



22ND INTERNATIONAL SYMPOSIUM ON BALLISTICS

November 14-18, 2005



**Vancouver
BC, Canada
Event #6210**



International Symposium on Ballistics 2005

International Symposium on Ballistics 2005 is jointly organized and supported by the National Defense Industrial Association, USA in conjunction with the International Ballistics Committee

Symposium Co-Chairman: William Flis

Symposium Co-Chairman: Brian Scott

PREVIOUS INTERNATIONAL SYMPOSIA ON BALLISTICS

1st	Orlando, Florida, USA	1974
2nd	Daytona, Florida, USA	1976
3rd	Karlsruhe, Germany	1977
4th	Monterey, California, USA	1978
5th	Toulouse, France	1980
6th	Orlando, Florida, USA	1981
7th	The Hague, The Netherlands	1983
8th	Orlando, Florida, USA	1984
9th	Shrivenham, UK	1986
10th	San Diego, California, USA	1987
11th	Brussels, Belgium	1989
12th	San Antonio, Texas, USA	1990
13th	Stockholm, Sweden	1992
14th	Quebec City, Canada	1993
15th	Jerusalem, Israel	1995
16th	San Francisco, California, USA	1996
17th	Midrand, South Africa	1998
18th	San Antonio, Texas, USA	1999
19th	Interlaken, Switzerland	2001
20th	Orlando, Florida, USA	2002
21st	Adelaide, South Australia	2004
22nd	Vancouver, BC Canada	2005

SYMPOSIUM SCOPE AND OBJECTIVES

The objective of the 22nd International Symposium on Ballistics is to focus on potential technical advances and break-throughs in the 21st century in the general areas of:

- Interior Ballistics
- Launch Dynamics
- Exterior Ballistics
- Projectile and Warhead Design
- Terminal Ballistics
- Vulnerability
- Modeling and Simulation
- Wound Ballistics

Over 200 papers will be presented by authors from 26 countries.

SYMPOSIUM PROGRAM

Monday, November 14, 2005

- 2:00 pm - 5:00 pm Registration
5:00 pm - 6:30 pm Reception in Exhibit Area

Tuesday, November 15, 2005

- 7:00 am Continental Breakfast and Registration
7:00 am - 6:00 pm Exhibits Open
8:00 am Opening Remarks
C. Samuel Campagna, National Defense Industrial Association
8:10 am Welcome and Opening Remarks
William Flis, DE Technologies, Inc. & **Brian Scott**, US Army Research Laboratory
8:20 am **Keynote Address**
Dr. Robert Walker, Director-General, Research and Development Programs (DGRDP), Defense Research and Development Canada
9:05 am **Invited Presentation**
From Columbia to Discovery: Understanding the Impact Threat to the Space Shuttle
James D. Walker, Southwest Research Institute
9:50 am Morning Break

General Oral Session #1

Chairpersons: B. Janzon and J. Carleone

- 10:20 am Plasma Ignition of a 30mm Cannon
Richard A. Beyer, Andrew L. Brant, Joseph J. Colburn, US Army Research Laboratories
10:40 am Numerical Computations of Subsonic and Supersonic Flow Choking Phenomena in Grid Finned Projectiles
Nicolas Parisé, SNC Technologies, Inc.; **Alain Dupuis**, Precision Weapons Section, Defense Research and Development Canada
11:00 am Multiple Explosively Formed Penetrator (MEFP) Warhead Technologies for Mine and Improvised Explosive Device (IED) Neutralization
Richard Fong, William Ng, Steve Tang, LaMar Thompson, U.S. Army Armament Research, Development and Engineering Center
11:20 am The Use of Electric Power in Active Armour Applications
Martin van de Voorde, R. Boeschoten, TNO Defence, Security and Safety
11:40 am Prevention of Sympathetic Detonation between Reactive Armor Sandwiches
Andreas Holzwarth, Fraunhofer-Institut für Kurzzeitdynamik
12:00 pm Lunch

22nd International Symposium on Ballistics

1:30 pm - 3:10 pm

Exterior Ballistics Poster Session
Chairpersons: Z. Wang and P.A. Karsten

Terminal Ballistics Oral Session #1
Chairpersons: E. Lindén and C. Anderson

1:30 pm

Bullet Impact on Steel and Kevlar®/Steel Armor – Experimental Data and Hydrocode Modeling with Eulerian and Lagrangian Methods*
Dale S. Preece, Vanessa S. Berg, Mathew A. Risenmay, Sandia National Laboratories

1:50 pm

Progress on the NDE Characterization of Impact Damage in Armor Materials
Joseph M. Wells, JMW Associates

2:10 pm

Design, Analysis, and Testing of an Unconfined Ceramic Target to Induce Dwell
Timothy J. Holmquist, Network Computing Services, Inc.; **C. Anderson, Jr.**, Southwest Research Institute; **Thilo Behner**, Ernst-Mach-Institut

2:30 pm

The Influence of Sabot Threads on the Performance of KE Penetrators against multiple plate targets
Nick J. Lynch, J. Stubberfield, QinetiQ

2:50 pm

Visualization of Wave Propagation and Impact Damage in a Polycrystalline Transparent Ceramic - AION
Elmar Strassburger, Fraunhofer Institut für Kurzzeiddynamik; **Parimal Patel, James W. McCauley**, US Army Research Laboratory; **Douglas W. Templeton**, US Army TARDEC

3:10 pm

Afternoon Break

3:40 pm - 5:20 pm

Terminal Ballistics Poster Session #1
Chairpersons: A. Diederer

Exterior Ballistics Oral Session
Chairpersons: W. Reinecke and A. Dupuis

3:40 pm

Advanced Time-Accurate CFD/RBD Simulations of Projectiles in Free Flight
Jubaraj Sahu, US Army Research Laboratory

4:00 pm

Aerodynamic Characteristics of a Grid Finned Projectile from Free-Flight Tests at Supersonic Velocities
Alain Dupuis, DRDC - Valcartier; **Claude Berner**, French-German Research Institute

4:20 pm

Recent Computations and Validations of Projectile Unsteady Aerodynamics
Roxan Cayaz, Eric Carette, Giat Industries; **Rémy Thépot, Patrick Champigny**, Office National d'Études et de Recherches Aéropatiales

4:40 pm

The Derivation of Spin Stabilised Projectile Yaw Rates and Ballistic Model Coefficients Using Conventional CW Doppler Radar Systems
John Tate, FLEET

5:00 pm

Research of Flight Characteristics of Rod-Type Projectile with Triangular Cross-Section
Wenjun Yi, Xiaobing Zhang, Jianping Qian, Ballistic Research Laboratory of China, Nanjing University of Science & Technology

5:20 pm

Adjourn for the Day

22nd International Symposium on Ballistics

Wednesday, November 16, 2005

- 7:00 am Continental Breakfast and Registration
- 7:00 am - 5:00 pm Exhibits Open
- 8:00 am Administrative Remarks
- 8:10 am - 9:50 am **Terminal Ballistics Poster Session #2**
Chairpersons: J. Riegel and E. Hirsch
- Exterior Ballistics Oral Session #2**
Chairpersons: P. Nel and E. Schmidt
- 8:10 am Impact of Nose-Mounted Micro-Structures on the Aerodynamics of a Generic Missile
Daniel Corriveau, Defence R&D Canada (DRDC - Valcatier)
- 8:30 am Ballistic Simulations and Wind Tunnel Testing of 120 mm Mortar Bomb Tail Fin Geometries – In Search for Extra Range
Jukka Tiainen, Ari Makkonen, Patria Weapon Systems Oy; **Mikko Korhonen, Timo Salaranta**, TKK/Laboratory of Aerodynamics
- 8:50 am Bringing Solid Fuel Ramjet Projectiles Closer to Application – An Overview of the TNO/RWMS Technology Demonstration Programme
Ronald G. Veraar, TNO Defence, Security and Safety Research Group Rocket Technology; **Guido Giusti**, Rheinmetall Waffe Munition Schweiz AG
- 9:10 am Analysis of Gliding Control for an Extended-Range Projectile
Zhongyuan Wang, Houqian Xu, Jinguang Shi, Wenjun Yi, Shaosong Chen, Ballistic Research Laboratory of China, Nanjing University of Science & Technology
- 9:30 am Theoretical Design for a Guided Supersonic Projectile
Pierre Wey, Claude Berner, Eckhart Sommer, Volker Fleck, Henry Moulard, French-German Research Institute of Saint-Louis (ISL)
- 9:50 am Morning Break
- 10:20 am - 12:00 pm **Warhead Mechanisms Poster Session**
Chairpersons: R. Fong and F. Mostert
- Interior Ballistics/Launch Dynamics Oral Session #1**
Chairpersons: C. Candland and C. Woodley
- 10:20 am Ceramic Gun Barrel Technology
Lawrence W. Burton, Jeffrey J. Swab, Ryan Emerson, Robert Carter, US Army Research Laboratory, Weapons & Materials Research Directorate
- 10:40 am M865E3 Cold Target Impact Dispersion Study
Kerry Henry, Army Research Development & Engineering Center; **Jason W. Gaines**, General Dynamics-OTS
- 11:00 am An Alternative Technique to Evaluate and Characterize Pressure Waves in Large Calibre Guns
Victor Schabert, Denel Land Systems Western Cape
- 11:20 am Two-Dimensional Modelling of Mortar Internal Ballistics
Clive R. Woodley, David Finbow, QinetiQ; **Vladimir Titarev, Eleuterio Toro**, Numeritek Limited

11:40 am The Mechanism Analysis of Interior Ballistics of Serial Chamber Gun
Sanjiu Ying, Charge Design Laboratory of China, Nanjing University of Science & Technology; **Xiaobing Zhang**, **Qaxiong Yuan**, **Yan Wang**, Ballistic Research Laboratory of China, Nanjing University of Science & Technology

12:00 pm Lunch

Terminal Ballistics Oral Session #2
Chairpersons: M. Mayseless and T. Holmquist

1:30 pm Behind Armor Debris Computations with Finite Elements and Meshless Particles
Gordon R. Johnson, **Robert A. Stryk**, Network Computing Services, Inc.

1:50 pm Experimental and Numerical Study of the Penetration of Tungsten Carbide into Steel Targets During High Rates of Strain
Eva K. Friis, Nammo Raufoss AS, **Oyvind Froyland**, **John F. Moxnes**, FFI (Norwegian Defence Research Establishment)

2:10 pm Fragmentation Behavior of Tungsten Alloy Cubes on Normal Aluminum Plate Targets
Karl Weber, Fraunhofer-Institut für Kurzzeitdynamik, Ernst-Mach Institut

2:30 pm The Failure Kinetics of High Density DEDF Glass Against Rod Impact at Velocities From 0.4 to 2.5 km/s
Thilo Behner, **V. Hohler**, **M. Moll**, Fraunhofer Institut für Kurzzeitdynamik (Ernst-Mach Institut); **Ch. E. Anderson Jr.**, Southwest Research Institute; **D. L. Orphal**, International Research Associates, Inc.; **D. W. Templeton**, US Army RDECOM-TACOM

2:50 pm Mine Neutralisation with Small Calibre Projectile Impact
Mark Dijkstra, **J.H. Meulman**, TNO Defence, Safety and Security

3:10 pm Afternoon Break

Vulnerability, Lethality and Wound Ballistics Oral Session
Chairpersons: R. Vaziri, A. Persson

3:40 pm The Application of Critical Perforation Analysis (CPA) to Military Personal Armour Research and Evaluation
Catherine H. Crawford, **Philip Gotts**, Defence Clothing Research and Project Support

4:00 pm An Efficient Mechanistic Approach to Modelling the Ballistic Response of Multi-Layer Fabrics
Ali Shahkarami, **Reza Vaziri**, **Anounsh Poursartip**, Composites Group, Departments of Civil Engineering and Materials Engineering The University of British Columbia; **Navin Tajani**, DuPont Advanced Fibers Systems

4:20 pm Pencilling – A Novel Behind Armour Blunt Trauma Injury
Eluned A. Lewis, Defence Clothing Research and Project Support; **Ian Horsfall**, **Celia Watson**, Engineering Systems Department, Royal Military College of Science, Cranfield University

4:40 pm Scaling the Dynamic Response of Armored Vehicle's Floor Subjected to a Large Buried Charge
Avidov Neuberger, MOD, Tank Program Management; **S. Peles**, IMI, Central Laboratory Division; **D. Rittel**, Technion, Israel Institute of Technology, Faculty of Mechanical Engineering

5:00 pm Fragment Patterns Behind Concrete Structures Caused by KE Projectiles
René Jeanquartier, D. Hoffmann, S. Lampert, B. Lehmann, Armasuisse

5:20 pm Adjourn for the Day

Thursday, November 17, 2005

7:00 am Continental Breakfast and Registration

8:00 am - 11:00 am Exhibits Open

8:00 am Administrative Remarks

8:10 am - 9:50 am **Interior Ballistics/Launch Dynamics Poster Session**
Chairpersons: C. Woodley and C. Candlant

Warhead Mechanisms Oral Session #1
Chairpersons: M. Murphy and P.Y. Chanteret

8:10 am Soft-Recovery of Explosively Formed Penetrators
David E. Lambert, Matthew Pope, Air Force Research Laboratory, Munitions Directorate; **Stanley Jones, Jonathan Muse**, University of Alabama, Aerospace Engineering and Mechanics

8:30 am The Gurney Velocity: A "Constant" Affected by Previously Unrecognized Factors
Joseph E. Backofen, BRIGS Co.

