



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 Society Members,

I hope this message finds you in good health. Year 2020 is a special year. Yes, of course, the COVID virus is one of the reasons. But it is also special because it is the Society's 10th anniversary since its foundation in 2010. We have been very fortunate to have many volunteers willing to dedicate their time, energy, and sometimes money to make the Society better without expecting anything in exchange. I want to thank all the Board members, committee members, and the volunteers that make this society the best society in the field.

I feel proud of all the legacy the Society has received, we are truly standing on the shoulders of giants. One of those giants was the late Jack Riegel, our founding President, who conceived the Society as it is: a democratic, dynamic, and open forum for people to exchange technical knowledge. I encourage all the members to enjoy and take advantage of this unique framework that he initiated and was followed by brilliant people from the Board and membership. Do not hesitate to write me at president@ballistics.org if you would like to get involved or help the Society in anyway.

It has now been one year of our standing conference in Hyderabad. The conference really exceeded all my expectations as the venue, the organization, the food, and the attractions were all outstanding. The conference will, no doubt, remain as a fond memory and will serve as a guide and legacy for future conferences.

This year the Society had to make unprecedented decisions. As you probably know by now, the Board has decided to postpone our Reno, Nevada, conference one full year until May 2022. It was not an easy decision as the conference is our main interaction channel for technical →

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HELP NEEDED FROM MEMBERS!

- 1. Recruit new members:** spread the word and get your colleagues to join
- 2. Get involved:** see the website for a list of committees & projects with contacts
- 3. Send or post cool photos:** Wanted: good photos showing ballistic events in all fields

Upload photos at www.ballistics.org

As always, remember to be responsible with copyright, sensitive, or restricted information!

discussions, which will be dearly missed. Fortunately, ASMI, the company that manages our conference, supported our decision and was able to negotiate with the venue a one-year delay without any penalties. Additionally, the authorities are already talking about vaccines, that media announce as very effective, with vaccination campaigns hopefully starting at the beginning of 2021. All this indicates that by May 2022 travel restrictions may have been lifted so that we can celebrate our conference as usual.

In the meantime, the Board and Committees have been very active and have worked hard to make our Society better. The Board voted in favor of including one new topic area in the next conference that will be called "Emerging Technologies". Initially this area will encompass subjects like Hypersonics and Directed Energy, but as topics evolve and become more popular the topic areas may get revised again. The Board also voted in favor of a new Educational Strategy that brings important changes like having the Society be responsible for organizing the short courses, setting-up for hybrid courses that can be taught both in-person and remotely, and other policies that will reshape how the Society engages our education mission.

I wish to all the IBS family a very happy 2021, hopefully with a quick return to normal life.

Sincerely,

Sidney Chocron

President, International Ballistics Society



THE 31ST ISB IN HYDERABAD

by Dinesh K. Pal

Terminal Ballistics Research Laboratory,
Chandigarh, India

For the first time, the 31st International Symposium on Ballistics (ISB-2019) was held in Hyderabad, India, from 4th to 8th November 2019, organised by International Ballistics Society, U.S.A. and The Aeronautical Society of India, Hyderabad Branch. The Symposium was co-chaired and inaugurated by Dr. V. K. Saraswat, Member, NITI Aayog, Government of India and Dr. G. Satheesh Reddy, Secretary, Department of Defence (R&D), Chairman DRDO and Chairman AeSI, Hyderabad Branch. It was convened by Dr. Y. Sreenivas Rao, Project Director, Area Defence and Secretary AeSI, Hyderabad Branch.



Inaugural ceremony of 31st ISB

Sh. KPS Murthy, Director HEMRL, Chairman AeSI Pune Branch and Chairman of ISB-2019 organizing committee, welcomed all the dignitaries and delegates and gave an overview of the symposium. During his inaugural address, Dr. G. Satheesh Reddy said that “symposium will fuel the growth of research and development in niche technologies associated with ballistics in India”. In Dr V. K. Saraswat address, he stated that ballistics being a very specialized technological field, requires in-depth understanding of various phenomenon, both theoretically and practically. In addition, it is essential to have state-of-the-art facilities and knowledge of

stringent safety requirements for development and testing. The keynote address was delivered by Dr. Ernest Baker, Technical Specialist Officer, Warhead Technology Munitions Safety Information Analysis Centre, NATO HQ. The event was attended by Directors, Project Directors, Industry partners, eminent academicians and senior members of AeSI, among others. Dr. Y.Sreenivas Rao thanked all the dignitaries, delegates, participants, exhibitors and sponsors. Dr. Rao specially thanked and appreciated Dr. Dinesh Pal and Mrs. Jayashree for their hard work and meticulous planning in organizing the symposium.



Dr. V. K. Saraswat, Member, NITI Aayog, Government of India at the exhibition hall

The symposium started with its unique tradition of one day tutorials for the benefit of students and beginners. 102 participants from India and abroad enrolled for the tutorials, which was delivered by six experts. The topics covered were : (i) Initiators by Dr. James Stuart, Franklin Applied Physics Lab., USA, (ii) Ordnance systems for aerospace applications by Baby Abraham, Group Director HESG/ASOE from VSCC, Trivandrum, (iii) High Energy Material Technology by Shri KPS Murthy, Director HEMRL, Pune (iv) Interior Ballistics of Guns by Clive Woodley, Imperial College, London, (v) Terminal Ballistics by Dr. Manjit Singh, Director TBRL, Chandigarh and (vi) Detonation and Deflagration by Prof. K. Ramamurthy, IIT Chennai.



Silver Life Membership Certificate being handed-over to TBRL delegates by Dr. Sidney Chocran, President of International Ballistics Society to Dr. Dinesh Pal and his TBRL delegates

The symposium had presentations in six key areas of ballistics consisting of internal ballistics, external ballistics, terminal ballistics, launch dynamics, explosion mechanics, and vulnerability and survivability. More than 400 abstracts were received, which was reviewed by expert reviewers from different countries. The symposium was attended by 274 participants with 114 from India and 163 participants from 30 different countries. The symposium had 72 oral presentations including 6 student awardee oral presentations, 198 poster presentations, 1 key note address and 3 plenary lectures. Scientists from more than 10 DRDO laboratories, participated.



Delegates attending the 31st ISB Hyderabad

Scientists and Experts from various prestigious and renowned laboratories in the world took

part in this symposium, such as Lawrence Livermore National Laboratory, Army Research Laboratory, Los Alamos National Laboratory, Sandia Lab, BAE systems, Imperial College, Cranfield University, BAE Systems U.K., South African Ballistics Organization (SABO), Fraunhofer Institute Germany, QinetiQ U.K., Picatinny Arsenal, USA,) and DRDO laboratories from India etc.



Address by the President of the IBS

The event was successful in increasing the visibility of the major advances and contributions that have been made in the field of defence, space and civil applications.



Celebration after successful completion of the 31st ISB Hyderabad

INCREDIBLE INDIA

by Thomas Hartmann
NUMERICS GmbH, Germany

The International Symposium on Ballistics (ISB) traditionally offers a high-level scientific program and it definitely followed this tradition in Hyderabad. But it is not the scientific program alone that makes this symposium so attractive. Therefore, also the venue and the social program should not remain unmentioned in this review of the 31st International Symposium on Ballistics.



S. Chocron and J. Walker at the opening ceremony

The 31st ISB was probably the most colourful symposium ever. The opening ceremony on Monday evening made clear that this symposium would be different from its predecessors. Thereby, the tribute to Saraswati, the Hindu goddess of knowledge, was just the introduction to a series of cultural experiences to be made throughout the symposium.



Indian traditional dance presented by professionals...



...and by beginners

The dinner at the Hotel ITC Kohenur on Tuesday night can be described a firework display of colours and interactive cultural sensations. Sing and dance performances from all part of India combined with traditional food and entertaining interludes made this evening not just memorable, but also gave the participants at least a small idea of the enormous cultural variety the country has to offer.



Drummers playing at the reception at ITC Kohenur

The excursion on Wednesday took the participants to the Golkonda Fort, a fortified citadel and an early capital city of the Qutb Shahi dynasty, which is listed as an archaeological treasure on the official "List of Monuments" prepared by the Archaeological Survey of India. Golkonda has a long and highly interesting history, which was brought to the participant in detail by professional guides.

*Entrance of Golconda Fort**Inside Golconda Fort*

Unfortunately, the planned visit of the Qutubshahi Tombs had to be skipped because of the enormous traffic on the roads. Therefore, the next stop was directly for High Tea at the Hyderabad Deccan Golf Course, which reflected India's British heritage and as such pictured another piece of India's multifaceted culture.

*Inside Chowmahalla Palace*

After tea, the groups were taken to the social events' highlight – the gala dinner. A better location for the gala dinner could probably not have been chosen. The inside of the impressive Chowmahalla Palace put into bright light provided a special atmosphere that made the short rain shower be forgotten in an instant. It also provided a unique scenery for the presentation of the Student Awards and especially for the epitaph to John P. (Jack) Riegel III, the Founding President of the International Ballistics Society, who had passed away 3 months before the symposium. This was definitely a memorable evening.

*Gala Dinner*

Finally, the charismatic Mrs. Shivani Sen, who presented the complete symposium, must also be mentioned. From the first to the last session as well as at the social events she was always there with a helping hand and a smile on her face. Thank you for that and a big thank you to all the organisers, who made it possible to experience "Incredible India" the way we did.

*Shivani Sen*

AWARD WINNERS

The International Ballistics Society assists the National Defense Industrial Association, QinetiQ, and the South African Ballistics Organization in the recognition of authors during the International Symposium on Ballistics.

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 31st ISB in Hyderabad the following students were awarded:

- **Guillaume Arnoult**, France

Category: Exterior Ballistics & Flight Dynamics

Title of Paper: *Aerodynamic Coefficient Reconstruction of a Controlled Spin Stabilized Projectile Using Mono and Multi Fidelity Surrogate Models*

University: ESTACA, France

- **Pratyashee Changmai**, India

Category: Interior Ballistics

Title of Paper: *On the Study of Automated Identification of Firearms Through Associated Striations*

University: Gawuhati University, India

- **Bir Bahadur Sherpa**, India

Category: Explosion Mechanics

Title of Paper: *Interface Study of Explosive Welded Al-Steel Joint Using Ultrasonic Phased Array Technique*

Institution: Ph.D Scholar at the Academy of Scientific & Innovative Research (AcSIR), India

- **Véronique de Briey**, Belgium

Category: Exterior Ballistics & Flight Dynamics

Title of Paper: *Influence of Crossing the Transonic Domain for Precision Ammunition*

University: Royal Military Academy, Belgium

- **Tatiana Evgenievna Zavodova**, Russia

Category: Terminal Ballistics

Title of Paper: *Using of Fluoropolymer Materials to Defeat Lightly Armored and Easily Vulnerable Targets*

University: Ural Federal University, Russia

- **Zetu Jiba**, South Africa

Category: Interior Ballistics

Title of Paper: *Coating Processes Towards Selective Laser Sintering of Energetic Material Composites*

University: University of Pretoria, South Africa



Jack Riegel Student Award winners

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 31st ISB in Hyderabad the award went to

M. Ravid, A. Weiss, A. Borenstein, V. Favorsky and N. Shapira

for their paper

Oblique Penetration of Metal Plates by 25mm APDS-T Projectile – Modeling and Verification



Louis and Edith Zernow Award presented to Moshe Ravid (right) by Ernest Baker

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 31st ISB in Hyderabad the award was presented to

A. Moumen

for his paper

Visualization of Muzzle Flow and Projectile In Flight Flow Using the Background Oriented Schlieren Technique



Rosalind and Pei Chi Chou Award presented to Abdelhafidh Moumen (left) by Paul Locking

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 31st ISB in Hyderabad the award was presented to

F. Majiet and F. J. Mostert

for their paper

Evaluation of the Dynamic Fracture Characteristics (Plasticity) of Shaped Charge Jets at Different Strain Rates and Characterised Initial Liner Microstructure



Neil Griffiths Award presented to F. Majiet (middle) and F. Mostert (right) 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 31st ISB in Hyderabad the award was presented to

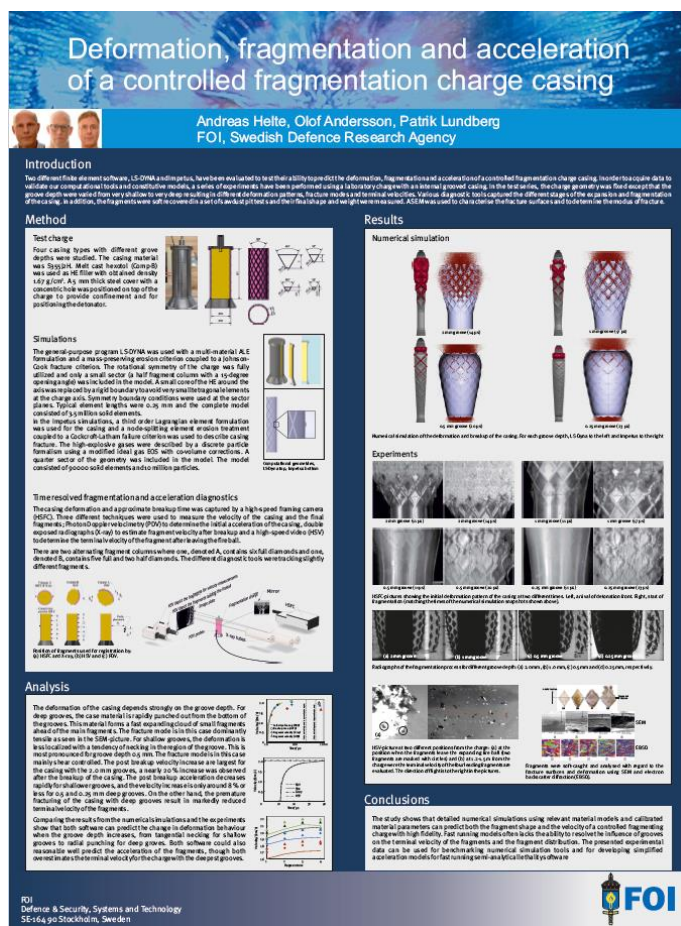
A. Helte, O. Andersson and P. Lundberg

for their poster titled

Deformation, fragmentation and acceleration of a controlled fragmentation charge casing



SABO Award presented to Olaf Andersson (middle) and Andreas Helte (right) by Tleyane Sono



