

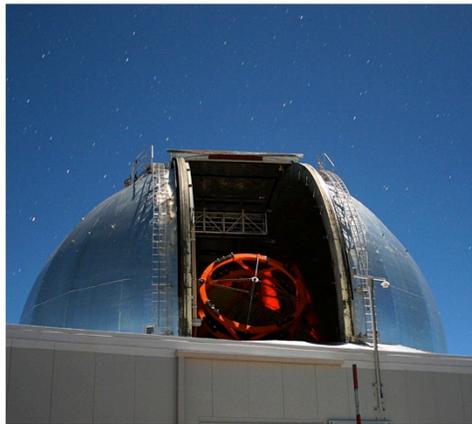
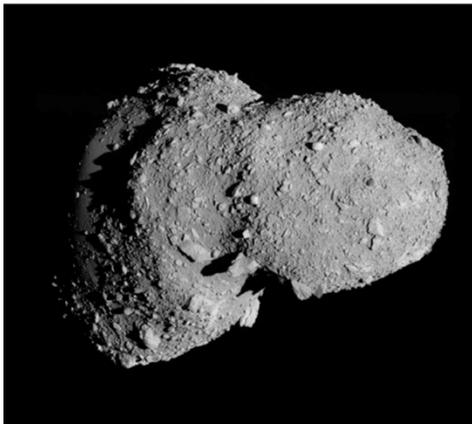
National Aeronautics and Space Administration



Asteroid Initiative Idea Synthesis

Asteroid Capture Systems

Jasen Raboin, Andre Sylvester

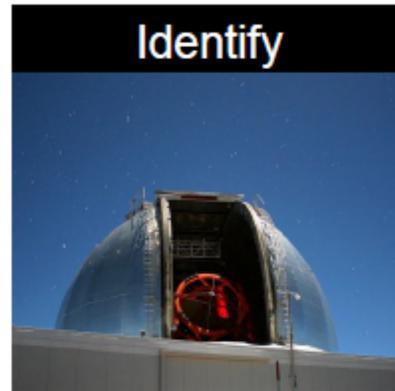


Join the discussion and send questions to: [#CatchAsteroid](#)

