A PROTOTYPE GATEWAY INTERSTELLAR DUST COLLECTOR (GIDC).

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Introduction: The Gateway Interstellar Dust Collector (GIDC) is a proposed flight instrument designed to capture space dust in cislunar space. The instrument would be delivered to Gateway as a stowed payload aboard an assembly or logistics mission. The instrument is deployed from the Gateway Science Airlock (SAL) via a robotic arm and installed on an exterior mount (either the hull directly or an attached boom). The IDC is then deployed to provide approximately 1 m^2 of collection area using different types of aerogel cells and aluminum foil strips to capture cosmic particles. After an extended period of time, the IDC is then retracted and returned to the Gateway interior via the SAL. The crew would package the instrument into a protective case and stow aboard the Orion spacecraft for return to Earth. Sample curation and analysis would be completed at NASA JSC by the Astromaterials Research and Exploration Science division based upon their prior experience with the NASA Stardust mission.

Background: Dust collectors aboard the NASA Ulysses and Galileo spacecraft identified a stream of interstellar particles in the heliosphere [1], leading to a flight experiment targeting these particles. The NASA Stardust mission was launched in Feb 1999 with two main objectives: 1) capture sample particles from the 81P/Wild 2 comet, and 2) capture samples from the interstellar dust stream. The sample return canister returned to Earth in January 2006. From the Stardust Interstellar Preliminary Examination (SIPE), 71 particles tracks were identified in the silicate aerogel cells of which 2 were consistent morphology and trajectory to interstellar dust. An estimate of 12 total interstellar dust particles in the aerogel cells is expected based upon particle population density and trajectory. There were 25 craters in the aluminum foil strips of which 4 contained residue consistent with extraterrestrial material [2].

GIDC Design: The overall concept of the GIDC is based upon the Stardust Interstellar Dust Collector (SIDC) design containing a grid of 132 silica aerogel cells with a collection area of 1039 cm^2. The Stardust mission analysis team also studied crater impacts from parts of the spacecraft structure, which was not originally considered a sample collection area. This included 291 strips of aluminum foils with an area of 150 cm^2 [2].

The proposed GIDC is sized to fit within the NASA Habitable Airlock (HAL) SAL, which is the hardware available for testing science procedures at JSC in 2018. The furled GIDC is 23” long, 11” wide, and 15.6” tall. There are 6 panels each composed of 15 thin aerogel cells (each approximately 11 cm x 11 cm). The total of 50 cells provides a collection area of 1.04 m^2 when fully deployed to a width of 88” (see Figure 1). The frame structure of the GIDC is also covered in foil and other metallic materials for particle capture. Consideration is being given to materials on the underside of each panel for possible capture materials. Since the instrument is not designed for EVA, no hand-holds or externally replaceable units are included in the instrument.

The GIDC may include a combination of aerogel cells composed of silica (like Stardust) and other materials. One problem with silica aerogel is similar chemical composition to the particles being captured. The silica aerogels also contain carbon due to impurities, which complicates analysis of organics in the sample. Using rare, trace elements, such as Tantalum, in aerogel materials would ease sample analysis since the substrate is different composition from the expected captured particles [3]. A tile-like aerogel composed of Tantalum-Oxide (Ta_2O_5) prepared by the sol-gel method has successfully created a high porosity, high surface area, low density aerogel monolithic [4], which is perhaps suitable for GIDC.

Determining particle velocity and trajectory is a difficult task, as experienced with Stardust analysis. An alumina aerogel doped with Chromium III creates a material that enters a strong fluorescent state at temperatures above 1450C, thus generating a clearly identifiable track in the cell from a particle trapped at high velocity [5]. A possible improvement to the GISD design is inclusion of a Dust Trajectory Sensor (DTS) capable of accurately detecting particle trajectory and velocity. This would aid velocity analysis of micron sized particles in the aerogel cells [6].