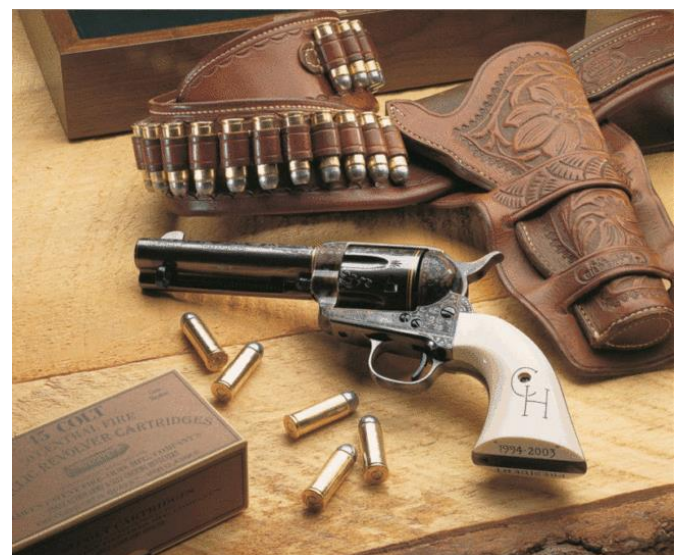
Award-winning poster by A. Helte, O. Andersson and P. Lundberg; click on the photo to open the poster as .pdf on the IBS website.

Congratulations to all award winners!

DID YOU KNOW...?

...that in the Wild West, it was most common to load 6-shot revolvers with only 5 rounds (the so-called 'Cowboy Load')?

The problem is that back in those days revolvers had rather simple trigger mechanisms. They were so-called single action – they required to cock the hammer before you could pull the trigger. This is why in old western movies the cowboys always use one hand to cock the gun and the other hand to aim and shoot. The striking pin in these revolvers was integrated with the hammer. It was a simple design, but it did have a rather dangerous flaw.



Single action revolver (Image credit: U.S. Fire Arms Mfg. Co. via Wikimedia (CC BY-SA 3.0))

The revolvers at that time had no safety mechanisms yet and in its resting position, the hammer was actually resting with the striking pin right on the percussion cap. In simple terms: a slight hit on the hammer could result in an unintentional shot. And there were many opportunities for such a hit. Just imagine a cowboy riding on a horse with the revolver flopping around? An accident was just a matter of time...

IN MEMORY OF JACK RIEGEL III

speech given by Todd Rumbaugh,
Hadland Imaging, USA
at the Gala Dinner at the 31st ISB in Hyderabad

“Good evening everyone – thank you Sidney (Chocron) and IBS community for the introduction and the privilege to speak with you on behalf of the Riegel family.

For those who may not know me, my name is Todd Rumbaugh and I am the President and CEO of Hadland Imaging. We specialize in high-speed and ultra high-speed, visible and IR photography, including X-ray and range instrumentation.

I first met Jack in the late 1990s when he worked at Southwest Research Institute. He used to tell people how excited and proud he was in purchasing and using one of Hadland’s early Imacon468 intensified cameras that recorded 100 million frames per second.

In 2006, Jack, Don Berry and I met up at the ARA conference and hung out every night at the bar till way past its closing... talking about life, ballistics, instrumentation, gas guns and the like. We had a blast. Jack was always fun to be around... never a dull moment, the conversation always stimulating and entertaining.

A few years later and several conferences past, I approached Jack and asked him if he would be interested in working part-time for Hadland. He told me he was retired and that he and his wife, Roxy, were moving from Virginia and building a house in Texas. I explained that we would be delighted if he were to join us when he could, and we would work him into the mix at Hadland.

Jack agreed that it was a perfect blend and match for us and joined Hadland in 2016.

ABOUT JACK

John P. Riegel III, better known as Jack, had a lifelong passion for the sciences, through which he made many personal and professional connections in a long career with defense technology and research firms. He was a natural leader and Ambassador and it’s no surprise he was the Founding President of the International Ballistics Society.

Jack held many titles over the years – from senior class president and captain of the football team in high school; scholarship recipient, educator and mentor during his college years; engineer, scientist, researcher and leader in his professional career.

Jack was a husband; a larger-than-life dad to his children and Santa Claus to his grandchildren. Jack was a shining example of a man devoted to his family, friends, community and making the world a little better through knowledge and personal commitment.

Jack’s wife, Roxy said, “He really enjoyed mentoring, teaching and getting involved with numerous organizations, always trying to make a difference in someone’s life and the community.”

Jack worked at Southwest Research Institute, where he spent 27 years. At the same time, he was an active member of multiple science-based organizations with an emphasis on ballistics, often holding leadership positions, including: The Founding President of the International Ballistics Society and chairman of the National Defense Industrial Association’s ballistics division.

In 1990, he acted as co-chairman to the International Symposium on Ballistics held in San Antonio Texas – one of the many annual conferences he attended around the globe. Jack’s travels led him to develop a wide assortment of friendships and professional relationships.

“He has friends and colleagues from all over the world,” Roxy said. “Everybody tells me he’s the smartest man they know.”

Following his extended time at Southwest Research, Jack moved to Washington DC to work for QinetiQ North America, and eventually, he went out on his own, starting a private consulting firm, R3 Technology, Inc. and in 2016 he went to work with Hadland Imaging.

Unfortunately, Jack passed away suddenly on September 8th, 2019 at the young age of 64. He had recently returned home after a surgery he had on August 25th. We last saw each other a few days earlier at the Aeroballistic Range Association (ARA) Conference in Milwaukee, Wisconsin. He was an incredible friend and colleague, devoted husband and father and he lived to help others. He is sadly missed everyday. A true ambassador to the Ballistics Community and life in general.

On behalf of his family and the community he loved and cherished, we are all honored that the student award has been renamed to recognize Jack’s many contributions to IBS. I know he is looking down upon us now and smiling. Thank you again for this opportunity to speak to you tonight and to International Ballistics Society and the 31st International Ballistics Symposium for all of their support.”



John P. Riegel III

NEWS FROM THE MEMBERSHIP CHAIR

by Clive Woodley

Institute of Shock Physics, Imperial College
London, UK

Chair of the Membership Committee

A warm welcome to all members, past and new, of the IBS from the Membership Committee (MC). Currently the MC comprises the following members, in alphabetical order: Dennis Baum, Markus Graswald (as Secretary), Thelma Manning (as Treasurer), Dinesh Pal and Clive Woodley (Chair). As many new members have joined the IBS following the very successful 31st ISB in Hyderabad in November 2019, it is worth reminding everybody of some of the benefits of being a member.

The IBS has a complete and unique archive (see File Store) of all the papers that have been published in the Proceedings of the ISB from the 1st to the 31st. These are all available to members, either free or at a discounted price, except for those papers published in the Proceedings of the 31st ISB. Papers from the 31st ISB will be available in May 2021, after the 32nd ISB has taken place – this delay is due to copyright agreements with the publishers, Destech. Each membership term, members can download, free of charge, a limited number of individual papers. The number of credits (equivalent to papers) is available in each member's login information page. For the 1st and 2nd ISB, all papers are free. In addition, many oral presenters at the recent ISBs have kindly made their presentations available in PDF format. These are all free to download, providing the IBS members with a unique resource. If you have any problems using the File Store then please contact the MC Chair at membership@ballistics.org.

One of the many enjoyable activities of the MC is reviewing the members to identify those who are eligible for promotion to Senior and Fellow.

