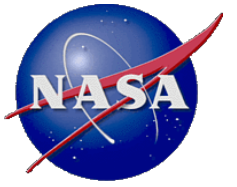
National Aeronautics and Space Administration



In Situ Measurement Activities at the NASA Orbital Debris Program Office

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26 October 2016, JAXA Tsukuba Space Center

Outline

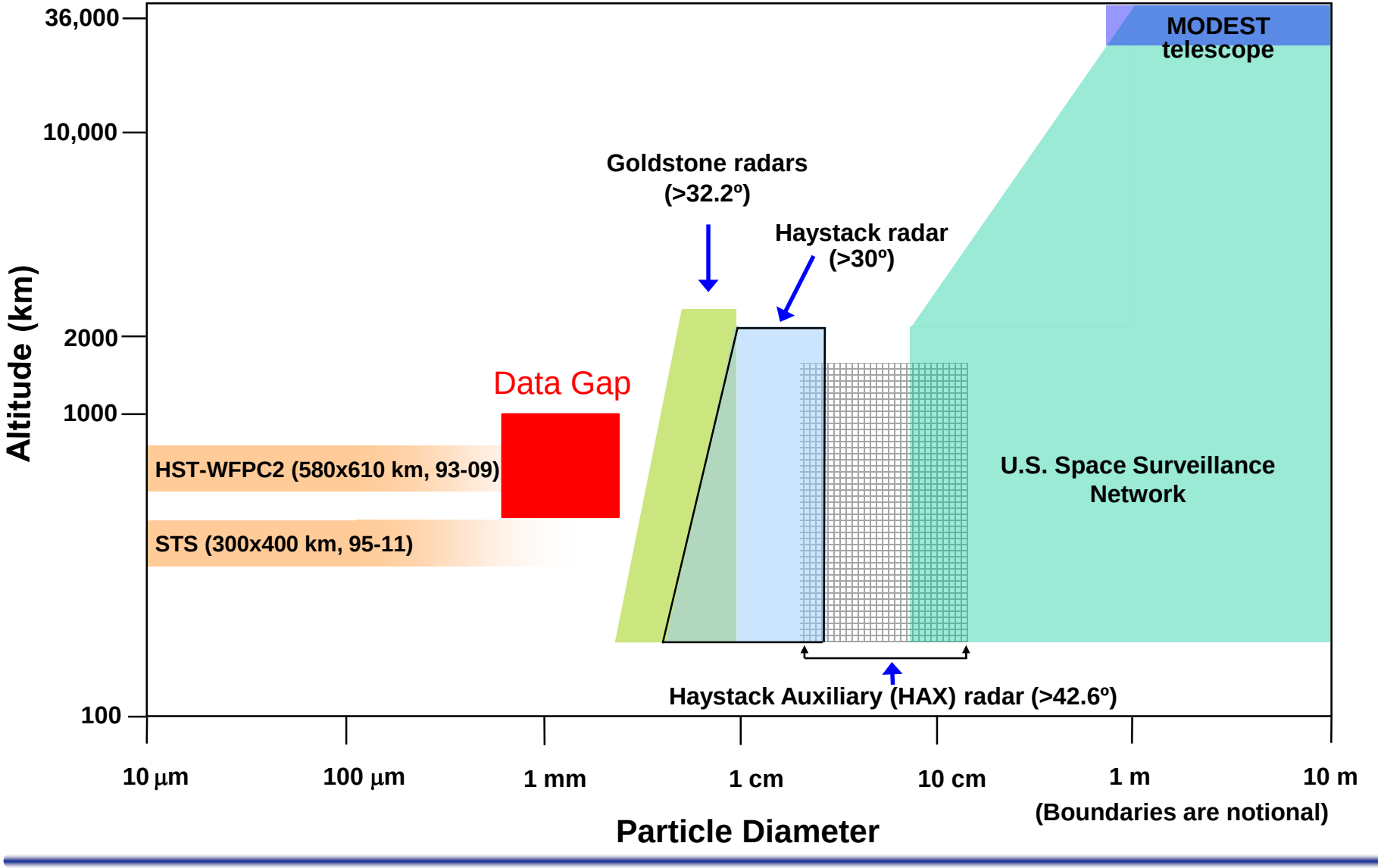
- **Objective**
- **Past projects**
  - PINDROP
  - LAD-C
  - LADEE-DEBIE
  - MMSE
  - FOMIS
  - IMMUSE
- **Present project**
  - SDS
- **Future project**
  - High LEO altitude DRAGONS

