

Open Global Community NEO Workshop

February 22, 2011, 8 am – 6:30pm
George Washington University
School of Media and Public Affairs
Jack Morton Auditorium
805 21st Street, NW, Washington, DC 20052
(Foggy Bottom Metro Stop)

Target NEO: Providing a Resilient NEO Accessibility Program for Human Exploration Beyond LEO

Workshop will address these questions: *Do we have adequate NEO targets for a robust, resilient, forward-looking but affordable human spaceflight program beyond LEO over the next two decades? What do we know in the context of human exploration of NEOs, and what information is lacking? Which missing information is critical, and which is “nice to have”? On what timescale is that information necessary? What level of effort and resources are necessary to resolve outstanding issues on that timescale? What is the community consensus on the costs and benefits of resolving those issues?*

Workshop Forum and Outcome: *The workshop will include six (6) technical sessions and a broad introduction and closing session with confirmed expert-speakers. A (Q)uestion and (A)nsWER period will be accommodated during each session. Following the workshop, a community expert-opinion based report will be delivered to major stakeholders for review and consideration. An oral briefing will also be delivered at the March 2011 Lunar and Planetary Science Conference (LPSC).*

Attendees: *Domestic and internationally recognized small body experts, in both the robotic and human space-flight joint community, to include but not limited to: small body scientists and related analytical and operational experts, mission designers, systems engineers, mission operations, safety, radiation, etc. Experts across government, academia, industry, and other organizations are encouraged to attend.*

Acknowledgements:



THE GEORGE WASHINGTON UNIVERSITY
THE ELLIOTT SCHOOL
OF INTERNATIONAL AFFAIRS
THE SPACE POLICY INSTITUTE



Ball Aerospace
& Technologies Corp.

Agenda

7:00 - 8:00am Registration and Light Breakfast

8:00 - 8:15am Welcome, Scott Pace, George Washington University, Director, Space Policy Institute and Rich Dissly, Ball Aerospace

8:15 - 8:50am Session 1: Introduction, Workshop Scope, Overview of Flexible Path Vision

Session Moderator: John Logsdon, George Washington University, Faculty, Space Policy Institute

Session purpose: The 2009 Augustine Committee reviewed the future U.S. human spaceflight program, with the ultimate goal to extend human presence into the solar system, beyond LEO, the Moon and ultimately to Mars. Their report, which fed into the new Administration's vision, crafted a "flexible path approach" to potentially achieve these goals. The flexible path includes numerous destinations; Near Earth Objects, in particular, have emerged as a likely first destination. This session will summarize the scope of the workshop and its outcome, overview the flexible path vision, its NEO focus, the examination of NEO targets to enable the first human flight, and the importance of global cooperation; and thus set the stage for following detailed workshop discussions.

Panel:

- **Thomas Jones, Veteran Astronaut, Senior Research Scientist, Florida Institute for Human & Machine Cognition; "NEO Search Required for Operations & Exploration Risk Reduction"**
- **Scott Pace, George Washington University, Director, Space Policy Institute; "Sustainable Human Space Exploration"**
- **Dave Korsmeyer, Chief, Intelligent Systems Division, NASA Ames Research Center, NASA Analysis Lead: Augustine Committee Flexible Path Option; "The Augustine Commission and the Flexible Path"**

8:55 - 10:15am Session 2: The NEO Population: Knowns and Unknowns

Chairs: Andy Cheng, Johns Hopkins University Applied Physics Laboratory and Lindley Johnson, NASA Headquarters, Science Mission Directorate

Session purpose: With the nation's announced goal of sending a human mission to a NEO by 2025, the population of these objects and their distribution in orbital element space has become a critical issue. Although more than 7,000 NEOs are known, the numbers and physical characteristics of the NEOs in extremely Earth-like orbits, which are the most accessible NEOs, are highly uncertain. This session will review current understanding of NEO population and status of NEO observational programs.

Panel:

- **Tim Spahr - Director, Minor Planet Center, SAO; “MPC Operations and Update”**
- **Don Yeomans - Program Scientist/Mgr., NASA NEO Program Office, Jet Propulsion Laboratory; “Precision NEO Orbit Prediction at JPL”**
- **Scott Stuart - Deputy PI, LINEAR, Massachusetts Institute of Technology Lincoln Laboratory; “Searching for NEOs”**
- **Amy Mainzer – WISE Deputy Project Scientist, Jet Propulsion Laboratory; “Space-based NEO Detection and Tracking, NEOWISE and Beyond”**
- **Al Harris - NEO Population Studies, Consultant; “NEO Population Estimates”**

10:15 - 10:30am Break (15 min) 2nd Floor Lobby

10:30 - 11:50am Session 3: Mission Design: Getting There and Back

Chairs: Brent Barbee, NASA Goddard Space Flight Center and Dan Adamo, NASA Johnson Space Center, ret., Consultant

Session purpose: The objectives of this session are to provide an overview of the important aspects of end-to-end NEO human mission design, i.e., getting there and back, summarizing the current state of the art, and determining the next steps in NEO mission design research. Topics to be addressed by panelists include results from recent surveys of the known NEO population for human space flight accessibility, relevant trajectory design techniques, limits of achievable parameters for NEO human space flight missions, launch reliability considerations, and key findings from current NEO mission design research.

