The Collaborative Acceptance and Distribution for Measuring Europan Samples (CADMES) Sample Delivery System for a Future Europa Lander.  C. A. Malespin\textsuperscript{1}, P. Chu\textsuperscript{2}, V. Pinnick\textsuperscript{1}, A. Grossman\textsuperscript{2}, P. Barfknecht\textsuperscript{1}, M. Francom\textsuperscript{1}, D. Wegel\textsuperscript{1}, Z. Gonnsen\textsuperscript{1}, E. Lalime\textsuperscript{1}, M. Casey\textsuperscript{1}, and M. Amato\textsuperscript{1}, \textsuperscript{1}NASA Goddard Space Flight Center, charles.a.malespin@nasa.gov, \textsuperscript{2}Honeybee Robotics, Altadena, CA.

Introduction: An efficient and effective approach to preserving sample integrity and minimizing payload mass for a future Europa Lander can be realized by integrating the sample handling functions into a single subsystem, while providing flexible and customizable interfaces to the instrument suite that is ultimately selected. The Collaborative Acceptance and Distribution for Measuring Europan Samples (CADMES) system was selected for ICEE2 funding, and provides a robust and flexible delivery mechanism that leverages GSFC and Honeybee experience from prior flight sample handling systems, here applied to the unique and challenging environment of Europa.

Description: The CADMES system, Figure 1, is a sample handling system that can accommodate multiple instrument interfaces, while preserving and maintaining composition and integrity of a Europan sample. Maturing a sample distribution system early with the pre-project lander team using a variety of different classes of instruments benefits future instrument providers. CADMES will demonstrate a robust, but flexible, solution which can be tailored to the selected payload, but has also been demonstrated to work with a variety of accommodations.

The original proposed CADMES sample delivery system was based on the Curiosity Rover’s Sample Analysis at Mars (SAM) Sample Manipulation System (SMS), and baselined a simple chain link carousel. This approach assumed each instrument would be able to accept sample at the same vertical location, and that all sample cups were identical. One of the initial trade studies during the first year of ICEE2 was to meet with each instrument team and collect their preferred sample door location, along with any other accommodation requirements, including sample cup preferences and necessary features. Collecting these requirements from the ICEE2 teams drove the decision to move away from the heritage SMS-like carousel, and utilize the current swing arm mechanism shown in Figure 2.

CADMES has been working closely with both the JPL pre-project Europa Lander team, and with each of the analytical instruments which were awarded ICEE2 studies. Part of the ICEE2 study served as a proof of concept where CADMES led and supported multiple instrument interface and accommodation meetings between JPL and each ICEE2 instrument. These discussions were a useful exercise in understanding the diverse set of requirements needed by Europa instrument teams, driving CADMES to develop a flexible sample handling mechanism which can eventually be adapted to suit many different instrument combinations.
Figure 2 illustrates the current CADMES concept. The swing arm consists of a rotation stage, linear extension system, and gripper mechanism, each driven by an actuator. The swing arm is able to access each cup individually, latch onto them with a gripper, remove them from a passive launch restraint, and move them to a sample delivery funnel. A passive mechanism in the swing arm keeps the sample cups vertical during this manipulation. The swing arm then moves to one of three sample delivery ports. Each cup shares similar interface features to the passive launch restraint and gripper mechanism, but customization of other features to suit individual instruments is expected for a future Europa Lander implementation. CADMES worked closely with each ICEE2 instrument team to develop custom sample cups, and demonstrate flexibility of the design.

A passive spring-loaded door is opened by the motion of the swing arm, allowing a linear extension stage to move the sample cup through the delivery port and into the instrument, which is inside the lander vault, Figure 3. Once inside the “receiving room” the instrument is responsible for constraining the sample cup (shown generically by passive clips in Figure 3), and performing any other operations necessary for their experiment. CADMES releases the sample cup, allowing the instrument to analyze the sample. The sample cup can later be retrieved using the same actions.

CADMES utilizes an annular dust shield disc which is also used for contamination protection of the cups. Not shown in Figure 2, this disc rotates around the central CADMES axis, driven by motion of the swing arm. All sample cups are passively constrained to a radiator. This radiator connects to a single-use separation mechanism which actuates after landing to thermally isolate the sample cups from the lander to keep them cold (<150 K) inside of CADMES.

CADMES worked closely with the pre-project lander team to iterate the CADMES design, taking into account sampling arm physical envelope requirements, lander thermal predictions and ICEE2 instrument payload accommodations.

**Future testing:** CADMES hardware will undergo cryogenic thermal vacuum testing, radiation testing, and vibration testing in the summer of 2020. We will demonstrate a sample transfer under Europa thermal conditions that validate CADMES requirement to not deliver a sample above 150 K.