8:50 am Influence of Post Detonation Burning Process on Blast Wave Parameters in Air
Meir Mayseless, E. Muzychuk, IDF, Mil.; **M. Mayseless, I. Belsky, IMI**, Central Laboratory

9:10 am Steerable Fragment Masses
Manfred Held, TDW/EADS

9:30 am Penetration Performances of Tungsten-Copper Shaped Charge Liner
Seong Lee, Eun Pyo Kim, Youngmoo Kim, Sung Ho Lee, Moon-Hee Hong, Joon-Woong Noh, Agency for Defense Development

9:50 am Morning Break

10:20 am - 12:00 pm **Vulnerability/Lethality/Wound Ballistics Poster Session**
Chairpersons: W. Gooch

Interior Ballistics/Launch Dynamics Oral Session #2
Chairpersons: B. Burns and R. Cayzac

10:20 am 3-D Finite-Element Gun Launch Simulation of a Surrogate Excalibur 155-mm Guided Artillery Projectile - Modeling Capabilities and its Implications
M.R. Chowdhury, A. Frydman, US Army Research Laboratory; **J. Cordes, L. Reinhardt, D. Carlucci**, US Army ARDEC, Analysis and Evaluation Division

10:40 am Method of Calculating Initial Firing Data of Artillery Laser Terminal-Guidance Weapon System
Feipeng Zeng, Liren Liu, Faculty of Artillery Command, Nanjing Artillery Academy

- 11:00 am Caseless Ammunition & Advances in the Characterization of High Ignition Temperature Propellant
Patricia M. O'Reilly, Erin Hardmeyer, Chad Sensemig, US Army ARDEC; **Ben Ashcroft**, Alliant Techsystems; **Dave Cleveland**, The Johns Hopkins University, 0Applied Physics Laboratory; **Bo Engel, Paul Shipley**, AAI Corporation
- 11:20 am Ballistic Launch to Space
Edward Schmidt, M. Bundy, US Army Research Laboratory
- 11:40 am A Novel Launcher for Cavitating Weapons
Chris J. Weiland, Pavlos P Vlachos, Dept of Mechanical Engineering Virginia Tech; Jon J Yagla, Mechanical Engineer Engagement Systems Department Naval Surface Warfare Center
- 12:00 pm Lunch
- Warhead Mechanisms Oral Session #2**
Chairpersons: R. Brown and M. Held
- 1:30 pm The Role of Rayleigh Taylor Instability in Shaped Charge Jets Formation and Stability
Simcha Miller, Gershon Kliminz, Rafael Ballistic Center
- 1:50 pm Simulation of Cylinder Expansion Tests Using an Eulerian Multiple-Material Approach
Laura K. Donahue, R.C. Ripley, Martec, Ltd.
- 2:10 pm Application of Powder Tantalum Material for Explosively Formed Penetrator Warhead
Richard Fong, William Ng, Steven Tang, Michael Hespos, US Army Armament Research, Development and Engineering Center
- 2:30 pm Oilwell Perforators: Theoretical Considerations
Brenden M. Grove, Schlumberger Reservoir Completions Center
- 2:50 pm Planar Cutting Jets from Shaped Charges
Geoffery EB Tan, T.K. Lam, Y.K. Tham, DSO National Laboratories
- 3:10 pm The Study on Lethality Simulation Method for Fragment Warhead
Yang Yunbin, Qu Ming, Qian Lixin, Institute of Structural Mechanics, China Academy of Engineering Physics
- 3:30 pm Adjourn for the Day
- 4:00 pm - 5:30 pm Reception

Friday, November 18, 2005

- 7:00 am Continental Breakfast and Registration
- 8:00 am Administrative Remarks
- Terminal Ballistics Oral Session #3**
Chairpersons: I. Cullis and D. Nandlall
- 8:10 am Performance Evaluation of Multi threat Body Armour Systems
B. Anctil, M. Keown, Biokinetics and Associates Ltd.; **G. Pageau, M. Bolduc D. Bourget**, Defence R&D Canada – Valcartier

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- 8:30 am Finite Element Simulations and Experiments to Determine the Residual Damage of a CFRP Composite Material After Ballistic Impacts
Koen Herlaar, M. Van der Jagt-Deutekom, TNO Defence, Security and Safety
- 8:50 am The Effect of Boundary Conditions on the Ballistic Performance of Textile Fabrics
Colin R. Cork, University of Manchester, School of Materials
- 9:10 am Terminal Ballistic Effects of Low Density Materials Used as Confinement Plates for Explosive Reactive Armour
Hanspeter Kaufmann, RUAG Land Systems; **André Koch**, Armasuisse
- 9:30 am Quantification of the Effect of Using the Johnson-Cook Damage Model in Numerical Simulations of Penetration and Perforation
Charles E. Anderson Jr., T. R. Sharron, Southwest Research Institute; **Timothy J. Holmquist**, Network Computing Services, Inc.
- 9:50 am Morning Break
- General Oral Session #2**
Chairpersons: V. Sanchez-Galvez and P. Cuniff
- 10:20 am Comparisons of Internal Ballistics Simulations of the AGARD Gun
Clive R. Woodley, QinetiQ; **Alain Carriere, Patrice Franco, Dieter Hensel, Julien Nussbaum**, Institut Franco-Allemand de Recherches de Saint-Louis (ISL); **Tatjana Gröge**, Ernst-Mach-Institut (EMI); **Stefan Kelzenberg**, Fraunhofer-Institut für Chemische Technologie (ICT), **Baptiste Longuet**, DGA/DCE/ETBSr3
- 10:40 am Wind Tunnel Verification of the Performance of a Smart Material Canard Actuator
Paul Weinacht, William F. Drysdale, Travis Bogetti, Rod Don, US Army Research Laboratory; **James T. Arters, Jack R. Vinson, Aaron R. Hickman**, University of Delaware; **Lamar Auman**, US Army Aviation and Missile RD&E Center; **Oded Rabinovitch**, Technion Israel Institute of Technology
- 11:00 am Fragmentation of Metal Cylinders Using Thermobaric Explosives
M.R. Dunning, Defence Research and Development - Suffield, **W.S. Andrews**, Department of Chemistry and Chemical Engineering, Royal Military College of Canada; **K.M. Jaansalu**, Department of Metallurgical and Materials Engineering, The University of Montana
- 11:20 am A Novel Test Methodology to Assess the Performance Ballistic Helmets
B. Anctil, M. Keown, Biokinetics and Associates Ltd.; **D. Bourget, G. Pageau**, Defence R&D
- 11:40 am Ballistic Analysis of Bulgarian Electroslag Remelted Dual Hard Steel Armor Plate
William Gooch, Matthew Burkins and David Mackenzie, US Army Research Laboratory, Weapons and Materials Research Directorate; Stefan Vodenicharov, Institute of Metal Science, Bulgarian Academy of Sciences
- 12:00 pm Presentation of Awards
The Rosalind and Pei Chi Chou Award for Young Authors
The Neil Griffiths Memorial Award
The Louis and Edith Zernow Award
- 12:15 pm Invitation to the 23rd International Symposium on Ballistics, Tarragona, Spain, 2007
- 12:25 pm Closing
William Flis, DE Technologies, Inc. & **Brian Scott**, US Army Research Laboratory

