National Aeronautics and Space Administration

Development of the Space Debris Sensor (SDS)

Joe Hamilton
SDS Principal Investigator
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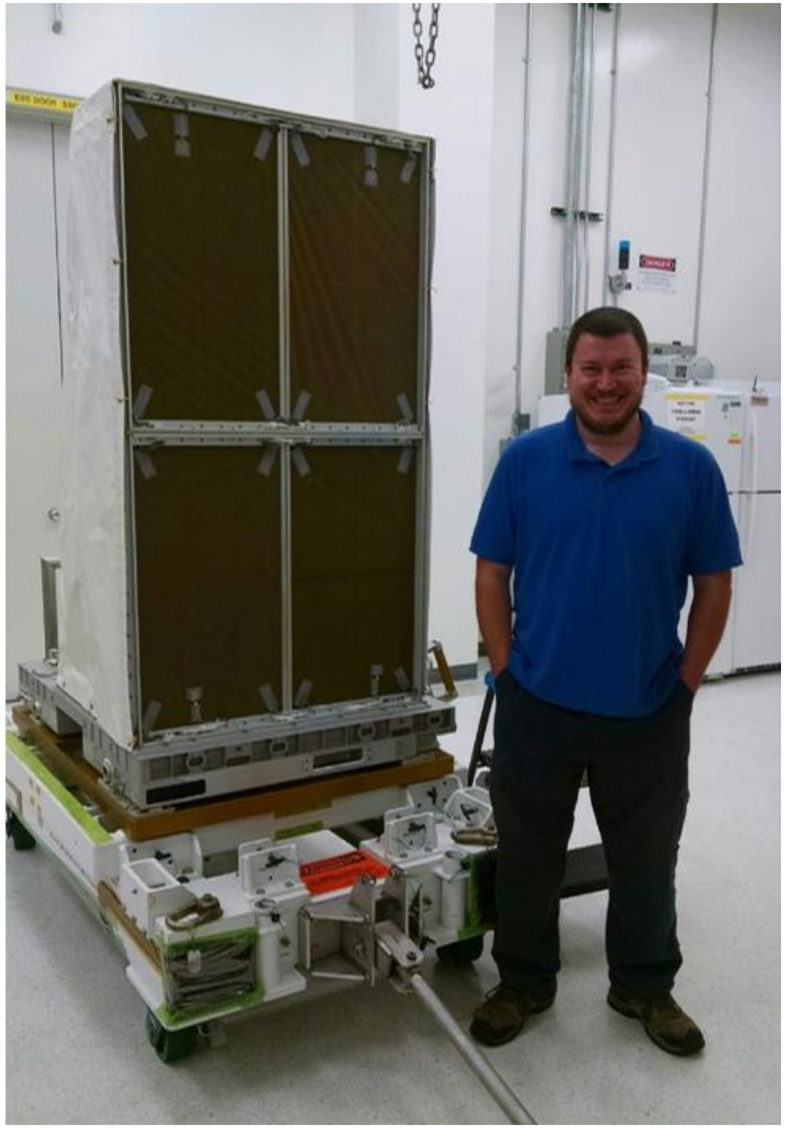
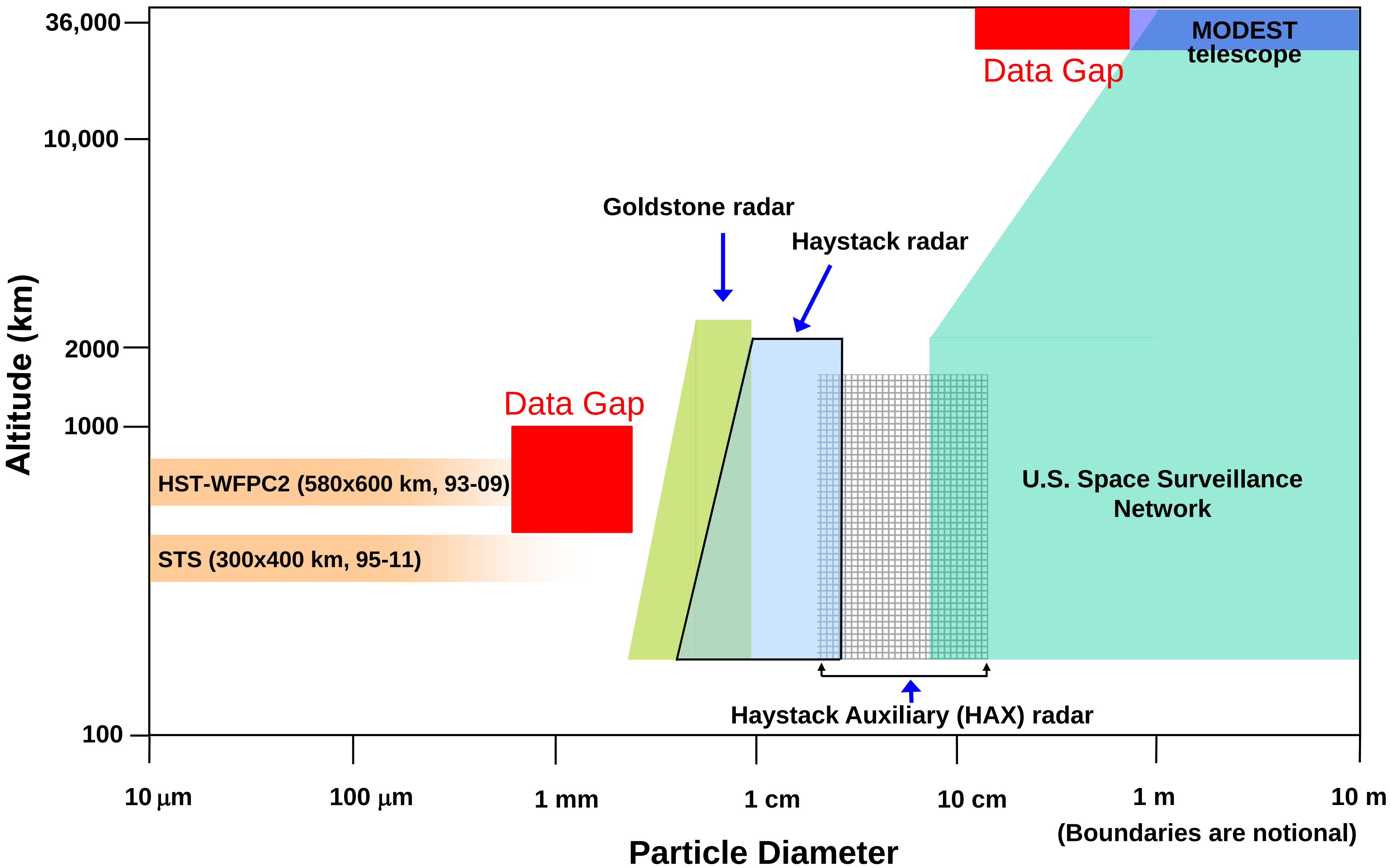


