Comet Surface Sample Return Probes

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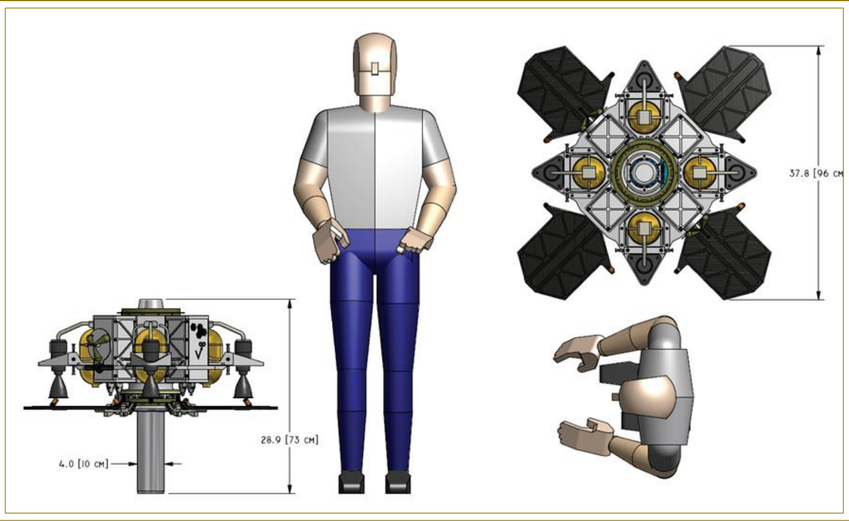
Background

The next New Frontier Mission, NF4, will be selected from a list of five candidates, one of which is the Comet Surface Sample Return (CSSR) mission. The science objectives of the CSSR are:

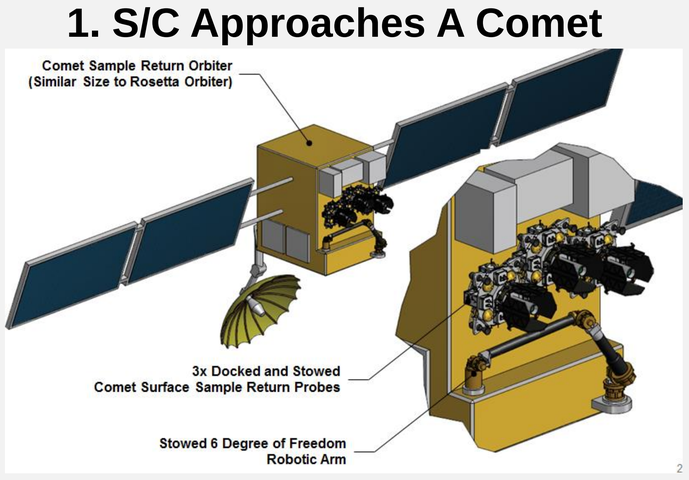
1. Acquire and return to Earth a macroscopic (≥500 cc) comet nucleus sample from a depth of at least 10 cm (at least 3 diurnal thermal skin depths), if the region has shear strength <50 kPa
2. Preserve complex organics (kept at <300 K)
3. Do not allow aqueous alteration (keep at ≤263 K)

A CSSRP is a small scale spacecraft, transported to a comet on a larger conventionally sized spacecraft. This small spacecraft impacts the surface of a comet, retains a sample within a hermetically sealed canister, and ascends from the comet surface to deliver the sample to an Earth Return Vehicle. The CSSRP is sized to allow multiple probes to travel on a single larger spacecraft for redundancy purposes. The CSSRP takes advantage of many existing small-scale spacecraft systems, forming a modular design made of many flight-qualified subsystems. This methodology will ultimately reduce the cost and development time of the overall system, potentially increasing the appeal for various commercial and NASA applications.