POSTER SESSIONS START HERE

Exterior Ballistics Poster Session
1:30 pm - 3:10 pm Tuesday, November 15

- 1913 Fractional Calculus for Design of Aerodynamic Missile's Autopilot and Digital Realization
Bangchu Zhang, Chenming Li, Zipeng Han, Zou Yun, Fuming Xu, Ballistic Research Laboratory of China, Nanjing University of Science & Technology
- 1915 The Simulation of Rocket Trajectory in Simulink
Xin Changfan, Nanjing University of Science & Technology
- 1924 Establishing a Pitch Damping Test Capability at CSIR Defencetek
Fabrizio Dionisio, CSIR, Defencetek
- 1944 The Investigation About Using Different Guidance Laws on Improving Impact Point Deviation of a Rocket
Handong Zhao, Fang Wang, Qingshang Liu, Key Laboratory of Instrumentation and Dynamic Measurement, North University of China
- 1951 Numerical Integration Method Based on 4th Lagrange Polynomial of Strap-Down INS System
Guoguang Chen, Xiaoli Tian, Changfan Xin, Yaqi Bao, North University of China
- 1952 Research on Real Time Trajectory Measure Device of Range
Changfan Xin, Guoguang Chen, Xiaoli Tian, North University of China
- 1953 Research on Attitude Control Strategy of Glide Range Extend Rocket
Xiaoli Tian, Guoguang Chen, Changfan Xin, North University of China
- 1954 Optimal Algorithm of Glide Range Extend Rocket's Trajectory
Guoguang Chen, Xiaoli Tian, Changfan Xin, North University of China
- 1978 Practical Propulsion by Directed Energetic Processes
Joseph P. Backofen, BRIGS Co.
- 2014 Investigating the Method of Obtaining Ammunition Roll Attitude by Detecting the Geomagnetic Vector
Hongsong Cao, Guoguang Chen, Department of Mechatronics Engineering, North University of China
- 2065 External Ballistic Trajectory Computations for Direct/Indirect Fire Weapon Systems
David J. Norton, General Dynamics Canada
- 2087 The Influence of Laser Rangefinder Parameters on the Hit Probability in Direct Tank Fire
Vladimir Cech, OPROX, Inc., **Jiri Jevicky**, Department of Mathematics, University of Defense
- 2123 Flight Dynamics Modeling and Experiment for Composite Concepts. Application to Ribbon Aerodynamic Stabilization
Christopher Grignon, S.Heddadj, Giat Industries
- 2128 Onboard Measurements with Magnetic Sensors: Determination of the Attitude and the trajectory Position
V. Fleck, E. Sommer, S. Changey, French-German Research Institute (ISL); **D. Beauvois**, Ecole Supérieure d'Électrotechnique (Supelec)
- 2133 Aerodynamic Characteristics of a Long Range Spinning Artillery Shell Obtained from 3D Magnetic Sensors
V. Fleck, E. Sommer, C. Berner, French-German Research Institute (ISL); **A. Dupuis**, DRDC
- 2143 Experimental Testing and Numerical Simulation of Separation Disturbances for Two-Stage Kinetic Energy Missiles
Nicolas Parisé, SNC Technologies, Inc.; **Richard Lestage, Françoise Lesage**, Precision Weapons Section, Defense Research and Development Canada Valcartier
- 2147 Numerical Study on the Base Drag Characteristics of a Base Bleed Projectile with a Central Propulsive Jet
Chang-Kee Kim, Agency for Defense Development; **J.Y. Choi**, Pusan National University, Department Aerospace Engineering

2169 Solid Fuel Ramjet (SFRJ) Propulsion for Artillery Projectile Applications – Dynamic Testing Progress
Anton Stockenström, Dynax

3010 Pitch and Bending During In-Flight Extension
W. G. Reinecke, Institute for Advanced Technology; **M. G. Miller**, Physical Sciences, Inc.

4004 Improvements in Aerodynamic Design for KE Less-Lethal Projectiles
Jamie H. Cuadros, Arts & Engineering

Terminal Ballistics Poster Session #1
3:40 pm - 5:20 pm Tuesday, November 15

1001 Numerical Simulations of Silicon Carbide Tiles Impacted by Tungsten Carbide Spheres
Constantine G. Fountzoulas, Jerry C. LaSalvia, Bryan A. Cheeseman, Weapons and Materials Research Directorate; **Michael J. Normandia**, Ceradyne, Inc.

1007 Shock Mitigation for Blast Protection Using Hertzian Tapered Chains
Robert Doney, US Army Research Laboratory; **Surajit Sen**, Department of Physics, State University of New York at Buffalo

1011 A Predictive Model for the Dwell/Penetration Transition Phenomenon
Jerry C. LaSalvia, US Army Research Laboratory

1012 Effect of Ceramic Thickness on the Dwell/Penetration Transition Phenomenon
Jerry C. LaSalvia, US Army Research Laboratory

1014 The Development of Hybridized Thermoplastic-Based Structural Materials with Applications to Ballistic Helmets
Shawn Walsh, Brian R. Scott, David M. Spagnuolo, AMSRD-ARL-WM-MB

1015 Time Resolved Observation of the Deformation and Surface Strain of a Textile Fabric Subject to Ballistic Impact
Brian Scott, Peter Dehmer, US Army Research Laboratory; **Timothy Schmidt**, Trillion Quality Systems

1016 Analytic Design Trends of Fabric Armor
Brian Scott, Chian-Fong Yen, US Army Research Laboratory

1018 High-Speed Photographic Study of Wave and Fracture Propagation in Fused Silica
Elmar Strassburger, Fraunhofer-Institut für Kurzzeitdynamik, Ernst-Mach-Institut (EMI); **Parimal Patel, James W. McCauley**, US Army Research Laboratory; **Douglas W. Templeton**, US Army TARDEC

1022 Low Velocity Ballistic Properties of Shear Thickening Fluid (STF)–Fabric Composites
M. J. Decker, R. G. Egres, N. J. Wagner, University of Delaware, Dept. of Chemical Engineering and Center for Composite Materials; **E. D. Wetzel**, U.S. Army Research Laboratory

1023 An Approximate Solution of the Long-Rod Penetration Equations
William Walters, Cyril Williams, ARL, Terminal Effects Division

1901 Tubular Projectile Interaction with Stationary and Moving Oblique Plates
Olof Andersson, Swedish Defence Research Agency (FOI), Weapons and Protection Division

1911 A Study on the Moving Features of Double-Layer Explosive Reactive Armor with Definite Angle by Numerical Simulation and Experiments
Zhengxiang Huang, Xianfeng Zhang, Gang Li, School of Mechanical Engineering, Nanjing University of Science & Technology

1927 Mechanics of Structural Design of EPW Warhead
X.W. Chen, Institute of Structural Mechanics, China Academy of Engineering Physics

1928 Armour Qualification Utilizing Maximum Likelihood Ballistic Limit Calculation
Moshe Ravid, Shlomo Galperin, Rimat Advanced Technologies, Ltd.