Panel:

- **Damon Landau, Outer Planet Mission Analyst, Jet Propulsion Laboratory; “NEO Trajectories on a Flexible Path to Mars”**
- **Bret Drake, Architect, Exploration Missions and Systems Office, NASA Johnson Space Center; “Architectures for Human Exploration of Near-Earth Asteroids”**
- **Ron Mink, Mission Systems Engineer, Mission Systems Engineering Services & Advanced Concepts Branch, NASA Goddard Space Flight Center; “Enabling Affordable Human Asteroid Missions by 2025”**
- **Josh Hopkins, Principal Investigator for Advanced Human Exploration Missions, Lockheed-Martin Space Systems Company; “Short, Simple Asteroid Missions: The Plymouth Rock Approach”**
- **Chel Stromgren, Chief Scientist for Strategic Analysis, SAIC; “Getting to the Starting Line: Launch and Assembly Reliability for Deep Space Missions”**

11:50 - 12:35pm – Lunch on site (45 min) Downstairs Lobby

12:35 - 1:55pm Session 4: NEO Characteristics for Safe and Meaningful Human Exploration

Chairs: Andy Rivkin, Johns Hopkins University Applied Physics Laboratory and Paul Abell, NASA Johnson Space Center

Session purpose: To discuss the known physical characteristics of NEOs obtained from spacecraft and ground-based observations and to identify an optimum set of NEO characteristics (spin rate, internal structure, size, composition, etc.) that would be most desirable for safe and meaningful human exploration. Additional discussion will focus on: How best to determine the physical characteristics of candidate NEO targets necessary prior to human exploration (via ground-based and/or space-based assets); What methods, measurements, and instruments are required to provide the necessary data for target selection and qualification, and; When should these data be obtained so as to best inform scientists and engineers designing and planning future human NEO exploration missions.

Panel:

- **Patrick Michel, Senior Researcher, University of Nice, CNRS, Cote d'Azur Observatory;** *“Physical Properties of NEOs: Current Knowledge from Observations, Simulations, and Their Possible Influence for the Design of a Human Mission”*
- **Lance Benner, Research Scientist, Jet Propulsion Laboratory;** *“Arecibo and Goldstone Radar Characterization of NEO Mission Targets”*
- **Joe Nuth, Senior Scientist, NASA Goddard Space Flight Center;** *“Do we Really Understand the Rocks that Astronauts Might be Visiting?”*
- **Dan Scheeres, Professor, Department of Aerospace Engineering Sciences, University of Colorado;** *“The Asteroid Surface Environment, Knowns and Unknowns”*
- **Mike Hess, Chief of the EVA, Robotics, and Crew Systems Operations Division, NASA Johnson Space Center;** *“Extravehicular Activity Considerations for Near-Earth Object Operations”*

2:00 - 3:20pm Session 5: Mission Duration: Quantifying the Risks

Chairs: Dan Mazanek, NASA Langley Research Center and Rob Landis, NASA Ames Research Center

Session purpose: Discussion of the effects and associated risks on humans and vehicle systems during long duration interplanetary space missions to NEOs. A variety of areas will be discussed, including radiation exposure (cumulative dosage and episodic risks), physiological effects, psychological & social-psychological concerns, habitability issues, system redundancy, contingencies, abort scenarios, etc., along with NASA's cumulative experience to date.

Panel:

- **Craig Kundrot, Deputy Program Scientist, Human Research Program, NASA Johnson Space Center;** *“Long Duration Space Missions: Human Subsystem Risks and Requirements”*
- **Jack Stuster, Vice President, Principal Scientist & Author, Anacapa Sciences, Inc.;** *“Acceptable Risk: Human Missions to Near-Earth Objects”*
- **Ron Turner, Fellow, Analytical Services, Inc. (ANSER);** *“Radiation Risks and Challenges Associated with Human NEO Missions”*
- **Andy Thomas, Astronaut (STS/MIR/ISS), ESMD Architecture Development, NASA Johnson Space Center;** *“Some Crew Perspectives of a NEO Mission”*

3:20 - 3:35pm Break (15 min) 2nd Floor Lobby

3:35 - 4:55pm Session 6: Affordable Options for Increasing the Accessible NEO Catalog

Chairs: Rich Dissly, Ball Aerospace and Ken Hibbard, Johns Hopkins University Applied Physics Laboratory

Session purpose: The trade space for survey options for further identification of potential human-accessible NEO targets will be discussed, and then examined in some detail through the presentation of several different survey concepts that span this trade space. Capability (an assessment of discovery completeness) as a function of cost will be explored for the various options considered.