These reviews are conducted at regular intervals, but members are always welcome to nominate people at any time. The MC conducted a promotion review earlier this year and recommended a number of members to the Board for promotion. Before listing those successful members, it is worth summarising the main guidelines for promotion to Senior and Fellow. For both levels a key criterion is that the member is active in some way. For Senior, the person should have been a member of the IBS for at least 8 years during which time they should have attended 50% of the ISBs held and having 4 papers published in that period. For Fellow, the person should have been a member of the IBS for about 20 years during which time they should have attended 50% of the ISBs held and having 10 papers published in that period. These are guidelines only. Accelerated promotion is possible by attending relevant courses, lecturing at relevant courses and serving on IBS committees. If you have attended a course and would like a record of it kept in your membership data then please contact the MC Chair at membership@ballistics.org.

The members promoted to **Senior** were:

Trent Shackelford	Fernand Vandeput
Sal Fanelli	Christine Dickinger
Mikhail Sotskiy	John Kump
Michael Markovcy	Matthew Kaufman
Jose Maccera	Zvika Bar
Bob Sykes	Thomas Borders
Michael Courtney	Stephan Boehmer
Jan Ferreira	Andras Nelhiebel
Nick Petti	Thomas Mason
Vasen Subroyen	Amy Courtney
Henry Embling	Bo Song
Kofi Nimoh	Usiel S. Silva Rivera
Nicolas Eches	Zvi Asaf
Jaroslav Pechacek	John Song
Heihachiro Iida	Sreenivas Rao
Vijay K. Saraswat	Baoming Li
Mark Helliker	Peng Huang

Stefan Buehler	Michael Minnicino
Jon Toreheim	Christer Thuman
Bartlomiej Plonka	Henry Chu
Guy Gettle	M. Nejad Ensan
Terje Egge	Robert Bowen
Carlton Adam	Thomas Hartmann
Tom Saghei	Zbigniew Leciejewski
Thomas Pettersson	Jonas Persson
Mark Riches	Linda Heuer
Michael Nusca	Roger Veldman
Todd Rumbaugh	Vic Kelsey
G. Jenaro de Mencos	Charles DeFrance
Sebastian Wurster	Dinesh Kumar B. Pal
Ove Dullum	Tleyane Sono

The members promoted to **Fellow** were:

Vladimir Cech	David Davison
Jim DeSpirito	Zheng-xiang Huang
Sergey Ladov	Stanislav Rolc
Nevin Rupert	Vladislav Veldanov
Adam Wisniewski	Xiao-bing Zhang

If you would like to nominate anybody, even yourself, for promotion then please contact the MC Chair at membership@ballistics.org.

EDUCATION COMMITTEE OUTLOOK WITH OUR CURRENT WORK ON LONG TERM EDUCATION STRATEGY FOR THE SOCIETY

by Markus Graswald

Chair of the Education Committee

When the International Ballistics Society (IBS) was founded in 2010 one of its stated objectives was: to enhance professional opportunities by providing short courses, opportunities for peer reviewed publications, and additional activities to promote career development of members of the International Ballistics Society. Successive

Presidents of the Society have tasked the Education Committee (EC) with the delivery of this objective.

The Education Committee (EC) considers the continuing education of our members to be an important benefit of membership in the International Ballistics Society (IBS) and it is our goal to develop offerings that meet member needs. Two member surveys have been performed by the committee in 2012 and 2017. Based on these results, a newly developed program of four introductory courses was held at the 30th International Symposium on Ballistics (ISB) in Long Beach in 2017. Attendees provided useful feedback for the EC.

The novel educational strategy has been designed to pursue the Societies objectives and enhance professional opportunities by providing an educational program on introductory and advanced levels in various delivery forms. It provides guidelines, policies, and procedures on such course programs. It may also help to increase the attractiveness of the Society through new career opportunities and other membership benefits leading eventually to more and / or longer memberships than in the past.

New aspects that are currently prepared or being considered are:

- The Education Committee has agreed a policy that places all courses under its control and direction. This policy was accepted by Board of Directors in June 2020. It places additional responsibilities on both the Education Committee and the local ISB organizer.
- Short courses during the Reno symposium in 2022 will be given in a hybrid approach to members personally attending on site and a parallel, interactive live stream to registered attendees.
- The Education Committee is also pursuing the idea of a make or buy-in approach where the committee offers a number of courses

they have developed as well as look to external subject-matter experts to deliver additional courses, e.g., advanced courses on specific topics of interest. This will ensure the EC is in full control of a course so does a high standard and quality over time.

If you have any feedback to us and / or if are experienced in training and education and like to actively support our committee, please contact us at education@ballistics.org.

THE IBS PERIODIC BULLETIN HAS A NEW LOOK

by Thomas Hartmann
NUMERICS GmbH
Petershausen, Germany
Chair of the Communications Committee

As a regular reader of the IBS Periodic Bulletin you will have noticed that this issue is looking different from its precursors.

After many years, Nicolas Eches had to give up the Chair of the Communications Committee so I have taken over from him. So first of all, I want to thank Nicolas (who will still be serving as a Board Member) for his hard and passionate work in the Committee and especially for all the effort he has put into the newsletter over the years. He has done a great job!

The new team is not fully set up yet and this is why it is not introduced here. However, postponed is not abandoned. We will catch up on this in the next issue of the newsletter.

Anyway, different people have different ideas, so the structure and the layout of the IBS Periodic Bulletin have been reworked. Besides a look on past and future events and information on the society's current work, decisions and plans, we intend to intensify the scientific topics.

Our idea was to include "Technical Notes", which offer the possibility to also share topics and findings with the community, which are usually not considerable enough for a journal or a conference paper.

We had therefore launched a call for contributions and the response was quite impressive. We had significantly more proposed topics than we could include in this issue and we thus had to reject several proposals. This was rather unfortunate because the rejected proposals were definitely not less interesting. We can just hope that these contributions will be offered again for the next issue...

THE NEWSLETTER NEEDS YOU!

In this issue, we have three contributions from different fields of ballistics. However, we will need more contributions in the future if we want to continue on our way.

Within the field of ballistics, there are practically no restrictions on the topics: experimental – numerical – theoretical. So, no matter if you have observed anomalies or failure in experiments, if you have improved a measurement technique or if you have found something interesting in a simulation – please consider sharing your finding with the community.

"We all need people who will give us feedback. That's how we improve." (Bill Gates)

This is true for all of us and we – the authors and editor – need feedback as a basis for improvement, too. So, tell us what you like about the newsletter – and especially, what you do not like; and of course, feel free to make suggestions.

For contributions, feedback and suggestions, please send an email to communications@ballistics.org.

FRENCH-GERMAN RESEARCH INSTITUTE OF SAINT-LOUIS (ISL)

**Frontline research for the development of
technical innovations in the fields of defence
and security**

edited by Teresa Fras, Patrick Gnemmi and
Vivienne Gaskell



Founded in the late 1950s, the French-German Research Institute of Saint-Louis (ISL) is a unique international research organisation jointly operated by France and Germany offering dedicated research in defence and security technologies fully in line with the future capability requirements of the armed forces.

Over the years, ISL has been recruiting scientists from all over Europe, providing the Institute with an unparalleled multiplicity of skills, multicultural diversity and research excellence.

ISL's frontline research activities are structured according to five major challenges and rely on the broad range of competences offered by highly specialised interdisciplinary teams. The five major challenges include energetic materials and systems, future gun systems and smart ammunition, survivability of weapon systems, protection and performance of dismounted soldiers and advanced situational awareness.