1934 Perforation of Concrete Targets by an Eroding Tungsten-Alloy Rod
Stephan Lampert, Rene Jeanquartier, Armasuisse

1955 Ballistic Properties of Single-Melt Titanium-6Aluminum-4Vanadium Alloy Plate
Brij J. Roopchand, US Army Tank-Automotive and Armament Command, Armament Research, Development, & Engineering Center

1987 Preliminary Investigations of Potential Light Weight Metallic Armour Applications
Martin van de Voorde, A.M. Dierderen, K. Herlaar, TNO Defence, Safety and Security

2001 Oblique Warhead Penetration and Perforation of Multi-Layered Metallic Targets
Yongxiang Dong, Feng Shunshan, Wang Fang, State Key Laboratory of Explosion Science & Technology, Beijing Institute of Technology

2019 Influence of Projectile Material on Yawed Long Rod Projectiles Penetrating Oblique Plates
Ewa Lidén, Swedish Defence Research Agency (FOI), Weapons and Protection Division

2035 Advanced Aliphatic Polyurethane Resins for High Durability and Superior Ballistic Performance Laminated Glass
Francisco Folgar, INTER Materials, LLC

2037 Impact and Penetration of B4C Ceramic, Aluminum, and Beryllium by Depleted Uranium Rods at 2.0 KM/S
Scott A. Mullin, James D. Walker, Carl E. Weiss, Southwest Research Institute; **Paul O. Leslie**, Los Alamos National Laboratories

2122 A Comparison of Some Analytical and Empirical Models for Kinetic Energy Penetration of Semi-Infinite and Finite Thickness Steel Targets
Nick J. Lynch, J T Mills, QinetiQ

2181 Computed Tomography of High-Speed Events
Karsten Michael, Philip Helberg, Fraunhofer Institute for High Speed Dynamics, Ernst-Mach-Institut

2186 Characterization of Behind-Armor Debris Particles from Tungsten Penetrators
Brad A. Pedersen, S. Bless, Institute for Advanced Technology

Terminal Ballistics Poster Session #2
8:10 am - 9:50 am Wednesday, November 16

2050 On the Critical Thickness of Ceramic to Shatter WC-Co Bullet Cores
Paul J. Hazell, Engineering Systems Department, Cranfield University, Royal Military College of Science; **C. J. Roberson**, Advanced Defence Materials Limited

2060 The Effect of Spaced Armour on the Penetration of Shaped Charge Warheads
James D. Shattock, Cranfield University

2072 Modeling Impact and Penetration Using a Deterministic and Probabilistic Design Tool
David S. Riha, Jason B. Fleming, Ben H. Tucker, Scott A. Mullin, James D. Walker, Carl E. Weiss, Southwest Research Institute; **Edward A. Rodriguez, Paul O. Leslie**, Los Alamos National Laboratories

2106 On the Ballistic Efficiency of the Three Layered Metallic Targets
Stanislav Rolc, Military Technical Institute of Protection; **Jaroslav Buchar**, Mendel University; **Giovanni Cozzani**, OTO MELARA S.p.A **Vojtech Hruby**, University of Defence

2107 Effect of the Temperature on the Ballistic Efficiency of Plates Made From Cast Iron
Stanislav Rolc, Military Technical Institute of Protection; **Jaroslav Buchar**, Mendel University

2113 Displacement Device to Measure the Acceleration of the Bulge of RHA Plates Under Anti-Tank Mine Blast
Manfred Held, TDW/EADS; **Peter Heeger**, WTD; **Josef Kiermeir**, CONDAT

- 2116 Defeating Mechanisms of Explosive Reactive Armour Sandwiches
Manfred Held, TDW/LFK/EADS
- 2121 Comparisons of Unitary and Jacketed Rod Penetration into Semi-Infinite and Oblique Plate Targets at System Equivalent Velocities
John Stubberfield, N J Lynch, QinetiQ; **I Wallis**, QinetiQ Farnborough
- 2126 Finite Element Simulations and Experiments of Ballistic Impacts on High Performance PE Composite Material
Koen Herlaar, M. Van der Jagt-Deutekom, TNO Defense, Security and Safety
- 2129 The Use of Foam Structures in Armoured Vehicle Protection Against Landmines
David A. Cendón, Vicente Sanchez-Galvez, Francisci Galvez, Alejandro Enfedaque, Departamento de Ciencia de Materiales, E.T.S.I. Caminos, Canales y Puertos, Universidad Politecnica de Madrid, Spain
- 2136 The Numerical Simulation of the Impact of an Aluminum Cylinder into a Steel Cone
Izak M. Snyman, Defencetek Landwards Programme, CSIR
- 2139 Characterization of Al 6061-T6 using Split Hopkinson Bar Tests and Numerical Simulations
Amal Bouamoul, Manon Bolduc, DRDC - Valcartier
- 2145 Finite Element Modeling of Light Armoured Vehicles (LAV) Welds Heat Affected Zones Sublected to an Anti-Vehicular (AV) Blast Landmine Loading: A Summary of the Numerical Model and Experiment
Patrice Gaudreault, Defence Research & Development Canada; **Amal Bouamoul, Robert Durocher, Benoit St-Jean**, DRDC Valcartier
- 2151 Designer Projectiles by Density Variation: Towards the Nano-Projectile
John P. Curtis, QinetiQ
- 2160 Numerical Simulation for the Front Section Effect of Missile Warhead on the Target Perforation
Ho Soo Kim, Ki-Sun Yeom, Seong Shik Kim, Agency for Defense Development (ADD); Larry Sotsky, US Army ARDEC
- 2180 The Penetration Process of Projectiles into Long Bars in the Axial Direction
Dan Yaziv, G. Gans, Y. Reifen, RAFAEL
- 2199 The Electromagnetic Launch Trends Utilization for Shaped Charge Jets Penetration Depth Decrease
S.V. Demidkov, Effective Soft Ltd.
- 3003 Simulation of the Perforation of Low Mass Long L/D Rods Against Finite RHA Plates
P. Church, I. Cullis, A Bowden, D Gibson, QinetiQ, Ltd.
- 3011 Deflection and Fracture of Tungston Rods by Yawed Impact
S. Bless, R. Russell, Institute for Advanced Technology; **K. Tarcza**, US Army ARDEC; **E. Taleff**, Department of Mechanical Engineering, The University of Texas at Austin; **M. Huerta**, The University of Texas at El Paso
- 3012 Anomalies in the Strength of Alumina under Dynamic Compression
T. Beno, S. Bless, S.Nichols, Institute for Advanced Technology
- 3014 On the 3D Visualization of Ballistic Damage in TI-6AL-4V Applique Armour with X-Ray Computed Tomography
J.M. Wells, JMW Associates; **W.H. Green, N.L. Rupert**, US Army Research Laboratory, Weapons & Materials Research Division; **John M. Winter, Jr.**, ORISE Contractor at WMRD; **S.J. Cimpoeru**, DSTO Melbourne
- 4012 Analytical Models for Foam, Ice and Ablator Impacts into Space Shuttle Thermal Tiles
James D. Walker, Sidney Chocron, Walt Gray, Southwest Research Institute
- 4013 CTH Simulations of Foam and Ice Impacts into the Space Shuttle Thermal Protection System Tiles
Sidney Chocron, Walt Gray, James D. Walker, Southwest Research Institute
- 4016 Damage Created in Composite Sheet by Explosives – Effects of Fibre Type, Explosive Mass and Attenuating Material
M. R. Edwards, R. Unwin, Centre for Materials Science and Engineering, Cranfield University