Purpose of Capture Systems Session



- Three Main Mission Segments



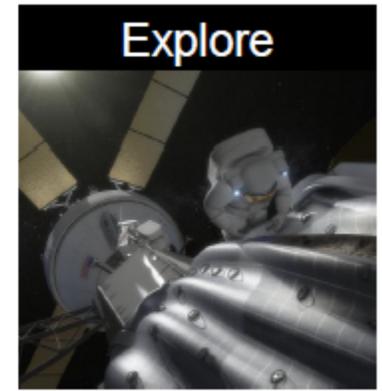
Identify

Asteroid Identification



Redirect

Asteroid Robotic Redirection Mission

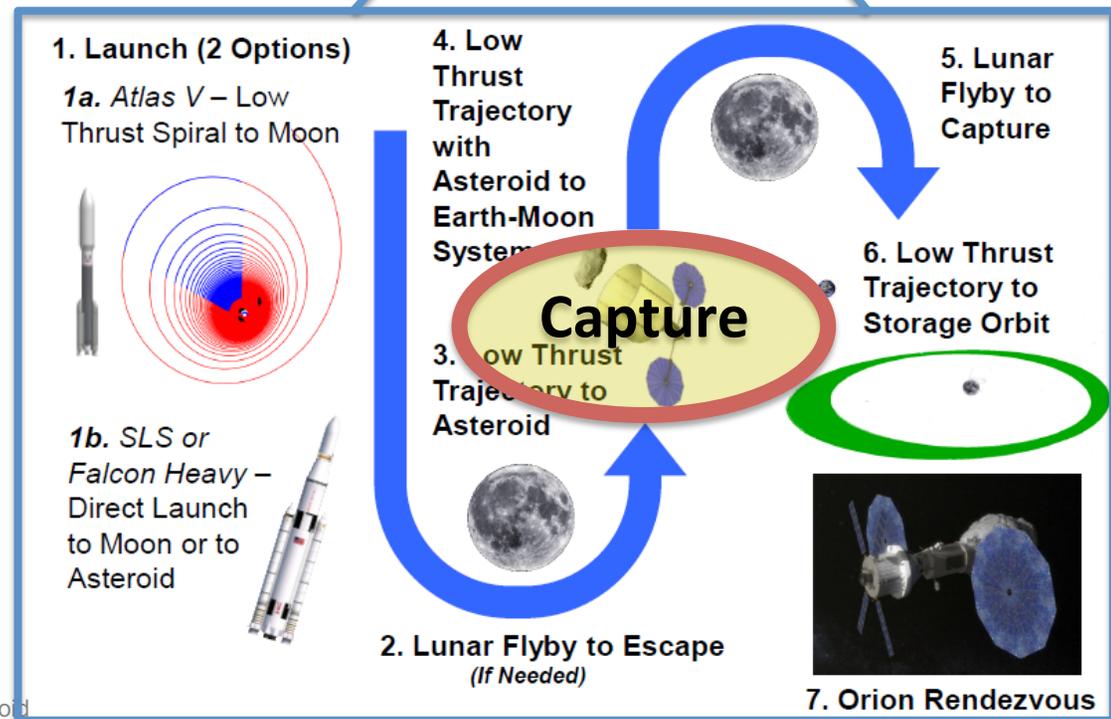


Explore

Asteroid Redirect Crewed Mission

- Focus on Redirect Segment

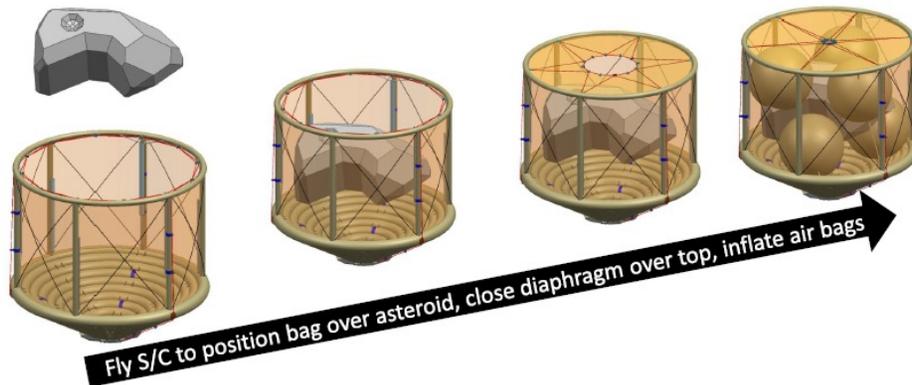
- Specifically Capture Phase



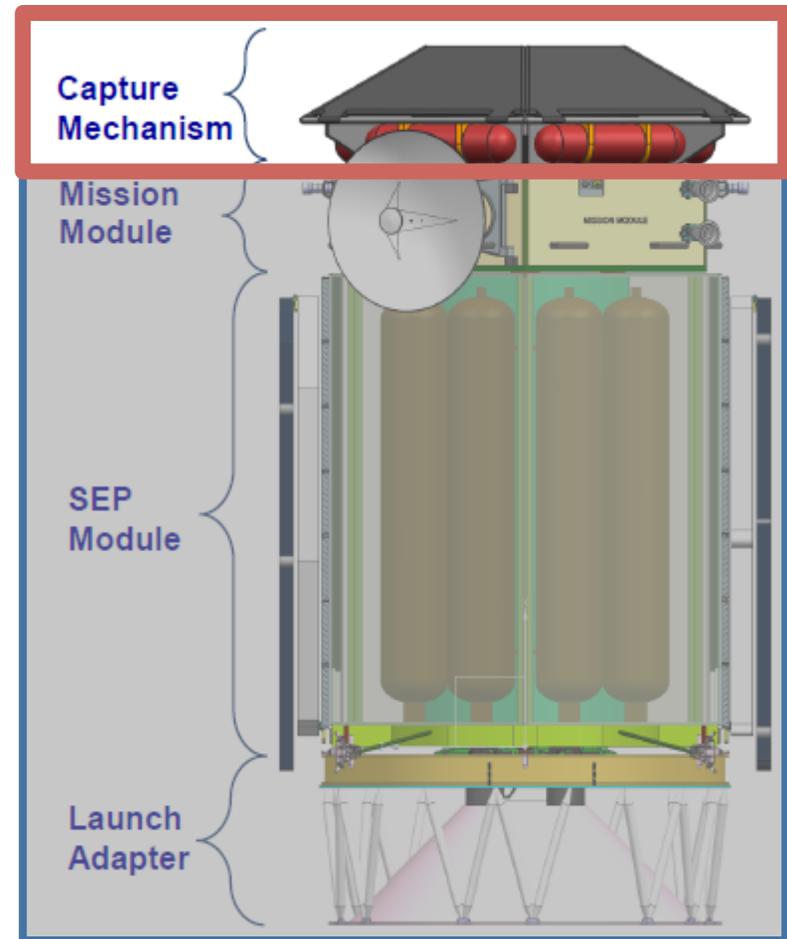
Purpose of Capture Systems Session



- Transparently explore highest rated responses related to the capture mechanism to provide input for NASA planning



Reference Capture Mechanism & Sequence



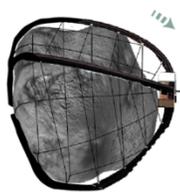
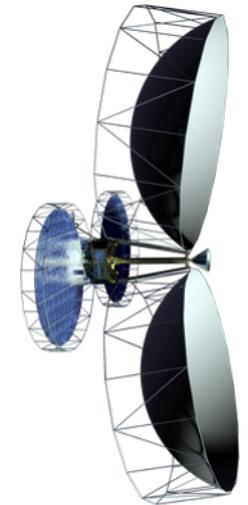
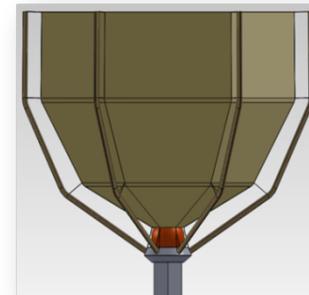
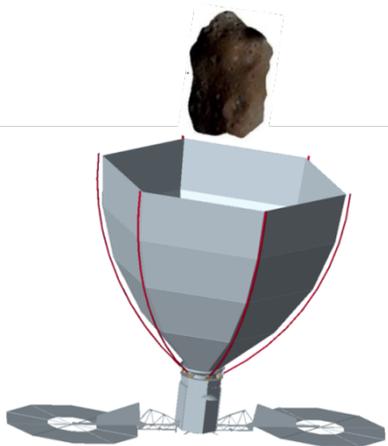
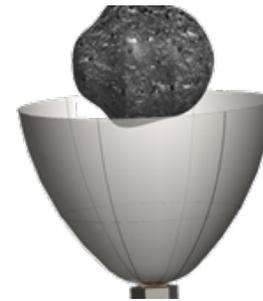
