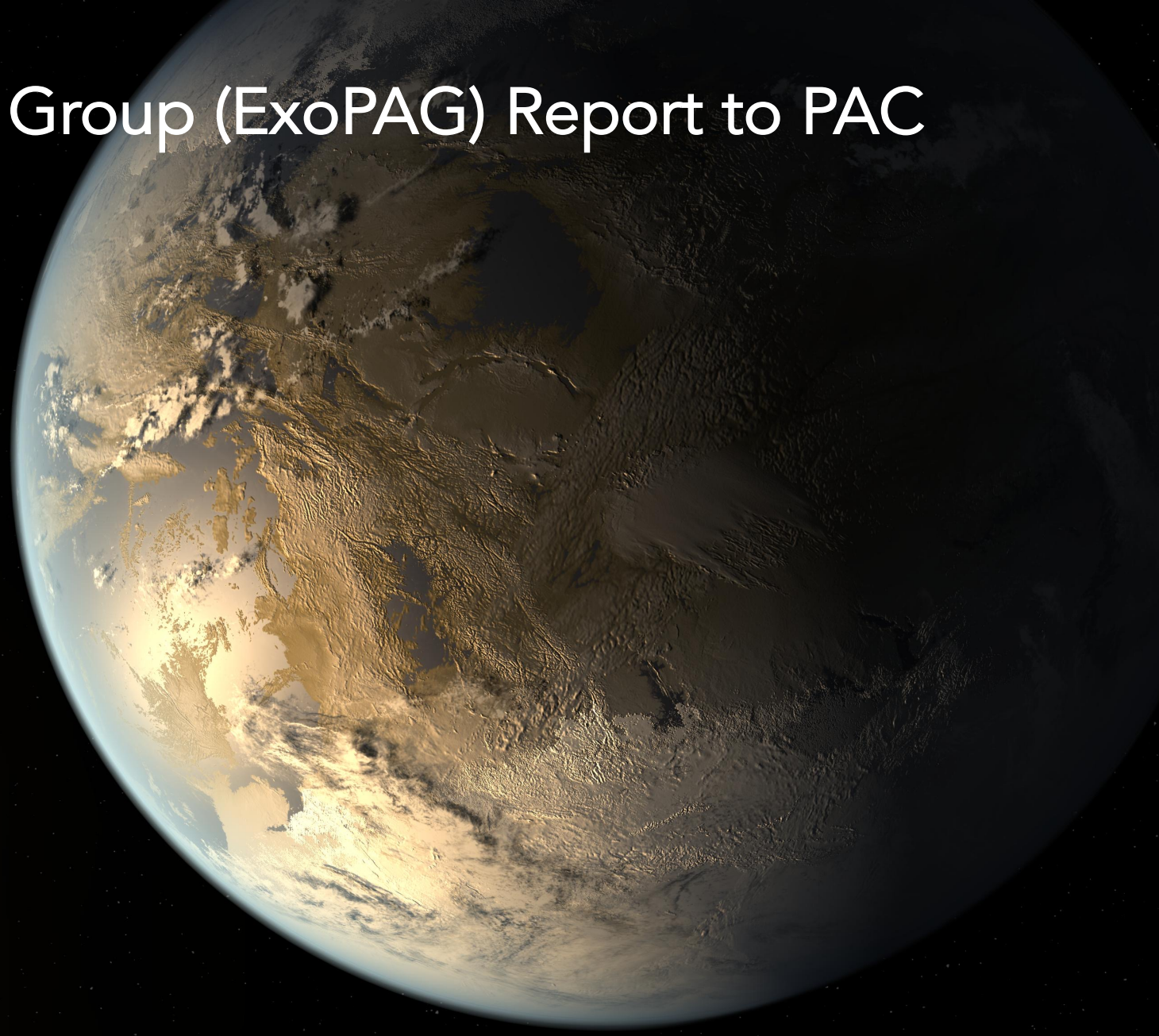
ExoPAG

Exoplanet Program Analysis Group (ExoPAG) Report to PAC

Michael Meyer (U. Michigan)
Chair, ExoPAG Executive Committee

June 21, 2022



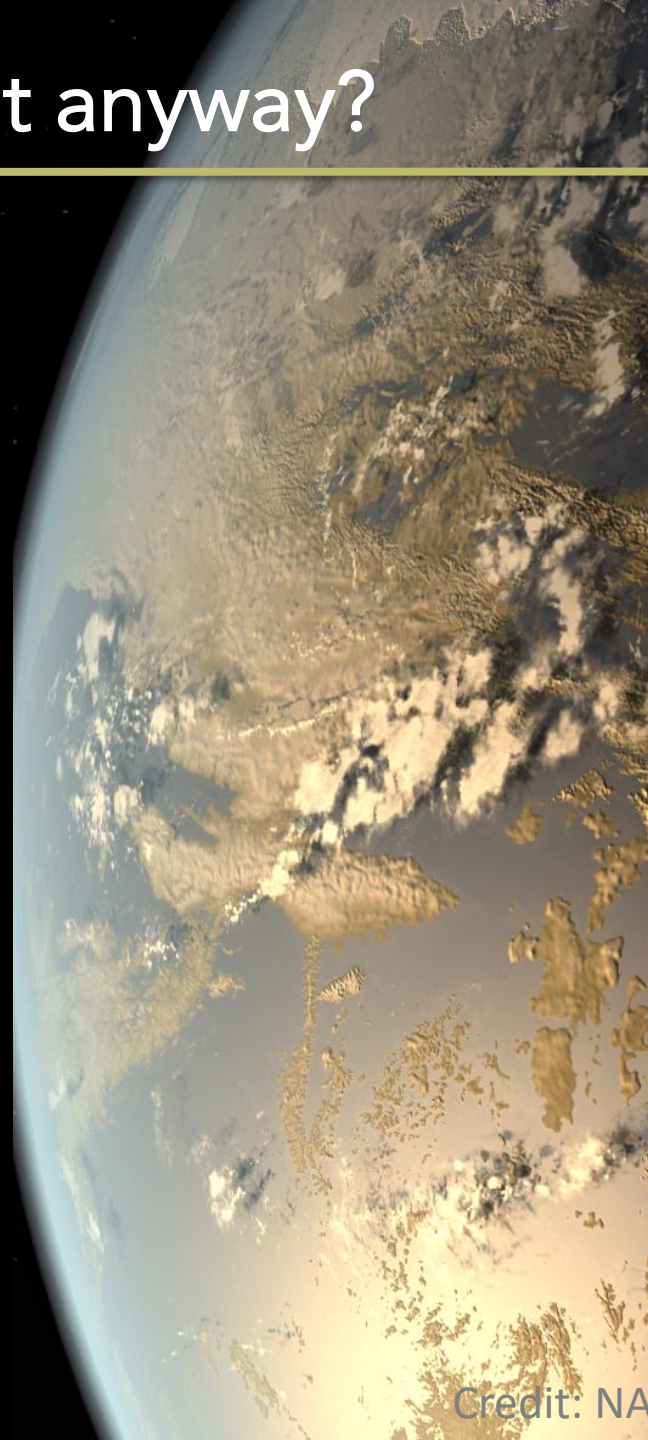
Credit: NASA

Exoplanet Program Analysis Group: What is that anyway?

ExoPAG Terms of Reference

Exoplanet Program Analysis Group
Chartered by the Astrophysics Division

1. Articulate & prioritize science drivers for Exoplanet Exploration research;
2. Evaluate capabilities of potential missions to achieve program goals;
3. Evaluate ExEP activities with broad community input;
4. Articulate & prioritize new mission technologies; and
5. Provide findings on all related program activities including:
   - ground-based observing,
   - theory and modeling programs,
   - laboratory astrophysics,
   - suborbital investigations,
   - data archiving and
   - community engagement.

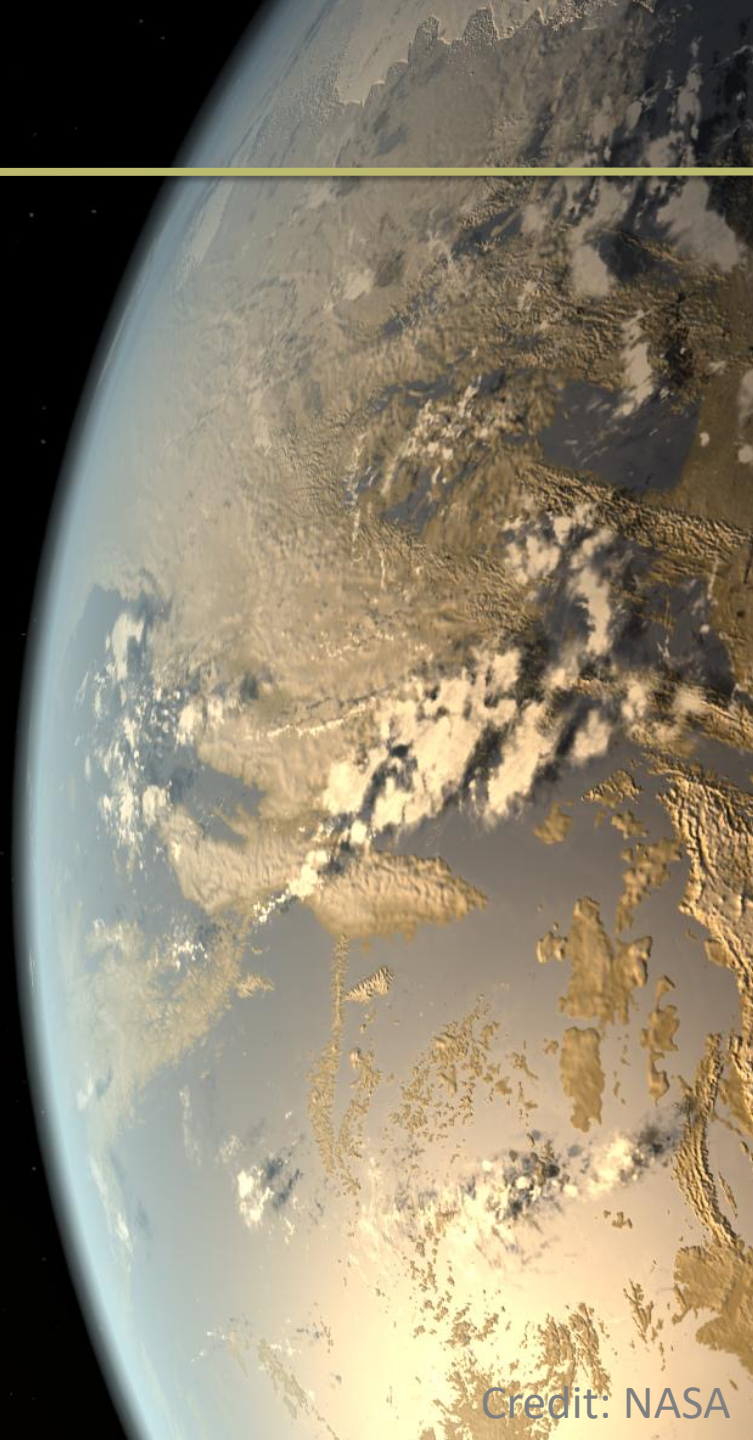


Credit: NA

ExoPAG Executive Committee

Michael Meyer (Chair)	*University of Michigan*
Natasha Batalha	NASA-Ames
Jacob Bean	The University of Chicago
Michael Bottom	The University of Hawaii
Ofer Cohen	University of Massachusetts Lowell
Knicole Colon	Goddard Space Flight Center
John Debes	Space Telescope Science Institute
Tiffany Kataria	*JPL/Caltech*
Ilaria Pascucci	The University of Arizona
Josh Pepper	*Lehigh University*
Dmitry Savransky	*Cornell*
Laura Schaefer	Stanford University
Douglas Hudgins (Astrophysics)	NASA HQ
Hannah Jang-Condell (ExEP DS)	NASA HQ
Doris Daou (Planetary Liaison)	NASA HQ
Richard Eckman (Earth Liaison)	NASA HQ
Gaylan Fowler (Heliophys Liason)	NASA HQ

