

NASA Status: WG3 MMOD Protection

Interagency Space Debris Coordination Committee (IADC)
Virtual Workshop VC2
26 April 2021

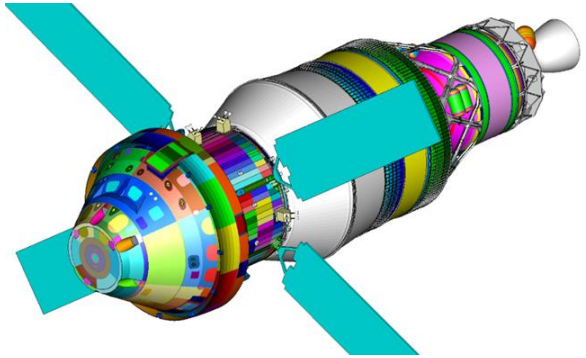
NASA JSC-XI5/Eric L. Christiansen
NASA JSC (JETS)/Jim Hyde
NASA JSC (JETS/UTEP)/Josh Miller

National Aeronautics and Space Administration

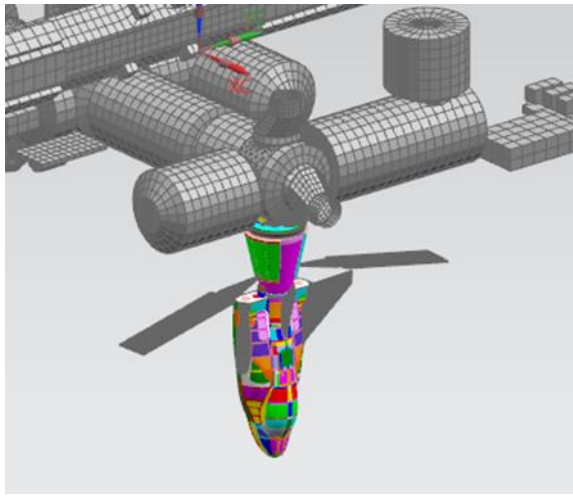
Summary of Meteoroid and Orbital Debris (MMOD) Protection Activities

- **Orion & Upper Stage:**
  - Performed testing and analysis jointly with ESA, Airbus and TASI to reduce mass of ESM for future missions
  - Artemis-I and Artemis-II MMOD verifications complete
    - Artemis-I 2021 uncrewed, Atemis-II 2023 crewed
- **ISS Commercial Crew & Cargo Vehicles**:
  - Shielding incorporated into SpaceX and Boeing commercial crew vehicles to meet ISS and Commercial Crew Program (CCP)
    - Significant changes made to both vehicles to meet MMOD requirements
  - In process of hypervelocity impact (HVI) tests on many areas of the ISS cargo vehicle from Sierra Nevada Corporation
  - Completed HVI tests on samples representative of areas of the HTV-X vehicle being provided by JAXA to update ballistic limit equations used in risk analysis
  - Performed post-flight MMOD damage inspections of SpaceX Dragon cargo vehicle after ISS resupply missions (SpX-17 through SpX-21 missions)
  - ISS impact database maintained by HVIT of observed impacts (ground-based inspections)
    - >1400 records, 2019 IOC paper by Hyde, et al.

Orion with upper stage



SNC Cargo Vehicle



National Aeronautics and Space Administration

Summary of Meteoroid and Orbital Debris (MMOD) Protection Activities

- **Gateway (orbital station about moon):**
  - Assessing overall MMOD risk to all Gateway elements (penetration risk & loss-of-crew risk)
  - Focus on early elements: Power and Propulsion Element (PPE) risk assessments and test plans
  - Meteoroids primary risk, but orbital debris risk is part of risk assessment for the Earth departure phase
- **Human Landing Systems (HLS):**
  - Supported all 3 HLS teams in assessing minimum mass options to meet MMOD protection requirements (HVI tests and analysis)
  - Meteoroids are the primary risk driver, but lunar secondary ejecta is also included when vehicle on lunar surface
  - MEM 3 meteoroid model used in the risk assessments
  - Apollo-era secondary ejecta model is currently used in assessments (SP-8013)
  - New secondary ejecta model under development by NASA MSFC, and release planned later this year





Summary of Meteoroid and Orbital Debris (MMOD) Protection Activities

- **Summary of AI 36.1 Shape Effects Study and WG3 internal tasks**
  - AI 36.1 – to be discussed at this IADC by all - presentation by J. Miller
  - IT 32-18 – “Fluid lines” for Vulnerability Report – To be provided this IADC & would like to close with the submission
  - IT 35-3 – “Inflatable shields” for PM – need to defer to next IADC
  - IT 37-3 – “Propose new PM risk assessment benchmark parameters – Jim Hyde to present, would like to close after discussion/agreement with members
  - IT 37-8 – “Advanced shielding information & assessments” – NASA suggests we can summarize the work that has been previously published on testing approach & results comparing different shield materials/configurations.
    - Ref.1: NASA TP-2003-210788, Meteoroid & Orbital Debris Shielding