Objective

- **Conduct in situ measurements to better characterize the small (millimeter or smaller) orbital debris (OD) populations in low Earth orbit (LEO)**
  - *Orbital debris <3 mm pose the highest penetration risk to most spacecraft.*
  - *For the flux for particles <3 mm, orbital debris model validation for altitudes above 600 km is most effective using in situ data.*

(NASA/TM-2015-218780)

Orbital Debris Measurement Coverage

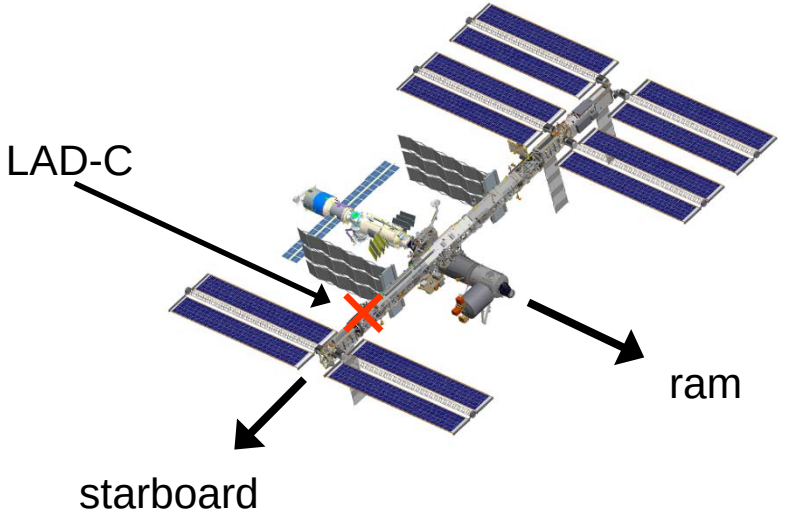


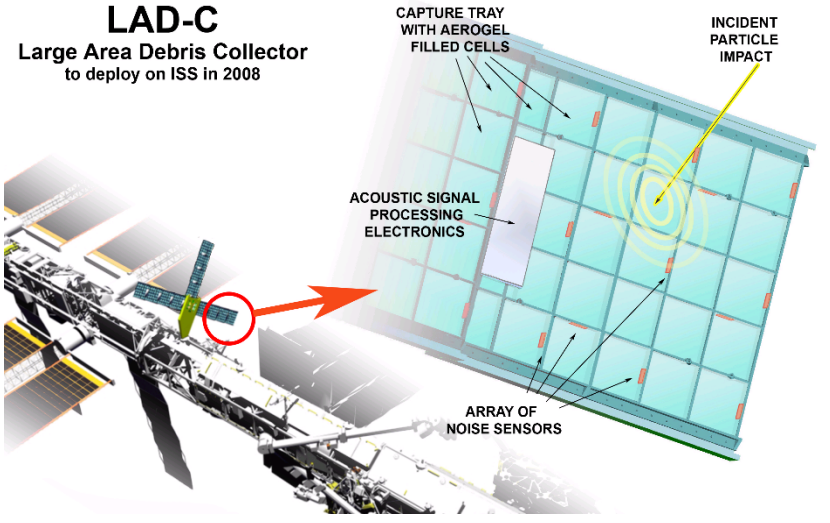
Past Projects (1/6)

- **Particle Impact Noise Detection and Ranging on Autonomous Platform (PINDROP)**
  - Objective: To develop acoustic sensors for MMOD impact detections
  - Funding source: NASA's Planetary Instrument Definition and Development Program (PIDDP), 2003-2005
  - Team: Naval Research Lab (NRL), NASA Orbital Debris Program Office (ODPO)
  - Best sensor material: Polyvinylidene fluoride (PVDF)
  - Hypervelocity impact targets (with PVDF sensors attached) tests:
    - **Al, aerogel, mylar, circuit board, Kevlar, spectra shield, multi-layer insulation**