ARV Flight System Concept

Selecting RFIs for Presentation

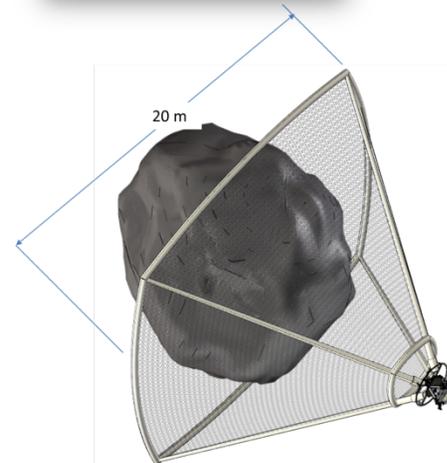


- **Each Capture System RFI submission was ranked against:**
 - Factor 1: Relevance to RFI objectives.
 - Factor 2: Impact. Does the idea have the potential to make a major impact in ensuring mission success?
 - Factor 3: Maturity. Is the concept or technology sufficiently mature that it can be incorporated into mission plans?
 - Factor 4: Affordability. Does the concept or technology have the potential to significantly improve mission affordability?
- **Two reviewers read each RFI, then assigned a 1-5 rating for each factor. Each rating was discussed in a review team meeting for potential inclusion in this workshop.**
- **RFI's with an average rating between 4 and 5 were invited to the workshop.**