Warhead Mechanisms Poster Session
10:20 am - 12:00 pm, November 16

- 1914 Experimental Investigation of Equivalent Blast Characteristics for Aluminiferous Explosive in Shallow Underwater
Wenbin Gu, Jianqing Liu, Qingli Su, Weiping Zhou, Ballistic Research Laboratory of China, Nanjing University of Science & Technology
- 1935 Break-up of Copper Shaped – Charge Jets: A Combined Experimental/Numerical/Analytical Approach
Jacques Petit, Centre d'Etudes de Gramat; **V. JeanClaude, C. Fressemgeas**, Laboratoire de Physique et Mecanique des Materiaux, Universite de Metz/CNRS
- 1949 A Theoretical Analysis for Initial Fragment Velocity and Peak Overpressure of a Blast Fragmentation Device
Jin Jianming, Institute of Structural Mechanics, China Academy of Engineering Physics
- 1963 Scaling the Dynamic Response of Armored Vehicle's Floor Subjected to a Large Buried Charges
Avidov Neuberger, IMOD, MANTAK, Tank Program Management; **S. Peles**, IMI Central Laboratory Division; **D. Rittel**, Technion, Israel Institute of Technology, Faculty of Mechanical Engineering
- 1984 High-Speed Flash X-Ray Computed Tomo-Cinematography
Philip Helberg, Karsten Michael, Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut
- 2002 The Influence of Parameters Other Than Liner Velocity on Shaped Charge Jet Coherence
Frederik Mostert, CSIR Defencetek; **C. J. Terblanche**, Denel Land Systems - Western Cape; **M. F. Maritz**, Department of Applied Mathematics, University of Stellenbosch
- 2053 Comparison of Vulnerability and Performances of Insensitive Munitions (IM) and Non IM Directed Energy Warheads
Frederic Peugeot, MSIAC, NATO HQ
- 2059 Trumpet Shaped Liners' Influence on Slug Properties
Eitan Hirsch, Consultor; **Meir Mayseless**, IMI Central Laboratory
- 2077 A Study on the Structure of Small Caliber EFP
Chen Zhigang, Zhao Taiyong, Hou Xiucheng, Dong Surong, The Research Institute of Explosive Demolition & Defence Technology, North University of China; **You Zheng**, Department of Precision Instruments and Mechanics, Tsinghua University
- 2078 A Framework for the Analyses and Visualization of X-Ray Computed Tomography Image Data using a Compute Cluster
Jeffrey R. Wheeler, US Army Research Laboratory; **William H. Green**, US Army Research Laboratory, Weapons & Materials Research Division; **Michael Schuresko**, Baskin School of Engineering, University of California; **Michael Patrick Lowery**, Computational Mathematics Department, University of California
- 2137 An Artillery Shell for Anti-Bunker Applications (155 ABS)
Rémi Boulanger, Giat Industries; **Anders Vangen Jordet, Dagfinn Hoff**, NAMMO Raufoss
- 2141 Development of a TMRP-6 Surrogate Mine
Yves Baillargeon, A. Sirois and G. McIntosh; DRDC Valcartier
- 2148 Use of Foamed TNT Mixtures as a Dispersion Charge of Submunitions
Jun Sik Hwang, S.-K. Kwon, C.-K. Kim, S.-W. Kwon, S.-S. Kim, S.-H. Moon, Explosive Trains and Gun Propellant Team, Agency for Defense Development
- 2152 Wall Breaching Tandem Warhead
Andreas Helte, Torgny Carlsson, Håkan Hansson, Svante Karlsson, Jonas Lundgren, Lars Westerling, Håkan Örnhed, Swedish Defence Research Agency, FOI, Weapons and Protection Division
- 2156 An Analytical Penetration Model for Jets with Varying Mass Density Profiles
Milton F. Maritz, Stellenbosch University; **Klaus D. Werneyer**, TTP Products; **Frederik J. Mostert**, Defencetek

2168 Peripheral Initiation Technology Development

Arthur S. Daniels, Ernest L. Baker, William J. Poulos, Vladimir M. Gold, B. Fuchs, US Army ARDEC

2175 Shaped-Charge Jet Stability Calculations: The Role of Initial and Boundary Conditions

James S. Stolken, S. Christian Simonson, Mukul Kumar, Lawrence Livermore National Laboratory

3007 Enhanced Focused Fragmentation Warhead Study

Richard Fong, William Ng, Peter Rottinger, Steve Tang, US Army Armaments Research, Development and Engineering Center

4015 Microstructure and Properties of the Explosively Formed Petals in Aluminium Alloys

M. R. Edwards, J. M. Cassar, Centre for Materials Science and Engineering, Cranfield University

Interior Ballistics/Launch Dynamics Poster Session

8:10 am - 9:50 am November 17

1017 In-Bore Mechanics Analysis of the M855 Projectile

Joseph T. South, James F. Newill, US Army Research Laboratory

1020 Dynamic Strain Measured in a 105-mm Composite Gun Barrel - A Fiction or Reality

Jerome T. Tzeng, US Army Research Laboratory

1916 A Vector Way for Calculating Propellant's Combustion Performance

Wei Zhifang, Department of Mechanical and Electronic Engineering, North University of China

1931 Interior Ballistics Code Applied to ETC Concept: Computations and Validations

Gilles Legeret, Dominique Boisson, Giat Industries

2004 The FHIBS Internal Ballistics Code

Clive R. Woodley, Steve Billett, QinetiQ; **Caroline Lowe**, Department of Applied Mathematics and Theoretical Physics, Centre for Mathematical Studies, University of Cambridge; **William Speares**, The Cylinders; **Eleuterio Toro** Laboratory of Applied Mathematics, Faculty of Engineering, University of Trento

2005 Modelling the Ignition of 40mm Gun Charges

Clive R. Woodley, QinetiQ

2020 Thermo-Mechanical Erosion Study of the 120mm Chromium Coated Gun Barrel: Computation and Validation of the Heat Exchange Boundary Condition

Dominique Boisson, Gilles Légeret, Roxan Cayzac, Giat Industries

2031 MOBIDIC-NG: A 1D/2D CFD Code Suitable for Interior Ballistics and Vulnerability Modelling

Baptiste Longuet, Pascal Millet, Eric Taiana, ETBS; **Patrick Della, Pieta Christiane Reynaud**, SNPE Matériaux Energétiques CRB; **Patrice Franco, Alain Carrère**, Institut Franco-Allemand de Recherches de Saint-Louis (ISL); **Gilles Légeret, Dominique Boisson**, Giat Industries; **Alexandre Papy**, ERM ABAL 30

2070 Barrell Life Results of the 5.56 mm XC77A1 Cartridge

Etienne Munger, SNC Technologies, Inc.

