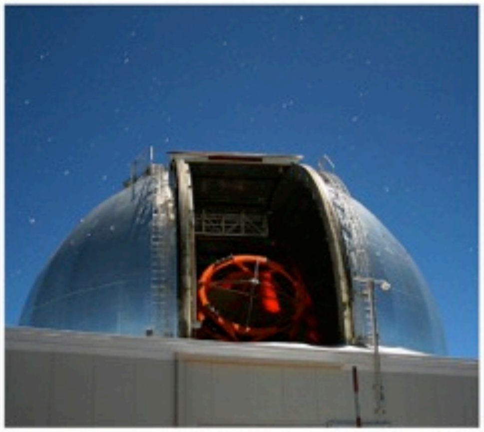
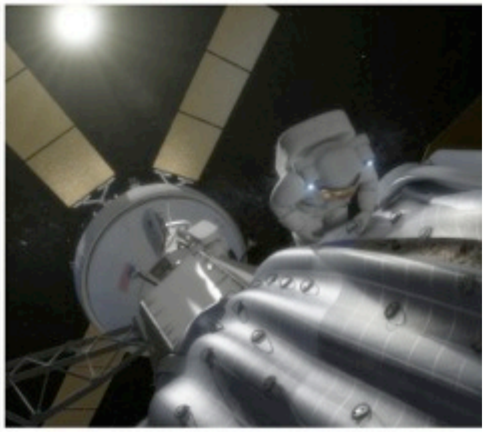
National Aeronautics and Space Administration

