Identification and Significance of Innovation

- MMOD-IMLI is a novel multi-layer system which provides both high performance thermal insulation and lightweight MMOD protection
- MMOD-IMLI uses discrete spacers to control layer spacing and support high strength ballistic layers, resulting in:
  - Lower heat leak per layer or mass than conventional MLI
  - Lower mass for equivalent protection than Stuffed Whipple shields
- Micrometeoroid and Orbital Debris (MMOD) protection for spacecraft, space instruments and orbital fuel depots is critical to mission safety.
- Cryogenic propellants, and their thermal insulation, are also an important part of NASA’s future missions.
- Orbital fuel depots must provide low or Zero Boiloff cryopropellant loss and maintain flightworthiness over extended missions in LEO.

TRL at the end of Phase I: TRL3

Technical Objectives and Work Plan

- Modeled and analyzed MMOD protection available from MMOD-IMLI shield designs, using fluence for an orbital fuel depot/LEO mission
- Designed MMOD-IMLI shield using ballistic Nextel and Kevlar layers
- Fabricated 120-layer MMOD-IMLI coupons & 8-layer blanket
- Conducted hypervelocity impacts; shield stopped 5.4mm Al @ 6.6km/s
- Measured heat leak to be 1.56W/m² for 8 layer blanket
- Evaluated MMOD-IMLI for MMOD protection and thermal performance, demonstrated feasibility, actual results close to modeled predictions

Phase I work included:
Task 1. Analyze mission and MMOD fluence
Task 2. Develop MMOD Ballistic Limit Equations to model MMOD shield
Task 3. Design MMOD-IMLI blanket/shield for selected critical diameter
Task 4. Build MMOD-IMLI prototype 120-layer coupons and 8-layer blanket
Task 5. Conduct Hypervelocity Impact testing
Task 6. Conduct thermal testing
Task 7. Evaluate results and publish final report

NASA applications:
- MMOD protection is critical to NASA extended duration missions
- MMOD and thermal protection is needed for spacecraft, space instruments, satellites, space stations, habitats and orbital fuel depots
- Cryopropellants require thermal insulation for storage and transfor
- MMOD-IMLI could provide both thermal insulation and MMOD shielding in one integrated lightweight blanket/shield

Non-NASA applications:
- Commercial & DoD satellite and cryogenic space-instrument integrated MMOD thermal blanket/MMOD shield
- Commercial space stations/habitats
- Commercial Orbital Transportation Services vehicles

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