POLICY, PATHWAYS, TECHNIQUES, AND CAPABILITIES: PRINT ONLY

Anderson R. C. Hodges K. Burdick J. Lester D.
Future Planetary Science Opportunities Augmented by Exploration Telepresence **[#8103]**
We report on a workshop about low latency telerobotics in the interest space science. This workshop considered a strategy where nearby astronaut-scientists do field science at high efficiency, lower cost, and greater safety than with workers on-site.

Aru M. Janhunen P.
E-Sail for Fast Interplanetary Travel **[#8056]**
The electric solar wind sail is a propellantless propulsion concept that utilizes solar wind to produce small but continuous thrust, which can accelerate a spacecraft to speeds of 20 to 30 au/year. This opens new possibilities for space exploration.

Aye K.-M. Muench A.
Data Technologies for Planetary Science of the Next 3 Decades **[#8215]**
We describe our vision on the required data and reproducibility technologies for the next 3 decades.

Beauchamp P. M. Cutts J. A. Mercer C. Dudzinski L. A.
Technology Planning for NASA's Future Planetary Science Missions **[#8051]**
As we look far into the future and imagine what we might be doing in planetary science in 2050 and beyond, we must also develop an iterative, dynamic technology planning process that fulfills our goals and is flexible enough to accommodate changes.

Becker T. L. Edmundson K. L. Sides S. Hare T. M. Laura J. R.
Looking to 2050: The USGS Integrated Software for Imagers and Spectrometers (ISIS) **[#8218]**
Astrogeology Science Center develops and maintains software (ISIS) in support of planetary data for a diverse set of missions. We plan to provide support through the future while adapting to changes in hardware, software, and science requirements.

Bennett C. J.
The Incorporation of Multi-Dimensional Spectroscopic Techniques in the Future of Planetary Science **[#8194]**
The 3D-IR Raman technique described offers unique capabilities and advantages over traditional spectroscopic techniques including unambiguous identification of chiral biomarkers potentially down to parts per quadrillion levels (10^{-15}).

Berliner A. J. McKay C. P.
The Terraforming Timeline **[#8031]**
We propose the following abstract on a martian terraforming timeline as a guide to shaping a roadmap and planetary science research over the coming century.

Bleacher J. E. Evans C. A. Graff T. G. Young K. E. Zeigler R.
Planetary Science Training for NASA's Astronauts: Preparing for Future Human Planetary Exploration **[#8088]**
Astronauts selected in 2017 and in future years will carry out *in situ* planetary science research during exploration of the solar system. Training to enable this goal is underway and is flexible to accommodate an evolving planetary science vision.

Cichan T. Murrow D. W. Jolly S. D. Bierhaus E. B. Clark B.
Science Possibilities Enabled by the Mars Base Camp Human Exploration Architecture **[#8208]**
The Mars Base Camp architecture study reveals scientific possibilities enabled by a crewed orbital base camp, and that collaborative human and robotic missions should be part of the vision for Mars exploration by 2050.

Cutts J. A. Pauken M. Hall J. L. Baines K. H. Grimm R.
Future Role of Aerial Platforms at Venus **[#8089]**
This paper reviews the brief experience with deploying aerial platforms at Venus, the various mission concepts that have been proposed over the last three decades, and a vision for their application through 2050.

Dankanich J. W. Lozano P. C.
Dual Mode Green Propulsion for Revolutionary Performance Gains with Minimal Recurring Investments **[#8155]**
Dual mode green propulsion has potential to supplant state of the art alternatives. Mission potential includes doubling science payloads for reference missions, increasing targets for a Trojan tour, and enabling missions such as Ceres Sample Return.

Eubanks T. M. Radley C. F.
Extra-Terrestrial Space Elevators and the NASA 2050 Strategic Vision **[#8172]**
Extra-terrestrial space elevators are technically feasible with current materials and can be part of a transportation network to fulfill NASA's strategic exploration goals for the next three decades.

Grady M. M. Russell S. S. Euro-Cares Team
The Requirement for a Returned Sample Curation Facility in Europe **[#8075]**
A description of European aspirations for a curation facility for samples returned from a space mission.

Hagerty J. J. Mouginis-Mark P. Schultz P. H. Williams D. A.
The NASA Regional Planetary Image Facility Network: A Globally Distributed Resource for the Planetary Science Community **[#8063]**
Between now and 2050 the RPIFN will serve as a resource for helping users to locate, access, and exploit increasingly complex and voluminous data sets. New initiatives in data visualization will also make valuable resources increasingly accessible.

Haqq-Misra J.
Sustainable Policy Solutions for Space Settlement **[#8001]**
I describe two sustainable policy models for the shared use of space. I discuss the strengths and weaknesses of these ideas in light of existing international agreements and provide a direction for further research on space settlement policy.

