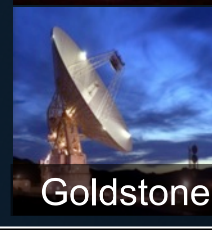
National Aeronautics and Space Administration

Asteroid Redirect Mission Reference Package for NextSTEP BAA

Asteroid Redirect Mission: Three Main Segments

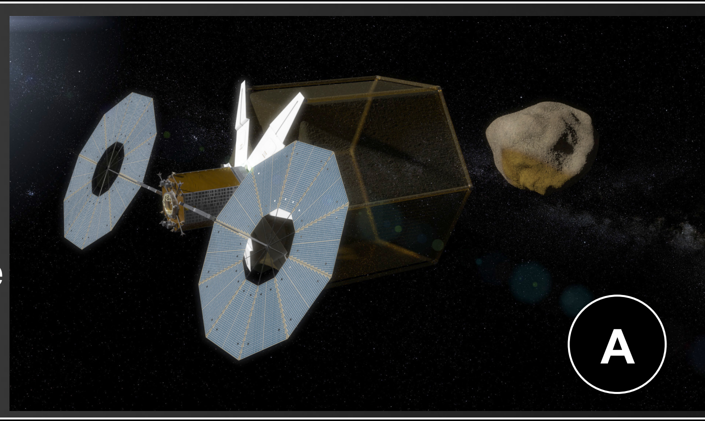
IDENTIFY

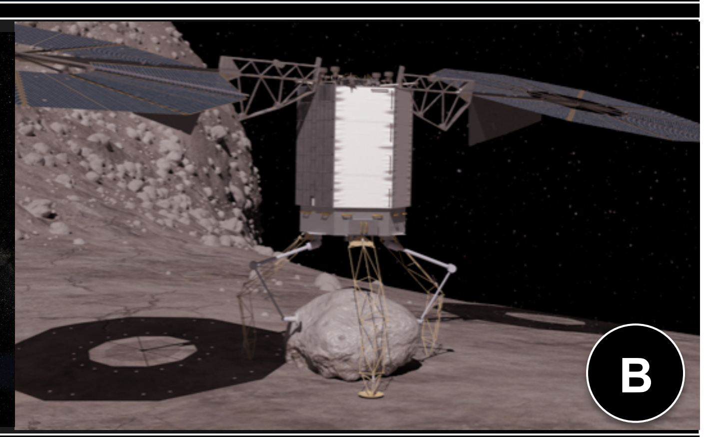
Ground and space based assets detect and characterize potential target asteroids



REDIRECT

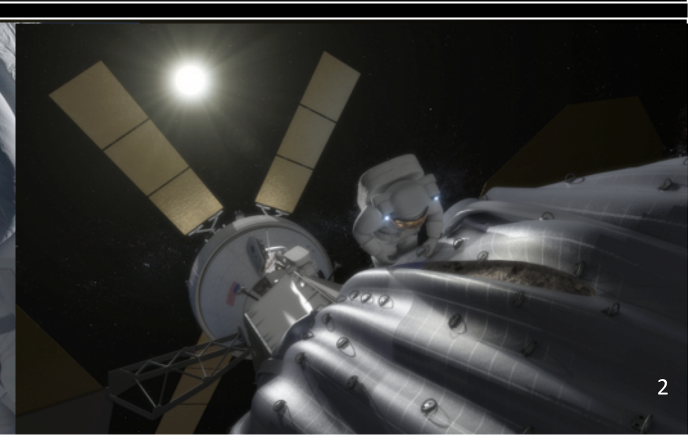
Solar electric propulsion (SEP) based system redirects asteroid to cis-lunar space (two capture options)



