A MICROMETEOROID DECELERATION AND CAPTURE EXPERIMENT: CONCEPTUAL EXPERIMENT DESIGN DESCRIPTION; J. H. Wolfe and R. W. Ballard, San Jose State University; G. C. Carle and T. E. Bunch, NASA Ames Research Center.

To determine the prevalence of biogenic and prebiotic compounds in the solar system, it will be necessary to examine material from many classes of objects. Elemental, isotopic and molecular measurements of returned samples of comets, asteroids, and micrometeoroids, including those of possible extra-solar origin, would provide information on a particularly important class, namely the primitive objects. Extraterrestrial micron-sized particles in the vicinity of Earth are one source of such materials that might otherwise be inaccessible. The Space Station seems ideally suited as a platform to provide the required space, power, long lifetime, and logistical support for the collection of these particles.

The key issue regarding the collection of extraterrestrial particles in a pristine form concerns their capture in a nondestructive manner which cannot be accomplished after atmospheric entry or hypervelocity impact in space. The collection experiment must be designed to minimize thermal and mechanical alteration(s). It is well known from many studies of extraterrestrial particles, collected by NASA's U-2 high-altitude flights, that cometary particles are quite friable and contain a high proportion of volatile constituents. Little is known about interstellar dust that may be entering the solar system, but it is likely that these particles may be simularly delicate and, in addition to possible organic components, they may be mantled by ices. Among the many constraints that must be considered in designing a collection experiment in line with our goal, the most critical issue is the problem of dealing with the hypervelocities (about 20 km/sec) of the incident particle. Preliminary calculations show that an electrostatic microparticle collector in principle, should be able to sufficiently decelerate micron-sized (or smaller) particles traveling at speeds of about 20 km/sec, relative to the collector, to less than 2 km/sec.

The preliminary conceptual design for a Cosmic Dust Collector is illustrated in the attached figure and is described below:

1. For the case of Low Earth Orbit (LEO), dust particles enter the collector through the collimator at a few volts negative potential due to charging in the ionosphere, at a velocity of 1-50 km/sec. The collimator is required in order to provide the particles with a rather well-defined path through the measurement and collection system. In the interplanetary medium the incoming dust particles would have similar velocities, but would be charged to a few volts positive due to photo effect.

2. The particles then pass through an electron stream and are charged to about 1 KV negative (regardless of incoming polarity). A magnetic field of about 1 gauss is applied perpendicular to the electron stream in order to greatly increase the electron path length and thereby reduce the current (power) requirements for the electron gun.

3. The 1 KV negatively charged particle then passes through three sensing grids coupled to charge sensitive preamps (CSP). The comparison of the two pulses provided by S_1 and S_2 are utilized by the microprocessor to determine the charge, q, on the particle (pulse amplitude) and its velocity, v (by time of flight). The third sensing grid, S_3, is kept at about 20 KV negative so that the dust particle will now be decelerated in passing from S_2 (zero potential) to S_3. S_3 is capacitively coupled to its CSP and the pulse from S_3 is utilized by the microprocessor to determine the particle's energy,

E, and therefore its mass, m (again by time of flight) by comparison with the pulses from S_1 and S_2.

4. After traversing all three sensing grids, all critical information on the dust particle (q, v, and E) has been determined so that the microprocessor can now precisely program the high-voltage switching network for the proper timing in the grounding of the successive deceleration grids.

5. As determined by the microprocessor, each successive deceleration grid, D_1, D_2, D_3, etc., is grounded just after the dust particle passes, thus reducing the particle's energy by the amount q*100 KV at each stage.

6. The microprocessor also determines at which stage the particle will fall below a certain critical energy ($E \leq q*100KV$) where all remaining grids remain unswitched so that the particle will drift to the collector.

7. The collector is kept at about 100V positive and is covered with gold foil to eliminate contamination and is removable for subsequent return to earth for detailed analysis. The whole collector area is bathed with low-energy electrons so the particles, after they come to rest on the collector, will electrostatically "stick" to the collector foil.

8. Affixed to the back of the collector plate is an array of acoustic detectors. These detectors provide information to the Space Station telemetry system to varify that an event has taken place. When a "hit" occurs, the signals from each acoustic detector are analyzed by the microprocessor to: (a) determine exact location of the hit (for data analysis), and (b) pass the largest amplitude signal on to the multichannel spectrum analyzer (MCSA) for spectral analysis. Spectral analysis provides: (a) distinction between actual micrometeoroid and a "false" signal (due to thermal creaks for example), and (b) information on particle momentum and possibly even information on composition.

9. These acoustic detectors can also be attached to the instrument housing (about 90 m^2 or more) in order to determine the total micrometeoroid flux in the vicinity of the Space Station. Signals from these sensors would utilize the Cosmic Dust Collector microprocessor and MCSA with a priority interrupt when a particle is detected by the Dust Collector sensing grids.

Rough estimates of flight hardware requirements on the Space Station are as follows:

Size: 4 m x 4 m x 20 m
Volume: about 320 m^3
Area: about 340 m^2
Weight: about 1200 kg
Power: 10's of KW continuous, but can be duty cycled
Telemetry: < 1 Kb/sec
Location: attached to outside
Field of View: about 20° x 20°
Orientation: not critical (but prefer not to view sun)
Crew Time: 16 to 32 hours to assemble; 1 hour/month for servicing

COSMIC DUST COLLECTOR