Background

- DRAGONS concept and technology has been under development with intermittent grants since 2002
- The goal of DRAGONS is to provide in-situ statistical data on the debris population that is too small for ground-based remote sensing to accomplish.
  - Results would be used to update the Orbital Debris Engineering Model (ORDEM)
  - **Current estimate of the small debris population is based on inspection of exposed surfaces returned on Shuttle (Retired 2011)**
- The DRAGONS team includes the NASA Orbital Debris Program Office, the NASA Hypervelocity Impact Technology group, the NASA/JSC Engineering Directorate, Jacobs, the United States Naval Academy, the Naval Research Lab, Virginia Tech, and the University of Kent.

Orbital Debris Measurement Coverage

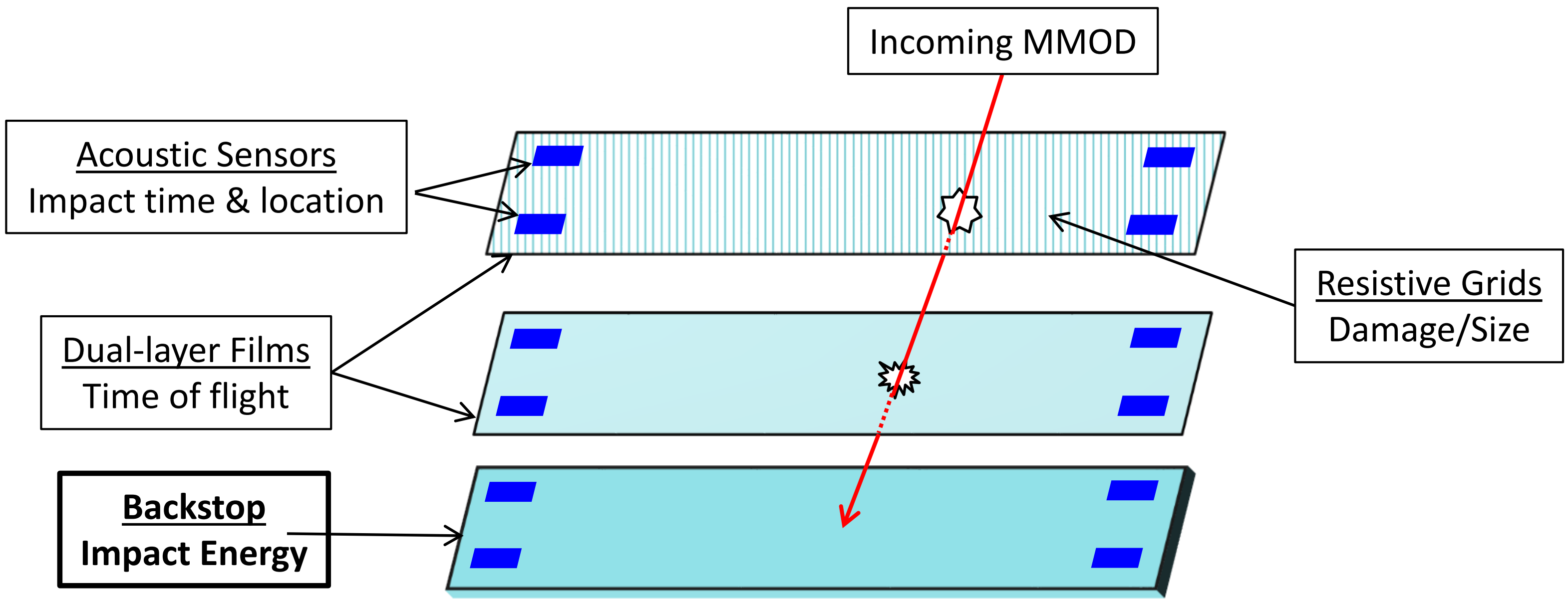


What is SDS?

- **DRAGONS is an impact sensor designed to detect and characterize collisions with small orbital debris.**
  - 50µm to > 1mm debris size detection
  - Characterize debris size, speed, direction, and density
- **The Space Debris Sensor (SDS) is a flight demonstration of DRAGONS on the International Space Station**
  - Approximately 1 m^2 of detection area facing the ISS velocity vector
  - Minimum two year mission on Columbus External Payloads Facility(EPF)
  - Minimal obstruction from ISS hardware
  - Development is nearing final checkout and integration with the ISS
  - Current launch schedule is SpaceX 13, ~ Sept 2017, or SpaceX 14, ~ Jan 2018

Detection Principles

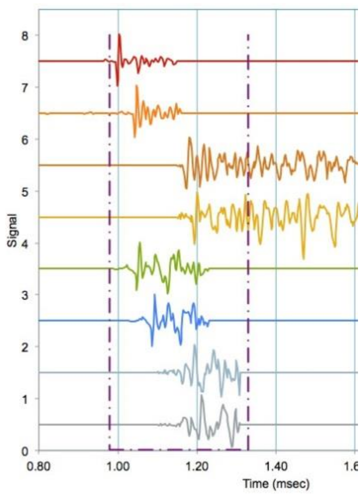
- SDS combines dual-layer thin films, an acoustic sensor system, a resistive grid sensor system, and sensored backstop
- Impact detection and recording capability
  - **Impact time, particle size, impact speed, impact direction, and impact energy/particle density**



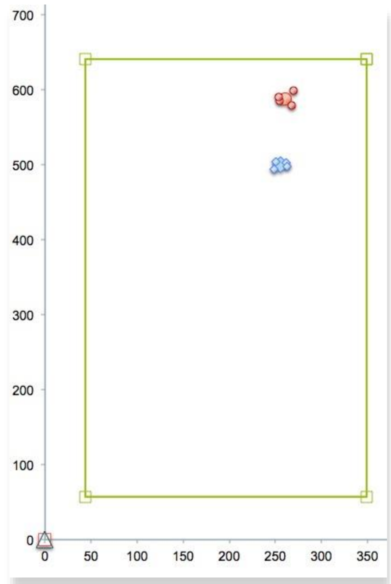
Example 0.4 mm 30° Stainless Steel 7 km/s