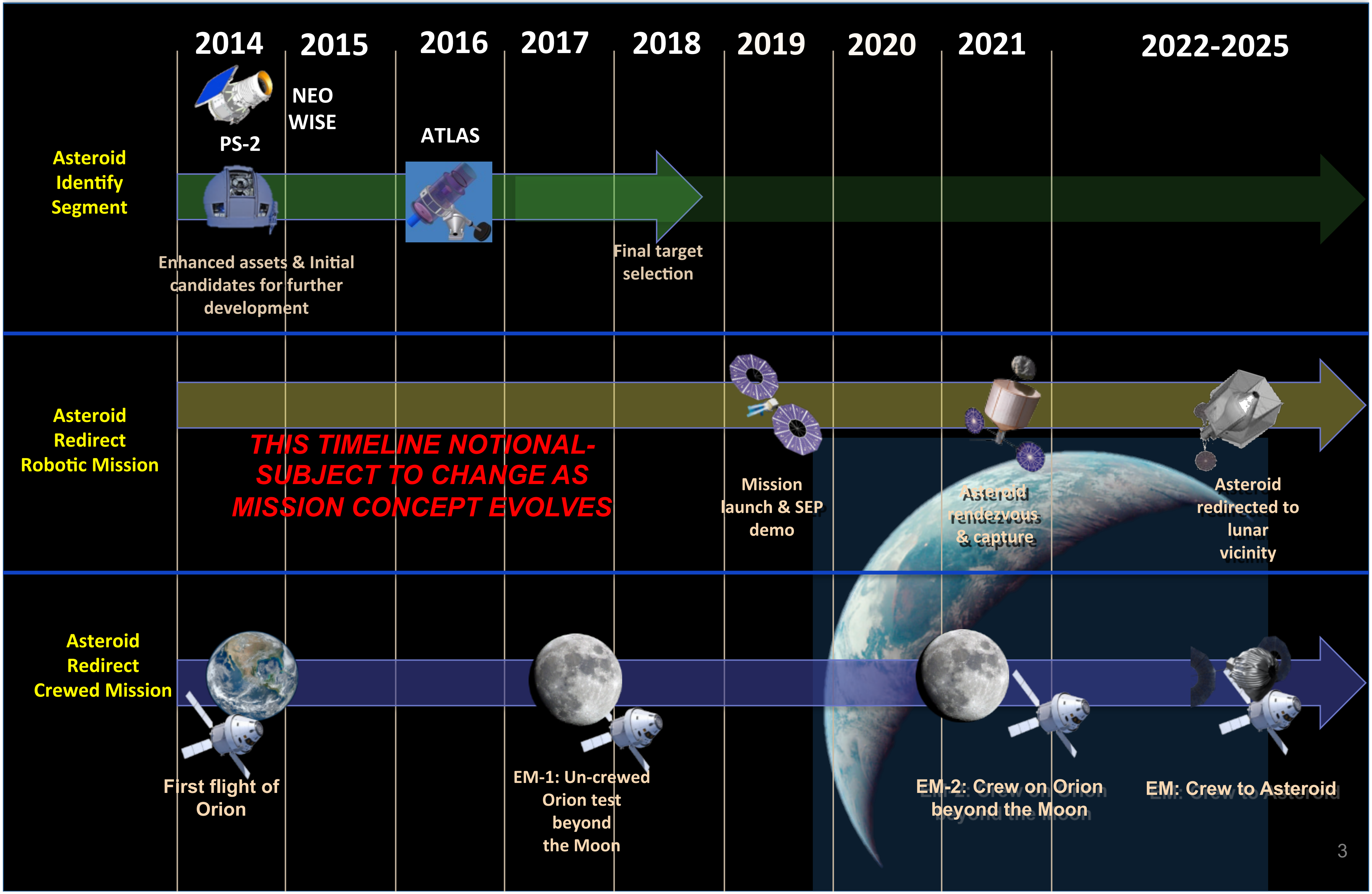


EXPLORE

Crews launches aboard SLS rocket, travels to redirected asteroid in Orion spacecraft to rendezvous with redirected asteroid, studies and returns samples to Earth

