Component: NAVY

Topic #: N20A-T001

Title: Optimized Energy-Attenuating Seat Design for Ground Vehicles

Technology Areas: Bio Medical

Acquisition Program: Program Executive Office (PEO) Land Systems, (FNC Armored Reconnaissance Vehicle)

ITAR: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Quantify how differences in warfighter pelvis geometry and seated posture affect the injuries they receive in vehicle blast events. Use this knowledge to optimize energy-attenuating seat design.

DESCRIPTION: Effectively informing energy-attenuating seat design for vehicle accelerative loading events requires an understanding of how changes in occupant size, gender, posture, and anthropometry affect how injuries present. It also requires a thorough understanding of pelvis and lumbar fractures in addition to potential ligament, organ, and vascular damage.

Ground vehicle underbody blast events that occurred during Operation Iraqi Freedom and Operation Enduring Freedom resulted in many mounted warfighters sustaining injuries to their pelvis and lumbar spine structures [Ref 5]. As a result, many ground vehicle programs have incorporated blast-mitigation technologies within their vehicles to try to protect warfighters against such injuries. However, current blast mitigation technologies are typically only designed to protect a 50th percentile male occupant. Since military vehicle occupants encompass a wide range of anthropometric variability, there is a high likelihood that many are not being protected with the current technologies.

Accurately predicting the occurrence of injuries and identifying how they present are important steps in designing effective blast mitigation. However, this is quite challenging across the wide spectrum of warfighter anthropometries and seated postures, since variability in anthropometry and seat posture can affect how injuries occur. As an example, pelvis injuries associated with vertical loading present differently depending on the occupant’s bone strength. For those with weaker bones, the injuries tend to present in pubic rami or sacral fractures [Ref 3]. For those with stronger bones, the injuries tend to present in ligamentous injuries. Both cases can lead to vertical and rotational instabilities in the pelvis, which can result in quite severe injuries. Spinal fractures are also prevalent in cases where the pelvis is being loaded vertically. Accelerative events that occur over a shorter duration typically result in injuries to the pelvis, whereas longer duration accelerative events often result in spinal fractures instead [Ref 5].

Energy-attenuating seats for ground vehicles are typically designed to protect a 50th percentile male [Ref 4] during a five meter per second to eight meter per second vertical drop with pulse durations of approximately 6 milliseconds [Ref 1]. While the energy-attenuation might perform well in those specific conditions, it may experience issues with occupants who are not 50th percentile males or whose posture differs from the test condition. In one study, the energy-attenuation device did not engage for a 5th percentile female occupant [Ref 4], resulting in an injury.

The Phase I effort will not require access to classified information. If need be, data of the same level of complexity as secured data will be provided to support Phase I work. The Phase II effort will likely require secure access, and the contractor will need to be prepared for personnel and facility certification for secure access.
Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Security Service (DSS). The selected contractor and/or subcontractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DSS and Marine Corps Systems Command in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: 1) Investigate how anthropometric variability and changes in seated posture affect pelvis and lumbar spine injury. 2) Develop capability to accurately predict pelvis injury, lumbar spine injury, femur fracture, and soft tissue injuries of warfighters. 3) Demonstrate an initial concept design to improve energy-attenuating devices for seats based on the results of 1) and 2). Provide a Phase II development plan with performance goals and key technical milestones that will address technical risk reduction.

PHASE II: Establish and deliver injury metrics developed through experimentation and/or modeling and simulation that define how anthropometric variability and changes in seated posture affect pelvis and lumbar spine injuries. Develop and deliver a tool to accurately predict pelvis and lumbar spine injuries of warfighters. Quantitatively demonstrate that the injury metrics are biofidelic and that the injury prediction tool correctly captures injury prediction based on the Marine Corps requirements described above. Mature the design of an energy attenuating device, build and deliver a prototype of the energy attenuating device, and develop and deliver a finite element model of the energy attenuating device with material and geometry information. Demonstrate through test and/or simulation that the energy attenuating device meets the requirements described above. Prepare a Phase III development plan to transition the technology to Marine Corps use. It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL-USE APPLICATIONS: Investigate how anthropometric variability and positioning differences inform injuries to other body regions. Expand the injury metrics and injury prediction tools to encompass injuries beyond the pelvis and lumbar spine. In addition, develop and test additional blast mitigation technologies. Integrate the blast mitigation technologies into seats and vehicles.

The technologies developed under this STTR topic can be marketed to military ground vehicle designers and manufacturers, the automotive industry, and the aerospace industry.

REFERENCES:


KEYWORDS: Energy-Attenuating Devices; Injury Prediction; Injury Metrics; Pelvis; Pelvic Injuries; Lumbar Spine Injuries; Seat Design; Anthropometric Variability