Layer 1 hole
Broke 3 lines

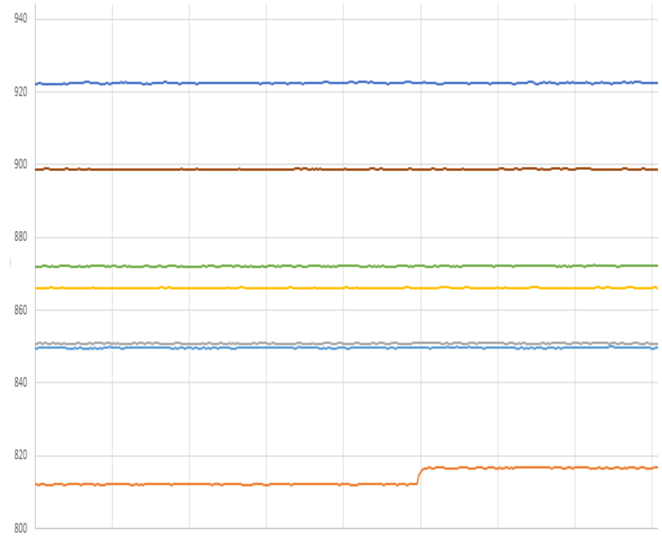
Filtered Acoustic Data



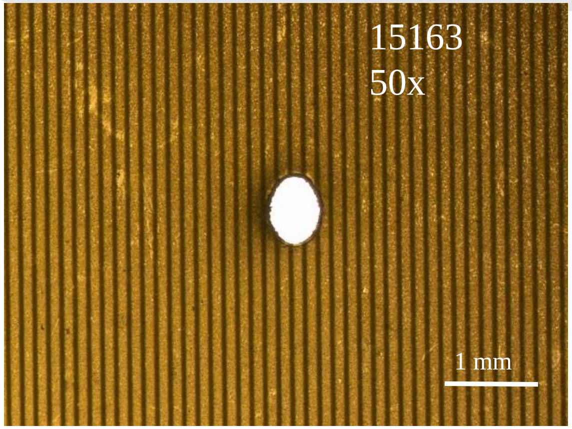
Location
Red=Layer 1;
Blue = Layer 2

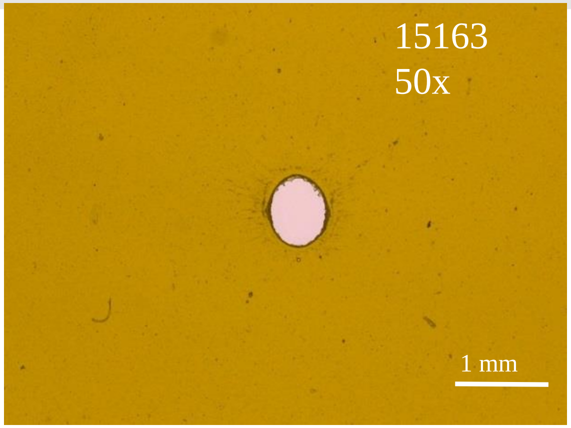


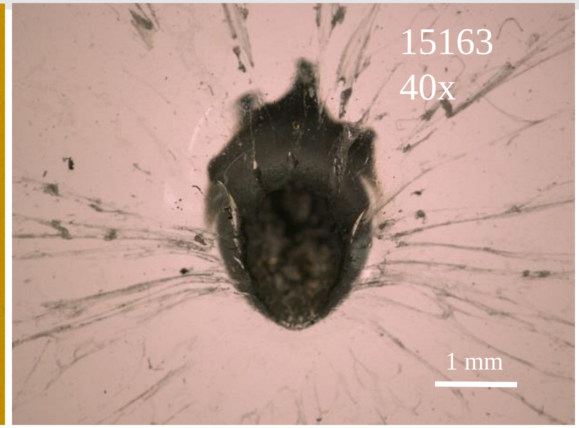
Resistance change consistent with 3 line break