Thank you for your service…

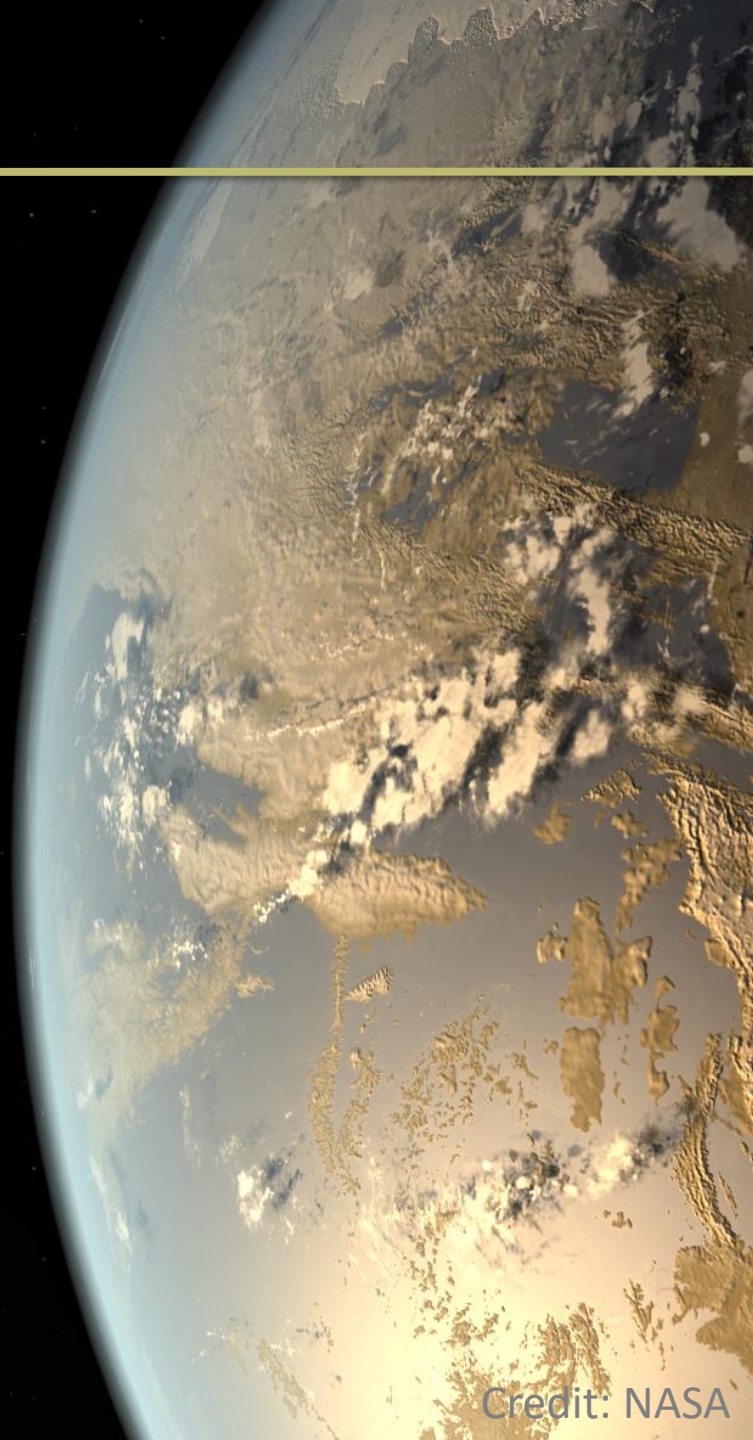


Credit: NASA

ExoPAG Executive Committee

Michael Meyer (Chair Emeritus)	*University of Michigan*
Natasha Batalha	NASA-Ames
Jacob Bean	The University of Chicago
Michael Bottom	The University of Hawaii
Ofer Cohen	University of Massachusetts Lowell
Knicole Colon	Goddard Space Flight Center
John Debes	Space Telescope Science Institute
Diana Dragomir	*U. New Mexico*
Erin May	*JHU/APL*
Bertrand Mennesson	*JPL/Caltech*
Ilaria Pascucci (Chair)	*The University of Arizona*
Laura Schaefer	Stanford University
John Wisniewski	U. Oklahoma
Douglas Hudgins (Astrophysics)	NASA HQ
Hannah Jang-Condell (ExEP DS)	NASA HQ
Doris Daou (Planetary Liaison)	NASA HQ
Richard Eckman (Earth Liaison)	NASA HQ
Gaylan Fowler (Heliophys Liason)	NASA HQ

Welcome to our newest members!



Credit: NASA

ExoPAG 26 June 11-12, 2022
AAS #240, Pasadena, CA

June 11, 2022

Session 1 (Chair: Michael Meyer)	Speaker	Time (PDT)	Duration	End
Welcome	Michael Meyer	9:00 AM	0:15	9:15 AM
NASA Headquarters Exoplanet Exploration Program	Hannah Jang-Condell	9:15 AM	0:30	9:45 AM
Exoplanet Exploration Program (ExEP) Office	Christine Moran	9:45 AM	0:15	10:00 AM
ExEP Science	Eric Mamajek	10:00 AM	0:20	10:20 AM
NExScI and NASA Exoplanet Archive Update	David Ciardi	10:20 AM	0:20	10:40 AM
BREAK (30 min)		10:40 AM	0:30	11:10 AM
Early Career Talk: Novel Methylated Biosignatures: Outcomes of a General Metabolic Process as a New Class of Biosignatures	Michaela Leung	11:10 AM	0:15	11:25 AM
Early Career Talk: Precise Dynamical Masses of New Directly Imaged Companions from Combining Relative Astrometry, Radial Velocities, and Hipparcos-Gaia eDR3 Accelerations	Emily Rickman	11:25 AM	0:15	11:40 AM
ExEP Technology Update	Brendan Crill	11:40 AM	0:30	12:10 PM
LUNCH BREAK (90 min)		12:10 PM	1:30	1:40 PM

Session 2 (Chair: Knicole Colon)	Speaker	Time (PDT)	Duration	End
Early Career Talk: On the nature of small planets orbiting low-mass stars	Rafael Luque	1:40 PM	0:15	1:55 PM
Where We Explore	Anjali Tripathi	1:55 PM	0:15	2:10 PM
Exoplanets with Gaia	Timothy Brandt	2:10 PM	0:30	2:40 PM
SIG 3 Update: Exoplanet/Solar System Synergies	Laura Mayorga (remote share)	2:40 PM	0:30	3:10 PM
BREAK (30 min)		3:10 PM	0:30	3:40 PM

Session 3 (Chair: Diana Dragomir)	Speaker	Time (PDT)	Duration	End
Overview of NExSS Working Groups	Dawn Gelino	3:40 PM	0:15	3:55 PM
NExSS Quantitative Habitability	Rory Barnes	3:55 PM	0:20	4:15 PM
Coronagraph Innovation	Rus Belikov/Kevin Fogarty (remote share)	4:15 PM	0:20	4:35 PM
Adjourn		4:35 PM		

June 12, 2022

Session 4 (Chair: Bertrand Mennesson)	Speaker	Time (PDT)	Duration	End
Early Career Talk: First results from the Distant Giants survey: 10 new long-period companions	Judah Van Zandt	9:00 AM	0:15	9:15 AM
Recap of Precursor Science Workshop	Terri Brandt (remote share)	9:15 AM	0:15	9:30 AM
ExoSET- Exoplanet Science Evaluation Team	Rhonda Morgan	9:30 AM	0:20	9:50 AM
Great Observatories Maturation Program (GOMaP) Interfaces to ExoPAG	Gary Blackwood	9:50 AM	0:15	10:05 AM
GOMaP Stage 1 Technology Activities	Nick Siegler	10:05 AM	0:20	10:25 AM
BREAK (20 min)		10:25 AM	0:20	10:45 AM

Session 5 (Chair: M. Meyer)	Speaker	Time (PDT)	Duration	End
Business Meeting: Introduce incoming Chair, Discuss New SIGs/SAGs, Discuss Potential New Findings, Review progress on past suggestions, propose new suggestions, Announcements, etc.		10:45 AM	1:30	12:15 PM
Adjourn		12:15 PM		

June 12, 2022

Joint Program Analysis Group (PAG) Session 3:00-5:00 PDT (*Sheraton Pasadena Hotel - Piazza Room*)

ExoPAG 26
Code of Conduct
June 11-12, 2022

Attendees of ExoPAG 26 are expected to abide by the following Code of Conduct.

The organizers are committed to making this meeting productive and enjoyable for everyone, regardless of gender, sexual orientation, disability, physical appearance, body size, race, nationality or religion. We will not tolerate harassment or bullying of participants in any form. Please follow these guidelines:

- Behave professionally. Harassment, bullying, and sexist, racist, or exclusionary comments or jokes are not appropriate. Harassment includes sustained disruption of talks or other events, inappropriate physical contact, sexual attention or innuendo, deliberate intimidation, stalking, and photography or recording of an individual without consent. It also includes offensive comments related to gender, sexual orientation, disability, physical appearance, body size, race or religion.
- All communication should be appropriate for a professional audience including people of many different backgrounds. Sexual language and imagery is not appropriate.
- Be kind to others. Do not insult or put down other attendees. Critique ideas, not people.
- If participants wish to share photos or contents of talks/slides of any attendee or speaker on social media, we ask that they first get permission.

Participants asked to stop any inappropriate behavior are expected to comply immediately. Attendees violating these rules will be asked to leave the event at the sole discretion of the organizers.

Any participant who wishes to report a violation of this policy is asked to speak, in confidence, to Hannah Jang-Condell (hannah.jang-condell@nasa.gov) or Michael Meyer (mrmeyer@umich.edu)

ExoPAG Recent Activities (since February PAC)

- Reviewing proposals/reports for/from SAGs/SIGs
- New APD Cross PAG activities:
  - Astro 2020 Discussions (met with P. Hertz).
  - Cross PAG SAG on URM in APD Space Science (R. Hickox).
  - Cross PAG SAG on Great Observatories (G. Tremblay).
- ExoExplorers 2022 program on-going (T. Kataria).
- Report out to APAC in March.
- Supporting GOMAP Precursor Science Workshops.
- New actions re: Astro 2020 (e.g. met w/ NExSS).
- Review new proposed findings.

Credit: NA

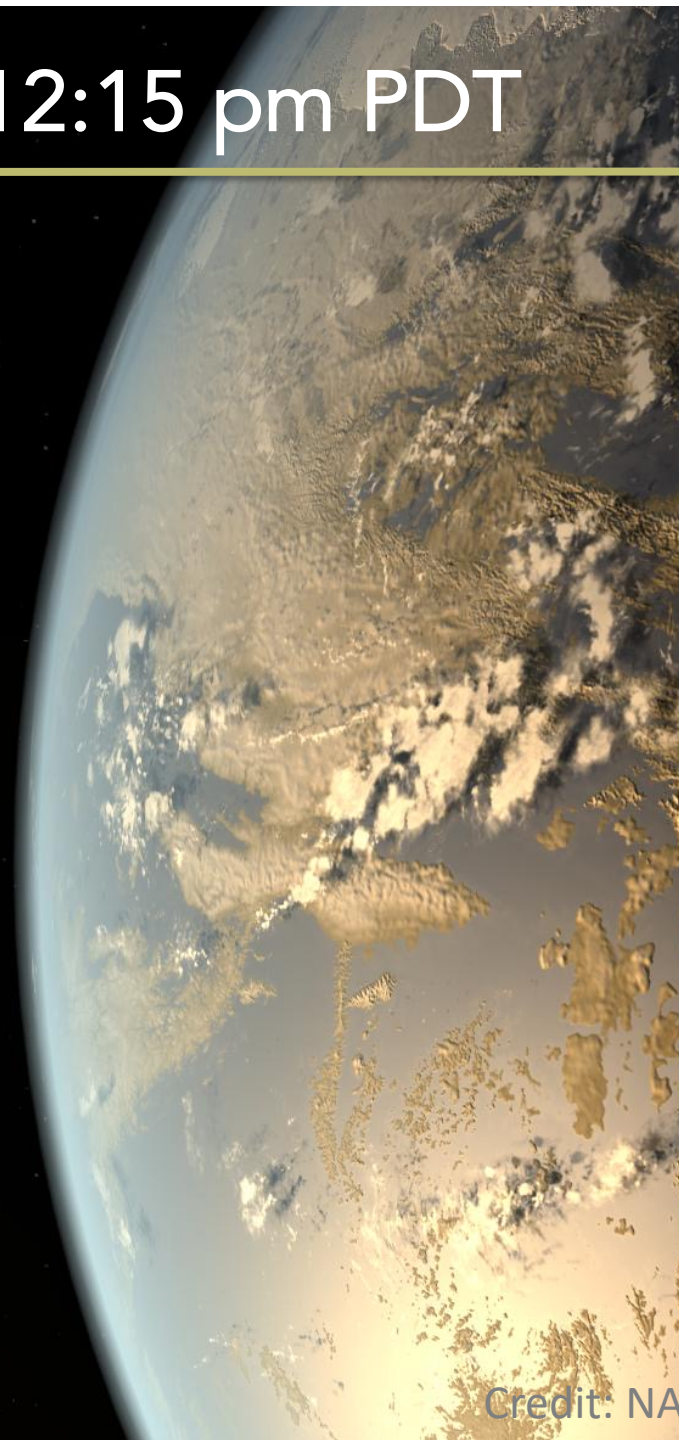
Current Status of SAGs and SIGs

Close Year	SAG or SIG	Title	Lead
----	SIG 2	Exoplanet Demographics (on-going)	Christiansen & Meyer
----	SIG 3	Exoplanet Solar System Synergies (on-going).	Meadows & Mandt
----	SAG 21	Stellar Contamination on Transit Spectra (final report accepted)	Rackham & Espinoza
----	SAG 22	Exoplanet Host Properties (final report accepted)	Pepper, Stark, & Hinkel
----	SAG 23	Debris Disk Properties of Exoplanet Hosts (initiated)	Debes, Rebollido, & Hasegawa

