

National Aeronautics and Space Administration



Exploration of NEOs Objectives Workshop Summary

**Presentation to NAC Exploration Committee
September 21, 2010**

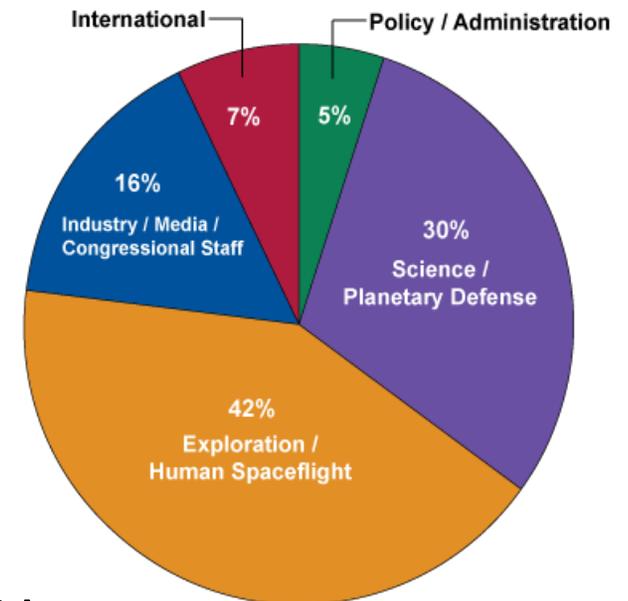
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Exploration of NEOs Objectives Workshop (Explore NOW)



- Details
 - August 10-11, 2010
 - Conducted at Mayflower Renaissance Hotel in Washington, D.C.
- Goals:
 - Increase collective knowledge and understanding of NEOs
 - Communicate NASA's plans for a human mission to a NEO
 - Capture external input on human mission objectives
- Participation:
 - Onsite: 175 registered participants
 - Webcast: Approximately 1700 viewers from USA, China, Canada, Russian Federation, United Kingdom, Japan, Czech Republic, Germany, Netherlands and Ukraine



Explore NOW Key Players



Chair: Marguerite Broadwell

Breakout Topic	Lead	Facilitators
Precursor Investigations, #1	Jay Jenkins	Mike Conley, Paul Gilbert
Precursor Investigations, #2	Sandra Magnus	George Sarver, Mike Wargo
Technologies	Barbara Wilson	Chris Moore, Eileen Stansberry
Concept of Operations	Doug Craig	John Connolly, Mike Gernhardt
Planetary Defense	Lindley Johnson	Bill Ailor, Peter Garretson
Synergies	Chris Culbert	Kathy Laurini, Brian Wilcox
Policy/Participatory Exploration	Gale Allen	Victoria Friedensen, Scott Pace

Explore NOW Approach



Approach:

- Invite the world's experts and leaders in human spaceflight, science of NEOs, planetary defense and policy.
- Focus scope on human objectives 'at or on' a NEO
- Day One - Begin by increasing participants knowledge of NEOs, NASA's interests, and some objectives for a human NEO mission through briefings and panel discussion with experts from academia, DoD, international space agencies, OSTP and NASA. (8:00am-2:15pm)
- Follow with all participants brainstorming on the objectives of a human NEO mission, activities needed to achieve them and target NEO characteristic (2:15pm-5:30pm)
 - 7 breakout groups of 18-30 people
 - Each group lead present summary of group's input in general session
- On Day Two, 7 breakout groups brainstorm on 6 different topics using the same set of objectives and activities for a human NEO mission.
 - Summarize and brief the condensed set of mission objectives from Day One.
 - Brainstorm the topics, then present results in the general session and receive additional inputs, discussions. (8:30 am-5:00 pm)

Identified Objectives for Human NEO Mission



- Objectives – 300 discrete ideas for a human mission to a NEO, summarized as follows:
 - 1. Demonstrate deep space capabilities**
 - a) Human Health – physiological, radiation, psychological
 - b) Systems – radiation & hazard shielding, closed loop ECLSS, power, ISRU, communications, advanced propulsion capabilities
 - c) Operations – autonomous operations, in-flight training
 - 2. Characterize NEOs** – composition, porosity, size, spin rate, binary...
 - 3. Mitigate the threat of NEOs to planet Earth**
- Synergy among human spaceflight, science and planetary defense communities in the need to understand characterization of NEOs
- Activities to achieve Objectives included:
 - Sample handling
 - Testing hardware and software systems
 - Deploying scientific Instruments
 - Testing deflection techniques

Identified Potential Precursor Investigations Needed



- **Precursor Investigations: What do we need to know before we can send a human to a NEO?**
 - **Key observation:** Regardless of the specific human objectives at a NEO, the same kinds of knowledge and measurements are desired from precursor missions.
 - Target Selection – knowledge gaps:

Knowledge Gap	Potential Measurement Techniques	Desired Information	Criticality
Unknown distribution and Availability of targets	<ul style="list-style-type: none"> • IR telescope survey • Ground Based • Telescopes 	<ul style="list-style-type: none"> • Size • Spin/rotation rate • Spectral type • Shape • Debris environment • Wobble • Brightness • Pole orientation • Accurate orbit info 	Critical
Relationship between spectral type and chemistry/structure	<ul style="list-style-type: none"> • Surface based measurements 	Needed if precursors do not go to exact NEO humans will	Critical
Gravity field	Note: There was debate on whether this information was truly needed. Thought by some to be negligible.		

