized.

Dr. **Alan Ashworth** is the Chief Scientist for the Human Effects Center of Excellence for Scalable and Non-Lethal Weapons (HECOE) at the U.S. Air Force Research Laboratory (AFRL), and a Senior Adjunct Professor at the University of Texas. In his previous Air Force position, Dr. Ashworth was the consultant to the Chief Scientist of the Air Force for all behavioral research conducted at Air Force laboratories. During his 28 years with the Air Force, he has developed and executed dozens of diverse research programs, including artificial intelligence and virtual reality for coalition training, visual identification of hostile aircraft, and computational modeling of behavioral response to scalable and non-lethal weapons. Moreover, Dr. Ashworth lead a five-year, multi-million-dollar research program to counter improvised explosive devices (C-IED) that significantly increased IED detection in Afghanistan. He has published over 80 scholarly papers and earned the U.S. Meritorious Civilian Service Award. For his C-IED research, he was selected as the Outstanding Scientist of the U.S. Air Force. Dr. Ashworth earned two Master's Degrees and a Ph.D. in Cognitive Neuroscience from Yale University.

Notes

A review of less lethal weapons manufacture, trade and (mis)use - human rights and trade control implications

M Crowley and N. Corney

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At a time of unprecedented global unrest and social protest, an increasing number of law enforcement agencies are using less lethal weapons to control public gatherings, manage prisons and police borders on a greater scale, both in number and geographical spread, than ever. There is wide divergence in the types and quantities of weapons used, selection and testing procedures, procurement practices, policies and procedures for use, and the content of training, both between countries and between different agencies within the same country.
Traditionally the manufacture and trade in less lethal systems has been dominated by companies based in Europe and North American. However, evidence shows that this is changing.

This paper presents some initial results and illustrative cases from an ongoing global survey of less lethal weapons, highlighting a range of traditional and novel less lethal weapons that are now being manufactured, traded and deployed by law enforcement officials throughout the world in custodial and non-custodial contexts. The paper presents less lethal law enforcement weapons and equipment in the following categories: electric shock weapons and devices; kinetic impact devices; and riot control agents; briefly examining the particular physical/medical effects of each weapon type and highlighting relevant human rights concerns associated with its use. Consequently the paper assesses whether the less lethal weapon or equipment in question can be used legitimately and if so under what constraints; or whether the manufacture, trade and use of certain less lethal weapons should be prohibited. Finally the paper highlights some examples of the current less lethal weapons marketplace, and examines recent international initiatives to more effectively regulate the trade in less lethal weapons and law enforcement equipment.

N. Corney is a research associate at the *Omega* Research Foundation, Manchester, UK. He has published and presented research on a wide range of military, security and police issues over the past 20 years, including the selection and testing of less lethal weapons, police use of force and crowd control in Northern Ireland, and the human rights implications of less lethal technologies.

Dr **Michael Crowley** is Honorary Visiting Senior Research Fellow at Bradford University and a Research Associate at the Omega Research Foundation. He has undertaken research and published widely on arms control, security and human rights issues for over 25 years. His latest book, co-edited with Professor Malcolm Dando and Dr Lijun Shang is: Preventing Chemical Weapons: arms control and disarmament as the sciences converge, published by the Royal Society of Chemistry in 2018.

Notes

Contemporary development, promotion and use of remote control riot control agent delivery mechanisms: challenges for effective State regulation

M. Crowley

Although the use of riot control agents (RCAs) as a method of warfare is prohibited under the Chemical Weapons Convention (CWC); the employment of such toxic chemicals for law enforcement including domestic riot control purposes is permitted, provided they are used in “types and quantities” consistent with such purposes. This paper examines the challenges faced by States in ensuring effective regulation of development, trade and use of RCAs and associated delivery mechanisms in the light of ongoing technological and market developments.

