Ames Research Center

# Lunar Sample Return Entry Systems Analysis

*Presented to HoneyBee Robotics*


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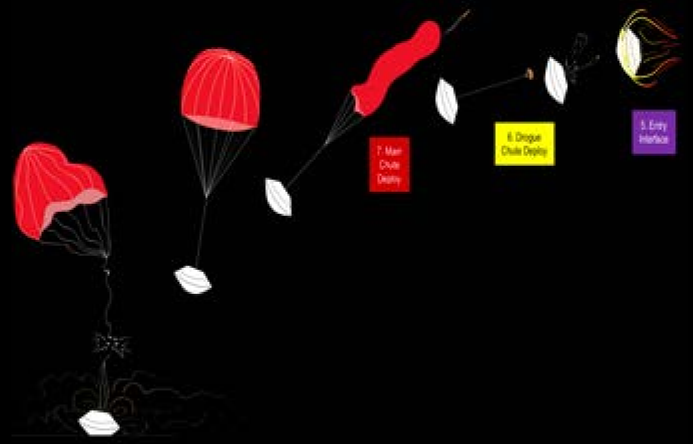
# Research Objectives

## Primary Objective

To analyze and design a re-entry capsule that will return a sample from asteroids, comets, moons and planets.

## Secondary Objectives

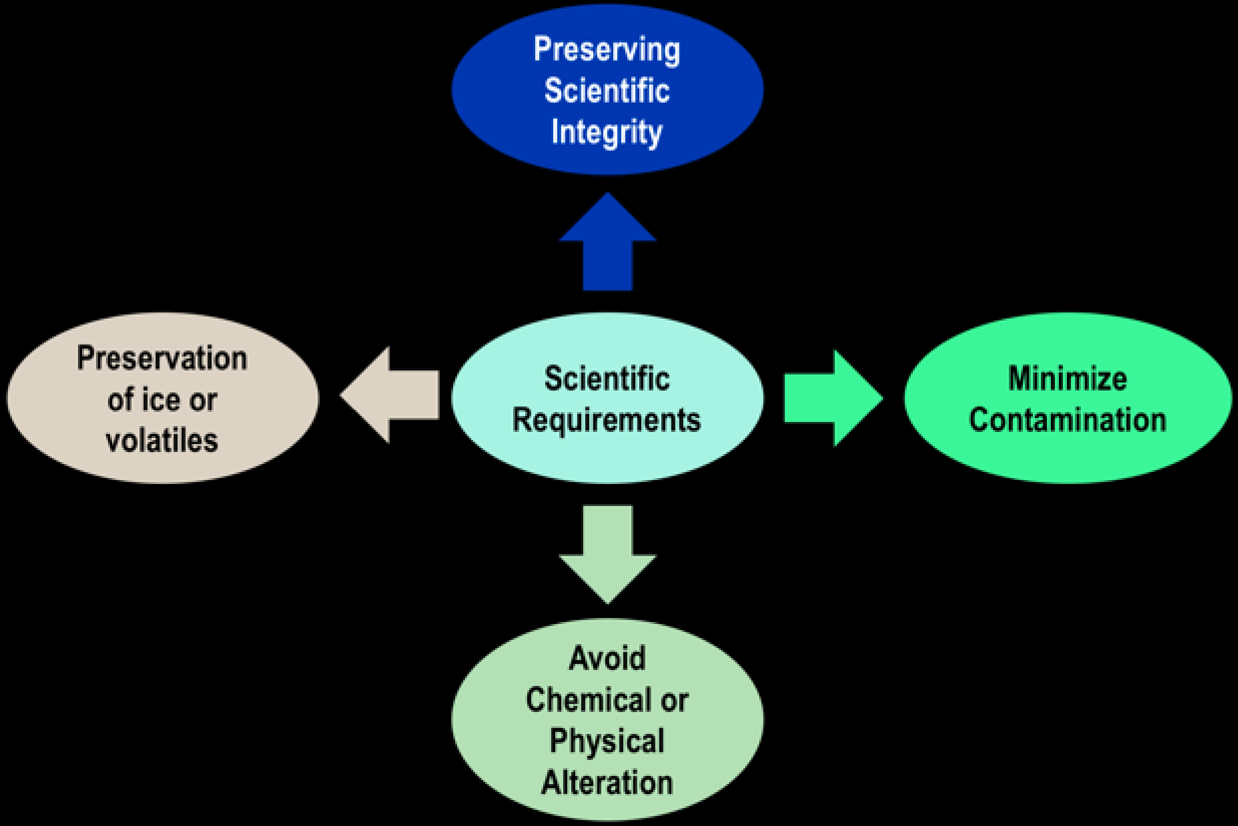
To understand the thermal properties of various sample types and how their composition affects the sample return capsule (SRC) design.



