UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND READINESS

DEC 19 2023

The Honorable Jack Reed
Chairman
Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

The Department's response to section 734 of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115–91), "Longitudinal Medical Study on Blast Pressure Exposure of Members of the Armed Forces," is enclosed. Section 734 requests that the Secretary of Defense provide a final report not later than 4 years after the date the study began and provide the results of the study.

The Department's study was able to demonstrate that it is possible/feasible to capture blast information from our weapon systems, store that information safely and generate exposure reports for individuals and units in a training environment. It is also possible to collect data from sensors both on an individual or nearby in the training environments.

There are ongoing science and technology investments in this space to improve the Department's ability to link exposure data to specific health and injury outcomes. The Department intends to leverage section 734 results to continue to inform training and operational safety doctrine, protocols, and policies to best protect the Warfighter.

Thank you for your continued strong support for the health and well-being of our Service members. I am sending a similar letter to the House Armed Services Committee.

Sincerely,

[redacted]

Ashish S. Vazirani
Acting

Enclosure:
As stated

cc:
The Honorable Roger F. Wicker
Ranking Member

[redacted]

UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND
READINESS

The Honorable Mike D. Rogers
Chairman
Committee on Armed Services
U.S. House of Representatives
Washington, DC 20515

DEC 19 2023

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Sincerely,

[redacted]

Ashish S. Vazirani
Acting

Enclosure:
As stated

cc:
The Honorable Adam Smith
Ranking Member

Report to the Committees on Armed Services of the Senate and the House of Representatives

Longitudinal Medical Study on Blast Pressure Exposure of Members of the Armed Forces

December 2023

The estimated cost of this report or study for the Department (DoD) of Defense is approximately $786,000 for Fiscal Year 2022-2023. This includes $734,000 in expenses and $52,000 in DoD labor.
Generated on 21 September 2023
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INTRODUCTION

This report is in response to section 734 of the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2018 (Public Law 115–91), which requests a report on a longitudinal medical study on blast pressure exposure of members of the Armed Forces. Experiences by Service members in recent conflicts and training environments illuminate concerns related to the possible effects of blast pressure exposure on brain health. Increased knowledge and communication about the physical and cognitive effects of blast pressure exposure resulted in increased Congressional interest of Service member use of heavy weapon systems in training and combat. Additionally, growing evidence of public interest in these exposures was presented in a report released in May 2018 by the Center for a New American Security titled "Protecting Warfighters from Blast Injury," which described high blast pressure exposures of members of the Armed Forces.

Section 734 activities fall under the Department's Warfighter Brain Health initiatives[1] that seek to optimize warfighter brain health, specifically cognitive and physical performance, identify known and emerging brain threats in military environments, and detect brain injury immediately when it occurs to combat its effects on warfighters, their families, first line leaders/commanders, and their communities at large. This report specifically addresses blast pressure exposure from the use of kinetic weapons in training and operations.

GOAL AND SCOPE

The intention of section 734, also referred to as the Blast Overpressure Studies (BOS), was to improve the Department's understanding of the impact of blast pressure exposure from weapon systems on the brain health of Service members and better inform policy for risk mitigation, unit readiness, and health care decisions. The BOS effort included a series of studies and assessments to achieve the request in the section 734 language rather than a single longitudinal study. The objectives were to evaluate whether the Department of Defense (DoD) could monitor, record, and analyze blast pressure exposure in training and garrison environments as well as to evaluate the feasibility and advisability of putting this information into a DoD record for later retrieval by operational and medical personnel. In addition, the objective was to review the Department's current safety standards concerning certain weapons and munitions and to implement mitigation strategies as appropriate. Monitoring, documentation, and safety were the three main areas of engagement to satisfy this congressional mandate. To ensure a comprehensive review and analysis, BOS included contributions from blast engineers, munitions testing and operational personnel, safety officers, healthcare providers, and others, for a comprehensive approach to interpreting blast exposure data and developing recommendations for enhancing blast exposure safety in the training and operational environments.

This multi-disciplined expertise was represented in the BOS pilot structure which included an advisory workgroup and five lines of inquiry or LOIs with following focus areas: Surveillance (LOI 1), Weapons Systems (LOI 2), Exposure Environment (LOI 3), Blast Characterization

[1] Department of Defense Warfighter Brain Health Initiative: Strategy and Action Plan 2022. https://media.defense.gov/2022/Aug/24/2003063181/-1/-1/0/DOD-WARFIGHTER-BRAIN-HEALTH-INITIATIVE-STRATEGY-AND-ACTION-PLAN.PDF

(LOI 4), and Health and Performance (LOI 5), to address the congressional requirements. An interim report submitted on April 11, 2019 provided the pilot structure, study methods and action plan.

BLAST OVERPRESSURE STUDY PILOT (BOS-P)

The foundation of the BOS pilot efforts was a three-phase BOS pilot or BOS-P (Figure 1) which examined individually identifiable blast overpressure (BOP) exposure through body-worn blast wearable sensors to collect data, perform quality control measures and management across DoD systems to connect to medical records.

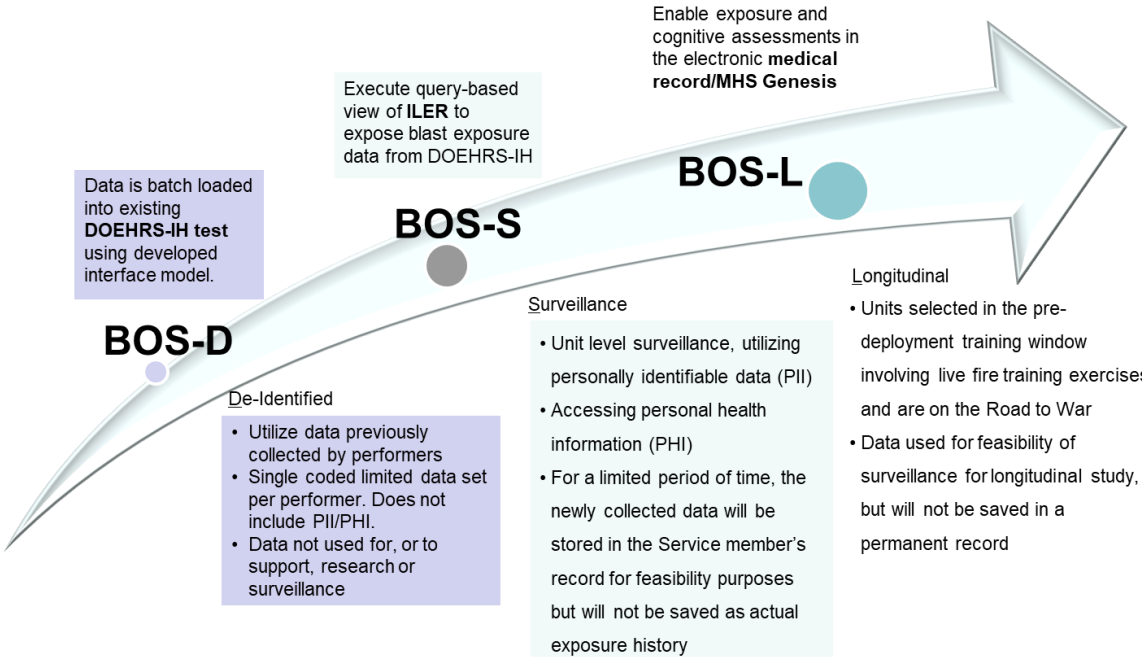


Figure 1. Blast Overpressure Studies- Pilot (BOS-P) Approach

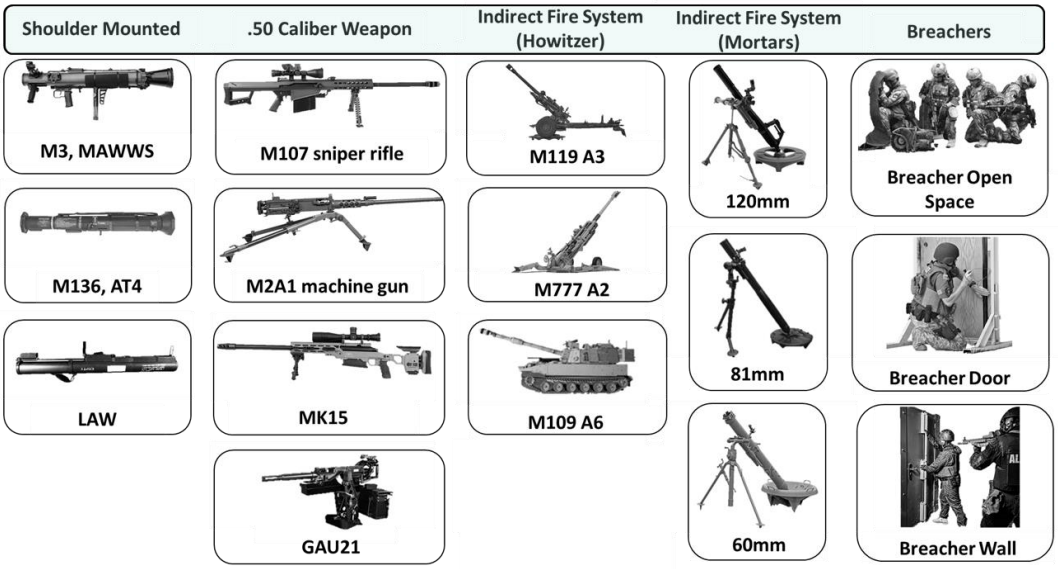
The goal of BOS-D was to establish and demonstrate the ability to ingest and move data, which was previously collected from ongoing DoD studies from blast wearable sensors, between systems and into a Service member exposure repository. This would allow us to review and analyze the data for possible exposure and ultimately health effects. In addition, this demonstration assessed the ability to integrate BOP exposure data with Defense Occupational and Environmental Health Readiness System Industrial Hygiene (DOEHRS-IH), Individual Longitudinal Exposure Record (ILER), and Military Health System (MHS) GENESIS. The goal of BOS-S was to establish and demonstrate the ability to ingest and move newly collected, identifiable blast wearable sensors data into a Service member's record in controlled training environments with issuance and retrieval of the body worn wearable sensors on the same day. The BOS-S study was able to demonstrate the ability to collect contextual data related to blast wearable sensors monitored exposure, how to safely include personally identifiable information in a DOEHRS-IH production test environment and use this information to generate exposure reports. BOS-L expanded the BOS-S investigation to examine body-worn, wearable sensors for blast overpressure exposure monitoring in more dynamic training environments and over a 3-month period of time.