Panel:

- **Andy Cheng, Chief Scientist, Space Department, Johns Hopkins University Applied Physics Laboratory;** *“NEO Orbit Simulation Approach”*
- **Lynne Jones, LSST Solar System Project Scientist, University of Washington;** *“NEO Detection Capabilities of LSST”*
- **Ken Hibbard, Senior Spacecraft Systems & Operations Engineer, Johns Hopkins University Applied Physics Laboratory;** *“NEAR-Earth Survey Telescope (NEST) Human Robotic Precursor Mission Concept”*
- **Amy Mainzer – WISE Deputy Project Scientist, Jet Propulsion Laboratory;** *“Next-Generation Space-Based IR NEO Surveys”*
- **Robert Arentz, Adv. Systems Manager, Ball Aerospace;** *“A Candidate NEO Survey Mission for Affordable Human Spaceflight Target Assurance”*

5:00 - 6:00pm Session 7: Workshop Session(s) Summary

Chairs: James Garvin, NASA Goddard Space Flight Center and Cheryl Reed, Johns Hopkins University Applied Physics Laboratory

Session purpose: Workshop session Chairs will summarize their sessions (6 min each). Engage the audience in final Q and A (30 min).

Panel:

Session 2: The NEO Population: Knowns and Unknowns

Chairs: Andy Cheng, Johns Hopkins University Applied Physics Laboratory and Lindley Johnson, NASA Headquarters, Science Mission Directorate

Session 3: Mission Design: Getting There and Back

Chairs: Brent Barbee, NASA Goddard Space Flight Center and Dan Adamo, NASA Johnson Space Center, ret., Consultant

Session 4: NEO Characteristics for Safe and Meaningful Human Exploration

Chairs: Andy Rivkin, Johns Hopkins University Applied Physics Laboratory and Paul Abell, NASA Johnson Space Center

Session 5: Mission Duration: Quantifying the Risks

Chairs: Dan Mazanek, NASA Langley Research Center and Rob Landis, NASA Ames Research Center

Session 6: Affordable Options for Increasing the Accessible NEO Catalog

Chairs: Rich Dissly, Ball Aerospace and Ken Hibbard, Johns Hopkins University Applied Physics Laboratory

6:05 – 6:35 pm Session 8: NASA HQ Feedback on Workshop Discussions

Chairs: James Garvin, NASA Goddard Space Flight Center and Cheryl Reed, Johns Hopkins University Applied Physics Laboratory

Session purpose: Obtain workshop feedback from NASA Headquarters Directorate leadership, major stakeholders on what they've heard from the day's discussions.

Panel:

- **Charles Gay, NASA Headquarters, Deputy Associate Administrator, Science Mission Directorate**
- **Sam Scimemi, NASA Headquarters, Deputy, International Space Station, Space Operations Mission Directorate**
- **Benjamin Neumann, NASA Headquarters, Director, Advanced Capabilities Division, Exploration Systems Mission Directorate**

6:35 – 8:30pm Social 2nd Floor Lobby

Biographies

Alphabetical Order

Dr. Paul Abell

NASA Johnson Space Center (JSC)

Paul Abell is the Lead Scientist for Planetary Small Bodies assigned to the Astromaterials Research and Exploration Science Directorate at the NASA Johnson Space Center in Houston, Texas. His main areas of interest are physical characterization of near-Earth objects (NEOs) via ground-based and spacecraft observations, examination of NEOs for future robotic and human exploration, and identification of potential resources within the NEO population for future resource utilization. Paul is also a science team member on the Hayabusa near-Earth asteroid sample-return mission, and was a member of the Hayabusa sample return recovery team.

Daniel R. Adamo

Astrodynamics Consultant (JSC (ret.))

Dan Adamo is currently an independent consultant in the field of astrodynamics. His recent work includes near-Earth asteroid accessibility support to the Review of U.S. Human Space Flight Plans Committee, development of a design reference mission placing human explorers on the Martian moon Deimos, deployment strategy development for a near-Earth asteroid survey telescope operating near the orbit of Venus, and trajectory expertise contributed to multiple NASA near-Earth asteroid exploration studies. From 1979 to 2008, he was employed as a contractor at Johnson Space Center, involved with space mission trajectory simulation, design, and operations. While at JSC, he supported sixty Space Shuttle flights from Mission Control's Flight Dynamics Officer (FDO) Console. Dan is the recipient of numerous NASA Group Achievement awards, the Silver Snoopy Award, four Space Shuttle flight control certifications, and he holds three copyrights to trajectory software applications of his own design.

Robert F. Arentz

Ball Aerospace & Technologies Corp.

Bob Arentz is a New Business Manager for the Civil and Operational Space unit at Ball Aerospace and Technologies Corp. He has 38 years of experience at Ball with more than 15 years of hand-on experience developing infrared sensor systems for astrophysical applications, including IRAS, COBE, NICMOS, and the Spitzer Space Telescope. He recently led a design team at Ball for an IR survey telescope mission concept, and contributed to the recent National Research Council report "*Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies.*"

Brent Wm. Barbee

NASA Goddard Space Flight Center (GSFC)

Brent Barbee is currently a Flight Dynamics Engineer in the Navigation and Mission Design Branch of the NASA Goddard Space Flight Center where he specializes in spacecraft trajectory design and optimization, mission design and analysis, rendezvous and proximity operations, and trajectory analysis and design for missions to Near-Earth Objects. Mr. Barbee has worked on a variety of projects at Goddard, including the ongoing NHATS (Near-Earth Asteroid (NEA) Human Space Flight (HSF) Accessible Targets Study). In addition, he participated in a 2006 NASA report to Congress regarding the analysis of alternatives for dealing with the problem of hazardous Near-Earth Objects. Mr. Barbee is a graduate of the University of Texas at Austin (MS Aerospace Engineering, 2005).