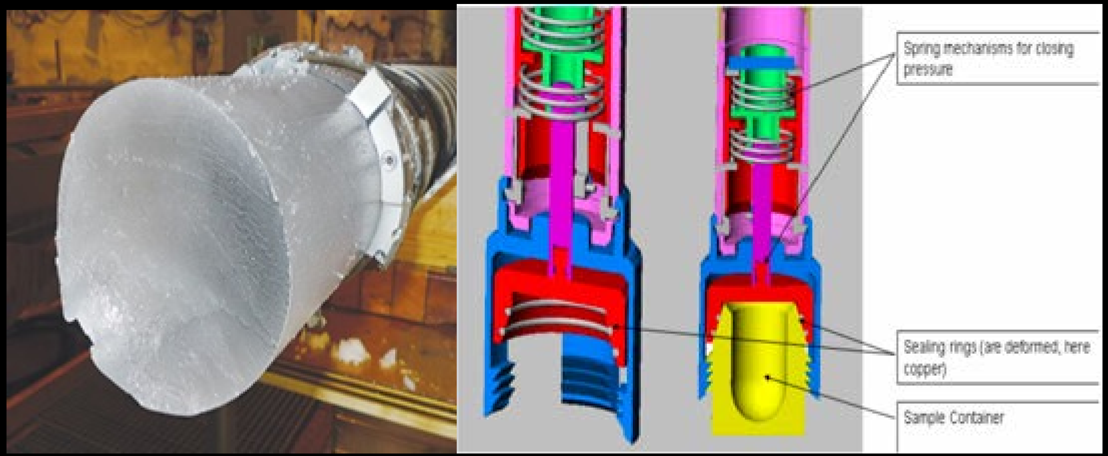
To provide an entry, decent and landing (EDL) operations analysis for the proposed return capsule including sample preservation and handling logistics.