The BOS-S phase was conducted at Fort Campbell, KY, with 88 Army Soldiers from the 101st Airborne Division and the BOS-L phase (2-3 months) was conducted at both Fort Campbell, KY, and Twentynine Palms, CA, with 245 Soldiers and 248 Marines. The pilot study used commercially available watch-sized body-worn wearable sensors in a three-sensor system to capture BOP exposure of the individual.

TIER 1 WEAPONS

To better target the objectives of this legislation, the Department focused on specific weapons and munitions the Services use regularly and, as a result, the most important weapons to explore for monitoring, documentation, and safety issues. The Department developed a list of "Tier 1" weapon systems (Figure 2) identified by the Services which was organized based on four different categories: shoulder-mounted, 50 caliber weapons, indirect fire systems and breaching charges.

Figure 2. Tier 1 Weapons Systems



These were the weapons and munitions of interest for blast monitoring, documentation and safety purposes. To gain insights and develop an understanding of the blast exposures that result from firing or detonating Tier 1 weapon systems, DoD collected blast wearable sensors monitoring information, analyzed weapon system safety guidance, conducted analysis on the health and performance effects and, identified knowledge gaps and policy deficiencies that could be used to inform recommendations.

STUDY ELEMENTS

Element 1: Monitor, Record and Analyze Blast Pressure Exposure

The BOS-P implemented personnel monitoring with over 500 Service members by using commercially available watch-sized body-worn blast wearable sensors in a three-sensor system to capture BOP exposure on the individual. Through the BOS-L study, DoD was able to monitor, record the blast wave parameters, and analyze the data. This work included the

movement of blast relevant data into DOEHRS-IH test environment and connection to the MHS GENESIS through ILER (Discussed later in Element 4). DoD developed and updated blast overpressure exposure reports based on feedback from the operational and clinical communities and leveraged subject matter experts in behavioral science, human factors, and health data science to inform graphics and language used to communicate BOP exposure information to Service members, leadership, and clinicians. The BOS pilot analyzed data to improve understanding of blast overpressure exposures to members of the Military Services. Additionally, as part of the BOS-P, the Department developed and tested automated software for quality-control of blast pressure exposure during weapons training. Quality control of exposure data is critical for ensuring that commanders do not make decisions based on erroneous data (e.g., helmet drop) and that Service member records include only accurate exposure data.