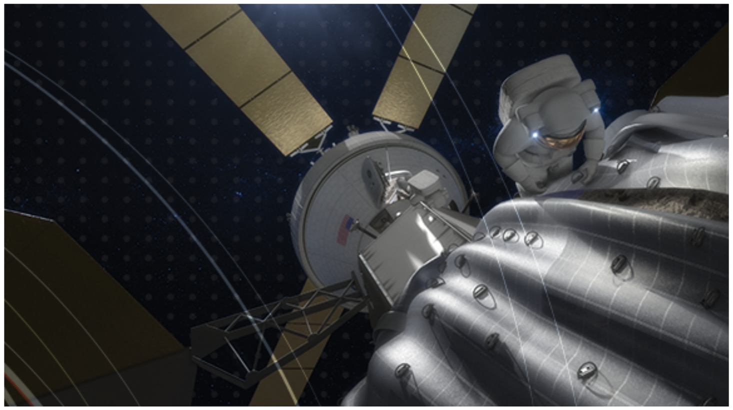


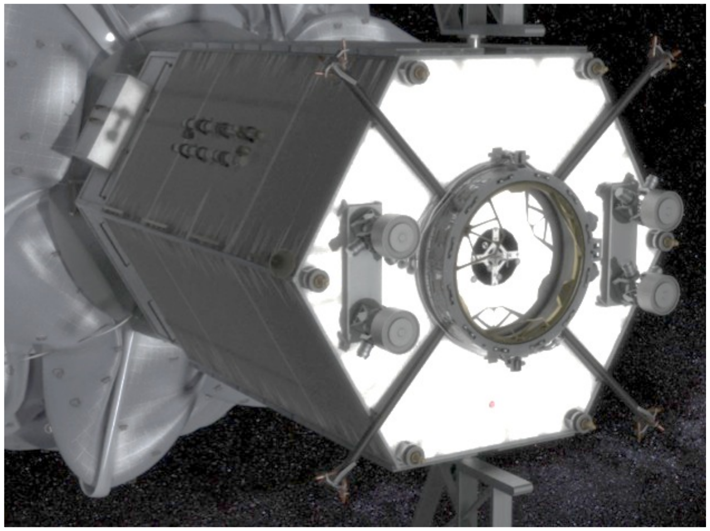
Asteroid Redirect Mission Alignment Strategy



Current Objectives of Asteroid Redirect Mission*

- Conduct a human exploration mission to an asteroid in the mid-2020's, providing systems and operational experience required for human exploration of Mars.
- Demonstrate an advanced solar electric propulsion system, enabling future deep-space human and robotic exploration with applicability to the nation's public and private sector space needs.
- Enhance detection, tracking and characterization of Near Earth Asteroids, enabling an overall strategy to defend our home planet.
- Demonstrate basic planetary defense techniques that will inform impact threat mitigation strategies to defend our home planet.
- Pursue a target of opportunity that benefits scientific and partnership interests, expanding our knowledge of small celestial bodies and enabling the mining of asteroid resources for commercial and exploration needs.