Dr. Lance Benner

NASA Jet Propulsion Laboratory (JPL)

Lance Benner is a Research Scientist at the Jet Propulsion Laboratory, where he specializes in radar imaging of near-Earth objects. He has authored more than 50 papers on near-Earth asteroids, main-belt asteroids, and comets. He is a frequent observer at the NSF Arecibo Observatory and at NASA's Goldstone Solar System Radar Facility. He contributed to the recent National Research Council report "*Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies.*"

Dr. Andrew F. Cheng**Johns Hopkins University Applied Physics Laboratory (APL)**

Andrew Cheng is the Chief Scientist for the Space Department at the Johns Hopkins University Applied Physics Laboratory. He previously served as Deputy Chief Scientist for Space Science, Science Mission Directorate, NASA HQ during 2007-2008. He was an Interdisciplinary Scientist on the Galileo mission to Jupiter, a Co-Investigator on the Cassini mission to Saturn, and a NASA Co-Investigator on the Japanese-led Hayabusa mission to a near-Earth asteroid. He was also Project Scientist for the Near Earth Asteroid Rendezvous (NEAR) mission. He currently is a member of the MESSENGER science team and Principal Investigator for the LORRI instrument on the New Horizons mission to Pluto and the Kuiper Belt. Dr.Cheng has served on many NRC panels and NASA advisory groups.

Bret Drake**NASA Johnson Space Center (JSC)**

Bret Drake is currently leading the future Mission Planning and Analysis activities for the Exploration Missions and Systems Office at NASA's Johnson Space Center. For the past several years Mr. Drake has led the Agency in the design and analysis of human exploration mission approaches beyond low-Earth Orbit including missions to the Moon, Near-Earth Objects, and Mars. Mr. Drake has been involved in various agency strategic planning activities for NASA's exploration efforts for over twenty years including the NASA 90-day study and the White House Synthesis Group, Integrated Space Plan, Exploration Systems Architecture Study and the Review of Human Space Flight Plans Committee (aka Augustine Committee).

Dr. Richard Dissly**Ball Aerospace & Technologies Corp.**

Rich Dissly is a Sr. Manager at Ball Aerospace & Technologies Corp., responsible for business development in space sciences for the Civil and Operational Space organization. He has over 15 years of experience developing scientific instrumentation, the last 10 for planetary flight applications. Previous to Ball, Rich was a research scientist at the NOAA Aeronomy Laboratory, where he was responsible for the design, fabrication and deployment of instrumentation for the measurement of trace atmospheric species from aircraft. Rich received his doctorate in Planetary Sciences from Caltech in 1994.

Dr. James B. Garvin**NASA Goddard Space Flight Center**

Jim Garvin is currently the Chief Scientist at the NASA Goddard Space Flight Center (GSFC). In this role, Dr. Garvin brings the experience gained from his 25 year career as a NASA scientist, spanning such disciplines as Earth system science, Mars Exploration, lunar exploration, Venus, asteroids, and the outer planets. As the Lead Scientist for Mars Exploration at NASA, Dr. Garvin was instrumental in restructuring the Mars Program in 2000. At present he is continuing his scientific research as a Co-investigator on NASA's ongoing Lunar Reconnaissance Orbiter (LRO), as well as on Canada's Radarsat-1 and Radarsat-2 missions. He has published over 60 research articles, ranging from remote sensing of oceanic islands on Earth, to the characteristics of rocks on Mars, Venus, and the Moon. Dr. Garvin holds a PhD in planetary geological sciences from Brown University

Charles J. Gay**NASA Headquarters**

Charles "Chuck" Gay is currently the Deputy Associate Administrator for the Science Mission Directorate at NASA Headquarters. He was previously Deputy Director of the Heliophysics Division and the Deputy Director of the Earth Sun System Division, where he was responsible for the development and operations of over 50 spacecraft, spanning multiple NASA Centers, agencies, industry teams, and international partners. Mr. Gay has over 20 years of experience in the aerospace industry at Litton Advanced Systems, Martin Marietta, Lockheed Martin, and Fairchild. He has experience with many successful NASA flight programs including TDRS, Magellan, TOPEX, Terra, and EO-1. Mr. Gay has received the NASA Public Service medal, a Silver Snoopy award, and a Presidential Rank Award for Meritorious Service. Mr. Gay received an M.S. in Structural Engineering from the University of Maryland.

Dr. Alan Harris**NASA Jet Propulsion Laboratory (JPL (ret.))**

Alan Harris received his PhD in Earth and Space Sciences at UCLA in 1975, and spent 28 years at JPL, in the tracking and navigation group and then in the Earth and Space Sciences Division as a Senior Research Scientist. His specialty has been small body dynamics and evolution, both orbital and rotational, of asteroids, comets, satellites, and ring particles. Over the past two decades he has participated in numerous studies by NASA, NRC, and international bodies evaluating all aspects of the NEO impact hazard (impact probabilities and consequences, survey design and progress, mitigation strategies, and even social and political aspects). Now retired from JPL, Harris continues an active research program sponsored by NASA and NSF, and serves as a frequent consultant to NASA and JPL on the NEO Program.

