8th International Forum on Blast Injury Countermeasures

1 - 3 May 2024

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Preface

This report documents the proceedings of the 8th International Forum on Blast Injury Countermeasures (IFBIC). The forum provides a venue for experts from around the world to share information on emerging research, discuss critical knowledge gaps, and develop new partnerships.

IFBIC 2024 was hosted by The MITRE Corporation, a private not-for-profit company that manages several Federally Funded Research and Development Centers (FFRDCs), chartered in the public interest by Congress to address science and technology challenges facing the federal government. In support of the U.S. Army Medical Research & Development Command (MRDC), the MITRE-operated Center for Enterprise Modernization FFRDC sponsored by the U.S. Treasury, Internal Revenue Service, performed this task under an Indefinite Delivery Indefinite Quantity contract (TIRNO99D0005, delivery order "Support for DoD Blast Injury Research Coordinating Office", HT9425-24-F-0267).

The Defense Health Agency, the Under Secretary of Defense for Research and Engineering (USD(R&E)), USAMRDC, the U.S. Department of Defense (DoD) Blast Injury Research Coordinating Office (BIRCO), and the National Defense Medical College (NDMC), Ministry of Defense, Japan, jointly sponsored IFBIC 2024. MITRE hosted the Forum at its McLean, VA, campus on 1–3 May 2024.

This report highlights research topics and key themes addressed in the presentations, outcomes of the discussions, and recommended actions.

Executive Summary

The 8th International Forum on Blast Injury Countermeasures (IFBIC), held 1–3 May 2024, brought together participants from United States, Japan, the United Kingdom, Germany, Canada, Italy, and Australia with a broad range of expertise related to blast injury prevention, mitigation, and treatment. The forum provides a venue at which blast injury experts can discuss in-process research and exchange creative ideas to inform future research and operational recommendations. Outcomes of previous forums have supported updates to experimental methods and new partnerships for collaborative research initiatives. This report summarizes the presentations and findings, highlighting emerging research and themes of importance to the blast injury community.

The objectives of the 8th forum included:

a) Assembling an international forum focused on multi-disciplinary science and medicine is necessary to increase our understanding of blast injury and its countermeasures from bench to bedside.

b) Achieving a mutual understanding of international efforts in blast injury research.

c) Identifying knowledge gaps requiring collaborative research.

d) Increasing understanding and promoting further collaboration to improve prevention, clinical diagnosis, and treatment addressing the entire spectrum of blast-related injuries.

The forum provided the opportunity for participants to present innovative research, discuss urgent threats, and identify solutions. The international cross-disciplinary collaboration supports rapid investigation into the causes of blast injury and characterization of vulnerabilities, and informs countermeasures to prevent, mitigate, and treat blast injuries. Countermeasures include personal protective equipment; weapons and vehicle systems engineered for safety; tactics, techniques, and procedures for injury prevention; and medical interventions tailored to the treatment of blast injuries.

The diverse backgrounds of participants enabled the forum to increase awareness of strategies and research techniques across domains – an opportunity not offered at conventional scientific meetings. Participants shared preliminary findings, exploratory studies, and other work in progress, allowing early feedback, work shaping, and collaboration among participants.

The forum highlighted the potential impacts of ongoing research efforts such as providing increased injury prediction accuracy, preventing injuries through materiel and administrative control solutions, detecting injuries when they occur, improving treatment outcomes, and establishing accurate research models for both the blast exposure and biological impacts. Findings from the forum included that there is insufficient information to inform blast injury treatment, limited data on blast exposure and the effects of different environments on Service member exposures, there is no requirement to support blast sensor acquisition, the complex relationship between blast exposures and injury is not yet well understood, and it is difficult to translate findings from emerging research into actions to prevent, mitigate, and treat blast injuries. Overarching recommendations were identified based on the review of current research, knowledge gaps, challenges, and planned future research by the community: 1) consider the full range of blast exposure effects, 2) improve diagnosis and monitoring of blast effects, and 3) take a multifaceted approach to developing countermeasures to blast injury.

Table of Contents

Introduction and Background

International cross-disciplinary collaboration supports rapid investigation of blast injury causes and characterization of vulnerabilities, and informs countermeasures to prevent, mitigate, and treat blast injuries. Countermeasures include various types of personal protective equipment (PPE); weapons and vehicle systems engineered for safety; tactics, techniques, and procedures (TTPs) for injury prevention; and medical interventions specifically tailored to treating blast injuries.

The Department of Defense (DoD) Blast Injury Research Coordinating Office (BIRCO), in collaboration with the National Defense Medical College (NDMC), Ministry of Defense, Japan, sponsored the 8th International Forum on Blast Injury Countermeasures (IFBIC), hosted by the MITRE Corporation on 1–3 May 2024 in McLean, Virginia. Over 140 individuals registered for the meeting, including blast injury experts from Australia, Canada, Germany, Italy, Japan, the United States, and the United Kingdom. During the meeting they shared information about knowledge gaps and described their approaches, insights, and recommendations for improvements in prevention, clinical diagnosis, and treatment of blast-related injuries.

The diverse backgrounds of the participants enabled the forum to increase awareness of strategies and research techniques across domains – an opportunity not offered at conventional scientific meetings. Participants presented preliminary findings, exploratory studies, and other efforts in progress, allowing early feedback, work shaping, and collaboration among forum participants. Discussions spanned blast injuries described in DoD Directive 6025.21E (Figure 1).

PRIMARY
- Blast lung
- Eardrum rupture and middle ear damage
- Abdominal hemorrhage and perforation
- Eye rupture
- Blast-induced mild traumatic brain injury (mTBI)

SECONDARY
- Penetrating ballistic (fragmentation) or blunt injuries
- Eye penetration

TERTIARY
- Fracture and traumatic amputation
- Closed and open brain injury
- Blunt injuries
- Crush injuries

QUATERNARY
- Burns
- Injury or incapacitation from inhaled toxic fire gases

QUINARY
- Illnesses, injuries, or diseases caused by chemical, biological, or radiological substances (e.g., "dirty bombs")

Figure 1. DoD Directive 6025.21E definitions of blast injuries

IFBIC started as the Japan–U.S. Technical Information Exchange Forum on Blast Injury (JUFBI), which brought together researchers with a broad range of knowledge and expertise to share national experiences and evidence-based approaches pertaining to blast injuries. JUFBI held meetings in June 2016, April 2017 and May 2018, all in Tokyo. At the end of JUFBI 2018, the organizing committee decided to change the organization's name to International Forum on Blast Injury Countermeasures to reflect the participation of additional nations such as Australia, Canada, Germany, South Korea and the United Kingdom.

The 8th forum had the following broad objectives:

- Assembly of an international forum focused on multi-disciplinary science and medicine necessary to increase our understanding of blast injury and its countermeasures from bench to bedside.
- Achieving a mutual understanding of international efforts in blast injury research.
- Identifying knowledge gaps requiring collaborative research.
- Increasing understanding and promoting further collaboration to improve prevention, clinical diagnosis, and treatment addressing the entire spectrum of blast-related injuries.

Emerging Research Related to Blast Injuries

Participants in the 8th IFBIC represented a broad range of organizations across academia, industry, and governments (see Appendix C for a list of participants). The forum featured 56 presentations, including briefings by leadership, program managers, and researchers (see Appendix B for the meeting agenda). Eight keynote presentations provided information that spanned national strategies and introduced deep insights into broad areas of blast injury prevention, diagnosis, and treatment. The technical presentations addressed emerging blast injury research and the importance of collaboration. Topics included exposure monitoring at the population level, detection/diagnosis of effects resulting from both acute and cumulative exposures to blast, computational modeling, and considerations for injury prevention and treatment. Discussions following the presentations covered important areas for potential exploration such as improving the healthcare benefits and treatment of blast injuries, enhancing capabilities to monitor exposure, establishing requirements to enable fielding of wearables for blast measurement, correlating blast exposures to injury, and translating research into practice to meet immediate operational needs.

The following sections summarize the information presented, grouped by topic rather than by the order followed in the agenda.

Welcome

Dr. Troy Mueller, MITRE's Managing Director for the U.S. Department of Veterans Affairs and the Defense Health Agency (DHA), welcomed participants to the MITRE campus. He described MITRE's status as an independent not-for-profit company that operates six Federally Funded Research and Development Centers (FFRDCs), which deliver unbiased technical expertise to help the U.S. Government solve complex challenges. MITRE supports BIRCO by collating information gathered from scientific research, subject matter experts, and DoD stakeholders, and reviewing the state of the science to provide recommendations in support of BIRCO's mission.

Figure 2. Goals of the 8th International Forum on Blast Injury Countermeasures.

Dr. Raj Gupta of BIRCO and Dr. Satoko Kawauchi of NDMC, co-chairs of IFBIC 2024, then welcomed participants and noted the importance of collaboration on blast injury prevention, mitigation, and treatment to improve health outcomes (Figure 2). They highlighted the far-reaching collaboration across laboratories and nations that help meet this goal.

COL Jake Johnson, Director of BIRCO, introduced the U.S. Army Medical Research and Development Command (USAMRDC) and BIRCO, noting that BIRCO is in the process of transitioning to DHA. He emphasized the critical role of research, since the DoD lacks sufficient information to solve the problems of blast injury prevention, mitigation, and treatment. He noted there that the research community has many opportunities for collaboration (Figure 3.)

Figure 3. Examples of opportunities for collaboration

COL Johnson then introduced his fellow General Cochair, Dr. Satoshi Tomura, Professor in the Division of Traumatology, Research Institute, NDMC. Dr. Tomura also welcomed the participants and thanked the meeting hosts for their support and for supplying the meeting venue. He commented on the large size of the meeting, with more than 140 participants from seven countries, and stated that he looked forward to fruitful discussions at the forum.

Lieutenant General Naruo Kuwada, NDMC's Vice President, reported that the college has graduated over 2,000 doctors and 700 nurses. He emphasized the severity of the challenges to the security environment faced by the Japanese Self Defence Forces (JASDF), stating that Japan must adapt to new threats and methods of warfare. He suggested ways of enhancing Japan's defense capabilities, transforming the medical function, and promoting defense cooperation in military medicine. He underscored the need for adapting to new challenges and mentioned updates to Japan's National Defense Strategy, including strengthening defense capabilities in seven key areas. He also noted NDMC's efforts to modernize medical education, learned from recent conflicts and potential lessons from Ukraine. He concluded by stressing the importance of international collaboration, citing examples of collaboration between Japan's Air Defense Force and the 711 Human Performance Wing on examining jet fuel toxicity and analysis conducted jointly by the Uniformed Services University (USU) of the Health Sciences and NDMC on storage of genetic material and other specimens (Figure 4).

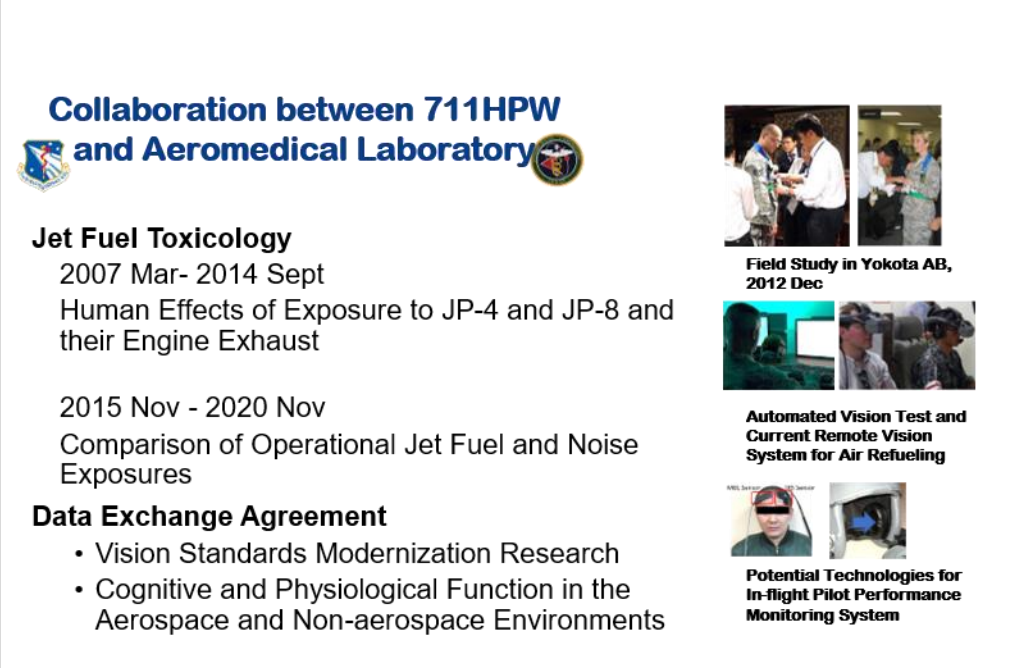


Figure 4. US and Japan cooperative research project in Koku-Jieitai

Dr. David J. Smith, the U.S. Deputy Assistant Secretary of Defense for Health Readiness Policy and Oversight, described the DoD's efforts to mitigate blast-related brain injuries. He praised the IFBIC partnership and researchers' work to address gaps and understand the impact of blast-related threats on Service member's cognitive and physical performance. He reported on the DoD's efforts to monitor, measure, and store data, which include blast modeling and collection of data on cognitive function (Figure 5). He mentioned the DoD's November 2022 guidance that focuses on minimizing blast exposure effects. The DoD is refining this guidance, collecting exposure data, and conducting a business case analysis to improve exposure monitoring. The DoD also works with partners such as the North Atlantic Treaty Organization (NATO) and leverages capabilities developed by researchers and Service members such as U.S. Special Operations Command's novel 3D printing methods for improving directionality of the blast pressure during wall breaching operations. Dr. Smith emphasized the need to translate more research findings into treatment, establish research-based exposure limit thresholds, and improve medical evaluations. He noted that all members of the military community, including weapon developers, have a role to play in limiting exposure to blast. Finally, Dr. Smith invited the meeting participants to visit the DoD's health.mil/brain website for further information and updates.

Figure 5. Military Exposure to Low Level Blast (LLB)

Blast Overpressure (BOP) Exposure Monitoring

Briefings focused on monitoring exposure to blast spanned methodologies for measuring exposure and the epidemiology of exposure. Common themes included the need for collaboration and future work to ensure data accuracy and applicability to complex military environments.

Measurement Methodologies

Figure 6. Blast Tracker 2 gauge including microphone and accelerometry

Presenters described different aspects of measuring blast exposure. Projects had used a wide range of gauges and measurement techniques, including gauges by B3, MedEng, and Advanced Materials and Devices, Inc. (AMAD). Researchers and commercial products had increased uniformity in exposure metrics and considerations of data quality control (e.g., real/not real assessment).

Dr. Jean-Philippe Dionne of MedEng described the Blast Tracker 2 (Figure 6) and spoke specifically about machine learning (ML) strategies for exposure monitoring, including calculation of incident pressure and methods to improve the quality of recorded event data. The algorithms underlying the tracker showed promise in initial investigations of data quality, detection of blast directionality and calculation of side on pressure, and identification of weapon systems that produced the blast.

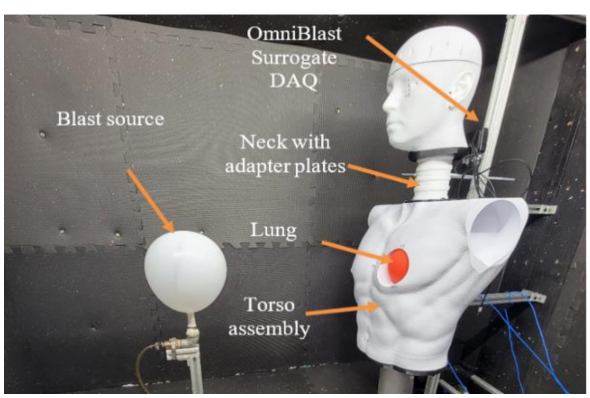


Figure 7. OmniBlast™ surrogate

Dr. Barkan Kavlicoglu of AMAD then provided an overview of his company's products OmniBlast™ Air, Water, and Surrogate. He described an investigation using the OmniBlast™ surrogate to investigate the effects of a combat helmet on exposure. The OmniBlast™ surrogate includes a silicone-based brain simulant with sensors placed in the brain material (Figure 7). In laboratory testing the AMAD researchers found that the helmet increased peak pressure in some, but not all, locations under the helmet.

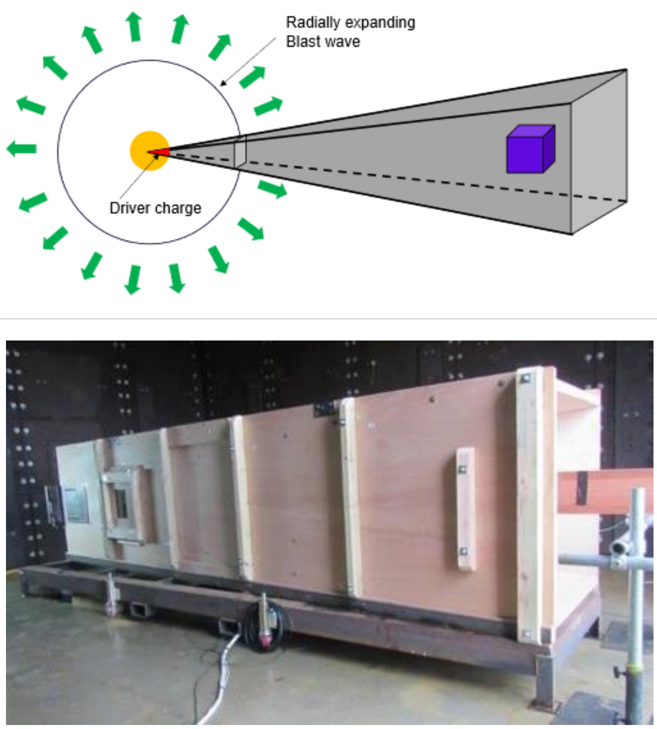


Figure 8. Design principle and prototype of a device that models exposure to blast waves.

Two presenters from the United Kingdom's Defence Science and Technology Laboratory (Dstl), Dr. Andrew Sedman and Dr. Abigail Spear, discussed the development and use of a prototype blast loading device to measure muscle cell response to BOP. Dr. Sedman reported on design decisions and lessons learned in developing the equipment that replicates exposures to real-world blasts of up to 0.82 MPa (120 psi) incident pressure in the sample holder with Det and PE7 explosive driver charges (Figure 8). Dr. Spear presented the evaluation of the effects of blast exposure on 3D scaffolded muscular tissue to support increased understanding of soft tissue injuries from blast, focusing on progressive tissue loss (PTL). The Blast Injury Sensing and Diagnosis section of this report describes the muscular cell loading component in additional detail.

Figure 9. JSOHA equipment for exposure assessment

A presentation by Mr. Shawn Boos and Ms. Olivia Webster from the Defense Centers for Public Health – Aberdeen (DCPH-A) described the approach to multisensor data collection (Figure 9) used by the Joint Servicemember Occupational Health Assessments (JSOHAs). This approach extended exposure evaluations at test centers to provide information on exposure to fielded weapons, including evaluation of chemical, blast, and noise hazards. These assessments also yielded information about use of the weapons and whether individuals know about and follow existing safety guidance. JSOHA provides information to Service members as they come off the range to increase awareness of their exposures and take appropriate actions. The exposure information is standardized to support inclusion in Service member records. Ms. Webster's briefing centered on assessing brain health risk resulting from BOP. The Dose Response section of this report discusses this topic in greater detail.

Dr. Gupta of BIRCO described the BOP Tool – a software package with a computational model to guide placement of weapons and personnel for range safety planning. The tool can provide estimated exposures based on the weapon, round, and location and posture of the individual (Figure 10). The BOP Tool includes two modules. The Site Module provides information on the predicted blast exposure zone to help configure the training area, guiding decisions on reducing cumulative blast exposure through adjustments in weapon placement, personnel positioning, and site modifications. The Scene Module presents three-dimensional visualizations of blast exposure on human body models, allowing users to adjust personnel postures and positions to evaluate different mitigation strategies effectively.

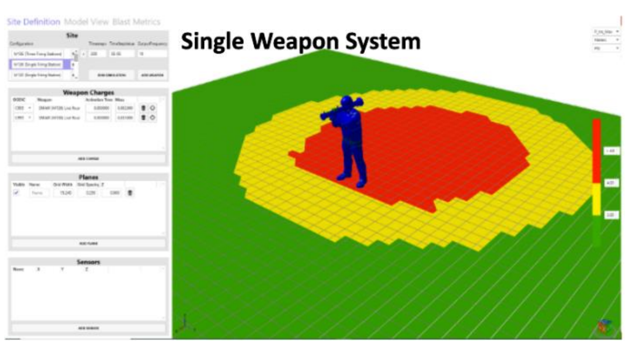


Figure 10. BOP Tool simulation of a single firing event's exposure zones.

Dr. Harsha (Teja) Garimella of CFD Research Corporation and Dr. David Palmer of Federal Strategies then demonstrated the tool for both stand-alone use by the DoD and integration with the Range Manager's Toolkit, which is currented used by the DoD to mitigate other range training hazards (e.g., projectiles, fragments). Later, Dr. Garimella discussed modeling of confined spaces and planned updates to the BOP Tool algorithms to account for more complex environments with reflective surfaces.