Izenberg N. R. McNutt R. L. Grinspoon D. H. Bullock M. A.
Venus and Mars Piloted Interplanetary Roundtrip Expeditions: Science Opportunities of the Next Human Spaceflight Age **[#8005]**
Piloted flybys of Venus may be valuable - even essential - components of the human path to Mars in the coming decades, and present unique synergistic opportunities for Venus planetary science.

Johnson L. Carr J. A. Boyd D.
Deployable Propulsion, Power, and Communications Systems for Solar System Exploration **[#8013]**
NASA is developing thin-film based, deployable propulsion, power, and communication systems for small spacecraft that could provide a revolutionary new capability allowing small spacecraft exploration of the solar system.

Kaplan M. Tadros A.
Advanced Space Robotics and Solar Electric Propulsion: Enabling Technologies for Future Planetary Exploration **[#8232]**
Obtaining answers to questions posed by planetary scientists over the next several decades will require the ability to travel further while exploring and gathering data in more remote locations of our solar system. Timely investments need to be made in developing and demonstrating solar electric propulsion and advanced space robotics technologies.

Landis G. A. Oleson S. R.
Concepts for Exploring the Surface of Venus **[#8178]**
New technologies for high-temperature electronics and components make the design of future missions to Venus feasible.

Laura J. R. Fergason R. L. Skinner J. Gaddis L. Hare T. Hagerty J.
Envisioning a Planetary Spatial Data Infrastructure **[#8110]**
We present a vision of a codified Planetary Spatial Data Infrastructure to support vertical and horizontal data integration and reduce the burden of spatial data expertise from the planetary science expert.

Lawrence D. J.
Permanently Shaded Regions: Future Exploration of a Unique Solar System Environment **[#8053]**
Permanently Shaded Regions (PSRs) are a unique environment from which we can learn fundamental information about the solar system. PSRs are still largely unexplored, and so provide great promise for future science and exploration.

Lewis R. Lupisella M. Bleacher J.
Site Planning and Design to Enable Planetary Science and Human Exploration **[#8223]**
It is critical to properly plan site layout and design of science and habitation assets about and within planetary exploration zones following planetary protection policies and environment management practices for effective robotic and human missions.

Linaraki D. L. Oungrinis K. A.
The Creation of a Beneficial Bioshpere from CO_2 in the Clouds of Venus **[#8135]**
This research resulted in an architectural design for a Venus colony based on multiple factors combination, such as psychology of space, predicted near-future technology, and the identified environmental conditions on Venus.

Loghry C. S. Oleson S. R.
Low Cost Space Access for Planetary Science Missions Using High Power Solar Electric Propulsion **[#8212]**
Rideshare is a low-cost method of space access but has limited launch options. An Orbital Maneuvering Vehicle can be used to achieve ideal orbits. Leveraging electric propulsion allows for orbits of interest for planetary science missions.

MacDonald A. C. Smith P. Daniels M. Besha P. Joseph N. Dolgopolov A.
Strategic Geography of the Solar System and Beyond **[#8168]**
This project is a large infographic with narrative descriptions highlighting elements of the human geography of the solar system that, while not scientific in nature, may have long-run strategic implications for the planetary science community.

Mansell J. R. Johnson N. D. Elliott J. R. Saikia S. J.
An Integrated "Sandwich" Method for Planetary Landing Site and Exploration Zone Selection **[#8116]**
We present a quantitative "sandwich" method of additively combining global maps of relevant data to highlight the most favorable regions of a planetary body for landing human or robotic missions.

Mardon A. A. Mardon C. A.
The Position of Artificial Intelligence in Robotic Space Missions in the Inner and Outer Solar System in 2050 **[#8040]**
Overview discussion of artificial intelligence in robotic missions in 2050.

McEwen A. Bagenal F. McKinnon W. Hansen C. Barnes J. Beauchamp P. Bowman J. Edgington S. Hendrix A. Hofstadler M. Hurford T. Moore J. Paty C. Rathbun J. Sayanagi K. Schmidt B. Spilker L. Turtle E.
Vision for Exploring the Outer Solar System **[#8140]**
Outer solar system targets uniquely address NASA's top-level strategic goal to ascertain the content, origin, and evolution of the solar system and potential for life. The emerging priority is to understand ocean worlds and search for life.

Mercer C. R. Landis G. A.
Interactive Science on Mars **[#8054]**
Swarms of small citizen-driven rovers can conduct Mars surface science missions. Transportation and communication technology needed for human exploration can enable this new interactive science mission architecture.

Miller M. J. Abercromby A. F. J. Chappell S. Beaton K. Kobs Nawotniak S. Brady A. L. Garry W. B. Lim D. S. S.
Extra-Vehicular Activity (EVA) and Mission Support Center (MSC) Design Elements for Future Human Scientific Exploration of Our Solar System **[#8201]**
For future missions, there is a need to better understand how we can merge EVA operations concepts with the established purpose of performing scientific exploration and examine how human spaceflight could be successful under communication latency.