The breadth of the research portfolio varies from complex detailed simulations to free-field testing, which results in a comprehensive approach towards tangible solutions. ISL bridges a gap between studies proposed in a civilian perspective by the academic community and applications required by the military end-users. Because of its bi-national background, ISL acts at European level as a unique R&T hub of ideas and solutions developed for the benefit of frontline soldiers and interior civilian security.

MISSION

ISL is located on the French-German-Swiss borders in Saint-Louis, Southern Alsace, very near to the Swiss city of Basel and the city of Weil-am-Rhein in Southern Germany. Easy access to the Institute is ensured by the near-by EuroAirport and a railway station is situated at walking distance from the main ISL site. The proving grounds accessible via a 20-minute car ride allow a fast approach to the experimental stands when tests with larger masses of explosive materials or tests on flight systems are needed.

Currently, around 400 people are employed at the Institute and all the teams are multinational. The management, Research Advisory Board and Board of Directors are composed of both French and German members.

Synergistic scientific divisions perform their studies according to the instructions and programmes of the French and German Ministries of Defence. ISL research is also prepared through projects of the European Defence Agency. In the security sector, ISL activities cover the joint requirements of France and Germany through national or inter-ministerial research programmes of both countries. Multiple studies are also based on cooperation within the European Union, in particular through programmes of the European Commission (e.g. H2020). ISL also has the capacity to meet the specific requirements of third-party customers, either public-sector entities or private

industrial companies. The Institute has scientific partnerships with many universities and research institutes worldwide. Every year at ISL, around thirty theses are started in diverse disciplines. ISL researchers are internationally acknowledged and participate in international conferences, lecture at various universities and provide specialised qualification-improving training. In addition, ISL hosts a wide range of scientific symposia and conferences on site in Saint-Louis, bringing together academic and industrial experts from the areas of defence and security.

PIONEERS IN FRENCH-GERMAN COOPERATION

The first French-German research group settled in Saint-Louis in the very first days after the end of World War II. In late May 1945, Professor Hubert Schardin, a renowned German scientist, was invited to Saint-Louis to perform research for France. Initially regarded as a temporary solution, the originality and quality of the research results obtained coupled with the enthusiasm shown by the French and German co-workers led to the decision to continue research on more stable terms. The team headed by Ingénieur Général Robert Cassagnou developed into the “*Laboratoire de Recherches de Saint-Louis*” (LRSL) and the research continued on a binational basis. A treaty concluded by France and Germany on 31 March 1958 allowed ISL to commence officially its activities on 22 June 1959. Just ten years after the official foundation, the number of staff increased to 460 German and French scientists and engineers.

ISL was founded as a homogeneous binational research institute with its own legal personality. Its foundation anticipated the rapprochement between France and Germany, which was solemnly confirmed by the friendship treaty of 1963 and is constantly manifested in the policy of both nations. Until now, ISL brings together the best of these two technical-

scientific cultures as well as highly qualified talents from all over Europe.



French and German Ministers of Defence, Franz-Joseph Strauss and Jacques Chaban-Delmas sign the ISL treaty, 31 March 1958


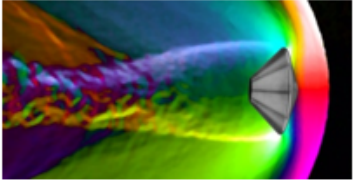


RESEARCH ACTIVITIES

ISL research is carried out in various specialist fields and at differing technology readiness levels (TRLs), from basic research to the development of preindustrial prototypes that can be integrated into operative equipment. Ultimately, the objective of ISL research is to provide partners and customers (public funders, industrial partners and end-users) with technological solutions, which can be embedded through an industrial development process into operational equipment.

The research investigations performed at ISL are divided into four major disciplines, each of them treating several research domains.

SELECTED TEST FACILITIES

To carry out a large number of diverse investigations, the Institute has well-equipped laboratories with modern devices and experimental set-ups, including:

	ISL Divisions	Few exemplary topics
	Energetic and advanced protective materials	<ul style="list-style-type: none"> ➤ Development of energetic nanomaterials for application in <u>detonics</u> and interior ballistics ➤ New ways of improving the ballistic properties of materials and their compositions for protection systems ➤ Improving weapon efficiency: ignition of propellants, synthesis of enhance-performance of energetic materials
	Flight techniques for projectiles	<ul style="list-style-type: none"> ➤ Improving the controllability of solutions to enhance their efficiency, to reduce collateral damage and the logistics' footprint ➤ Innovative aerodynamic architectures and control devices to reach metric precision and ranges of over 100 km ➤ Developing bidirectional communication and telemetry systems
	Laser and electromagnetic technologies	<ul style="list-style-type: none"> ➤ Development of high-energy eye-safe lasers ➤ Increasing muzzle energy and the development of realistic projectiles for electromagnetic railguns ➤ Power supply technologies for pulsed high-power applications
	Protection technologies, security, situational awareness	<ul style="list-style-type: none"> ➤ Advanced localization methods based on video systems and active imaging systems ➤ Kinetic and explosive threats defeating by optimized techniques of destruction, neutralization or mitigation e.g. an application for a new French-German MGCS) ➤ Development of novel protection systems for individual soldiers, e.g. hearing protection with enhanced communication features ➤ Research on autonomous sensors for zone surveillance and self-learning of sensing systems

Main research disciplines and some topics investigated at ISL

- A multipurpose free-flight outdoor testing range tailored for flat firing of free-flight models, such as i.e spin- and/or fin-stabilized projectiles and space vehicles
- Guns and launchers for standard ammunition or arbitrarily shaped projectiles instrumented with high-speed cameras, flash x-rays and full field deformation measurements with Digital Image Correlation

- Stands to conduct field tests concerning protection against explosive and ballistic threats for mobile platforms and infrastructure
- Trisonic wind tunnel to study the flight behaviour of objects in speed conditions ranging from the subsonic via the transonic to the supersonic domain and offering the possibility to do low-cost testing using models at a reduced scale.
- Spark Plasma Sintering device offering the possibility to obtain solid materials from powder and bulk material within a very short time using metals, ceramics, polymers and composites
- Hopkinson bars to perform material characterisation at very high strain rates
- Fibre-coupled, moveable spectrometer for comprehensive THz spectroscopy characterisation
- High-power industry laser sources to investigate the physical and chemical degradation of materials when subjected to a laser beam
- Clean room class 100 for development and consolidation of power semiconductor process capabilities from single chip to 100-mm wafer size
- Acoustic chambers to test acoustic sources, sensors and audio equipment in various controlled conditions of the acoustic environment.

A front-line mover for the last 60 years, ISL's innovations stem from its in-depth knowledge of physical phenomena, its cooperation with other research institutes, the academic world and numerous public and private partners as well as from its capacity to adapt and develop an open culture based on the cross-fertilisation of ideas. Thanks to its binational status, ISL has an important role to play as catalyser for future cooperation within the framework of the European Defence Fund. ISL's input

regarding the improvement of protection and security systems has earned recognition from the scientific and defence communities at international level. As in the past, ISL is committed to continuing its frontline research in the interests of defence and security for France and Germany, taking a leading role in Europe.



Examples of ISL test facilities Top to bottom): trisonic wind tunnel, anechoic chamber, explosive test stand and 1000 m firing line on the proving ground

For more information please visit the official ISL page <https://www.isl.eu/>.