# Ground Rules and Assumptions

## Scientific Requirements



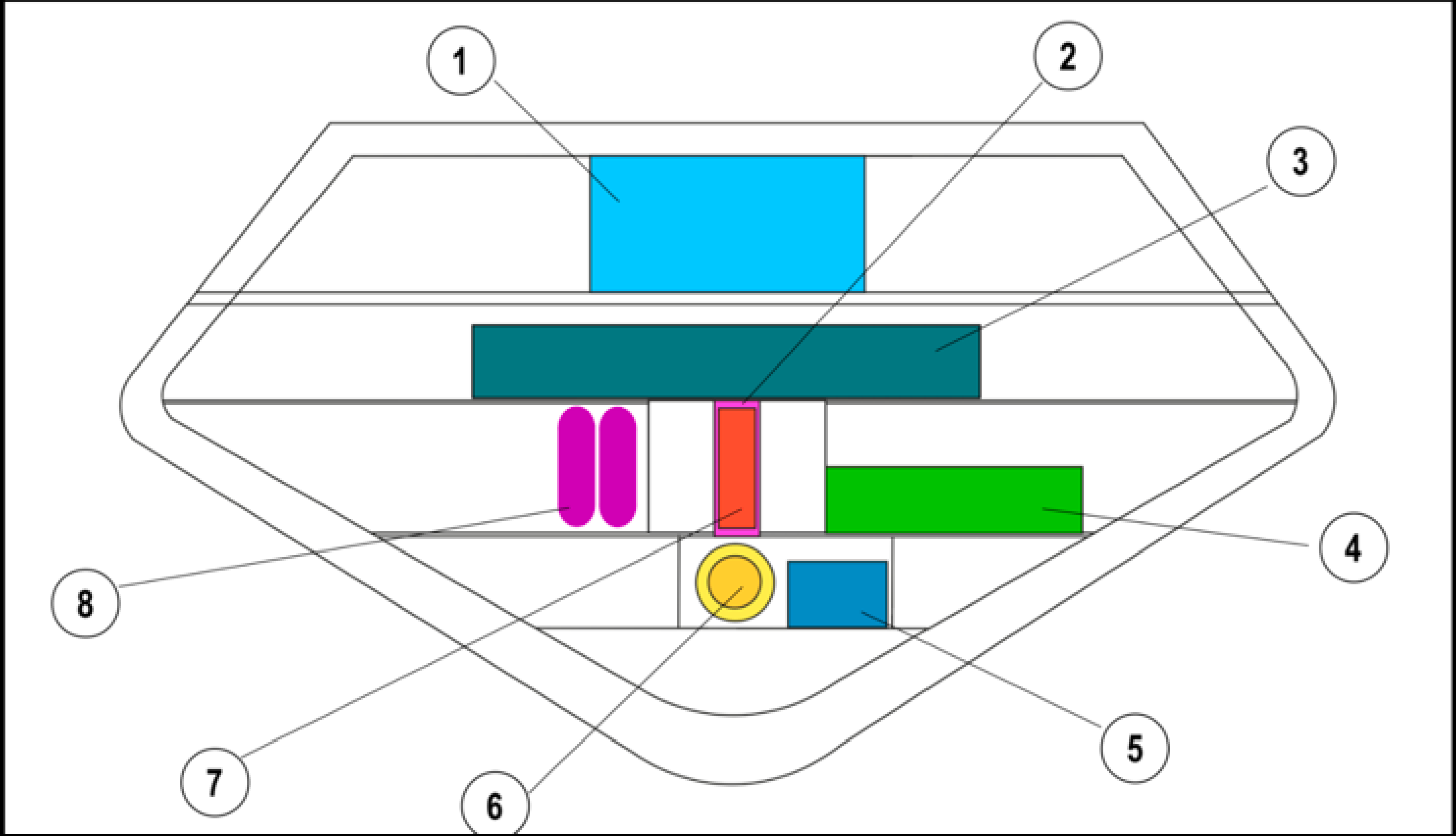

## Cryogenic Sample




- The shape of the sample container is a cylinder
- Sample containment vial is hermitically sealed
- Composition of the sample shall be a core ice of 25 mm
- The sample and its containment system shall not exceed 30 kg
- There shall be little to no void space between the core sample and sample container