IDC Procedure Testing: A conceptual prototype of the Gateway IDC was fabricated in the summer of 2018, with deployment and retrieval procedures testing during the fall of 2018. The procedures were executed during NASA Gateway habitation module ground tests. These tests are a component of Broad Area Agreement (BAA) contracts with commercial companies to develop Gateway habitation modules concepts for testing by NASA personnel as an input to Gateway requirements. A lesson learned from these procedures is to have the entire GIDC packaged as a single unit rather than requiring crew to add/remove individual cells from the frame. The placement of the GIDC on the Gateway exterior depends upon future vehicle design, but the goal is for the GIDC to be passive requiring little or no Gateway power or communications once deployed and unfurled. The expected deployment period is 195 days (like SIDC) [2].

References: [1] Grun et al. (1993), *Nature 362*, 428. [2] Westphal A. J. et al. (2014) *Meteoritics & Planet. Sci., 49 Nr 9*, 1720-1733. [3] Lisse C. M. et al. (2008), *LPS XXXIX*, 2298. [4] Ren H. et al. (2010), *J. Sol-Gel Sci. Technol. 53*, 307-311. [5] Burchell et al. (2006), *Annu. Rev. Earth Planet. Sci. 34*, 385-418. [6] Grun et al. (2012) *Planetary and Space Science 60*, 261-273.

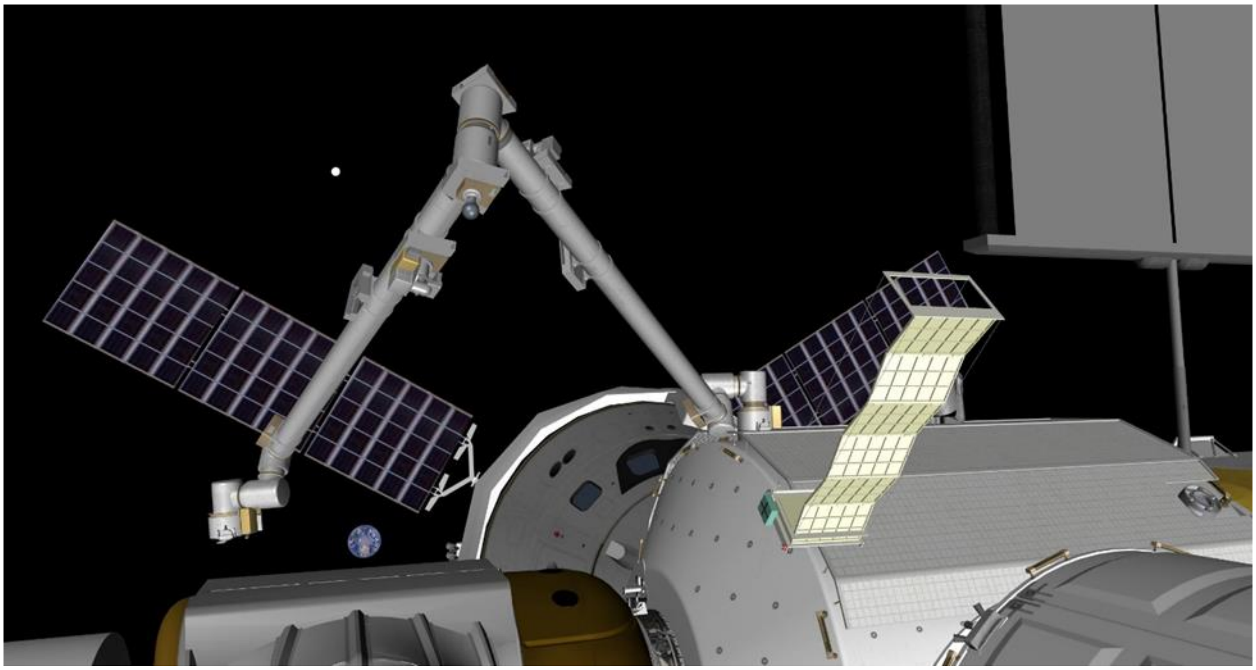

Figure 1 – Prototype Gateway Interstellar Dust Collector deployed during habitation ground tests (fall 2018)