SPECTRAL RED-SHIFT IN DEFLAGRATION

by O. J. Morley, D. M. Williamson
Cavendish Laboratory, The University of
Cambridge, Cambridge, UK

INTRODUCTION

The study of the ignition and growth of reaction in energetic materials is an important and continually active research area. The requirements by end-users for their weapons to meet defined confidence levels in their safe storage, transport and deployment represent a significant challenge.

This challenge demands an integrated numerical simulation-experiment methodology to both characterize and validate material and reaction models and predict the output of a system when subjected to thermo-mechanical stimuli.

The use of laboratory-based testing permits the deployment of instrumentation to measure the response of an energetic material.

These detailed experimental data have in-turn stimulated the development of improved, physically based material and reactive flow models and numerical techniques to explain the experimental observations. The predictions made by the new models then stimulates the development of new instrumentation techniques to validate them.

The team at the Cavendish laboratory has been active in this area for many years to provide experimental measurements of the physical properties of energetic materials and their response to various stimuli. A core element of this research has involved the application of existing instrumentation techniques in new ways and the development of new instrumentation methods that exploit the physics of materials under dynamic conditions.

A current area of research seeks to exploit the optical spectroscopy of a range of energetic reactions. This research is part of Olivia Morley's PhD studies in conjunction with her supervisor David Williamson.

TEST DESCRIPTION

The optical emission of HMX deflagration has been studied, exploiting the presence of highly emissive sodium impurities. The emission spectrum of sodium is characterized by the sodium D-lines, which are red-shifted under pressure.

Deflagration was initiated using both a conventional fall-hammer and – for the first time – a Hopkinson bar apparatus, allowing a wider range of deflagration conditions to be observed. Measurements were taken of the sodium peak position, Fig.1, which permitted determination of the temperature (T), and the reaction pressure (P). This allowed the red-shift of sodium under deflagration conditions to be calibrated¹ at $(950 \pm 30) \text{ PT}^{-0.7} \text{ nm}$, being in good agreement with collisional theory estimates, Fig. 2, and allowing an optical measurement of pressure which can be exploited in a range of experiments.

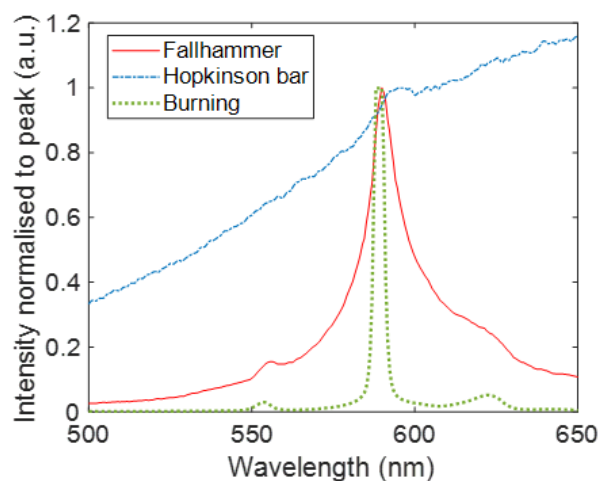


Figure 1: Sodium peak as seen in the emission spectrum of HMX burning, and in fall-hammer and Hopkinson bar deflagration.

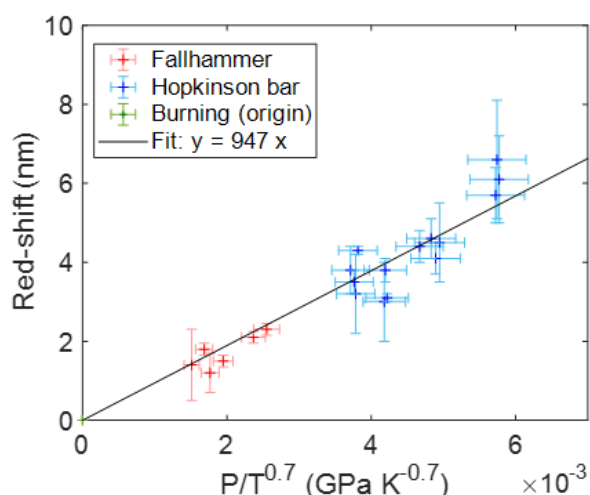


Figure 2: Position of peak centre against functional form given by collisional theory.

This new optical measurement provides a method for determining both the temperature and pressure of reaction in a material under a range of loading conditions. This in turn has the potential to provide a data that will challenge existing ignition and growth of reaction models.

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CHALLENGES IN DEVELOPMENT OF MULTI LAYERED FRAGMENTATION WARHEAD

by K.D. Dhote, P.N. Verma

Armament Research and Development Establishment (ARDE), Pune, India

INTRODUCTION

Airborne targets are effectively neutralized by preformed fragmentation warheads. Design of optimum warhead needs precise estimation of fragment spatial distribution. Analytical models, simulations and experimental data are employed for design. The methodology for single layer fragment arrangement on explosive filled casing is well researched. On explosion of multi layered fragmentation warhead, fragments undergo complex interactions causing to wide dispersion. The article presents the challenges in simulation and experimental techniques for dispersion study, which assist in tailoring fragment spray as per weapon system requirements.

SIMULATION

The physics of multi layered fragment separation dynamics is explained in the reference [1]. Predominance of shock wave transmissions is for a few microseconds and explosion gas dynamics is for tens of milliseconds. Shock wave reverberations causes initial fragment separation and deformation. Simultaneously, gas dynamics comes into play leading to casing expansion and acceleration of fragments. Fragment in the layer closest to the explosive attains highest acceleration causing impact on next fragment and so on. Multiple interactions between the fragments happens before it gets separated and attains final velocity and direction. Separate domains of shock transmissions or flow dynamics or contact dynamics have

been dealt by many researchers both analytically and using simulation techniques. But, combined effect from explosive detonation till final dispersion of the fragments in the multi layered fragmentation warhead is highly complex. It involves changing physical phenomena from hydrodynamic shock compression of solids to fluid-structure interaction to contact dynamics which depends on mechanical strength of material. Explicit dynamics simulations do help to some extent in understanding these nonlinear phenomena. However, they are computationally extensive and require long run time.

EXPERIMENT

Experiments also involve its challenges in recording the shock dynamics events as well as the subsequent interaction of the fragments in presence of detonation products. Flash x-ray technique to capture all the fragments laid in single layer and its analysis for dispersion is given in reference [2]. Similar technique was adopted for multiple layered fragmentation warhead. X-ray image along with warhead configuration is shown in Fig. 1. Fragment dispersion is high due to multi layered arrangement and all the fragments could not be captured in flash x-ray. Main limitation was experienced in conclusively correlating partially captured fragment beam to assess dispersion.

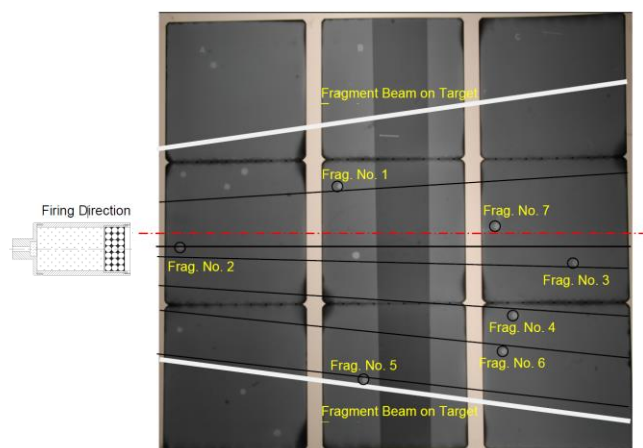


Figure 1: Flash x-ray trials.