Michael Hess**NASA Johnson Space Center (JSC)**

Michael Hess is currently the Chief of the EVA, Robotics, and Crew Systems Operations Division at the NASA Johnson Space Center. He previously served as Division Chief of the Operations Division in the Mission Operations Directorate and as the MOD Program lead for the Space Station Program, and for the initialization of the Constellation Program and ESMD. In his career at NASA, Michael has served as an Extravehicular Activities Officer, planning and monitoring spacewalks from Mission Control. He has provided astronaut training and flight control for numerous EVAs, and served as a lead for space walks on STS-87, 96, 101, and 106. Michael is a Harvard Senior Executive Fellow, has a Silver Snoopy award, and is a NASA Distinguished Leadership Medal recipient.

Kenneth Hibbard**Johns Hopkins University Applied Physics Laboratory (APL)**

Ken Hibbard received his B.S. degree in aerospace engineering from the Pennsylvania State University in 1996. Upon graduating, he worked on the ACE, SOHO, and Swift spacecraft as a spacecraft systems and operations engineer at NASA GSFC. Now at JHU/APL, Mr. Hibbard served as the MESSENGER Deputy Mission Operations Manager. He is currently a senior systems engineer supporting multiple programs, proposals, and mission studies, including his role as Formulation Deputy Project Systems Engineer for the Jupiter Europa Orbiter (JEO) outer planet flagship mission.

Josh B. Hopkins**Lockheed-Martin Space Systems Company**

Josh Hopkins currently leads a team of engineers at Lockheed Martin who develop plans and concepts for a variety of future human exploration missions, including visits to asteroids, Lagrange points, and the moons of Mars. He is responsible for the Plymouth Rock mission study for human exploration of Near Earth Asteroids using the Orion crew exploration vehicle. In a similar capacity he previously led Lockheed Martin's technical team to determine mission capabilities for the Altair lunar lander. During his 14 years with Lockheed, Mr. Hopkins has helped develop numerous space transportation systems and launch vehicles. He received his B.S. in Aeronautical and Astronautical Engineering from the University of Illinois.

Lindley Johnson**NASA Headquarters**

Lindley Johnson is assigned to NASA Headquarters Science Mission Directorate, Planetary Science Division, as the Lead Program Executive for the Discovery Program, and as the Program Executive for the Near Earth Object Observations Program. Prior to NASA he served 23 years of Air Force active duty, and obtained the rank of lieutenant colonel while working a variety of national security space systems, receiving 15 major individual or unit awards. After joining NASA, he was the Program Executive for NASA's Deep Impact mission to comet Tempel 1, launched in January 2005 to deliver an impact probe to the comet's surface and explore the composition and interior structure of short-period comets. Lindley has received NASA's Exceptional Achievement Medal for his work on comet and asteroid missions.

Dr. Lynne Jones**University of Washington**

Lynne Jones is a research scientist at the University of Washington where she has worked for four years on LSST, specializing in ground-based survey techniques. For her thesis she conducted a deep 'digital shift and stack' survey for TNOs at the University of Michigan, which was followed by an NSF International Research Fellowship at University of British Columbia to work with the CFEPS collaboration to search for TNOs over several hundred square degrees. Her work has expanded to include studying precise photometric calibration as well as automated detection of moving objects at all distances throughout the Solar System. She has been co-chair of the LSST Solar System Science Collaboration for the past three years.

Dr. Thomas D. Jones**Veteran NASA Astronaut**

Tom Jones, former NASA astronaut, is a scientist, speaker, author and consultant. In more than 11 years with NASA, Tom flew on four space shuttle mission to Earth orbit. On his last flight, Dr. Jones led three spacewalks to install the centerpiece of the International Space Station – the *Destiny* laboratory module. Tom's latest book is *Planetology: Unlocking the Secrets of the Solar System* for National Geographic (with Ellen Stofan) in 2008. Tom has served on the NASA Advisory Council and is a board member of the Association of Space Explorers. He is currently serving on the National Research Council's Committee on Human Spaceflight Crew Operations. Tom is a distinguished graduate of the U.S. Air Force Academy, and holds a PhD in planetary science.

Dr. David Korsmeyer**NASA Ames Research Center**

David Korsmeyer is a NASA Senior Executive, and the Chief of the Intelligent Systems Division at NASA Ames Research Center. He began his career at Ames in 1991 as an aerospace engineer supporting advanced software and information technology infusion into NASA missions. He is a recognized leading researcher in the area of distributed and collaborative systems for wide area information management. Recently he was the lead of the NEO mission concepts study for the Constellation Program, and supported the Human Space Flight Review Panel where he led the technical analysis for the Flexible Path Architecture. Dr. Korsmeyer received his M.S. and PhD in aerospace engineering and astrodynamics from the University of Texas at Austin and is a Sloan Fellow with a Master's in business management from the Stanford School of Business.

Dr. Craig Kundrot**NASA Johnson Space Center (JSC)**

Craig Kundrot is the Deputy Program Scientist for NASA's Human Research Program. He also leads the Science Management Office for the HRP. A graduate of Northwestern and Yale Universities, his research was in biochemistry and biophysics. He was on the faculty at the University of Colorado prior to joining NASA where his positions have included Biotechnology Senior Scientist; and Branch Chief for the Biotechnology and Materials Science in NASA's microgravity program.