Asteroid Initiative Idea Synthesis

CREW SYSTEMS FOR ASTEROID EXPLORATION

Steve Stich, Mark McDonald



Join the discussion and send questions to: #NASAasteroid

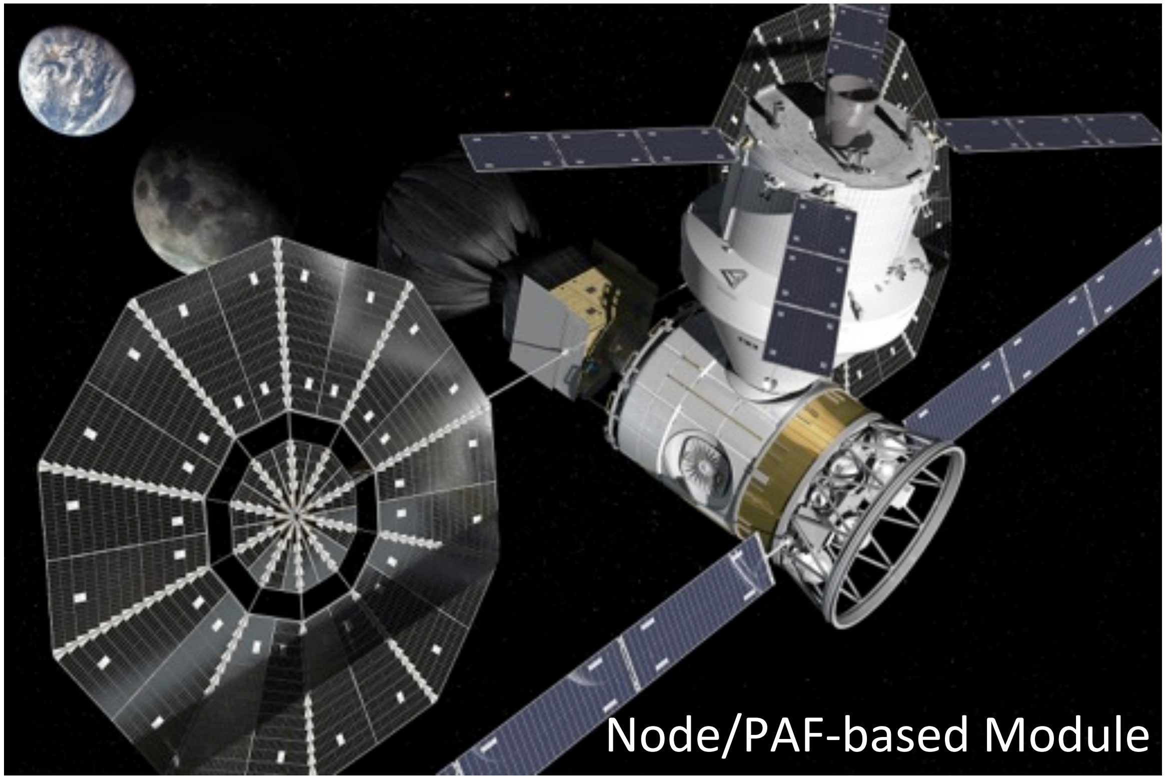
RFI Selection Process

- Our panel of experts carefully reviewed 22 RFI's in the area of Crew Systems and Extensibility.
- Proposals were selected based on:
  - Merit for the mission
  - Extensibility towards next missions (Lunar, Deep Space, and towards Mars)
  - Design maturity
  - Applicability towards mission guidelines
- Consolidated into 13 presentation/discussions representing industry, NASA, international, and academia.

Key Discussion Areas

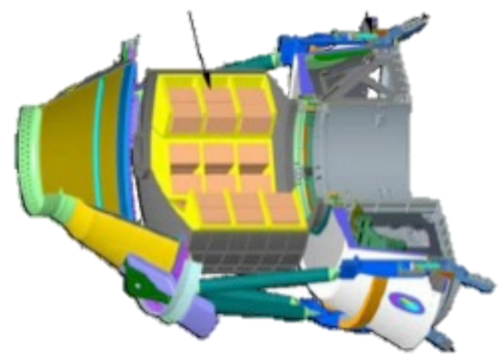
1. Extensibility for Exploration (Boeing, Lockheed, MDA, Oceaneering Space Systems)
2. Anchor Technique Trades (Honeybee, JPL, GSFC, Univ. Maryland)
3. Translation and EVA Tools Trades (JPL, Honeybee, MDA, Univ. Maryland, KSC, ATK, SSL, GSFC)

1. Extensibility-Workshop Ideas



- The use of an "exploration module" allows for longer missions with increased capabilities for new functions.
- Can also serve as abort location.
- Enables Mars extensibility.

- Upfront design considerations for hardware flexibility are crucial for efficiency of development.



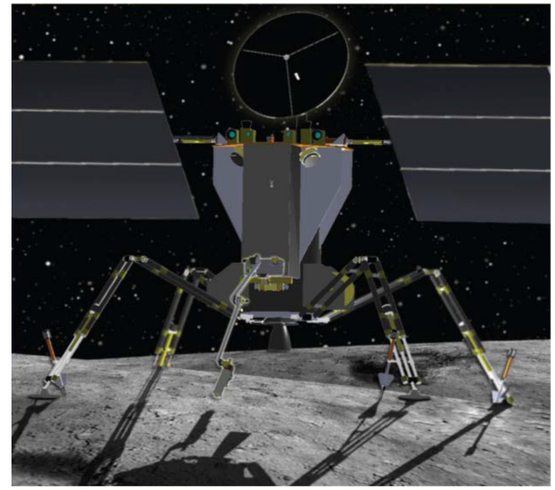
- Concept for external stowage (pantry) on Orion.

1. Extensibility

- Adding capability early into ARV can reduce requirements on Orion and future missions.
- Numerous robotic concepts were presented to compliment EVA capabilities.
- Balance of safety, flexibility, performance, and cost
- Designing for servicing and serviceability
- Affordability likely to be the key driver in the initial path forward

2. Anchor Techniques – Workshop Ideas

- Innovative suite of ideas were discussed for anchoring techniques, both for vehicle, as well as for crew and tools.
  - Extended the breadth of concepts on how to anchor to the surface of an asteroid.
- Upcoming robotic missions to asteroids will help community further understand Asteroid composition.
- Gaining a better understanding of the composition as well as characterizing a target asteroid (or an asteroid population) will drive the selection of techniques used for anchoring and sample acquisition



2. Anchor Techniques

- Ground studies and testing will be needed to evaluate concepts as well as extending techniques to the ISS as a platform.