In his briefing, Mr. Peter Alt from Fort Liberty, North Carolina, discussed the U.S. Special Operations Command's brain health strategies to monitor and mitigate exposures. He described Light Detection and Ranging (LiDAR) mapping and 2D models that help inform decisions about exposures by location, and the use of 3D-printed charge forms to direct blast away from individuals (Figure 11). He noted his broad collaboration across DoD agencies to support improved exposure monitoring, detection of injuries, and recording of blast exposure in Service member records.

Figure 11. 3D printed, tamped charge demonstrating focused explosive energy

Epidemiology

Presentations on epidemiology described blast exposure and health outcomes from different blast exposure scenarios. Dr. Douglas Brungart, Walter Reed National Military Medical Center, gave a keynote briefing on bridging between exposure monitoring and the effects of blast to inform injury prevention standards. He cited data showing that blast and high-level impulse noise are associated with increased loss of hearing and problems with auditory processing, even when they do not result in higher audiogram thresholds, and noted that these effects were especially prevalent in individuals who indicate that they frequently notice changes in their hearing after exposure to loud noise, regardless of the source. He also discussed the use of boothless audiometry and wearable dosimeters (Figure 12) to develop a preliminary dose-response curve capable of predicting the probability that a measurable change in hearing would occur as a function of LAeq8Hr [A-weighted 8-hour Equivalent Sound Level] noise exposure. In addition, Dr. Brungart noted that hearing is dominated by bone conduction when double protection is used, and that this might explain why acute hearing symptoms often seem linked to other symptoms of repeated exposure to low-level blast.

Figure 12. WAHTS-TABSINT boothless audiometer system for field data collection

COL Machiko Kawasaki of the Japan Ground Self-Defense Force delivered a briefing on peak blast wave intensity of the 120 mm Mortar RT (M120) as measured by a series of wearable blast gauges placed on and below the helmet of a head model. Measurements were taken in different locations and orientations around the weapon system. Exposure magnitude varied by location around the weapon system, with the highest exposure at the loader’s position (Figure 13). The findings showed that the Japanese helmet significantly reduced the blast exposure.

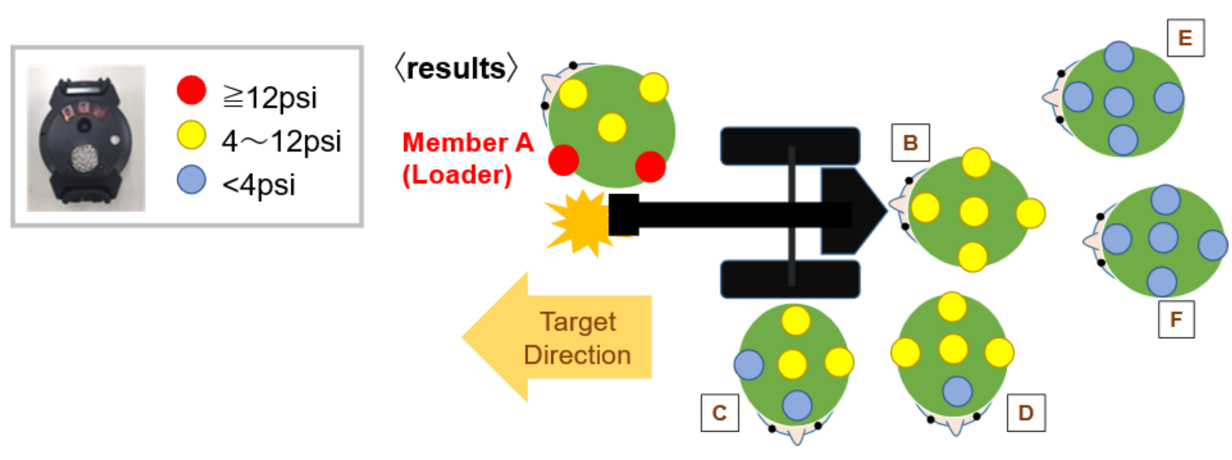
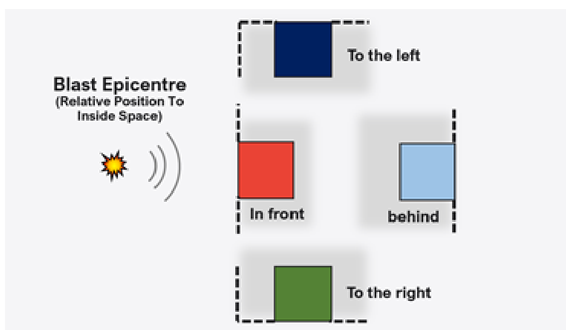


Figure 13. Varying exposure magnitudes by location around the 120 mm Mortar RT (M120)

Dr. Jack Denny from the University of Southampton presented the results of a study he conducted that accurately mapped the locations of over 300 victims injured by the 2020 Beirut Blast. The study evaluated how different factors influenced injury patterns and severity, including distance from the blast epicenter, elevation, inside and outside locations and other characteristics of the urban environment. He reported on the high incidence of complex lacerations and penetrating injuries, noting that individuals located near windows in rooms that faced the port, were more likely to suffer these injuries (Figure 14). Additionally, victims located closer to the epicenter or outside at the time of the blast typically had more severe injuries, whereas the study found that victims' elevation and clothing type did not influence the number or severity of injuries.



	Laceration & Penetrating Injuries		P value
	No	Yes	
Orientation of the room			
Facing the blast	8 (30.8%)	141 (62.9%)	0.002
Blast on the right	10 (38.5%)	28 (12.5%)	
Blast on the left	2 (7.7%)	25 (11.2%)	
Blast behind the participant	5 (19.2%)	25 (11.2%)	
N/A	1 (3.8%)	5 (2.2%)	

Figure 14. Incidence of lacerations and penetrating injuries by orientation toward blast epicenter

Dr. Eric Schneider of the Yale University School of Medicine and Dr. Fabio Leonessa of the Henry M. Jackson Foundation and USU gave briefings on the COmbat and traiNing QUeryable Exposure/event Repository (CONQUER) Operational Monitoring Program. While the briefings included considerations pertaining to exposure monitoring and data accuracy, they focused primarily on the broad range of exposure data that has been collected and how it can be used. The speakers noted that exposure monitoring can provide important insights into strategies for mitigation. For example, monitoring of tank training showed that individuals inside the tanks had no appreciable exposures but individuals outside the tank experienced high exposures that would not have been identified or captured without the use of gauges. CONQUER can look across very large sets of data to detect variations in exposures and identify outliers that could be due to unusual TTPs or human error. Dr. Schneider also discussed how exposure monitoring can inform process changes to decrease blast exposure. He provided an example from sniper training where review of the exposure data led the command to increase the distance between firing lanes, significantly reducing exposure to BOP (Figure 15).

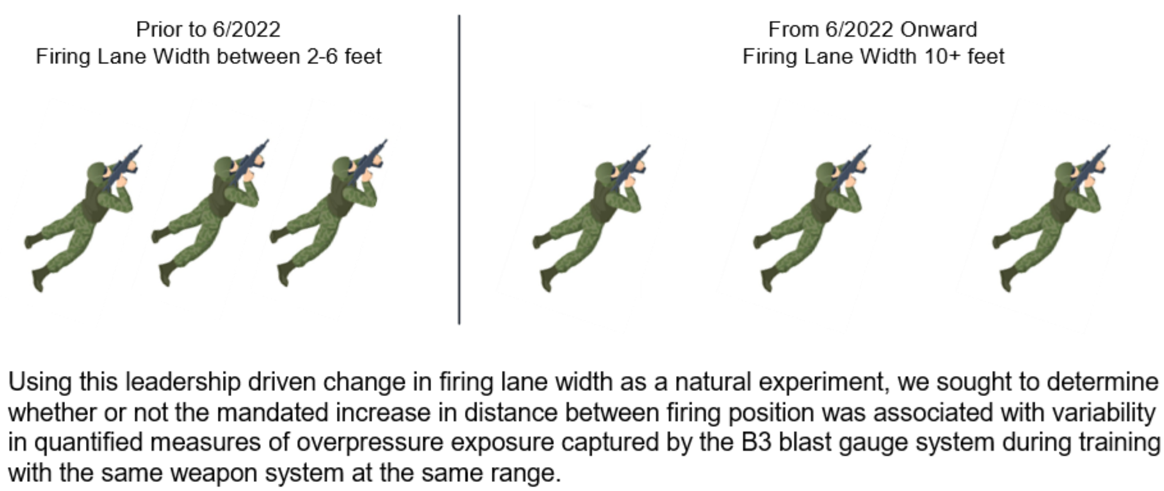


Figure 15. Command increases distance between firing lanes to reduce exposure to BOP

Blast Injury Sensing and Diagnosis

Researchers presented methods and findings at the human, animal, tissue and cellular levels aimed at identification of blast effects.

The keynote address by Dr. Ratnesh Lal, University of California San Diego, described the use of nanomedicine to support identification and treatment of blast injury. He noted that nano-biophysics can help identify the cause and etiology of blast-induced traumatic brain injury (bTBI) to support diagnoses and predict outcomes and provided several examples. Researchers can investigate nano-scale measurement in live systems, as well as hemichannel and oxidative stress related to TBI pathologies, and conduct investigations in vitro. Amyloid diseases can be identified by atomic force microscopy. Additionally, nano-shuttle platforms can use magnets to cross the blood-brain barrier (BBB) to support treatment. Capabilities could also incorporate implantable devices for biomarker detection, including detection of pathogens with low sample volumes. He noted that these capabilities can increase access while maintaining portability, privacy, and affordability (Figure 16).

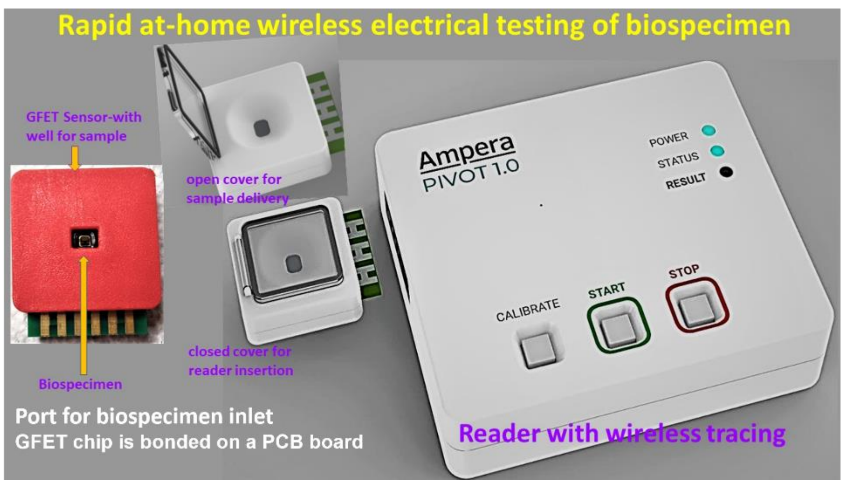


Figure 16. Portable GFET sensor device

Dr. Satoko Kawauchi from the Japanese NDMC Research Institute described the Institute's work on leveraging laser shockwaves in rat models to investigate astroglia scarring and fibrotic reactions (Figure 17). The researchers evaluated the extent of damage caused by different impulse levels, including the effects over days, and identified delayed onset of inflammation, which could support future identification of a therapeutic target.

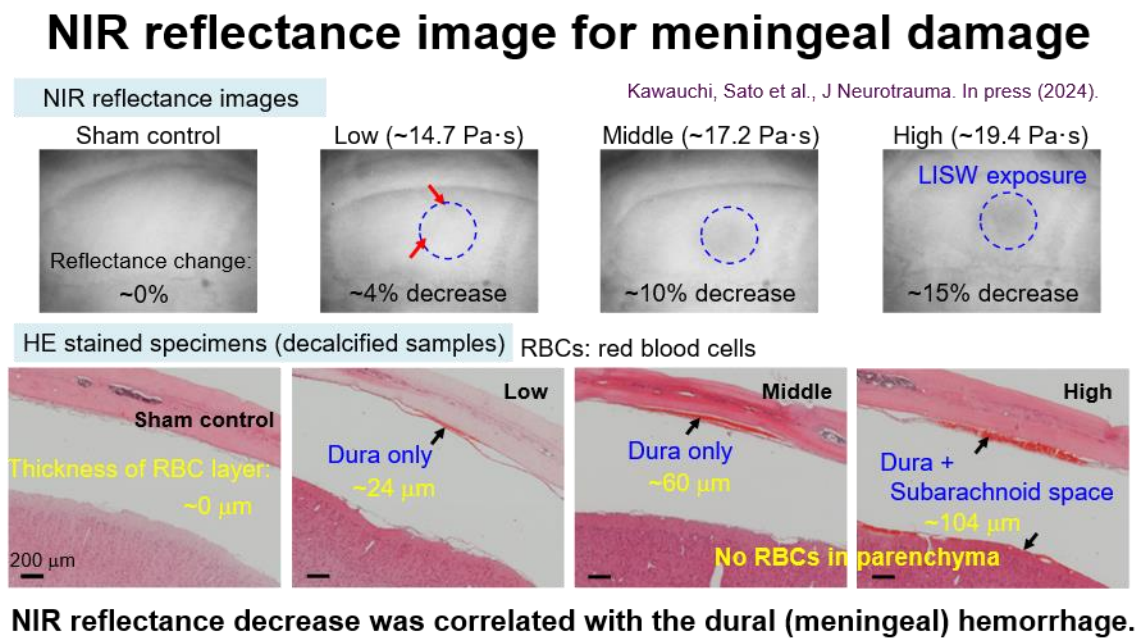


Figure 17. Neuropathological effects of low, medium, and high laser-induced shock waves on the rat brain.

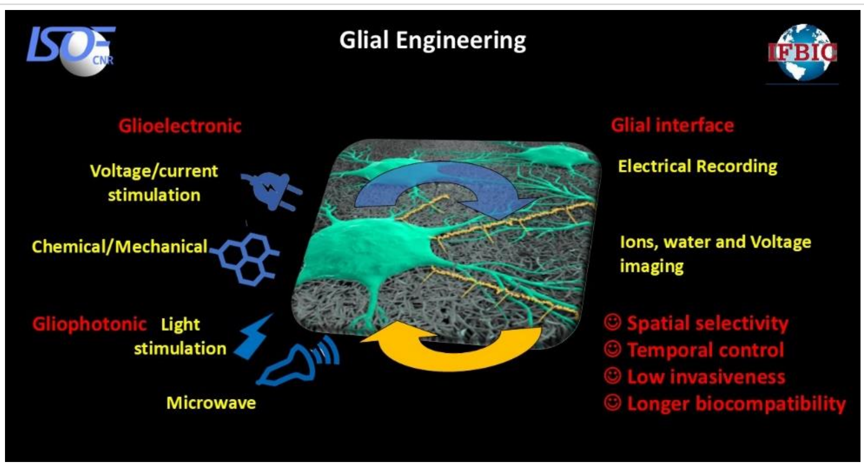


Figure 18. Glial engineering approaches aim to excite astrocytes using various technologies.

Dr. Valentina Benfenati of Italy's Institute for Organic Synthesis and Photoreactivity delivered a keynote address on the use of multiscale probing and sensing tools to better understand the role of astrocytes in brain function (Figure 18). Following a brief description of the institute's Glial Engineering & Interfaces Lab, she gave an overview of the physiology of astrocytes, their various calcium pathways, and the calcium signaling process. She detailed the Institute's ongoing efforts involving the configuration and manipulation of astrocytes and the observed response of astrocytes and nearby neurons at the nanomechanical, atomic, and nanoscale levels. Findings of the studies she described include that: 1) electric fields via graphene oxide and reduced graphene oxides can be used to elicit calcium signals in astrocytes selectively to drive their function on possible nearby neurons, 2) astrocytes can respond to mechanical stimulation at the nanoscale and mesoscale levels, and 3) microwave stimulation and gold nanoclusters could serve as tools to understand the role of astrocytes in blast injury. Overall, results indicated that glial engineering has potential to reveal mechanisms and treatment solutions for dysfunction in brain communication caused by blast.

Dr. Abigail Spear of Dstl described tissue structures they made to scale (so blast scaling was not needed), which enabled investigation of molecular and cellular responses to BOP over time. She described changes in gene expression and metabolic activity. Low blast loading increased metabolic activity (in line with clinical therapeutic use of shock), while exposure to high levels of BOP decreased it (Figure 19). This ongoing research is currently conducting further down-stream analysis, and the team aims to report its findings in the open literature.

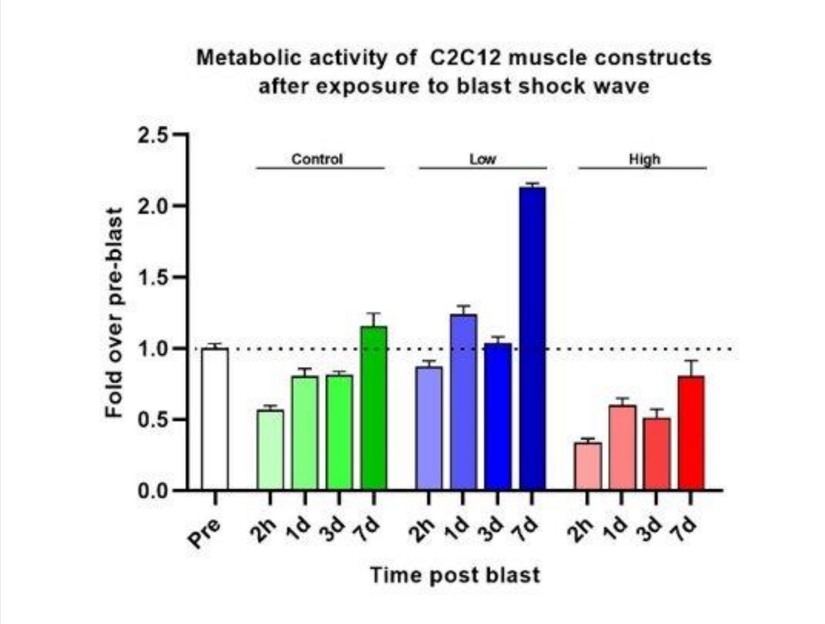


Figure 19. Low blast exposure increased metabolic activity over seven days post-blast exposure, while high exposure led to a decrease that persisted over this time

Dr. Stephen Ahlers of the Naval Medical Research Command delivered a briefing on behalf of Dr. James Stone from the University of Virginia. He noted that more research is necessary to broaden the types of effects to look for to include mental health symptoms, since the cumulative effects of repetitive blast exposure are not solely neurocognitive in nature. He stated that using the Blast Exposure Threshold Survey (BETS) and Generalized Blast Exposure Value (GBEV) to quantify blast exposure can help identify safe thresholds for exposure and inform identification of other indicators, including blood and imaging biomarkers (Figure 20). He noted that the researchers had observed unique cumulative neurological outcomes resulting from repetitive exposures to artillery weapon systems, suggesting that exposures to blast from different weapon systems or explosives may have distinct neurological effects on brain health. The blast community can learn lessons from the impact community's actions regarding chronic traumatic encephalopathy syndrome (TES). Currently the number of physical impacts to the head over a career is the primary identified risk factor for TES and diagnosis includes consideration of mental health outcomes.

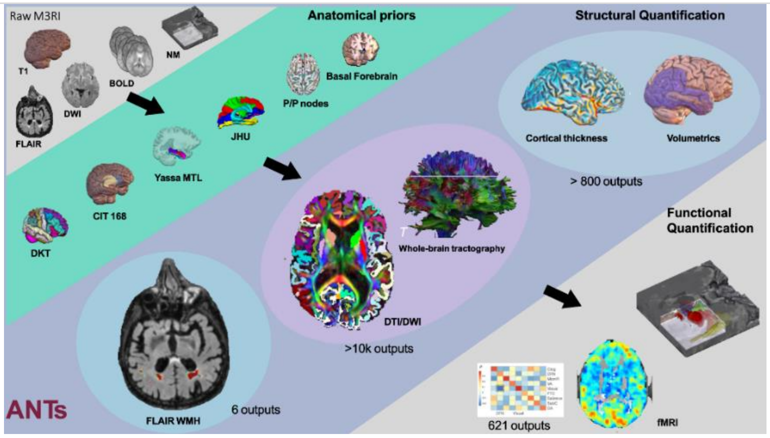


Figure 20. Neuroimaging and brain analysis techniques for comprehensive quantification of brain health.

Dr. Rebecca Ivory from the Mental Illness Research, Education, and Clinical Center, VA Puget Sound Health Care System, highlighted the importance of community engagement (CE) to ensure that findings are meaningful and translatable to military action. She noted that many Service member populations are tired of data-gathering efforts. CE creates relationships, enables the community to understand research priorities, and ensures meaningful research outcomes (Figure 21).

CURRENT bTBI PROJET: SOF CE PATHWAY

Initial Engagement

1st Vso Contact
- Membership Sampling
- 2nd & 3rd Vso Contacts
  - Membership Sampling

Network Recruiting
- Social Media Volley
  - Network Sampling
- Individual Pocs
  - Network Sampling

Cohort Results

+25 Contacts (Ongoing)
- Within 7 Days
- Networking → Networking

Recruitment Through Trust
- Immediate Buy-in

Active Engagement
- Extra Mile
- Continued Contact

Figure 21. Structured approach used for engaging the SOF community for the bTBI project

Therapies, Treatments, and Prevention

Briefings addressed the need for early intervention and administration of drugs and other therapies to significantly reduce downstream effects from blast injuries. Additionally, presenters highlighted that blast-related injuries are complex and may require different treatments depending on the mechanism of injury.