The paper specifically examines the contemporary development, testing, production and promotion by a range of State and commercial entities of a wide variety of “remote control” RCA means of delivery - dissemination mechanisms incorporating automatic or semi-automatic systems where the operator is directing operation of the platform and/or RCA delivery device at a distance from the target. These include: indoor fixed installation RCA dispersion devices; external area clearing or area denial devices; automatic grenade launchers; multiple munition launchers; and delivery mechanisms on unmanned ground vehicles and unmanned aerial vehicles.

The paper examines the implications of the continuing development and promotion of an ever widening range of “remote control” RCA delivery mechanisms for existing State regulation, highlighting the potentially serious consequences for national, international and human security of inadequate controls, and presenting recommendations for the international community to address this issue through the development, adoption and implementation of collectively agreed international standards in this area.

Dr **Michael Crowley** is Honorary Visiting Senior Research Fellow at Bradford University and a Research Associate at the Omega Research Foundation. He has undertaken research and published widely on arms control, security and human rights issues for over 25 years. His latest book, co-edited with Professor Malcolm Dando and Dr Lijun Shang is: Preventing Chemical Weapons: arms control and disarmament as the sciences converge, published by the Royal Society of Chemistry in 2018.

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Effects associated with the pulsed current of electroshock devices.

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Background. Electroshock devices or conducted electrical weapons (CEW) are widely used for self-defence and for the detention of offenders by law enforcement agencies. The number of models is growing every year. This is due to the increase in the efficiency of the CEW and reduce the harm caused to health, with respect to their use. Each new device must undergo medical and biological studies to study the effects caused by the new current parameters.

Aims. The purpose of work – experimental estimation bioeffects of 2 samples of CEW with other (in comparison with earlier studied) current parameters.
Method. We conducted the biomedical research of 2 samples of Russian-made CEW on biological model - rabbits. Exposure time - 3 s. We employed (before, during exposure (3 s) and after exposure) the following methods: cardiogram, pneumogram, motor manifestations.

Results. The findings of the research illustrate that the main reaction at the time of exposure is reduced to tonic seizures (in all animals), which could be accompanied by loss of orientation, respiratory failure and pulse rate. At the time of exposure and for 2 minutes there was a significant decrease in respiratory rate. Heart rate and respiration stabilized by 5-10 minutes after exposure. The next day and a week later, all of the above reactions were not observed.

Conclusion. A score system was used for complex impact assessment, which helped to statistically significantly compare the effectiveness of different CEW. According to this assessment, it is concluded that the scores on the studied new samples do not go beyond the norms established for the relevant special means.

T. Fomina has 4 years experience in biomedical research at SRC-FMBC, now she is a postgraduate student at SRC-FMBC. Graduated from First Moscow State Medical University named after I.M. Sechenov in 2016. Speciality – preventive medicine.

Notes

Methodology for the creation of an anthropometric 3D finite- element model of the human head for blunt impacts simulation

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The goal of this paper is to present a methodology to generate an anthropometric 3D FE model of the human body. Firstly, given the complexity of most of the human body organs, a semi-automatic acquisition procedure based on CT-scan images is first used to extract the surfaces of different anatomical structures using the “InVesalius” software. These surfaces are made of triangular STL geometrical mesh of the corresponding structures. Secondly, with the purpose of using hexahedral elements, the reconstruction of the geometry is manually performed by generating the contours of the extracted surfaces. These contours are defined on a set of predefined planes. Then, solids are created from the surfaces that are delimited by the contours. Finally, the solids are generated and meshed and material models are assigned for validation purpose.

Ndompetelo Nsiampa (ir PhD) is a researcher in the department of weapons systems and ballistics of the Royal Military Academy in Brussels, Belgium. His research is mainly focused on the development of the finite element models of human body for the simulation of blunt impacts. He is a member at NATO level of a group of experts namely NLKE ToE (Non Lethal Kinetic Energy Team of Experts) who meet twice a year for information exchange and for defining non-lethal standardisation methods.