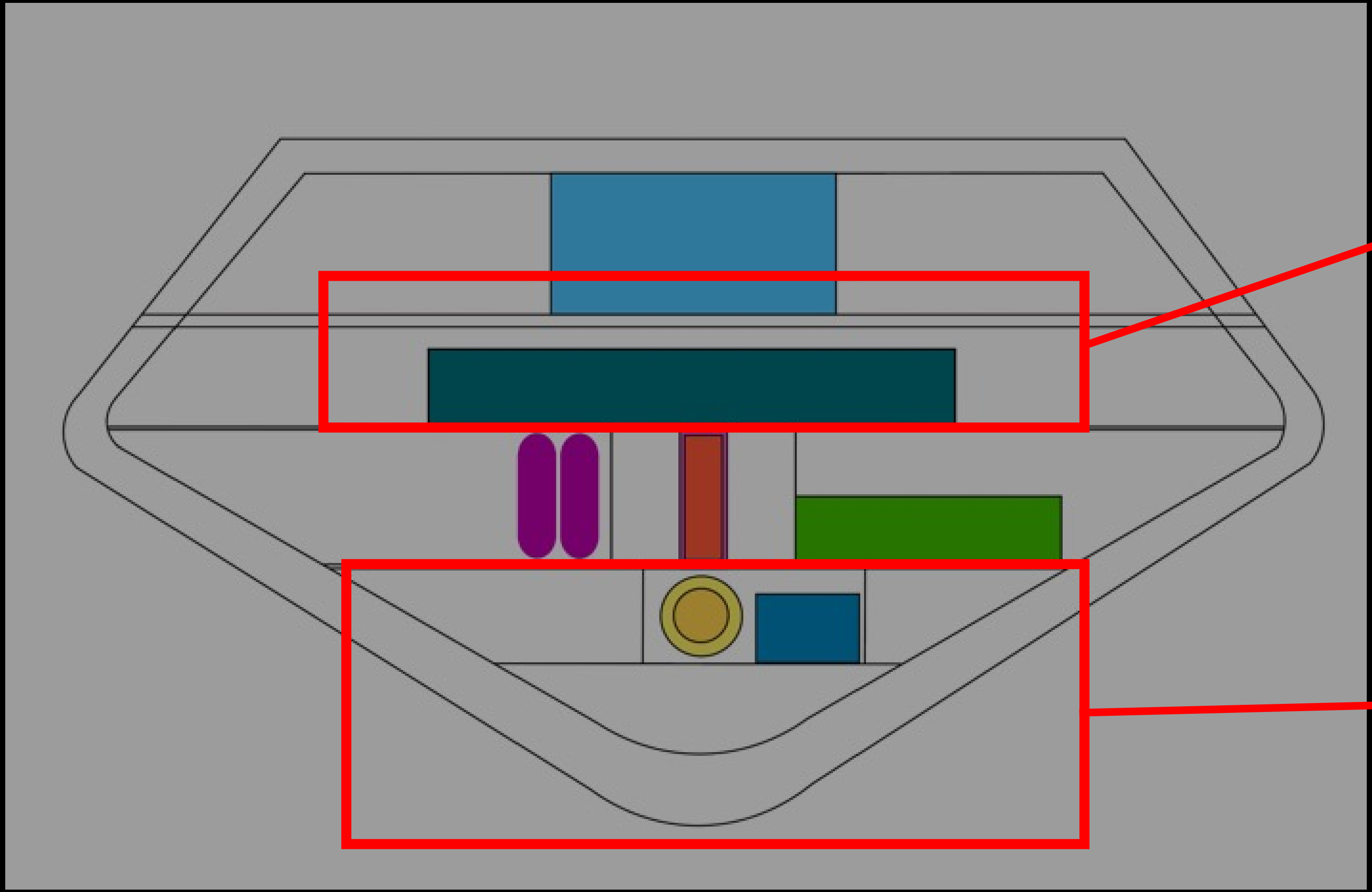
# Schematic of Conceptual Design

*Lunar Cryogenic SRC Subsystems:*




| No. | Description |
|---|---|
| *1* | *Parachute* |
| *2* | *Sealed Sample Container* |
| *3* | *Electronics and Sensors Housing* |
| *4* | *Additional Gas Sample Container* |
| *5* | *Batteries* |
| *6* | *Micro Cryocooler* |
| *7* | *Sample Container* |
| *8* | *Pressure Relief System* |

# Research Focuses



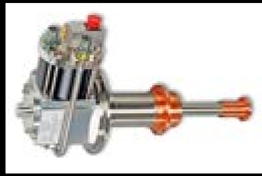
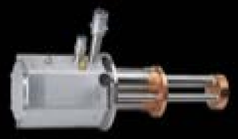
## Temperature and Pressure Monitoring System

- Collects data to improve future SRC designs

## Cryocooling Mechanism

- Actively cools sample container from jettison until capsule arrives at a curation facility