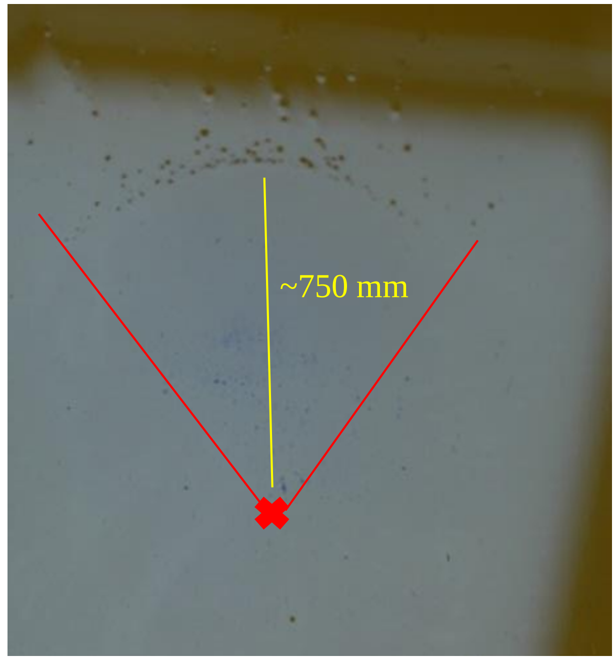
500µm 440C Stainless Steel



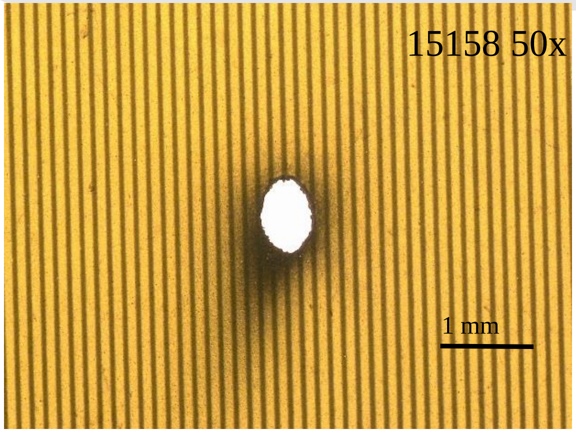


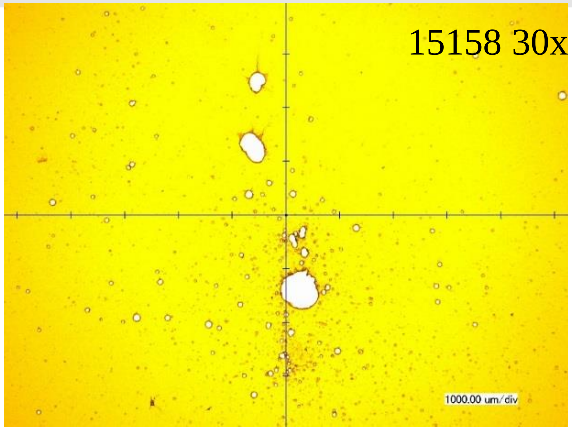


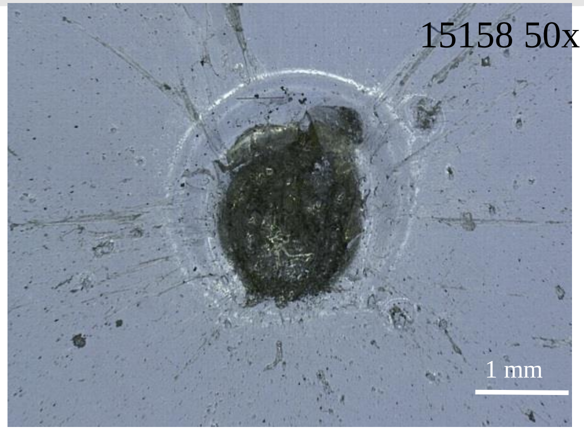
- Steel maintains shape throughout
- No visible break up of particles during impacts
- Steel shots produce significant secondary ejecta from Lexan back plate
- Ejecta has enough velocity to penetrate and dimple Kapton layer in wide arc downstream from shot
- Straight-on shots produce halo around entry hole; As shot angle increases the damage moves further away from hole



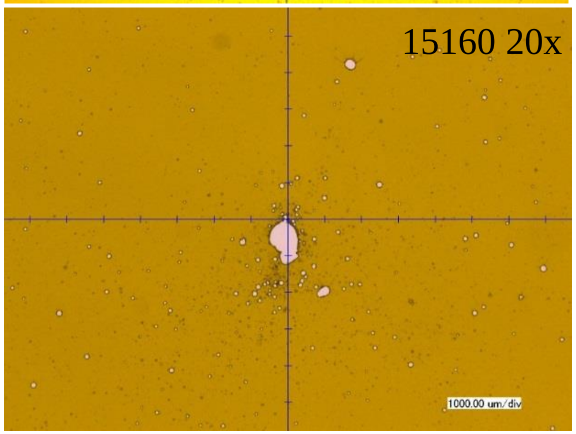
500µm Aluminum Al 2017-T4

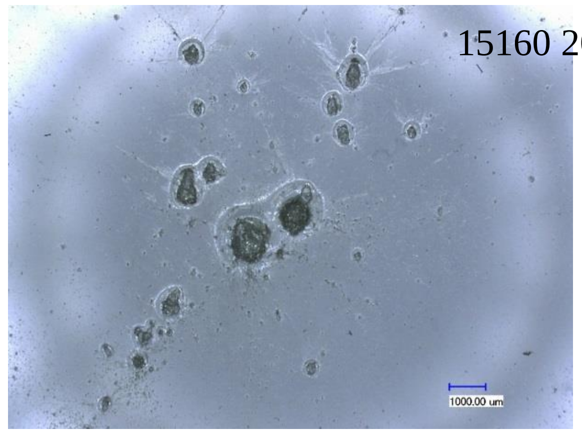




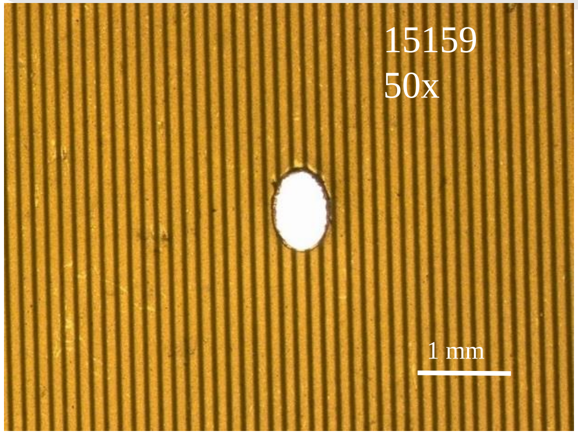


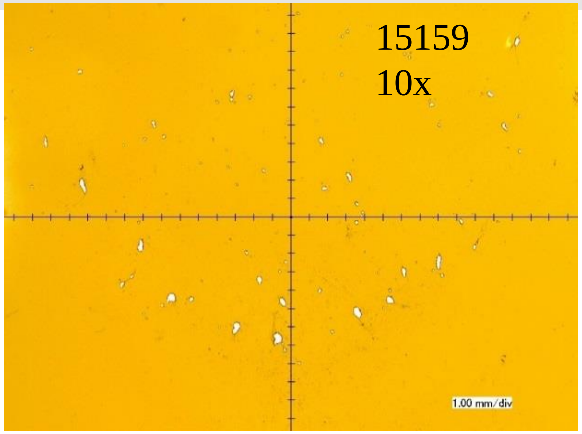
- Aluminum particles show break-up after first layer
- Amount of break up varied in the three shots
- One shot left a clean crater on Lexan back plate
- Two other shots had a collection of smaller craters
- No sign of ejecta damage on Kapton layer