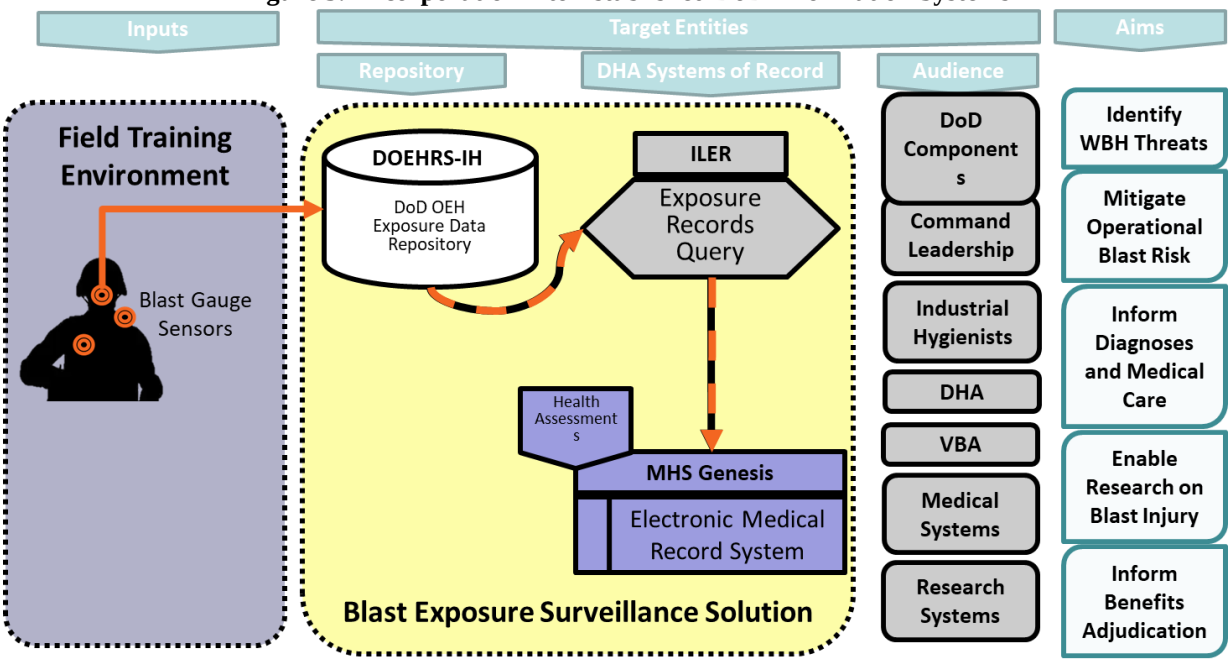
The Department was unable to demonstrate the ability to monitor, record or analyze blast pressure exposure in combat environments. The DoD did not evaluate the resources that would be necessary to monitor, record and analyze across a large unit. The conduct of the BOS-P was resource intensive using blast wearable sensors. However, the Department's ability to monitor, record, and analyze a Service member's exposure to blast may be accomplished through recording shot counts, questionnaires/surveys and a military occupational specialty to be used as a proxy. The BOS pilot effort did not evaluate these alternatives for blast exposure monitoring; however, the Department plans to conduct a business case analysis and review lessons learned from this effort to inform its way forward with blast monitoring.[2] The Department established the feasibility of BOP exposure monitoring and advisability of providing Service members with blast exposure information to inform decisions.

Element 2: Assess the Feasibility and Advisability of Including Blast Exposure History

The Department demonstrated it is feasible in a test environment using blast wearable sensors to capture Service member blast exposure history. However, the BOS pilot did not evaluate the resources necessary to document data from blast wearable sensors on a broad scale. The Department plans to conduct a business case analysis and review lessons learned from this effort to inform its way forward with the documentation of blast exposure[3]. The BOS-P assessed the feasibility and advisability of including BOP exposure history in the Service and/or medical record of members of the Military Services, piloted implementation of a personnel monitoring, and analyzed data to improve understanding of BOP exposures to members of the Military Services. A key consideration of tracking and surveillance of the BOS program was the inclusion of BOP exposure data within existing DoD record systems (Figure 3).