2117 Further Investigation of the Effect Known as Electrothermal Pyrolysis

Steve R. Fuller, M.J. Taylor, QinetiQ

2150 Determination of Force and Temperature Impact on Missile's Fuel Charge in Process of Ignition

Dmitriy Orlov, GDT Software Group

2161 Unsteady Intermediate Ballistics: 2D and 3D CFD Modelling, Application to Sabot Separation

Roxan Cayzac, Eric Carette, Giat Industries, Division Munitions; **Thierry Alziary de Roquefort**, Université de Poitiers, Laboratoire d'Études Aérodynamiques; **Philippe Bidorini, Emmanuel Bret, Pascal Delusier, Serge Secco**, DGA/ETBS, Direction de l'Expertise Technique

2166 Large Caliber Firing with Electro Thermal-Chemical Ignition (ETI)
Jonathan D. Shin, John J. O'Reilly, David T. Keyser, US Army Research, Development and Engineering Center - TACOM; **Jahn Dyvik**, United Defense L.P.

3006 Rail Gun Test Projectile for Improved Developmental Testing of Precision Munition Electronics
T. Myers, D. Carlucci, J.A. Cordes, US Army ARDEC, Analysis and Evaluation Division, Fuze and Precision Munitions Technology Directorate

4010 Improved Mortar Barrel Thermal Model
M. Pocock, C. Guyott, Frazer-Nash Consultancy Ltd; **P. Locking**, BAE Systems, Land Systems

Vulnerability/Lethality/Wound Ballistics Poster Session
10:20 am - 12:00 pm November 17

1855 On Incorporating XCT into Predictive Ballistic Impact Damage Modeling
Joseph M. Wells, JMW Associates

1878 New Soft-Target Failure Criteria for System-Analytical Considerations
Markus J. Estermann, RUAG Defence, Warhead Division; **Beat P. Kneubuhl**, Aramasuisse

1941 Protecting Vehicles from Landmine Blasts
Sheri L. Hlady, Denis Bergeron, Defence R&D Canada – Suffield; **Rene Gonzalez**, US Army, PM Light Tactical Vehicles

1957 Office of Naval Research Limb Protection Program
Graham K. Hubler, NRL

1980 Survivability and Lethality Assessment Software Based on Virtual Mode Technology
Lu Yonggang, Qian Lixin, Yang Yubin, Liu Tong, Institute of Structural Mechanics, CAEP

1981 “TBM-Xpert” - A New Endgame Code: Features and Validation
Werner Arnold, EADS-TDW Gesellschaft für verteidigungstechnische; **E. Rottenkolber**, NUMERICS GmbH

1989 The Use of Ballistic Knowledge in Ammunition Safety Cases
Martin van de Voorde, TNO Defence, Safety and Security

2011 A Note on the Roecker-Ricchiuzzi Model of Penetrator Trajectory Instability
William J. Flis, DE Technologies, Inc.

2022 Numerical Calculation and Simulation of Missile Jet-Airplane Interaction
Feipeng Zeng, Faculty of Artillery Command, Nanjing Artillery Academy

2111 Need for Enhanced Protection Against Blast Threats for Soldiers Exposed to Roadside Improvised Explosive Devices (IEDs)
François-Xavier Jetté, Jean-Philippe Dionne, Aris Makris, Med-Eng Systems, Inc.; **Karl Masters**, PEO Soldier; **Christine Perritt**, PM Soldier Equipment

2119 WitnessMan: The Software Tool to Design, Analyse and Assess a Witness Pack with Respect to Military and Medical Effects on an (Un)protected (Dis)mounted Soldier.
Theo L.A. Verhagen, R. Kemper, H. Huisjes, S.G. Knijnenburg, A. Pronk, M.H. van Klink, TNO Defence, Security and Safety

2154 Injury Risks Resulting from Deminer Position
François-Xavier Jetté, Jean-Philippe Dionne, Ismail El Maach, Aris Makris, Matt Ceh, Med-Eng Systems, Inc.; **Denis Bergeron**, Defence R&D Canada Suffield

2163 RPG Mitigation for Military Vehicles
Karl Pfister, Dipl. Ing (FH) Armatec Survivability Corporation

2164 Protection Against Closely-Spaced Impacts by Small Arms Bullets

Michael J. Iremonger, Cranfield University, Royal Military College of Science; **Abdullah Alsalmi**

3013 Vulnerability Evaluations of 30mm Airburst Ammunition

Quoc Bao Diep, **Eimund Smedstad**, Nammo Raufoss AS; **Nick Rogers**, System Design Evaluation (SDE)

3018 Challenges and a Solution in Determining Land Mine or IED Neutralization Effectiveness

Robert Colbert, **Mark Majerus**, **William Clark**, DE Technologies, Inc.

4011 Numerical and Experimental Analysis of the Detonation of Sand-Buried Mines

N. Heider, **A. Klomfass**, Fraunhofer-Institut für Kurzzeitdynamik, Ernst-Mach-Institut

The symposium registration fees are:

	Regular	Late/Onsite after 10/28/05
	\$950 (US)	\$1045 (US)
IBC Committee Appreciation Dinner	\$75 (US)	
Guest at Both Receptions	\$75 (US)	
Guest at One Reception	\$50 (US)	

The symposium registration fee includes attendance at all sessions, bound symposium proceedings with CD, continental breakfasts, coffee breaks, lunches, receptions, and administrative costs. The registration fee will also include a compact disc (CD) which contains a cumulative database of titles, authors and abstracts of all of the 22 Ballistics Symposia.

To register online for this conference visit: <http://register.ndia.org/interview/register.ndia?~Brochure~6210>. You can also visit the NDIA website at www.ndia.org and select "Schedule of Events". Then select 2005 November and scroll down to the 22nd International Symposium on Ballistics. Once there, select the blue "Register" link in the lower left hand corner of your screen. Review your information and then select "submit" one time only and then select "confirm". On-line registration will close at 5:00 pm EST on October 28, 2005. You must register on-site after this date.