Past Projects (2/6)

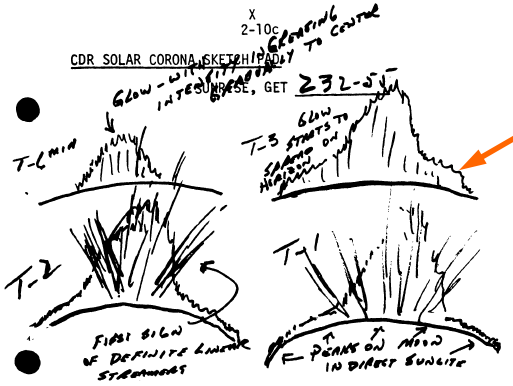
- **Large Area Debris Collector (LAD-C) on the ISS**
  - Objective: To characterize the large (0.1 – 1 mm) MMOD environment at ISS altitude with 10 m^2 aerogel and PVDF acoustic sensors
  - U.S. funding sources: DoD STP, NASA ODPO
  - Team: NRL/USNA, NASA ODPO, ESA, JAXA, Kent (UK)
  - DoD SERB Nov 2004, PDR May 2006, terminated Jan 2007

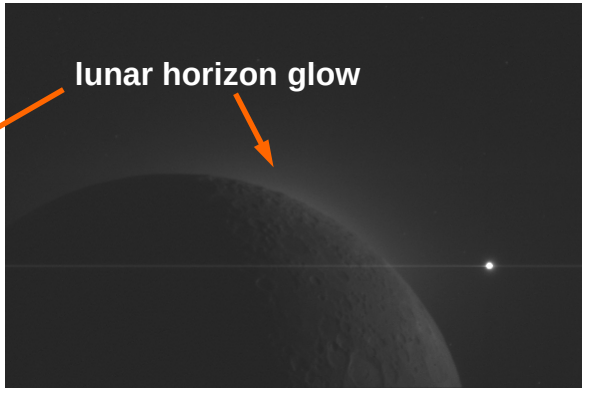


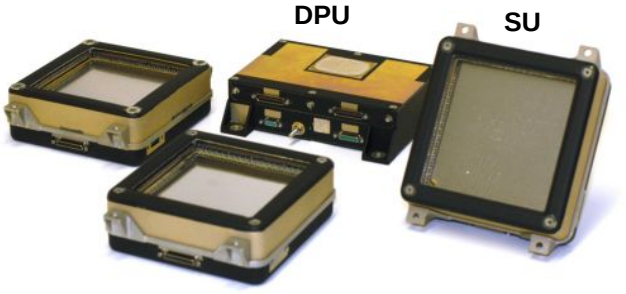


Past Projects (3/6)

- **Lunar Atmosphere and Dust Environment Explorer (LADEE) mission opportunity (2011)**
  - Objective: A build-to-print approach to deploy a Debris In-orbit Evaluator (DEBIE) to characterize the sub-μm lunar horizon glow particles at ~50 km above the lunar surface
  - Components: Impact ionization sensor, acoustic momentum sensor
  - Team: ODPO, ESA, MPIK, MSFC, NRL, UM, USNA, VT
  - Status: Proposal was not selected (December 2008)