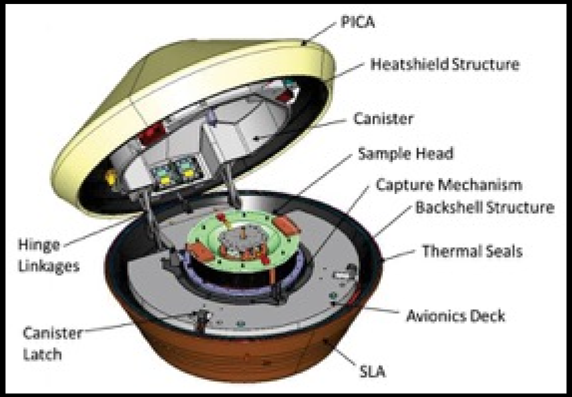
# Cryocooler Technology

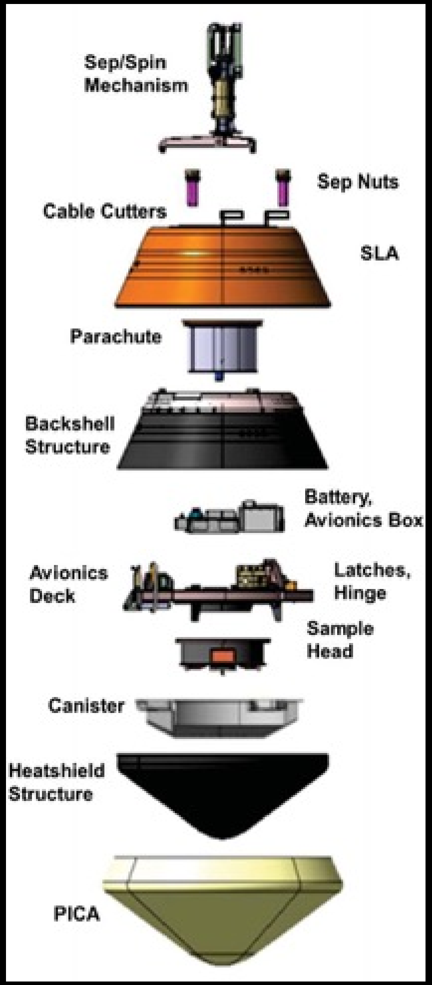
| Cryocooler Type | Temperature | Advantages | Disadvantages | |
|---|---|---|---|---|
| Stirling  | 80 K | High Thermal Efficiency, Small Size and Mass | Vibrations | ✗ |
| Pulse Tube  | 80 K | Lower Vibrations, Expensive | Low Thermal Efficiency | ✓ |
| Gifford-McMahon  | 170 K | Operate in any orientation, Inexpensive | Moderate Vibration, Low Thermal Efficiency | ✓ |
| Joule-Thompson  | 4 K | Low Vibrations, Low Temperatures, High Cooling Power | Requires Hybrid Design | ✗ |
| Reverse Brayton  | 65 K | High Capacity | Complex in Design, Under development | ✗ |

# SRC Design Ground Rules and Assumptions

## OSIRIS-REx Inspired Capsule Design

OSIRIS-REx Sample Storage Sequence




## SRC Ground Rules and Assumptions

- The capsule shall have automated actuators that open the upper structure when the sample is retrieved and close once the sample has been mounted into the capture mechanism
- The capsule shall include thermal seals within the inner edge of the backshell structure
- The capsule includes necessary functions and capabilities to perform soft landing
- Active cooling shall begin from capsule release upon sample capture within a duration of 50 – 100 hrs.
- The required heat lift is within 4 – 12 W thermal

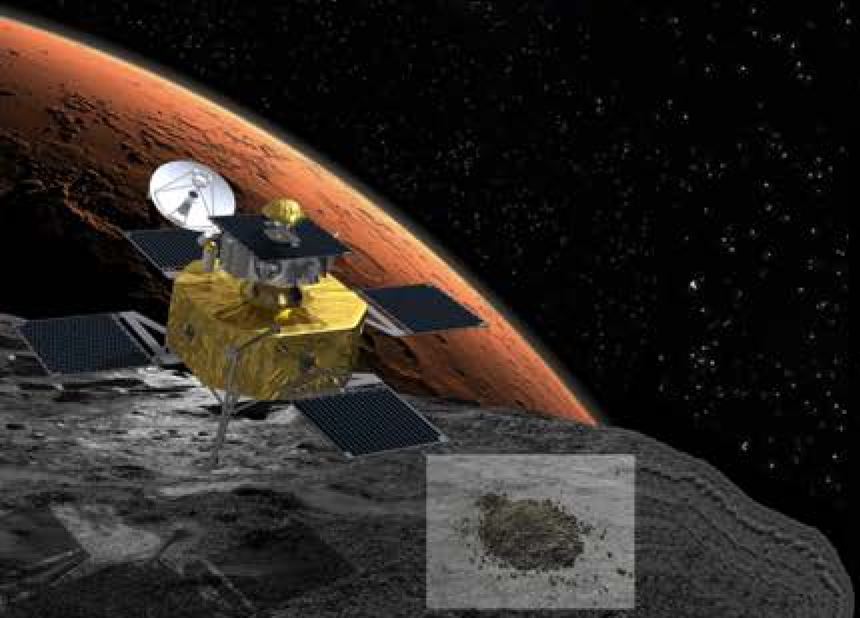
# Future Work

- Run simulations based on proposed vehicle specifications
  - Analyze Heat Load, Deceleration, Velocity, Altitude and Dynamic Pressure
- Provide CAD drawing of cryocooler and power supply subsystem
- Develop a quantitative table including subsystem specifications, sizing and expected performance output

# Acknowledgements


Mentors:

- Alan Cassell, Systems Engineer, NASA Ames Research Center
- Ethiraj Venkatapathy, Senior Technologist, NASA Ames Research Center

# QUESTIONS?