Dr. Nobuaki Kiriu described NDMC's work on the effects of Dimorpholamine, a respiratory stimulant (RS) developed in the 1950s, that acts on the brain stem for lifesaving treatment in the hyperacute phase of blast injury. Dimorpholamine is currently available only in Japan. In its work, NDMC determined that the effects of respiratory arrest from blast injury resulted from exposure of the neck/brain stem region to blast, not from exposure of the chest. Administering Dimorpholamine to pigs following blast exposure enabled the pigs to return to normal breathing rates, while three-quarters of the pigs not given Dimorpholamine did not survive (Figure 22).

The Result and Statistical analyses

	Non-RS group	RS group	P-value
N	4	5	
Survived	1	5	
Dead	3	0	0.0476

RS: Respiratory Stimulant

Figure 22. Survival rates of pigs exposed to blast waves and administered RS-Dimorpholamine

Dr. Mei Sun of USAMRDC provided an overview of the neurosensory injury prevention and treatment programs at the Military Operational Medicine Research Program (MOMRP). These programs aim at understanding the mechanisms of neurosensory injuries in visual, auditory, and vestibular dysfunction and to develop strategies for preventing and treating them (Figure 23). The speaker noted that MOMRP is looking for collaborators to work in both short- and long-term efforts centered on more than 20 current research focus areas. These include, but are not limited to, brain-computer interface translations, improved understanding of tinnitus, regenerative medicine for sensory injury treatment, and noise dosimeters and hearing protection. Recently the neurosensory research program was transitioned to DHA and been renamed Sensory Systems Program. DHA will report updated information on the program at IFBIC 2025.

1. **Prevent/Restore Vision:** Improve prevention, restoration, regeneration, and rehabilitation of vision following service-related traumatic injury. (Obj.1)
2. **Prevent/Restore Hearing:** Improve prevention, restoration, regeneration, and rehabilitation of hearing & balance following service-related traumatic injury. (Obj.2)
3. **Basic Mechanism:** Enhance understanding of the neurosensory mechanisms. (Obj.3)
4. **Treatment for hazardous consequence:** Develop treatment strategies for the neurosensory system after hazardous military exposures. (Obj4)
5. **Prevention for hazardous consequence:** Provide prevention solutions and strategies to address hazardous military exposure induced neurosensory injury. (Obj.5)
6. **Portable devices:** Develop portable device and assessment system for neurosensory injury prevention and treatment solutions and strategies. (Obj.6)

Figure 23. Priority research objectives for Neurosensory Injury Prevention & Treatment Program

Prof. Satoshi Tomura of NDMC described the effects of intravenous administration of hydrogen-enhanced water on bluntforce- and blast-induced TBI models in mice. NDMC's research focused on exploring the roles of reactive oxygen and reactive nitrogen species (ROS/RNS) and their effects on downstream TBI. The researchers injected fluid with increased hydrogen concentrations intravenously into mice 30 minutes after they received a blast injury; the mice then underwent a battery of behavioral and cognitive testing. NDMC performed histology 28 days later. The results demonstrated that brain injury from exposure to blast and blunt force have different mechanisms, as hydrogen prevented worsening brain edema in blunt-induced TBI but not in bTBI. Hydrogen suppressed depression-like behavior in bTBI, but not in blunt force-induced TBI (Figure 24).

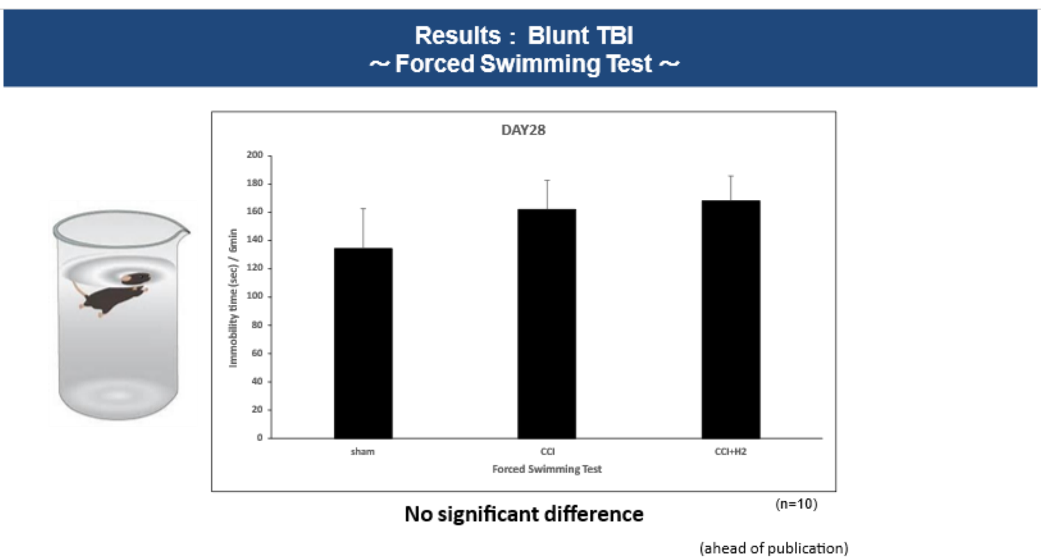


Figure 24. Hydrogen water prevented worsening of depression like behaviors after bTBI

Dr. Alexander Bobrov from the Walter Reed Army Institute of Research (WRAIR) discussed the need to improve combat-relevant BOP exposure animal models so that researchers can develop therapeutics against wound infections. He noted that 81–87% of blast injuries are polytraumatic and tend to have more severe consequences, including risk of infection, than non-blast related injuries. He stressed the need to investigate bacterial loads, wound closure, survival, and tissue collection to understand potential pathogenic conditions of combat wounds sustained from blast injuries (Figure 25). He also reported that the presence of fungus in wounds significantly lengthens recovery time. While antifungal treatments help, they do not always fully remove all fungal spores from the injury.

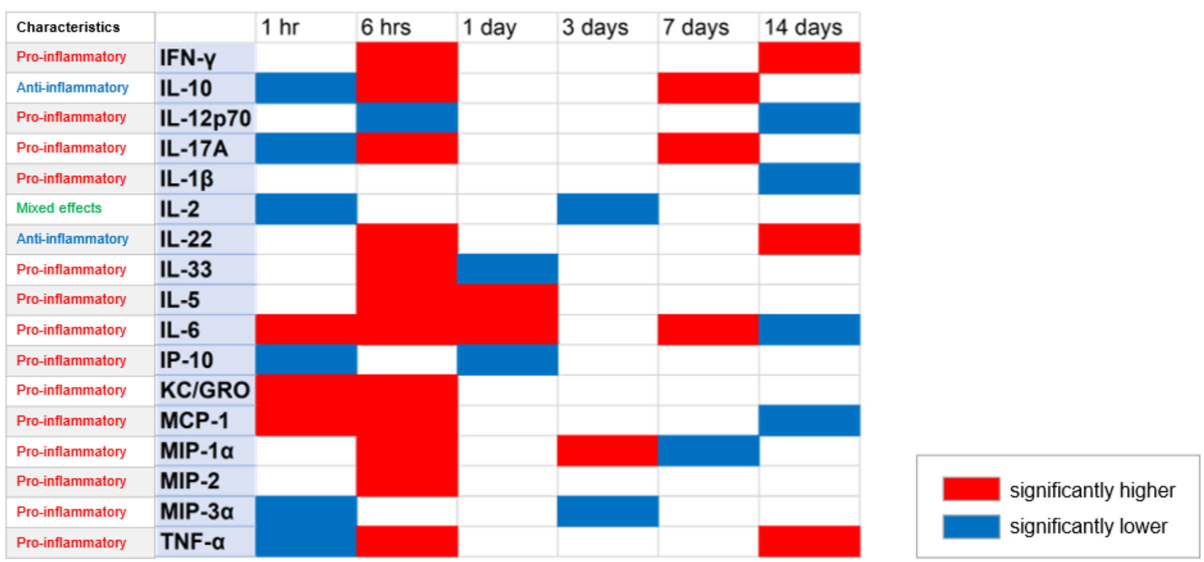


Figure 25. Pro-inflammatory response results from Balb/C mice exposed to 20 psi BOP with the advanced blast simulator at WRAIR

Modeling and Simulation of Blast Exposure and Injury

The forum included two sessions (Session 4 on 2 May and Session 6 on 3 May) focused on modeling and simulation (M&S) of blast exposure and injury. Presentations related to M&S spanned topics such as experimentation with multiscale sensing, physical experimentation, computational simulation, ML, and modeling approaches to improve understanding of the effects, pathology, and medical and operational implications of blast. Overall, the presentations revealed advancements in experimental and computational M&S capabilities, the need to acquire and incorporate data from both operational and training environments, and current gaps that warrant further research to improve M&S of blast injury.

Dr. Anthony Santago II of MITRE described the findings of the DoD Working Group on Computational Modeling of Human Lethality, Injury, and Impairment from Blast-related Threats. His presentation focused on the working group's development of a modeling capability for the M&S of human lethality, injury and impairment from blast-related threats (Figure 26). It covered the underlying framework and concept of operations that enable the interoperability and composability of M&S capabilities, as well as a five-year action plan and implementation plan for development of the modeling capability. Dr. Santago identified research gaps and overarching research themes from a science and technology scan used to prioritize future working group actions.

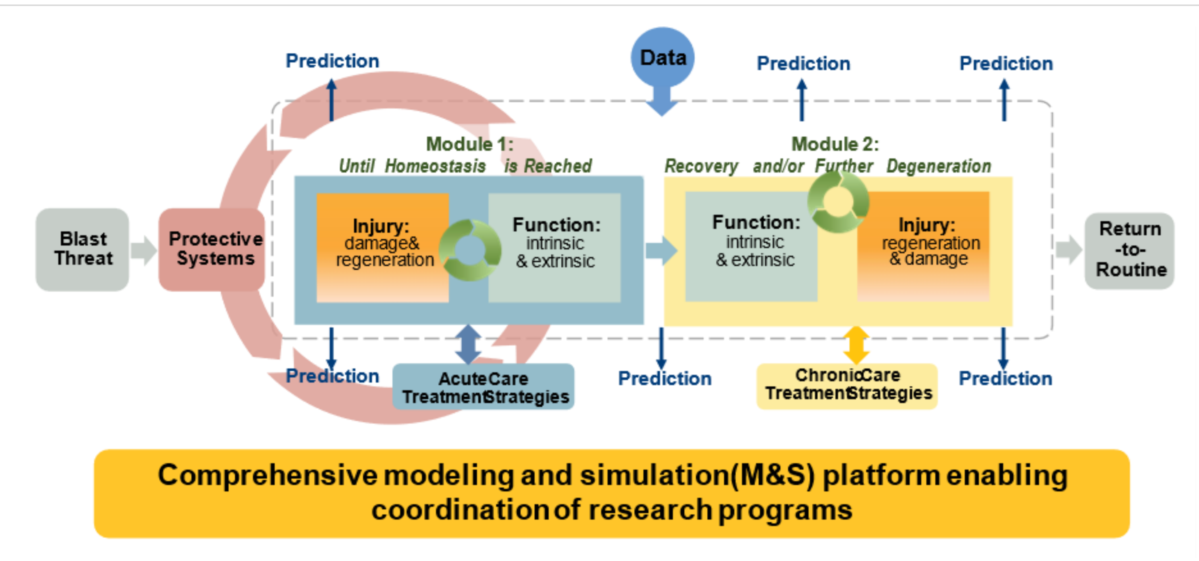
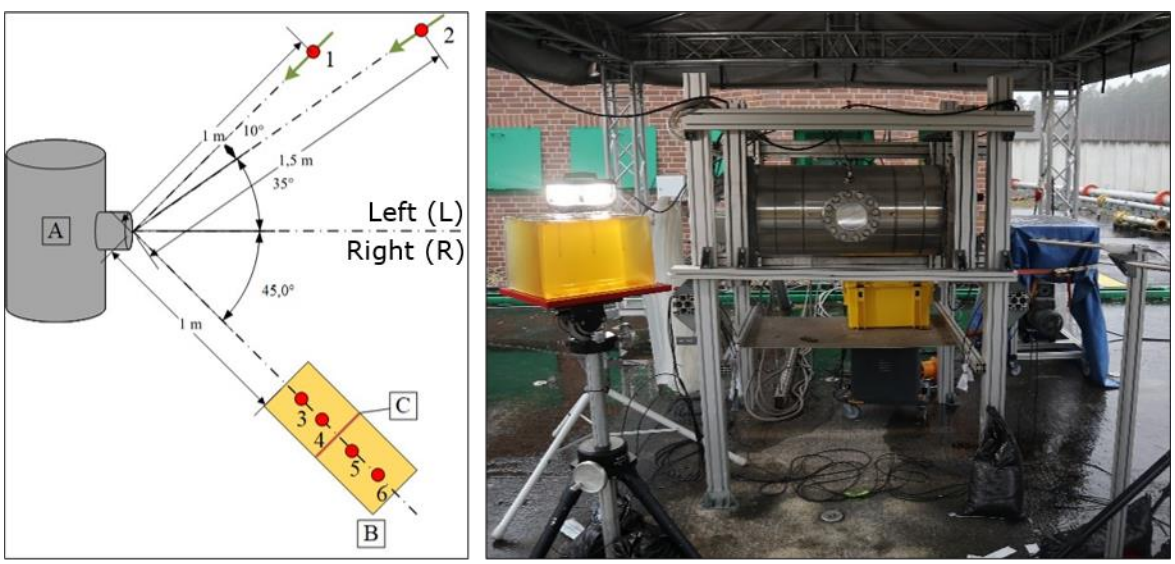


Figure 26. The desired M&S capability under development

Dr. Denes Agoston from the USU presented the results of a study on blood-based protein biomarkers of the effect of repeated exposures to subconcussive levels of primary blast during heavy weapons training. The study findings demonstrated the unique physics of primary explosive blast and its biological targets that must be considered in biomedical research that focuses on the identification of the pathomechanism of primary blast exposures. It also showed the power of ML approaches in the analysis of protein biomarker data. One approach, the decision tree, can identify blood-based protein biomarker signatures of exposure levels and can help identify the molecular pathomechanism of repeated exposures to subconcussive levels of primary blast and its temporal evolution. The presentation also highlighted the differences in biomarker signatures between participants at the baseline (i.e., prior exposures that must be taken into consideration when evaluating the individual's susceptibility to and recovery from blast exposures). His preliminary findings also demonstrated that repeated exposures to subconcussive levels of primary blast during heavy weapons training can trigger auto-immune response that can be responsible for the reported long-term neurological symptoms. Overall, the presentation emphasized the value of using blood-based biomarker analysis in the development of protocols that optimize the individual Warfighter's safety, maximize force readiness and prevent potential adverse long-term outcomes.

Two briefings focused on the development and implementation of a novel experimental method for generatinge shock waves to investigate the primary explosive effect. The first, given by CPT Henrik Seeber of Helmut Schmidt University, provided an overview of the experimental setup for a shock wave generator and the development of a generic, geometrically simplified gelatine-based torso model to visualize and measure characteristics of the blast. He compared pressure curve and peak pressure data from the shock wave generator to those produced by 70 grams of pentaerythritol tetranitrate (Figure 27). The presenter noted that more work is needed to adequately represent the negative pressure phase, but that other aspects of the shock wave generator performed quite well. CPT Seeber then introduced a prototype of a sensor carrier for operators, called StEk, which includes high-fidelity pressure sensors that can be used to record exposure of individuals to low-level blast.



Schematic view, example STM with bone structure

Overview photo, front view

Figure 27. Experimental setup for validation of the shock wave generator

Mr. Noah Meisner from Karagozian & Case discussed shock tube experiments paired with computational fluid dynamics simulations to simulate the effects of low-pressure blast on both helmeted and unhelmeted skulls. The simulations employed two separate approaches, both approaches using Computational Fluid Dynamics (CFD) to model experiments. The first was a trinitrotoluene (TNT) equivalence-based approach that utilized scaling based on Kingery-Bulmash calculations. The second modeled the high-pressure, high-energy region of the shock tube more closely. Results indicated that the first approach is not suitable for simulating free-field blast effects on the skull due to noticeable differences in predicted impulse versus the actual results of experiments. However, with careful modeling of the shock tube, results from CFD simulation closely matched those of experiments (Figure 28), demonstrating the ability to simulate the response of the skull to blast with high fidelity.

Another presenter from Karagozian & Case, Mr. Joe Magallanes, introduced the concept of utilizing meshfree methods, such as reproducing kernel particle method (RKPM), for investigating countermeasures to blast injury. He reported that meshfree methods can be generated from finite element models, or directly from medical imaging, and enable more efficient and unconditionally stable predictive blast simulations. Furthermore, these methods can incorporate models of state-of-the-science materials. He presented example applications demonstrating the use of meshfree RKPM on the simulation of blast loads to the brain (Figure 29), and the effects of behind-armor blunt trauma on the torso. Future efforts will center on maturing and validating meshfree methods for modeling specific injury mechanisms, blast fluid-structure interactions, and extreme behind-armor blunt trauma, as well as the development and validation of a meshfree torso model as part of a DHA Phase II Small Business Innovation Research project.

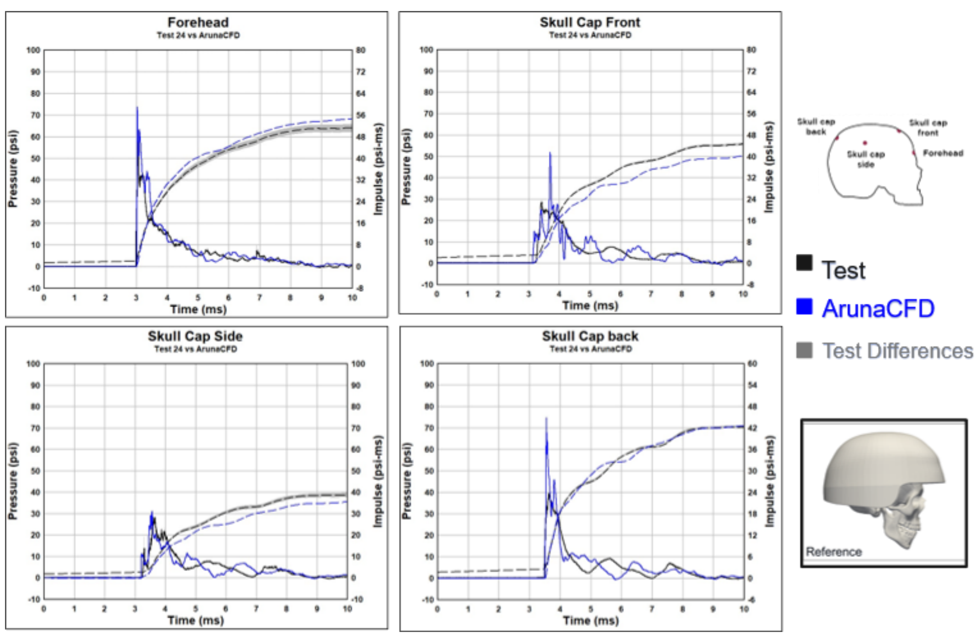


Figure 28. CFD simulation closely matched those of experimental helmeted BOP exposure data.

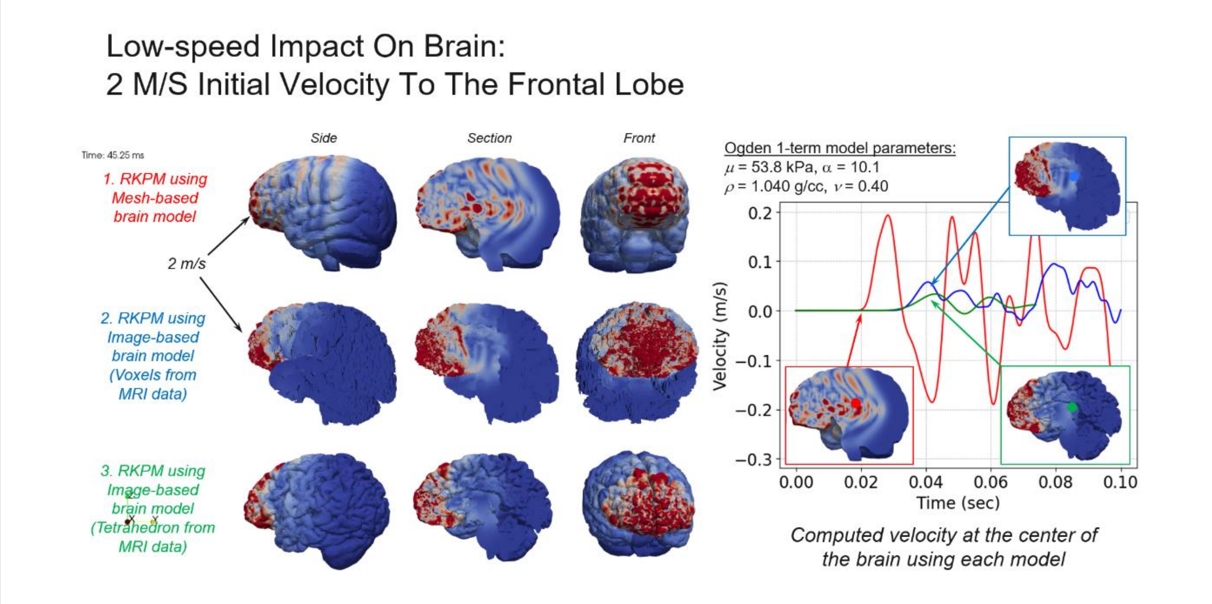


Figure 29. Simulation of blast loads to the brain using three different RKPM approaches

Dr. Leanne Young of Applied Research Associates, Inc., described modeling the medical and operational impact of blast in the battlefield. Her talk provided an overview of how the Defense Threat Reduction Agency (DTRA) Reachback program will use M&S capabilities to predict the type and severity of primary, secondary, and tertiary blast injuries likely to occur in ground combat operations. This capability, named HIT4Battlefield, has an artificial intelligence (AI) engine that uses Bayesian Belief Network principles to integrate models, input from subject matter experts, and historical blast injury data to predict injury likelihood and severity. Furthermore, it aims to map injury predictions to commonly used injury metrics, including an abbreviated injury score, military combat injury score, and military functional incapacitation score. Dr. Young noted DTRA's current collaborations with BIRCO, the Joint Theater Trauma Registry (JTTR), and the Naval Health Research Center (NHRC), and invited members of the audience to participate in this initiative (Figure 30).