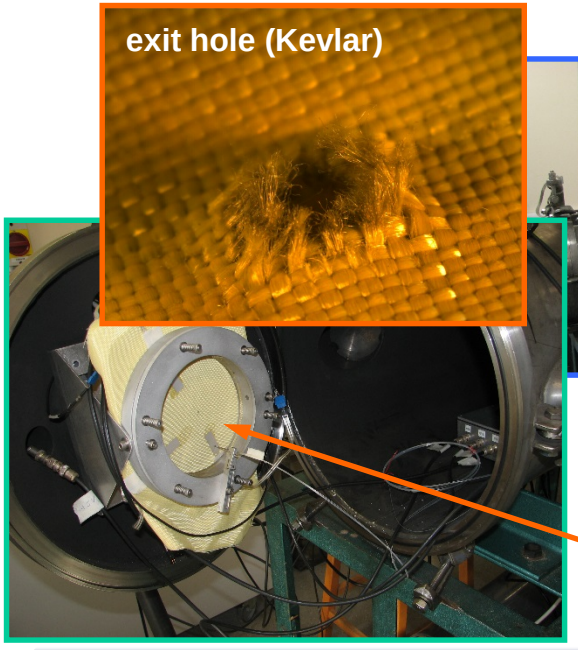


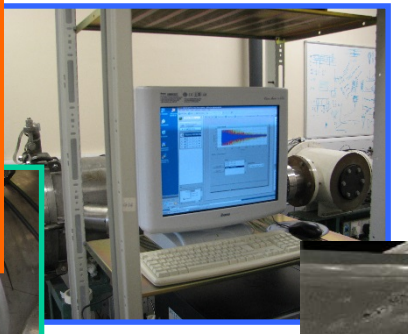


DEBIE

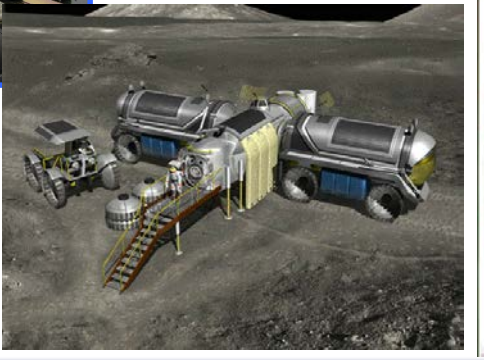
Past Projects (4/6)

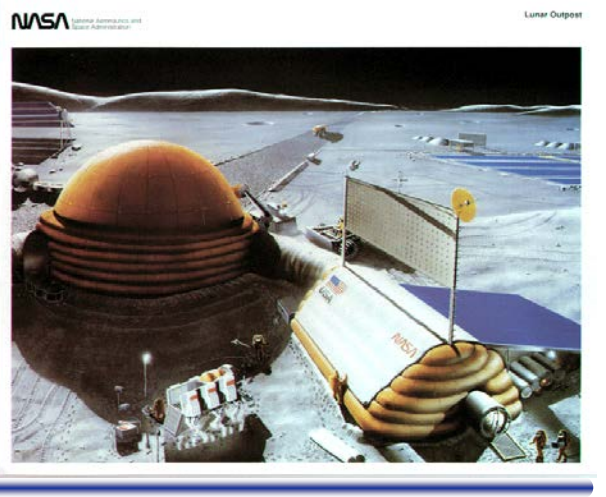
- **Micrometeoroid and Lunar Secondary Ejecta (MMSE)**
  - Objective: To explore the feasibility of using acoustic sensors to monitor potentially damaging impacts on large-scale instruments and lunar habitats
  - U.S. funding sources: NASA HQ OCE, NASA ODPO
  - Team: ODPO, Kent (UK), NRL, USNA, VT





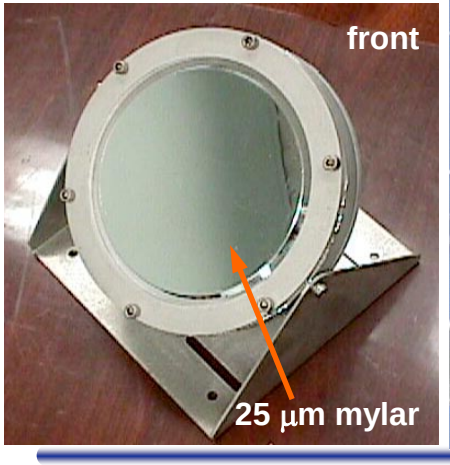
DAQ (Kent)