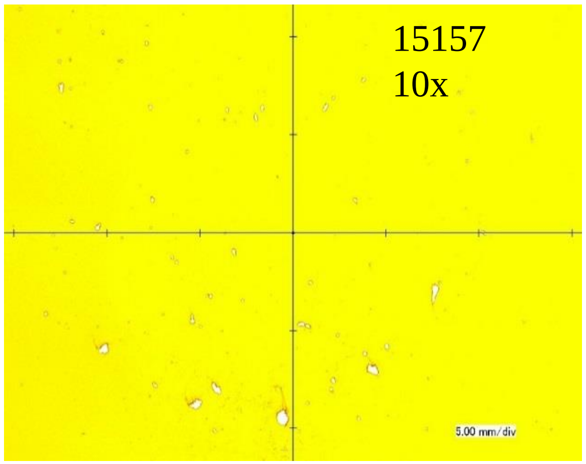
500µm PMMA Plexiglass

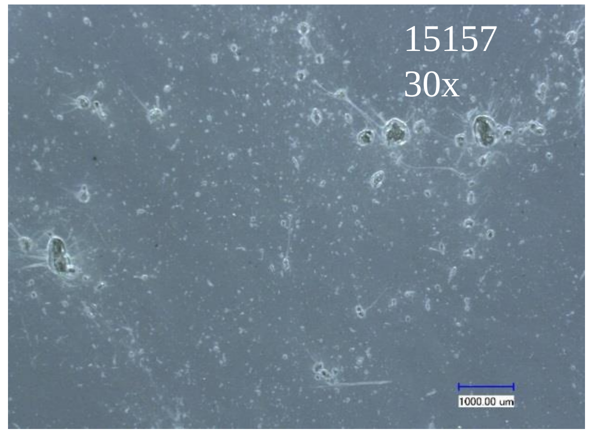




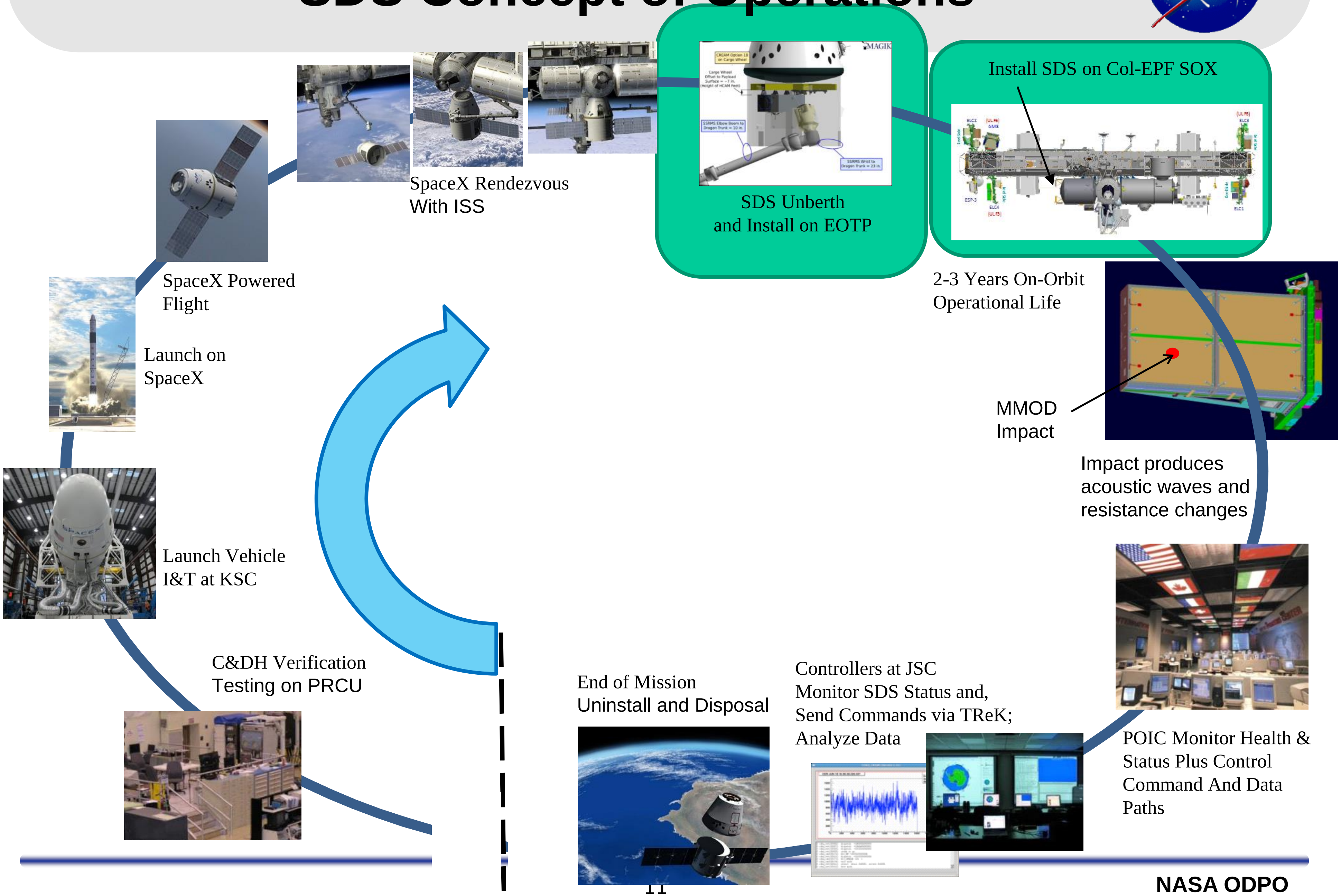
- Only one plastic shot showed up on the Lexan back plate
- No craters on Lexan – only residue

- Plastic particles broke up significantly after impacting the NCAS grid
- ‘Half circle’ hole pattern on Kapton layer with largest hole at bottom of the circle
- Same break up pattern for all shots - ~25mm wide by 20mm tall area of holes