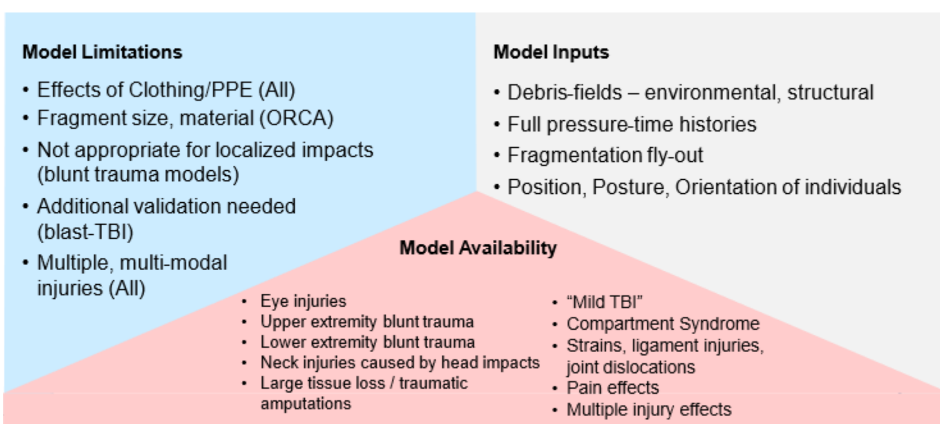


Figure 30. DTRA's ongoing initiatives target these capability gaps

Dr. Rohan Banton, U.S. Army Combat Capabilities Development Command (DEVCOM), presented research that investigates internal wave mechanics in the brain exposed to repeated shock wave impacts. Researchers performed numerical simulations on a surrogate head model exposed to blasts ranging from 300 kPa down to occupational levels of exposure at 30 kPa. The talk included an overview of the blast parameters, such as peak pressure and blast interval, by various weapon systems. The presenter demonstrated the use of a BOP model to predict the pressures and deviatoric stresses in a surrogate model of the skull and brain resulting from exposure to Royal Demolition eXplosive (RDX). DEVCOM also explored pressures and impulses at different regions of the brain and compared the findings to experimental results on animals exposed to blast from various weapon systems (Figure 31). The presentation concluded with a summary of outcomes from the simulation studies. The findings included that maximum pressures affect the proximal and distal brain regions, regardless of blast orientation, and that internal pressure undulation and frequencies dominate the internal brain response.

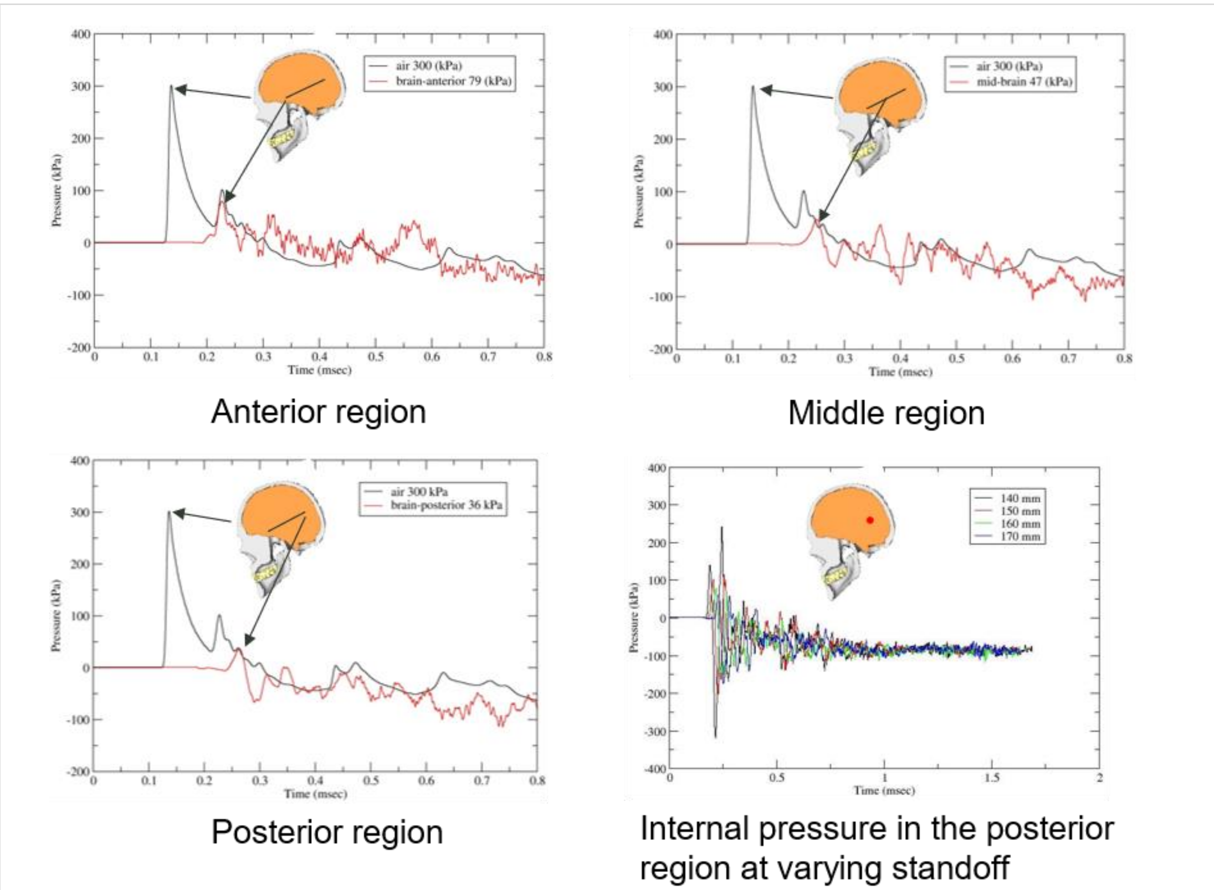


Figure 31. DEVCOM observed pressure in air and brain at different regions of the surrogate brain (200 mm standoff)

In his briefing, Dr. Andrew Dominijanni of MITRE described methods for preserving peak underpressure characteristics during reconstruction of blast waveforms. First, he introduced the features and characteristics of the blast waveform. He noted that empirical approaches model key parameters of the blast waveform using tabulated parameters based on stand-off distance and effective explosive mass. However, problems arise when modeling the negative phase of the blast wave, as Kingery-Bulmash equations only contain positive phase parameters, and the Friedlander equation cannot be used to represent a waveform that satisfies both positive and negative phase constraints. Dr. Dominijanni presented details on an alternative approach, including the variable decay coefficient, that generates a more realistic representation of the negative pressure phase. He also described the similarities and differences between CFD simulations using the different waveform reconstruction methods. In conclusion, he noted that the alternative reconstruction approaches preserve minimum pressure, but that other parameters deviate significantly from tabulated values in the negative pressure phase, indicating that functions with additional degrees of freedom are necessary to satisfy both positive and negative phase constraints (Figure 32).

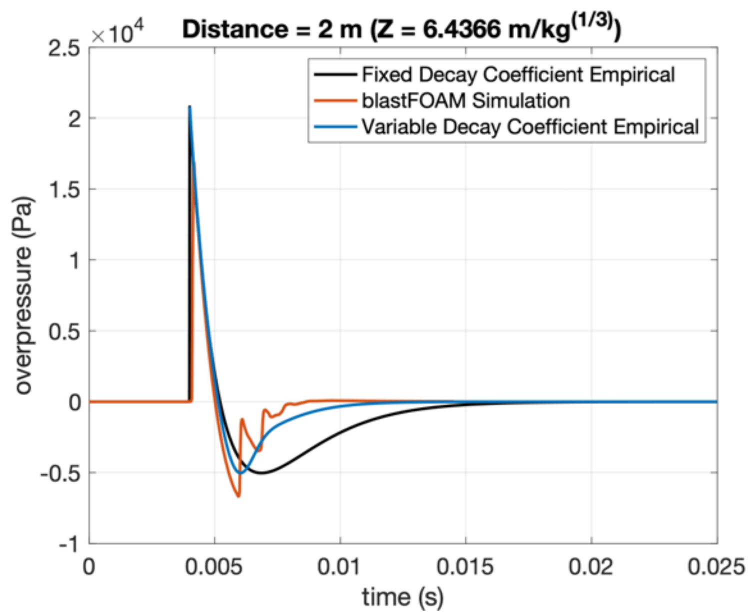


Figure 32. Initial testing indicates the variable decay waveform more accurately represents the negative phase of blast waves

Dr. Brandon Casper of the Naval Submarine Medical Research Laboratory (NSMRL) presented the keynote address for Session 6, which described findings from NSMRL's study of human exposure to underwater blast. He first explained the differences between in-air and underwater blast, including the more rapid travel of sound under water, greater density and incompressibility of water, and greater viscosity of water as compared to air and gave an overview of underwater guidance and current limitations. Dr. Casper then presented NSMRL's general research approach, which includes the development of biological, mechanical, and computational models of both humans and animals (in this case, sheep and fish). He provided details on the Quantitative Instrumented Torso (QUINT), an experimental model of the torso (lungs included) with incorporated sensors. NSMRL placed QUINT underwater in a pressure vessel, where high-speed cameras and the integrated QUINT sensors captured the effects of underwater blast (Figure 33). Results aligned well with ground truth. At the end of his talk, Dr. Casper briefly discussed an effort to develop a software application that provides guidance on safe standoff from underwater blast based on populating the tool with newly collected data on underwater blast injury.

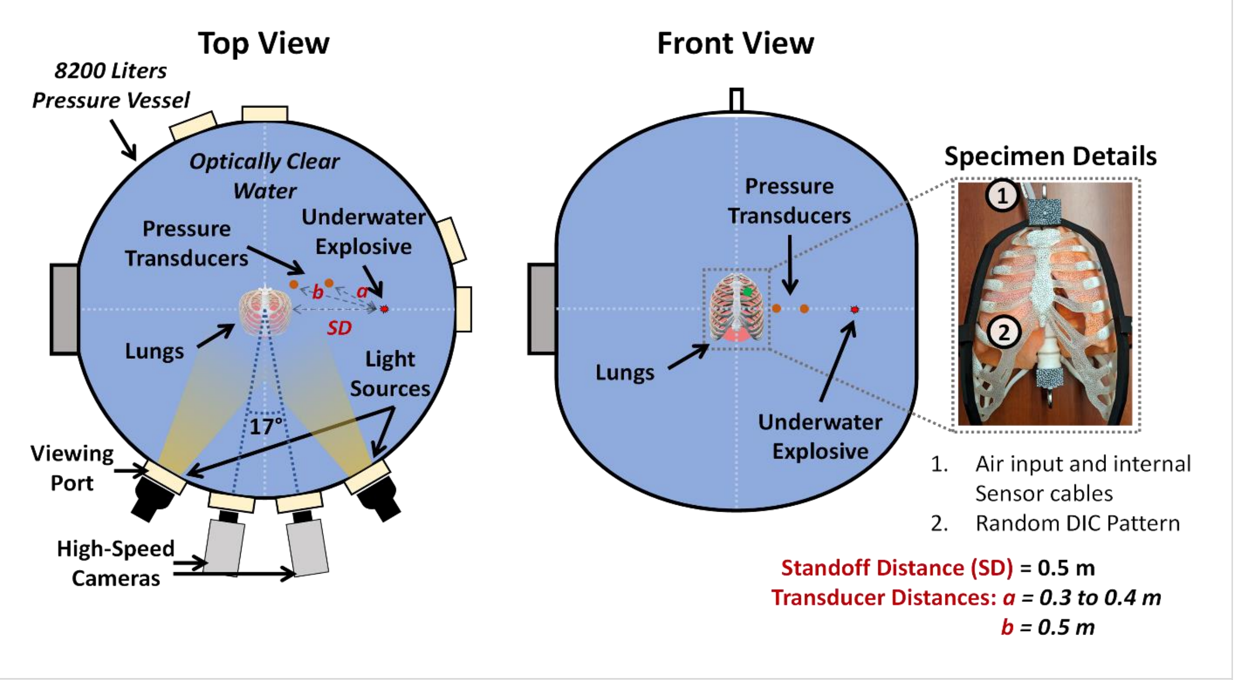


Figure 33. NSRML's experimental approach using QUINT to study underwater blast exposure effects

Dr. Amit Bagchi of the U.S. Naval Research Laboratory (NRL) described a conceptual framework for assessing combat helmet performance that considers blast, blunt impact, and thermal loading. After summarizing the evolution of the helmet, he gave an overview of NRL's earlier research on BOP and blunt trauma. The talk provided details on the development of a finite element model of the head and a notional helmet. Simulation results showed the minimum and maximum pressures and the maximum strain rates at various regions of the head and helmet for both 5-pad and 7-pad helmet configurations in response to overpressure loading, blunt impact loading, and thermal loading. Dr. Bagchi proposed using equal-weighted or differential-weighted methods to combine results from the three loading types to calculate an overall helmet performance score (Figure 34). By doing so, researchers could derive performance criteria for safe helmets to address the full spectrum of threats.

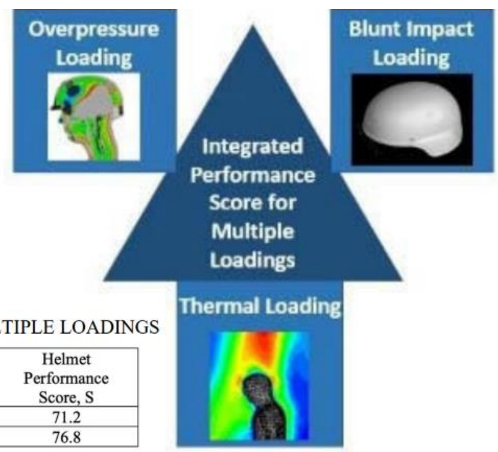


TABLE 4: OVERALL HELMET PERFORMANCE SCORE FOR MULTIPLE LOADINGS

Pad configuration	S_{blast}	S_{blunt}	$S_{thermal}$	Helmet Performance Score, S
7-pad	82.0	49.3	82.3	71.2
5-pad	77.4	64.7	88.4	76.8

Figure 34. Helmet performance metric integrating results from three loading types

Blast Exposure and Brain Health

The forum featured two sessions dedicated to blast exposure and brain health. The presentations related to blast exposure and brain health fell into three general categories: brain injury identification, injury mechanisms, and dose response. Individual briefings within those categories centered on biomarkers, including non-traditional or alternative biomarkers; methods for monitoring endogenous biomarkers following blast injury for changes over time; the effects of diet on brain response to blast injury; and the use of nanomaterials to monitor cellular injuries following blast injury.

Injury Identification

Dr. Dan Perl from the USU of Health Sciences delivered the keynote address for Session 5 in which he summarized the background of impact and bTBI, history of blast exposure, and identification of blast-associated brain injury, including “shell shock.” He discussed blast-related injury in military personnel and perspectives from his work with the DoD/USU brain tissue repository. Dr. Perl noted that the repository is the only brain bank in the world that contains only tissue from the brains of US Service members. These Service members had suffered from a wide range of after-effects from combat exposures to blast, including TBI and neuropsychiatric disease, among others. Astrocyte damage in living Service members (Figure 35) had been correlated with behaviors such as drug addiction, changes in sleep-wake cycles, slowed motor responses, modified decision making, and depression-like behavior.

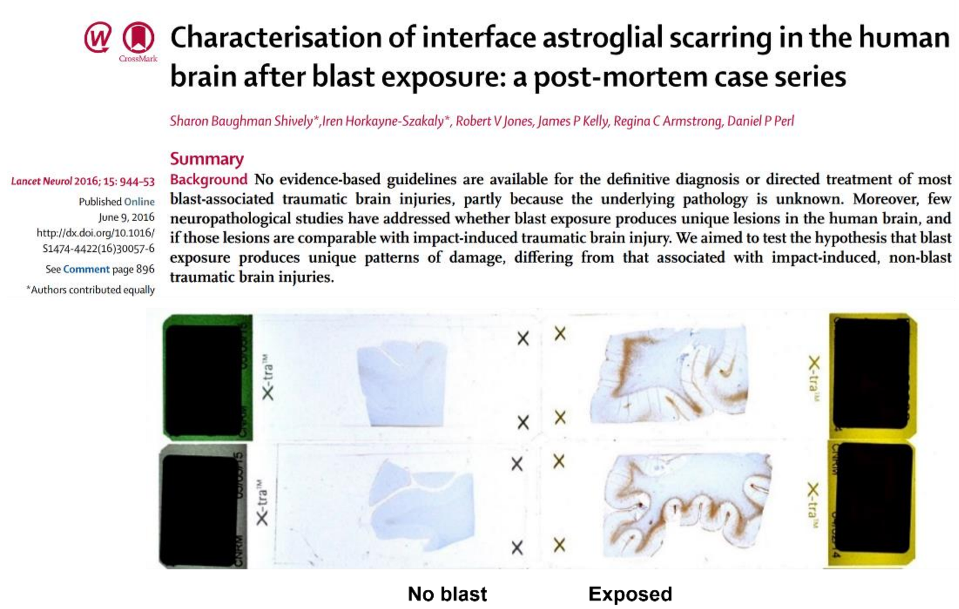


Figure 35. Interface astroglial scarring was identified in symptomatic, heavily blast-exposed Service Members in 2016.

Dr. James DeMar from WRAIR discussed the acute proteome changes observed in the brain and plasma of ferrets following blast exposure (Figure 36). He noted that TBI biomarkers were not detected in blood plasma at 10 seconds or four hours after blast injury, except that the glial fibrillary acidic protein (GFAP) biomarker showed downregulation at the four-hour point. At ten seconds after blast injury brain biomarkers were not significantly downregulated but still trended down. In contrast, four hours after blast-injury the brain exhibited an even presence of both down- and up-regulated biomarkers. The WRAIR researchers concluded that significant changes occurred in levels of numerous plasma proteins, but all at the post-four-hour mark.

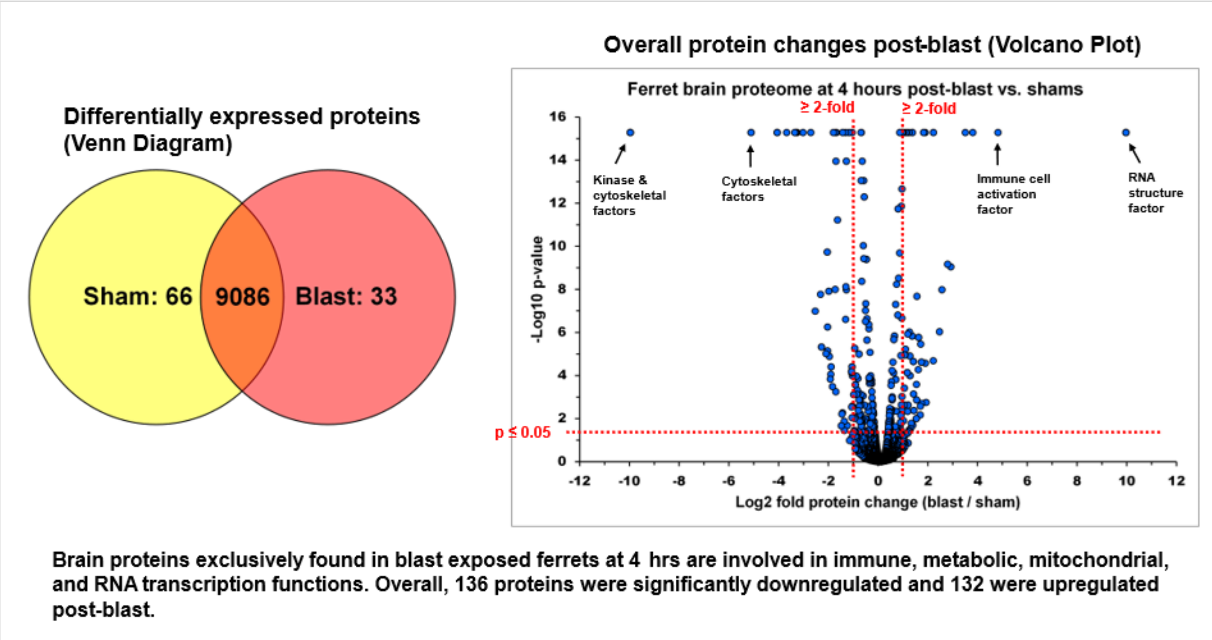


Figure 36. Ferret brains exposed to blast demonstrated great proteome alterations at 4 hrs.