Dr. Damon Landau**NASA Jet Propulsion Laboratory (JPL)**

Damon Landau is an Outer Planet Mission Analyst at the Jet Propulsion Laboratory where his primary interests are mission design and trajectory optimization. Before beginning his career at JPL he received a Ph.D. in 2006 from Purdue University where he examined various strategies for the sustained human exploration of Mars. In February 2007 Damon moved to sunny California to pursue the glamorous life of robotic space exploration. His current work involves the preliminary design of interplanetary missions with a focus on combining gravity assist trajectories with solar electric propulsion. Damon also performs trajectory analyses in preparation for Juno's arrival at Jupiter in July of 2016.

Robert R. Landis**NASA Johnson Space Center (JSC)**

Rob Landis is an employee of Ames Research Center permanently assigned to NASA Johnson Space Center. After nearly seven years in the planetarium field, he began his NASA odyssey at Space Telescope Science Institute, implementing moving target observations on the Hubble Space Telescope, including the Comet P/Shoemaker-Levy 9 impacts on Jupiter. Rob also did a stint at JPL, where he led uplink operations for both Cassini and the Mars Exploration Rovers. A former flight controller for the International Space Station, Rob has supported ISS missions in Russia and Germany. He now works in the Constellation Program's Exploration Mission Systems Office at JSC. Rob has a B.S. in astrophysics from Michigan State University.

Dr. John M. Logsdon**Former Director of GWU Space Policy Institute**

John Logsdon is Professor Emeritus of Political Science and International Affairs at George Washington University's Elliott School of International Affairs. He was on the faculty of the George Washington University for 38 years. He was the founder and long-time Director of GW's Space Policy Institute. From 1983-2001, he was also Director of the School's Center for International Science and Technology Policy. Dr. Logsdon's research interests focus on the policy and historical aspects of U.S. and international space activities. Dr. Logsdon was a member of the NASA Advisory Council from 2005-2009 and remains a member of the Council's Exploration Committee. He has also served as a member of the Committee on Human Space Exploration of the Space Studies Board on the NRC, and on the Vice President's Space Policy Advisory Board. He is a recipient of the Distinguished Public Service and Public Service Medals from NASA. He holds a Ph.D. in Political Science from New York University (1970).

Dr. Amanda Mainzer**NASA Jet Propulsion Laboratory (JPL)**

Amy Mainzer is an astrophysicist at JPL. She was the Principal Investigator of a cryogenic camera which serves as the fine guidance sensor for the Spitzer Space Telescope and has been in operation since 2003. She built the First Light Camera (FLITECAM) for NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA). Amy became the Deputy Project Scientist for the Wide-field Infrared Survey Explorer (WISE) in 2003, working to ensure that WISE met its science requirements. She is also the principal investigator of NEOWISE, an enhancement to the WISE project for capability to find new asteroids. Her other research interests include population studies and physical modeling of asteroids and comets, as well as brown dwarfs and gas giants.

Daniel D. Mazanek**NASA Langley Research Center**

Mr. Mazanek is a Senior Space Systems Analyst at NASA Langley Research Center with over 21 years of experience in space architecture, spacecraft design, and simulation development. Mr. Mazanek has led multiple study efforts to investigate sending humans beyond low-Earth orbit, including the development of a Near-Earth Object (NEO) crewed mission concept for NASA's Exploration Synergy Mission Assessments Study in 2005, and was the Comet/Asteroid Protection System Study lead under NASA's RASC program in 2001-2002. Mr. Mazanek is currently the NEO human mission lead analyst at LaRC for NASA's Human Exploration Architecture Team.

Dr. Patrick Michael**University of Nice, CNRS, Côte d'Azur Observatory, France**

Patrick Michel is the leader of the Planetology Group of the Côte d'Azur Observatory (France). He is a Senior Researcher at CNRS, and an expert on the collisional processes between small bodies, their dynamical evolution and their physical properties. In particular, his simulations of asteroid disruption were the first to reproduce the formation of asteroid families, suggesting that most family members are rubble piles formed by gravitational re-accumulation of small fragments. He recently started investigating the dynamics of granular materials in various conditions of gravity that can help to understand the motion of regolith on asteroid surfaces. He actively participates in space mission studies devoted to NEO science and hazard mitigation. The asteroid (7561) is named PatrickMichael in recognition for his work on secular resonances in the inner Solar System.

Ron Mink**NASA Goddard Space Flight Center (GSFC)**

Ron Mink is a Mission Systems Engineer in the Mission Systems Engineering Services & Advanced Concepts Branch at GSFC, specializing in formulation of asteroid rendezvous and sample return missions, both for science and for reconnaissance of future human targets. From 2008-2010 Mr. Mink supported GSFC's Exploration Systems Project by leading a NASA inter-center team investigating secondary payload missions launched on the Constellation Ares V launch vehicle. Recently he served as Lead Systems Engineer for GSFC's Space Environment Testbeds Project, delivering a space radiation environment research payload that will launch in 2012. Mr. Mink graduated from the University of Wisconsin-Madison in 1994 with a Bachelor of Science degree in Physics.