Credit: NA

ExoPAG 26 Business Meeting: June 12 10:45-12:15 pm PDT

- Update on new SAG23 (I. Rebollido).
- Voted on proposed finding concerning XRP funding:
  - 13 % success rate doesn't support young diverse community or efficiently make progress towards NASA's strategic goals.
  - 34 in favor, 0 against, 1 abstention.
- New ideas for ExoPAG priorities and activities:
  - Support for new Cross PAG SAG in support of GOMAP Activities for IROUV.
- Review of progress on past suggested actions.
- Feel free to share announcements for the community.
  - TDAMM (J. Pepper), and new Astrophysics Mission School!
- Executive Committee interested in considering new format for meetings including better use of shared time together (and better presentations).



Credit: NA

ExMAG

Extraterrestrial Materials Analysis Group (ExMAG)

PAC meeting, June 2022

Barbara Cohen, Chair
ExMAG.community@gmail.com

ExMAG membership

ExMAG STEERING COMMITTEE

ExMAG Chair
Barbara Cohen

Astromaterials Curator
Francis McCubbin

NASA HQ Liaison
Jeff Grossman

Exploration Hardware Subcommittee
Space-exposed hardware collections, future hardware
Rhonda Stroud, acting

Facilities and Informatics Subcommittee
Sample curation facilities, databases, and catalogs
Pierre Haenecour
Rhiannon Mayne

Chair:
Barbara Cohen (GSFC)

Members:
Jemma Davidson (ASU), Vice-Chair
Emma Bullock (CIW), Secretary
Jessica Barnes (U of Arizona)
Kate Burgess (NRL)
Justin Filiberto (LPI)
Jon Friedrich (Fordham)
Juliane Gross (Rutgers)
Pierre Haenecour (UA)
Lydia Hallis (U Glasgow)
Munir Humayun (FSU)
Manavi Jadhav (UL)
Rhiannon Mayne (TCU)
Larry Nittler (CIW)
Caroline Smith (NHM London)
Rhonda Stroud (NRL)

Lunar Sample Subcommittee
Apollo samples, Artemis sample planning
Jessica Barnes

Mars Sample Subcommittee
MMX and Mars Sample Return planning
Justin Filiberto and Caroline Smith

Microparticle Subcommittee
Cosmic Dust, Stardust mission, microparticle impacts
Rhonda Stroud

Asteroid Subcommittee
Hayabusa, Hayabusa-2, OSIRIS-Rex
Munir Humayun

Meteorite Subcommittee
Antarctic meteorites
Jon Friedrich

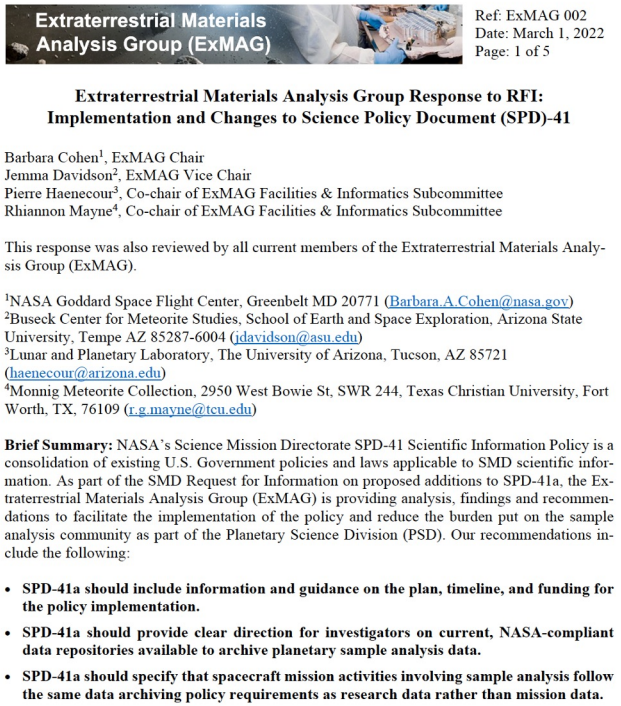
Genesis Subcommittee
Genesis mission
Larry Nittler

ExMAG recent activities

- Science Mission Directorate SPD-41 Feedback
- ExMAG is using Google Docs for committee business – it is free and accessible, but insecure. Is this an issue? Is there a better solution?
- Spring 2022 Meeting - Virtual, April 13-14 2022
  - Focused on curation and collections reports
  - Lightning science talks that highlighted what people are doing with the collections
  - Lots of actions for the committee; three findings for PAC
- Fall 2022 Meeting - Virtual, October 12-13, 2022
  - Decadal Survey, upcoming missions, facilities & informatics

ExMAG feedback for SPD-41

- NASA's Science Mission Directorate SPD-41 Scientific Information Policy
- **Recommendations**
  - SPD-41a should include information and guidance on the plan, timeline, and funding for the policy implementation.
  - SPD-41a should provide clear direction for investigators on current, NASA-compliant data repositories available to archive planetary sample analysis data.
  - SPD-41a should specify that spacecraft mission activities involving sample analysis follow the same data archiving policy requirements as research data rather than mission data.
- ExMAG is looking forward to engaging with the Planetary Data Ecosystem activity to include issues and topics specific to sample analysis that have not been considered so far



Extraterrestrial Materials Analysis Group (ExMAG)

Ref: ExMAG 002
Date: March 1, 2022
Page: 1 of 5

Extraterrestrial Materials Analysis Group Response to RFI: Implementation and Changes to Science Policy Document (SPD)-41

Barbara Cohen[1], ExMAG Chair
Jemma Davidson[2], ExMAG Vice Chair
Pierre Haenecour[3], Co-chair of ExMAG Facilities & Informatics Subcommittee
Rhiannon Mayne[4], Co-chair of ExMAG Facilities & Informatics Subcommittee

This response was also reviewed by all current members of the Extraterrestrial Materials Analysis Group (ExMAG).

[1]NASA Goddard Space Flight Center, Greenbelt MD 20771 (Barbara.A.Cohen@nasa.gov)
[2]Buseck Center for Meteorite Studies, School of Earth and Space Exploration, Arizona State University, Tempe AZ 85287-6004 (jdavidson@asu.edu)
[3]Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721 (haenecour@arizona.edu)
[4]Monnig Meteorite Collection, 2950 West Bowie St, SWR 244, Texas Christian University, Fort Worth, TX, 76109 (r.g.mayne@tcu.edu)

Brief Summary: NASA's Science Mission Directorate SPD-41 Scientific Information Policy is a consolidation of existing U.S. Government policies and laws applicable to SMD scientific information. As part of the SMD Request for Information on proposed additions to SPD-41a, the Extraterrestrial Materials Analysis Group (ExMAG) is providing analysis, findings and recommendations to facilitate the implementation of the policy and reduce the burden put on the sample analysis community as part of the Planetary Science Division (PSD). Our recommendations include the following:

- **SPD-41a should include information and guidance on the plan, timeline, and funding for the policy implementation.**
- **SPD-41a should provide clear direction for investigators on current, NASA-compliant data repositories available to archive planetary sample analysis data.**
- **SPD-41a should specify that spacecraft mission activities involving sample analysis follow the same data archiving policy requirements as research data rather than mission data.**

Spring 2022 Meeting

Time (EDT)	Wednesday April 13
10:00 AM	**Coffee with ExMAG leadership**
11:00 AM	Welcome, ExMAG activities, HQ updates, JSC Curation update
12:25 PM	Hayabusa & OSIRIS-REx
2:00 PM	**---Break ----**
2:30 PM	Genesis
3:30 PM	Apollo, Artemis, and Chang'E
5:00 PM	**END OF DAY 1**
Time (EDT)	**Thursday April 14**
10:00 AM	**NASA HQ Q&A for ECRs**
11:00 AM	Stardust, microparticle impacts, and space-exposed hardware
12:30 PM	MMX and Mars Sample Return
1:50 PM	**---Break ----**
2:20 PM	Meteorite collections
3:50 PM	**ExMAG Findings and Discussion**
5:00 PM	**END OF DAY 2**

No Due Date (NoDD) Selection Information

ExMAG and the community eagerly anticipate learning more about the progress that NASA is making using its No Due Date (NoDD) grant submission and review process, and the submission and selection statistics. In ExMAG's community discussion, we were alerted to the fact that under NoDD, PIs with "selectable" proposals are experiencing heightened uncertainty regarding when final adjudications will be made, enabling them to prepare for work or additional proposals. Though we understand the NoDD programs are evolving, **ExMAG recommends that in their evaluation documents, NASA programs provide a date by which "selectable" proposals would be informed of their final status**.

Resuming ANSMET Activities

For over four decades, the U.S. has annually performed meteorite recovery through ANSMET (the Antarctic Search for Meteorites Program). The meteorites recovered by ANSMET are vitally important for planetary research, providing scientists from around the world with samples of planetary bodies not easily obtainable by other means. Due to the ongoing COVID-19 pandemic, the 2020-21 and 2021-22 ANSMET field seasons were canceled, and we were recently made aware that the 2022-2023 season has also been canceled. **ExMAG again recommends that NASA and NSF ensure the continuity of terrestrial sample collection efforts by resuming a robust ANSMET field season as soon as practical.**

Chang'E-5 Sample Availability for US Researchers

The successful Chang'e 5 mission has returned the first new lunar samples in decade and scientists the world over continue to be involved in their analysis. However, federally-funded US researchers continue to face concerns about working with Chang'E samples using NASA funding, which could constitute a violation of the Wolf Amendment. **ExMAG continues to encourage NASA to explore a path to permit sample exchange and reciprocal sample loans between NASA and CNSA for the Chang'E-5** and Apollo samples specifically, and potentially to broaden such a program to encompass the substantial Antarctic meteorite collections of both nations and future sample-return missions. *(endorsed by LEAG)*

MAPSIT

Mapping and Planetary Spatial Infrastructure Team (MAPSIT)

Findings for the Planetary Advisory Committee (PAC) June 21, 2022 Meeting

MAPSIT Steering Committee

Brad Thomson (Univ. Tenn.), *Chair*

Julie Stopar (LPI), *Vice Chair*

Brent Archinal (USGS)

Ross Beyer (SETI/NASA Ames)

Dani DellaGiustina (Univ. Arizona)

Sander Gossens (NASA Goddard)

Justin Hagerty (USGS), *Ex Officio*

Trent Hare (USGS)

Jay Laura (USGS)

Sam Lawrence (JSC), HEOMD rep, *Ex Officio*

Myriam Lemelin (Université de Sherbrooke, Canada)

Jeannette Luna (Tennessee Tech Univ.)

Becky McCauley Rench (NASA HQ), *Ex Officio*

Moses Milazzo (Other Orb), *Ex Officio*

Pete Mouginis-Mark (Univ. Hawaii)

Andrea Naß (DLR, Germany)

Jani Radebaugh (Brigham Young Univ.), *past Chair*

David Williams (Arizona State Univ.)