-or-

You may fax the completed registration form contained in this brochure to (703) 522-1885.

-or-

You may mail the completed registration form contained in this brochure to: Event # 6210, National Defense Industrial Association, 2111 Wilson Boulevard, Suite 400, Arlington, VA 22201-3061.

Payment must be made at the time of registration. Registrations will not be taken over the phone.

Cancellations and Refund Policy

Registrants who cannot attend the 22nd International Symposium on Ballistics must provide written notification via email to bbommelje@ndia.org or fax to (703) 522-1885 on or before September 16, 2005 to avoid a cancellation fee.

Cancellations received between September 16, 2005 and October 28, 2005 will receive a refund minus a \$75 cancellation fee. No refunds will be given to cancellations received after October 28, 2005 however, **SUBSTITUTIONS ARE WELCOME IN LIEU OF CANCELLATIONS.**

You must have a government picture identification (drivers license, passport, military ID, etc.) to receive a symposium badge. Badges must be worn at all times during the symposium.

Special Needs

NDIA supports the Americans with Disabilities Act of 1990. Attendees with special needs should call (703) 522-1820 prior to October 3, 2005.

Hotel Accommodations

A limited block of rooms have been reserved at the Fairmont Waterfront Hotel. The industry room rate is \$219 Canadian (approximately \$180 US). The government symposium room rate is approximately \$114 Canadian (\$94 US). Please call (604) 691-1991 to make reservations.

In order to ensure the discounted NDIA rate, please make reservations early and ask for the NDIA room block. Rooms will not be held after Tuesday, October 11, 2005 and may sell out before than. Rates are also subject to increase after this date.

**The government room rate applies only to active duty military and civilian government employees. It is not available to government contractors, retired military or retired civilian government employees. ID cards and/or travel orders will be required at check-in to verify rate eligibility.*

GENERAL INFORMATION

Symposium Attire

Appropriate dress for this symposium is business for civilians (coat and tie) and class A uniform for military.

Inquiries

For more information regarding the symposium contact Britt Bommelje, Meeting Planner at (703) 247-2587 or bbommelje@ndia.org.

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IBC Committee Appreciation Dinner

The IBC Committee Appreciation Dinner will be held on Friday, November 18, 2005 in Vancouver. This dinner is open to IBC Committee members and their guests only. If you and your guest would like to attend, please make a note of it on the registration form. There is a \$75 charge per person to attend.

“The Department of Defense finds this event meets the minimum regulatory standards for attendance by DoD employees. This finding does not constitute a blanket approval or endorsement for attendance. Individual DoD component commands or organizations are responsible for approving attendance of its DoD employees based on mission requirements and DoD regulations.”



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Vancouver Convention Center

Vancouver, BC, CANADA

November 14-18, 2005

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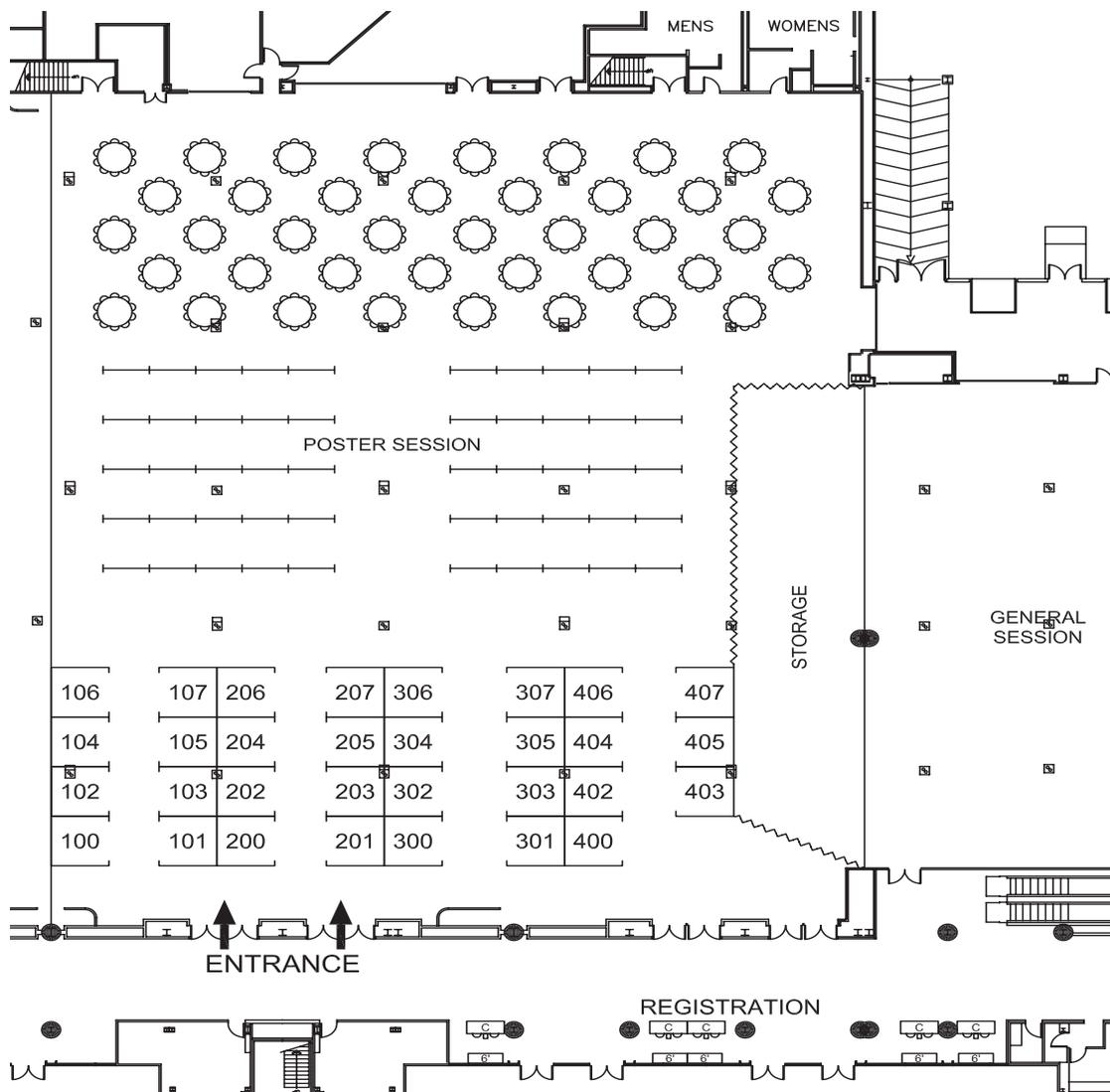


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- Monday, November 14: 4:00pm - 7:30pm
- Tuesday, November 15: 7:00am - 6:00pm
- Wednesday, November 16: 7:00am - 5:00 pm
- Thursday, November 17: 8:00am - 11:00am
- Friday, November 18: 8:00am - 11:00am

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