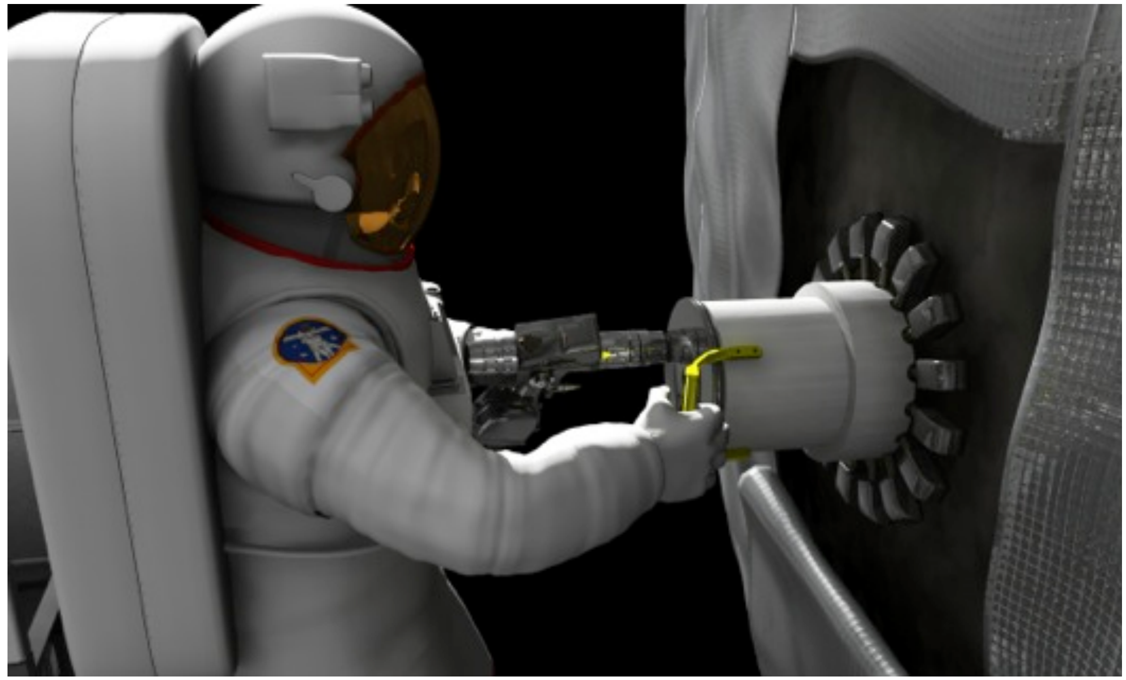
- NASA continues to develop EVA concepts and will utilize testing in various labs such as the Neutral Buoyancy Laboratory (NBL) to improve our understanding of the integrated system of mobility suits and tools.

- Robotic anchoring techniques have commonality and cross-application to crew tools, such as drilling.

3. Translation and EVA Tools

- Nature of the asteroid will be unknown, requiring flexibility and wide range of tools and techniques.

- Session discussed the various tasks; capture of rock, anchoring, surface sampling, drilling, sample storage.

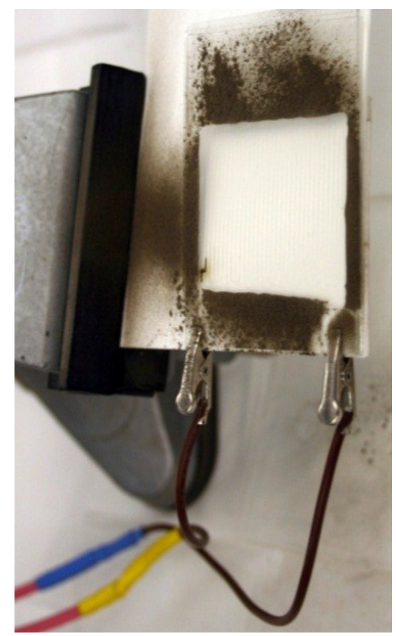


- Broad range of ideas and techniques which will allow the community to move forward and further refine the mission design, EVA techniques, and crew training.

- Broad agreement that we must leverage previous experience and flight proven design to expedite development, increase reliability, and reduce risk.