MAPSIT Findings (1 of 4)

Finding: MAPSIT endorses the reconstitution of GEMS (Geologic Mapping Subcommittee)

- A draft Operational Charter for GEMS has been provisionally approved by MAPSIT. This charter is open for comments
- Goal of GEMS is to identify and plan for geologic mapping-related needs within the planetary data ecosystem. GEMS will:
  - Serve as a dedicated communication conduit
  - Ensure a dedicated venue for the collection and consolidation of perspectives from various scientific communities and disciplines regarding mapping
  - Participate in discussions with the USGS Planetary Mapping Group
- Draft charter posted: https://www.lpi.usra.edu/mapsit/

MAPSIT Findings (2 of 4)

Finding: MAPSIT is encouraged by MRO Overguide support for conversion of legacy data, but is discouraged by lost science

- This is a follow-up on a previous MAPSIT Finding (Feb 2022) regarding SPD-41, the Scientific Information policy for SMD
- A prior concern was that multiple data standards are likely without additional funding to convert legacy data
- For MRO, the Planetary Mission Senior Review 2022 “strongly recommend fully funding Overguide #2 for conversion of previous mission data to PDS4 format”
  - This is a positive development that will help address this concern for MRO data
  - However, data conversion was imposed upon active missions (not from community advocacy), and science took a hit. E.g., CRISM is turned off.
  - Other instrument and mission teams producing data under legacy standards should continue to seek additional support to conform to new standards

Source: https://www.lpi.usra.edu/NASA-academies-resources/PMSR22-Final-Report-Package.pdf

MAPSIT Findings (3 of 4)

Finding: MAPSIT encourages continued progress on body-specific Planetary SDIs (Spatial Data Infrastructures)

Example 1: Europa SDI progress

- Formed in 2020 with primary goal to make Europa spatial data (e.g., from Galileo, Voyagers I and II), as discoverable, accessible, and usable as possible.
- For more information: Laura, J. R., Bland, M. T., Fergason, R. L., Hare, T. M., & Archinal, B. A. (2018). Framework for the development of planetary spatial data infrastructures: A Europa case study. *Earth and Space Science*, *5*, 486–502. https://doi.org/10.1029/2018EA000411

MAPSIT Findings (4 of 4)

Finding: MAPSIT applauds the VIPER team for including a lead cartographer in their planning and practice from an early stage

- Volatiles Investigating Polar Exploration Rover (VIPER) team anticipated the importance of geospatial data to their mission, and designated a lead cartographer role
- Some other missions have done this in less formal ways, e.g., Dr. Fred Calef (JPL) is the “keeper of the map” for Mars Science Laboratory
- MAPSIT recommends that NASA strongly encourage or even require this practice

Upcoming relevant activities

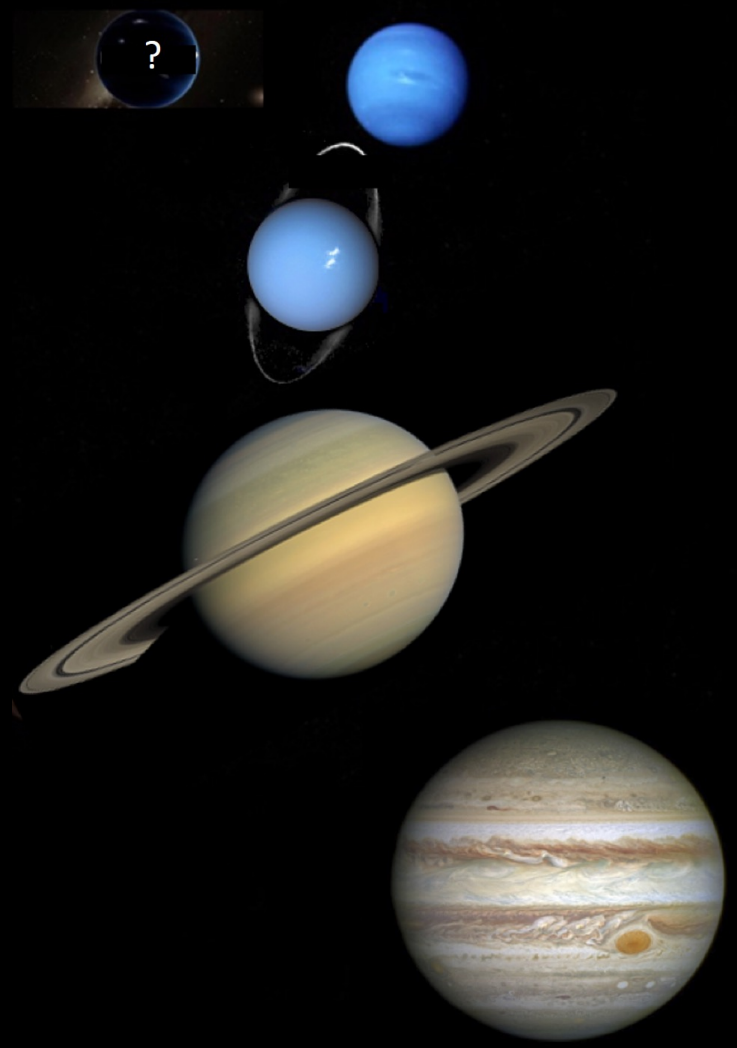
- Planetary Geology Mappers' Meeting, 23-24 June 2022 in Flagstaff, AZ, hybrid format
  - Organizers: Dr. Jeanette Luna (TN Tech) and Jim Skinner (USGS)
- Open Source Science Data Repositories Workshop, 27–30 September 2022
  - Follow-on to the previous Data Repositories Workshop hosted at Glenn Research Center in 2018
  - Organizer: Dr. Steve Crawford, Science Data Officer, Science Mission Directorate
- Technology Showcase to enable future science, Oct 2022
  - Purpose of the showcase is to allow developers of technologies to promote their innovations to scientists and mission managers with the power to influence mission proposals

OPAG

OPAG Update to the Planetary Science Advisory Committee (PAC)

Linda Spilker (JPL), Jeff Moore (NASA ARC), OPAG Co-Chairs, PAC Meeting, 21 June 2022

Outer Solar System: Many Worlds to Explore



OPAG *is* the Comparative Planetology AG

Large KBOs:

OPAG overall impressions of Decadal Survey (OWL)

- **OPAG White paper and Goals Doc are in good agreement with OWL in most areas**
  - **Overall OPAG is very pleased**
- OWL Major Science Questions are Similar to those in OPAG Goals Doc
- OPAG and OWL also consistent with respect to small sat missions, technology development, R&A, and supporting an Ocean Worlds program
- Large Mission Recommendations are Compatible
  - OPAG top recommendation for a new start was an **Ice Giant Systems** mission
    - OWL prioritizes the **Uranus Orbiter and Probe** (UOP) as the highest-priority new Flagship mission for initiation in the decade 2023-2032.
  - OPAG's next large directed mission priority is a mission to search for life or biosignatures on an ocean world, namely **Europa or Enceladus**.
    - The second- highest priority new Flagship mission in OWL is the **Enceladus Orbilander**.
- New Frontiers:
  - The Outer Planets fare well in the NF 6/7 list (3 or 4 of 8 or 9 destinations)
  - Io Observer: not in the NF-6 list

Additional OPAG impressions of OWL

- Issues of concern to OPAG:
  - Outer planets science is significantly reduced in the Level compared to Recommended Program
    - In particular, OPAG is uneasy with the idea that MSR is not allowed any decreases in scope in order to control its costs.
      - **MSR cost increases plus inflation could delay any new missions to the outer Solar System to beyond the next decade.**
  - NF-5 might be the only NF new start in the next decade
    - NF-5 is a hold over from V&V, and does not incorporate recommendations from OWL
    - NF-6, while in the Recommended Program, is “late, or not included” in the Level Program
    - NF-7 is not included in either the Recommended or Level Program
  - Using recommended OWL cost caps, NF is the only program where inner and outer planet missions compete on a level playing field
    - OWL –recommended Discovery cost caps (with the suggested cost structure) are not favorable for outer planet missions
    - For instance, given **current** inflation rates IVO, as studied in 2020-2021, would not fit in an $800M Discovery A-F cap.
  - No support for dedicated solar system space telescope (e.g. for time-domain science)

A selection of *draft* OPAG Findings from June 2022 meeting

- **Finding 1. Start Uranus Orbiter and Probe in FY24**
  - OPAG urges NASA to seek a New Start for Uranus Orbiter and Probe in the FY24 budget, with launch no later than 2032. Starting the mission in FY24 will ensure full science return by maximizing access to the fully illuminated north polar regions of the Uranian system as recommended by OWL for UOP. It will also ensure workforce continuity and maintain the opportunity for a New Start of Enceladus Orbilander within this decade as recommended by OWL.
- **Finding 2. Release the New Frontiers 6 AO as soon as possible**
  - Given that the NF-5 AO will be released earlier than assumed by OWL and the importance of NF for outer planets science, OPAG encourages NASA to release the NF-6 AO as early as possible, consistent with the OWL recommendations, to ensure the OWL-recommended NF-6/7 lists have selection opportunities in the next decade.
- **Finding 3. Ensure adequate RPS availability for upcoming missions** (Update of Finding #1 from the OPAG Fall 2021 meeting)
  - The latest NASA RPS plan (which was formed before OWL recommendations) shows a significant mismatch between Pu^{238} and clad availability, production rates, and RTG needs for OWL-recommended missions.

OPAG Action Items from June 2022 meeting

- OPAG and SBAG are acting to form a working group sourced from OPAG, SBAG, and the broader Ocean Worlds community to develop a coherent Ocean Worlds strategy, as recommended by OWL, for consideration by NASA. This proposed strategy would consolidate R&A, technology development, interagency collaboration, and workforce maturation in support of OWL-recommended missions to Ocean World targets. This action is consistent with a recent SBAG finding to do the same.

- OPAG strongly endorses the community-led actionable recommendations to advance Inclusion, Diversity, Equity, and Accessibility (IDEA or DEIA) within the planetary science and astrobiology community, such as those identified in OWL's State of the Profession chapter, the NASEM report "Advancing DEIA in the Leadership of Competed Space Missions", and "A Consensus Report on Recommendations from the 2022 Advancing IDEA in Planetary Science Conference", among others.

Extra/backup slides

Uranus Ideal Arrival

- One Uranian year = 84 earth years
- Voyager flew by Uranus in 1986 when the sun was shining on the south pole
  - Very little atmospheric activity was visible (although no NIR data was available)
  - Only the southern hemispheres of the moons were illuminated
- The sun crossed the equator (equinox) in 2007
  - Noticeable atmospheric activity became apparent in 2004; still ongoing
- The sun will be shining on the north pole in 2028
  - Could image the un-imaged northern hemisphere of the moons
  - But, the atmosphere may be in a quiescent phase
- Next solar equatorial crossing will be in 2049 – **ideal arrival by 2049!**
  - Uranian atmosphere will be active
  - Both hemispheres of moons can be imaged, including previously unimaged northern hemispheres
  - Unique ring viewing at equinox; search for vertical structures and dusty rings similar to Cassini
  - Lit global coverage degrades as subsolar latitude moves toward south pole
- Absolute "Deadline" is before 1986 + 84 = 2070
  - A mission arriving that late will only see what Voyager saw

Comparison to OWL

UOP Timeline

- Current schedule per OWL and NASA HQ
  - UOP new start 2024 or 2028

- UOP:
  - No substantial tech development required
    - Development schedule can be on short-ish duration, ~6-7 years
  - With 2024 new start can launch in 2031
    - Arrive in 2044, tour brings dates up to “ideal” 2049
  - With 2028 new start can launch in 2036 or 2038
    - Misses the 2049 arrival date but still gets to Uranus in 2052 when most of the northern hemispheres of the moons are illuminated and the atmosphere is still active, but will be less optimal for ring science
- The start of this mission should not be delayed beyond 2028
- If slips in the MSR schedule cause that level of delay consider shifting the order…

Getting to Uranus

- UOP Flagship Study
  - Nominal launch date June 2031; Arrival late 2044
  - Launch opportunities from 2029 to 2038; arrivals range from 2042 to 2052 (for the 2038 launch)
  - Followed by a 2 to 4 year tour

