INTERNATIONAL BALLISTICS SOCIETY

The International Ballistics Society (IBS) promotes the science of ballistics internationally. The IBS provides for technical interchange via an International Symposium on Ballistics and provides professional development for its members by providing opportunities for publication, short courses, student programs, and other activities to promote career development.

President's Editorial

Dear IBS Family,

It is with a profound sense of honor and humility that I write to you as the newly elected President of the International Ballistics Society.

I am deeply grateful to the Board for their trust in electing me. Reflecting on this moment, I am taken back to my very first symposium in **Tarragona in 2007**. Back then, I could never have imagined that my journey would lead me here. I hope my story serves as a motivation for our young scientists and engineers: attend the symposia, present your work, and engage with this incredible community. The path from a first-time attendee to leading the Society is open to everyone who shares our passion for ballistics.

I would like to extend my sincere congratulations to our new and re-elected Board members: **Don Carlucci, Sidney Chocron, and Thelma Manning**. I look forward to working alongside you.

Looking Back at Jacksonville

Looking back at our 34th ISB gathering in Jacksonville, FL this past May, we can be proud of a truly great symposium. I must commend the co-chairs, **Don Carlucci and Casey Uhlig**, for doing a fantastic job in putting together an outstanding technical program.

While it was unfortunate that Don, Casey, and several delegates from other countries could not attend physically, the spirit of the Society remained strong. It was a wonderful opportunity for those present to meet, discuss, and deepen the personal connections that form the backbone of our community.

A special note of thanks goes to **James Walker** for his dedicated service as President. His leadership has guided us through significant times, and we are grateful for his contributions.

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Issue #14, January 2026

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Get Involved!

Don't just be a name on a list – be an active part of the scientific community!

Visit the website www.ballistics.org for a list of committees & projects and bring yourself in.

My Vision: Bridges and Innovation

As we move forward, I have been thinking deeply about what is needed for our future. My vision rests on two main pillars:

- **Openness as a Bridge**: I believe our Society and our symposia must serve as a bridge connecting the East and the West, the North and the South. Science speaks a universal language, and the International Symposia on Ballistics is the platform where that dialogue happens.
- **Empowering the Next Generation**: We must make the Society and its symposia even more attractive, specifically for young ballisticians. They are the future of our field.

To support this vision, we are implementing concrete changes for **Cape Town 2026**. We are planning **two-track sessions** to allow for more oral presentations and focused engagement, introducing **digital posters** to modernize our poster sessions, and offering **advanced lectures on Sunday** to provide deeper educational value.

Shaping Future Symposia

The Board has also made strategic decisions regarding our schedule. Moving forward, **every third symposium** will be held in North America. This ensures a balanced rotation, meaning our next conference after Cape Town will be held outside of North America.

Furthermore, I want to initiate an open discussion on how we can better learn from past symposia. We need to transfer experiences—both the challenges and the successes—to new organizers effectively. Continuous improvement is key to our longevity.

The Road to Cape Town 2026

I am thrilled that it is now less than a year until our next symposium in **Cape Town in October 2026**.

Our co-chairs, **Thanyani Pandelani and Tleyane Sono**, along with the engaged organizers from **SABO**, are preparing a great venue for us. The **Call for Papers** has already been sent out, and I encourage you to submit your abstracts.

Closing Thoughts

Finally, I want to thank every single person involved in running this Society. It is important and valuable work, and it is all done without compensation. Your passion is what keeps the IBS alive.

I want this to be an interactive presidency. If you have feedback, ideas, or would like to get personally involved in the Society, please do not hesitate to write to me at president@ballistics.org. Committees are actually a great way for young people to get involved so if you are interested please contact the committee chairs or me.

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I wish you and your families the very best for the New Year!

Sincerely,

Markus Graswald

President, International Ballistics Society

LOOKING BACK AT THE 34TH ISB…

by Don Carlucci and Casey Uhlig
US Army DEVCOM
34th ISB Chairs

A warm reception was had for the attendees of the 34th International Symposium on ballistics which took place in toasty Jacksonville, Forida USA from 19-23 May 2025. Despite the turmoil experienced by the U.S. Government employees in attending (neither of the session co-chairs were present) the conference was a success.

Conference Registration Desk

The key note speaker, Dr. Ron Barrett gave a talk on discarding saboted ammunition used for aerial gunnery that was both entertaining and informative. Special thanks from the co-chairs goes out to Mr. Bill Gooch, a retired ordnance engineer who passed on some pearls of wisdom from his many tears of experience. Dr. James Walker was kind enough to ask Bill if he would speak and Bill was, in turn, kind enough to do so.

Roughly 200 abstracts were submitted and reviewed for the conference. After review and withdrawals this translated to 51 oral and about 100 poster presentations. The tutorials that were offered on Monday and Friday were all well attended. The Tour of the U.S. Navy Destroyer, U.S.S. Orleck Naval Museum went well with 145 people attending.

Conference Hall

Exhibition Hall

The Symposium itself attracted more than 260 participants in total from many different nationalities, the Symposium audience as in total almost 152 tutorial registrations were received.

David Price recognized for his work as a session chair

The symposium concluded with the presentation of awards. Congratulations to all.

The IBS again showed that the International Ballistics Society is resilient organization that will continue to push the state of the art in the field of ballistics. Enough thanks cannot be given to all of the folks who contributed to the success of this symposium with special accolades to the folks who performed last minute changes to present their work as oral presentations. Looking forward to see you all in Capetown, South Africa, in 2026!

WELCOME TO THE SUNSHINE STATE – OUTSIDE THE ISB'S TECHNICAL PROGRAM

by Thomas Hartmann
NUMERICS GmbH, Germany

Even though it is one of the major cities, Jacksonville is probably not the first place you will think of when you hear "Florida". Personally, I will always associate Florida with the 26th ISB in Miami and the almost legendary Miami Beach boat cruise. However, Jacksonville is a city of diverse neighborhoods with a top-notch arts and culture scene, unbeatable food, and a wide variety of family-friendly attractions, parks, and nature preserves – and not to forget with 22 miles of beaches.

Historically, its strategic location on the St. Johns River made Jacksonville a major port for lumber, cotton, and other goods, as well as a key naval base, which it is still today. So with its cultural offerings and its military background, JAX can be considered as a good choice – even though also financial aspects may have played a role…

This is probably also why all social activities took place in or in walking distance to the conference venue – the Hyatt Regency Jacksonville Riverfront.

Welcome reception on the roof terrace...

The welcome reception took place on mid-level roof terrace with a scenic view on one of Jacksonville's landmarks: the John T. Alsop Jr. Bridge.

The "Sunshine State" was living up to its name and with temperatures continuously above 30° C (86° F) it was good that food and drinks were mainly served in the climatized adjacent ballroom.

…and in the ballroom

Already at the welcome reception it became clear that the US visa issuance rules and the travel restrictions for the US military were taking their toll. There were practically no Chinese or Indian participants and even the US symposium chairs could not be present. Independent

thereof, the setup was perfect to acclimatize and to catch up with colleagues and friends. However, (and at least to me, this was a fly in the ointment) one had to hurry since the whole reception was scheduled to last only 1.5 hours. Therefore, many used the rest of the evening to explore the bars in the vicinity of the hotel.

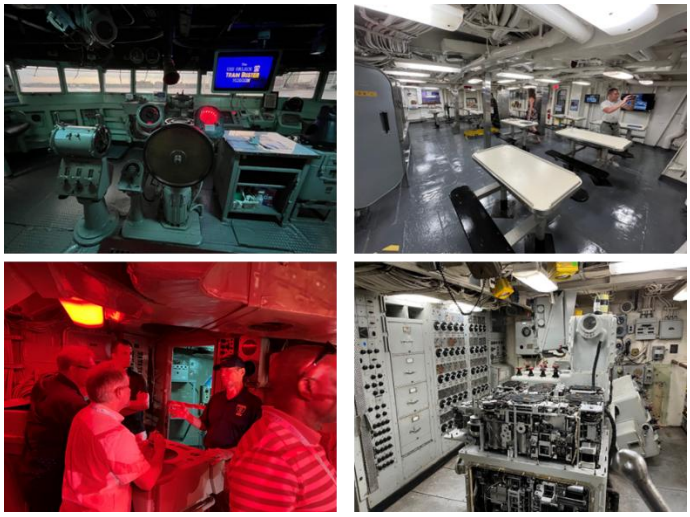
After an interesting conference day on Tuesday the main social events were scheduled for Wednesday afternoon and evening.

With Jacksonville having a long naval tradition and the US Navy's Naval Air Station (NAS) Jacksonville being the largest installation in the Navy Region Southeast today, a Navy related destination was chosen for the afternoon excursion.

USS Orleck at the pier

Divided into small groups, participants were able to visit the nearby destroyer USS Orleck, a decommissioned Gearing-class destroyer that served in the United States Navy from 1945 to 1982.

After being decommissioned by the U.S. Navy in 1982, the ship was sold to Turkey where it served as TCG Yücetepe (D 345) until 2000. After its decommissioning from the Turkish Navy, it was returned to the U.S. and became a museum ship.



Impressions from inside the USS Orleck

The tour provided interesting insights not only into the cramped quarters and the technology of the time, but also into daily life on the ship and its history. Especially the interaction with the museum staff – practically all Navy veterans – gave the visit a personal touch.

In the evening, the conference dinner was held. While the venue, one of the hotel's conference / ballrooms was anything but spectacular, the organizers made up for this with good food and excellent service.

Reception in the exhibition hall

The evening started with a brief reception in the exhibition hall and followed by the traditional procedure with the presentation of the student awards and the society promotions (congratulations to all award winners and to the new Ballistics Science Fellows Clive Woodley and Sidney Chocron in particular).

Presentation of the Student Awards

After a delicious dinner and good wines also this event ended relatively early.

In summary, the social program was (once again) very well organized and a perfect occasion for professional discussions and private chats.

ASMII Organizing Team

Finally, a big thank you to Clay Tyeryar and his team from ASMII who did everything they could to make the conference enjoyable as it was!

AWARD WINNERS

The International Ballistics Society assisted by QinetiQ and the South African Ballistics Organization awards the best authors in different categories during the International Symposium on Ballistics. The following authors were honored for their contributions to the 34th ISB in Jacksonville…

JACK RIEGEL STUDENT AWARDS

The Jack Riegel Student Award is awarded to the best papers from students presenting their work at the ISB (full eligibility requirements can be found on the IBS website).