3. Translation and EVA Tools

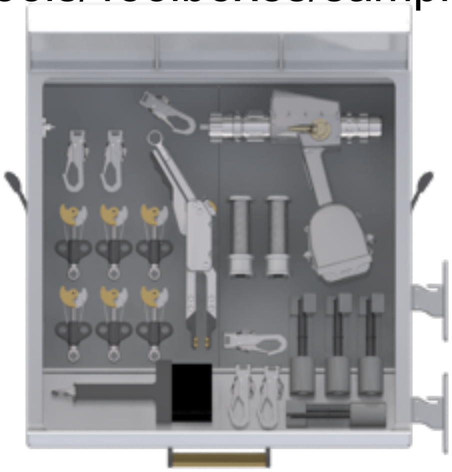
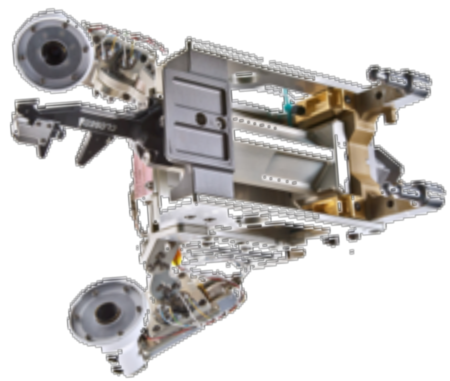
- Remote sensing techniques along with traditional concepts could provide insight and help address uncertainties about an asteroid surface and material composition.
- Worksite preparation, including the interface between tools and crew will need to be further explored.



- The Neutral Buoyancy Laboratory (NBL) is an important asset to test capabilities in a relevant environment.
  - Crucial to better understanding the function of tools, translation, and operations around the asteroid.
- Contamination of the EVA suit will be a challenging issue, as we learned from our lunar missions.
  - Tools that can be used with (or in) the suit will have to be designed to address these issues.

2. Translation and EVA Tools

Tools/Toolboxes/sample containers

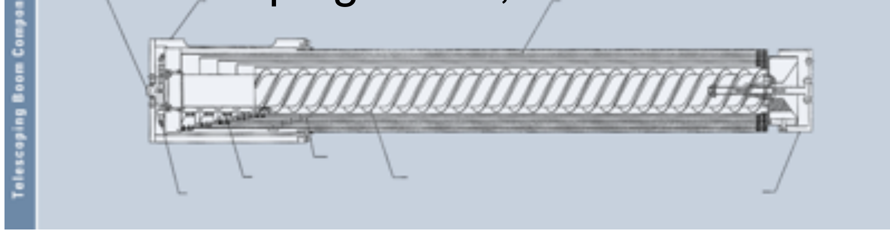





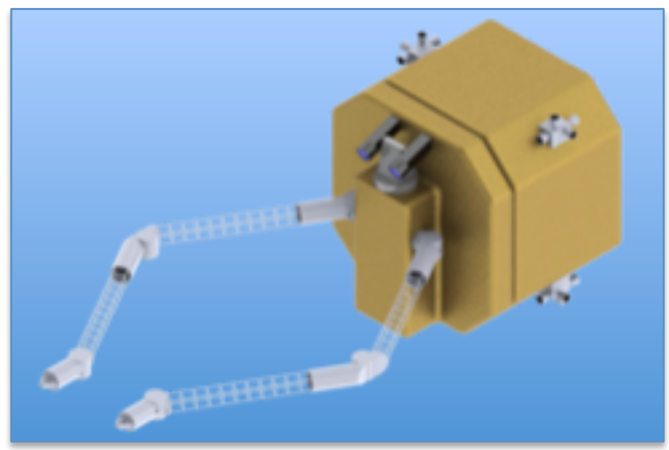
2. Translation and EVA Tools

Properly designed robotic tools such as arms can augment EVA crew member efficiency