Launch Date	C3 (km²/s²)	Path	DSM (km/s)	UOI (km/s)	PLΔV (km/s)	Post-UOI Mass (kg)	TOF (yrs)
9/30/2029	13.7	EVEEJU	0.00	1.221	1.221	7865.2	14.5
10/31/2029	11.3	EVEEJU	0.00	1.901	1.901	6665.4	13.1
3/7/2031	17.5	EVEEJU	0.05	1.722	1.771	6068.7	12.5
4/3/2031	28.6	E(DV)EJU	0.65	1.033	1.68	4934.7	13.5
6/13/2031	**27.1**	**E(ΔV)EJU**	**0.77**	**1.011**	**1.783**	**4919**	**13.4**
6/15/2031	27	E(ΔV)EJU	0.72	1.251	1.968	4643.5	12.7
7/18/2031	19.8	EVEJU	1.07	1.763	2.834	4089.3	11.6
8/1/2031	18	EVEJU	1.05	1.374	2.426	4855	12.3
8/9/2031	20.2	EVEJU	1.06	1.504	2.561	4433.5	12
4/29/2032	**28.8**	**E(ΔV)EJU**	**0.60**	**0.956**	**1.558**	**5111.5**	**12.8**
5/3/2032	29.2	E(ΔV)EJU	0.76	1.147	1.904	4527.2	12.2
8/15/2032	49.5	E(ΔV)EJU	0.42	1.302	1.726	3056.3	11.8
1/8/2033	*23.6*	*EVEEU*	*0.42*	*1.012*	*1.434*	*5933.3*	*15.3*
5/27/2034	*23.1*	*EVEEU*	*0.68*	*0.946*	*1.629*	*5626.4*	*15.2*
2/28/2036	*28.2*	*EVEEU*	*0.54*	*0.974*	*1.519*	*5240.5*	*15.3*
1/8/2038	*35.5*	*EVEEU*	*0.00*	*1.307*	*1.307*	*4812.3*	*14.2*

Exhibit 3-24. *Feasible launch opportunities with (2029–2032) and without (2033–2038) Jupiter gravity assists. Lighter colors = the best solutions. Bold = primary and backup baselines; italics show example windows without Jupiter flyby.*

Recent and Upcoming OPAG-related Meetings

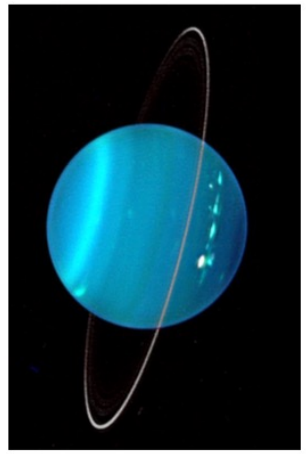
Upcoming Meetings:

- **Next OPAG Meeting at LPI, Houston** (15-17 November, 2022) (Hybrid)
- **PAC meeting at NASA HQ** (21-23 June, 2022) (Hybrid)
- **Possible Town Hall at EPSC in Granada, Spain** (18 – 23 September 2022)
- **Possible Technology Showcase by NASA HQ** (October 2022, date TBD)
- **Possible Town Hall at DPS in London, Ontario** (2 – 7 October 2022)
- **Possible Town Hall at AGU in Chicago** (12 – 16 December 2022)
- **Town Hall at LPSC in Houston** (7-11 March 2023)

Outer Planets Assessment Group (OPAG) Charter

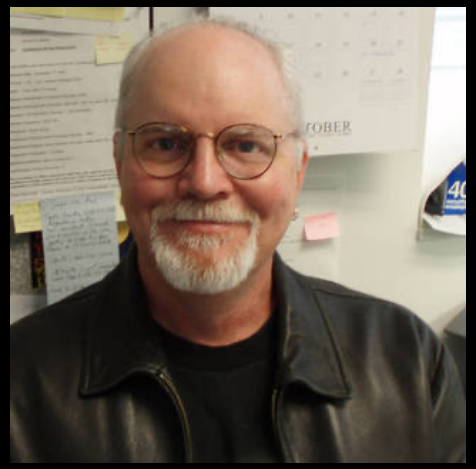
https://www.lpi.usra.edu/opag/

- NASA's community-based forum to provide science input for planning and prioritizing outer planet exploration activities for the next several decades
- Evaluates outer solar system exploration goals, objectives, investigations and required measurements on the basis of the widest possible community outreach
- Meets twice per year, summer and winter
  - Most recent meeting (hybrid): June 14-15 2022
- OPAG and Small Bodies Assessment Group (SBAG) have Joint custody of Pluto system and other planets among Kuiper Belt Objects



KBO planets

OPAG Steering Committee



Jeff Moore
OPAG Co-Chair
Ames Research Center

Linda Spilker
OPAG Co-Chair
Jet Propulsion Lab

* Newest members *

Tibor Balint
Jet Propulsion Lab

Alex Hayes
Cornell University

Sean Hsu
Univ. of Colorado, Boulder

OPAG Steering Committee

Kennda Lynch
Lunar and Planetary Institute

Kathleen L. Craft
Applied Physics Laboratory

Krista Soderlund
University of Texas

Morgan Cable
Jet Propulsion Lab

Kunio Sayanagi
Hampton University

OPAG Steering Committee

Scott Edgington
Jet Propulsion Lab

Amanda Hendrix
Planetary Science Institute

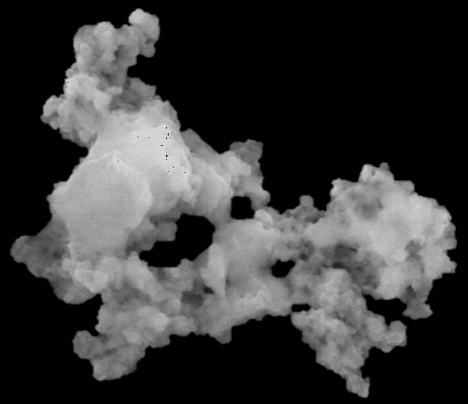
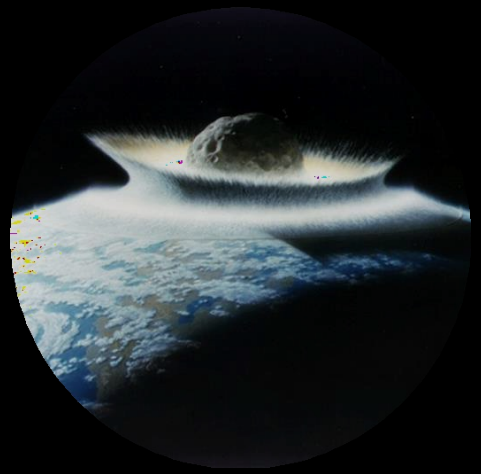
Lynnae Quick
NASA Goddard

Kathleen Mandt
Applied Physics Laboratory

Terry Hurford
NASA Goddard

Carol Paty
University of Oregon

SBAG

SBAG
SMALL BODIES ASSESSMENT GROUP

Bonnie J. Buratti, SBAG Steering Committee Chair
Jet Propulsion Laboratory, California Institute of Technology

June 21, 2022 NASA Planetary Science Advisory Committee (PAC)
Virtual Meeting

© 2022. Government funding acknowledged

www.lpi.usra.edu/sbag/

The Steering Committee

Present Steering Committee

Justin Atchison (JHU/APL) Technology Lead
Maitrayee Bose (Arizona State Univ.)
Bonnie Buratti (NASA JPL/Caltech), Chair
Michael Busch (SETI Inst.)
Terik Daly (APL), Early Career Secretary (rotated off)
Jessie Dotson (NASA Ames), Planetary Defense Lead
Henry Hsieh (Planetary Science Institute)
Mihaly Horanyi (Univ. of Colorado, Boulder)
Stephanie Jarmak (SWRI) Early Career Secretary (2.5 year term)
Stefanie Milam (NASA GSFC)
William O'Hara (Sierra Nevada Corp.), Human Exploration Lead
Jennifer Scully (NASA JPL/Caltech)
Timothy Titus (USGS, Flagstaff)

Thomas Statler NASA Headquarters Liaison
Jake Bleacher Human Exploration and Operations Mission Directorate (HEOMD) Liaison
Paul Abell (JSC) HEOMD Observer

New Members (August 2022): Joseph Masiero (IPAC/Caltech) replaces Jessie Dotson as Planetary Defense Lead; Olivier Barnouin (JHU/APL) and Prajkta Mane (LPI/NASA JSC) replace Jennifer Scully and Maitrayee Bose.
Lori Feaga replaces Bonnie Buratti as Chair, Bonnie continues on the Steering Committee for one year

Steering Committee selects Chair and Steering Committee members from among nominations, applications. Requests go out on the DPS Newsletter, Planetary Exploration Newsletter (PEN), and our listserv. General membership open.

Summary of significant findings

Two significant findings from SBAG#27 (June 7-9, 2022):

1. Planetary Radar
2. NEO Surveyor

One Informational:

Ocean Worlds inter-AG collaborative working group

Two others (SIMPLEx and PDART) are being worked

Note: all findings from SBAG#27 will be posted on the LPI website

Significant Finding #1 from SBAG Meeting #27: RADAR

Radar: SBAG recommends that NASA continue to work with NSF and other agencies to develop a concerted plan for new national resources for planetary radar. This path follows the Decadal Survey recommendation to "develop a plan for ground-based planetary radar capabilities comparable to or exceeding those of the Arecibo Observatory necessary for achieving planetary defense objectives". As well as serving the needs of planetary defense and the broader area of small body science, new radar resources will enable further scientific studies of objects throughout the Solar System.

SBAG#26 Similar Finding: RADAR: SBAG commends NASA for supporting additional asteroid radar observations at other facilities in order to meet a portion of the scientific and planetary defense goals previously accomplished by the Arecibo Observatory. SBAG encourages NASA to continue planned upgrades to radar capabilities at the Goldstone and Canberra Deep Space Network sites, and recommends that NASA continue to work with NSF and other agencies to develop new planetary radar facilities. The current efforts to install a planetary radar system at the existing Green Bank Telescope are an example of how such collaborations can aid the development of additional planetary radar capabilities.

In SBAG #22, #23, and #24 (2020 and 2021), findings on Radar were also advanced, and in the years before as well. This area is a longstanding one of concern and support for SBAG. SBAG commissioned a White Paper *Recovery of Near-Earth Object Science and Planetary Defense Capabilities Lost Due to the Demise of Arecibo:*

https://www.lpi.usra.edu/sbag/documents/SBAG_RadarRecovery_20210305_formattedRTD.pdf

Significant Finding #2 from SBAG Meeting #27: NEO Surveyor

NEO Surveyor: SBAG reiterates its previous support for NEO Surveyor and recommends that NASA should seek to fully fund NEO Surveyor for a timely launch in 2026 as previously planned. NEO Surveyor would greatly accelerate the fulfillment of the George E. Brown Congressional goal of discovering 90% of the near-Earth asteroid (NEA) population larger than 140 meters in size. The National Academies of Science, Engineering, and Medicine's report Finding Hazardous Asteroids Using Infrared and Visible Wavelength Telescopes has emphasized the importance of a space-based near-infrared asteroid survey, and the Decadal Report "Origins, Worlds, and Life" states that "Congressionally directed NEO detection goals will be ideally advanced by the Near-Earth Object Surveyor (NEO Surveyor)".

SBAG#26 Similar Finding: SBAG congratulates NASA and its partners on bringing the NEO Surveillance Mission to its present level of development. Past SBAG findings and the National Academies of Science, Engineering, and Medicine's Finding *Hazardous Asteroids Using Infrared and Visible Wavelength Telescopes* have emphasized the importance of a space-based near-infrared asteroid survey mission, and we reiterate that support once more. NEOSM would provide a major contribution towards fulfillment of the George E. Brown Congressional goal of discovering 90% of the near-Earth asteroid (NEA) population larger than 140 meters in size, while characterizing the diameters of a significant fraction of that NEA population. Additionally, NEOSM would provide a dataset important for small-body science, human exploration, and resource utilization. <u>SBAG encourages NASA's continued commitment to the mission and cadence of activities necessary to support the 2026 launch of NEO Surveyor.</u>

In SBAG #22 and #24 (2020 and 2021), findings on NEO Surveyor were also advanced, and in the years before for NEOCam as well. NEO Surveyor is a longstanding area of concern and support for SBAG.