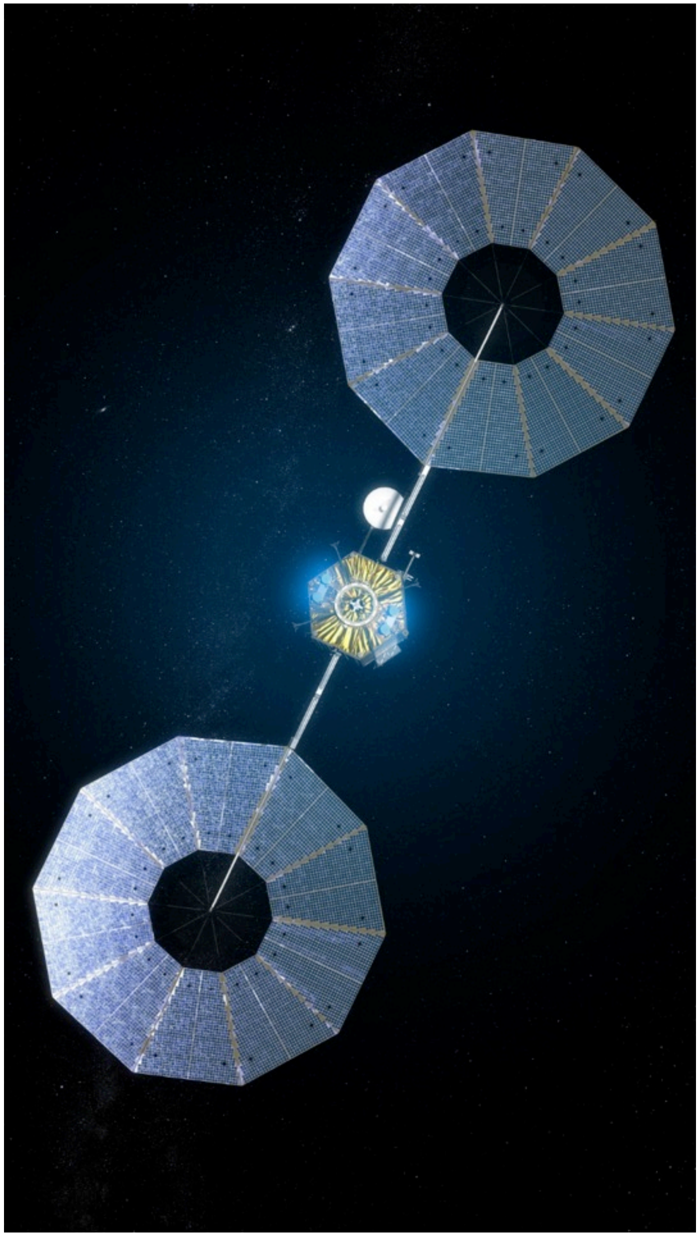




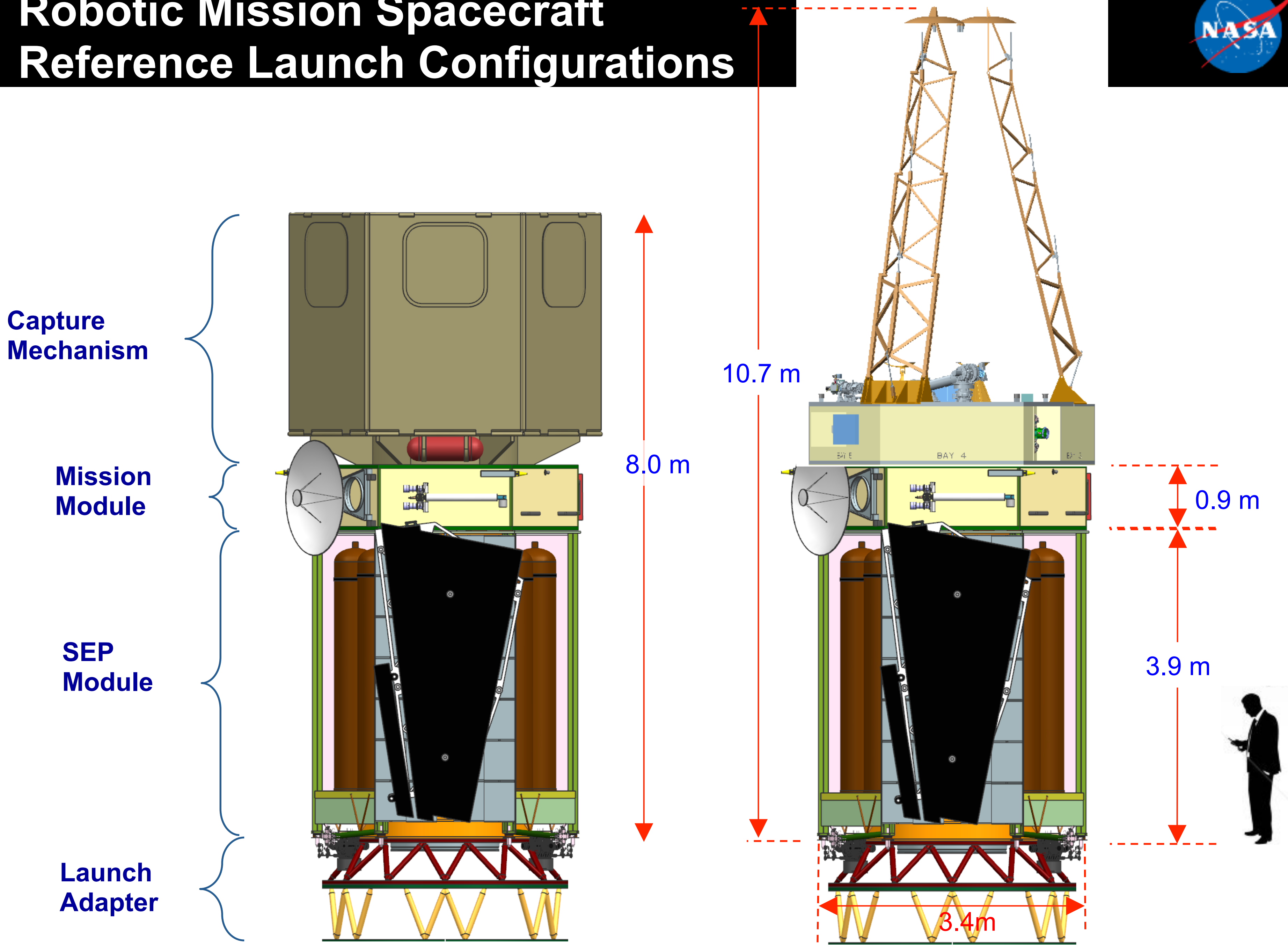
* Mission objectives will be clarified for Phase A (after Mission Concept Review)