Notes

Improved simulation of a human thorax subjected to ballistic impact

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Studying the mechanical response of the human thorax submitted to ballistic impacts is a challenging field of research. Because of ethical considerations, it is not possible to perform tests on the human body. Therefore numerical simulations are one of the alternatives for evaluating the human thorax mechanical response. During previous works, a simplified human thorax submitted to low velocity impacts without ballistic protection was modeled. However, it didn't model all organs inside the thorax. Only the heart, lungs, trachea and aorta were considered, with voids between those organs. Due to these voids, it is not possible to simulate high velocity impacts on a protected thorax as shock waves are involved which can lead to injury. This paper will focus on a method of filling these voids in order to simulate shock wave propagation. It is based on a coupling between Lagrange, Euler and ALE objects. The new thorax model has been validated with data from literature.

I got my Master degree of Engineer in material science in 2005. I have worked for Belgian Defence at the Royal Military Academy for the Department of Civil and Materials Engineering since November 2005. I got my PhD in December 2017. I am studying the dynamic behaviour of materials and their characterization. The work involves experiments, finite element modelling and simulations. Most of the applications are related to the ballistic and blast protective structures among which the bulletproof vests. As an example, I was implicated in a project related to the development of combination between ballistic textile and granular materials against improvised explosive devices and a study related to the behind armour blunt trauma. I am currently working on the effects of thermal ageing on the performances of the materials constituting the ballistic protections.

Notes

AERODYNAMICAL CFD STUDY OF A NON-LETHAL 12-GAUGE FIN-STABILIZED PROJECTILE

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Nowadays, the trajectory model for a subsonic fin-stabilized projectile at low angle of attack is typically a point-mass model (PMM), taking only gravity and a constant zero-yaw drag into account. This choice can be qualitatively justified for non-lethal projectiles given the short ranges. The disadvantage of this approach is the lack of prediction on the precision and the attitude of the projectile when hitting the target, because of a possible instability in flight. However, the use of non-lethal projectiles requires that the impact conditions are met, otherwise more serious injuries may occur. Therefore, the consideration of other forces and moments acting on the projectile in flight is mandatory to predict static and dynamic stability, already in the body shape design as well as in the controller design process in the field of non-lethal ammunitions. Starting from a geometry in caliber 12-gauge, static coefficients (drag, lift and pitch) for different angles of attack using steady RANS-simulations with a low-order turbulence model were found. Different trajectories were then analysed using those coefficients and the difference between the PMM and a 3-DOF accounting for drag, lift and pitch in function of the angle of attack is indeed negligible in height and in range as long as the launch conditions are completely undisturbed. The slightest destabilization makes the PMM completely inappropriate. Knowledge of the pitch damping coefficient then becomes a necessity to optimize stabilization following minor disturbances.

Mrs **Véronique de Briey** has a master in engineering and is a doctoral candidate where she specializes in weapon systems and ballistics, more specifically in exterior ballistics. After working as officer in a cavalry unit, she chose the academic way as an assistant in the department of weapons systems and ballistics of the Royal Military Academy in Brussels.

Notes

U.S. AFRL Program for Computational Behavioral Modeling

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The U.S. Air Force Research Laboratory (AFRL) has ongoing research interests in computational behavioral modeling. Reported here is research on the development of the software application Simulating Agent Response to Directed Energy Applications and New Technology (SARDEAN), a near-real-time behavioral modeling program for operationally relevant scenarios. SARDEAN simulates the behavior of individuals in crowds that have been exposed to a wide range of novel weapon technologies (e.g., directed energy, scalable weapons, non- lethal weapons). The behavioral engine in SARDEAN is built upon valid psychological theory and data from rigorous laboratory studies and relevant field studies. Moreover, SARDEAN leverages cutting-edge industry techniques for modeling physics-based 3D environments and uses agent-based navigation algorithms such as Qualitative Spatial Reasoning, Dynamic Avoidance, and Hierarchical Path Finding. SARDEAN is designed to allow operators to develop operationally accurate scenarios and test behavioral responses to any scalable or non-lethal weapon that can be behaviorally characterized. A number of AFRL behavioral research programs feed data into SARDEAN, thus continuously updating its accuracy and operational applicability.

