

# ***Assessment of Layered Seat Cushion Configurations for Underbody Blast Protection***

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## **Introduction:**

Underbody Blast (UBB) events are increasingly prevalent in military settings (Vasquez et. al. 2018, Spurrier et. al. 2016). Protection of Warfighters is a necessity and optimizing seat cushion configurations is critical to reducing lumbar spine loading during these events. Previous testing has evaluated polyurethane (PU) foam as an energy-absorbing (EA) material for UBB protection. However, high-density PU and other foams common for EA purposes can be uncomfortable for prolonged seating. Incorporating a habitability foam layer over the high-density EA foam may improve occupant comfort while maintaining or enhancing protective performance.

## **Objective:**

To evaluate the impact of layering viscoelastic (VE) habitability foam on top of PU foam for occupant protection against UBB events.

## **Methodology:**

Six 4-inch-thick cushion configurations of PU foam layered beneath various VE habitability foam types were assessed using the Sub-System Drop Tower (SSDT) at the US Army Occupant Protection Lab (OPL) at the Selfridge Air National Guard Base. Cushion configurations included 4 inch PU foam, 2 inch PU with 2 inch VE type A, 2 inch PU with 2 inch VE type B, 3 inch PU with 1 inch with VE type A, 3 inch PU with 1 inch VE type B, and 3 inch PU with 1 inch VE type C. A rigid seat was mounted on the SSDT platform, with the PU foam layered beneath the habitability foam. A restrained and instrumented 50<sup>th</sup> male Hybrid III anthropomorphic test device (ATD) was seated on each cushion configuration. A total of 23 tests were conducted and analyzed.

Two injury assessment methods were applied. The first utilized the compression/flexion cadaveric lumbar spine injury risk function of Ortiz-Paparoni et al. (2020). The lumbar injury criterion ( $L_{ic}$ ) risk is calculated using the lumbar resultant force and y-axis lumbar moment. The second method utilized an injury criterion specified in Enhanced Injury Assessment Reference Values (e-IARVs) established by the US Army's Occupant Centric Platform Technology-Enabled Capability Demonstration (OCP TECD) program (Wodzinski et. al. 2017). Peak platform accelerations were selected to generate IARV % results within the OCP TECD IARV categories (**Good**, **Acceptable**, and **Not Acceptable**). Graphical comparisons of e-IARV versus peak platform acceleration were generated for each cushion configuration (Figure 1). The e-IARV results were compared to  $L_{ic}$  values to assess consistency between ATD-based and cadaver-based injury metrics. This comparison links the study results to real-world lumbar injury risk.

## **Results:**

Figure 1 illustrates that PU foam alone may not be the optimal cushion for UBB events. The figure shows that VE type B decreases the injury metric for both 2-inch PU and 3-inch PU by 7 and 14%, respectively, increasing the survivability likelihood.

**Conclusions:**

Habitability foam is not intended to function as a primary energy-absorbing material; however, it can reduce injury risk when paired with an EA material. Cushion thickness alone does not determine EA performance. The type of foam and cushion configuration significantly influence protective capability. Future work will focus on identifying optimal cushion combinations to further increase the platform pulse range while maintaining occupant comfort and protection.

**Figure 1:** Overview of IARV % and  $L_{ic}$  compared to Peak platform acceleration illustrating that PU foam alone is not the optimal cushion for UBB events.