Identified Potential Precursor Investigations Needed (Continued)



- NEO Characterization – knowledge gaps:

Knowledge Gap	Potential Measurement Techniques	Desired Information	Criticality
Regolith properties	<ul style="list-style-type: none"> • Radar imaging • High resolution imagery • Mineralogy (XPS, GRS) • Langmuir probe • Light meter probe • Thermal imager 	<ul style="list-style-type: none"> • Penetration resistance • Particle size distribution • Composition • Electric properties • Magnetic properties • Toxicity • Chemistry 	Criticality of specific information Is dependent on main objectives of human tasks at the asteroid. Most focused on understanding human interaction with body, hazards, dust behavior.
Surface/sub-surface structural properties	<ul style="list-style-type: none"> • Geo-tech measurements • Mossbauer spec • Contact probes • Impact tests • Drilling tests • Sample collection 	<ul style="list-style-type: none"> • Morphology • Shear strength • Stability • Porosity • Cohesion • Temperature • Density 	

Identified Primary Technology & Capability Gaps



What technologies and/or capabilities are needed for a human mission to a NEO?

- Major capability gaps centered around four primary areas:
 1. Proximity operations - operations for surface and subsurface access
 2. Characterization – surface/internal target, sample acquisition and handling
 3. Mission autonomy - autonomy and robustness required for deep space missions
 4. Human Health Systems - life support and challenges for human health
- Technology development options to address the capability gaps were identified for all of these.

Identified Concepts of Operation



What are the concepts of operations for a human mission to a NEO?

- Identified concepts of operations for each mission phases (i.e., LEO & Preparation, In transit to a NEO, At NEO and Earth Return) with focus on operations at a NEO.
- Types of Operations at a NEO included -

Category	Operations at a NEO
Human Spacecraft	Field surveys, NEO orbit insertion and station keeping, deployment of exploration vehicle, monitor spacecraft system performance, and exploration vehicle rendezvous and dock with Mothership
EVA	Astronaut EVA to surface from Exploration vehicle
Science	Core sampling and deep drilling, Seismic surveying, Sample collection (bulk and selective) ISRU demos, deployment and emplacement of packages (e.g., seismic sensors, tracking devices)
Robotics	Tele-robotic operations such as Aercam, autonomous drilling, and ISRU testing (prior to EVA, during and after EVA), leaving behind robotic assets

Identified Planetary Defense Info & Capability Needs



What NEO knowledge do we need for planetary defense? What capabilities are needed?

- Identifying and characterizing NEOs; overlaps with science and human mission needs
- Capability to test deflection concepts
- Capabilities and tools for planetary defense include:

Purpose	Capabilities and Tools
Rapid Impulse	Surface and sub-surface explosives, kinetic energy impact, nuclear standoff
Slow Push	Surface ablation techniques (test with small laser, mirror for focused sunlight, measuring mass and velocity of any ejects), enhanced natural effects , gravity tractor, attached thruster, mass driver

Identified Synergies in Human – NEO, Moon & Mars Missions



What are the synergies with a human mission to the Moon and Mars?

- Moon and NEOs similarities (on the surface) include:
 - EVA dust mitigation (NEO may be worse environment)
 - Sample acquisition, storage and handling, in-situ analysis
 - Capabilities for accomplishing similar science task (e.g., volatiles, geology, plasma interactions, dust and surface charging, etc.)
- Mars and NEOs similarities (on the surface) include:
 - Autonomous operations (crew/body interactions)
 - Communication and navigation software
 - Equipment for science operations
 - ISRU capabilities
- Some key differences include:
 - Radiation shielding and mitigation is going to be different on the surface of Mars
 - Mobility through the environment
 - Ability to collect samples and dust mitigation techniques (may be different in a gravity environment)



What policy considerations must be addressed?

- Discussed the need for stability in policies impacting human spaceflight
 - Agreed that a potentially viable means to increase stability would be a decadal study on human space exploration conducted by or modeled after those by the National Academies.

How could we engage the public?

- In terms of engaging the public, the term “Near Earth Objects” is not easy for the public to understand or relate to – unappealing.
 - Participants suggested using the term “Near Earth Asteroids” or simply “asteroids”
- Shift focus from promoting "study and you can become an astronaut" to "come with us and explore the universe!" Expand the message.

Identified Actions for Follow Up



Several of the actions identified include:

- Address whether humans can go to a NEO that has not been visited by a robotic precursor.
- Identify and prioritize knowledge needed before sending humans to a NEO.
- Conduct a study of the database of known NEOs using various filters to evaluate the potential known target set for a human mission.
- Develop a clear understanding of the wide range of assets available to help characterize NEOs across the international community and other government agencies.
- Identify mission cadence and phasing.
- Identify synergies in the science, planetary defense and human spaceflight discrete NEO characterization objectives, requirements and interests.
- Review capabilities and technologies needed for a NEO mission against existing capabilities, those needed for Moon and Mars, those needed for science and/or planetary defense, and those in development by others, both domestic and globally, for possible collaboration.

Explore NOW Impact and Next Steps



- **Impact:**
 - Increased understanding of NEOs;
 - Identified objectives of a human mission to a NEO;
 - Facilitated and is advancing collaborations within the NASA and with the international community, industry, and other Federal Agencies; and
 - Advanced the pace of policy discussions and resolution on planetary defense – agency roles, responsibilities...
- **Next steps:**
 - Complete follow up actions and use the input from the workshop to help formulate NASA's exploration architecture and programs
 - HEFT II and ESMD Study Teams (xPRM, ETDD, FTD)
 - Incorporate input into the formulation of NASA's concept maps on human exploration of the solar system.
- *Report, presentations, video, and reference information are available @ www.nasa.gov/exploration.*