Dr. Karima Jeneh Perry from DEVCOM Army Research Laboratory reviewed DEVCOM's work on calcium dynamics of neural networks in the presence of fluorescent protein-templated Au nanoclusters. She reported that nanoclusters placed under pressure increased their fluorescence. When used as biomarkers, the nanoclusters exposed to increased pressure indicated morphological and functional changes in astrocyte calcium. DEVCOM validated this research by modulating calcium dynamics while monitoring the nanoclusters. Dr. Perry described how the change in nanocluster fluorescence correlated with the change in astrocyte calcium (Figure 37).

Mr. Chris Wilson from Special Operations Forces (SOF) Acquisition, Technology, & Logistics gave a briefing on the Comprehensive Strategy for Special Operations Forces Warfighter Brain Health. He noted that SOF's work focuses on both Warfighters and their families. SOF completes a neurocognitive assessment (i.e., ANAM [Automated Neuropsychological Assessment Metrics]) of each SOF member every three years and its research programs are investigating a range of technologies and interventions to improve Warfighter performance (Figure 38). SOF does not use diagnostic tools that require refrigeration but has novel capabilities such as onsite freeze drying for samples. The Command is building on brain bank work by USU to investigate in vivo imaging of blast effects. Mr. Wilson closed his talk by noting that SOF's work shows how policy can translate into action.

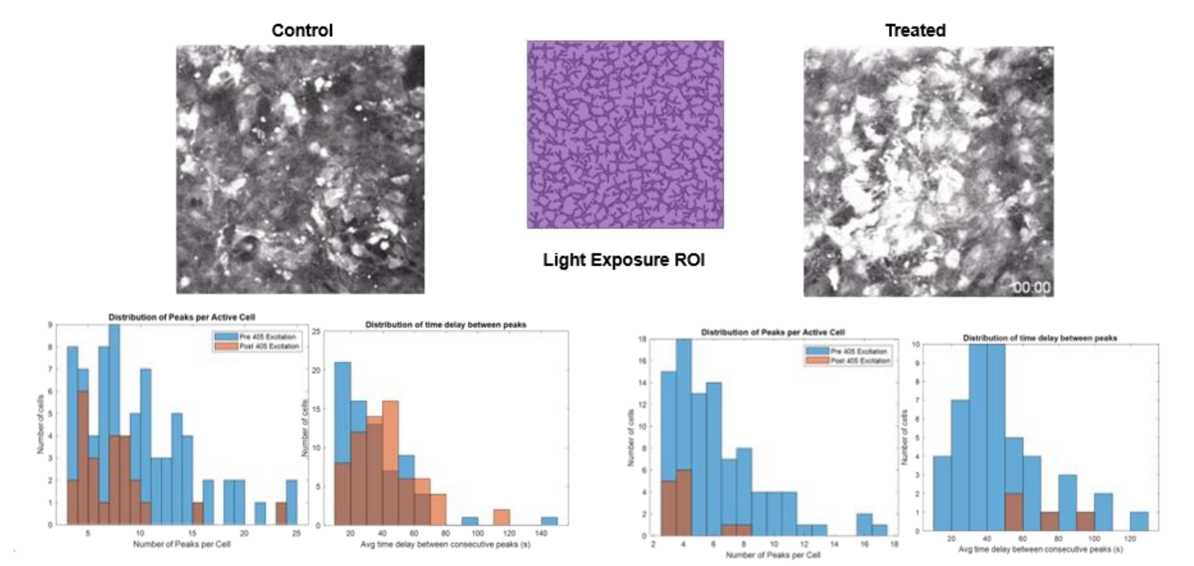


Figure 37. Calcium dynamics are reduced in Au nanocluster treated cells

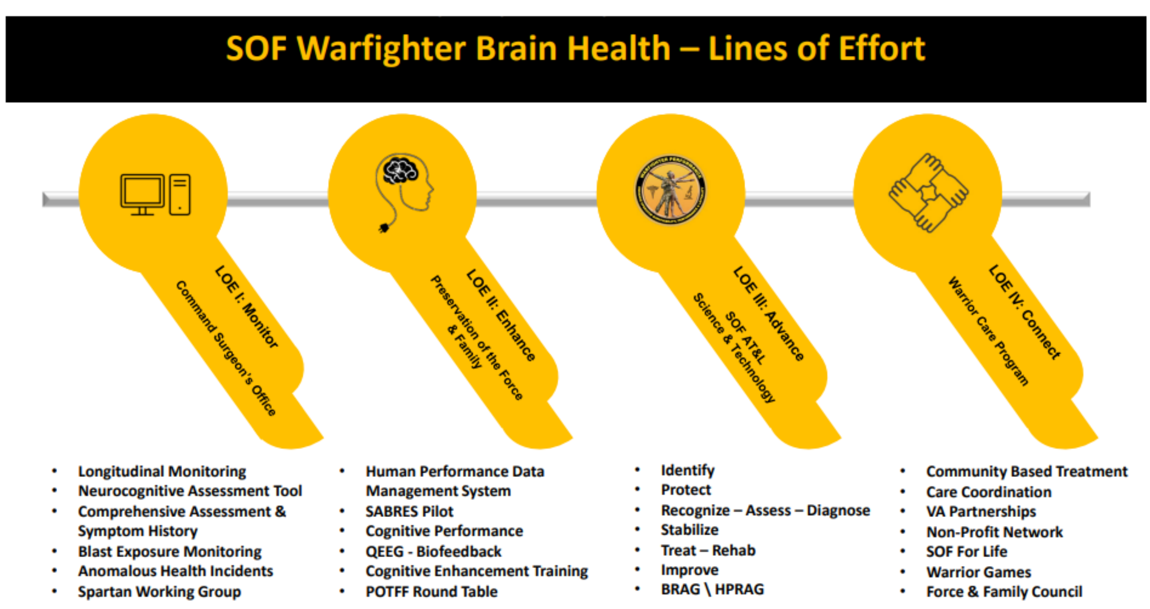


Figure 38. SOF's major lines of effort for Warfighter brain health

Lt. Col. (retd) Paul Scanlan, formerly in the Australian Army, described the impact of research and recommendations across geographic backgrounds. He emphasized the importance of U.S. collaboration with nations such as Australia and of sharing research results. He commented on earlier attitudes toward exposure to blast (e.g., fainting due to blast exposure was a mark of honor) and how (fortunately) this viewpoint has changed, but more must be done to alter the miliary culture in this area. Australia specifically must increase its monitoring of exposure and data collection, take blast exposure into account during training, evaluate Service members for mild brain injury, and prevent or mitigate brain injuries. Unique to Australia is the Royal Commission into Defence and Veteran Suicide, which helps to collect testimony and other information. Col. Scanlan noted the complexity of influencing and implementing strategies to understand and mitigate BOP effects. He thanked members of the research community around the world for their work and requested that researchers continue collecting information to support blast injury prevention and mitigation.

Injury Mechanisms

Dr. Wolfgang Losert of the University of Maryland gave the keynote presentation for Session 5, which focused on sensing physical signals with cytoskeletal dynamics. He noted the benefits of his laboratory's collaborations with researchers across the United States, Europe, and Australia. The briefing described the potential for mechanical and electrical stimuli to monitor and affect the behavior of cells and tissues, including cell migration as a part of the immune response, wound healing, and promotion of neural network performance (e.g., for memory and cognition) (Figure 39). These mechano-chemical waves can provide in-vivo information about the physical environment and neurological function.

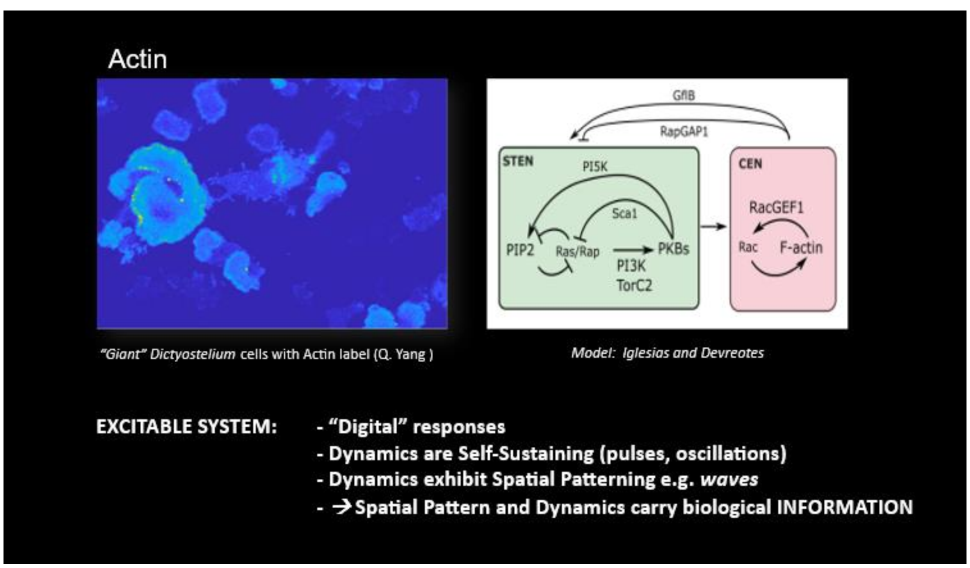


Figure 39. Actin's mechano-chemical excitable system conveys biological information

Dr. Molly Goodfellow, from the University of Maryland's School of Medicine, described chronic neurobehavioral changes following multiple simulated aeromedical evacuations in a ferret model of under-vehicle blast-induced TBI. She noted how often an injured Service member requires one or more aeromedical evacuations, which could influence the injury outcome. Working with underbody blast in the ferret model, she and her team of researchers showed that hypobaric conditions do not exacerbate injury volume or microglial activation. Following the simulation of one aeromedical evacuation, the researchers detected motor deficits in the ferrets, and multiple flights increased anxiety (Figure 40). Dr. Goodfellow ended her briefing with a request that researchers conducting underbody blast experiments use a flexible plate hull instead of a solid plate hull to emulate real vehicles more accurately.

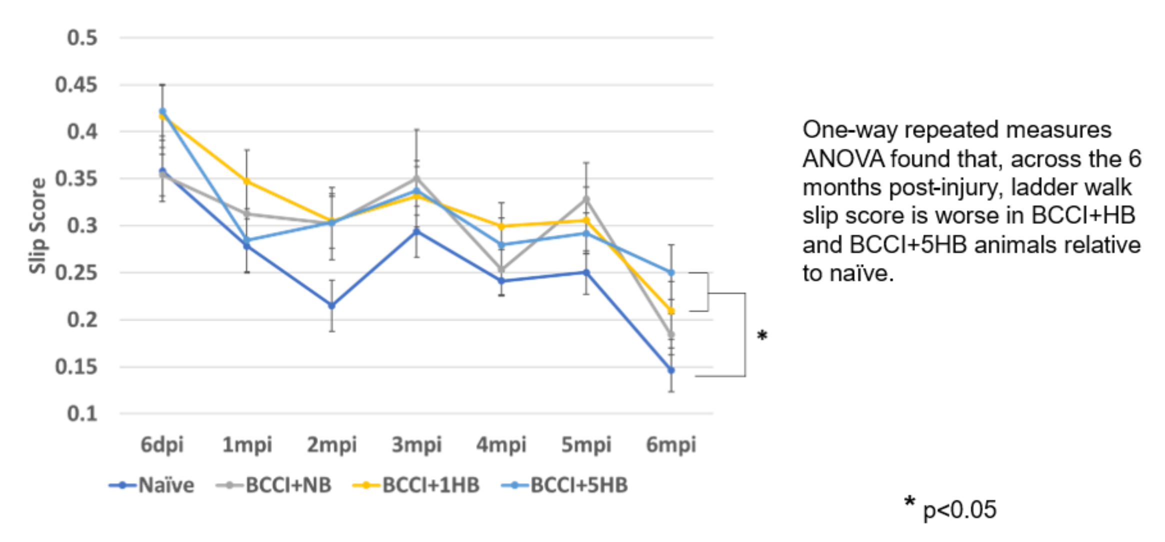


Figure 40. Exposure to hypobaric conditions following injury induces motor deficits.

The briefing by Dr. Venkata (Rama) Kakulavarapu presented the findings of collaborative work between WRAIR and DEVCOM Army Research Labs (ARL) on blast-induced changes in BBB permeability using protein-templated fluorescent metal nanoclusters. These nanoclusters were non-toxic, unlike other agents such as Evan's blue. They accurately detect the blast-induced BBB disruption as manifested by the extravasation of gold- Bovine Serum Albumin (BSA) nanoclusters in the frontal cortex, thalamus, and hippocampus (Figure 41). The researchers validated results with histology using Prussian blue staining, which indicated that cerebral microbleeds correlated with the observance of the gold nanoclusters.

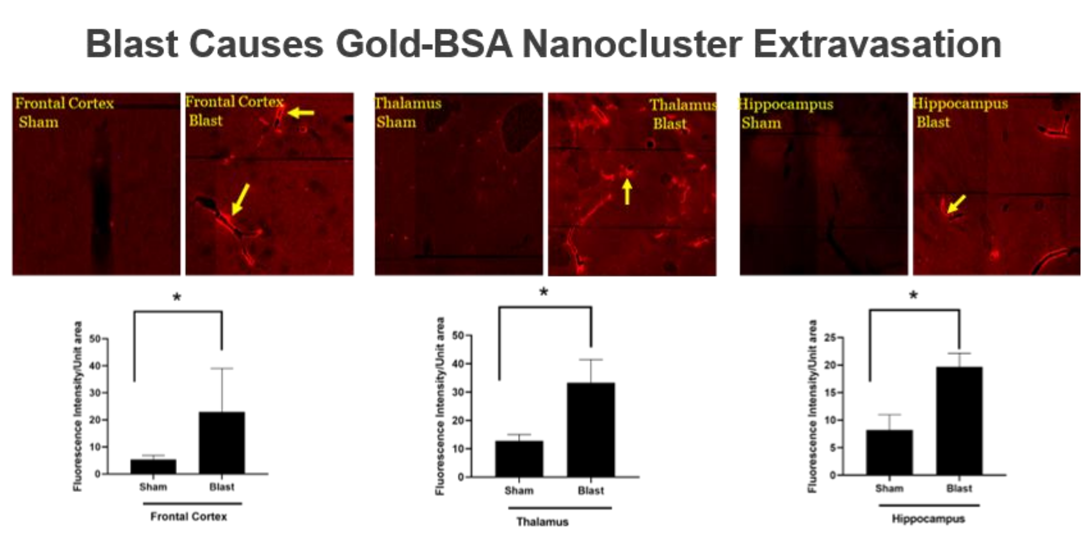


Figure 41. 25 psi blast overpressure exposure acutely disrupts the BBB

Dr. Mital Patel of WRAIR discussed how blast exposure dysregulates neuronal signaling and immune response in the brain and blood under different dietary conditions. Current human diets have a high level of omega-6 polyunsaturated fatty acids (PUFAs), and a deficiency in omega-3 fatty acids such as docosahexaenoic acid and eicosapentaenoic acid (EPA). Dr. Patel reviewed WRAIR's work with blast exposure in rat models where different cohorts were fed diets either high or low in docosahexaenoic acid and PUFAs. Results indicated diets deficient in both docosahexaenoic acid and PUFA inhibited brain transcription profiles associated with neuronal plasticity, inflammation, neurovascular coupling, and angiogenesis (Figure 42). WRAIR researchers also identified impairments in balance and coordination when rats were fed higher docosahexaenoic acid and PUFA diets for up to 14 days following blast injury.

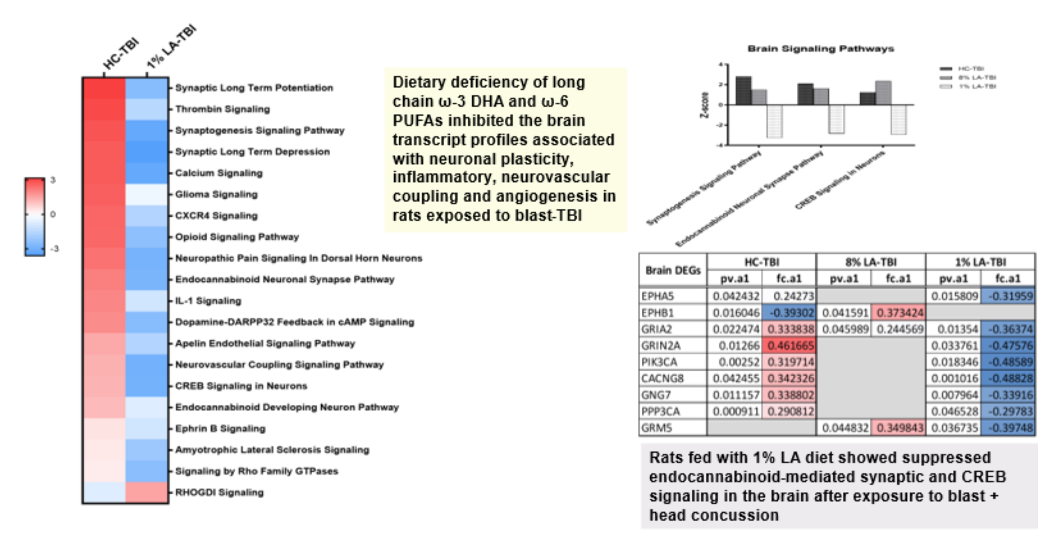
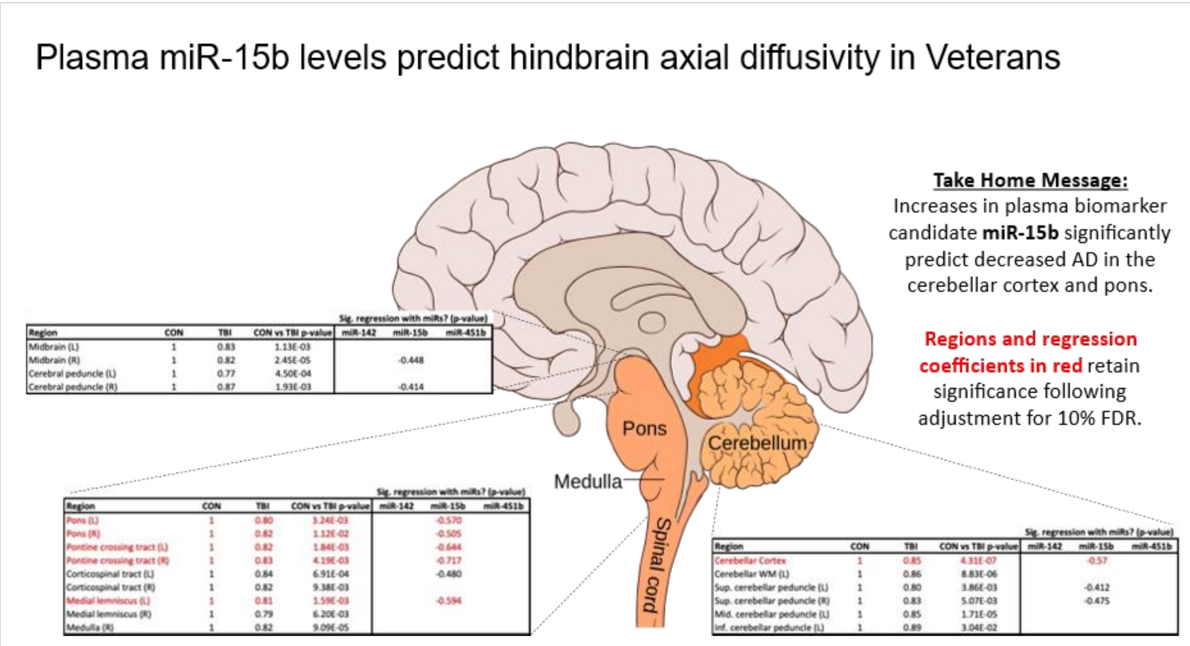


Figure 42. Diet impacts brain networks in blast-TBI rats; 1% LA diet (omega-6/3 ratio 1:1) is beneficial, reducing signaling disruption and tissue damage

A briefing by Dr. James Meabon of the U.S. Department of Veterans Affairs Northwest Mental Illness Research, Education, and Clinic Center (MIRECC) and the University of Washington Department of Psychiatry and Behavioral Sciences described the relationship between blood micro-ribonucleic acid (miRNA) concentrations and diffusion Magnetic Resonance Imaging (dMRI) measures in Veterans with mTBI caused by blasts. The first phase of the study involved tracking differentially expressed miRNAs post 20 psi blast exposure in mice, revealing correlation in the reduction of serum miRNAs and brain stem fractional anisotropy. The second phase translated these findings to Veteran subjects and found similar results (Figure 43). Dr. Meabon also highlighted the ongoing development of two-sensor MRI technology and emphasized the urgent need for accurate biomarkers of blast injury in the field.



