Prioritized Technology: Ice Sample Return – Integrated Cryogenic Chamber (ICC)

Technical Goal

Preserve an ice sample at cryogenic temperatures during return (about 7 years) and Earth re-entry for three classes of missions:
An integrated cryogenic chamber includes three types of technologies: Phase Change Materials (PCM); multistage shield and heat switch; and mechanical cryocooler.

- Class 1: Sample kept between 100K – 150K
  - Adapt current PCM (e.g. Argon), cryocooler, shield, and heat switch tech. for larger heat sink caused by sample size. Develop baseline integrated Cryogenic Chamber.
- Class 2: Sample kept between 65K - 100K
  - Improve from class 1, heat switch reliability & multistage switch.
- Class 3: Sample kept 55K - 65K
  - Improve from class 2; Adapt N2 PCM
  - Improve heat switch reliability & improve efficiency of passive radiator cooling;
  - develop battery powered 2nd stage cryocooler for earth entry vehicle
- Perform trade studies between use of passive thermal radiators (PTR), size of cryocoolers, and number of cryocoolers for different mission classes and Understand location of cryocoolers: internal or external to the earth entry vehicle.
- Challenges: If batteries power a cryocooler in earth return vehicle, then battery life could be a concern. The ICC needs a hermetic seal to maintain the vacuum in the ICC needed to minimize heat transfer.

Technical Status

Current:

- Mars (MSR), asteroid (OSIRIS-REx), comet (CSSR in New Frontiers 4) return sample without cryocooler, potentially with phase change material to maintain < 263K through sample recovery on Earth.
- Cryocoolers exist for cooling small flight instruments, but not for the larger volume return samples. The ice samples are much larger, thus, thermal mass of samples are also much larger than the current instruments.
- No Integrated Cryogenic Chamber has been developed.
- The Verveka et al. Cryogenic Comet Nucleus Sample Return study (NASA SDO-12367) suggested two cryocoolers to keep samples below 125K, one powered by the spacecraft and one powered by batteries in the earth entry vehicle. The study assumed a 30 cm long by 15 cm diameter cooled volume.

Mission Applications

What science is enabled if we achieve the goal?

1. Return of ice samples that contain evidence of habitability and/or potential life, e.g. from Europa or Enceladus.
2. Subsurface comet nucleus sample that contains information about the formation of the solar system.

Class	Europa, Enceladus, Comet
1 <150K	• Minimize chemical processes of non-volatile organics; • Maintain complex organics; • Maintain crystalline ice • Maintain evidence of potential life (non-comet)
2 <100K	• Stop chemical processes of non-volatile organics; • Maintain volatile organics. • Maintain amorphous ice (comet)
3 <65K	• Maintain native state (temp ≤ original environment) • Retain CO2, ammonia