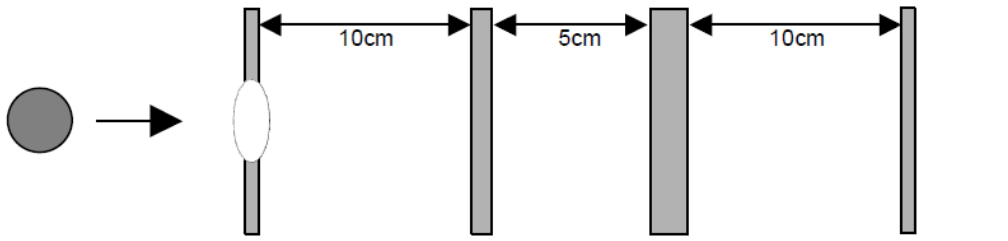
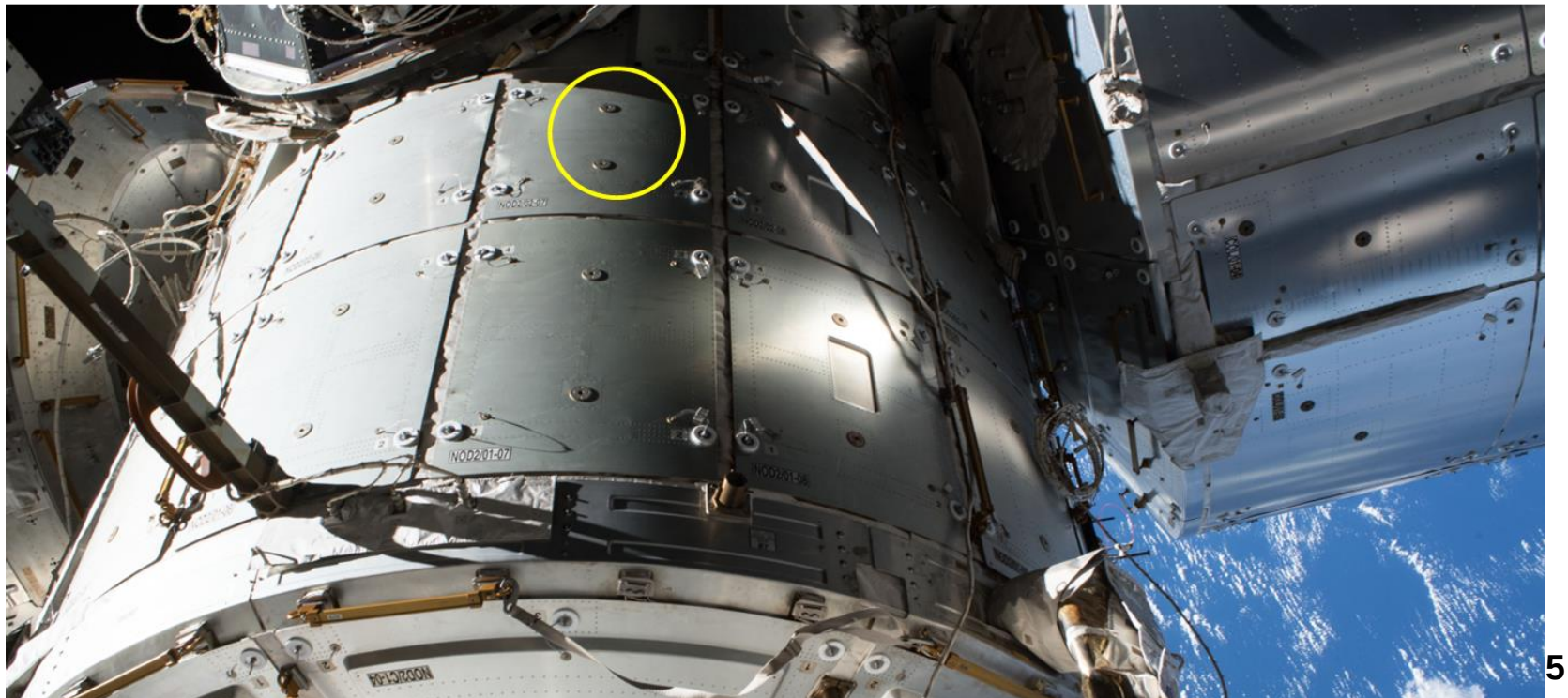


Fig. 3-5. Shield materials screening test setup.

Observed Hypervelocity Impact Damage

- **Remote photo surveys performed of Node 2 exterior surface in November-December 2020**
  - Supported investigation of sharp/metallic noise reported by crew (turned out to be from non-MMOD cause)
  - A video survey of the exterior using a camera on the remote manipulator system confirmed an impact damage

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Node 2 exterior survey

- The damage appeared to be a through perforation of the outer bumper, approximately 6mm diameter
- Damage was at most 2 years old (previously obtained photos of the area showed no damage)