Informational slide on additional finding

Ocean worlds inter-AG collaboration: The SBAG community is in favor of establishing an inter-AG collaborative working group between OPAG and SBAG on ocean worlds. This plan is in keeping with the Decadal Survey recommendation that "NASA should develop scientific exploration strategies, as it has for Mars, in areas of broad scientific importance, e.g., Venus and ocean worlds, that have an increasing number of U.S. missions and international collaboration opportunities." SBAG suggests that such an inter-AG collaboration could be led by liaison representatives from OPAG and SBAG; include all interested parties from the ocean worlds community (e.g., astrobiologists and oceanographers); and could take the form of an inter-AG working group, potentially including semi-regular coordinated OPAG and SBAG meetings or other activities.

Other Updates

1. SBAG #27 Meeting June 7-9, 2022 in Washington DC. Agenda is in backup material. Findings should be posted on the website within two weeks (LPI controls website, not SBAG). Other findings on SIMPLEx and PDART are also being worked.
2. Robin Canup and Phil Christensen gave presentations at the meeting on the Decadal Report, and questions were asked. They were appreciative of our work on white papers, surveys, and talks before the committee. SBAG is in full support of the Decadal Report and intends to use it as a guide in our future work.
3. Early career activities are ongoing: lightning talks; 15-minute talks; travel grants; one-on-one mentoring at meetings; slack channels; possible poster sessions in the future.
4. Selection of two new representatives to the inter-AG working group on inclusion, diversity, and equity will be in the next couple of months. Jennifer Scully and Jessie Dotson will be rotating off.
5. Next meeting in January 2023 (exact date being worked)
6. Meetings of SBAG are twice a year, in January and June

Summary

1. SBAG appreciates the support from the PAC and NASA on the various findings and initiatives we've advanced.

2. The critical findings are the ones on Radar and NEO Surveyor. SBAG has had a long history of supporting these two areas, and the Decadal underlines their importance.

3. SBAG is behind the Decadal Report 100%.

4. Backup (SBAG#27 agenda) follows

Agenda (Tuesday)

Tuesday, June 7, 2022: NASA Status, Decadal Report and, Early Career

PDT	EDT	Speaker	Title
Moderator: Bonnie Buratti			
9:00 a.m.	12:00noon	Bonnie Buratti	Welcome and Introduction of Steering Committee
9:05 a.m.	12:05 p.m.	Tom Statler	Planetary Science Division Overview (Lori only does one AG meeting)
9:45 a.m.	12:45 p.m.	Tom Statler	Response to SBAG 26 Findings
10:00 a.m.	1:00 p.m.		**Break — East Coast Lunch**
Moderator: Jennifer Scully			
10:40 a.m.	1:40 p.m.	Phil Christensen and Robin Canup	Decadal Report
11:30 a.m.	2:30 p.m.		**Open Mic**
12:20 p.m.	3:20 p.m.		**Break – West Coast/Midwest Lunch**
Moderator: Stephanie Jarmak			
1:00 p.m.	4:00 p.m.	Luisa Fernanda	Early Career Invited Talk: Inspection of Fast Rotating Asteroids observed with Arecibo Observatory's Planetary Radar S-Band System
1:15 p.m.	4:15 p.m.	Kiana McFadden	Early Career Invited Talk: Thermophysical Modeling of Near-Earth Asteroid, 2100 Ra-Shalom
1:30 p.m.	4:30 p.m.	Lindley Johnson	Planetary Defense Coordination Office Update
1:45 p.m.	4:45 p.m.		**Open Mic**
2:30 p.m.	5:30 p.m.		Adjourn

Agenda is at:
https://www.lpi.usra.edu/sbag/meetings/sbag-27/

Agenda (Wednesday and Thursday)

Wednesday, June 8, 2022: NEO Program and Mission reports

PDT	EDT	Speaker	Title
Moderator: Maitrayee Bose			
9:00 a.m.	12:00 noon	Milan Kroupa Marc Costa Paul Dalba Keanna Jardine Maxime Devogele	Lightning talks (2 minutes each)
9:15 a.m.	12:15 p.m.	Amy Mainzer	NEO Surveillance Update
9:35 a.m.	12:35 p.m.	Joseph Masiero	NEOWISE update
9:45 a.m.	12:45 p.m.	Elizabeth Dotto Angela Stickle	DART Update
10:10 a.m.	1:10 p.m.		**Break – East Coast Midwest Lunch**
Moderator Jessie Dodson			
11:10 a.m.	2:10 p.m.		**Open Mic**
11:30 a.m..	2:30 p.m.	Carol Polanskey	Psyche
11:45 a.m.	2:45 p.m.	Hal Levison	Lucy
12:00 noon	3:00 p.m.		**Break – West Coast Lunch**
12:45 p. m.	3:45 p.m.	Dan Scheeres	Janus
1:00 p.m.	4:00 p.m.	Julie Castillo-Rogez	NEA Scout
1:15 p.m.	4:15 p.m.	Daniella DellaGuistina	OSIRIS-REx
1:30 p. m.	4:30 p.m.		**Open Mic**
2:15 p. m.	5:15 p.m.	Tomohiro Usui	MMX
2:30 p. m.	5:30 p.m.	Toru Yada	Hayabusa2

Thursday, June 9, 2022: Steering Committee Meets; MPC, PDS, Radar

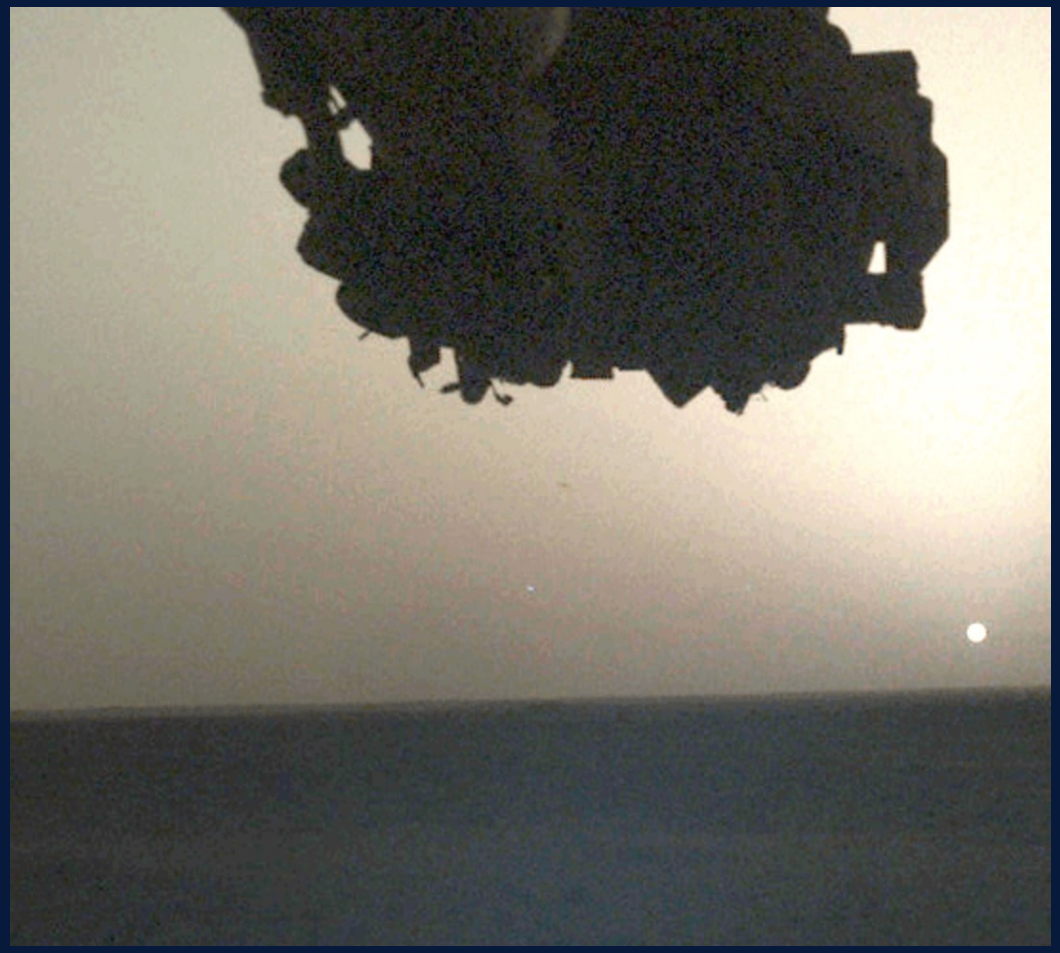
PDT	EDT	Speaker	Title
7:00 a.m.	10:00 a.m.		Steering Committee Executive Session
Moderator: Tim Titus			
8:00 a. m.	11:00 a. m.	Federica Spoto	Minor Planet Center
8:10 a.m.	11:10 a.m.	James Bauer	PDS Small Bodies Node
8:20 a. m.	11:20 a.m.	Rick Binzel	Apophis T-7 meeting report
8:30 a. m.	11:30 a. m.	Edgard Valentin-Rivera	IDEA Update
8:45 a.m.	11:45 a.m.	David Dunham	Upcoming Didymos occultations
8:50 a. m.	11:50 a.m.	David Trilling Althea Moorhead	Meeting updates (<5 minutes each) ACM 2023 Meteoroids June 13-17th, 2022
9:00 a. m.	12 noon	Luke Sollitt	NSF small bodies update
9:15 a. m.	12:15 p. m.	Patrick Taylor	Greenbank status
9:30 a. m.	12:30 p. m.	Flaviane Venditti	Arecibo update
9:45 a. m.	12:45 p. m.	Marina Brozovic	Goldstone update
10:00 a.m.	1:00 pm		**Open Mic**
10:30 a.m.	1:30 p.m.		**Adjourn**
10:30 a. m.	1:30 p.m.		Steering Committee Executive Session (working lunch)

MEPAG

MEPAG Report to the Planetary Science Advisory Committee

R Aileen Yingst, Chair

21 June 2022

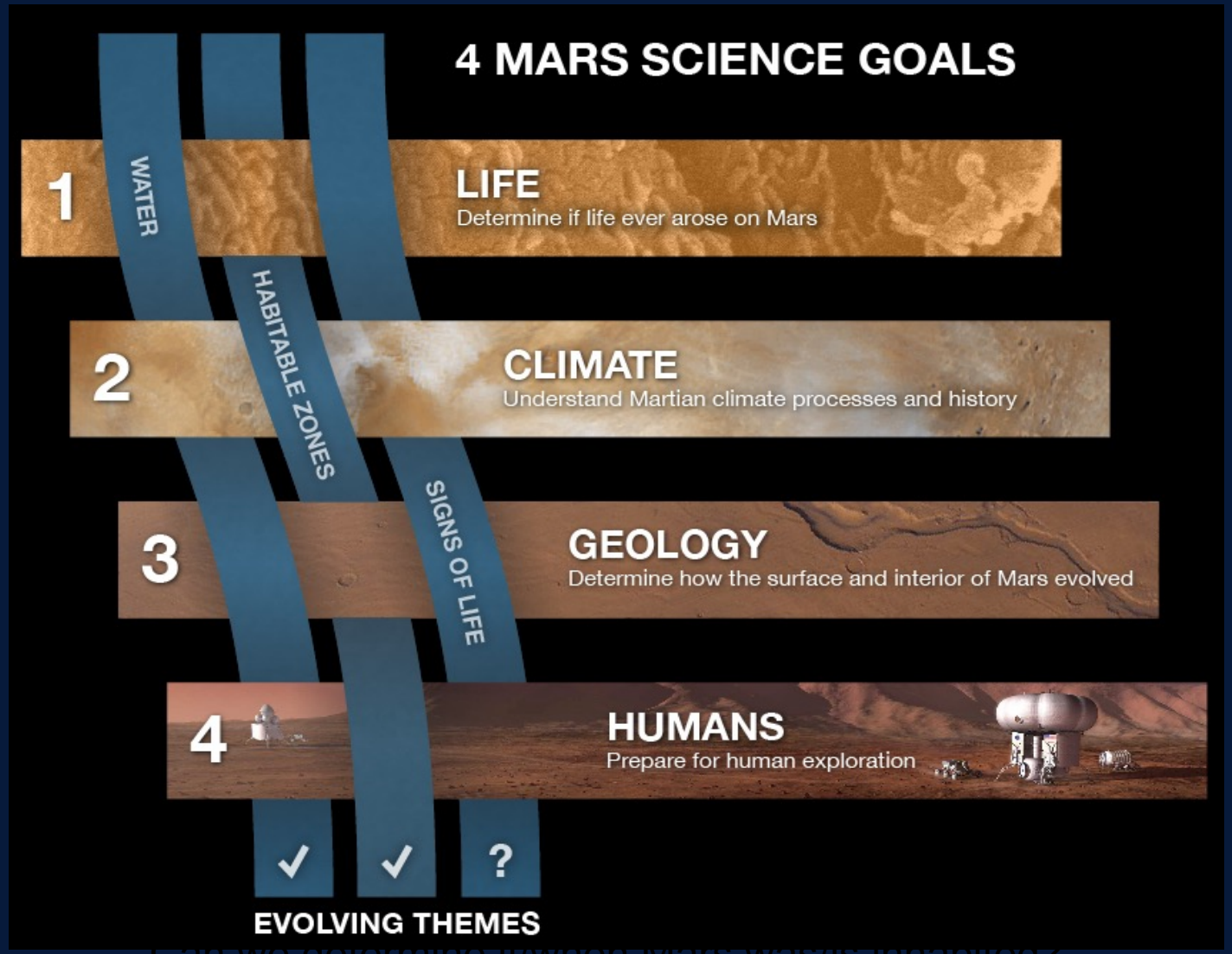


InSight captures sunset on Mars, 10 April 2022
NASA/JPL-Caltech

Mars Exploration Program Analysis Group (MEPAG)

*The **Mars Exploration Program** is an integrated program of research activities and robotic flight missions dedicated to:*

- *Understanding how Mars has evolved as a planet*
- *Discovering whether there is evidence of life, past or present*
- *Preparations for future exploration by humans on Mars itself*



Can we determine if/when Mars was/is inhabited?