High Speed Camera (HSC) is an alternate technique wherein captured fragment spatial location can be traced back to its original position before explosion [1]. Typical test arrangement is shown in Fig. 2. A fragment generator warhead (FGW) is placed on a wooden stand. On firing, HSC records fragment impact on particle boards. Then, recovered fragments from straw boards assist in correlating its origin due to sequential fragment arrangement in multiple layers where in each fragment has unique identification number engraved. Test warhead and recovered fragments are shown in Fig. 3.

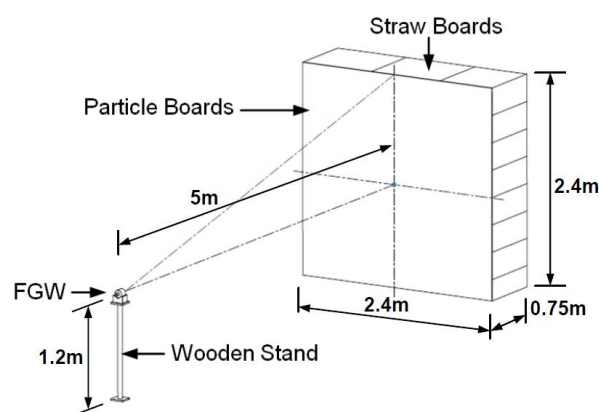


Figure 2: Initial experimental arrangement.



Figure 3: Test warhead and recovered fragments.

CONCLUSION

In brief, limitations of simulation and experimental techniques experienced by the authors are presented. Test methods to evaluate multi layered directional fragmentation warheads are discussed. The method using HSC along with soft recovery is generic in nature and being adopted for evaluation of various

fragmentation warheads. The data generated by these tests help in development of warheads to generate tailored spatial distribution as per weapon system requirements.

ACKNOWLEDGMENT

We are thankful to director ARDE for encouraging and permitting to publish the article.

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TECHNIQUE TO EMBED AN INFLATED LUNG INTO A GELATIN BLOCK

by Amy Pullen^{1,2}, David Kieser^{1,2}, Thomas Plummer² and Gary Hooper¹

¹University of Otago, Christchurch, NZ, ² New Zealand Defence Force

INTRODUCTION

Physical injury models are usually based on animals; however, tissue simulants such as ballistic soap and gelatin have been used as synthetic injury models[1-7].

Ballistic gelatin was developed as a model to replicate projectile behaviour within porcine thigh muscle [8-11]; therefore using gelatin as a tissue simulant is best reserved for comparisons rather than using it as a surrogate.

Tissue simulants are commonly used in ballistic evaluations and are considered best practice, but there is an ongoing debate about their relevance and the use of tissue simulants[4, 5] along with calls to improve the anatomical relevance of synthetic injury models by introducing bony structures and organs[5].

Therefore, this technical note describes a tested and proven technique to embed a single inflated porcine lung into ballistic gelatin.

METHOD

When procuring lungs, they typically come as a set with a portion of the trachea, and therefore they will need to be separated to allow a single lung to be embedded. Lungs should be cleaned to remove any blood and inspected for structural integrity to ensure they are capable of being inflated and will not fill with gelatin.

Using a sharp scalpel, carefully separate the lungs, ensuring not to accidentally slice the lung, and to leave enough of the bronchus to be able to clamp it to prevent the lung filling with water or gelatin (Figure 1), weigh the lung and record the weight. Fit a flexible plastic tube into the trachea and tightly cable tie the bronchus to prevent the tube from falling out (Figure 2).



Figure 3: Separated lung



Figure 4: Lung with flexible tube inserted and cable tie positions

Fill a container with water and place the lung in the water, lungs are naturally buoyant and will float; therefore, they will need to be held under the water. Slowly fill the lung with dry air or nitrogen and use water displacement to determine the quantity of air that the lung has been inflated with. Clamp off the tube using a strong spring clamp and fill the end of the tube with putty.

Make a batch of gelatin and allow to cool to 45°C (it should be noted that if the gelatin is too hot, it will cook the lung). Once the gelatin has cooled, pour it into the mould to approximately 50mm below the top of the block height and place the lung into the gelatin and let it float on the surface.

Use a brace to hold the lung at 50mm from the intended block surface and top up the gelatin to the top of the brace (Figure 3). The lung should now be completely submerged by gelatin. Leave the blocks to set overnight at ambient temperature. The following day carefully remove the brace and top the mould up with gelatin that has cooled to 45°C (Figure 4). Leave to set overnight and transfer to chiller. If the brace cannot be removed without damaging the integrity of the lung, it is possible to shoot the lung through the gaps in the brace.

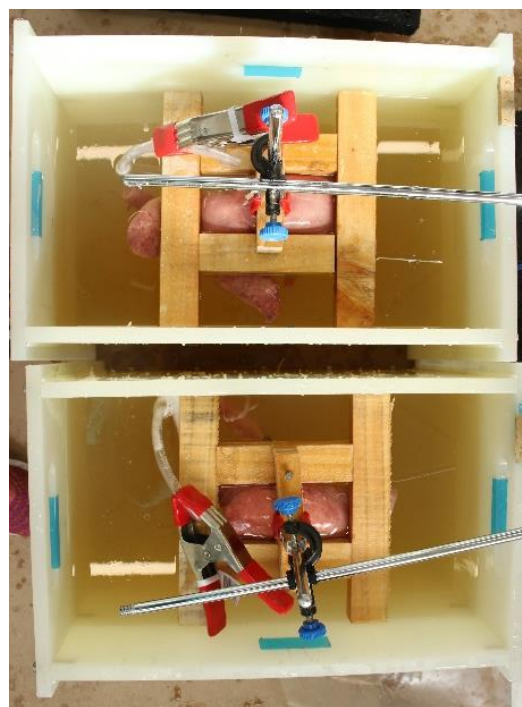


Figure 5: Lungs submersed by gelatin and retained by wooden brace

Remove the blocks from the moulds carefully ensuring not to pull on the plastic tube.



Figure 6: Mould topped up with gelatin

Before firing calibrate the gelatin [12], ensuring not to impact the lung. Stand the block on its end and if necessary, back with a calibrated plain gelatin block and strap them together (Figure 5). Although this creates interaction of the projectile passing from one block into another, testing has indicated that this has little effect (Figure 6). After shooting, remove the lung from the gelatin and reweigh it to ensure that gelatin has not seeped into the lung.



Figure 7: Lung model backed by plain gelatin block and strapped together



Figure 8: Temporary cavity formation across the gelatin blocks after projectile has passed through lungs

ACKNOWLEDGMENT

This research was funded by the Defence Technology Agency, New Zealand Defence Force

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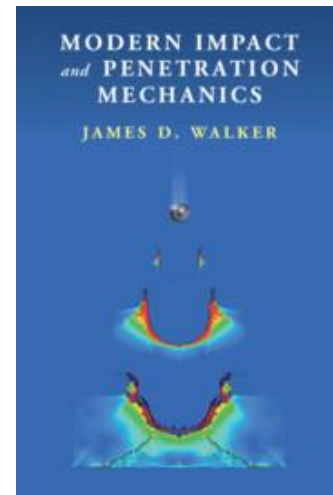
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BOOK (P)REVIEW

In this issue we present a book for those wanting to see and understand the mechanics of extreme dynamic events:



The book has not been published yet (available from February 2021), but it promises to cover the complete range of topics involved in impact and penetration mechanics: continuum mechanics, the Hugoniot jump conditions, plasticity theory, damage and failure theory, shock and wave propagation in both Eulerian and Lagrangian frameworks, and the high pressure and high-rate response of materials including their constitutive modeling. Additionally, a series of applications examples and extensive exercises shall ensure comprehension and explore new topics.