At the 34th ISB in Jacksonville the following students were awarded:

- **Niclas Mägerlein**, Germany

Category: Explosion Mechanics

Title of Paper: *Computer tomography-based fragmentation analysis of reactive materials*

University: Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Germany

Jack Riegel Student Award presented to Niclas Mägerlein (left) by Markus Graswald

- **Joseph Wilhelm**, USA

Category: Exterior Ballistics

Title of Paper: *External ballistics: parameter estimation using POD-RBF*

University: Embry-Riddle Aeronautical University, USA

Jack Riegel Student Award presented to Joseph Wilhelm (left) by Markus Graswald

Jack Riegel Student Award presented to Sierra Foley (left) by Markus Graswald

- **Gamin Guermonprez**, France

Category: Interior Ballistics

Title of Paper: *A methodology to simulate interior and intermediate ballistics with dynamic mesh technique and lumped parameter code*

University: Université Paris-Saclay, France

Jack Riegel Student Award presented to Gamin Guermonprez (left) by Markus Graswald

- **Sierra Foley**, USA

Category: Vulnerability

Title of Paper: *Assessment of skin penetration surrogates for use with less lethal impact munitions*

University: Wayne State University, USA

LOUIS AND EDITH ZERNOW AWARD

The Louis and Edith Zernow Award in Ballistics is presented to the author(s) of the paper containing the best advancement made in the fundamental nature of ballistics and presented within the proceedings of the International Symposium on Ballistics.

At the 34th ISB in Jacksonville the award went to

A. Piraino, I. Stroobant and A. Marcucci

for their paper

Effect of roll autopilot on ballistic flight of a guided ammunition

Louis and Edith Zernow Award presented to Annalisa Piraino (left) by James Walker

ROSALIND & PEI CHI CHOU AWARD

The Rosalind and Pei Chi Chou Award for Young Authors is given to authors 35 years of age or younger at the time of the Symposium for the best original contribution to the ballistic sciences (full eligibility requirements can be found on the ISB website).

At the 34th ISB in Jacksonville the award was presented to

D. Portillo

for his paper

High-Throughput Ballistic Limit Testing Using Laser-Induced Particle Impact Tests

Rosalind and Pei Chi Chou Award presented by Paul Locking and accepted on behalf of Daniel Prtillo by James Walker (right)

NEIL GRIFFITHS AWARD

The Griffiths Award is presented to the author(s) of the paper judged to have made the most significant contribution to a shaped charge technology at the International Symposium on Ballistics.

At the 34th ISB in Jacksonville the award was presented to

N. Reboul, A. Chinnayya, F Paintendre, S. D. Piagge, V. Jaulin, J. Limido, A. Collé, F. Rondot

for their paper

Experimental and numerical study of the interaction between a shaped charge jet and a single ERA moving plate

Neil Griffiths Award presented to Nicolas Reboul (left) by Clive Woodley

SABO AWARD

The South African Ballistics Organisation (SABO) Award gives recognition to the author(s) of the best poster as displayed and presented at the International Symposium on Ballistics.

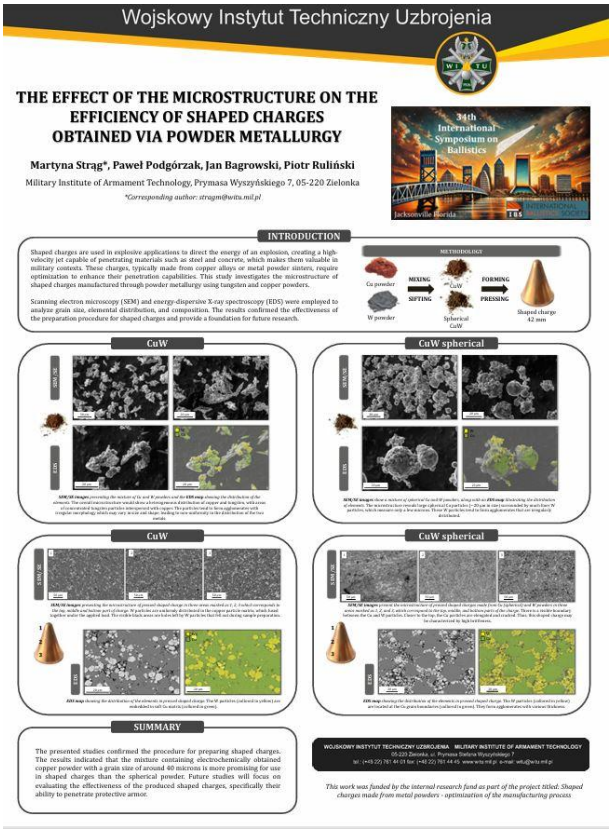
At the 34th ISB in Jacksonville the award was presented to

M. Strag, P. Podgórzak, J. Bagrowski, P. Rulinski

for their poster titled

The effect of the microstructure on the efficiency of shaped charges obtained via powder metallurgy

SABO Award presented to Martyna Strag (left) by Thanyani Pandelani



Award-winning poster (linked to the file on the IBS website)

Congratulations to all award winners!

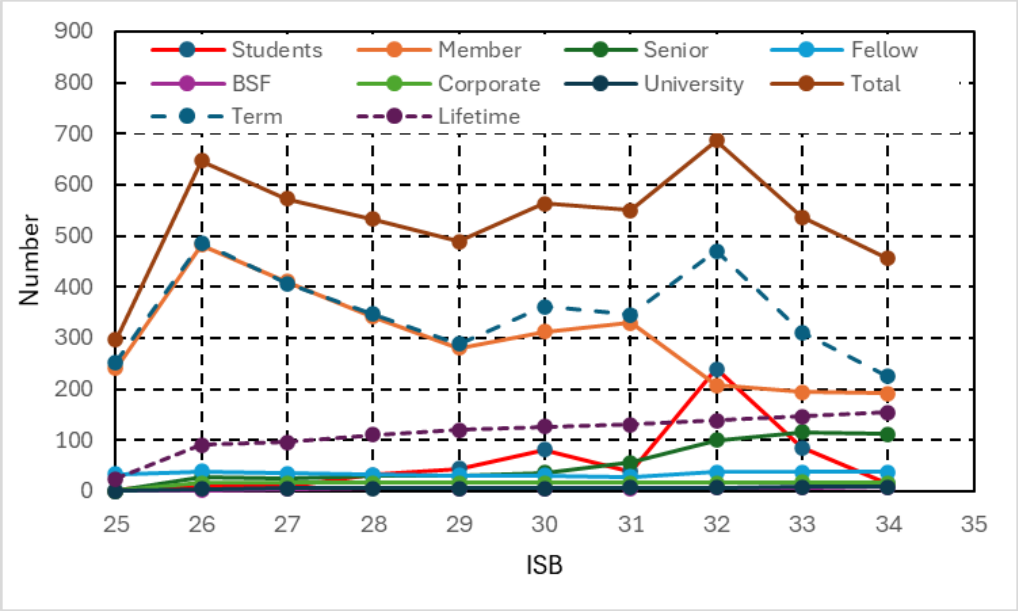
ANALYSIS OF MEMBERSHIP FROM THE 25TH INTERNATIONAL SYMPOSIUM ON BALLISTICS (ISB)

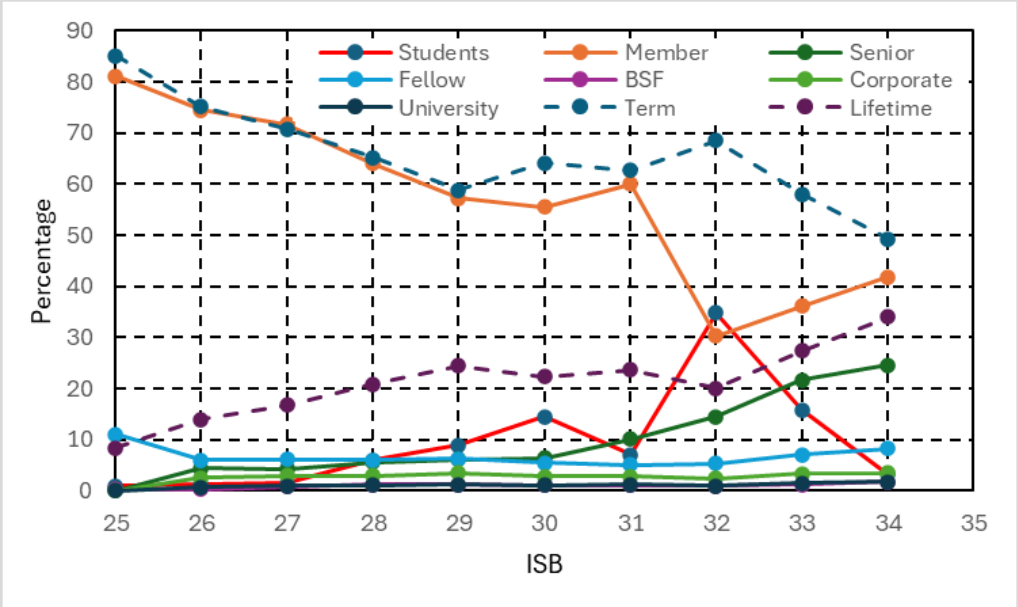
by Clive Woodley
Chair of the Membership Committee

The IBS has now been in existence for 15 years and has successfully held 10 ISB. The two graphs below show how the types of membership category have changed during this period, the first graph in absolute numbers and the second graph in percentage terms.

Referring to the first graph, it shows the IBS membership peaked at 686 after the 32nd ISB. The previous maximum was 647 after the 26th ISB. Since the 32nd ISB, the total membership has decreased to 456.

During the period, the number of Senior members has slowly increased to the current value of 112. Commensurate with this increase, the number of Members has decreased to 191. The reason for these changes is that many people have been active and a member long enough to be promoted to Senior.





Over the same period, the number of Fellows has increased slightly to 38 but has remained fairly constant in the range 28-39. There was a slight decline from the 26th ISB to the 31st ISB, but since then the numbers have increased to 38. These changes are mainly due to Fellows retiring or being promoted from Senior.

What is surprising, is the large variability in the numbers of students. The current number of student members, at 15, is the lowest since the 27th ISB. The Membership Chair will be investigating possible reasons why more students are not attracted to become members of the IBS – currently their membership fee is $15 compared with $50 and they get full membership rights. However, there are also students who come under universities as delegates who are not included in the student numbers. Students are vitally important to the IBS, as is shown by the Jack Riegel Student Awards. The future of the IBS depends upon students and members continuing their involvement, participating in committees and ISB.