Mars Exploration Program Analysis Group (MEPAG)

- Steering Committee (R. A. Yingst, Chair)
  - Jeff Johnson (JHU-APL) →*Past chair*
  - Don Banfield (Cornell) →*Goals Committee Chair*
  - Wendy Calvin (Univ. Nevada Reno)
  - Colin Dundas (USGS)
  - Justin Filiberto (JSC) →*IDEA Representative*
  - Briony Horgan (Purdue)
  - Scott Hubbard (Stanford University)
  - Kennda Lynch (LPI) →*IDEA Representative*
  - Sarah Stewart Johnson (Georgetown)
  - Michael Meyer (NASA HQ)
  - Jake Bleacher, Paul Niles (HEOMD, NASA HQ) Ex Officio
  - Dave Beaty, Michael Mischna, Rich Zurek (JPL)

Clouds over Mont Mercou, Gale crater, Mars.
Image credit: NASA/JPL-Caltech/MSSS

- Goals Committee (D. Banfield, Chair)
  - Goal I <*Life*> (Jen Stern, GSFC; Alfonso Davila, Ames)
  - Goal II <*Climate*> (Claire Newman, Aeolis Research; Dave Brain, Univ. Colorado)
  - Goal III <*Geology*> (Christina Viviano, APL; Rebecca Williams, Planetary Science Institute)
  - Goal IV <*Human Exploration*> (Jake Bleacher GSFC (Paul Niles, JSC); Michelle Rucker, JSC)

MEPAG activities

- 39th MEPAG Meeting, 2-4 May 2022
  - First report from release of Decadal Survey (DS) and discussion (MEPAG Findings 1-5)
  - Forum on Mars exploration in parallel with MSR: Given the guidance by DS, What are the high priority Mars science questions that could be addressed within funding and timing parameters available? (MEPAG Finding 6)
  - Program updates and outbriefs; IDEA plans and activities (MEPAG Finding 7)
- MCE-SAG (MEPAG Finding 6)
  - MSR is the consensus highest priority science goal for the Mars science community but, as noted in the last and current Decadal Surveys, the Mars Exploration Program (MEP) has additional important priorities that cannot be addressed by MSR alone.
  - The MEPAG Steering Committee is in the process of forming a Strategic Analysis Group (SAG) to identify and prioritize scientific objectives and/or investigations that could be executed within the next ten years, in parallel with the MSR effort and in conjunction with DS guidance.

MEPAG Findings from 39th MEPAG Meeting — Preamble

- MEPAG congratulates the Decadal Survey committee for their efforts on behalf of the entire science community, and specifically their clear recommendations for the Mars Exploration Program (MEP) and Mars Sample Return (MSR).
- MEPAG expresses deep sympathy to our colleagues regarding the suspension of the ExoMars rover launch due to the present international situation. MEPAG supports and will continue to follow ESA and the international community in their efforts to recover this very important science.

MEPAG Findings from 39th MEPAG Meeting (summarized)

- Decadal Survey initial comments: MEPAG strongly concurs with the Decadal Survey (DS) Origins, Worlds and Life (OWL) report on the importance of returning samples from Mars to Earth by the end of the decade (2033), on increased funding for R&A to support the massive return of data by planetary missions, including those at Mars, and to invest wisely in the technologies that can enable future exploration at Mars and across the Solar System.
- The DS also presented an overarching challenge to NASA and its Mars Exploration Program and thus to MEPAG that MEP should "…develop and execute a comprehensive architecture of missions, partnerships, and technology development to enable continued scientific discovery at Mars."
- *Consistent with OWL's text and reports from study groups such as MASWG and a KISS workshop, MEPAG believes that such a "comprehensive architecture" should begin with a new program of low-cost missions (<$300M) this decade, augmented by medium-class missions after the peak-spending phase of MSR.*

MEPAG Findings from 39th MEPAG Meeting (summarized)

- Medium Class missions: MEPAG affirms the language used in OWL whereby medium-class missions for Mars exploration are best defined and executed strategically within the MEP, and that MEP funding be restored to levels that would make a new start for the first of such missions possible late in the decade.
- *MEPAG stands ready to build on current studies with science analysis groups as needed to define and refine objectives of an astrobiology/ice science Mars mission, which by its placement in MEP further enhances the ability of the program to define compelling precursors and successors in a long-term exploration strategy. Given MEPAG's long-standing emphasis on competing mission scope & implementation, we look forward to community participation in a future SAG, SDT & AO informed by the community.*

MEPAG Findings from 39th MEPAG Meeting (summarized)

- I-MIM: While noting the controversial history of its beginnings, OWL states that "[w]ith engagement of the scientific community in measurement definition, I-MIM has the potential to be a pathfinding example of how Mars human exploration objectives can simultaneously advance high-priority science questions related to Mars climate and how scientific expertise can help successfully realize human exploration objectives for ISRU." MEPAG is grateful for NASA and partners' efforts toward organizing the I-MIM MDT, commends this committee's ongoing work, and is intrigued by its preliminary findings regarding the reconnaissance and science goals of the mission concept. MEPAG was surprised by the lack of funding for I-MIM in the FY23 Administration budget (prior to the release of the MDT report), and in light of the OWL endorsement of the importance of a Mars ice mapping-type mission.
- *MEPAG eagerly awaits completion of the final MDT study. This will enable the community to fully evaluate the degree to which the I-MIM mission concept addresses key goals of the Mars community regarding ice investigations, and will place in clearer context OWL discussions regarding I-MIM or a similar type of joint mission as an Agency-level priority.*

MEPAG Findings from 39th MEPAG Meeting (summarized)

- Infrastructure: The suite of heritage missions currently working synergistically at Mars constitute excellent examples of the program-level approach recommended by OWL for sustaining Mars exploration (as well as other areas of planetary exploration).
- *MEPAG encourages a systematic approach to supporting and refreshing Mars orbital science, monitoring, and relay requirements, a move that could dramatically enable highly productive Mars small spacecraft concepts. MEPAG also agrees with the Senior Review and OWL report that notes the exceptional value heritage mission extensions provide.*
- M2020 in relation to MSR: MEPAG is concerned regarding how MSR Program requirements (such as assessing locations for sample cache depots) are communicated, and their impacts on maintaining efficient progress toward accomplishing mission science goals.
- *MEPAG underscores the importance of discussion and clear communication at all levels as the Mars 2020 and MSR teams work to achieve a balanced mission operations approach that will sustain the goals of both MSR and MEP in an efficient manner during the entire course of the Mars 2020 mission.*

Backup slides

Complete Findings from MEPAG 39

Preamble

At the May 2-4, 2022 Mars Exploration Program Analysis Group (MEPAG) Meeting #39, the Mars community conducted an initial assessment of the recently released Planetary Science and Astrobiology Decadal Survey committee report, and received a preliminary report from the I-MIM MDT, a review of Mars Sample Return status, and several current mission updates, including the outcome of the 2022 Planetary Mission Senior Review and the initial planning for deploying the first cache by Perseverance. Before presenting findings from the meeting, MEPAG as a community wishes to express the following:

- MEPAG congratulates the Decadal Survey committee for their efforts on behalf of the entire science community, and specifically their clear recommendations for the Mars Exploration Program (MEP) and Mars Sample Return (MSR).
- MEPAG expresses deep sympathy to our colleagues regarding the suspension of the ExoMars rover launch due to the present international situation. MEPAG supports and will continue to follow ESA and the international community in their efforts to recover this very important science.

MEPAG Findings Overview

- The Mars Exploration Program Analysis Group (MEPAG) strongly concurs with the Origins, Worlds and Life (OWL) report on the importance of returning samples from Mars to Earth by the end of the decade (2033), on increased funding for R&A to cope with the massive return of data by planetary missions, including those at Mars, and to invest wisely in the technologies that can enable future exploration at Mars and across the Solar System.
- The Planetary Science and Astrobiology Decadal Survey also presented an overarching challenge to NASA and its Mars Exploration Program and thus to MEPAG that MEP should *"…develop and execute a comprehensive architecture of missions, partnerships, and technology development to enable continued scientific discovery at Mars."*
- *Consistent with OWL's text and reports from study groups such as MASWG and a KISS workshop, MEPAG believes that such a "comprehensive architecture" should begin with a new program of low-cost missions (<$300M) this decade, augmented by medium-class missions after the peak-spending phase of MSR.*

These and other findings are discussed in more detail in the following slides.

1. Finding: Decadal Survey initial thoughts 1, MEP

- The Planetary Decadal Survey report *Origins, Worlds and Life (*OWL) has unambiguously recognized the profound strategic and scientific benefits of the comprehensive program structure under which Mars exploration operates (the Mars Exploration Program, MEP). The report recommends the continuation of the MEP "success story," which strategically plans Mars exploration using the full umbrella of tools within the MEP architecture, from small to medium-class missions, and from infrastructure to development of enabling technology.
- *MEPAG enthusiastically endorses the recommendation that MEP "…develop and execute a comprehensive architecture of missions, partnerships, and technology development to enable continued scientific discovery at Mars." MEPAG believes that such a "comprehensive architecture" should begin with a new program of low-cost missions (<$300M) during the execution of the MSR flight program, augmented by medium-class missions after the peak-spending phase of MSR, as noted in OWL.*
- *The funding for this architecture of low-cost and New-Frontiers (medium) class MEP missions would come from restoration of MEP funding as recommended by OWL.*

2. Finding: Decadal Survey initial thoughts 2, MSR

- Mars Sample Return (MSR), with its goal of providing a scientifically return-worthy cache of samples for return to Earth, was noted by the last Decadal Survey as the highest priority for flagship missions in the decade 2012-2022. MSR remains the highest priority robotic exploration goal in OWL, for 2023-2032.

- *MEPAG welcomes the recommendation to finish MSR "as the highest scientific priority of NASA's robotic exploration efforts this decade" and to do so without undermining "the long-term programmatic balance of the planetary portfolio."*

3. Finding: Decadal Survey initial thoughts 3, R&A

- The OWL recommendation that PSD “increase its investment in R&A activities to achieve a minimum annual funding level of 10 percent of the PSD total annual budget” is timely and, given the magnitude of returned data from all the planetary missions, sorely needed.

- *MEPAG strongly encourages that NASA adopt the OWL recommendation to bring R&A funding to the 10% level, in line with pre-2018 levels.*

4. Finding: Decadal Survey initial thoughts 4, technology

- The many technology recommendations in OWL are welcomed, particularly as they pertain to the ability to reach the Mars surface in an affordable way and provide access to the subsurface as well. Recent studies have highlighted the benefits of technology that would enable a number of MEPAG goals (e.g., affordable access to the surface; high-volume communication; subsurface access; mobility).