Benjamin J. Neumann**NASA Headquarters**

Benjamin Neumann is the Director for the Exploration Systems Advanced Capabilities Division at NASA Headquarters, responsible for managing the technology development, human research, and robotic missions for NASA's Space Exploration initiative. Since joining NASA in 1991, Mr. Neumann has held a number of positions at NASA, including Lead Program Executive for the Lunar Precursor Robotics Program, where he oversaw the successful LRO and LCROSS missions. Mr. Neumann was also the Director of NASA's Innovative Partnerships Program, and was Manager for Communications and Outreach for Aerospace Research, where he led the development of the Agency's Aeronautics Blueprint, for the second century of aviation. Mr. Neumann graduated from the University of Michigan in 1981 with an M.S. in aerospace engineering.

Dr. Joe Nuth**NASA Goddard Space Flight Center (GSFC)**

Joe Nuth is the Project Scientist for the OSIRIS REX asteroid sample return mission study in the New Frontiers program. He is a Senior Scientist at NASA's Goddard Space Flight Center responsible for studies of the formation and processing of solids in circumstellar, interstellar and protostellar environments. He is also involved with several pre-proposal mission studies to comets and asteroids, including manned missions to a NEO. He was formerly the Head of Astrochemistry Branch at NASA Goddard. He has published more than 125 articles in refereed journals, primarily resulting from experimental studies of the formation, metamorphism and evolving spectral properties of dust in astrophysical environments.

Dr. Scott Pace**Director, George Washington Space Policy Institute**

Scott Pace is the Director of the Space Policy Institute and a Professor of Practice in International Affairs at George Washington University's Elliott School of International Affairs. His research interests include civil, commercial, and national security space policy, and the management of technical innovation. From 2005-2008, he served as the Associate Administrator for Program Analysis and Evaluation at NASA. He previously served as Chief Technologist for Space Communications in NASA's Office of Space Operations, responsible for issues related to space-based information systems. Dr. Pace also served as the Deputy Chief of Staff to NASA Administrator Sean O'Keefe. Prior to NASA, Dr. Pace was the Assistant Director for Space and Aeronautics in the White House Office of Science and Technology Policy. Dr. Pace has a Doctorate in Policy Analysis from the RAND Graduate School.

Cheryl Reed**Johns Hopkins University Applied Physics Laboratory (APL)**

Cheryl Reed is the Head of Program Development for the Civilian Space Business Area and Deputy Program Manager for Exploration Programs at Johns Hopkins University Applied Physics Laboratory. Since joining APL in 1985, Ms. Reed has held major project management roles for more than 20 national and international civilian and national security space programs. Additionally, she was the senior Space Department Project Administrator for more than a decade. She has significant experience in managing technical teams and programs at the concept, subsystem, instrument, spacecraft and mission levels, and throughout all program phases. Ms. Reed received an M.A., International Affairs from American University (1985) and a B.A. in Business Administration from New England College in Arundel, England (1982).

Dr. Andrew S. Rivkin**Johns Hopkins University Applied Physics Laboratory (APL)**

Andrew Rivkin is the supervisor of the Planetary Astronomy Section in the Johns Hopkins University Applied Physics Laboratory's Planetary Exploration Group. He has been making asteroid observations for well over 20 years, specializing in compositional analysis via infrared observations, including the first identification of ice and organic material on an asteroidal surface. He has also contributed to mission studies for the NRC's Planetary Science Decadal Survey and led the science organizing committee for 2008's International Asteroids, Comets, and Meteors Conference.

Dr. Daniel J. Scheeres**University of Colorado, Boulder**

Dan Scheeres is a professor in the Department of Aerospace Engineering Sciences at the University of Colorado, Boulder, and a member of the Colorado Center for Astrodynamics Research. Prior to this, he held faculty positions in aerospace engineering at the University of Michigan and Iowa State and was a member of the technical staff in the Navigation Systems Section at JPL. His research interests include the dynamics, control and navigation of spacecraft trajectories; the design of space missions; optimal control; planetary science; celestial mechanics; and dynamical astronomy. He is the recipient of two NASA Group Awards for his work on the NEAR mission, and Asteroid 8887 is named "Scheeres" in recognition of his contributions to the scientific understanding of the dynamical environment about asteroids.

Sam Scimemi**NASA Headquarters**

Sam Scimemi (pronounced *she-me-me*) is the Deputy for the International Space Station at NASA Headquarters within the Space Operations Mission Directorate. Mr. Scimemi has 25 years experience in human space flight, earth and space science missions as both a contractor and civil servant. He has been employed at four NASA centers; Johnson Space Center, Ames Research Center, Goddard Space Flight Center, and Headquarters. His career has encompassed real-time operations, flight software development and testing, International Partner negotiations and integration, system engineering, end-to-end testing, and policy and programmatic management. He graduated in 1984 with a B.S. in Mechanical Engineering from McNeese State University.