Two Options being evaluated for Robotic Asteroid Capture Mission

- **NASA is currently evaluating two options for accomplishing these mission objectives.**
- **Both options utilize a common 40kW class Solar Electric Propulsion Bus to transit from Earth to the target asteroid and return the captured asteroid material to a lunar distant retrograde orbit.**
- **Option A proposes to capture a small 4-10m class whole asteroid.**
- **Option B proposes to capture a 1-5m class boulder off of a larger parent asteroid.**



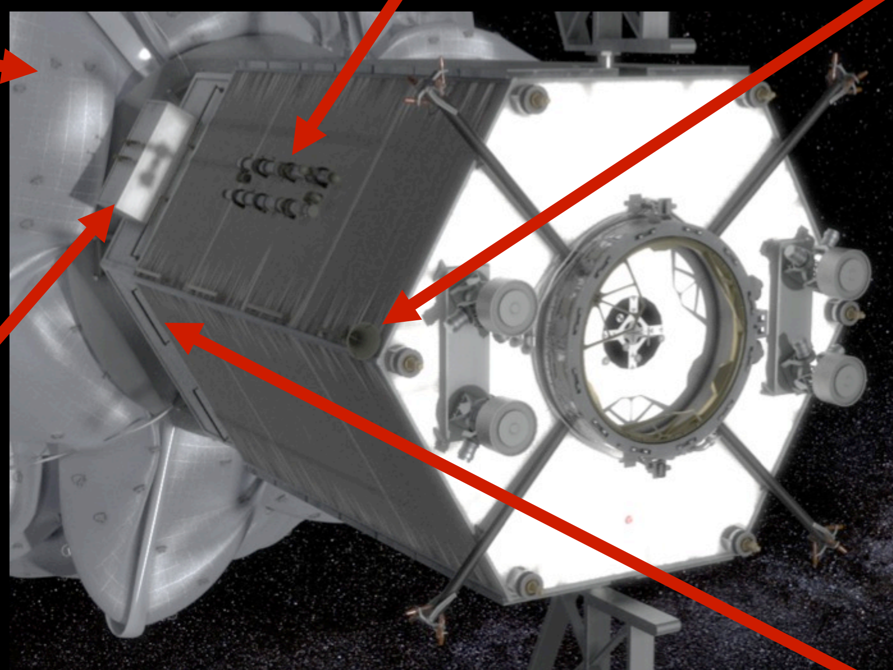
Robotic Mission Spacecraft Reference Launch Configurations



Accommodations for Crewed Mission

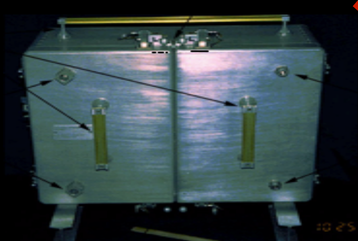
EVA Tether Points
•Hand-over-hand translation
•Temporary tool restraint
•Management of loose fabric folds

Extra Vehicular Activity (EVA) Translation Booms
•Translation Booms for Asteroid EVA



EVA Translation Attach Hardware
•Circumference of Mission Module at base of Capture System and ARV-Orion Interface

Hand Rails
- Translation path to capture bag
- Ring of hand rails near capture bag