[2] Section 735 of the NDAA for FY 2023 (Public Law 117–263), "Brain Health Initiative of Department of Defense."
[3] Section 735 of the NDAA for FY 2023 (Public Law 117–263), "Brain Health Initiative of Department of Defense."

Figure 3. Incorporation into Established DoD Information Systems



In the field training environment, raw blast wearable sensor data was collected from units. At the end of the monitoring period, the data were formatted to include all relevant Service member BOP exposure information and then uploaded the files into a section 734 pilot-established DOEHRS-IH test environment (as opposed to the production environment). Although storage of production blast exposure data into DOEHRS-IH remains to be implemented, interoperability of other Service member exposure data between DOEHRS-IH and MHS GENESIS does presently exist, facilitated through ILER.

As the principal data repository system of record for Service member health hazard exposures, DOEHRS-IH satisfies many requirements for managing BOP exposure monitoring records including provision of controlled access and interfaces with other systems. Interfacing systems can extract occupational exposure data and personnel records directly from the DOEHRS-IH system. Use of DOEHRS-IH as a central repository of BOP exposure data would prevent data redundancy storage issues (e.g., duplicative or conflicting data) creating a unique system of record.

The ILER is a DoD and Department of Veterans Affairs web application that links exposure data to an individual's record to support Service member health care management decisions. ILER is a federated query system that retrieves data from multiple sources to provide military service exposure information.

During the BOS pilot, the DOEHRS-IH team tested transmission of information from the DOEHRS-IH test environment to ILER. As part of the interface test, ILER personnel used DOEHRS-IH BOP exposure test information to develop and test a query facility for reporting individual's BOP exposure information in an Adobe Acrobat document format (*.pdf).

MHS GENESIS is the new electronic health record for the MHS, is linked to ILER via the Joint Longitudinal Viewer (JLV). Future development efforts plan to make this MHS GENESIS connection bi-directional. The availability of the JLV would make DOEHRS-IH data available to MHS GENESIS via the ILER application. Currently, blast data is not available through the JLV link.

Element 3: Review the Safety Precautions Surrounding Heavy Weapons Training

An important component of section 734 was to objectively evaluate the current state of knowledge of health and performance outcomes for Service members exposed to blasts in training and combat environments. Studies were reviewed that focused on humans exposed to occupational BOP. In addition to measuring and quantifying BOP exposure, understanding how this exposure impacts both warfighter health and performance is necessary to establish evidence-based guidance on BOP exposure thresholds. Table 1 summarizes the current understanding and research on the effects of BOP exposure from over 40 publications.

Table 1. Health and Performance Impacts of BOP Exposure

Impact Area	Clinical Domain	Key Findings
Performance	Neurocognitive	• Reports of alterations in cognitive performance, as measured by reaction time
Health	Symptoms	• Commonly include headache, slowed thinking, poor concentration, fatigue
	Medical Diagnoses	• Greater likelihood for TBI, tinnitus, cognitive problems, communication problems, and hearing problems
	Healthcare Utilization	• More likely to have an ambulatory encounter for tinnitus and post-concussive symptoms
Biological Correlates of Health and Performance	Neurosensory	• Effects on functional hearing, even without hearing loss. • Effects on neuromotor, vestibular, and eye-tracking alterations are unclear
	Biomarkers	• No clear trends
	Neuroimaging/ Neurophysiology	• No clear trends

The BOS pilot efforts included the collection of Tier 1 weapon system information and review of DoD policies, regulations, and tactics, techniques, and procedures. The review of weapon system materials and range safety tools, and discussion with the operational community revealed a gap in awareness of the amount of blast overpressure exposure produced by weapons systems. This led to the development of tools to inform Service members of anticipated BOP exposures based on their weapon crew position and proximity relative to the weapon systems and a prototype range safety planning capability to calculate and communicate BOP exposure to reduce unnecessary exposures in training.