The numbers of corporate members and university members have been fairly constant over the last 15 years, at approximately 16-18 and 5-8 respectively. University memberships have slowly increased but it is surprising more are not members, particularly as university membership is free, provided they show active participation in ISBs.

The two dashed lines show the number of lifetime members and the number of term members, ie those who renew each term (a term lasts approximately 18 months and is the time from one ISB to the next ISB).

Referring to the graph showing the percentages for each ISB, it is clear that the percentage of lifetime members is increasing, currently standing at 34%. In a similar manner, but trending in the opposite direction, the number of term members has slowly been decreasing, currently standing at 49% (the difference is due to other membership categories such as Emeritus members and university delegates).

Investigations conducted in the past indicate that many term members join for a particular ISB and do not continue their membership, despite the benefits such as free access to (a limited number each term of) ISB papers and an international network of ballisticians. Historically, about 50-70% of term members will renew their membership. Reasons identified for not continuing their membership include changing job, projects completing, having to pay the fees themselves and not attending the next ISB. Of course, many members view membership of the IBS part of their Continuing Professional Development – in some countries the membership fees will be tax deductible.

The decline in the number of term members has repercussions on the IBS finances because their membership fees form an important part of the IBS income. Consequently, it is important to slow and to reverse the decline.

Concluding this report, the Membership Committee will be focussing on the following areas over the next few years:

- Increase the number of students
- Increase the number of university members
- Increase the numbers renewing their membership.

NEW JOURNAL: "DAMAGE"

by Clive Woodley
Chair of the Publications Committee

Damage is a new academic, peer-reviewed journal managed by the editorial office which is responsible for the very successful Defence Technology journal.

Damage aims to provide an effective mechanism for promoting the development of damage and

protection theories and technological innovations in fields such as weapons, aviation, aerospace, shipbuilding, hydropower, cyberspace, and electromagnetic warfare.

Of particular relevance to ballisticians are the following areas:

- Mechanisms: Explosive blast wave damage, kinetic penetration damage, energy-focused armor-piercing damage, high-temperature effect damage, high-energy laser damage.
- Materials: Energetic materials, alloy materials, composite materials, new quality materials.
- Systems: Penetrating systems, energy damage, lethal damage, explosive damage, cloud burst damage.
- Simulation: High-fidelity damage modeling, multi-scale damage simulation, multi-physics damage simulation, detonation simulation.
- Fracture Evaluation: Target characteris-tics equivalence, bullet impact model, target damage criteria, vulnerability analysis model, vulnerability simulation method.
- AI Application - Machine learning for damage optimization, AI-driven autonomous damage decisions, digital twin of the damage system, digital twin of the damage field.
- Protective Materials/structures: Impact-resistant protective materials/structures, intrusion-resistant protective materials/structures, laserresistant protective materials/structures, new-generation protective materials/structures.

The journal is expected to be open for the submission of papers in 2026 with a conference, the International Damage Conference, being held in around October 2026. Further details will be available when confirmed.

JACK RIEGEL STUDENT AWARD WINNERS

by Markus Graswald
Chair of the Student Committee

The International Ballistics Society (IBS) offers awards to students in each of the six ballistics science disciplines who provide the best papers. The award covers the registration fee at the symposium and provides 1000 USD towards travel and accommodation expenses. These awards were named after Jack Riegel reflecting and honoring his achievements for the Society, especially as its Founding President in 2010.

The student committee (SC) who review the applications consists of Pengwan Chen (China), Thomas A Mason (USA), Markus Graswald (Germany), Shannon Ryan (Australia), Sebastian Wurster (Germany), and Mickael Zeidler (France). We received 16 high-quality applications for the recent symposium in Jacksonville by students from Belgium, Brazil, China, France, Germany, India, South Africa, Sweden, UK, and USA. We are grateful to all students who handed in their application – you all did a great job!

The four winners at 34th ISB in Jacksonville, FL, USA in May 2025 were:

- Interior Ballistics: Gabin Guermonprez, France, A methodology to simulate interior and intermediate ballistics with dynamic mesh technique and lumped parameter code.
- Exterior Ballistics: Joseph Wilhelm, USA, External ballistics: parameter estimation using POD-RBF.
- Explosion Mechanics: Niclas Mägerlein, France / Germany, Computer tomography-based fragmentation analysis of reactive materials.

- Vulnerability: Sierra Foley, USA, Assessment of skin penetration surrogates for use with less lethal impact munitions.

Congratulations again to all winners! We are looking forward to receiving your student application for the 35th ISB in Cape Town, South Africa, in October 2026. Please look for our announcements by broadcast email and on our website.

PROMOTION TO BALLISTIC SCIENCE FELLOW

The title Ballistic Science Fellow is awarded to those individuals who have distinguished themselves within the ballistics community. It is the highest honor awarded by the Society.

At the last ISB, the Board of Directors decided that this honor goes to **Clive Woodley** and to **Sidney Chocron**.

Clive Woodley (right) receiving his promotion to Ballistic Science Fellow from James Walker

Siney Chocron (right) receiving his promotion to Ballistic Science Fellow from James Walker

UPDATE ON SOCIETY EDUCATION

by Markus Graswald
Chair of the Education Committee

Providing high-quality education for our members has always been a major objective of the International Ballistics Society (IBS). It is the responsibility of the Education Committee (EC) to offer tutorial courses and promote the career development of Society members. The committee consists of Sidney Chocron (USA), Ian Cullis (UK), Markus Graswald (Germany), Dinesh Pal (India), Shannon Ryan (Australia), and Sebastian Wurster (Germany).

We received initial expressions of interest from 19 individuals and 8 course proposals, from which we eventually selected six courses. This was the tutorial course program at the 34th International Symposium on Ballistics (ISB) in Jacksonville, FL, USA, in May 2025:

- IB101: Introduction to Interior Ballistics and the Propellant Charge Design Process by WURSTER, Sebastian from Fraunhofer ICT, Germany
- EM101: Explosives Engineering by LIM, Bin from NMT, USA

- EB101: Exterior Ballistics by WEY, Pierre from ISL, France
- TB101: Introductory Terminal Ballistics by BURKINS, Matthew from Burkins Consulting, USA
- MT201: Hopkinson bar techniques for material characterization and component qualification under impact loading by SONG, Bo from Sandia National Laboratories, USA
- MT201: Ballistic properties of the UHMWPE fiber and its composites by WERFF, Harm and HEISSERER, Ulrich from Avient, NL

For the first time, we also offered courses on an advanced level (201s) that were given on Friday morning in parallel to the regular technical program. This mix of introductory and advanced courses were attended by more than 150 people. I would like to thank all those who attended, provided, or helped organize these courses!

For the upcoming symposium in Cape Town, South Africa, in October 2026, we plan an on-site tutorial program of both introductory and advanced courses. Introductory courses (101s) in fundamental fields of ballistics will be given on Monday. We also like to offer advanced courses (201s) again that will be given on the Sunday before the conference. The broadcast call for instructors was already sent out and we are looking forward to receiving course proposals.

We look forward to your feedback at education@ballistics.org.

Happy learning!

Dr. Markus Graswald
(Education Committee Chair)

LAB REVIEW

THE ACCREDITED BALLISTIC LABORATORY AT THE ROYAL MILITARY ACADEMY

by Cyril ROBBE, PhD
RMA, Belgium

THE ROYAL MILITARY ACADEMY

Rege duce pro jure et honore - By the King's command, for law an honour

The Royal Military Academy (RMA) is a military university institution located in the center of Brussels (Figure 1). The RMA is responsible for the academic, military, physical, and character development of future officers, as well as the ongoing training of officers throughout their careers in the Defence. It was founded in 1834 by the French Colonel Jean-Jacques Édouard Chapelié.

Figure 1. The Royal Military Academy facility, located in the heart of Brussels.

The academic training follows the organization of a university and is divided into two faculties: the Polytechnic Faculty and the "Social and Military Sciences" Faculty.

THE "WEAPON SYSTEMS AND BALLISTICS" DEPARTMENT

The "Weapon Systems and Ballistics" department (ABAL) of the RMA is mainly in charge of teaching cadets the applied science of ballistics. It does so through a unique blend of lectures, practical work in the laboratory, and project-based learning, including the use of numerical simulations. Besides, scientific research is conducted with the philosophy of combining all aspects of ballistics (internal, exterior, and terminal), thanks to its unique experimental capability and supported by long-standing expertise in the implementation of numerical simulations.

ABAL's expertise and facilities are also available to external companies through the organization of dedicated test sessions, the setup of project-based collaborations (short and long term), or through collaboration within the scope of externally funded projects (national or international).

THE ACCREDITED BALLISTIC LABORATORY

The Accredited Ballistic Laboratory hosts a 103.25 m indoor shooting range, located in the center of Brussels, at the heart of Europe, close to the European Institutions. This location allows easy access for potential partners. Teaching, research, and industrial testing are conducted in the domains of internal ballistics, exterior ballistics, terminal ballistics, and weapon systems. The infrastructure (Figure 2) is designed to withstand testing up to .50 AP conventional ballistic projectiles.

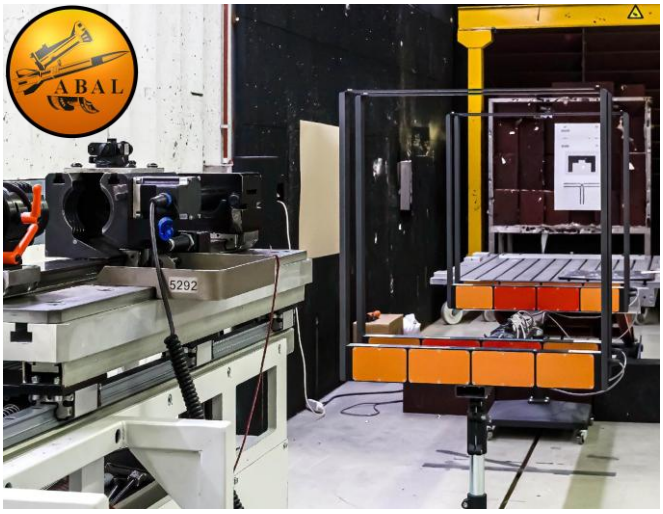


Figure 2. The end of the main shooting line of the Accredited Ballistic Laboratory.