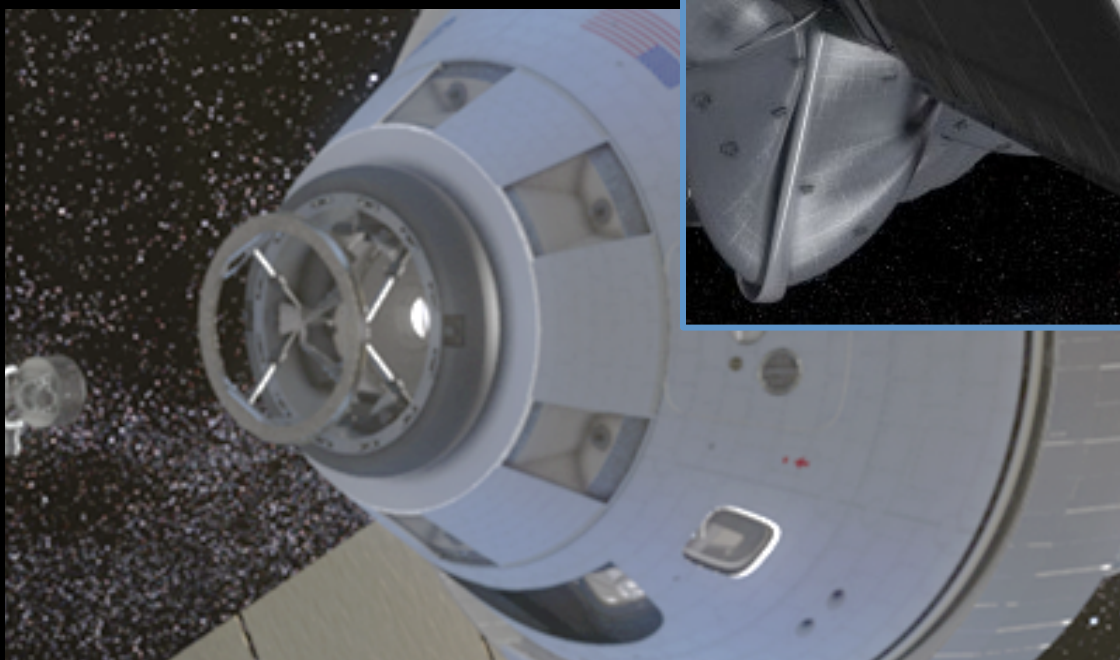


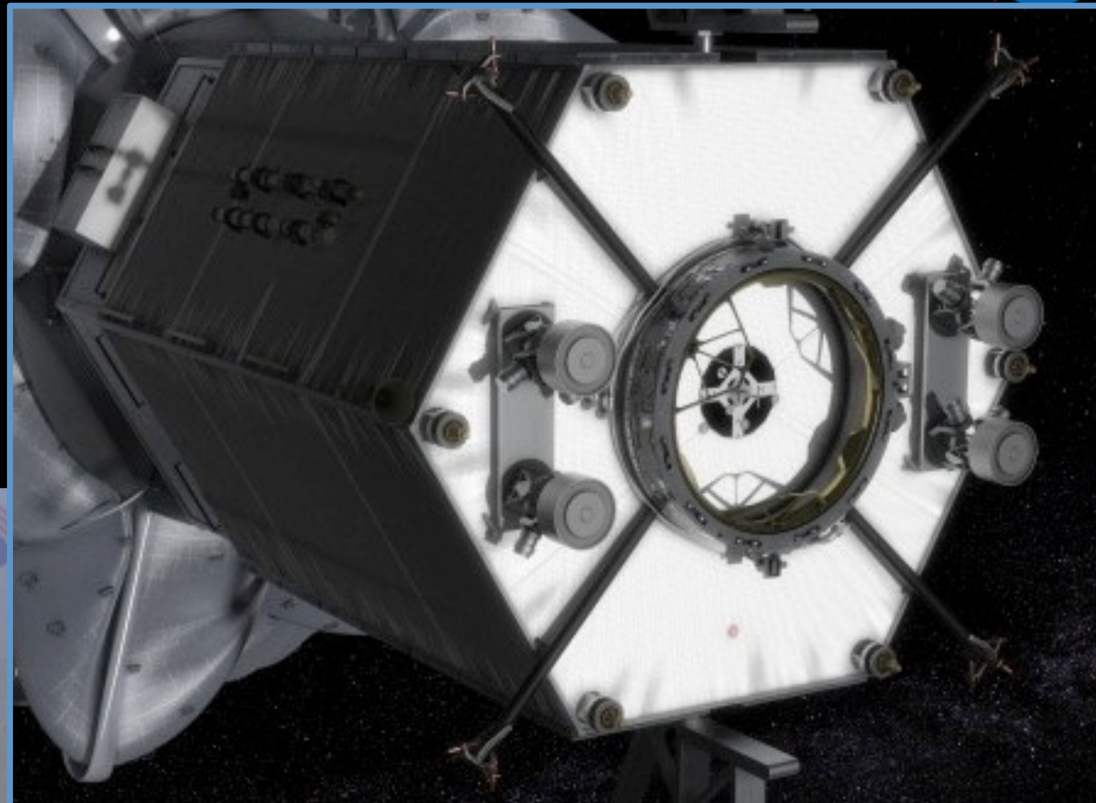
Pre-positioned EVA Tool Box
• Tool box stores 85 kg tools

International Docking System

Utilizing IDSS being developed by ISS for docking Orion to ARV

Active Half of Docking Mechanism





Passive Half of Docking Mechanism

Robotic Segment Forward Plan

- **NASA will downselect between robotic capture mission options A & B in mid December 2014**
  - This is for the Redirect Segment on slide 2

- **NASA will hold Mission Concept Review for the robotic mission in February 2015**

- **NASA has engaged industry and potential international partners in concept studies and potential partnerships for ARM and follow-on crewed missions**
  - cis-lunar proving ground demonstration of exploration objectives
  - developing capabilities for eventual human exploration of Mars

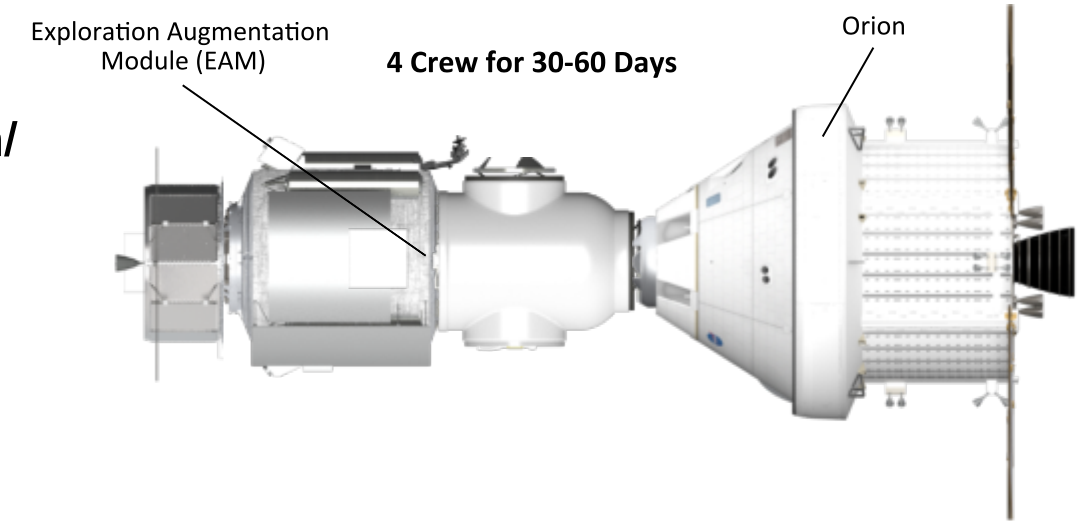
Performance of ARM robotic vehicle in support of Next Steps

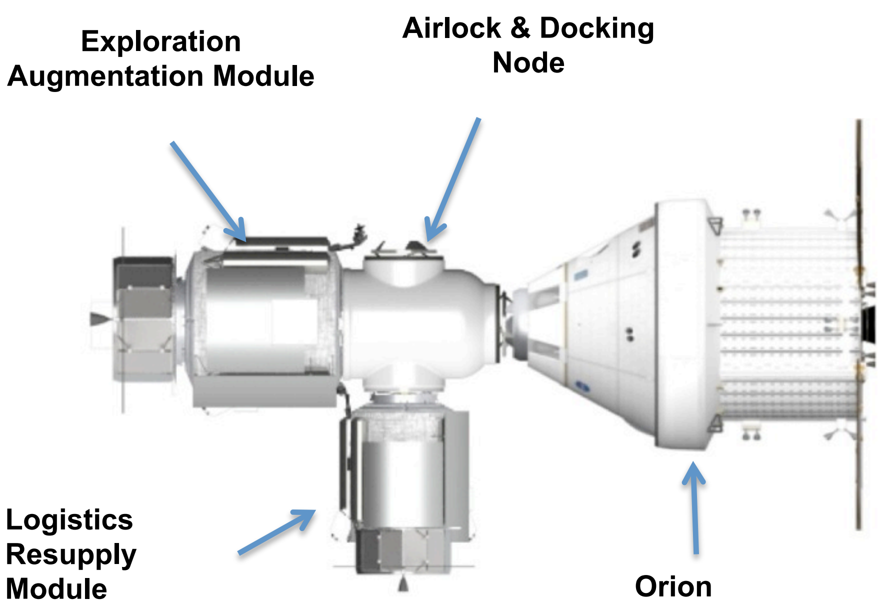
ARM robotic vehicle reference design can provide the following capabilities for docked vehicles:

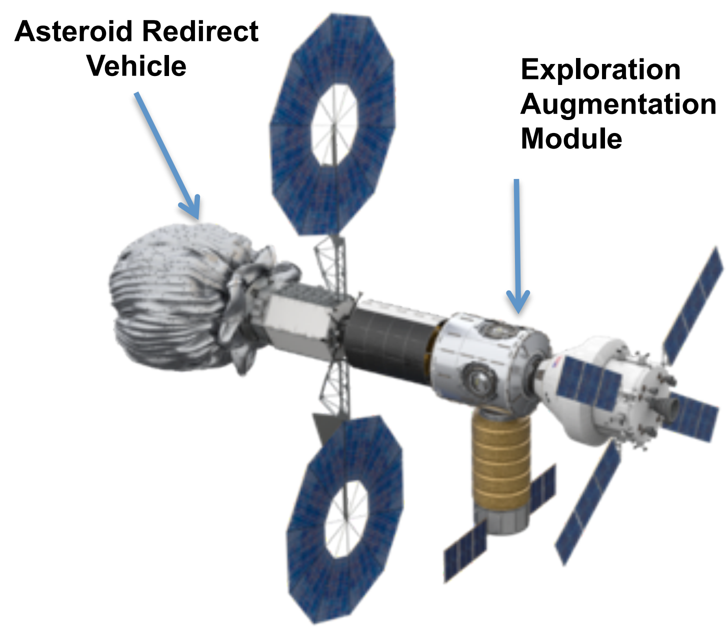
- ~40 kW of power at TBD voltage (currently 300 V unregulated)
- a two way data interface through the FRAM connector for a docked element
- S-Band transponder, useful for approach/docking
- X-Band comm link allowing downlink or uplink of docked element data
- A passive docking mechanism compliant with the International Docking Standard
- Coarse attitude control to maintain power and thermal constraints of the ARV vehicle when Orion is not docked
- Four 13kW Hall thrusters, three of which could be operated in parallel to provide approximately 40kW of SEP at 1 AU, limited by how much xenon propellant is remaining in the tanks
- Various tools for EVA

Near Term Proving Ground Future Mission Candidates

Delivery of Early Habitation/ Exploration Augmentation Module







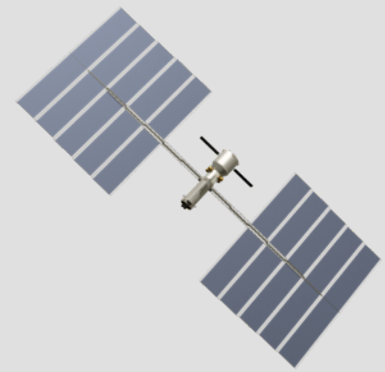
Use of ARM Solar Electric Propulsion

- **Current architecture concepts utilize ARM derived SEP**

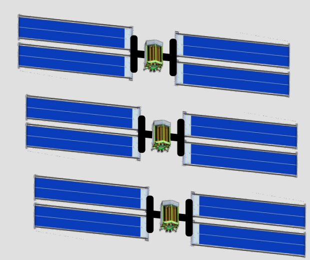
- **Pre-deploy crew mission assets to Mars utilizing high efficient SEP, such as**
  - Orbit habitats: Supports crew while at Mars
  - Return propulsion stages and/or return habitats
  - Exploration equipment: Unique systems required for exploration at Mars.

- **High thrust chemical propulsion for crew**
  - Low-thrust SEP too slow for crew missions
  - Crew travels on faster-transit, minimum energy missions: 1000-day class round-trip (all zero-g)

One Very Large SEP



Multiple ARM derived SEPs (100-250 Kw Class)



Summary

- **Sustainable human exploration can utilize split mission Mars approaches with SEP to pre-position cargo in Mars orbit.**

- **Contributions of ARM to sustainable human exploration include**
  – Pre-position architecture elements using SEP
  – Operate integrated crewed/robotic vehicle stacks in deep space;
  – Validate systems and operations at the surface of low-gravity bodies
  – Advance EVA systems
  – Verify sample selection, handling, and containment procedures critical to future deep-space missions

- **The successful demonstration of these technologies, systems, and operations in the Asteroid Redirect Mission will provide a critical step in NASA's journey towards sustainable human exploration of the solar system.**