Region	CON	TBI	CON vs TBI p-value	Sig. regression with miRs? (p-value) miR-142	miR-15b	miR-451b
Midbrain (L)	1	0.83	1.13E-03			
Midbrain (R)	1	0.82	2.45E-05		-0.448	
Cerebral peduncle (L)	1	0.77	4.50E-04			
Cerebral peduncle (R)	1	0.87	1.93E-03		-0.414	

Region	CON	TBI	CON vs TBI p-value	Sig. regression with miRs? (p-value) miR-142	miR-15b	miR-451b
Pons (L)	1	0.80	3.24E-03		-0.570	
Pons (R)	1	0.82	1.12E-02		-0.505	
Pontine crossing tract (L)	1	0.82	1.84E-03		-0.644	
Pontine crossing tract (R)	1	0.83	4.19E-03		-0.717	
Corticospinal tract (L)	1	0.84	6.91E-04		-0.480	
Corticospinal tract (R)	1	0.82	9.38E-03			
Medial lemniscus (L)	1	0.81	1.59E-03		-0.594	
Medial lemniscus (R)	1	0.79	6.20E-03			
Medulla (R)	1	0.82	9.09E-05			

Region	CON	TBI	CON vs TBI p-value	Sig. regression with miRs? (p-value) miR-142	miR-15b	miR-451b
Cerebellar Cortex	1	0.85	4.31E-07		-0.57	
Cerebellar WM (L)	1	0.86	8.83E-06			
Sup. cerebellar peduncle (L)	1	0.80	3.86E-03		-0.412	
Sup. cerebellar peduncle (R)	1	0.83	5.07E-03		-0.475	
Mid. cerebellar peduncle (L)	1	0.85	1.71E-05			
Inf. cerebellar peduncle (L)	1	0.89	3.04E-02			

Figure 43. Plasma miR-15b levels predict hindbrain axial diffusivity, highlighting the potential of specific blood miRNA as biomarkers for blast-induced injuries

Dr. Aarti Gautam of WRAIR described miRNA analysis that explored the immediate effects of TBI using animal models, specifically rodents and ferrets. He identified the ferret as a superior model due to its larger brain size and human-like cortex. Integrating findings from ferrets is also relatively easy, as the data is compatible with existing rodent research materials (Figure 44). The study utilized a range of analytical methods, including metabolomics, deoxyribonucleic acid (DNA) methylation, phosporoproteomics, and miRNA sequencing. Analysis of preliminary results shows that miRNA profiles in different tissues were unique, and that an upregulation of miRNA occurred at the four-hour mark. Some miRNAs were consistent across multiple time points and tissues, while others were not. Dr. Gautam concluded by stating that future efforts will continue data analysis, including gene analysis and tracking.

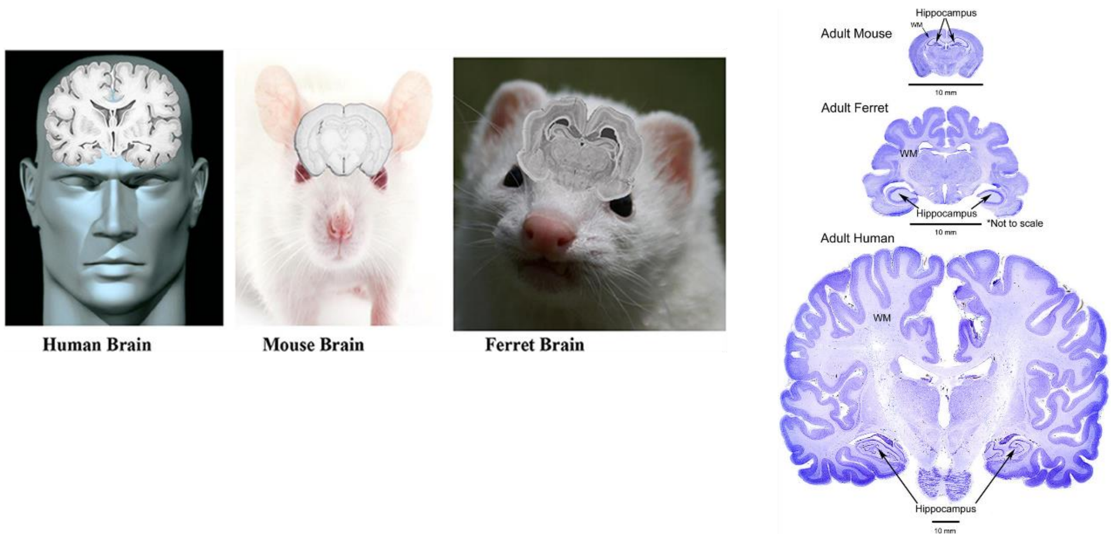


Figure 44. The ferret brain is a good model for TBI research due to its human-like structural characteristics compared to the mouse brain

Dose Response

Dr. Jeremy Kemmerer of the Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) presented the findings of a study exploring the dose-response relationship through continuous tracking of eye and body movement during exposure to breaching blast. The technology used included tracking electrooculography eye movement and accelerometer gait and balance and using a noise dosimeter to detect low-level blasts (Figure 45). The approach involved long-term monitoring of both physiology and exposure to identify thresholds. Results indicated a 160dB threshold for dose-response outcomes, potential signs of blast effects in instability of reaction time on ANAM tests, and a reduction in blink scores four hours post-exposure. Future work will include continued collaboration among MIT LL, the U.S. Army Medical Materiel Development Activity, and US Special Operations Command to develop wearable technology for early detection of BOP.

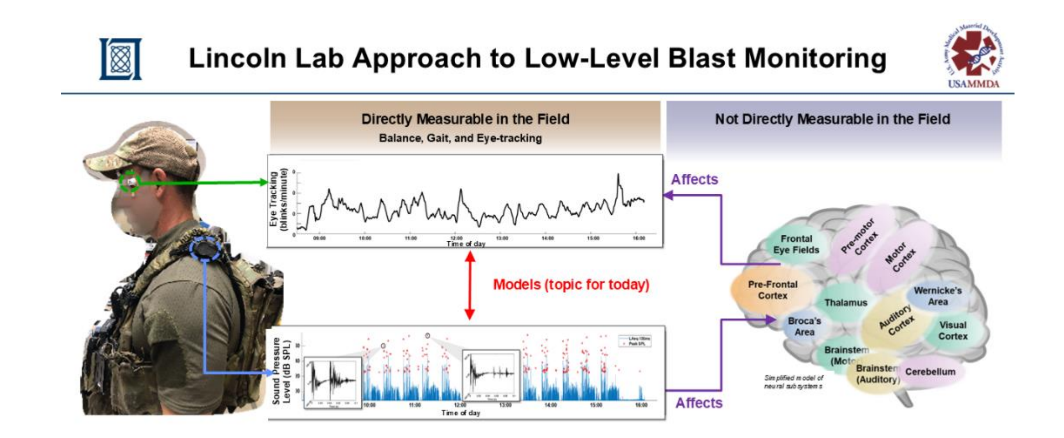


Figure 45. Continuous monitoring to relate blast exposure to physiological responses using field-measurable metrics: balance, gait, eye-tracking, and sound pressure levels

Dr. Walter Carr of WRAIR described a data-driven method for setting blast exposure thresholds in military training and operations. The approach involved extensive data collection from various military training sites that expose Soldiers to blast, including pre-exposure biosampling and cognitive and physiological testing of Service members. In the featured example of this threshold setting method, he reported how his team used the Defense Automated Neurobehavioral Assessment (DANA) cognitive test to indicate when the presence or absence of blast exposure effects could be determined. The study found that individuals with low exposure improve their performance on repeated tests, whereas those with high exposure do not. When applying this method, the research team developed a risk curve to predict the probability of slower cognitive performance post-exposure. In addition, Dr. Carr discussed Military Occupational Specialties (MOS) that require greater occupational exposure to blast and WRAIR's findings that some adverse outcomes shown in military medical records increase three-fold in Service members who have served for 8 years or more.

The presentation also covered the challenge of defining a threshold for BOP, which requires consideration of biomedical research and acceptable levels of risk. Other topics included eye tracking, hearing ability assessment, and detection of motion-elicited symptoms with the vestibular ocular motor screening (VOMS) tool. Dr. Carr noted that some of these assessments are cumbersome and therefore may present barriers for field implementation. Blood-based biomarkers of neurotrauma offer a potential alternative but can be cost prohibitive and difficult to assay in military training and operational settings. In conclusion, he acknowledged the need for comprehensive historical data on blast exposure.

Ms. Olivia Webster from DCPH-A gave a briefing on blast injury risk assessment, which is a part of JSOHA (covered in the Measurement Methodologies section). She described how the allowable number of rounds within a 24-hour period is set to result in <5% of individuals experiencing hearing loss and <1% having lung injury. Work is ongoing to determine the allowable number of rounds to prevent brain injury, including consideration of both acute and cumulative effects and beyond peak pressure of exposure (Figure 46). Based on the current 4 psi guidance, the action level would be set to 2 psi. DCPH-A is collaborating with WRAIR to identify the dose response for brain health and has also supported the development of the primary blast injury of brain ICD-10 codes to enable improved documentation of blast injuries.

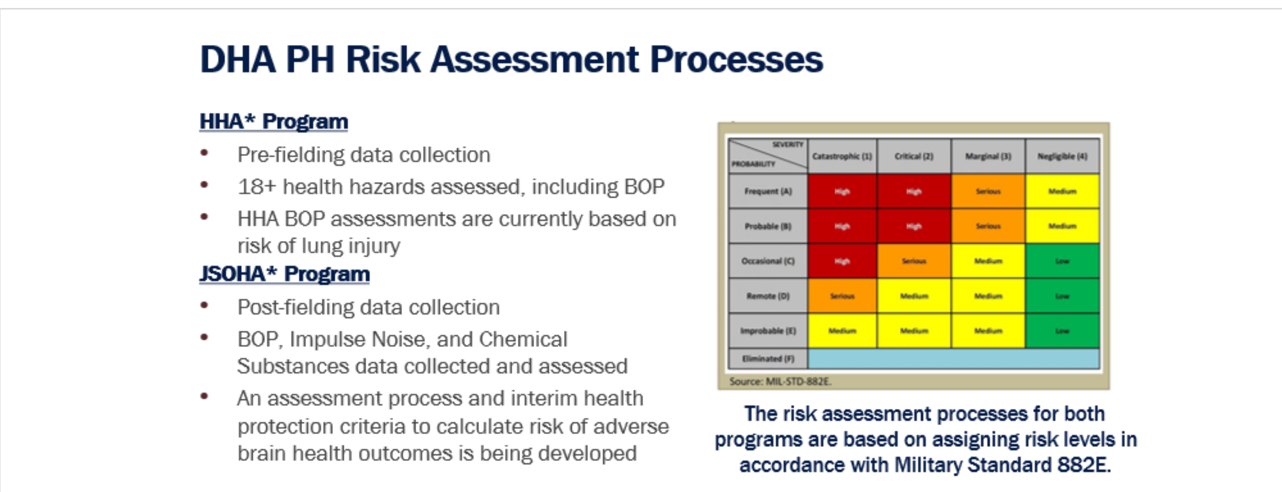


Figure 46. Developing assessment processes for blast overpressure risks in HHA and JSOHA programs

Survey and Topics for Future Meetings

The forum gives participants many opportunities for on-site and follow-up collaboration. The format of the forum allows attendees to ask technical questions regarding the methods used in experiments, and then follow up one-on-one with presenters for further discussion during breaks.

MITRE asked participants to provide feedback on the event, its impact on collaboration, and recommendations for future meetings. Twenty-nine participants completed the paper survey. Overall, 93% of the survey respondents reported that the presentations improved their understanding of international efforts in blast injury research and that they would recommend IFBIC 2025 to colleagues who did not attend IFBIC 2024, while 86% of the respondents agreed that both the information they learned and the connections they made will influence their research in the future. The most common recommendation was to include more discussion time in the agenda and keep sessions shorter. Participants also provided feedback about topics they would like to cover in the future. They included:

- Blasts on shipboard and in enclosures
- Animal blast testing and modeling (including the positive and especially negative aspects of current animal models)
- Multispecies mapping of blast injuries
- Debates about which common data elements to include in Service members' electronic medical records
- Prevention/mitigation, including guidelines for mitigation of mTBI resulting from exposure to repetitive low-level blast
- Diagnostic approaches
- The lag between research and policy
- Important, broadly applicable non-military blast events (e.g., Beirut explosion)
- Behavioral and sensory effects of blast.

Blast Injury Research Impacts

The technical presentations addressed emerging themes of blast injury research, including improving understanding of differences in exposure to BOP in different environments (e.g., individuals near tank training events, effect of elevation on injury patterns from the 2020 Beirut Blast) and collection of multisensory data, including chemical exposures from blast. Additionally, new insight into the pathomechanism of repeated subconcussive blast exposures, impacts on the BBB, proteome, astrocytes, immune system and advancements in investigation of blast injury topics and their potential impacts, including:

- Algorithms (e.g., Blast Overpressure Tool, Generalized Blast Exposure Value) and sensing technologies (e.g., wearables and surrogates) that increase the accuracy of predicted and measured exposures and improve the ability to correlate exposures to injuries
- Materiel for mitigation of blast, including new helmet designs and 3D-printed charge forms that reduce hazards by redirecting the force of the blast into the door of the building being breached and decrease explosive mass needed to achieve the same effect
- Changes to training, such as increased distance between firing lane positions, to reduce exposures
- New approaches used to assess blast exposure effects, such as blood biomarkers, nanomedicine, and boothless audiometry, which increase access to and sensitivity of health and performance measurements
- Methodologies, such as new shock wave generators and use of laser shockwaves, to increase accuracy of laboratory-based blast generation
- Biological models, including human tissue structures and ferret animal models, for improved translation into human injury and behavioral response
- Computational models that inform mitigation decisions by simulating blast loads to the brain, investigating the factors affecting exposures (e.g., helmets, crew positions), and predicting severity of injury
- Treatment methods, such as dimorpholamine to improve respiratory outcomes, and hydrogen-enhanced water to mitigate TBI effects
- Methods of accounting for treatment factors, including contamination (e.g., fungal), to improve prognosis.

Findings

- Insufficient information to inform treatment of blast injuries. Service members would benefit from improved care benefits and treatment of blast injuries.
- Limited data on blast exposure and the effects of different environments on Service member exposures. The ability to mitigate exposures and injuries would benefit from enhanced exposure monitoring, including further data collection, calculation of additional blast metrics (e.g., energy, impulse), and algorithm testing in more complex environments (e.g., indoors, between vehicles, different Service member orientations relative to the blast).
- Difficult to acquire and field wearable sensors to inform operational decisions. The community would benefit from DoD requirements to enable fielding of wearables for blast measurement.
- Complex relationship between blast exposures and injury is not yet well understood. Proposed research efforts include the effects of body orientation and variability in weapon use and protective equipment design across Services and countries. The research community is also working on the identification of early indicators of blast injury to help inform decisions.
- Difficult to translate findings from emerging research into actions to prevent, mitigate, and treat blast injuries. The IFBIC community, especially operational representatives, noted the importance of translating research to meet the immediate operational need to determine which blast exposures are unsafe and apply this information in the field as soon as possible.

Recommendations

Overarching recommendations were identified based on the review of current research, knowledge gaps, challenges, and planned future research by the community.

1. Consider the full range of blast exposure effects.

Clinical, research, and operational communities should holistically consider blast effects to inform policy, procedures, and future research. This includes impacts across the full range of blast injuries, human body response after exposures, and the effects of differences in environmental conditions, such as reflective surfaces, on both the exposures and resulting injuries.

- Blast effects are not limited to the head or immediate effects so there is a need to view individuals more holistically, including factors that affect individual susceptibility.
- Clinicians and scientists must understand blast effects across scales, including at the human, tissue, cellular, and subcellular levels, to guide prevention, diagnosis, and treatment.
- Understanding of the dose response characteristics of repeated BOP exposures, acceptable risk thresholds and correlating BOP exposure to degradation in performance and clinical sequels
- Future research must think broadly about blast exposures, including reflective environments, chemicals, and other factors (e.g., risk of fungal infection) that affect risk and severity of injury, as well as treatment effectiveness. Efforts need to consider different features of blast and the environment, such as blast propagation under a helmet and blast exposures that occur in-between vehicles.

2. Improve diagnosis and monitoring of blast effects.

The DoD should establish biomedically valid blast injury risk prediction models to inform policies and actions, including those centered on mitigation and triage for diagnosis. Additionally, especially for low-level cumulative effects of exposure, the DoD should sponsor research to enable early identification and diagnosis of the health and performance consequences of exposure to blast.

- Researchers and clinicians need to consider and identify the physiologic system target for diagnosis and injury in risk models to establish thresholds for clinical and operational action.
- Repositories of data on exposure and injury are important and should include detailed exposure data reflecting thorough monitoring of injuries, including training injuries in the Joint Trauma Registry.

3. Take a multifaceted approach to blast injury countermeasures.

Continued collaboration across nations and research domains is essential for enabling translation of research findings into real-world countermeasures. The DoD must address blast injury effects at multiple insertion points, including elimination of blast hazards during weapon and facility design, enhanced training and awareness to inform engineering and administrative controls (e.g., positions of instructors and bystanders), and development of protective equipment.

- A broad range of potential countermeasures support blast injury mitigation. In addition to methods to reduce exposure (e.g., increasing standoff distance, limiting rounds fired, requiring protective equipment), DoD should consider other strategies such as potential nutritional countermeasures and methods to reduce secondary pathology at a cellular level.
- Transitions of research findings into policy, operational decisions, diagnosis, and treatment will also be critical for mitigating blast effects.

Summary

Overall, the 8th IFBIC gave the international community of blast injury researchers the opportunity to share knowledge that will help improve future research and actions to mitigate blast injuries. The diverse backgrounds of participants enabled the forum to increase awareness of strategies and research techniques across domains – a benefit not offered by conventional scientific meetings. The presenters shared preliminary findings, exploratory studies, and other work-in-progress efforts, allowing early feedback, contributing to work shaping, and stimulating collaboration among forum participants.

The forum highlighted the potential impacts of ongoing research efforts such as providing increased injury prediction accuracy, preventing injuries through materiel and administrative control solutions, detecting injuries when they occur, improving treatment outcomes, and establishing accurate research models for both the blast exposure and biological impacts. Findings from the forum included that there is insufficient information to inform blast injury treatment, limited data on blast exposure and the effects of different environments on Service member exposures, there is no requirement to support blast sensor acquisition, the complex relationship between blast exposures and injury is not yet well understood, and it is difficult to translate findings from emerging research into actions to prevent, mitigate, and treat blast injuries. Overarching recommendations were identified based on the review of current research, knowledge gaps, challenges, and planned future research by the community: 1) consider the full range of blast exposure effects, 2) improve diagnosis and monitoring of blast effects, and 3) take a multifaceted approach to blast injury countermeasures. The forum succeeded in facilitating information sharing across communities and identifying critical areas for actions to prevent, mitigate, and treat blast injuries. Participants recommended future topics and improvements for future meetings.

The collaborative efforts will continue at the 9th IFBIC, to be hosted by NDMC on 7–9 May 2025 in Tokyo, Japan.

Appendix A: IFBIC 2024 Announcement

Third Announcement and Call for Papers

8th International Forum on Blast Injury Countermeasures (IFBIC 2024)

1 – 3 May 2024

The MITRE Corporation, McLean, Virginia

https://blastinjuryresearch.health.mil/index.cfm/about_us/international_collaboration

Objective and Scope

In recent years, attacks using explosive devices occur frequently, not only on battlefields and in regions of conflict, but also in urban areas in peacetime due to terrorism, resulting in a large number of blast injury victims. The US Department of Defense uses the *Taxonomy of Injuries from Explosive Devices* (as described in DoDD 6025.21E) to organize blast injuries into five groupings based on their approximate order of temporal incidence upon the body following an explosion. Primary injuries result from the blast shock wave. Secondary injuries result from penetrating fragments of material accelerated by the blast. Tertiary injuries result from accelerative loading or blunt impact to tissues. Quaternary injuries include dermal burns and toxic gas inhalation. Quinary injuries include contamination by nuclear, chemical, or biological agents. Primary injuries that are peculiar to blast shockwave exposures include mild blast-induced traumatic brain injury (bTBI), hearing loss, ocular injury, and lung injury. All body systems are vulnerable to secondary injuries due to penetrating fragments and tertiary injuries due to acceleration and blunt force trauma.

International cross-disciplinary collaboration is regarded as essential to investigate physical causes of blast injury, to characterize the vulnerability of anatomical systems and their functions to blasts, and to develop the means to prevent, mitigate, and treat blast injuries. Countermeasures may include personal protective equipment; weapons and vehicle systems engineered for safety; tactics, techniques, and procedures (TTPs) for injury prevention; and medical interventions tailored to the specific needs of blast injuries.

This International Forum on Blast Injury Countermeasures (IFBIC) started as Technical Information Exchange Forum between Japan and the United States, which brought together broad knowledge and expertise, and to share national experiences and evidence-based approaches for blast injuries. The former three Japan-US Technical Information Exchange Forum on Blast Injury (JUFBI) were held in June 2016, April 2017 and May 2018, all in Tokyo. At the end of JUFBI 2018, the organizing committee decided to change the forum name to International Forum on Blast Injury Countermeasures to reflect the expanding participation by additional nations such as Australia, Canada, Germany, South Korea and the United Kingdom. IFBIC 2023 was held in Tokyo, Japan.