The laboratory has unique expertise in accelerating non-conventional projectiles (Figure 2) up to 120 mm in diameter, with energy levels surpassing 50 kJ, through the development and/or optimization of dedicated pyrotechnic and pneumatic launchers.

A wide variety of small arms and ammunition are available in the laboratory. Its multi-purpose instruments include universal small-caliber receivers equipped with numerous test barrels up to .50 caliber, velocity radars and screens, multiple high-speed cameras, a high-speed thermal camera, and 3D and volumetric scanners.

Additional dedicated equipment is presented in the next sections.

The laboratory is uniquely accredited to ISO 17025 for the measurement of pressures inside the weapon, for the measurement of velocities outside the weapon, and for various ballistic resistance tests.

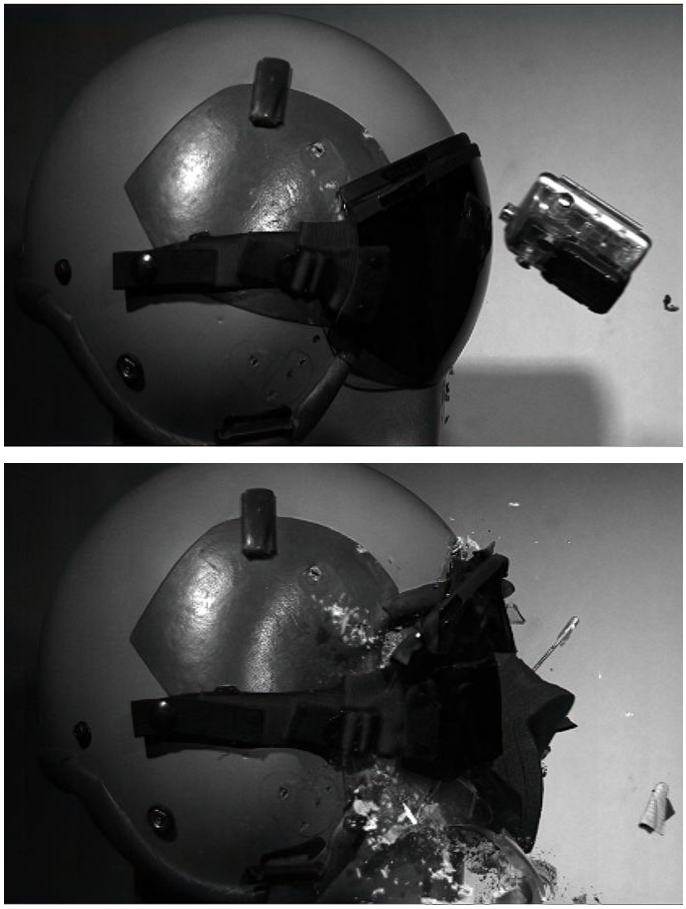


Figure 3. High-speed camera footage of an unconventional projectile – a small-sized camera impacting a jet pilot helmet, used to assess hazards during an ejection maneuver.

MAIN CAPABILITIES OF THE LABORATORY

Internal Ballistics - Barrel

The internal ballistics activities are dedicated to pressure measurements inside the barrel (C.I.P., NATO, and SAAMI protocols), using piezoelectric sensors supported by various calibration capabilities. Velocity measurements inside the barrel are also performed using a dedicated Doppler radar and a Photonic Doppler Velocimetry (PDV) device. Dimensional measurements and wear assessment are carried out using a Coordinate Measuring Machine (CMM) and a MicroView.

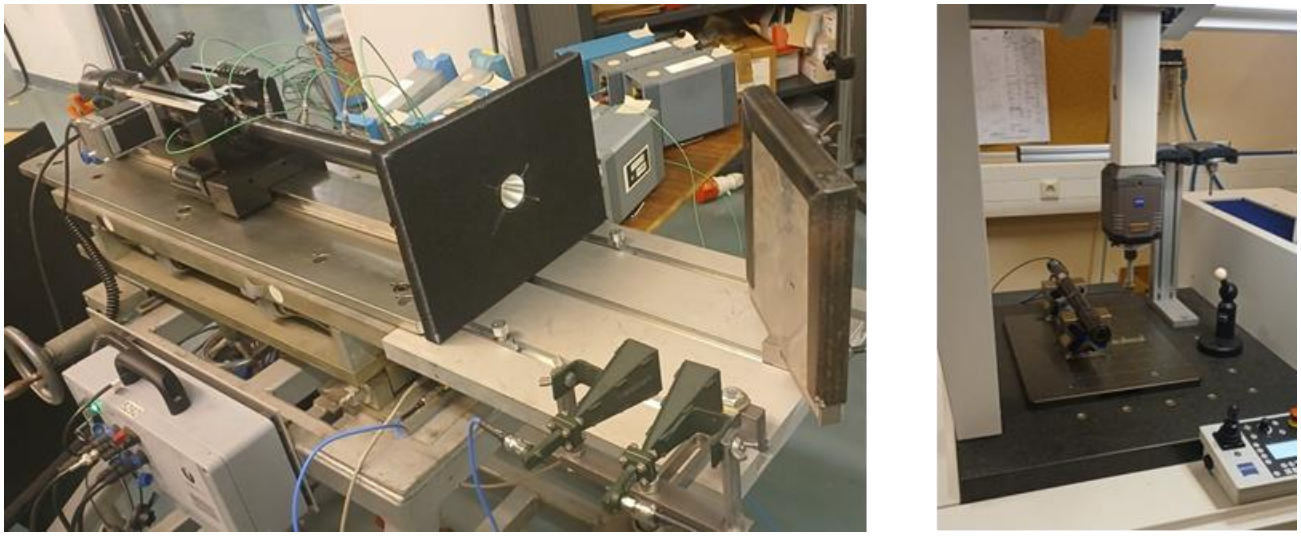


Figure 4. (Left) A 9-pressure-port 7.62 × 51 mm barrel with in-bore Doppler radar measurement – (Right) The Coordinate Measuring Machine measuring a barrel.

Internal Ballistics - Intermediate Ballistics

Unique, quantitative, non-intrusive, whole-field measurement methods based on high-speed, time-resolved Background-Oriented Schlieren (BOS) and Particle Image Velocimetry (PIV) techniques have been developed in the laboratory. These methods allow quantification of gas flow during the transient phase of intermediate ballistics in terms of gas density and velocity fields. Shadowgraphy and Schlieren techniques are also implemented.

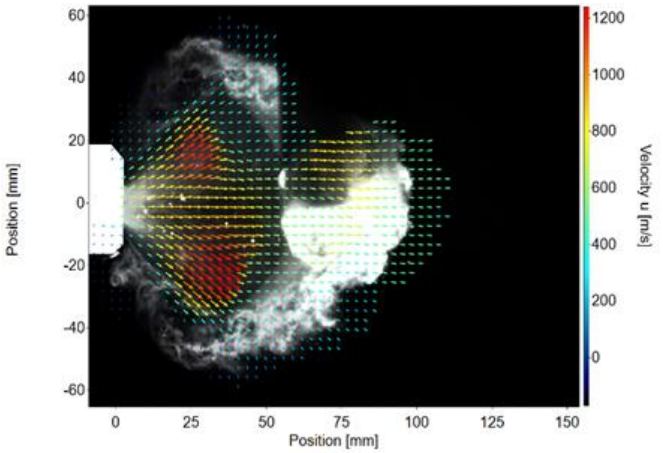


Figure 5(a). Velocity field of the main propellant flow generated during the launch of a 7.62 x 51 mm supersonic projectile.

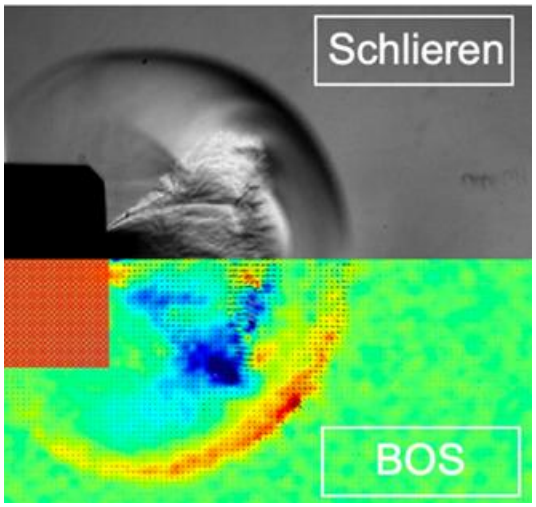


Figure 5(b). Comparison between Schlieren flow visualization and the quantitative BOS technique for a 5.56 × 45 mm projectile.

Finally, a recoil test bench allows for the comparison of weapon systems and the quantification of the efficiency of muzzle accessories.

Exterior Ballistics

Exterior ballistics encompasses the understanding of airflow to refine aerodynamic design, and the study of projectile stability to minimize

dispersion and enhance terminal behavior. The laboratory meets these demands thanks to a wind-tunnel and free-flight testing, implementing optical measurement techniques such as Background Oriented Schlieren (BOS), Schlieren and Shadowgraphy. Measurements are completed by state-of-the-art computational fluid dynamics.

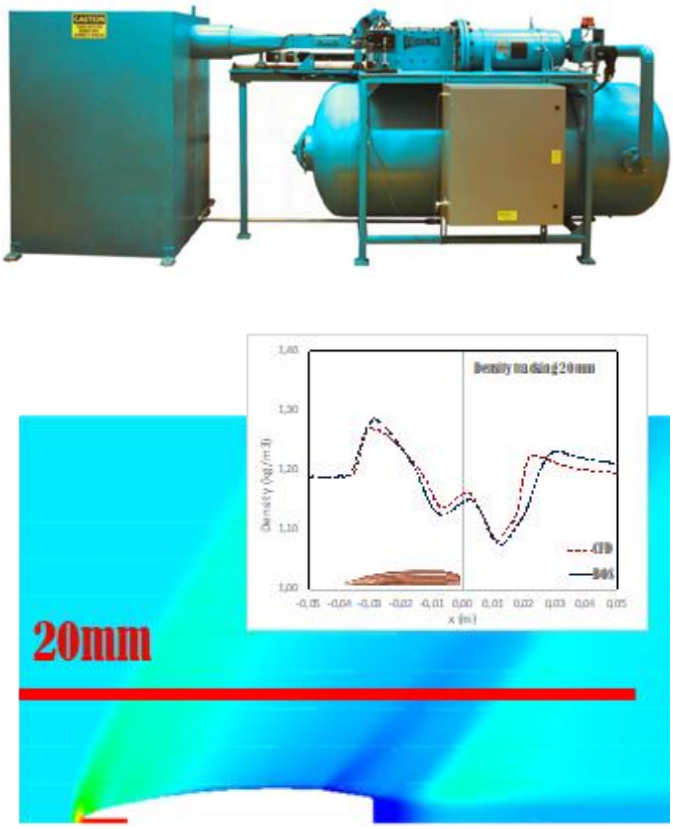


Figure 6. (Top) RMA Supersonic Wind Tunnel used for small-caliber projectiles (including sub-scaled geometries) – (Bottom) Density profile around a projectile in flight: comparison between Computational Fluid Dynamics and Background-Oriented Schlieren (from free flight).