This book is supposed to be appropriate for a variety of graduate courses, including Continuum Mechanics, Advanced Solid Mechanics, and Plasticity and Inelasticity Theory.

The author's name speaks for itself, so we may have high expectations...

AUTHOR: James Walker, Southwest Research Institute, Texas

FORMAT: Hardback

ISBN: 9781108497107



32ND INTERNATIONAL SYMPOSIUM ON BALLISTICS

RENO, NEVADA MAY 2022

The International Symposium on Ballistics (ISB) traditionally allows exposure to the most current state-of-the-art technology in ballistics, provides opportunities for interactions with some of the world's leading experts in the field of ballistics technology and offers the chance to present, exhibit and share scientific research and development with international group of professionals.

The International Symposium on Ballistics brings together experts to promote and facilitate the exchange of technical information; establish standards; effect coordination of research, exploratory development, and advanced development programs in the fields of External and Internal Ballistics, Launch Dynamics, Terminal Ballistics, Vulnerability and Survivability, Explosion Mechanics, and Emerging Technologies (Directed Energy and Hypersonics); and accomplish problem solving in areas of joint interest.

The society encourages the presentation of a wide range of papers at the ISB, from work in

progress through to high quality scientific papers. This is an exciting opportunity to learn and share with others in the field.

As the venue for the upcoming 32nd International Symposium on Ballistics, the Board of Directors has selected Reno, Nevada, USA. The ISB will take place in the week of May 7, 2022.



IMPORTANT DATES

The dates for abstract submission and for the submission of the Defence Technology (DT) Special Issue have not been fixed yet.

The complete timeline will be published on the ISB website soon.

VENUE

The symposium venue will be the Peppermill Resort Spa & Casino in Reno. Reno is located in the northwest section of the U.S. state of Nevada, about 22 miles (35 km) from Lake Tahoe and is known as "The Biggest Little City in the World". Reno is the county seat and largest city of Washoe County and sits in a high desert river valley at the foot of the Sierra Nevada.



Skyline and Downtown Reno

Reno offers a wide range of entertainment and educational attractions, many of which are also ideal for families. Some of the fun and unique things to do include hot-air balloon races, bowling tournaments, car shows, and concert performances. Reno also makes a great base if you are planning to visit the Lake Tahoe

recreational area 45 minutes away, as well as Pyramid Lake to the northeast of the city.



Reno Rodeo



Emerald Bay at Lake Tahoe

The Peppermill Resort Spa Casino is Reno's Premier AAA Four Diamond resort, boasting 1,621 luxurious guest rooms including the 600-room all-suite Tuscany Tower. Visit the remarkable three-story, 33,000-square-foot Spa & Salon Toscana featuring 24 treatment rooms, Northern Nevada's only Caldarium with indoor pool, sun deck and full-service salon.



The Peppermill Resort pool area

Enjoy slots, table games and poker in the 82,000-square-foot casino and race & sports book. Resort amenities include a posh 9,900-square-foot fitness center; two beautiful pools and three outdoor jetted spas, heated with on-site geothermal energy; designer boutique shopping, free WiFi Internet access for all guests; An exciting assortment of bars and lounges, including the iconic Fireside Lounge; and 9 award-winning restaurants offering authentic Chinese, inspired Italian, steaks and chops, seafood, deli and café dining.

Join us in Reno, Nevada in May 2022 and enjoy the beauty of the area while you meet with colleagues from around the world in this unique setting.

For information on sponsorships, exhibiting, and attending contact Clay Tyeryar at ctyeyar@asmii.net or +1 (703) 533-0251.

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TUTORIAL PROGRAM PLANNED FOR RENO

by Markus Graswald,
Chair Education Committee

Tutorial courses will be an integral part of each International Symposium on Ballistics. The major focus is, therefore, setting up a program of short courses in all fundamental areas of ballistics that can be provided at each symposium. These courses will be designed on an either introductory level (101s) or advanced level (201s) and are addressed towards R&D or technical managers, practitioners, students, or experts from other ballistics fields or engineering areas.

For the upcoming symposium in Reno, Nevada, USA, in 2022, we are currently considering setting up a program with a maximum of seven short courses:

- Introductory interior ballistics (IB101)
- Introductory launch dynamics and exterior ballistics (EB101)
- Introductory explosion mechanics (EM101)
- Introductory terminal ballistics (TB101)
- Introductory material tests & modeling (MT101)
- Advanced material tests & modeling (MT201)
- Introduction to hypersonic flight from a ballistic point of view (HY101)

These courses will be organized by the Education Committee and facilitated by ASMI. We plan on a hybrid approach, i.e., for members personally attending on-site and a parallel, interactive live stream to registered attendees. We recently launched a broadcast call looking for instructors providing proposals to the courses listed above. The final selection of the courses offered will be made nearer to the symposium. We will keep you updated!



“THE DIFFERENCE”

TDW Gesellschaft für verteidigungstechnische Wirksysteme mbH,

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- **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:

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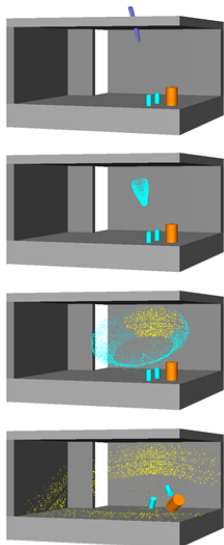
Southwest Research Institute (SwRI®) is a nonprofit engineering R&D center. The main facility is a 1200-acre campus in San Antonio, Texas where over 3000 employees perform contract research for both government and industry. SwRI's Engineering Dynamics Department in the Mechanical Engineering Division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

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



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| SPLIT-X: | Fragmentation Warhead Expert System |
| FI-BLAST: | Analysis of Combined Blast / Fragment Loads on Structures |

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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.

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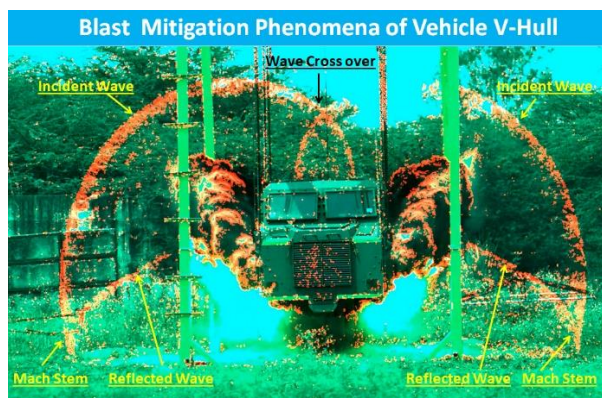
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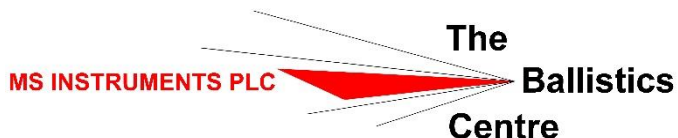
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