SAMPLE HANDLING CONSIDERATIONS FOR A EUROPA SAMPLE RETURN MISSION: AN OVERVIEW.

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Introduction: The intent of this abstract is to provide a basic overview of mission requirements for a generic Europan plume sample return mission, based on NASA Curation experience in NASA sample return missions ranging from Apollo to OSIRIS-REx. This should be useful for mission conception and early-stage planning. We will break the mission down into Outbound and Return legs and discuss them separately.

The Outbound Leg: The outbound leg is comprised of the flight to Europa with some manner of collection mechanism which will place plume material in a sample return capsule (SRC) for return to Earth. The outbound leg is designated as a Planetary Protection (PP) category III or IV mission if it is a flyby, with spacecraft cleanliess requirements sufficient to protect Europa from terrestrial contamination in the event of impact with Europa or other Galilean moons. For more information on PP requirements see Conley *et al* at this workshop and the COSPAR policy [1].

If we assume Europa's plumes are similar in composition to those of Enceladus and sampled by the Cassini mission, then Europa's plumes will contain >99% chloride salt-rich icy particles with both solid and volatile organic compounds [2]. Contamination control may be similar to the organic contamination requirements proposed by the Organic Contamination Panel (OCP) [3] and its Minority Report [4] for the Mars 2020 mission. The OCP limits total organic carbon (TOC) to no more than ~10x the expected concentration of organic compounds of scientific interest in the samples (low ~ppb levels) or lower if possible. Individual compounds of interest ("Tier I" compounds) are limited to no more than 1 ppb. All other compounds are labeled "Tier 2" and are limited to no more than 10 ppb. All contaminant values are given in total amount transferred to the sample. This is derived by measuring the contaminant loads of all sample collection hardware and assuming 100% transfer to sample, calculating upper limits for hardware surface contamination in terms of TOC per unit area. Typically this value is in the low ng/cm^2 TOC range but sample mass and collector surface area factor in. If the mission decides to capture volatiles during sample collection, encapsulation of the volatiles will be a mission-specified engineering challenge. At present, no NASA missions featured/feature an SRC that was sealed against gas escape after sampling, with the exception of Apollo.

The Return Leg: The return leg is defined as the flight after sample collection, to include both the return of the SRC to Earth and the extended curation mission. Curation is the scientific management of samples for an essentially infinite period after the flight phase is complete. The PP category for this phase is level V and is designed to protect Earth from potential Europan organisms. For more information on PP requirements see Conley *et al* at this workshop. Organic contamination control must continue at the same level throughout the return leg of the mission and into extended curation as in the outbound leg.

A Europan plume sample return mission must choose between preservation states for the mission return leg and subsequent curation. These choices can be summarized as ambient temperature, cold, or cryogenic preservation [5-7]. *Ambient T sample return* entails sample storage above the melting point of water ice and would require the mission to preclude any science requirement(s) to retain volatile species. This may be an option if the chosen sample capture method generates significant heat, e.g. via a Stardust-like high velocity capture. *Cold sample return* describes sample storage near 250 K, sufficient to maintain water ice as a solid and retain a suite of volatiles. Mission complexity and costs will rise commensurate with engineering requirements to maintain this temperature. Cold curation has been demonstrated and is feasible with current technology, but with implementation and maintenance costs to consider [8]. *Cryogenic sample return* would maintain samples around 40 K to preserve their volatile components with minimal loss. Feasibility would rely on current technologies developed for the superconductor industry. However, significant research and development effort would be required to tailor these technologies to sample return and long term curation of volatile samples.

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