Terminal Ballistics – Material and Structure

Under the ISO 17025–accredited quality scope, the laboratory is authorized to issue resistance certifications in accordance with multiple standards, including EN, VPAM, NIJ, and NATO. Its weapon systems include barrels for a wide range of ammunition—from .22 LR to .50 cal.—two compressed-air launchers for UIC and gravel projectiles, and a two-stage light-gas gun for launching Fragment Simulated Projectiles (FSPs). In addition to the all-purpose laboratory equipment, the measurement systems include a Projectile Orientation Measurement (POM) system for determining projectile yaw angle in flight, close to impact.

Figure 7. (Top) In-house pneumatic launcher developed for accelerating UIC projectiles – (Bottom) UIC projectile impacting the windscreen of a high-speed train.

Terminal Ballistics – Wound ballistics

Wound ballistics activities consist in assessing incapacitation probabilities as a function of impact conditions (projectile, velocity, attitude). The laboratory is able to produce ballistic gelatin and synthetic simulants that can be tailored to the application. The experimental setup combines high-speed cameras and homemade tracking capabilities to reconstruct the 3D trajectory of projectiles inside the block as well as the 3D geometry of the temporary cavity as a function of time. Crack-measurement methods are also

implemented (Fissure Surface Area and Wound Profile Method).

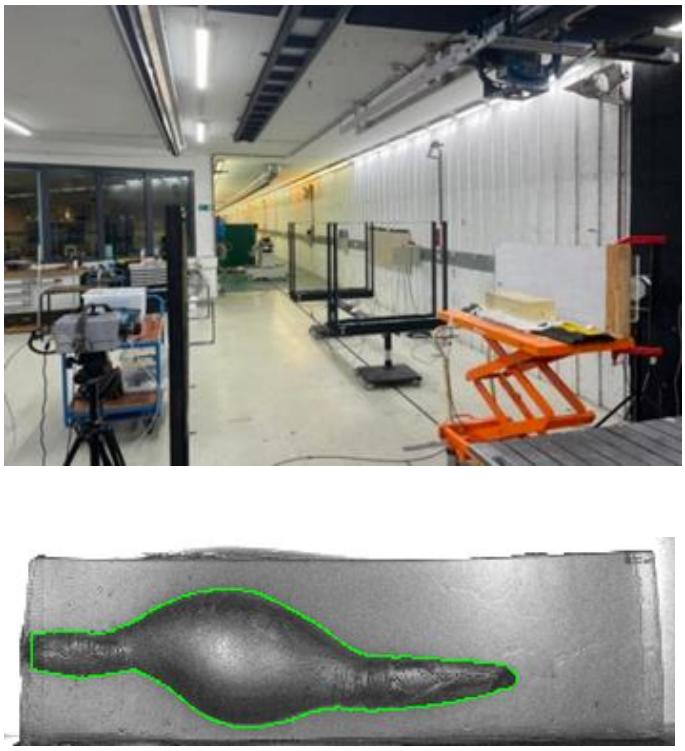


Figure 8. (Top) Wound ballistics experimental setup – (Bottom) Tracking of the temporary cavity and projectile kinematics of a 5.56 × 45 mm round impacting a gelatin block at 710 m/s, obtained using in-house tracking software.

Terminal Ballistics – Personal protections

The ABAL department conducts comprehensive terminal ballistics research and testing, covering projectile impact, penetration, fragmentation, and behind-armor and helmet effects.

The laboratory relies on all-purpose ballistic equipment, as well as dedicated material and structural test configurations, to support impact and penetration studies. Combined with numerical modeling, the laboratory investigates weapon–target interactions, armor response, and damage mechanisms, and can perform tests in accordance with STANAG, VPAM, NIJ, and CAST standards.

Figure 9. (Top) Testing ballistic protection and measuring the corresponding Back Face Signature – (Bottom) The Blunt Load Sensing Head-form (BLSH) wearing an helmet and its numerical twin for assessing Behind-Helmet Blunt Trauma.

Terminal Ballistics - Fragment testing and hypersonic impacts

The RMA ballistic laboratory's convertible single- and double-stage light-gas launcher is designed to accelerate 5.5 mm or 12 mm calibre, 4-gram launch packages up to 2500 m/s using helium gas.

This compact, cold-gas-driven launcher is used for high- and hypervelocity impact studies. In addition, a dedicated methodology using soil simulants and corresponding propulsion techniques to test lightweight textiles under the impact of secondary debris is also available. It highlights differences in material performance

between a soil-particle cloud and a fragment-simulating projectile (FSP).

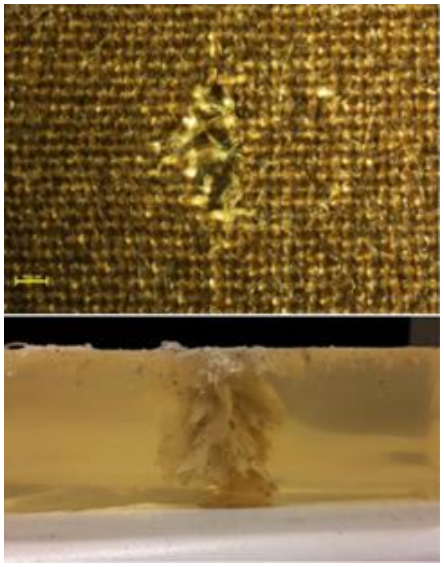


Figure 10. (Top) The double-stage light-gas gun – (Bottom) Fabric impacted by soil simulant and the corresponding penetration observed in the back-face gelatin.

Weapon Systems - Kinetic Energy Non-Lethal Weapons

The Kinetic Energy Non-Lethal Weapons (KENLW) laboratory is primarily focused on terminal ballistics. Its equipment includes a dedicated multi-barrel pneumatic launcher, high-speed cameras with in-house tracking software, thoracic surrogates (the 3-Rib Ballistic Impact Dummy (3RBID), the Blunt Trauma Torso Rig (BTTR), and custom-developed membranes), a head surrogate (Blunt Load Sensing Headform (BLSH)), a skin penetration surrogate, and characterization devices (force wall and Hopkinson bar). Combined with free-flight testing, stability assessment, dispersion testing and numerical capabilities, the laboratory enables full implementation of NATO STANREC 4744 evaluation procedures.

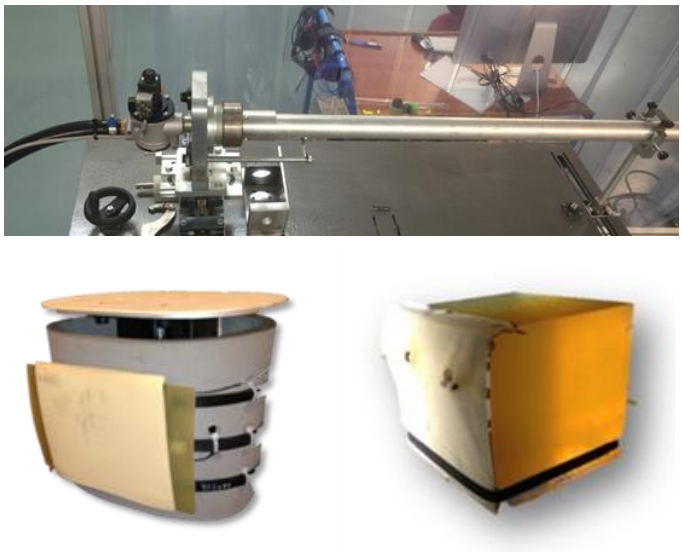


Figure 11. (Top) The KENLW multi-barrel pneumatic launcher – (Bottom, left) The 3RBID thoracic surrogate – (Bottom, right) The skin penetration surrogate.

Weapon Systems - Counter Unmanned Aircraft Systems (C-UAS)

The ABAL department applies the fundamental fields of ballistics for its "Counter-UAS" research projects, using theoretical and fundamental concepts to assess and optimize kinetic Counter-UAS systems. Experimentally, it combines exterior ballistics setups to quantify trajectories and dispersion patterns with terminal ballistics methods to evaluate the ballistic resistance of specific UAV components. The results are integrated into in-house software capable of addressing practical questions related to UAS engagement and optimization using unguided projectiles.

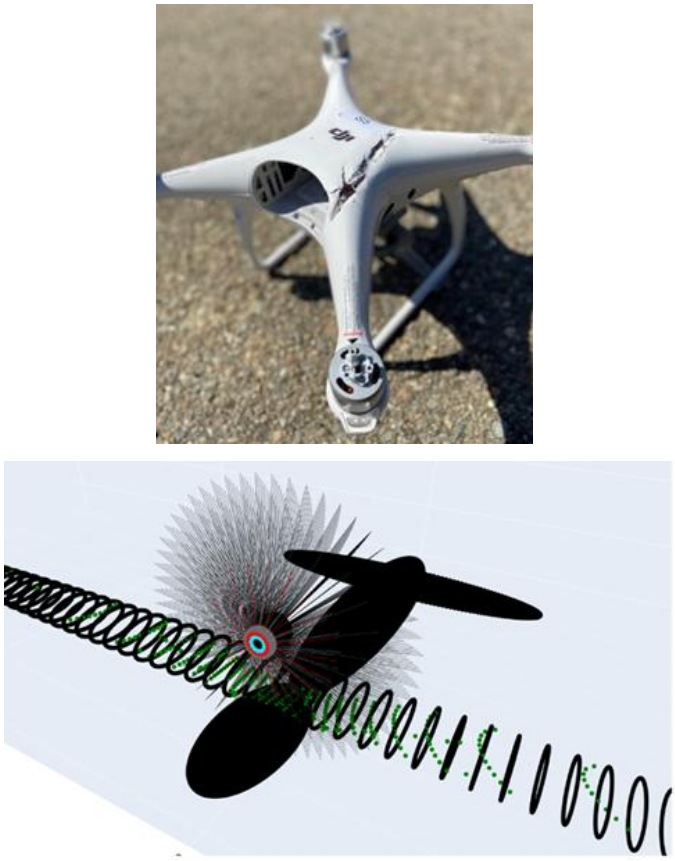


Figure 12. (Top) Impact of a 5.56 × 45 mm on a rotary-wing UAV – (Bottom) Representation of the fragmentation pattern of a 40 mm HE projectile detonated near a fixed-wing UAV and the resulting fragment impact locations, computed using in-house software.