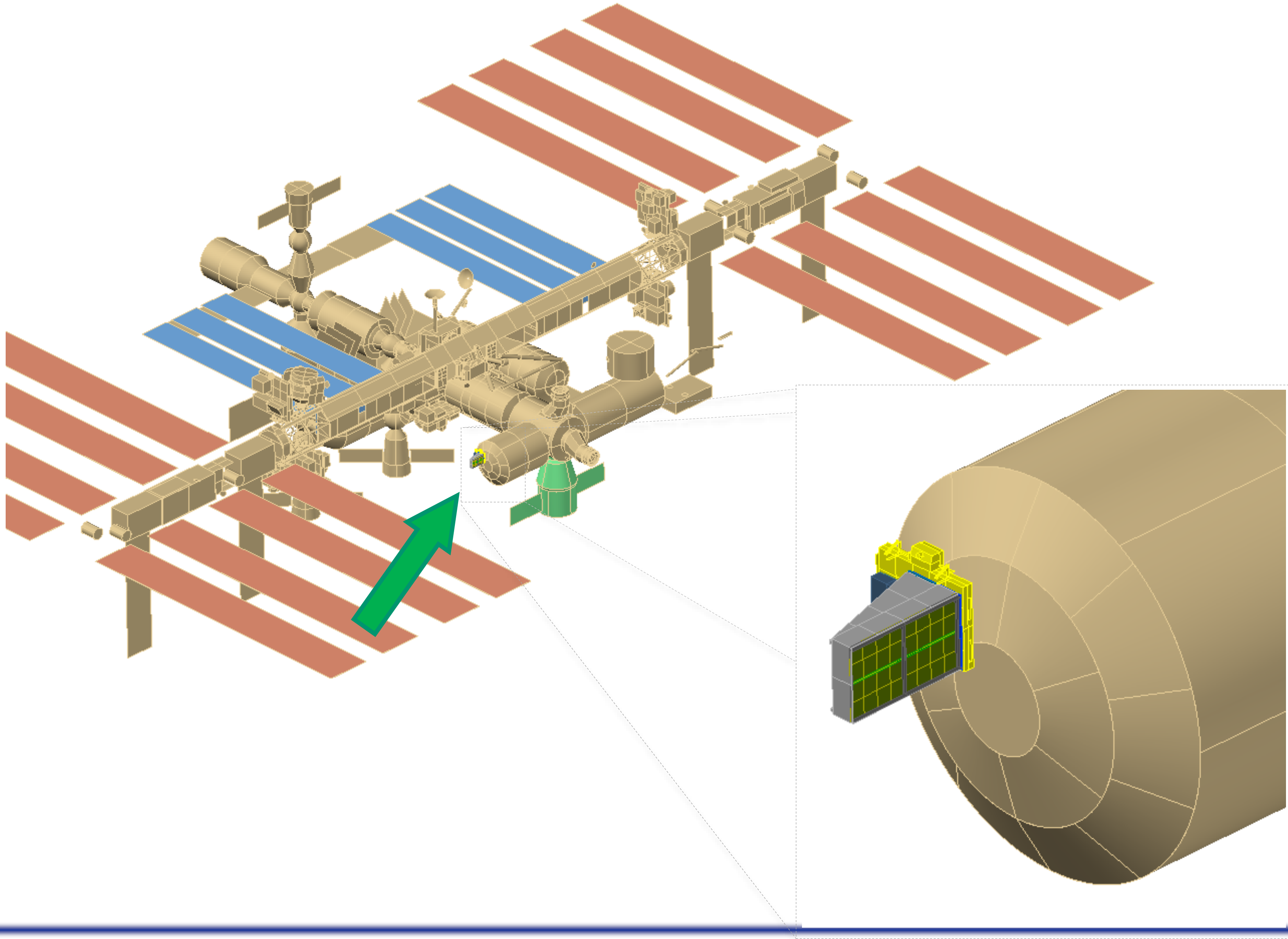




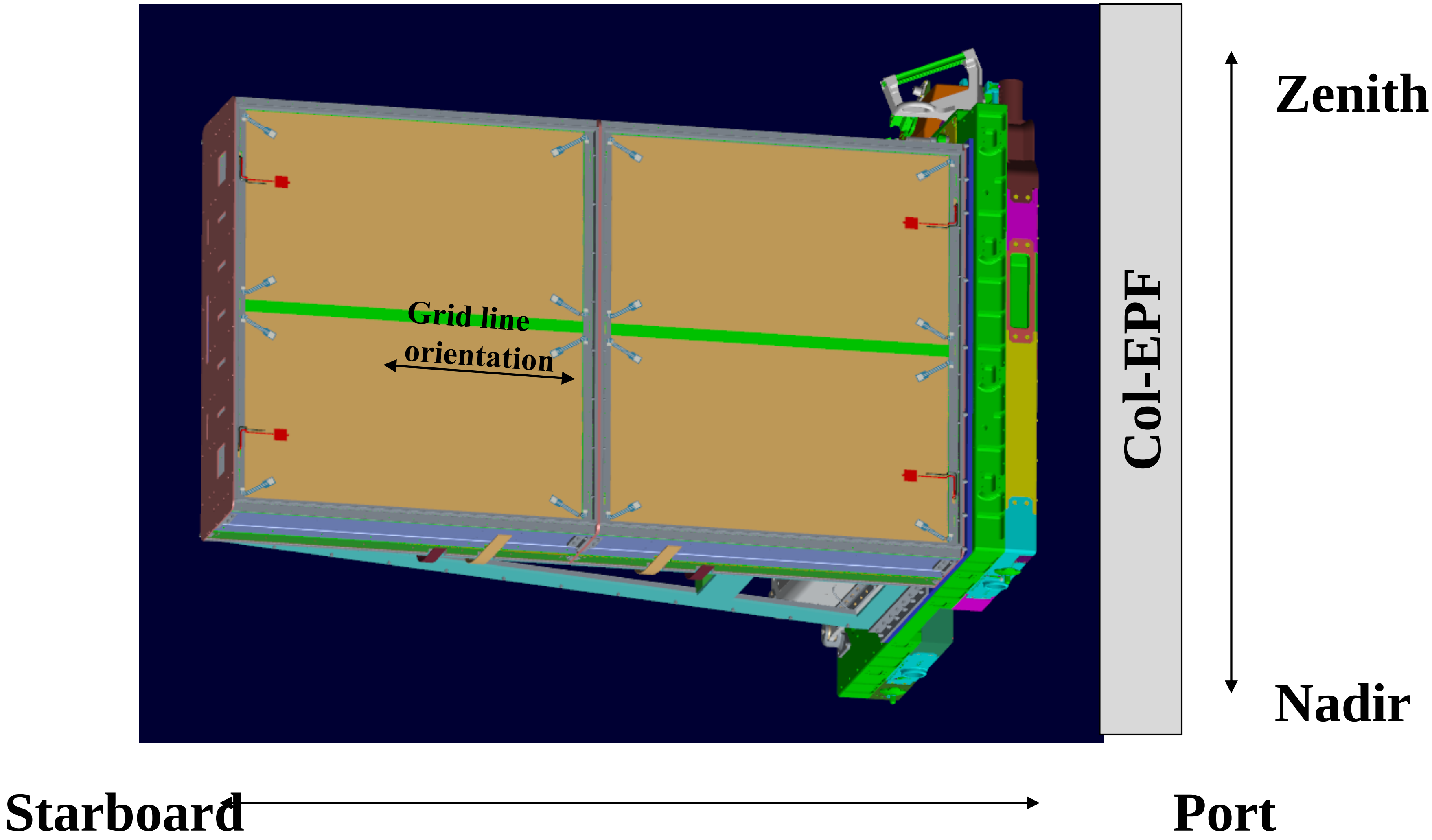
SDS Concept of Operations



SDS on Columbus-External Payload Facility

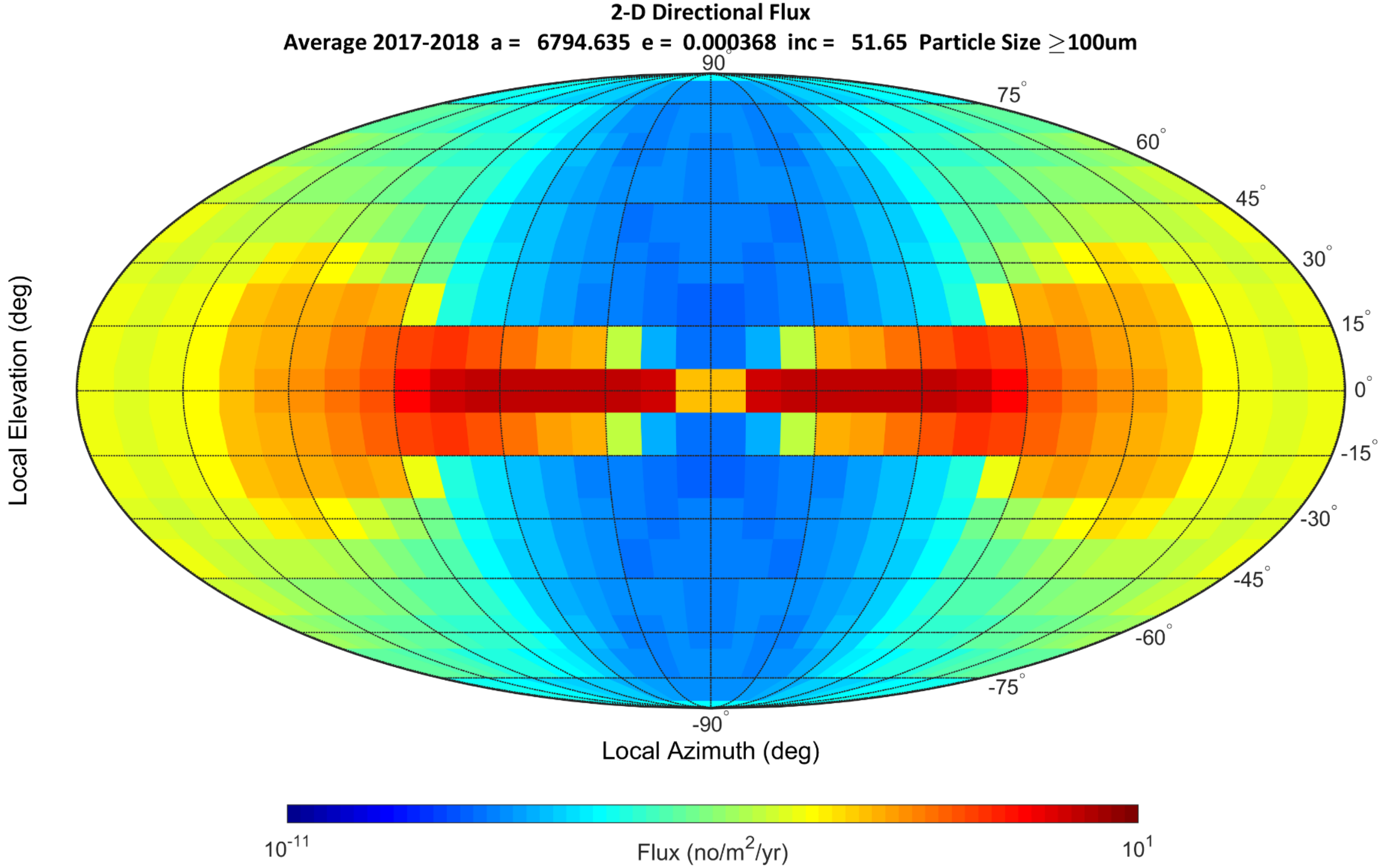


SDS ISS Orientation



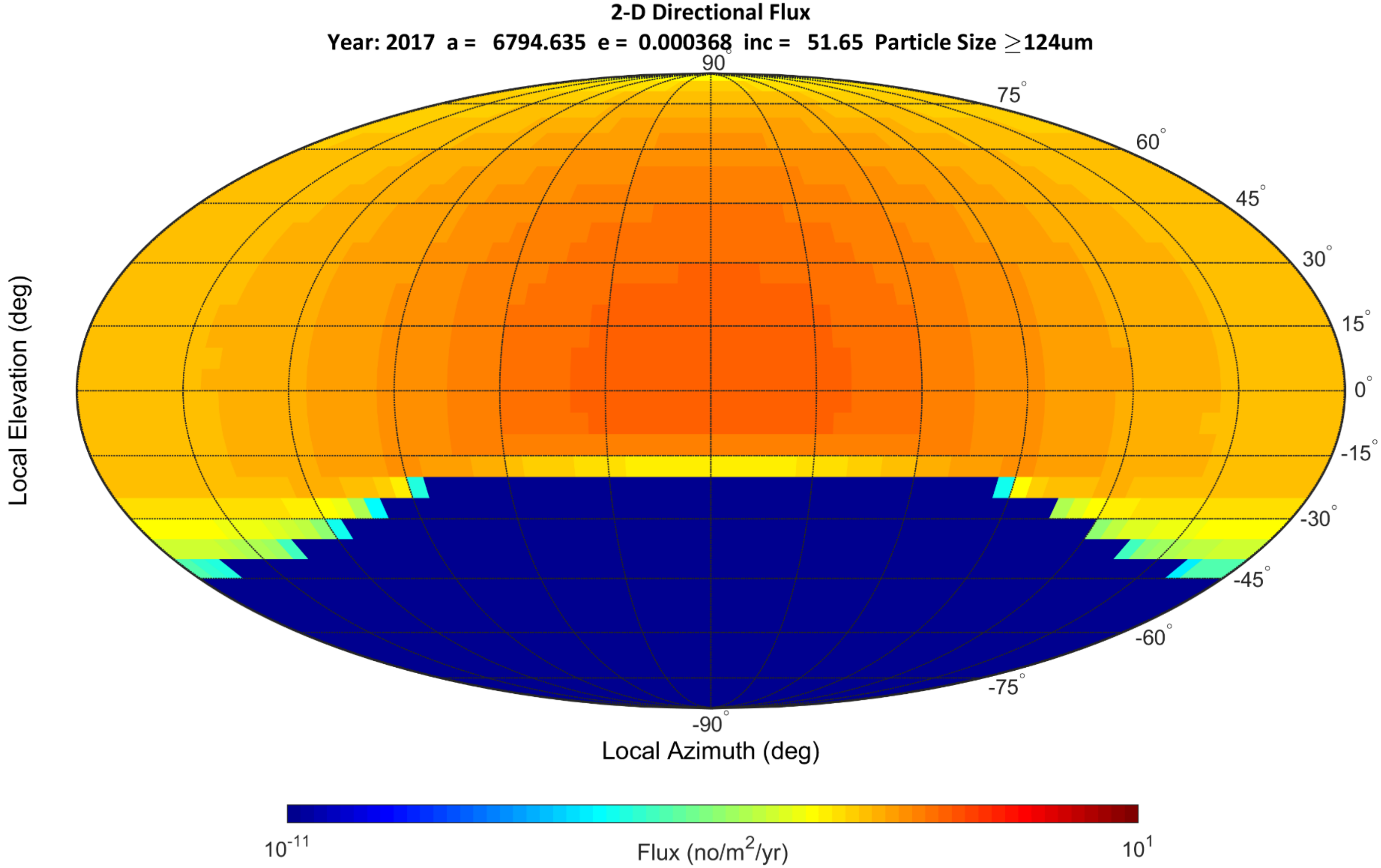
2-D Directional Flux – ORDEM 3.0

Orbital Debris Engineering Model (ORDEM 3.0)

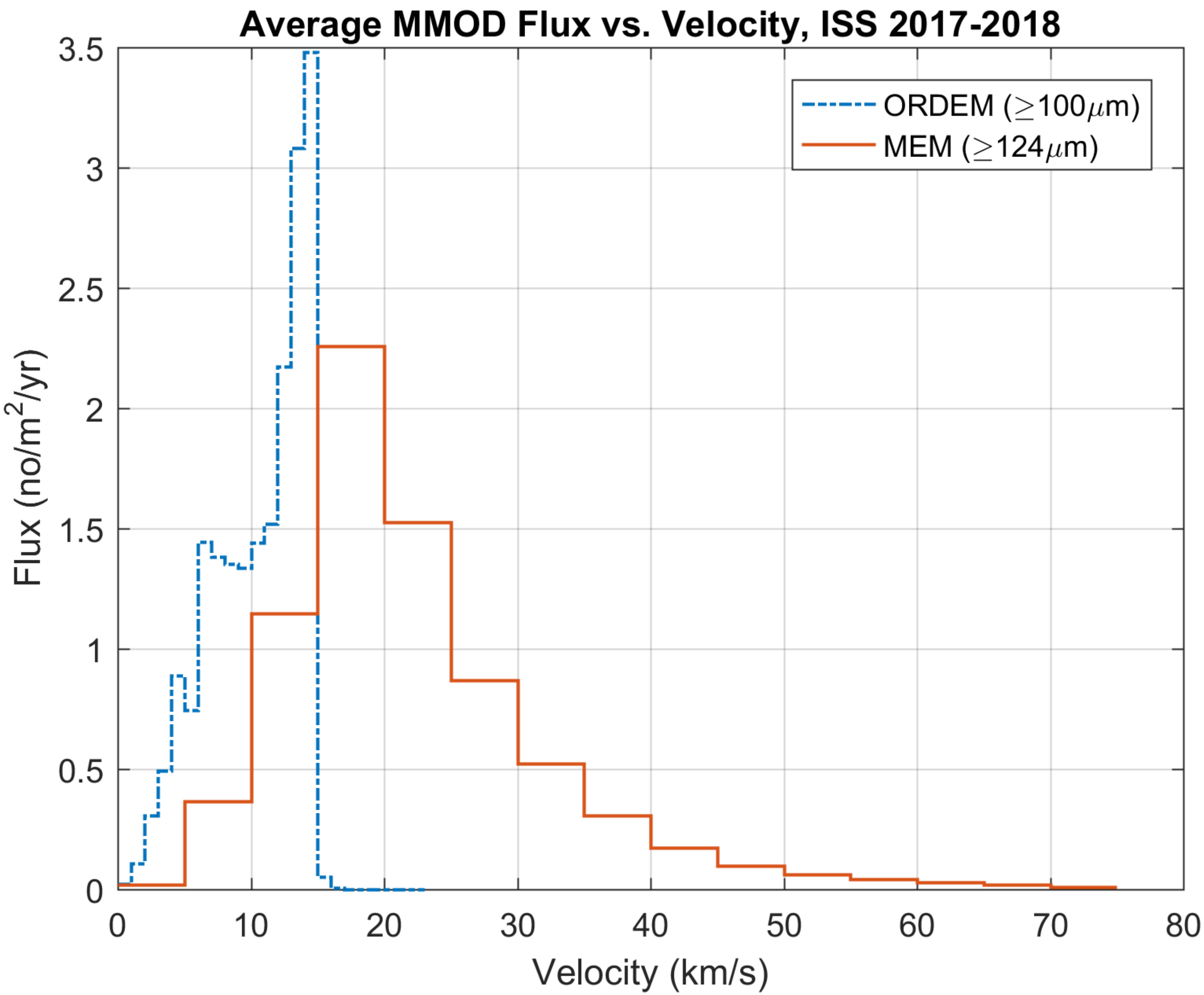


2-D Directional Flux – MEM 2.0

Micro-Meteoroid Engineering Model (MEM 2.0)



Predicted Flux vs. Velocity



Conclusions

- **SDS is the top priority for NASA ODPO development of orbital debris monitoring capability**
  - Addressing a gap in detection coverage
  - SDS will inform the design of future DRAGONS
- **The NASA ODPO will use the experience from SDS to improve the detection and characterization technology.**
  - Improved grids with 50µm width lines
  - Larger detection areas
  - Improved acoustic algorithms for speed, direction, and density calculations
- **The NASA ODPO is pursuing additional flight opportunities to put DRAGONS at higher altitudes**
  - Targeting flights in the 700 to 1000 km altitude region
  - Sun-synchronous orbits

Questions?