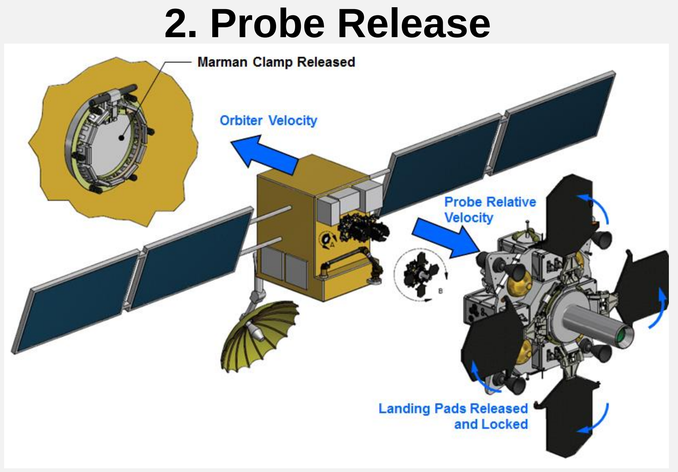
Comet Surface Sample Return Probe (CSSRP)



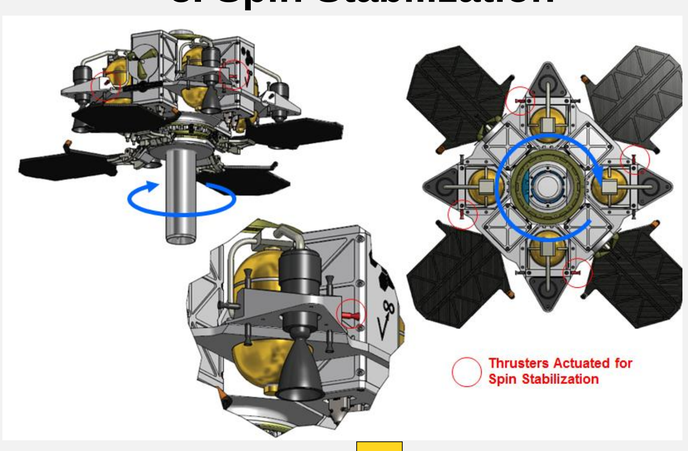
1. S/C Approaches A Comet



2. Probe Release



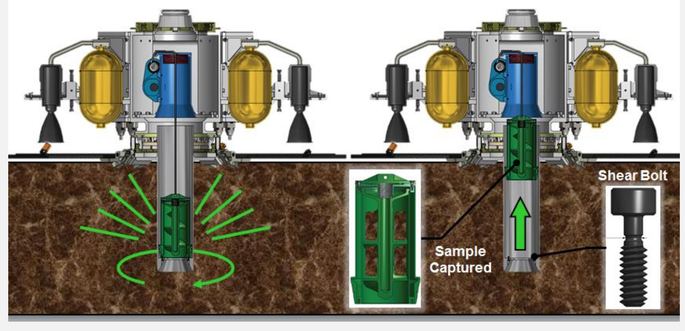
3. Spin Stabilization



4. Probe Descent

Probe impacts surface of Comet. Rotation and impact causes auger flutes to fill with sample. Foot pads prevent over-penetration

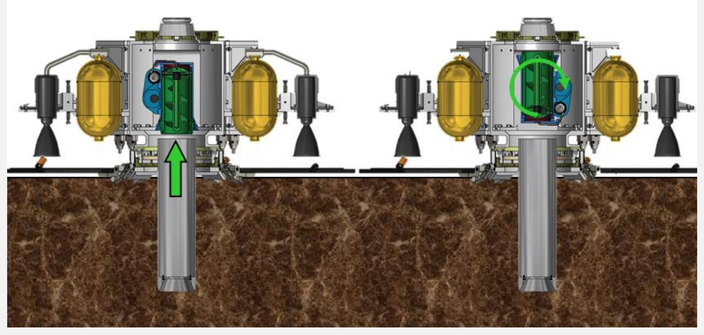
Winch retracts auger and casing along with captured sample. Fastener heads holding Auger casing in place are sheared, releasing Auger casing from Impactor



5. Retract Canister and Rotate

Winch fully retracts auger and casing into Flipper Mechanism. Spring is preloaded