These meetings have been very productive, involving active and fruitful discussions and exchange of creative ideas on a broad spectrum of blast injuries; identifying critical issues involving experimental and computational studies of blast-induced injuries; and creating new partnerships on joint research explorations to address the many scientific and technical challenges facing the field.

Building upon these successful meetings, the next IFBIC will be held from 1 – 3 May 2024 at The MITRE Corporation in McLean, Virginia.

The objectives for the 8th Forum include:

a. Assembly of an international forum focused on multi-disciplinary science and medicine necessary to increase our understanding of blast injury and its countermeasures from bench to bedside
b. Achieving a mutual understanding of international efforts in blast injury research
c. Identifying knowledge gaps requiring collaborative research
d. Increasing understanding and promoting further collaboration to improve prevention, clinical diagnosis, and treatment addressing the entire spectrum of blast-related injuries

The meeting agenda includes the following broad topic areas. Innovative research beyond this topic list will also be considered:

4. Blast injury epidemiology and environmental sensing of blast shockwave hazards

a. Clinical prevalence of varieties of blast injuries sorted by context, anatomy, and severity
b. Blast energy / physics / waveforms, reflections, effects of media (e.g., air vs. water vs. solid material)
c. Unique environments for blast (e.g., space, high altitude, subterranean, underwater)
d. Blast sensor engineering, test and evaluation, fidelity, usability
e. Correlation of blast sensing with clinical outcomes
f. Use of multiple sensors to reconstruct blast phenomena
g. Stimulus differences between operational and training environments
h. Conditions particular to Special Operations
i. Scaling effects between human and animal models of injury

5. Primary blast injury (due directly to shockwave effects)

a. Experimentally derived injury risk criteria for anatomical structures and their functions, including brain, ocular, auditory, and lung
b. Predicted incapacitation due to blast injuries (e.g., loss of neuromuscular control, reduced sensory or cognitive function, reduced respiration)

6. Secondary (penetrating ballistic fragments) and tertiary (acceleration and blunt force) blast injury

a. Experimentally derived injury risk criteria for anatomical structures and their functions
b. Predicted incapacitation due to blast injuries (e.g., loss of musculoskeletal force)

7. Long-term effects, cumulative effects, and chronic symptoms due to blast exposure

a. Brain: aberrant protein expression and accumulation (e.g., phosphorylated Tau)
b. Brain: chronic traumatic encephalopathy (CTE)-like symptoms
c. Brain: correlation and comorbidity with post-traumatic stress disorder (PTSD)
d. Effect of cumulative subclinical (i.e., not provoking diagnosis) exposures to blast phenomena for all body systems
e. Effect of repeated clinical (i.e., provoking diagnosis) exposures to blast phenomena for all body systems

8. Prevention, mitigation, treatment of blast injuries

a. Personal protective equipment (PPE) such as helmets, body armor, eye protection, hearing protection, etc.
b. Weapon and vehicle systems engineered for safety in blast environments
c. Tactics, techniques, and procedures (TTPs) for Warfighter safety in blast environments
d. Operational mission planning for needed medical response
e. Lessons learned from military operations
f. Resilience training (e.g., stress inoculation, mindfulness-based cognitive therapies to prevent sequelae of psychological trauma from blast exposures)
g. Biomedically-based design and acquisition standards for military equipment (materiel)
h. Biomedically-based health hazard assessments
i. Clinical current practices, interventions, surgeries, rehabilitative therapies
j. Polytrauma (blast/blunt/ballistic/etc.), penetrating wounds, burns, infection
k. Whole body hypothermia treatments for blast related injuries
l. Neurofeedback training for TBI and comorbid PTSD recovery

9. Diagnostic measures / biomarkers

a. Innovations in self-reported symptom inventories
b. Innovations in diagnostics based on observations by clinical staff
c. Innovations in molecular markers of blast injury
d. Innovations in biomedical imaging measures of blast injury
e. Innovations in behavioral or functional tests for blast injury (including quantitative EEG)

10. Computational modeling and simulation of blast phenomena and blast injury

a. Deformable finite element modeling (FEM) of stresses and strains
b. Injury risk criteria applied to force-time histories from FEM
c. Incapacitation risk criteria applied to injury predictions from FEM
d. Shockwave modeling
e. Innovations in coupling between computational fluid dynamics (CFD) and FEM
f. Integration of computational models with blast sensors and other sensors (e.g., strain gauges or force transducers on cadavers or simulant manikins)
g. AI / ML / data science in blast research

11. Characteristics comparisons between blast-related TBI and blunt TBI

12. New technology and methods for blast injury research and medicine

Contributions from all countries, as well as from young investigators, are welcome.

General Information

Meeting title:

The 8th International Forum on Blast Injury Countermeasures (IFBIC 2024)

Organized by:

U.S. Army, Medical Research and Development Command (USAMRDC)

U.S. Army Combat Capabilities Development Command (USA CCDC DEVCOM-ARL)

National Defense Medical College Japan (NDMC)

Important dates:		
Abstract submission deadline:	28	February 2024
Abstract acceptance notification:	14	March 2024
Registration deadline:	1	April 2024
Hotel reservation deadline:	25	March 2024
IFBIC 2024:	1 - 3	May 2024

A closed meeting for planning committee members will be held on Monday, 6 May 2024 at The MITRE Corporation in McLean, Virginia following the main portion of the meeting.

Venue:

MITRE Corporation Headquarters, Building 4, Robb Conference Room, 7515 Colshire Drive, McLean VA 22102 USA

Abstract Submission

Please prepare your abstract using the template provided at the conference website and the attachment template. Abstract submissions should be emailed directly to the IFBIC point of contact no later than close of business on 28 February 2024, 5:00 p.m. U.S. Eastern Standard Time.

IFBIC 2024 Point of Contact e-mail: IFBIC@mitre.org

All submitted abstracts will be reviewed by the IFBIC 2024 Program Committee and notification of abstract acceptance will be made by 14 March 2024. NOTE: Priority will be given to submitted abstracts that contain original findings that have not been reported in previous IFBIC forums. Prior research reported at IFBIC may always be included as background information in support of original findings that are new to the IFBIC venue.

Registration

Pre-registration is required for all participants, and participation will be limited by venue capacity. The pre-registration deadline is 1 April 2024. The meeting registration will be open for registration on or after February 5, 2024.

“On-site” meeting registration will not be offered.

There is no registration fee. An optional meeting expense charge of $140 USD will be collected online as part of the pre-registration process. **Due to the lack of restaurants convenient to the meeting location, meeting attendees are encouraged to sign up for catered lunch and refreshments provided on-site.** This charge covers hot and cold beverages including coffee, tea, snacks, and lunch during the three meeting days and the social gathering the first evening. Options will be available on-site for gluten-free, dairy-free, vegetarian, and vegan dietary restrictions. Registration for catering is done using the meeting registration.

IFBIC 2024 Point of Contact e-mail: IFBIC@mitre.org

Hotel Accommodations

For the participants who wish to stay near the Forum venue, a block of rooms have been reserved at both the Residence Inn Tysons Corner Mall and at the Archer Tysons Hotel. A list of other hotels in the area is also available on the registration website. Please be advised that May is a busy time in Washington, DC and rooms should be booked early.

Hotel Information:
You may contact the Residence Inn Tysons Corner directly at (703) 917-0800 or the Archer Tysons Hotel directly at (703) 912-0488 to reserve a room within the group block by mentioning that you are reserving with the ‘IFBIC 2024’ group or use the following reservation links:

Residence Inn Tysons Corner: link
Archer Tysons Hotel: link

Keynote and Tutorial Speakers

Keynote speakers will be announced closer to the meeting date.

Tutorial speakers have not yet been selected. **If you would like to lead a tutorial session, please submit a separate abstract for your proposed tutorial.** Abstracts for tutorial sessions must provide a title that begins with the word, “Tutorial:”. Abstract submission for tutorial sessions must follow the same guidelines as those for regular presentations, as described in the “Abstract Submission” section above.

Social Gathering

Optional evening social events include a meet-and-greet social with hors d’oeuvres the evening of Wednesday 1 May. All food service will provide on-site options for gluten-free, dairy-free, vegetarian, and vegan dietary restrictions. Costs of attendance at the social gathering are included in your participation fee for the Forum.

Meeting Organization Committee

General Chair:
Jacob (Jake) Johnson (USAMRDC, USA)

General Co-Chair:
Satoshi Tomura (NDMC, Japan)

Program Chair:
Raj Gupta (USAMRDC, USA)

Program Co-Chair:
Satoko Kawauchi (NDMC, Japan)

Members:
James Batchelor (Univ. of Southampton, UK)
Thomas DeGraba (NICoE, USA)
Lt. Colonel Dr. Steffen Grobert (Bundeswehr Office for Defence Planning, Germany)
Yasuyuki Honda (OASDHA, USA)
Shashi Karna (USACCDC Army Research Laboratory, USA)
Emrys Kirkman (DSTL, UK)
Nobuaki Kiriu (NDMC, Japan)
Yutaka Kodama (USACCDC DEVCOM, International Technology Center-Pacific (ITC-PAC), USA)
Adam Lewis (USAMRDC, USA)
Izumi Nishidate (TUAT, Japan)
Masayuki Ohta (NDMC, Japan)
Thuvan Piehler (USAMRDC, USA)
Masaki Takeda (ATLA, Japan)
Yuya Tanaka (JGSDF & MoD, Japan)
Akimasa Tashiro (NDMC, Japan)
Satoshi Tomura (NDMC, Japan)
Olivia Webster (DCPH-A, USA)
Therese West (USAMRDC, USA)

Meeting Secretaries:
Adam Lewis (USAMRDC)
Raj Gupta (USAMRDC, USA)
Satoko Kawauchi (NDMC, Japan)

Contact/Questions:
LTC Adam Lewis (USAMRDC, USA)
Brain Health Coordinator

DoD Blast Injury Research Coordinating Office
US Army Medical Research and Development Command
504 Scott Street, Fort Detrick, MD 21702
Telephone: (301) 619-7376
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Event Point-of-Contact (POC):
IFBIC@mitre.org

Partners and Sponsors

Appendix B: IFBIC 2024 Program

Check-in and Introductions	
-	**Wednesday, 1 May 2024:**
08:30	**Daily check-in at security desk and light breakfast**
09:00	**MITRE Welcome & Facilities Overview**
09:05	**MITRE Leadership Welcome and Introduction** Dr. Troy J Mueller *The MITRE Corporation, U.S.*
09:15	**Program Chair and Co-Chair Introductions and Meeting Overview** Dr. Raj K. Gupta and Dr. Satoko Kawauchi *DoD Blast Injury Research Coordinating Office, U.S. Army Medical Research and Development Command, U.S.,* *Division of Bioinformation and Therapeutic Systems, National Defense Medical College Research Institute, Japan*
09:25	**Participant Introductions**
09:45	**General Chair Welcome Remarks** COL Jacob (Jake) Johnson *DoD Blast Injury Research Coordinating Office, U.S. Army Medical Research and Development Command, U.S.*
09:55	**General Chair Welcome Remarks** Dr. Satoshi Tomura*, Division of Traumatology, Research Institute, National Defense Medical College, Japan*
10:05	**Keynote Address: Transformation of SDF medical function and international cooperation** LT Gen. Naruo Kuwada, Vice President *National Defense Medical College, Japan*
10:35	**Morning Break – 15 Minutes**
Session 1: Blast overpressure (BOP) Exposure Monitoring (1 of 2) *Co-chairs: Dr. Satoshi Tomura and Ms. Olivia Webster*	
10:50	**Evaluation of blast wave exposure on military personnel during firing heavy armaments** M. Kawasaki*, E. Nakayama, W. Nagata, Y. Shinada, K. Tashiro, S. Kurihara, R. Matsuda, S. Kawauchi, S. Sato, and N. Ito **Military Medicine Research Unit, Test & Evaluation Command, Japan Ground Self-Defense Force*
11:05	**Machine Learning Applications to Person-Borne Blast Dosimeter Data** J.P. Dionne*, Jeffrey Levine, and A. Makris *Med-Eng Holdings ULC, Canada*
11:20	**Blast Overpressure Tool for Range Safety** R. Gupta*, R. Spencer, E. Brokaw, W. Carr, M. Skotak, H. Garimella, L. Lalis, M. Oliver, D. Palmer, A. Przekwas, M. Xynidis, G. Dias, L. Danley, and A. Dominijanni **DoD Blast Injury Research Coordinating Office, U.S. Army Medical Research and Development Command, U.S.*
11:35	**Demo: BOP Tool** A. Przekwas, *CFD Research Corporation, U.S.,* and D. Palmer, *Federal Strategies, U.S.*
11:50	**Session Discussion**
12:05	**Keynote Address: Overview of DoD interest and action to support blast brain injury prevention, mitigation and treatment** Dr. David J. Smith, *Deputy Assistant Secretary of Defense for Health Readiness Policy and Oversight, U.S.*
12:35	**Lunch – 1 Hour**
13:35	**Keynote Address: Comparison of MHS Auditory Blast Injury Candidate Standards in Predicting Temporary Threshold Shifts using Body-worn Dosimetry** Dr. Doug Brungart *Audiology and Speech Center, Walter Reed National Military Medical Center, U.S.*

Session 2: Brain Injury Sensing and Diagnosis *Co-chairs: Dr. Raj Gupta and Dr. James Stone*	
14:05	**Interface astroglial scarring and fibrotic reactions in the rat brain exposed to a laser-induced shock wave(s)** S. Kawauchi*, A. Kono, Y. Muramatsu, G. Hennes, S. Seki, Y. Haruyama, Y. Komuta, I. Nishidate, S. Matsukuma, Y. Wang, and S. Sato **Division of Bioinformation and Therapeutic Systems, National Defense Medical College Research Institute, Japan*
14:20	**SOF Community Engagement: Designing bTBI Research and Translational Products That Meet Clinician and Operator Needs** R.A. Ivory* and J.S. Meabon **Mental Illness Research, Education, and Clinical Center, VA Puget Sound Health Care System, U.S.* **University of Delaware School of Nursing, U.S.*
14:35	**Invited Presentation: Considering repeated low-level blast exposure in the context of the current classification of TBI** J.R. Stone*, G.A. Elder, B.B. Avants, N.J. Tustison, E.A. Wilde, A.A. Lyons, L.A. Gladney, and S.T. Ahlers **University of Virginia School of Medicine, U.S.*
14:55	**Keynote Address: Nano-biophysics for TBI: Early warning, diagnosis, monitoring, therapy** Dr. Ratnesh Lal *Mechanical and Aerospace Engineering, Bioengineering, Program in Materials Science, University of California San Diego, U.S.*
15:25	**Afternoon Break – 15 Minutes**
Session 3: Therapies, Treatments, and Prevention *Co-chairs: Dr. Adam Lewis and Dr. Leanne Young*	
15:40	**Study on Effects of Dimorpholamine for Lifesaving Treatment in the Hyperacute Phase of Blast Injury** N. Kiriu*, D. Saitoh, K. Yamamura, R. Sasa, M. Fujita, S. Kawauchi, S. Sato, and S. Tomura **Division of Traumatology, Research Institute, National Defense Medical College, Japan* **Department of Traumatology and Critical Care Medicine, National Defense Medical College Hospital, Japan*
15:55	**The Military Operational Medicine Research Program – Neurosensory Injury Prevention and Treatment Overview** M. Sun *Military Operational Medicine Research Program, U.S. Army Medical Research and Development Command, U.S.*
16:10	**Effects of intravenous hydrogen water administration on blunt and blast TBI models in mice** S. Tomura* and K. Wada **Division of Traumatology, Research Institute, National Defense Medical College, Japan*
16:25	**At the End of the Barrel: Establishment of Improved Combat-Relevant Animal Models using Blast Overpressure Exposure to Develop Therapeutics against Wound Infections** A.G. Bobrov*, K.E. Rios, Y. A. Alamneh, R.J.R.S. Thanapaul, L.M. Werner, A. Roberds, M.P. Nikolich, J.B. Long, A.A. Filippov, V. Antonic, E.S. Bergmann-Leitner, V.S. Sajja, R.J. Cybulski Jr., and S.M. Noble **Bacterial Diseases Branch, Walter Reed Army Institute of Research, U.S.*
16:40	**Session Discussion**
16:55	**Daily Closing Remarks, and Adjourn** Dr. Raj K. Gupta
17:00	**Optional Evening Social (17:00 to 19:00, MITRE Robb Auditorium lobby)**

-	**Thursday, 2 May 2022:**
08:30	**Daily check-in at security desk and light breakfast**
09:00	**MITRE Welcome & Facilities Overview**
Session 4: Modeling and Simulation of Blast Exposure and Injury (1 of 2) *Co-chairs: Dr. Satoko Kawauchi and Dr. Anthony Santago II*	
09:05	**Tutorial: Findings from the DoD Working Group on Computational Modeling of Human Lethality, Injury, and Impairment from Blast-related Threats** A. Santago II *The MITRE Corporation, U.S.*
09:35	**Invited Presentation: Machine Learning Approach to Identify the Pathobiology of Repeated Exposures to Subconcussive Level of Primary Explosive Blast** D.V. Agoston*, J. McCullough, I-H. Lin, M. Eklund, W.M. Graves III, C. Dunbar, J. Engall , E.B. Schneider, F. Leonessa, and J.L. Duckworth **Department of Anatomy, Physiology & Genetics, Uniformed Services University, U.S.*
09:55	**Investigation of intracorporeal shock wave propagation using a simplified torso model and a shock wave generator - a progress report** H. Seeber*, D. Krentel, M. Gerbeit, and S. Grobert **Helmut Schmidt University – University of the Federal Armed Forces, Germany*
10:10	**Application of Meshfree Methods to Blast Injury Countermeasure Problems** J. Magallanes*, M. Hillman, I. Cardenas, J. Raygoza, N. Meisner*, Y. Wu, and J. Hamilton **Karagozian & Case, Inc., U.S.*
10:25	**Morning Break – 15 Minutes**
10:40	**Blast Load Pressure Over a Surrogate Human Skull: Shock Tube Experiments and CFD Computations** J. Hamilton, N. Meisner*, J. Magallanes, and D. VandeVord **Kargozian & Case, Inc., U.S.*
10:55	**Modeling the Medical and Operational Impact of Blast in the Battlefield** L. Young*, C. Wagner, T. Walilko, J. Mothershead, J. Rodriguez, and A. Wu **Applied Research Associates, Inc., U.S.*
11:10	**Session discussion**
11:25	**Keynote Address: Glial engineering: Multiscale probing and sensing tools to unveil the role of astrocytes in brain function and dysfunction** Dr. Valentina Benfenati *Consiglio Nazionale delle Ricerche, Istituto per la Sintesi Organica e Fotoreattività, Italy*
11:55	**Blast Injury and Brain Health in Australia** Lieutenant Colonel (retd). Paul Scanlan.
12:00	**Lunch – 1 Hour**
Session 5: Blast Exposure and Brain Health (1 of 2) *Co-Chairs: Dr. Steffen Grobert and Dr. Walter Carr*	
12:55	**Keynote Address: Blast-Related Injury in Military Personnel, Perspectives from the DoD/USU Brain Tissue Repository** Dr. Dan Perl *Department of Pathology, Uniformed Services University of the Health Sciences, U.S.*
13:25	**Chronic neurobehavioral changes following multiple simulated aeromedical evacuations in a ferret model of under-vehicle blast-induced traumatic brain injury** M. J. Goodfellow*, L. Jiang, B. Piskoun, A. Hrdlick, J.L. Proctor, S. Xu, U. Leiste, W. Fourney, and G. Fiskum **University of Maryland School of Medicine, Department of Anesthesiology and the Center for Shock, Trauma, and Anesthesiology Research (STAR), U.S.*
13:40	**Investigation of Blast-Induced Blood-Brain-Barrier Permeability Changes Using Protein-Templated Fluorescent Metal Nanoclusters**

	V. (Rama) Kakulavarapu*, K.J. Perry, M.K, S.P. Karna, R.K. Gupta, V.L. McLean, D.M. Wilder, V.S. Sajja, and J.B. Long **Blast Induced Neurotrauma Branch, Center for Military Psychiatry and Neurosciences, Walter Reed Army Institute of Research, U.S.*
13:55	**Blast Exposure Dysregulates Neuronal Signaling and Immune Response in the Brain and Blood under Different Dietary Conditions** M.Y. Patel*, R. Yang, S.M. Miller, N. Chakraborty, J. DeMar, A. Batuure, D. Wilder, J. Long, R. Hammamieh, and A. Gautam **Techwerks, U.S.* **Medical Readiness Systems Biology Branch, Walter Reed Army Institute of Research, U.S.*
14:10	**Acute Proteome Changes in the Brain and Plasma of Ferrets after Blast Exposure** J.C. DeMar*, L.S. Neff, J.L. Stephenson, N.I. Crespo Rosales, N.C. Gary, S. Dahal, V. S. Sajja, J.B. Long, A. Gautam, and R. Hammamieh **Medical Readiness Systems Biology Branch, Walter Reed Army Institute of Research, U.S.*
14:25	**Calcium Dynamics of Neural Networks in the Presence of Fluorescent Protein-templated Au Nanoclusters** K.J. Perry*, W. Losert, S.P. Karna, and R.K. Gupta **DEVCOM Army Research Laboratory, Aberdeen Proving Ground, U.S.* **University of Maryland, College Park Institute for Physical Science and Technology, U.S.*
14:40	**Session Discussion**
14:55	**Afternoon Break – 15 Minutes**
15:10	**Keynote Address: Sensing Physical Signals with Cytoskeletal Dynamics** Dr. Wolfgang Losert *Department of Physics, University of Maryland College Park, U.S.*
15:40	**USSOCOM Comprehensive Strategy for SOF Warfighter Brain Health – Advance Line of Effort** Mr. Chris Wilson *U.S. Special Operations Command, U.S.*
16:00	**Discussion**
16:20	**Daily Closing Remarks, and Adjourn** Dr. Raj K. Gupta

