CHARACTERIZING THE NEAR-EARTH COSMIC DUST AND ORBITAL DEBRIS ENVIRONMENT WITH LAD-C. J.-C. Liou¹, F. Giovane², R. Corsaro³, P. Tsou³, and E. Stansbery⁴, ¹ESCG/ERC, 2224 Bay Area Blvd., Houston, TX 77058, USA, jer-chyi.liou1@jsc.nasa.gov, ²NRL, ³NASA JPL, ⁴NASA JSC

Introduction: A 10 m² aerogel and acoustic sensor system is being developed by the US Naval Research Laboratory (NRL) with main collaboration from NASA Jet Propulsion Laboratory and the NASA Orbital Debris Program Office at Johnson Space Center. This Large Area Debris Collector (LAD-C) is tentatively scheduled to be deployed by the US Department of Defense (DoD) Space Test Program (STP) on the International Space Station (ISS) in 2007. The system will be retrieved after one year. In addition to cosmic dust and orbital debris sample return, the acoustic sensors will measure important impact characteristics for potential orbit determination of the collected samples. The LAD-C science return will benefit orbital debris, cosmic dust, and satellite safety communities. This paper outlines the need for a large-area cosmic dust and orbital debris in situ experiment such as LAD-C, and the expected dust/debris impacts on LAD-C during the mission.

Background: Cosmic dust particles, or micrometeoroids, are known to exist throughout the Solar System. The main sources of micrometer-to-centimeter sized dust in the inner Solar System are asteroids and comets (both long-period and short-period). The Earth's accretion rate of cosmic dust is estimated to be about 15,000 to 40,000 tons per year [1, 2]. In addition to cosmic dust, man-made orbital debris, from micrometer-sized solid rocket motor exhaust and satellite breakup fragments to meter-sized retired spacecraft and rocket bodies, also occupy the near-Earth space from about 100 km altitude up to the geosynchronous orbit region [3].

Justification: It is a well-known fact that meteoroid and orbital debris impacts represent a threat to space instruments, vehicles, and extravehicular activities. On average, two Space Shuttle windows are replaced per mission due to damage caused by meteoroid and orbital debris impacts. Of particular significance are particles about 50 µm and larger. Particles smaller than 50 µm are generally too small to be of concern to satellite operations. To have reliable impact risk assessments for critical space assets, a well-defined cosmic dust/orbital debris environment is needed.

The near-Earth cosmic dust flux does not vary significantly over time. On the other hand, the orbital debris populations in the 50 µm to 1 mm size regime are highly dynamic both in time and in altitude. However, there is a lack of well-designed, large surface area in situ measurements to better characterize the cosmic dust environment and to monitor the fast-changing small orbital debris populations since the return of the Long Duration Exposure Facility (LDEF) in 1990. There is a need for an updated mission.

Analyzing the chemical composition of the collected cosmic dust can provide clues to the origin and formation of the Solar System. The information also leads to a better understanding of the on-going physical processes (collisions, etc.) that their parents are going through. Many cosmic dust particles have been collected from the stratosphere and analyzed for their compositions [4]. However, a reliable dynamical link has not been established for any collected sample. The combined LAD-C acoustic sensors [5] and aerogel collectors [6] are designed to measure impact parameters (impact time, location, speed, direction) for large particles. With the information, the orbits of some of the collected samples can be determined for possible source identification.

What to expect: The expected number of cosmic dust and orbital debris impacts on LAD-C depends on the location of the system on ISS and the orientation of the detection surface. Both the location and orientation are limited by engineering constraints and the requirement to avoid significant ISS waste contamination. To maximize the science return for cosmic dust and orbital debris, careful planning is needed. Preliminary analysis indicates that a starboard/port-facing orientation will yield the most debris impacts while maintaining a high-level of cosmic dust impacts. In addition, a significant portion of orbital debris impacts on a starboard/port-facing surface will have impact speeds less than 7 km/sec, where the impact characteristics are better understood and the tracks embedded in aerogel are better preserved.

References: