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MULTI-SHOCK SHIELD PERFORMANCE AT 15 MJ FOR CATALOGUED DEBRIS

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ABSTRACT

While orbital debris of ten centimeters or more are tracked and catalogued, the difficulty of finding and accurately accounting for forces acting on the objects near the ten centimeter threshold results in both uncertainty of their presence and location. These challenges result in difficult decisions for operators balancing potential costly operational approaches with system loss risk. In this paper, the assessment of the feasibility of protecting a spacecraft from this catalogued debris is described using numerical simulations and a test of a multi-shock shield system against a cylindrical projectile impacting normal to the surface with approximately 15 MJ of kinetic energy.

The hypervelocity impact test has been conducted at the Arnold Engineering Development Complex (AEDC) with a 598 g projectile at 6.905 km/s on a NASA supplied multi-shock shield. The projectile used is a hollow aluminum and nylon cylinder with an outside diameter of 8.6 cm and length of 10.3 cm. Figure 1 illustrates the multi-shock shield test article, which consisted of five separate bumpers, four of which are fiberglass fabric and one of steel mesh, and two rear walls, each consisting of Kevlar fabric. The overall length of the test article was 2.65 m.

The test article was a 5X scaled-up version of a smaller multi-shock shield previously tested using a 1.4 cm diameter aluminum projectile for an inflatable module project. The distances represented by S1 and S1/2 in the figure are 61 cm and 30.5 cm, respectively. Prior to the impact test, hydrodynamic simulations indicated that some enhancement to the standard multi-

shock system is needed to address the effects of the cylindrical shape of the projectile. Based on the simulations, a steel mesh bumper has been added to the shield configuration to enhance the fragmentation of the projectile.

The AEDC test occurred as planned, and the modified NASA multi-shock shield successfully stopped the 598 g projectile using 85.5 kg/m^2. The fifth bumper layer remained in tact, although it was torn free from its support structure and thrown into the first rear wall. The outer Kevlar layer of the first rear wall tore likely from the impact of the fifth bumper's support structure, but the back of the rear wall was intact. No damage occurred to the second rear wall, or to the witness plate behind the target. Table 1 describes the damage levels observed.

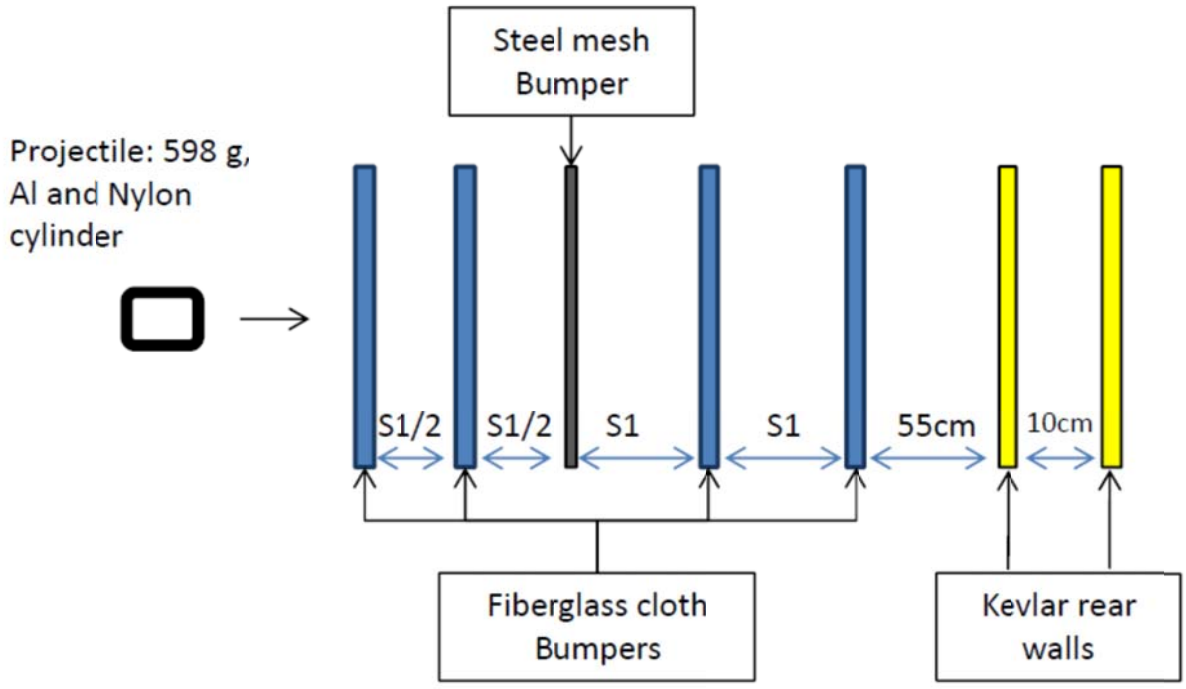

Figure 1. Diagram of multi-shock shield arrangement

Table 1. Multi-shock shield damage measurements

Bumper 1: Fiberglass	Bumper 2: Fiberglass	Bumper 3: steel mesh	Bumper 4: Fiberglass	Bumper 5: Fiberglass	Rear wall 1: Kevlar	Rear wall 2: Kevlar
130 mm diameter perforation	300 mm diameter perforation	600 mm diameter perforation	300 mm diameter perforation	No complete penetration	tear on outer fabric layer	No damage