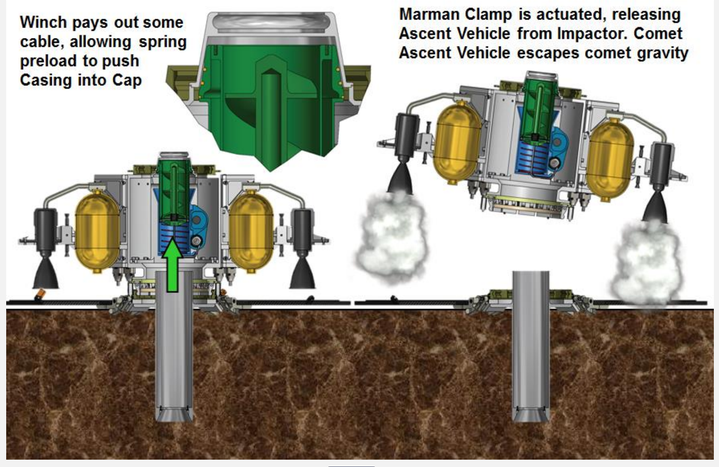
Launch Lock disengaged. Flipper Mechanism aligns Auger and Casing with Cap using passive redundant torsion springs



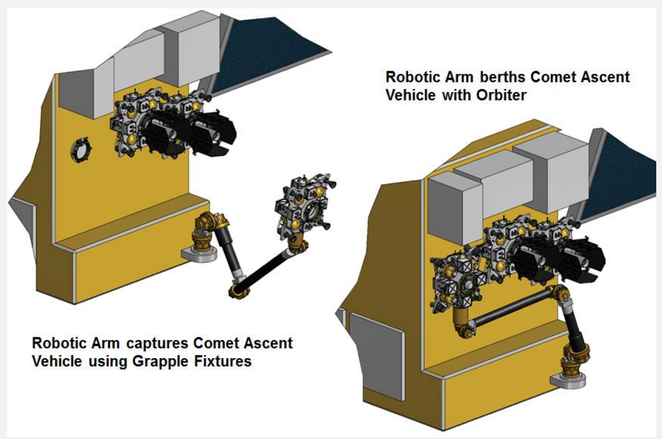
6. Seal Sample and Ascend

Winch pays out some cable, allowing spring preload to push Casing into Cap

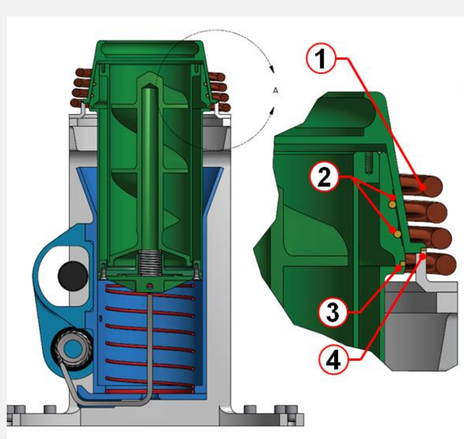
Marman Clamp is actuated, releasing Ascent Vehicle from Impactor. Comet Ascent Vehicle escapes comet gravity



7. Rendezvous, Capture and Berth

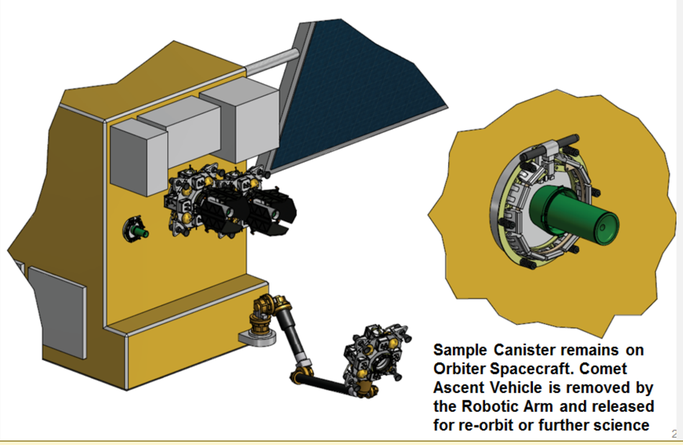


8. Hermetically Seal



1. Induction coil induces Eddy Currents in canister producing heat
2. Circular rings are initially not brazed. During braze process, these melt and re-solidify, sealing the inner canister to the cap
3. Rectangular braze initally holds outer canister to inner canister. During brazing process, this melts, separating the inner from the outer canister
4. Rectangular braze initially holds cap to the Comet Ascent Vehicle. During braze process this melts, separating the canister from the CAV