- Telescoping Boom, translation aids



- Concept for Crew Mobility

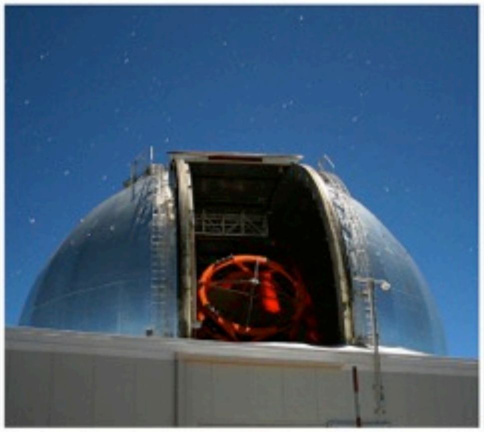


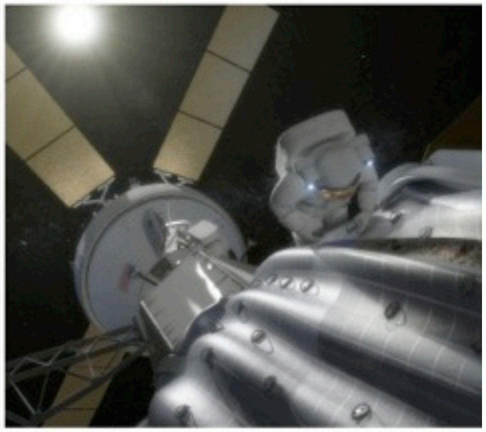
- Existing robotic arm developments from Canadarm2, Dextre, Shuttle, and DARPA FREND.

Crew Systems Session Recommendations

- The following items will be explored in more detail as part of the near term study:
  - Asteroid Exploration Module concept is enabling for extended duration missions in cis-lunar space and Mars.
  - Self-anchoring microspline drill as EVA tool concepts are matured.
  - Electrodynamic dust shield testing on EVA materials as a potential mitigation to dust.
  - Telecolescoping booms to provide access to a broader area of the asteroid
  - Wider suite of EVA tools in FY14 NBL runs
- Other robotic enhancements might be applicable in follow on missions as the overall cis-lunar space exploration strategy evolves

BACKUP



Asteroid Crewed Systems Session Agenda

Time (CST)	Topic	Speaker
1:30 p.m.	Introduction	Steve Stich- JSC
1:35 p.m.	Asteroid Exploration Module with airlock and docking ports to augment Orion capabilities	Michael Raftery Boeing
1:51 p.m.	Orion mission kit consisting of pantry module and robotic arm.	Douglas Ross Lockheed Martin
2:07 p.m.	Anchoring, sample acquisition, and ISRU approaches for asteroids	Jonathan Wrobel Honeybee Robotics
2:14 p.m.	Anchoring and sample collection devices	Jonathan Wrobel Honeybee Robotics
2:23 p.m.	Self-anchoring microgravity drill for use by crew to sample asteroid	Aaron Parness NASA Jet Propulsion Lab
2:30 p.m.	Mobile robot with microspline anchors	Aaron Parness NASA Jet Propulsion Lab
2:39 p.m.	Robotic manipulators, EVA tools, and human-robotic collaborative systems	Paul Fulford MDA Canada
2:50 p.m.	Free-flying camera for asteroid inspection; tether system to anchor crew; space utility vehicle for EVA	Dave Akin University of Maryland
3:01 p.m.	Electrodynamic dust shield, pneumatic regolith rake, percussive excavation shovel	Rob Mueller NASA Kennedy Space Center

Asteroid Crewed Systems Session Agenda (cont)

Time (CST)	Topic	Speaker
3:12 p.m.	Telescoping booms for astronaut translation and EVA tools	Doyle Towles ATK Space Systems
3:23 p.m.	ARV with robotic manipulators can be used to berth spacecraft with Orion and assist the crew during EVA	John Lymer Space Systems/Loral
3:34 p.m.	Oceaneering EVA suit and tool concepts.	Frank Eichstadt Oceaneering Space Systems
3:45 p.m.	EVA systems, robotic systems, and simulation and training	Ben Reed NASA Goddard Space Flight Center
3:56 p.m.	Break	
	Discussion Facilitated by Steve Stich	
4:10 p.m.	Extensibility	
4:30 p.m.	Anchor Technique Trades	
4:44 p.m.	Translation and EVA Tool Trades	
5:04 p.m.	Additional Mass Delivery for Utilization	
5:18 p.m.	Panel Observations/Forward Work	
5:28 p.m.	Closing Statements-Steve Stich	