Numerous Concepts Presented



⑦ Tether Deployment Drains Angular Momentum From Asteroid



Findings Relevant to Asteroid Redirect Mission



• Findings Relevant to the Mission

- Summary of the most promising ideas, including their innovativeness and potential for improving mission/system performance and affordability.
- Of the ideas presented, which achieve reduction of spinning/nutation of asteroid with minimal mass and structure?
 - Tether concepts are the most innovative approach for improving missions/system performance and affordability
 - Inflatable concepts have more mature ground system performance but less maturity for in-space use
 - Deployable structures/robotics concepts provide potentially greater control authority, more discussion is needed on mass requirements

Findings Relevant to Asteroid Redirect Mission



• Findings Relevant to the Mission

- Any technology development needed to mature the ideas to the point where they can be incorporated into system designs.
 - Tether systems need to be flight tested in LEO prior to use for asteroid missions. In addition, the implementation options for attaching the tether to the asteroid need further definition
 - Inflatable systems maturity would be enhanced with flight test in LEO to mature system concepts
 - Deployable structures and robotics concepts can explore implementation options for mass reduction

Findings Relevant to Asteroid Redirect Mission



• Findings Relevant to the Mission

- Relationships or linkages between the ideas that could help with mission/system concept integration.
 - Tether based free flyer could be combined with inflatable system for reduction in spin rate followed by capture and securing of asteroid
 - Anchoring systems concepts could be combined with tether based free flyers

Findings Relevant to Asteroid Redirect Mission



• Findings Relevant to the Mission

– Further studies or next steps

- Conduct trade between deployable booms and inflatable beams with respect to the reference concept. Evaluate metrics such as; mass & complexity of system, launch packaging, de-tumble loads & dynamics, retraction/restraint of asteroid against spacecraft, etc...
- In order to reduce the perceived risk of damaging large arrays/ antennas on the spacecraft during the de-tumble event:
 - Conduct study to investigate cost effective ways to pre-condition (de-tumble) asteroid, prior to capture, to make it a more cooperative target. Consider tethers, as a means of momentum transfer, in the study.
 - Conduct study to investigate ways to make the spacecraft more robust against the de-tumble event. Consider retractable arrays in the study.

Backup



Session Agenda



Time (CDT)	Topic	Speaker
8:00-8:05	Welcome	ANDRE SYLVESTER NASA Johnson Space Center
8:05-8:15	Background on Asteroid Capture Mission	BRIAN WILCOX NASA Jet Propulsion Lab
8:15-8:30	Asteroid research and modeling to improve understanding of small asteroid properties.	DANIEL SCHEERES Univ. Colorado Boulder
8:30-8:45	Anchoring system, lasso snare capture system	ERIK MUMM Honeybee Robotics
8:45-9:00	Two concepts for deployable capture bag using integral ribs or expanding hoops and telescoping booms.	KENNETH STEELE ATK Space Systems
9:00-9:15	Extendable/Retractable Boom Capture System	SCOTT BELBIN NASA Langley Research Center
9:15-9:30	Use under-actuated linkages for robotic grasping of asteroid	PAUL FULFORD MDA Canada

Session Agenda



Time (CDT)	Topic	Speaker
9:30-9:45	Assessment of alternative capture system concepts	CARLOS ENRIQUEZ Boeing
9:45-10:00	Momentum exchange tether to de-spin asteroid	HAROLD GERRISH MSFC
10:00-10:15	Nanosat deploys net to capture asteroid, then deploys multi-kilometer long tether to de-spin asteroid	JEFF SLOSTAD Tethers Unlimited
10:15-10:30	Airbeam inflatable tubes deploy capture bag	ALLEN LOWRY Airborne Systems
10:30-10:45	Asteroid redirection vehicle with solar electric propulsion and AstroMesh-based capture mechanism	HOWARD ELLER Northrop Grumman
10:45-11:55	Group Discussion	
11:55-12:00	Wrap Up	ANDRE SYLVESTER NASA Johnson Space Center