-	**Friday, 3 May 2024:**
08:30	**Daily check-in at security desk and light breakfast**
09:00	**MITRE Welcome & Facilities Overview**
Session 6: Modeling and Simulation of Blast Exposure and Injury (2 of 2) *Co-chairs: Dr. Brandon Casper and Dr. Henrik Seeber*	
09:05	**Keynote Address: Human Underwater Blast Exposure** Dr. Brandon Casper *Naval Submarine Medical Research Laboratory, Submarine Base New London, U.S.*
09:35	**Investigating internal wave mechanics in a surrogate head model based on repeated shock wave impact** R. Banton* and M. Kleinberger **U.S. Army Combat Capabilities Development Command Army Research Laboratory, U.S.*
09:50	**Preservation of the Peak Underpressure when Reconstructing the Blast Waveform** A. Dominijanni*, L. Schambach, J. Moore, and R.K. Gupta **The MITRE Corporation, U.S.*
10:05	**A Conceptual Combat Helmet Performance Assessment Framework Integrating Blast, Blunt Impact and Thermal Loading** A. Bagchi*, Y.Y. Khine, X.G. Tan, and D.R. Mott **Code 6350, Multifunctional Materials Branch, U.S. Naval Research Laboratory, U.S.*
10:20	**Session Discussion**

10:35	**Morning Break – 15 Minutes**
Session 7: Blast Exposure and Brain Health (2 of 2) *Co-chairs: Dr. Thuvan Piehler and Dr. Andy Sedman*	
10:50	**Predictive relationships between blood micro-RNA concentrations and diffusion magnetic resonance imaging measures in Veterans with chronic blast-mTBI** J.S. Meabon*, I. Lee, K. Wang, D. Lee, M. Omer, J.P. Mihalik, A. Crabtree, C. McEvoy, G. Means, P. Muench, and E.R. Peskind **VA Northwest Mental Illness Research, Education, and Clinical Center (MIRECC), VA Puget Sound Health Care System (VA Puget Sound), U.S.* **Department of Psychiatry and Behavioral Sciences, University of Washington, U.S.*
11:05	**Comprehensive Multi-Tissue miRNA Analysis Post-Blast Exposure in Different Animal Models** A. Gautam*, B. Misganaw, G. Dimitrov, L. Neff, J. Stephenson, A. Hoke, N. Gary, C. Moyler, D. Barnes, S. Dahal, V.S. Sajja, J. Long, and R. Hammamieh **Medical Readiness Systems Biology, Walter Reed Army Institute of Research, U.S.*
11:20	**Dose-Response from Continuous Tracking of Eye and Body Movement During Breaching Blast Exposure** J. Kemmerer*, J. Williamson, J. Kim, L. Kent, D. Curtis, and A. Anderson, Andrea Vincent, Christopher Smalt, and Hrishikesh Rao **M.I.T. Lincoln Laboratory, U.S.*
11:35	**Invited Presentation: A Data-driven Method for Setting Thresholds for Blast Exposure in Training and Operations** W. Carr*, J. Salib, M. Skotak, A. Misistia, I. Maxwell, A. Kranfli, D. Kulinski, D. Brungart, A. Boutte, J. King, B. Garfield, B. Johnson, J. Nemes, P. Wang, SGT E. Hernandez, SSG C. Cerda, G. Kamimori, J. McRae, J. O'Donnell, A. Bagchi, and C. LaValle **Walter Reed Army Institute of Research, U.S.*
11:55	**Session Discussion**
12:10	**Lunch – 1 Hour**

Session 8: Blast Overpressure (BOP) Exposure Monitoring (2 of 2) *Co-chairs: Dr. Sashi Karna and Dr. Satoko Kawauchi*	
13:10	**Spatial and Contextual Factors Influencing Blast Injury Patterns from the 2020 Beirut Explosion** J.W. Denny*, J. Batchelor, and S. Al-Hajj **University of Southampton, U.K.*
13:25	**Invited Presentation: Closed quarters breaching research efforts** P. Alt *Fort Liberty NC, U.S.*
13:40	**Mitigation of Overpressure Exposures in Sniper Training: Findings from the COmbat and traiNing QUeryable Exposure/event Repository (CONQUER) Operational Monitoring Program** E.B. Schneider*, F. Leonessa, J.K. Canner, T. Massow, W. Graves, J. Whitty, J. Reid, C. Dunbar, C.S. Ong, N. Obey, R. Bauman, and J.L. Duckworth **Yale University School of Medicine, U.S.*
13:55	**Effects of Combat Helmet on Blast Overpressure Utilizing a Surrogate Headform** B. Muzinich, K. Willens, B. Kavlicoglu*, and F. Gordaninejad **Advanced Materials and Devices, U.S.*
14:10	**Blast Overpressure Exposure During Training as a NEVER EVENT: Lessons Learned from M1A2 Tank Live Fire Exercises** E.B. Schneider*, F. Leonessa, J.K. Canner, T. Massow, W. Graves, J. Whitty, J. Reid, C. Dunbar, C.S. Ong, N. Obey, R. Bauman, and J.L. Duckworth **Yale University School of Medicine, U.S.*

14:25	**Assessing Risk of Adverse Health Outcomes Resultant of Blast Overpressure Exposure and Characterizing the Exposure Environment** O. Webster *Defense Centers for Public Health-Aberdeen, U.S.*
14:40	**FY18 NDAA Section 734 Blast Overpressure Study Line of Inquiry 3: Exposure Environment** A.J. Kluchinsky and O. Webster* **Defense Centers for Public Health-Aberdeen, U.S.*
14:55	**Afternoon Break – 15 Minutes**
15:10	**Prototype blast loading device (to explore muscle cell response)** A.J. Sedman, R.M.T. Staruch, and A.M. Spear* **Defence, Science and Technology Laboratory [Dstl], U.K.*
15:25	**Response of muscle cells to blast (from a prototype loading device)** R.M.T. Staruch, L. Cork, S. Macildowie, A.J. Sedman*, and A.M. Spear **Defence, Science and Technology Laboratory [Dstl], U.K.*
15:40	**Invited Presentation: Joint Service Member Occupational Health Assessments of Weapon Systems and Breaching Charges in Support of the Fiscal Year 2018 National Defense Authorization Act, Section 734** C. Maypole, S. Boos*, and O. Webster **Defense Centers for Public Health – Aberdeen, Aberdeen Proving Ground, U.S.*
15:55	**The COmbat and traiNing QUeryable Exposure/event Repository (CONQUER) Operational Monitoring Program: Epidemiological Examination of Overpressure Exposures** E.B. Schneider*, F. Leonessa, J.K. Canner, T. Massow, W. Graves, J. Whitty, J. Reid, C. Dunbar, C.S. Ong, N. Obey, R. Bauman, and J.L. Duckworth **Yale University School of Medicine, U.S.*
16:10	**Mitigation of blast overpressure exposure through personnel monitoring and characterization of the blast overpressure environment: the CONQUER operational monitoring program's experience** F. Leonessa*, T. Massow, W. Graves, J. Whitty, J. Reid, C. Dunbar, R. Bauman, S. Wiri, and J. Duckworth **Uniformed Services University for the Health Sciences, U.S.* **Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc., U.S.*
16:25	**Blast Overpressure (BOP) Tool for Exposure Metrics during Weapon Training in Open Field, Enclosed Spaces and Repeated Firing Events** H.T. Garimella*, A. Przekwas, and R.K. Gupta **CFD Research Corporation, U.S.*
16:40	**Session Discussion**
16:55	**Daily Closing Remarks and Final Meeting Adjournment** Dr. Raj K. Gupta

Appendix C: IFBIC 2024 Registered Participant List

Participant	Organization / Component
Prof. Denes V. Agoston M.D. Ph.D.	Department of Anatomy, Physiology & Genetics, Uniformed Services University (USA)
Dr. Stephen Ahlers	Naval Medical Research Center
Mr. Peter Alt	Fort Liberty
Dr. Peethambaran Arun	Walter Reed Army Institute of Research
Dr. Amit Bagchi	US Naval Research Laboratory
Mr. William Bagley	JHU WSE ERG
Dr. Rohan Banton	DEVCOM
Dr. Adam Bartsch	Prevent Biometrics
Professor James Batchelor	Univ. of Southampton
Dr. Valentina Benfenati	Institute for Organic Synthesis and Photoreactivity (ISOF), National Research Council of Italy (CNR)
Dr. Timothy Bentley	Office of Naval Research
Dr. Alexander Bobrov	Walter Reed Army Institute of Research
COL Michael Boivin	20th CBRNE Command
Mr. Shawn Boos	Defense Centers for Public Health - Aberdeen
Mr. F.Y. Bowling	HQ USSOCOM S&T
Dr. Elizabeth Brokaw	MITRE
Dr. Douglas S. Brungart	Walter Reed National Military Medical Center (WRNMMC)
Ms. Mylee Cardenas	USSOCOM
Dr. Walter Carr Ph.D.	Walter Reed Army Institute of Research (WRAIR)
Dr. Brandon Casper	Naval Submarine Medical Research Laboratory
Dr. YungChia Chen	WRAIR
Dr. Jeffrey Colombe	MITRE
Mr. Derik W. Crotts	Military Health System and the Defense Health Agency
CAPT (ret) Timothy Davis M.D. MPH	Self
Mr. Steven Dean	US Army DEVCOM Army Research Laboratory
Dr. Thomas DeGraba	National Intrepid Center of Excellence, Walter Reed National Military Medical Center
Dr. James DeMar	Walter Reed Army Institute of Research
Dr. Jack Denny	University of Southampton
Dr. Jean-Philippe Dionne	Med-Eng Holdings ULC, Canada
Dr. Valerie DiVito	USAMRDC/DHA
Dr. Andrew Dominijanni	MITRE
Dr. Christopher Doona	Natick Soldier Research, Development and Engineering Center
Dr. Matthew E. Downs	MITRE
Mr. Lawrence S. Emmer	USAMRDC
Dr./CPT Carly Epstein	US Army, 71st EOD
Mr. Scott Featherman	B3

Professor Gary Fiskum	University of Maryland School of Medicine
Mr. Mike Galarneau	Naval Health Research Center
Dr. Venkata Ravi Shankara Harsha (Teja) Garimella	CFD Research Corporation
Dr. Aarti Gautam	WRAIR
Dr. Michael Glass	DTRA
Dr. Molly Goodfellow	University of Maryland School of Medicine, Baltimore
Lieutenant Colonel/ Dr. Steffen Grobert	Bundeswehr (German Federal Armed Forces)
Dr Raj Gupta	USAMRDC
Dr. Joseph Hamilton	Karagozian and Case
Dr. Rasha Hammamieh	Walter Reed Army Institute of Research
MAJ Matthew Holtkamp	5th Security Force Assistance Brigade
Dr. Yasuyuki Honda	OASDHA
Dr. Kate Horne	Booz Allen Hamilton
Mr. Claiborne Hughes	HHS/ASPR/BARDA/CBRN
Dr. Chou Po Hung	DEVCOM ARL
Dr. Rebecca Ivory	Mental Illness Research, Education, and Clinical Center, VA Puget Sound Health Care System
Dr. Yijie Jiang	University of Oklahoma
COL Jacob Johnson	USA MRDC
COL Brian Johnson	Walter Reed Army Institute of Research
Dr. Catherine Johnson	Missouri S&T
Ms. Danae Johnson	MRDC PAO
Dr. Venkata (Rama) Kakulavarapu	Walter Reed Army Institute of Research
Dr. Shashi Karna	USACCDC Army Research Laboratory
Dr. Barkan Kavlicoglu	Advanced Materials and Devices, Inc
COL Machiko Kawasaki	Japan Ground Self-Defense Force
Dr. Satoko Kawauchi	National Defense Medical College Research Institute
Dr. Eric Keck	Defense Threat Reduction Agency (DTRA)
Dr. Jeremy Kemmerer	M.I.T. Lincoln Laboratory
Dr. David Keyser	USUHS
Dr. Yu Yu Khine	US Naval Research Laboratory
Dr. Nobuaki Kiriu	Division of Traumatology, Research Institute, National Defense Medical College
Dr. Timothy (AJ) Kluchinsky	Defense Centers for Public Health – Aberdeen
Dr. Tirtha Koirala	Blast Injury Research Coordinating Office (BIRCO)
Dr. Reuben Kraft	Penn State University
Dr. Alis Kranfli	Walter Reed Army Institute of Research
MAJ Stephen Krauss	USAMMDA
Dr. Devon Kulinski	Walter Reed Army Institute of Research
Lt Gen Naruo Kuwada	National Defense Medical College

Dr. Ratnesh Lal	University of California San Diego
Ms. Lisa Lalis	MITRE
Ms. Katherine M. Lee	DoD
Mr. Paul D. Legasse	USAMRDC Public Affairs Office
Dr. Fabio Leonessa	Henry M. Jackson Foundation
LTC Adam B. Lewis MD	BIRCO/JTAPIC
Ms. Jasmyne Longwell	Applied Research Associates
Dr. Wolfgang Losert	University of Maryland
Mr. Michal Maffeo	DEVCOM
Mr. Joe Magallanes	K&C
Dr. Aris Makris	Med-Eng Holdings ULC
Dr. Sanjeev Manthur	BIRCO/JTAPIC
Dr. Coty Maypole	*Defense Centers for Public Health – Aberdeen, Aberdeen Proving Ground, U.S.*
Dr. Kevin McNesby	DEVCOM ARL
Dr. James Meabon	VA Northwest Mental Illness Research, Education, and Clinical Center (MIRECC), VA Puget Sound Health Care System (VA Puget Sound), U.S. University of Washington.
Mr. Rishi Mehta	USAMRDC G-3, Outreach and Partnerships, IA Coordinator
Mr. Noah Meisner	Karagozian & Case, Inc.
Dr. Burook Misganaw	Walter Reed Army Institute of Research
Dr. Jerry Mothershead	ARA
Dr. Troy Mueller	MITRE
Ms. Maureen Mulholland	USSOCOM
Dr. Blake Muzinich	Advanced Materials and Devices, Inc
Dr. Masayuki Ohta	NDMC
LCDR Andrew Olson	OPNAV N81
Dr. David Otterson	DEVCOM Soldier Center
Mr. David Palmer	Federal Strategies
Dr. Matthew Panzer	University of Virginia
SGM (Ret.) Bruce Parkman	The Mac Parkman Foundation
Dr. Mital Y. Patel	Walter Reed Army Institute of Research
Dr. Dan Perl MD	Uniformed Services University
Dr. Karima Jeneh Perry	DEVCOM Army Research Laboratory, Aberdeen Proving Ground. University of Maryland.
Dr. Thuvan Piehler	MRDC
Ms. Karen M Pizzolato-heine	USARMY DEVCOM DAC
Dr. David Priemer	Uniformed Services University School of Medicine
Ms. DaRue Prieto	MRDC BIRCO
Dr. Andrzej Przekwas	CFD Research Corp
MAJ Ashleigh Roberds	Walter Reed Army Institute of Research
LTC Scott Robinson	DHA PH Aberdeen/ 20th CBRNE Command
Mr. Michael Said	DTRA RD-CXS A&AS

Dr. Venkatasivasai (Sujith) Sajja	Walter Reed Army Institute of Research
Dr. Anthony Santago	MITRE
Dr. Sunichi Sato	National Defense Medical College
Lieutenant Colonel (retd) Paul Scanlan	Founder, not for profit; former Australian Military
Dr. Eric B Schneider	Yale University
Dr. Andy Sedman	Dstl, UK MoD
CPT Henrik Seeber	Helmut-Schmidt-Universität Hamburg
Dr. Noah Showalter	Virginia Tech
Dr. Christopher Smalt	MIT Lincoln Labs
Dr. David J. Smith	Office of the Assistant Secretary of Defense for Health Affairs
Dr. Abigail Spear	Defence Science and Technology Laboratory (Dstl)
Ms. Rachel W. Spencer	MITRE
Dr. James Stone	University of Virginia
Mr. Todd Strader	C3M - Cohort of Chronically Concussed Mortarmen
Dr. Mei Sun	USARMDC
Dr. Gary Tan	U.S. Naval Research Laboratory
Ms. Chi N. Thai	DTRA
Prof Satoshi Tomura	National Defense Medical College
Dr. Ginu Unnikrishnan	BlueHalo
Dr. Pamela VandeVord	Salem VAMC
Dr. Christina Wagner	Applied Research Associates
Ms. Olivia Webster	DPHC-A
Dr. Lacie Werner	Walter Reed Army Institute of Research
Dr. Therese West	US Army MRDC, Combat Casualty Care Research Program
Dr. Kyle Willens	Advanced Materials and Devices, Inc
Mr. Christopher Wilson	HQ USSOCOM S&T
Dr. Suthee Wiri	Applied Research Associates
Dr. Rachel Woodul	DTRA
Dr. Aiguo Wu	DTRA
Dr. Leanne Young	ARA

Appendix D: Abbreviations and Acronyms

ABS	Advanced Blast Simulator
ACH	Advanced Combat Helmet
ALARA	As Low As Reasonably Achievable
AMAD	Advanced Materials and Devices, Inc.
ANAM	Automated Neuropsychological Assessment Metrics
BCA	Business Case Analysis
BETS	Blast Exposure Threshold Survey
BIRCO	Blast Injury Research Coordinating Office
BOP	Blast Overpressure
BOS	Blast Overpressure Studies
bTBI	Blast-Induced Traumatic Brain Injury
CBE	Cumulative Blast Equation
CFD	Computational Fluid Dynamics
CONQUER	COmbat and traiNing QUeryable Exposure/event Repository
CTE	Chronic Traumatic Encephalopathy
DANA	Defense Automated Neurobehavioral Assessment
DCPH-A	Defense Centers for Public Health - Aberdeen
DHA	Defense Health Agency
DEVCOM	U.S. Army Combat Capabilities Development Command
dMRI	Diffusion Magnetic Resonance Imaging
DMSO	Dimethyl Sulfoxide
DNA	Deoxyribonucleic Acid
DoD	Department of Defense
DOTMLPF-P	Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel, Facilities, and Policy
DTRA	Defense Threat Reduction Agency
EPA	Eicosapentaenoic Acid
FCT	Foreign Comparative Testing
FEM	Finite Element Modeling
FY	Fiscal Year
GBEV	Generalized Blast Exposure Value
GFAP	Glial Fibrillary Acidic Protein
HLB	High-level Blast
IFBIC	International Forum on Blast Injury Countermeasures
ILER	Individual Longitudinal Exposure Record
JTTR	Joint Theater Trauma Registry
JSOHA	Joint Service member Occupational Health Assessment
JUFBI	Japan-US Technical Information Exchange Forum on Blast Injury
LAeq8hr	A-weighted 8-hour Equivalent Sound Level
LIDAR	Light Detection and Ranging
LLB	Low-Level Blast
LOE	Lines of Effort
LOI	Lines of Inquiry
LTP	Long-term Potentiation
MACE	Military Acute Concussion Evaluation
MEMS	Microelectromechanical System
MIRECC	VA Northwest Mental Illness Research, Education, and Clinic Center
miRNA	Micro Ribonucleic Acid
MIT LL	Massachusetts Institute of Technology Lincoln Laboratory
ML	Machine Learning
MOMRP	Military Operational Medicine Research Program
MOS	Military Occupational Specialty
mTBI	mild Traumatic Brain Injury
NATO	North Atlantic Treaty Organization
NC	Nanoclusters

NDAA	National Defense Authorization Act
NDMC	National Defense Medical College, Japan
NHRC	Naval Health Research Center
NRL	US Naval Research Laboratory
NSMRL	Naval Submarine Medical Research Laboratory
NSWC-IHD	Naval Surface Warfare Center, Indian Head Division
OASD(HA)	Office of the Assistant Secretary of Defense for Health Affairs
pbTBI	primary blast-induced TBI
PET-CT	Positron Emission Tomography - Computed Tomography
PPE	Personal Protective Equipment
PSI	Pounds per Square Inch
PTSD	Post-traumatic Stress Disorder
PUFA	Polyunsaturated Fat
QUINT	Quantitative Instrumented Torso
RDX	Royal Demolition eXplosive
RKPM	Reproducing Kernel Particle Method
RNS	Reactive Nitrogen Species
ROS	Reactive Oxygen Species
SOF	Special Operations Forces
SOHA	Soldier Occupational Health Assessments
TBI	Traumatic Brain Injury
TES	Traumatic Encephalopathy Syndrome
TNT	Trinitrotoluene
TTP	Tactics, Techniques, and Procedures
USAMRDC	United States Army Medical Research and Development Command
USU	Uniformed Services University
VA	US Department of Veterans Affairs
VOMS	Vestibular Ocular Motor Screening
WBH	Warfighter Brain Health
WRAIR	Walter Reed Army Institute of Research