9. Release Comet Ascent Vehicle

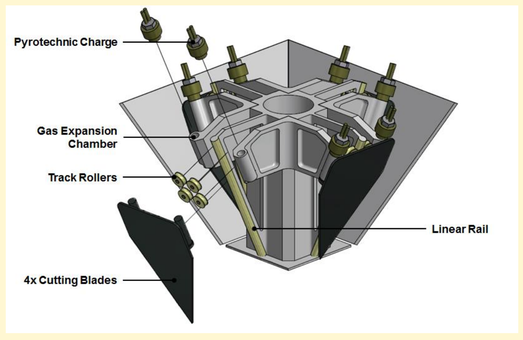


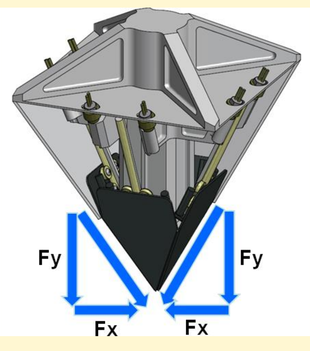
Sample Canister remains on Orbiter Spacecraft. Comet Ascent Vehicle is removed by the Robotic Arm and released for re-orbit or further science

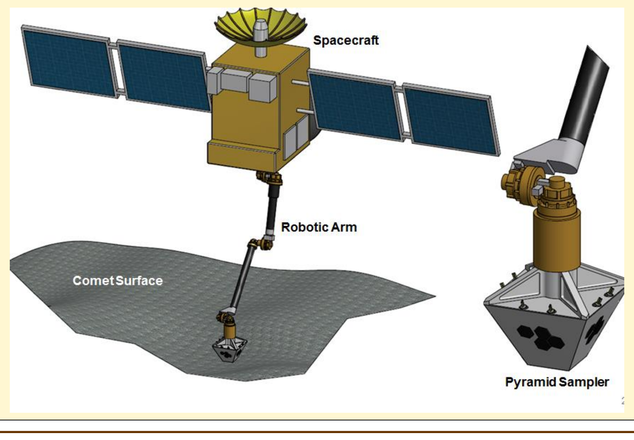
Pyramid Comet Sampler (PyCoS)

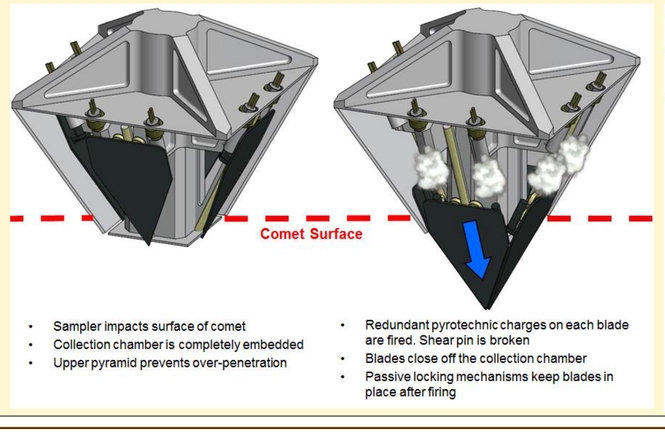
PyCoS is an upside down pyramid at the end of an arm. Once the base touches the comet, the blades pierce the surface trapping the sample inside. The arm pulls the sampler and delivers it to the sample retain capsule on the spacecraft.

- Since the blades penetrate at oblique angles, horizontal forces balance .
- The sampler won't get stuck since the sampler gets progressively smaller with depth.
- The pyramid shape allows angular and axial misalignments during delivery to ERV .
- Can be deployed same way as the sampler on the OSIRIS-Rex → future heritage.









- Sampler impacts surface of comet
- Collection chamber is completely embedded
- Upper pyramid prevents over-penetration
- Redundant pyrotechnic charges on each blade are fired. Shear pin is broken
- Blades close off the collection chamber
- Passive locking mechanisms keep blades in place after firing

- Earth Return Vehicle (ERV) opens
- Robotic Arm places sample collections system into ERV
- ERV closes, encapsulating sample inside