ARM Alternate Mission AR&D Concept of Operations

The **rendezvous phase** starts well beyond 10,000 km when the target asteroid first becomes visible in the narrow field of view (FOV) camera. At this time, the narrow FOV camera and the stellar background provide enough information to determine the relative bearing to the target, which is required to maneuver closer to the asteroid. At some point, a medium FOV camera will also provide usable images of the asteroid at the same time the narrow FOV camera produces detailed images of asteroid surface features that can be used for relative navigation.

Around the same time, the **asteroid characterization phase** begins with a series of flybys of the asteroid, approaching to within 1km of the surface. The objective is to navigate using two cameras—the medium and wide FOV cameras—and using images from the narrow FOV camera to monitor the asteroid spin rate, build a 3D map of the asteroid surface, and perform a detailed survey of potential boulder collection sites that have been previously identified. This phase ends with the spacecraft station keeping about a designated home point approximately 5 km from the asteroid center of mass in the asteroid orbital plane.

The purpose of the **boulder collection phase** is to perform a closed loop descent to the asteroid and grab a large boulder off the surface. Here, the medium and wide FOV camera images are feed into a real-time, onboard algorithm to determine relative position and attitude (or pose) between the spacecraft and the target boulder. Additionally, a 3D LIDAR is brought online at altitudes below 1 km to provide direct range measurements to the boulder, along with 3D range images that are used to compute another onboard pose measurement that is processed by the filter. By using a two-axis gimbal to point the medium FOV camera relative to the wide FOV camera, the medium FOV camera could be slewed to areas along the horizon that are feature rich for pose, while the wide FOV camera provides dedicated images of the boulder collection site.

The final phase of operations is the **gravity tractor phase** where the spacecraft will orbit near the asteroid and use its gravity to alter the orbit of the asteroid. This phase begins by precisely determining the current orbit of the asteroid using measurements from the narrow and wide FOV cameras in conjunction with Deep Space Network measurements of the spacecraft during free drift motion near the asteroid (at ~10 km). Afterwards, the spacecraft enters and maintains a halo orbit about the asteroid velocity vector at a distance of 500-700 m from the asteroid center of mass using measurements from the narrow and medium FOV cameras.