The BOS pilot reviewed current safety precautions and identified possible discrepancies and gaps. To address any inaccurate and inconsistent safety information, DoD established a database

for Allowable Number of Rounds and Noise Hazard Contours, which will help support access to consistent and up-to-date safety guidance information. To improve communication on the potential impacts of BOP exposure, DoD developed a specific blast exposure medical diagnosis (ICD-10 code) to enable future medical surveillance for BOP exposure, and enhanced and evaluated the Medical Cost Avoidance Model (MCAM) to support risk assessment decisions. MCAM estimates the medical-related costs, including avoidable costs (e.g., cost of treatment, lost time, disability, fatality, and recruitment/training).

Prior to the BOS pilot, DoD developed a post-fielding Health Hazard Assessment capability, which was available at the request of the weapon product manager. It evaluates the risks of weapon systems operations in training environments and provides commanders and other risk managers with an assessment of the Service member's exposures to potential occupational hazards. The BOS pilot completed Joint Service Member Occupational Health Assessment assessments for the Tier 1 Weapons.

With the information gained from the above efforts, the Assistant Secretary of Defense for Readiness issued a memorandum, "Interim Guidance for Managing Brain Health Risk from Blast Overpressure," November 2, 2022. The memorandum called on the DoD to manage risk of BOP exposures exceeding 4 pounds-force per square inch (psi) as a part of training, planning, and execution. It encouraged an *as low as reasonably achievable* approach for commanders to use with recommended strategies for mitigation.

Element 4: Assess the Feasibility and Advisability of Accessibility to Data[4]

As noted above, this element was addressed by the various phases of the BOS-P.

CONCLUSION

The BOS pilot was able to demonstrate that it is feasible to capture blast information from our weapon systems, store that information safely and generate exposure reports for individuals and units in a training environment. It is also possible to collect data from sensors both on an individual or nearby in the training environments. DoD was not able to demonstrate the feasibility of doing this in an operational environment. Some limitations in the state of the science of the blast sensor technology and the understanding of the injury mechanisms and

[4] Added per section 742 of the NDAA for FY 2020 (Public Law 116–92), "Modification of Requirements for Longitudinal Medical Study on Blast Pressure Exposure of Members of the Armed Forces and Collection of Exposure Information."
Additional language per section 742 relevant to section 734:
(b) Collection of Exposure Information- The Secretary of Defense shall collect blast exposure information with respect to a member of the Armed Forces in a manner-

(1) consistent with blast exposure measurements training guidance of the Department of Defense, including any guidance developed pursuant to-

(A) the longitudinal medical study on blast pressure exposure required by section 734 of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115–91; 131 Stat. 1444); and

(B) the review of guidance on blast exposure during training required by section 253 of the John S. McCain National Defense Authorization Act of Fiscal Year 2019 (Public Law 115–232; 10 U.S.C. 2001 note prec.);

(2) compatible with training and operational objectives of the Department; and

(3) that is automated, to the extent practicable, to minimize the reporting burden of unit commanders.

effects (cognitive, psychological, etc.) that could underly blast exposures limit the utility of real time exposure data on possible long term health effects and cumulative exposures.

There are ongoing science and technology investments in this space to improve DoD's ability to link exposure data to specific health and injury outcomes. These investments address standardizing blast data collection parameters and data processing methodologies. Other areas that will further our understanding of blast pressure exposure are to develop standardized research tools to estimate and capture cumulative exposures. In addition to wearable sensors, there may be opportunities to capture a Service member's exposure to blast such as shot counts, questionnaires/surveys and a military occupational specialty to be used as a proxy.

To determine the advisability of a blast monitoring effort would require the Department to evaluate costs and outcomes. The Department plans to conduct a business case analysis and review lessons learned from this effort to inform its way forward for a monitoring program that documents and analyzes blast exposures that may affect the brain health of Service members.[5] The safety initiatives outlined in this report informed the development of training materials for use by the operational community, which include professional military education courses for officers and non-commissioned officers to improve understanding of potential effects of BOP exposure and health and performance and to inform decisions on risk mitigation including on BOP effects as part of safety training. Training materials will be provided for the clinical population to inform medical care and coding. Current curriculums will be reviewed to find opportunities to support BOP exposure health and performance outcomes. The Department intends to leverage the BOS pilot to continue to inform training and operational safety doctrine, protocols, and policies to best protect the Warfighter.

[5] Section 735 of the NDAA for FY 2023 (Public Law 117–263), "Brain Health Initiative of Department of Defense."