Mustafi S. M. Purves L. P. Willis W. W. Nixon C. N.
Cryogenic Propulsion for Planetary Science Missions **[#8057]**
Liquid hydrogen and liquid oxygen cryogenic propellants can dramatically enhance NASA's ability to explore the solar system. New cryogenic storage techniques will allow NASA to quickly deliver more payload mass to planetary targets of interest.

Neal C. R.
Science and Explorations Synergies – 2050 **[#8186]**
Science and exploration synergies can produce partnerships for missions that achieve much more together than individual directorate funded missions. Mechanisms to facilitate such partnerships are discussed with examples.

Parrish J. C. Beaty D. W. Bleacher J. E.
New Paradigms for Human-Robotic Collaboration During Human Planetary Exploration **[#8018]**
Human exploration missions to other planetary bodies offer new paradigms for collaboration (control, interaction) between humans and robots beyond the methods currently used to control robots from Earth and robots in Earth orbit.

Pieters C. M. Eeed S.
Infrastructure! **[#8065]**
In order to accomplish bold exploration goals during the next several decades, the international space-faring community needs to seriously address infrastructure issues.

Rajagopal A. R. K.
A Long Term Approach on Quantum Computing for Deep Space Explorations **[#8219]**
A long term approach to effectively develop and use quantum algorithms in order to replace classic computation usage and to attack certain optimization areas in space exploration and replace with a far better alternative of quantum computation.

Scheidt D. H. Hibbitts C. A. Chen M. H. Paxton L. J. Bekker D. L.
On the Need for Artificial Intelligence and Advanced Test and Evaluation Methods for Space Exploration **[#8114]**
Implementing mature artificial intelligence would create the ability to significantly increase the science return from a mission, while potentially saving costs in mission and instrument operations, and solving currently intractable problems.

Schmitt H. H. *
Mars is the Earth's Only Nearby Early Life Analog, but the Moon is on the Path to Get There **[#8019]**
Mars provides a geological integration of the early solar system impacts recorded by the Moon and the contemporaneous water-rich pre-biotic period on Earth. Consideration of human missions to Mars needs to include a return to the Moon to stay.

Skinner J. A.
Evolving Planetary Geologic Mapping Efforts in Future Decades by Implementing a Common Framework for Scientific Investigation, Exploration, and Policy **[#8243]**
Planetary geologic maps constitute a fundamental and objective scientific foundation upon which research results are communicated and placed into a broader context and need to be strategically planned to support NASA's long-term goals.

Spann J. F. Niles P. B. Weber R. C. Needham D. H.
Science and Exploration Workshop: A Forum to Articulate Science Enabled by Space Exploration **[#8150]**
This talk outlines a plan to coordinate existing efforts that leverage human exploration and robotic investigations in a crucial step towards improving crew safety and enhancing science returns during upcoming space exploration operations.

Spry J. A.
Planetary Protection as an Enabler in the Exploration of the Solar System **[#8244]**
A review of the advances in planetary protection technologies and practice necessary for the exploration of the solar system in the 2050 timeframe.

Surampudi R. Bugga K. Grandidier J. Cutts J. A. Beauchamp P. M.
Venus Exploration Power Technologies **[#8093]**
Venus with its severe temperatures and pressures presents formidable challenges for powering *in situ* exploration vehicles. This paper describes possible approaches for both power generation and energy storage.

Venkatapathy E. Gage P. Munk M. Ellerby D. Stackpoole M.
Sample Return from Water Worlds: Requirements, Risks, and Enabling Technologies **[#8227]**
Planetary protection requirements make sample return missions from Mars, Enceladus, Titan, and Europa a grand challenge for entry, descent, and landing. Ways to address the challenges are explored with emerging new technologies.

Wiegmann B. Loghry C.
Routine and Recurring Economical Delivery of Missions (RAREDOM) to Beyond Earth Orbit Destinations **[#8154]**
The presentation will show how off-the-shelf hardware can be assembled into a deep space spacecraft that can deliver ~700 kg of scientific payload per GTO launch for a total cost of $50 to $80 million dollar range or $70k to $115k per kg of payload.

Yakovlev V. V.
Mars Terraforming — The Wrong Way **[#8010]**
Because of the damage that will injure the human physiology, the colonies on Mars and satellites are unpromising. The applied scientific elaborations connected with the independent biospheres creation with artificial gravitation should be the priority.

Yun P. Y.
NASA Planetary Science Division Vision 2050 Through Human Exploration **[#8009]**
Next 34 years PSD should play the role of the 21st century-version Lewis and Clark expedition to gather critical information about carefully chosen target celestial bodies in our solar system. PSD missions and human missions will benefit each other.

Zacny K. Morrison P. Vendiola V. Paz A.
Volatile Extractor (PVEx) for Planetary In Situ Resource Utilization **[#8082]**
Here we present a trade study and final approach for efficient extraction of volatiles from planetary regolith for the purpose of In Situ Resource Utilization. The project is SBIR funded and hardware is being fabricated.