OTHER LABORATORIES AT THE RMA

In addition to its in-house ballistic experimental capabilities summarized in the previous section, the ABAL department works on a daily basis in close collaboration with other departments of the RMA. This provides privileged access to additional capabilities and facilities relevant to ballistic research. A non-exhaustive list of such capabilities is presented below.

- **The Fluid Dynamics Laboratory** includes three wind tunnels, Particle Image Velocimetry (PIV) capability, and a sound signal acquisition system.
- **The Laboratory of Dynamics of Mechanical Structures** conducts vibration testing under specific temperature conditions.
- **The Laboratory for Energetic Materials and Blasting Engineering** performs the synthesis, analysis, testing, and assessment of explosives, propellants, and pyrotechnics.
- **The Structural and Blast Engineering Laboratory** includes a pyrotechnic bunker, shock tube facilities, high-speed stereoscopic imaging, and blast pressure measurement systems.
- **The Material Characterization Laboratory** is equipped with various quasi-static characterization test benches, a Charpy pendulum tester, and Hopkinson compression bars for dynamic testing under controlled temperature. Several microscopes, including an environmental scanning electron microscope (SEM), complement the equipment.
- **The Optronics Laboratory** features multiple fixed optical tables and the necessary testing equipment for evaluating military sensors in the optronics domain under harsh conditions.
- **The Robotics & Autonomous Systems Laboratory** supports research and design in rotary-wing and fixed-wing Unmanned Aircraft Systems (UAS), Unmanned Ground Vehicles (UGVs), and Unmanned Maritime Systems (UMSs).

Finally, since the ABAL Laboratory is part of the Military Academy and is led by military personnel, it frequently provides technical expertise to operational units and to the material command of the Belgian Armed Forces. This role also grants access to larger outdoor ranges, enabling the execution of specific experiments.

NUMERICAL SUPPORT

All the aforementioned experimental capabilities are systematically supported by numerical simulation expertise. The ABAL department possesses extensive experience and know-how in using both commercial and in-house codes to simulate internal, exterior, and terminal ballistics. Among other tools, this includes Ansys Fluent, LS-DYNA, Autodyn, MoBiDiC, and Split-X.

This dual expertise, combining both experimental and numerical capabilities, enables the system-atic validation of simulations using ABAL's own experimental results and database. This ensures relevant and dedicated validation of the performed simulations.

https://www.rma.ac.be/en

FROM FORMED SOFT BALLISTIC VESTS TO INJURY RISK ASSESSMENT: FINITE ELEMENT SIMULATIONS WITH HUMAN BODY MODELS

by Marcin Jenerowicz, Patrick Matt, Matthias Boljen
Fraunhofer EMI, Freiburg, Germany

INTRODUCTION

Behind-armour blunt trauma (BABT) occurs when a bullet does not perforate the armour but drives rapid back-face deformation (BFD) into the body [1,2]. This transient deformation imposes highly localized, high-rate loads that can lead to bruising, soft-tissue damage, rib fractures, lung contusions, and cardiac injuries [3]. Conventional certification methods based on permanent clay indentation do not capture the rapid motion and localized loading that determine injury risk in humans. To address this gap, a forming technique was used to drape multilayer soft ballistic vests onto finite element human body models (HBMs) [4] and a motion-based Substitute Impactor Layer (SIL) was employed to transfer measured armour BFD into donned vest–HBM systems [5,6]. Injury was assessed using established criteria (Viscous Criterion, VC; Blunt Criterion, BC), local strains in ribs, costal cartilage, and sternum, and energy-based measure of BFD input [5-7]. Anterior and posterior chest zones were defined to structure evaluation, and comparisons to post-mortem human subject (PMHS) blunt corridors [8,9].

Figure 1: (left) Fabric pack on the GHBMC M50 chest att 1 ms; (right) back face deformation of the HBM.

HOW WERE THE SOFT BALLISTIC VESTS FORMED ON HBMS, AND THE REAL BFD MOTION APPLIED?

Three HBMs were evaluated: GHBMC M50-P (average male), GHBMC F05-P (small female), and VIVA+ F50 (average female) [5,6]. The soft vest comprised multiple thin aramid layers. A quasi deep-draw inverse forming step draped the innermost fabric ply directly onto the 3D body surface; the shaped layer was then duplicated and stacked to full vest thickness, with boundary constraints representing stitching. This approach eliminated artificial gaps between clothing and skin and established natural contact and load transfer across the torso [4-6].

A hard ballistic plate (9 mm silicon carbide, SiC; 10 mm UHMW-PE) impacted by a non-penetrating 7.62×51 AP round provided the measured BFD history [5,6]. A rigid SIL replicated the time-varying displacement and shape of the armour's back face, pressing the vest and thorax in the same manner as in tests [5-7]. To express input severity transparently, the back-face area was partitioned into concentric rings and the

rings' kinetic energy was summed when they moved toward the body [5].

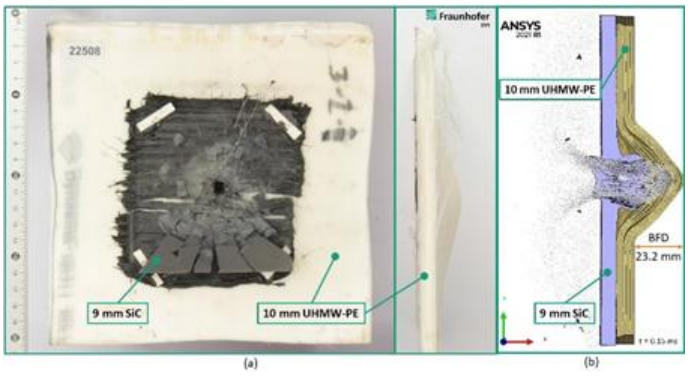


Figure 2: (left) Hard-ballistic plate (SiC and UHMW-PE) after impact at $v_P = 913\ m/s$); (right) corresponding simulation, max. BFD 23.2 mm at 0.15 ms.

Four chest zones were defined front-to-back for direct comparison: POI-F1 (mid-sternum between ribs 3–4), POI-F2 (rib-to-cartilage junction near ribs 4–5), POI-B1 (T7 vertebra), and POI-B2 (between ribs 9–10). Assessment included VC (product of chest compression and speed), BC (energy-based correlation that includes projectile energy and body wall thickness), local maximum principal strains in cortical bone and costal cartilage, and the energy input [5-7]. PMHS blunt corridors were reproduced for context [8,9], and a non-lethal B&T SIR GL-06 projectile (40×46 mm, ~75 m/s) was simulated at POI-F1 [6].

Figure 3: The GHBMC M50 model in cross-section with applied PPE and underlying tissue; (left) anterior with two impact zones: POI-F1 center of sternum, POI-F2 transition from 5th rib to cartilage tissue; (right) posterior with opposing impact zones: POI-B1 center vertebra T7, POI-B2 between 9th and 10th rib.

Forming the vest onto HBMs produced realistic body contact and revealed strain patterns that drive BABT outcomes [4,5].

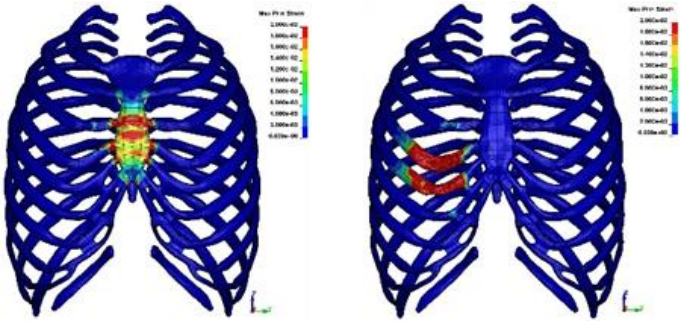


Figure 4: Maximum strains occurring up to the 2 % limit after BFD applied with SIL at t = 0.15 ms; (left) POI-1, (right) POI-2.

At the mid-sternum (POI-F1), strains were symmetric, with peaks at the centre of the BFD imprint and at sternum cartilage transitions. At the rib-cartilage junction (POI-F2), strain concentrated strongly at the junction and often propagated into adjacent ribs [5,6]. Default HBM strain thresholds (e.g., ~2% for cortical bone, ~1% for cartilage) were exceeded in several anterior cases, and literature break strains for ribs at lower rates (approx. 1.25–1.5%) indicate vulnerability in these junctions even when global chest compression is small [10].

Posterior zones (POI-B1/B2) showed meaningful local strains and vertebral motion, but VC and BC provided limited insight under localized back-of-chest loading [7]. Deflection-time histories matched in some instances PMHS corridors (notably IC-B), whereas force-time histories were often noisy and sensitive to mesh resolution and contact details. The SIR GL-06 impact case generated high local sternum and cartilage strains, highlighting sensitivity to mesh density near the impact site, contact definitions, and material damping [6].

Female HBMs generally exhibited larger deflections and higher local strains than the male model under matched inputs. The VIVA+ F50's

coarser surface mesh amplified displacement variability; GHBMC F05 localized strains more finely yet still exceeded thresholds [4,6]. Numerical controls such as explicit time-step settings and default damping affected oscillations and energy dissipation; early cartilage element erosion (default ~1% strain) could trigger non-physical failure progression under localized ballistic loading [5-7].

ARE VC AND BC ENOUGH?

VC and BC originate from contexts characterized by broader, lower-rate chest deformation [8,9]. In BABT, the chest often exhibits limited global compression, while small regions experience high local strains and shear. Consequently, VC and BC are informative for certain front-of-chest scenarios but underperform for posterior zones and small, high-rate BFD footprints. A simple energy-based perspective quantifying how much kinetic energy the moving armour back face delivers over its footprint—more directly reflects when and where the chest is loaded and aligns better with observed strain peaks [5].

