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
- 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

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

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