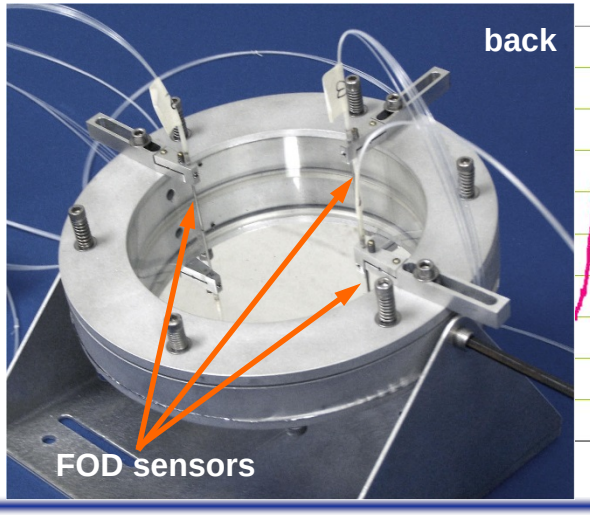


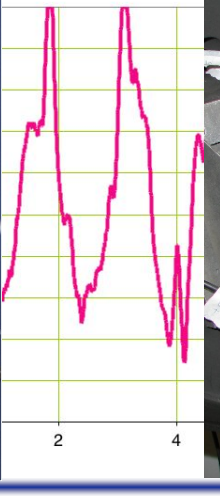


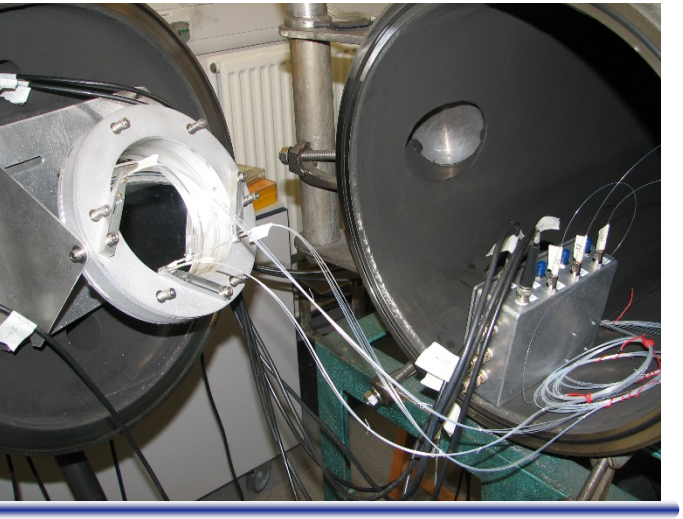
Past Projects (5/6)

- **Fiber Optic Micrometeoroid Impact Sensor (FOMIS)**
  - Objective: To develop prototype FOMIS units that can be assembled into a large-area (≥tens of m^2), low-cost, low-mass, and low-power MMSE impact detector on the lunar surface
  - Components: Thin film under tension, fiber optic displacement (FOD) sensors
  - U.S. funding sources: JSC (2008-2012)
  - Team: ODPO, Kent (UK), NRL, VT



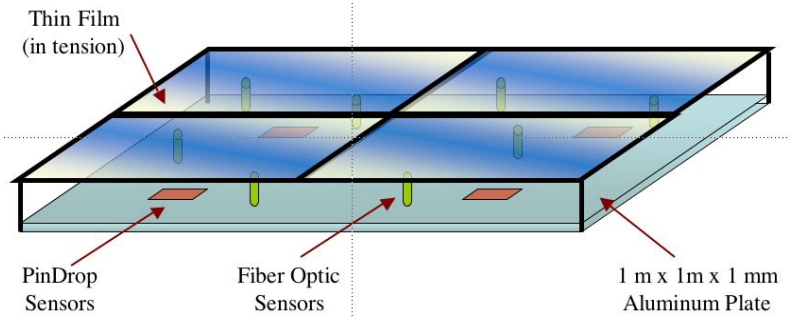


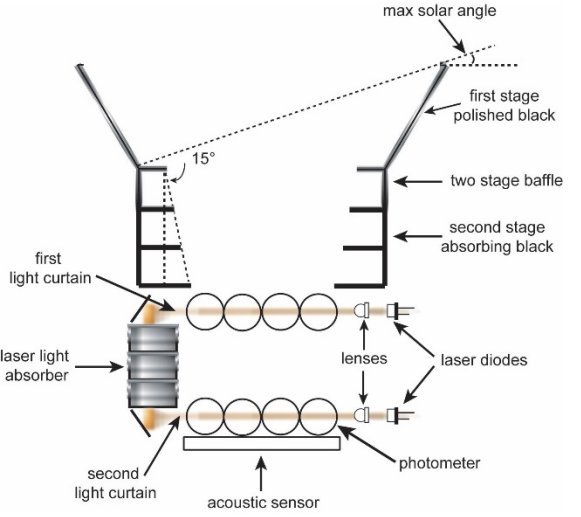




Past Projects (6/6)

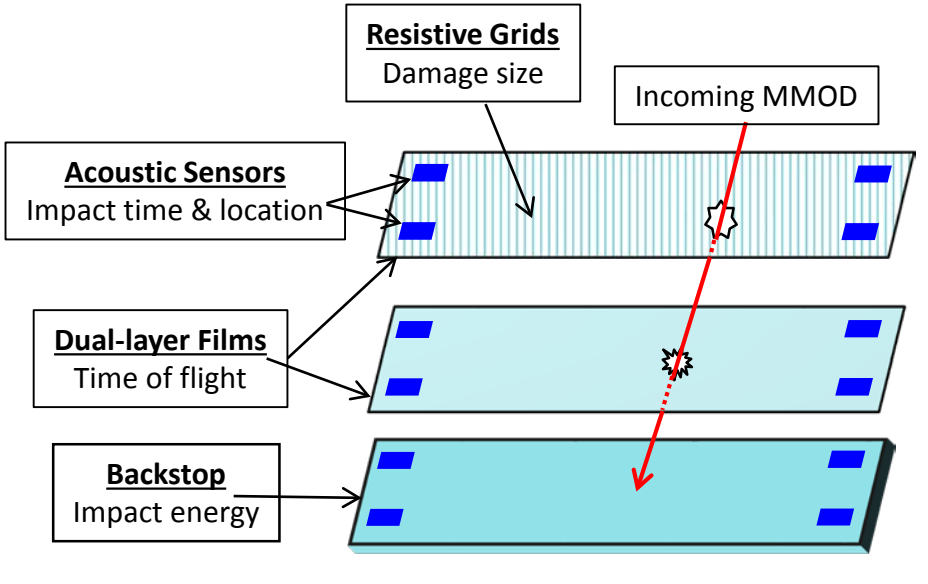
- **Impact Sensor for Micrometeoroid and Lunar Secondary Ejecta (IMMUSE)**
  - Objective: "Pre-Phase A" development of two integrated MMSE impact sensor systems
  - Components: FOMIS, PINDROP, dual-layer laser curtain sensors
  - U.S. funding sources: HQ SMD and ESMD (2009-2012)
  - Team: ODPO, Kent (UK), NRL, USNA, VT, MSFC

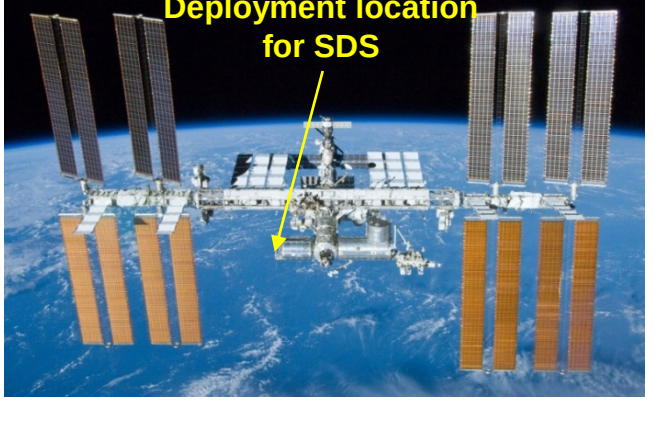




Present Project

- **Space Debris Sensor (SDS)**
  - The SDS, *i.e.*, the ISS Debris Resistive/Acoustic Grid Orbital Navy-NASA Sensor (DRAGONS) has been funded by the ISS Technology Demonstration Office for an ISS deployment in early 2018
  - The objectives are to mature the DRAGONS technologies and demonstrate its capability to measure impact time, impact flux, particle size, impact speed, impact direction, and impact energy/particle density





Future Project

- **The ODPO is actively pursuing flight opportunities to deploy a large area (≥1 m^2) DRAGONS to 700-1000 km altitude**
  - Rideshare
  - Secondary payload
- **The ODPO will continue to improve DRAGONS and seek opportunities for collaboration to address the key millimeter-sized orbital debris data gap in LEO**