Model fidelity currently limits robustness. Surface mesh resolution at the sternum and rib–cartilage junctions should be increased; vest–to-skin contact and inter-ply friction merit refinement; and rib and cartilage materials require rate-sensitive properties with validated failure limits for ballistic-rate loading [4-6]. Default erosion thresholds set for lower-rate applications can distort outcomes when localized strains rise quickly [5]. Posterior thorax assessment lacks well-established human corridors, complicating calibration and criterion selection, particularly for female anatomies that remain under-represented in available test data [6,7].

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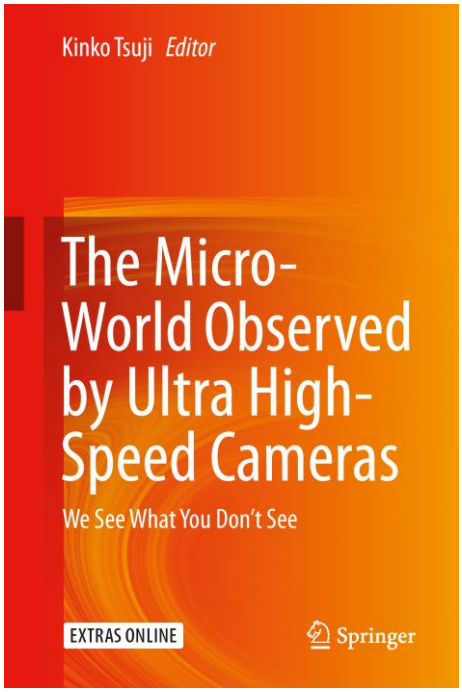
BOOK REVIEW

by A. Klavzar
French-German Research Institute of Saint-Louis, Germany

In this issue we present a book about ultra-high-speed cameras, describing different visualization techniques for ultra-high-speed events.



EDITOR: **Kinko Tsuji**

PUBLISHER: **Springer International Publishing AG 2018**

PAGES: **415**

FORMAT: **Hardcover, Softcover, eBook**

ISBN (Hardcover): **978-3-319-61490-8**

The book is edited by Kinko Tsuji as an employee of Shimadzu Europa GmbH. In the book, some chapters are written by the editor, others by several authors, some of well-known institutions as the Fraunhofer Institute for High-Speed Dynamics or the European Synchrotron Radiation Facility (ESRF).

As declared by the editor in the preface, the book aims to show to readers, not only to the high-speed specialists but also to people who have no experiences with high-speed cameras, what we can see and what kind of inspirations one can get for things to be done in the future.

The book describes and explains different high-speed imaging techniques and some applications of them, according to the title of the book focus is on micrometric imaging, still, some parts which explain certain techniques as e.g., CCD/CMOS sensor technology or Digital Image Correlation can also be applied to macroscopic events. A lot of examples are related to visualization of detonation shock waves or bullets in flight. According to the editor they think that many readers will learn about new ideas from the chapters of the book and start to look for future challenges in wider fields.

The book is structured in nine main parts. As a reader may not be interested in all techniques and applications described in the book, the different parts can also be purchased separately for the eBook version at least.

Each part starts with an abstract and keywords, what makes it easy to scroll through the book searching for a certain problem. At the end of each part references are given for further information.

In part I, Introduction, a brief introduction to high-speed cameras and certain issues as triggering and illumination are discussed. As an example, for a difficult case for both illumination and trigger the visualization of collapsing beer bubbles is used. And the question is answered why do we need high-speed cameras: For curiosity!

In part II, Pioneering Work on High-speed Cameras, on the example of collapsing bubbles the use of different types of high-speed cameras with increasing framing rates are reviewed. Those are for example rotating drum cameras, rotating mirror cameras, image converter

cameras, image splitting cameras for 2-D visualizations, but also holography as a 3-D visualization technique is reviewed.

In part III, Cameras with CCD/CMOS Sensors, the evolution of high-speed images sensors is described very detailed, by explaining the different sensor technologies from the development of the first digital high-speed video camera in 1989, until the ultra-high-speed cameras with 10 million frames per second.

In part IV, Shock Waves, gives an overview of the used visualization techniques and cameras to make the shock waves and their flow fields visible. Examples are given for example on shadowgraph, monochrome schlieren, color schlieren, shearing interferometry, polychrome Mach-Zehnder interferometry, etc. In this part, many of the examples are related to problems as blast waves or bullets in flight or underwater shock waves.

Part V, Materials Research, is devoted to the analysis of the mechanical behaviour of materials subjected to dynamic loadings via digital image correlation (DIC), Observation of Laser Materials Processing and Real-Time Hard X-ray Imaging for high-speed and ultra-high-speed visualization of the interior of opaque systems as they change with time.

Part VI, Combustion, deals with the development and application of high-speed laser visualization techniques in combustion research, the examples include studies of turbulent flames but also practical applications in engines.

In part VII, Explosions and Safety, the usage of high-speed cameras for the analyses of Vehicle born IEDS is described by usage of tracking software and digital image correlation for material characterization. Another example is the ignition of gas bubbles by shock-waves.

Part VIII, Droplets, deals with different phenomena of droplets analyzed by interferometry, observations of chemical reactions induced by the impact of a droplet.

In part IX, Microbubbles and Medical Applications, applications of high-speed cameras in medical research are described, mainly by the observation of micro bubbles.

The movies described in the different parts can be downloaded as movie files.

To summarize, for my opinion this book could be on the one hand helpful for someone searching for ideas, how high-speed cameras can be used to visualize different phenomena as fluid flow or deformations of solid. Also are the technical descriptions very helpful if someone is interested in detail in the functioning of high-speed cameras and to better understand test set-ups using high-speed cameras.

DID YOU KNOW…?

by Andreas Klavzar
French-German Research Institute ISL

…that the Falklands Coriolis story is a myth?

The Battle of the Falkland Islands was a First World War naval action between the British Royal Navy and German Navy on 8 December 1914 in the South Atlantic.

Battle of the Falkland Islands, by W. L. Wyllie

The result was a British victory with 10 killed and 19 wounded British sailors, but 1871 killed and 215 captured Germans.

To explain the Coriolis effect in physics lessons often the Falklands Coriolis story is told. For example, in Jerry B. Marion's *Classical Dynamics of Particles and Systems* it is written:

"During the naval engagement near the Falkland Islands [in the South Atlantic] early in World War I, the British gunners were surprised to see their accurately aimed salvos falling 100 yards to the left of the German ships. The designers of the sighting mechanisms were well aware of the Coriolis deflection and had carefully taken this into account, but they apparently were under the impression that all sea battles took place near 50° N latitude and never near 50° S latitude. The British shots, therefore, fell at a distance from the targets equal to twice the Coriolis deflection."

This story is wide spread in textbooks teaching physics, another example is NASA Reference Publication 1262 *Methods of Applied Dynamics* of M.H. Rheinfurth:

"During the British-German naval battle of the Falkland Islands (about 50 ° latitude), the British gun shots landed almost one hundred yards to the left of the German ships, because the firing tables had been calculated for Britain's northern latitude."

In C. M. Graney, "Wide of the mark by 100 yards: Textbooks and the Falklands Coriolis myth" *Phys. Today* (Feb. 2, 2002) it is explained why this story is a myth by analyzing the 1917 textbook *The Battle of the Falkland Islands: Before and After* by Commander Henry Spencer-Cooper.

Graney explains that the Falkland battle was already the second the British fought against the Germans in southern hemisphere, the first one was at Coronel, Chile, in November 1914. The issue to account for the reversal of the Coriolis effect in the Southern Hemisphere would have already been discovered at Coronel. Also does Spencer-Cooper not mention the Coriolis effect or of difficulty in targeting the initial long-range salvos. Instead, he says the British had faster ships and deliberately kept the range long. The officers apparently thought they could do better at long range than the Germans.

The 35th International Symposium on Ballistics will be held from October 25 to 30, 2026 in Cape Town, South Africa.

The International Symposium on Ballistics (ISB) is known to be the prime international scientific event in the field of ballistics.

The ISB 2026, in keeping with its theme, aims to attract a large number of leading experts from all over the world. The International Symposium on Ballistics 2026 will feature expert tutorials, robust discussion and thought-provoking presentations among ballistics professionals. As a first for the ISB, digital interactive posters will be featured on large format HD monitors on the most state-of-the-art technology. Furthermore, two-track sessions are planned to allow for more oral presentations during the conference.

The symposium covers all traditional areas of ballistics science:

- Exterior ballistics
- Interior ballistics
- Terminal ballistics
- Explosion and warhead mechanics
- Launch dynamics
- Vulnerability and survivability

but also welcomes papers and presentations on emerging technologies including hypersonics, AI, drones and other new technologies related to ballistics.

VENUE

The symposium venue will be the CAPE TOWN INTERNATIONAL CONVENTION CENTRE (CTICC) in Cape Town.

The CTICC is the leading international convention centre on the African continent. Besides world-class conference halls, the CTICC offers a variety of convenient on-site facilities, ensuring you never have to miss a thing. These include on-site medical assistance, prayer and parent rooms, free Wi-Fi and ATMs. Moreover, with over 1400 secure visitor parking bays available, the CTICC is highly accessible by car.

Cape Town International Convention Centre

Further information the CTICC is available under www.cticc.co.za.

Accommodation recommendations and booking links will be available on the official symposium website www.isb2026.org early February.

SOCIAL PROGRAM AND LEISURE ACTIVITIES

The social program at the 35th ISB will include a Welcome Reception on Monday evening, a Networking Function on Tuesday and a Conference Gala / Theme Dinner on Wednesday.

GOLD Restaurant (Conference Gala location)

Besides that, Cape Town itself offers a truly overwhelming range of leisure activities. You can take scenic trips to the Table Mountain, Chapman's Peak or Camps Bay, explore the hipster neighbourhood of Woodstock or tuck into Cape Town's local food and world-class wine.

Table Mountain Cable Car (© Cape Town Tourism)

Kirstenbosch Botanical Garden (© Cape Town Tourism)

Beach lovers will find plenty to do in Cape Town, as the city offers a variety of beach attractions along the scenic Atlantic Ocean. Popular activities include swimming, sunbathing, surfing, and windsurfing. Fishing is also a popular pastime, and there are many charter boats available for hire.

For those who enjoy a night on the town, Cape Town offers a wide range of options. The city is home to numerous clubs, bars, and restaurants, and there is always something new to discover.