Dr. Tim Spahr**International Astronomical Union MPC**

Tim Spahr is the Director of the International Astronomical Union sanctioned Minor Planet Center, the repository for all observations and orbit data on small bodies of our solar system. He attended the University of Arizona (1988-1992), studying physics and astronomy. Tim attended graduate school at the University of Florida studying celestial mechanics. As a graduate student, Tim conducted a photographic survey for minor planets, using the University of Arizona's Catalina Schmidt Telescope. After graduating from Florida, Tim wrote software for the Catalina Sky Survey (CSS) team from 1998 to 2000. The CSS became a major player in the NEO discovery field during this time. In May of 2000, Tim accepted a position at the Minor Planet Center, and specialized in refining MPC operations with respect to NEOs. Tim was promoted to MPC director in 2006.

Dr. Scott Stuart**MIT Lincoln Laboratories**

After obtaining a bachelor's degree in Computer Science from the University of Pennsylvania, Scott Stuart joined MIT Lincoln Laboratory in 1993. Scott's early days at Lincoln Laboratory included work on sensors for the Earth Observing-1 satellite. In 1997, he became involved with the initiation of a near-Earth asteroid survey called LINEAR. Entranced by the study of asteroids, Scott entered the graduate program in MIT's department of Earth, Atmospheric, and Planetary Sciences with support from Lincoln Laboratory. For his PhD thesis, Scott used data from the LINEAR survey to estimate the number and properties of the near-Earth asteroids. After completing his PhD in 2003, Scott returned to Lincoln laboratory where he has continued to work on LINEAR and other projects.

Chel Stromgren**Science Application International Corporation (SAIC)**

Chel Stromgren currently serves as the Chief Scientist of the Center for Strategic Analytics at Science Application International Corporation (SAIC). Mr. Stromgren leads the development of probability and risk-based strategic models and strategic analysis of complex system development. He has supported NASA in the analysis of Space Shuttle and ISS operations in the post-Columbia environment and has led the development of strategic campaign models for the lunar exploration and HEFT initiatives. He holds a Bachelor of Science degree in Marine Engineering and Naval Architecture from the Webb Institute and a Master of Science degree in Systems Management from the Massachusetts Institute of Technology.

Dr. Jack Stuster**Anacapa Sciences, Inc.**

Jack Stuster is Vice President and Principal Scientist of Anacapa Sciences, Inc., a human factors and applied behavioral sciences research firm located in Santa Barbara. He is a Professional Ergonomist specializing in the measurement and enhancement of human performance in extreme environments and has conducted research for NASA since 1982. Dr. Stuster's research concerning Antarctic winter-over experiences and expeditions is documented in *Bold Endeavors: Lessons from Polar and Space Exploration*, and he recently completed a content analysis of confidential journals maintained by astronauts during their six-month expeditions to the ISS. He received a bachelor's degree in experimental psychology from UC Santa Barbara, and masters and PhD degrees in anthropology from the same institution.

Dr. Andy Thomas**NASA Astronaut**

Andy Thomas began his career as a research scientist with the Lockheed Aeronautical Systems Co. in 1977, performing wind tunnel and flight test experiments. He joined JPL in 1989, where he led a program for microgravity materials processing in space. Dr. Thomas was selected by NASA for astronaut training in 1992. He flew his first flight into space on the space shuttle *Endeavour* in 1996 on STS-77. In 1998, he served as Board Engineer 2 aboard the Russian *Mir* Space Station for 130 days. Dr. Thomas completed his third space flight on STS-102 in 2001 where he completed a 6½ hour 'space walk' to install components outside the ISS. His most recent flight was on STS-114 in 2005, the 'return-to-flight' mission following the Columbia accident. In total, Dr. Thomas has logged over 170 days in space. He currently serves as liaison from the Astronaut Office to the various NASA organizations involved in planning deep space exploration. Dr. Thomas received a doctorate in mechanical engineering from the University of Adelaide in 1978.

Dr. Ron Turner**Analytic Services, Inc.**

Ron Turner is a Fellow with Analytic Services Inc. He is an expert in radiation risk management for astronauts, particularly in response to solar storms. He is on the National Research Council (NRC) Committee on Solar and Space Physics, is Co-Lead of the Research to Operations working group supporting the NRC Heliophysics Decadal Survey, and recently supported the NRC Committee for the Evaluation of Radiation Shielding for Space Exploration. Dr. Turner is on the Advisory Council to the National Space Biomedical Research Institute Center for Acute Radiation Research. He served on an NRC Committee looking at precursor measurements necessary to support human operations on the surface of Mars. Dr. Turner earned his Ph.D. in physics from the Ohio State University.

Dr. Don Yeomans**NASA Jet Propulsion Laboratory (JPL)**

Don Yeomans is a JPL Fellow, Senior Research Scientist, Manager of NASA's Near-Earth Object Program Office and Supervisor of the Solar System Dynamics Group. Dr. Yeomans was the Radio Science team chief for NASA's Near-Earth Asteroid Rendezvous (NEAR) mission. He is currently the NASA Project Scientist for the JAXA Hayabusa mission, and he is a scientific investigator on NASA's Deep Impact mission. He also provided the accurate predictions that led to the recovery of comet Halley at Palomar Observatory in 1982 and enabled the discovery of 164 BC Babylonian observations of comet Halley on clay tablets in the British Museum.

Notes: