National Aeronautics and Space Administration

Trades Affecting Mission Resilience and Extensibility

presentation to the

Asteroid Initiative Idea Synthesis Workshop

NASA's Goddard Space Flight Center

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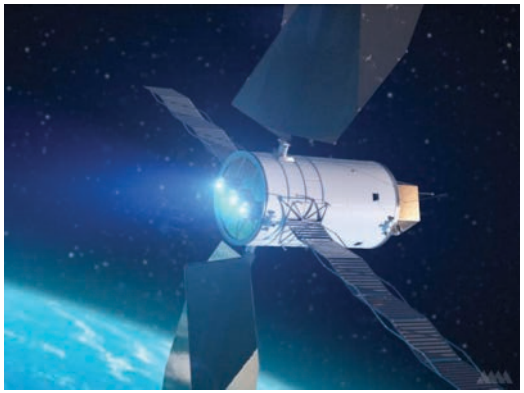
Introduction

- This mission is incredibly difficult
  - This is both good and bad
- Some significant challenges are:
  - Small targets are hard to find and characterize
  - Capture technologies difficult to prove on the ground
  - Mass, mass, mass
  - Signal latency due to target location
  - Tumbling complications
  - Short schedule
  - Limited EVA time

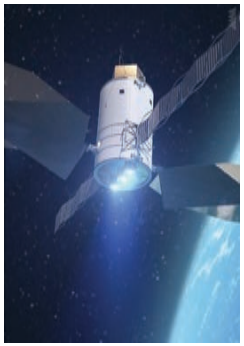


Driving Trades to Consider

- Monolithic vs. modular vehicles
- Optimized vs. generic capture techniques
- Large array/existing cells vs. smaller array/high-performance cells

…and, by the way, make the solution extensible for the future.

Monolithic vs. Modular Vehicles



Monolithic

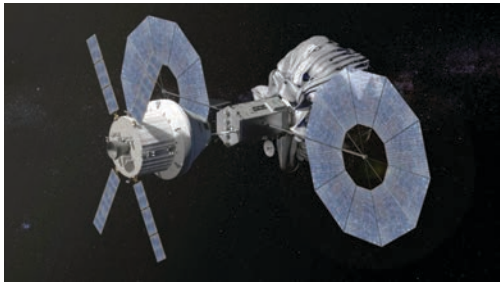
Modular

	Pro	Con
Monolithic	• Structure optimized per mission • One set of avionics	• Not repurposeable • Integration and test serial, not parallel • Vehicle movements limited by load imparted on solar arrays structure (maximum of 0.1g)
Modular	• Repurposeable, refuelable • Parallel integration and test • One-off for extended architecture • Capture vehicle is small and nimble • Capture vehicle could be made available to commercial partners	• Mass penalty for intervehicle interfaces • 1.8 sets of avionics

Optimized vs. Generic Capture Techniques

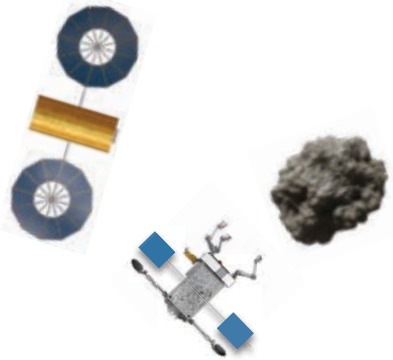
	Pro	Con
Optimized	• Resources devoted to development of single technique	• If target is outside bounds of capability, then it's a bad day – Shape – Spin – Composition
Generic	• Wider range of targets retrievable • Multiple techniques • Can be used to aid EVA phase • Ability to perform science activities (asteroid material analysis) during long duration burns (several years) • Ability to obtain a second asteroid	• Potential mass penalty • Potential cost penalty

Large Array/Existing Cells vs. Smaller Array/High Performance Cells

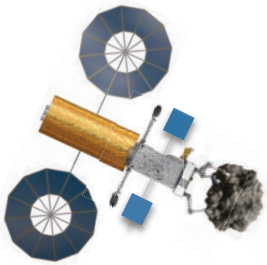


	Pro	Con
Large Array/ Existing Cells	• Existing cell technology yields lower cost per cell • Leverages NASA investment in this technology	• Deployment of arrays is difficult • Long bending moment • Very low first frequency mode
Smaller Array/ High-Performance Cells	• Deployable array size within heritage • Shorter moment of inertia • Higher first frequency mode	• Higher unit cost per cell • New technology effort

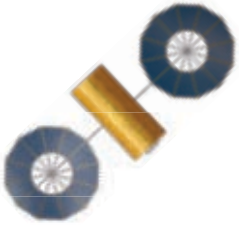
Proposed Architecture



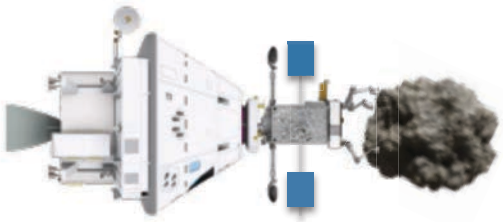
Cooperative Remate



Cruise to DRLO

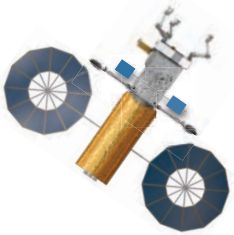


SEP Tug demate followed by Orion cooperative mate



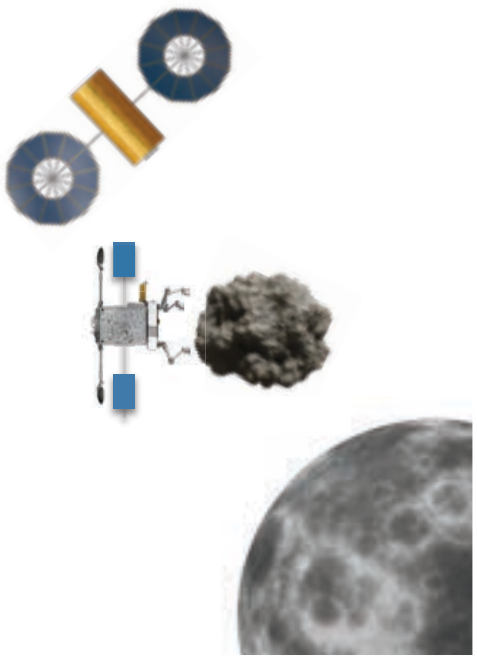
Robotic arms assist EVA

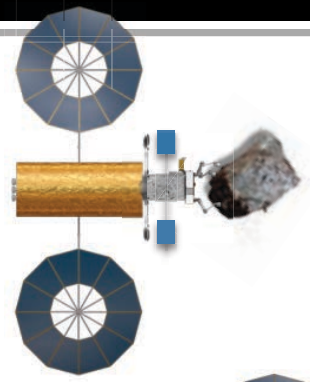
Separation prior to rendezvous



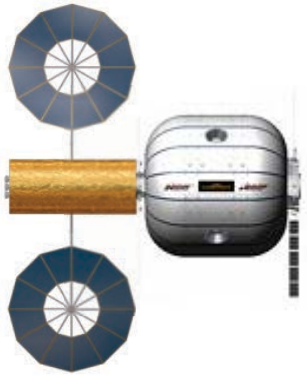
Launch

Options Following Nominal Mission

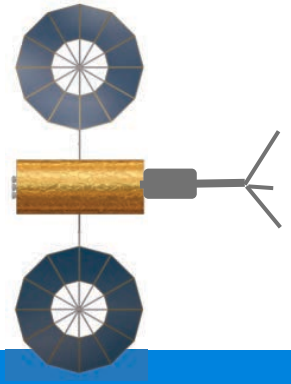




Option 1: Capture and transfer another asteroid



Option 2: SEP Tug is used for future HEOMD mission



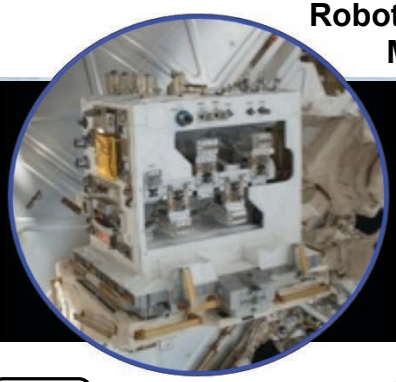
Option 3: Provide SEP Tug to commercial partner

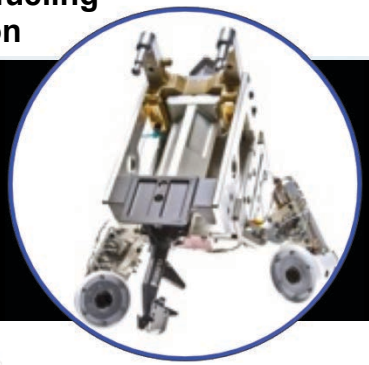
Leveraging ARM assets for exploration extensibility.

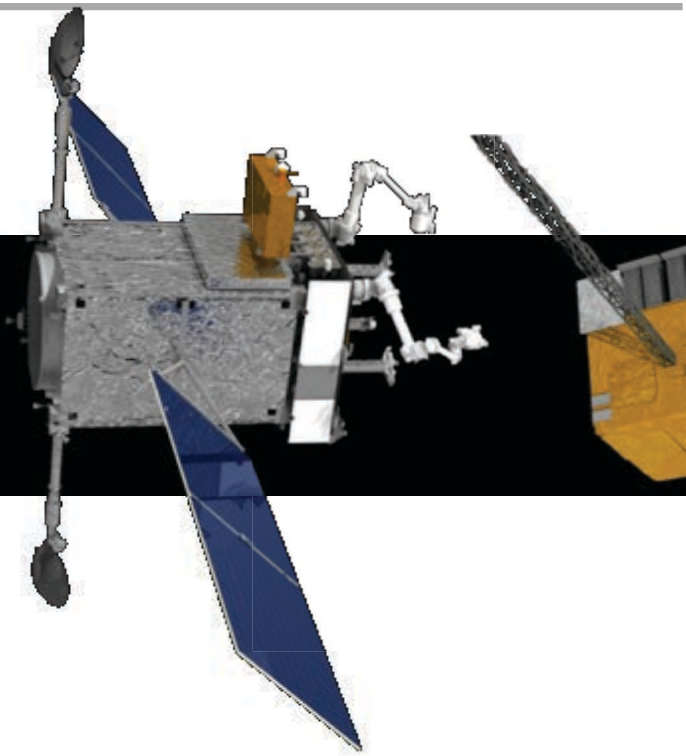
Present-day Activities Leading to Servicing Capabilities

IN SPACE

Robotic Refueling Mission





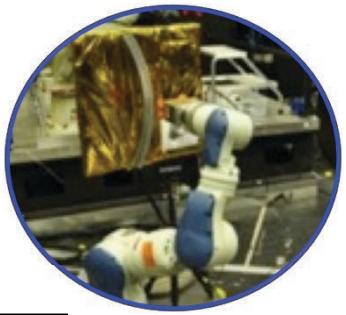


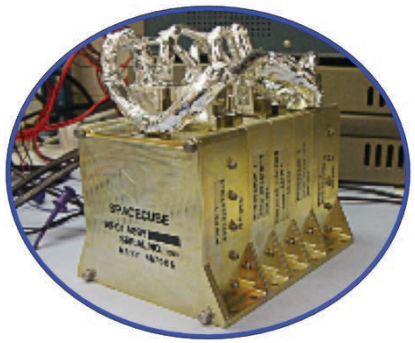
Fluid Transfer

Advanced Robotic Tools

ON GROUND

Argon





AR&D Sensors & Algorithms

Dexterous Robotics

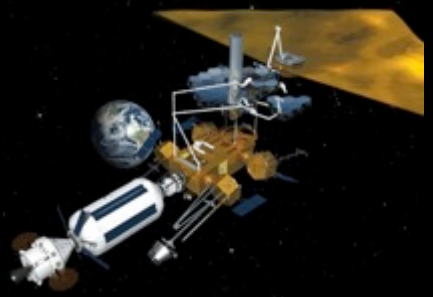
High-speed, Fault-tolerant Computing

Servicing Capabilities Are Extensible to Exploration Goals

Human Exploration

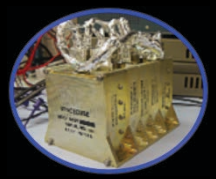
Commercial Fleet Management

Observatory Servicing



On-orbit Assembly

Asteroid Missions



Propellant Depot

Orbital Debris Mitigation and Remediation