Cape Town Night Life (© Cape Town Tourism)

You can also seize one of the plenty opportunities to experience the rich African culture in terms or art, sing and dance or just hang out with wild African penguins at Stony Point. The list of possible activities is practically endless.

Finally, shopping in Cape Town is a truly unique experience. The city is home to a variety

of markets, malls, and local shops, offering something for everyone.

Cultural Music Event (© Cape Town Tourism)

Leisure tours including booking links for you and your companion will be available on the ISB 2026 website early February. Or let yourself be inspired by one of the recommendations available in the Official Guide to Cape Town.

IMPORTANT DATES

There are a few important dates to note in the run-up to the symposium.

31. Jan.:	Deadline for Full Paper Submission for Defence Technology
22. Feb.:	Abstract Submission Deadline + Student Award application open
21. Apr.:	Student award applications including full paper due
24. Jul.:	Full version of Symposium proceedings paper due

TRAVEL INFORMATION

Cape Town is accessible through Cape Town International Airport. Information on and booking of airport transfers will be available on the ISB 2026 website in early 2026.

Please note that a visa may be required to travel to South Africa. Click here for a summary of what you need to know about South Africa's entry requirements for the ISB 2026, or inform yourself on the official South African Department of Home Affairs website.

Please note that visa applications can take up to 3 months, depending on the local consulate/embassy in your region. Should you require an ISB 2026 visa letter for your visa application, kindly note you will receive a system generated one once your payment for your registration fees has been received and cleared.

Join us in Cape Town in October 2026 and enjoy the beauty of the area while you meet with colleagues from around the world.

SPONSORING AND EXHIBITION

The ISB 2026 will provide an opportunity companies and organisations to market their services and products through exhibiting, advertising and sponsorship. Sponsorships will cover various aspects of the conference including pre, during and post the conference. In exchange for sponsorships the sponsor will receive exclusive branding, marketing, naming rights and speaker opportunities.

The sponsorship prospectus will be available here early 2026.

"THE DIFFERENCE"

TDW Gesellschaft für verteidigungstechnische Wirksysteme mbH,

a 100% subsidiary of MBDA Germany, is experienced in the design and manufacture of warheads systems including the associated fuzes and safe and arm devices. TDW was founded in 1958. Since then, more than two million warhead systems have been produced at and delivered from its site in Schrobenhausen, located in the Greater Munich Metropolitan area. With approximately 150 employees, TDW operates as an essentially autonomous full-service company at one integral site. Our product portfolio includes all kinds of warhead systems such as shaped-charge, blast/fragmentation-, and penetrators and their combinations in single-, tandem-, or multiple-charge systems for MBDA Group as well as other missile, torpedo, and precision-guided munition system houses worldwide.

TDWs value creation chain encompasses all of the following activities to their full extent:

- **Concepts, Designs, and their Assessment,**
- **Development and Qualification,**
- **Manufacture and Integration,**
- **Testing and Verification &Validation.**

An own manufacturing, integration and testing area located nearby the development and all other supporting departments represents a major asset in terms of time and value for money for a development / qualification and series production program. It includes high explosives processing (mixing, casting or pressing), mechanical workshops, inert assembly lines, warhead final assembly lines, a chemical lab, as well as an environmental testing lab and the test range. TDW is in the fortunate position owning a test site of approx. 21 ha, where we can perform almost every static test for warheads and environmental testing for even complete missile systems. A rocket sled track is available to conduct dynamic warhead and missile tests.

Available key technologies include flexible response, target adaptive, and low collateral damage warheads, insensitive explosive charges with outstanding safety under extreme mechanical and thermal threats which provide nonetheless ultimate destructive performance, as well as intelligent highly shock-resistant fuzing systems.

Thanks to governmental-funded and self-funded research and development, TDW is today at the forefront of technologies for future warhead systems comprising:

- **Scalable Effects Warheads (Dial-a-RADIUS®)**
- **Multi-Effects Warheads (Dial-an-Effect)**
- **Reactive Materials Warheads (Dial-a-Blast)**

For further information, please visit our website at www.tdw-warhead-systems.com/en/ or contact michael.korte-weich@mbda-systems.de.

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QinetiQ

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More than 75% of our workforce carry high-level national security clearances.

NEXTER GROUP is a leading actor in the land-defence industry. Today it is the principal partner of the French Army, and its equipment is used in over 100 countries.

In a world of constantly changing threats, the Group's 2,700 employees listen carefully to customers to provide the solution best adapted to their specific needs. Innovation, protection and adaptability are the key guidelines by which NEXTER designs its products and services.

With nearly 11% of annual sales dedicated to research and development, NEXTER introduces increasingly innovative and high-quality products onto the world market while meeting customers' deadlines and budgets.

Descending from Giat Industries, NEXTER is continuing a long tradition that could be considered to start in the XVIIth century, during the reign of Louis XIV in France, when the Royal Arsenal was created at the Bastille.

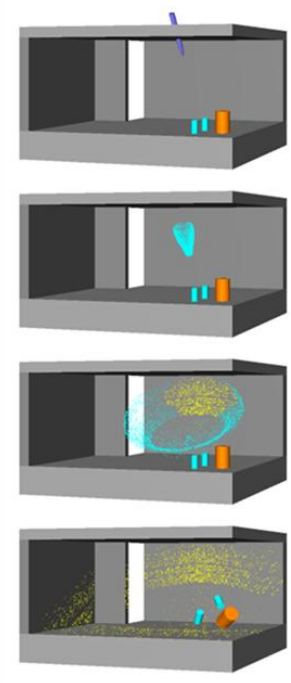
For more information visit https://www.nexter-group.fr/

Southwest Research Institute (SwRI®) is a nonprofit engineering R&D center. The main facility is a 1200-acre campus in San Antonio, Texas where over 3000 employees perform contract research for both government and industry. SwRI's Engineering Dynamics Department in the Mechanical Engineering Division works on armor and impact physics.

1. SwRI maintains multiple indoor, outdoor ballistic, and remote range facilities, where small and medium arms are tested against various armor configurations. Land mines, IEDs, and arena tests can also be performed to assess the survivability of vehicles and structures.
2. Low, medium, and high-strain-rate laboratory testing facilities provide the ability to characterize materials and then develop constitutive models (equation of state, strength, and failure) for use in computational tools.
3. SwRI has extensive experience with the three primary software tools used for ballistics and explosive-loading: CTH, LS-DYNA, and EPIC. SwRI has modified all three for new constitutive models and boundary conditions.

Visit www.engineeringdynamics.swri.org for more information or www.penmech.swri.org for the Penetration Mechanics weeklong course taught every year.

Engineering Services & Software for Defence Industry and Government Agencies



NUMERICS GmbH is a consultancy engineering and software development company located close to Munich, Germany. NUMERICS is serving its customers world-wide with tailored solutions to their problems in the complete field of ballistics: from detonation to terminal effects.

NUMERICS also offers a set of professional engineering software products for weapon effects and V/L analysis:

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中国兵工学会
China Ordnance Society

Founded in April 1964 and affiliated with the China Association for Science and Technology, the China Ordnance Society is an academic social group composed of science and technology workers for China Ordnance.

The purpose of the China Ordnance Society is to serve the defense construction and economic development by organizing science and technology workers and to promote and develop scientific ideas and disciplines. Its main task is to organize academic exchange, publish academic periodicals, promote the development of science and technology, propagate scientific information and popularize scientific knowledge.

The Society has general members, senior members and fellows and so on. It has all together 22562 members, among which more than 585 are senior members and 34 are fellows.

Ellwood Group, Inc. is a family-owned, privately-held company that has been operating for over 100 years. Through growth and acquisition, EGI has become a major supplier of high-quality, engineered, heavy metal components to customers all over the world. While EGI has grown significantly and now employs over 2,000 employees, the same family values are just as important now and they were 100 years ago.

EGI's leadership team works closely with employees on important topics such as safety and continuous improvement. EGI employees are skilled professionals who are committed to the long term success of the company. EGI business unit companies manufacture and market metal products to customer in industries such as oil and gas, power generation, mining, infrastructure and construction, aerospace, defense, railroad, automotive, industrial machinery, metal processing, gearing/power transmission, and shipbuilding. Over many years of business, EGI has spent millions of dollars for new equipment and to rebuild existing equipment, as well as to expand our manufacturing spaces. We have increased our capacity and enhanced our capabilities to keep pace with our largest and most technically demanding customers.

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For further information, please visit www.ellwoodgroup.com.

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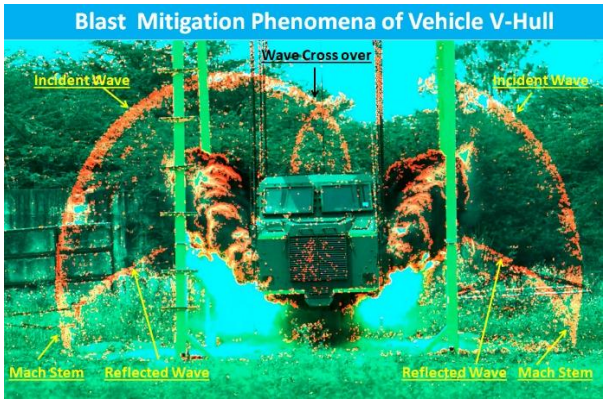
चरम प्राक्षेपिकी अनुसंधान प्रयोगशाला
Terminal Ballistics Research Laboratory
सेक्टर-30, चंडीगढ-160030 / Sector-30, Chandigarh – 160030
[आई0 एस0 ओ0 9001:2015 प्रमाणित प्रयोगशाला] / [An ISO 9001:2015 Certified Laboratory]



Terminal Ballistics Research Laboratory (TBRL) was envisaged in 1961 as one of the modern armament research laboratories under the Department of Defence Research & Development. The laboratory became fully operational in January 1968. It is actively involved in design, development and testing of ammunition and explosive warheads. The laboratory is also involved in testing of personal and vehicle armour against small arm ammunition and explosive blast. The laboratory has instrumented test infrastructure to generate data on blast, shock, lethality, fragmentation, impact and penetration.

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The Fraunhofer Institute for High-Speed Dynamics, known under the name Ernst-Mach-Institut (EMI) is one of the 60 institutes of the German Fraunhofer society. Fraunhofer is a non-profit organization which specialises in applied research and has close links to German government authorities. It is the biggest research organization in its field in Germany and one of the essential European research organizations.

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Services include design, test and evaluation, threat analysis and advice, third party reviews and expert witness testimonies, as well as full project management of design through to build and installation / integration / production.

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