Mr. **Joshua Musick** is the Program Manager for Simulating Agent Response to Directed Energy Applications and New Technology (SARDEAN), and a Research Computer Scientist for the Optical Radiation Bioeffects Branch of the U.S. Air Force Research Laboratory. Prior to his civilian position, Mr. Musick was a Captain in the U.S. Air Force, where his primary technical responsibilities included the design and implementation of theory and data into computational models which he tested with first-principles physics simulations running on a High-Performance Computing (HPC) cluster. He earned the Outstanding Performer designation and led the AFRL Commanders Cup Team during advanced concept events run in distributed simulations. In developing SARDEAN, he integrated cognitive, social, and behavioral models from academia and AFRL laboratory and field experimentation into a 3D agent-based near-real-time application. Mr. Musick has also developed tools for rendering Directed Energy hazard volumes, system integration with virtual reality displays, and scenarios that run in Distributed Interactive Simulations (DIS). Mr. Musick earned a Bachelor's Degree in Computer Science Engineering from the University of Michigan, and is completing a Master's Degree in Software Engineering at the University of Texas at Austin.

Notes

In-band laser damage to an uncooled thermal infrared imager

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Abstract

Thermal infrared imaging sensors based on uncooled microbolometer focal plane arrays are exceedingly vulnerable to pixel damage from low-power laser weapons that irradiate at a wavelength in band to the sensing element. This group of thermal imagers, which operate in the 8-12 micron waveband (LWIR), is vital for both civilian and military applications; essentially, they offer an acceptable performance at significantly lower-cost and lower-power requirements when compared to cooled thermal cameras. The objective of this research was to investigate the effect of irradiation by a continuous-wave (CW) laser on an uncooled thermal imager with a microbolometer array of vanadium oxide; in particular, we focused on how the image was dazzled and pixels were damaged with increasing laser power density. We irradiated a focal plane array of size 640x480 pixels by a tunable quantum cascade laser a few meters away, which was fixed at a wavelength of 10.6 micron (in-band to the array). As the power was increased, we observed those pixels directly illuminated by the laser spot saturate, diffraction and blooming effects occur across the image that quickly led to pixel damage for an exposure of only a few seconds at power densities less than 1 mW/cm-2. In conclusion, damage was inflicted to pixels on the microbolometer array well before any significant dazzling over the image. Future research will focus on explaining the thermal effects associated with the rapid transition from dazzle to damaged pixels, and investigating countermeasures to mitigate this threat.

Gareth joined the Royal Military Academy in 2014 to research the management of infrared signatures from warships. Recently, his research has moved to the assessment of the vulnerability of infrared imaging systems to a laser weapons threat. He has over 20 years of defence related research spent working for the UK mod at DERA Malvern (now dstl/qinetiq) and the EU Joint Research Centre Ispra (VA), Italy. He holds a degree in Physics and Meteorology from Reading Univ. (UK) in 1990, a Phd in Electro-magnetic scattering from surfaces from Cranfield Univ. (UK) in 2001 and a Masters in Applied Computer Sciences from VUB in Brussels (BE) 2013.

Notes

Evaluation of Natural Capsaicin (N.Cap) in Pepper Spray by GC-MS/FID, NMR and HPLC as an alternative to the use of Oleoresincapsicum (OC)

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GC-FID/MS, NMR and HPLC was used to study the Natural Capsaicin (N.Cap) in pepper sprays in order to show the capsaicinoids in a raw material as well as solution in spray canister. Natural Capsaicin was used instead the Oleoresin Capsicum (OC) while maintaining the usual effect with the advantage of a better chemical control. In addition, the non-flammability safety characteristics have been increased since N.Cap does not contain the flammable substances present in the OC. NMR and GC-FID/MS results showed 60% of capsaicin and 30% of dihydrocapsaicin agreeing with a typical ratio expected. Other capsaicinoids were detected in lower concentrations. Substances such as oils and resins, which are normally found in the OC, are not detected in significant concentrations. HPLC alternative method was evaluated about resolution and the capsaicinoids ratio measurement. The dilution of raw materials (N.cap) in dichloromethane avoid intermediary processes of extraction or concentration of analyte. It was able to carry out an analysis with a solution directly collected from spray by only one dilution step. Contaminants such as PAVA and others could be observed in the same analysis by GC-MS without changes in the methodology. A review of the literature was carried out comparing the usual aspects about capsaicinoids contents in OC sprays solution, where find reported between 1 to 40% of capsaicinoids in the solutions showing a large range of active substance concentration in commercial products. The method allows control in the production and safety evaluation of the product by user.

Nilton Geraldo de Oliveira Junior, *PhD. Chemical Science, 2012, UNICAMP-SP-Brazil.* PROFESSIONAL: form 2013 to present is Researcher at Condor Non-Lethal Technology and R&D Coordinator with development of new products tasks and research design of non-lethal weapons and ammunitions, create new chemical methods and new formulations. BACKGROUND: Research Chemist at UNICAMP-SP-Brazil: Characterization of materials by XRD, XPS, UV-Vis, FTIR, CG-MS, DSC, DTA and others (2007-2012). Professor at the Chemical Engineering Course at UNIANCHIETA-SP, Brazil: Thermodynamic, Organic Process, Chemistry (2009-2012).

Notes

Thoracic wall behavior, pulmonary injuries, physiological impairments and numerical approach after thoracic blunt trauma in pigs

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Blunt thoracic impacts occur in many traumatic circumstances. When it comes to weapons, mainly two situations are in the front stage: Behind armour blunt trauma (BABT) and direct ballistic impacts by non lethal kinetic weapons (NLKW). These are responsible, among other, of lung contusions, rib fractures and cardiac output impairment.
Of today, it is not well known what the real mechanisms are responsible for such injuries: kinetic energy, momentum, pressure, force, impulse, displacement...
To address this issue, we conducted an experimental program on live anesthetized large animals. Right thoracic wall was impacted with non-deformable 60mm round projectiles. A large range of impact speed and two different projectile weights allowed us to assess different kinetic energies and momentums. Rib cage displacement, intrathoracic pressure as well as lung contusion size and physiological impairments were recorded.
These data were compared to other criteria (kinetic energy, momentum, deformation, speed, acceleration, viscous criterion, blunt criterion...) to find correlations.

LCL **Nicolas PRAT** is currently appointed to the French Armed Forces Institute of Biomedical Research (IRBA, France) and head of the combat casualties research Unit. He graduated at the University of Lyon in 2005. From 2005 to 2007, he served in the “Gendarmerie” (French Military Police) as a general practitioner. In 2007, he passed the National Military Competitive Exam of Research, and since then, he has coped with both his military fellowship in Integrated physiology (until 2013) and a PhD in physiology (until 2011). He got the research certification in May 2013. In this field of competence, he has worked on numerous traumatic injury research themes including wound ballistics, personal armor systems, hemorrhage control, thoracic trauma and emergency surgery. LCL Prat holds different academic diplomas and post-graduated courses focused on traumatic injuries: wound ballistics (2003), catastrophic medicine (2003), forensic sciences (2004), biomechanics engineering (2004), forensic medicine (2008), PHTLS and ATLS courses (2009-2010). In addition, he is an Instructor and the National Educator for ATLS. He teaches also Combat Casualty Care Skills to military physicians and nurses who are being deployed. He spent 3 years as an exchange officer at the US Army Institute of Surgical Research (2012-2014).

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