- *MEPAG welcomes opportunity for MEP to use all the strategic tools available to it, to explore Mars, including innovations like low-cost missions and associated support of technology maturation. MEPAG will study the many recommendations in this area with the intent of identifying ways in which its studies could further refine OWL recommendations.*

5. Finding: Decadal Survey initial thoughts 5, MLE

- While MEPAG previously advocated that Mars be included in the New Frontiers competition, it affirms the language used in OWL whereby medium-class missions for Mars exploration are best defined and executed strategically within the MEP, and that MEP funding be restored to levels that would make a new start for the first of such missions possible late in the decade. MEPAG agrees with OWL that astrobiology and ice science objectives would have high value for such medium-class missions (e.g., Mars Life Explorer, MLE).
- *MEPAG stands ready to build on current studies with science analysis groups as needed to define and refine objectives of an astrobiology/ice science Mars mission, which by its placement in MEP further enhances the ability of the program to define compelling precursors and successors in a long-term exploration strategy. Given MEPAG's long-standing emphasis on competing mission scope & implementation, we look forward to community participation in a future SAG, SDT & AO informed by the community.*

6. Finding: Mars exploration concurrent with MSR

- OWL recommended that the Mars Exploration Program (MEP) strategically plan and execute Mars exploration concurrent with MSR. Several highly relevant community-based studies are now available regarding concurrent exploration avenues, including the recommendations of the Decadal Survey report, the updated MEPAG Goals Document, the MASWG report, the KISS Workshop ('Revolutionizing Access to the Mars Surface'), ICE-SAG and Nex-SAG, the Low-Cost Science Mission Concepts for Mars Exploration Workshop, and the I-MIM MDT preliminary report.
- *MEPAG strongly endorses the need for a strategic plan for exploration concurrent with MSR that is science driven. To that end, MEPAG will stand up a Mars Concurrent Exploration (MCE) SAG, tasked with identifying and prioritizing scientific objectives and/or investigations that could be executed within the next ten years, in parallel with the MSR effort and in conjunction with DS guidance for the MEP. This effort is planned to be completed by mid-September, 2022.*

7. Finding: Inclusion, Diversity, Equity, Accessibility

- The “State of the Profession” section in OWL offers many important recommendations for improving Inclusion, Diversity, Equity and Accessibility (IDEA) in the planetary community. MEPAG welcomes the workshop “Advancing IDEA in Planetary Science”, hopefully the first of many, and looks forward to the work of the AG-based IDEA committee.

- *MEPAG applauds the inclusion of a detailed IDEA section in OWL, enthusiastically supports the work of the IDEA representatives on our Steering Committee and the AG-wide committee they serve on, and looks forward to implementing recommendations to support a more inclusive, diverse, equitable and accessible Mars science community. MEPAG recommends continued NASA support of this initiative, and encourages continued engagement and concrete movement.*

8. Finding: Infrastructure

- The assets conducting ongoing orbital science and rover data return are aging but continue to provide crucial science data and communication relays. The need for continued reconnaissance science and systematic monitoring has been identified by a number of studies, and the relay burden will only increase given the arrival of missions to be launched in the next decade. Approaching both orbital science and relay needs by design will maximize resources for the entire program.
- *MEPAG encourages a systematic approach to supporting and refreshing Mars orbital science, monitoring, and relay requirements both in the near-term for upcoming missions, and in the longer term (a move that could dramatically enable highly productive Mars small spacecraft concepts). New architecture and aggressive approaches could leverage new technology to substantially increase bandwidth for Mars which could be enabling for small missions.*

9. Finding: Current missions

- The latest Senior Review provided high ratings for the ongoing Mars missions, and the Decadal Survey report (OWL) noted the exceptional value that such mission extensions are providing. This is particularly true for Mars where mission extension has greatly enhanced the scientific return of landed (e.g., Perseverance, InSight, Curiosity) and orbital (synergies among MAVEN, MRO, TGO, ODY & HOPE) missions. This is an excellent example of the program-level approach recommended by OWL for sustaining Mars exploration (as well as other areas of planetary exploration).

- *MEPAG agrees with the above conclusions and encourages continued support of these missions at levels necessary to maintain high scientific return.*

10. Finding: I-MIM Measurement Definition Team

- While noting the controversial history of its beginnings, OWL states that "[w]ith engagement of the scientific community in measurement definition, I-MIM has the potential to be a pathfinding example of how Mars human exploration objectives can simultaneously advance high-priority science questions related to Mars climate and how scientific expertise can help successfully realize human exploration objectives for ISRU." MEPAG is grateful for NASA and partners' efforts toward organizing the I-MIM MDT, commends this committee's ongoing work, and is intrigued by its preliminary findings regarding the reconnaissance and science goals of the mission concept. MEPAG was surprised by the lack of funding for I-MIM in the FY23 Administration budget (prior to the release of the MDT report), and in light of the OWL endorsement of the importance of a Mars ice mapping-type mission.
- *MEPAG eagerly awaits completion of the final MDT study. This will enable the community to fully evaluate the degree to which the I-MIM mission concept addresses key goals of the Mars community regarding ice investigations, and will place in clearer context OWL discussions regarding I-MIM or a similar type of joint mission as an Agency-level priority.*

11. Finding: MSR in relation to Mars 2020

- MEPAG applauds the ongoing MSR Program mission element studies and engineering tests such as those involving the Mars Ascent Vehicle Integrated System (MAVIS) and Earth Entry System (EES). MEPAG also appreciates the rationale for establishing the MSR Campaign Science Group and the MSR/MEP Joint Steering Group to ensure frequent, high-level discussions among key leadership. However, MEPAG is concerned regarding how MSR Program requirements (such as assessing locations for sample cache depots) are communicated within the context of otherwise highly constrained Mars 2020 mission operational scenarios, and their impacts on maintaining efficient progress toward accomplishing mission science goals.
- *MEPAG underscores the importance of discussion and clear communication at all levels as the Mars 2020 and MSR teams work to achieve a balanced mission operations approach that will sustain the goals of both MSR and MEP in an efficient manner during the entire course of the Mars 2020 mission.*

LEAG

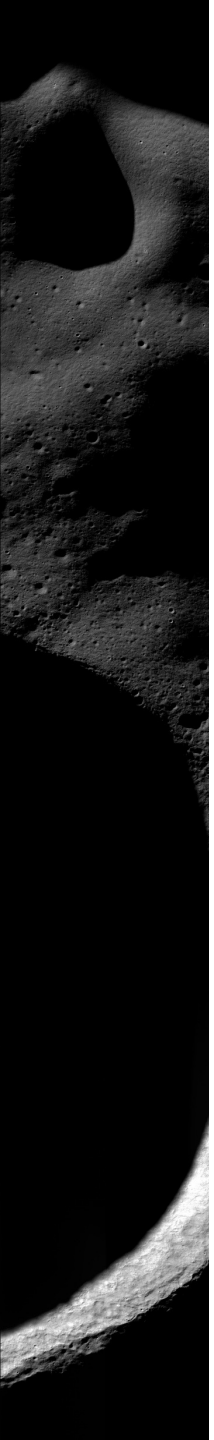
Lunar Exploration Analysis Group Updates and Action Requests-

June 2022 Edition

Dr. Amy L. Fagan, LEAG Chair

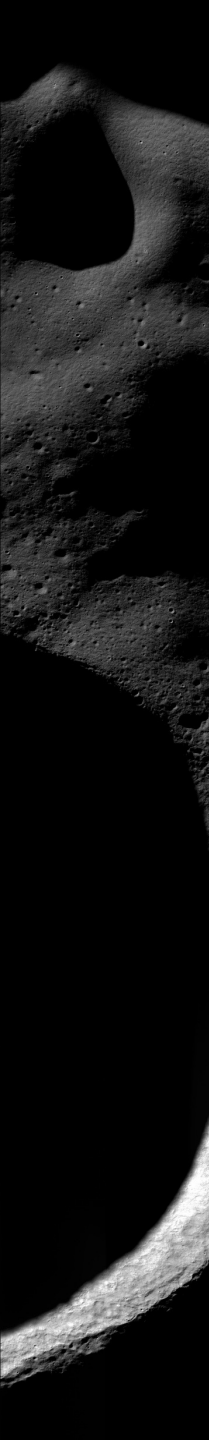
Presented to NASA Planetary Advisory Committee

21 June 2022



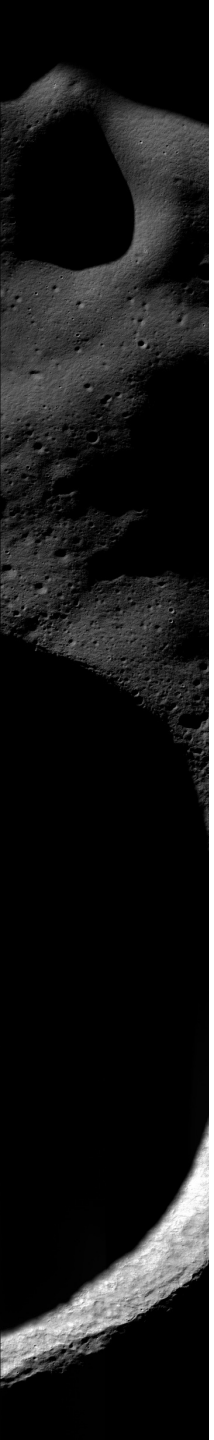
LEAG Activities since Feb 2022 (last PAC update) and Upcoming

- **Continuous Lunar Orbital Capabilities (CLOC) [Nov. 2021-Aug. 2022]**
  - Co-Chairs: Ben Greenhagen and Carle Pieters
    - Members: John Keller, Mark Robinson, Julie Stopar, Tim Glotch, Lauren Jozwiak, James Tuttle Keane, Paul Lucey, and Angela Stickle
  - Draft findings to be presented at SSERVI Exploration Science Forum (July 21)
  - Full Report to be presented at LEAG annual meeting (August 25) and delivered to HQ soon after
- **Town Hall on the Planetary Science and Astrobiology Decadal Survey (2023-2032) [May 19]**
  - Survey Overview; Mercury and Moon Panel; Human Exploration; Endurance-A concept; Technology
  - Questions submitted online + Upvoting
- **NASA's Moon to Mars Draft Objectives**
  - Responses submitted to RFI→ Will have representation at Workshop June 28-29
- **UPCOMING: Annual Meeting August 23-25**
  - In-person @ Johns Hopkins Univ. Applied Physics Lab + Virtual Component
  - Topics include: HQ and mission updates; Decadal Survey; IDEA; and Goals discussion



LEAG Community Excitement, Gratitude, and Support

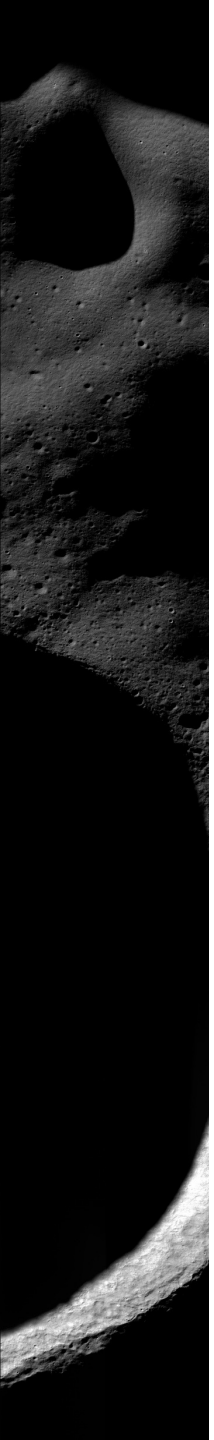
- **Appreciation and gratitude for ESSIO adapting PRISM based on community feedback**
  - November LSSW on CLPS
  - Individual conversations between ESSIO leadership, LEAG Executive Committee, CAB leadership
  - ExComm and community have strong support for future PRISM calls where proposers can propose site
  - SALSA-Stand ALone Site Agnostic
- **Excitement for upcoming calls demonstrating the drive towards the Moon and support for lunar science and exploration**
  - e.g., competed Artemis III Geology Team, PRISM-SALSA, PRISM-3, Artemis III/V deployed instruments, Lunar Terrain Vehicle Instruments, and next SSERVI selection
- **The Decadal Survey strongly highlights the value of lunar exploration, both human and robotic, for <u>ALL</u> of planetary science.**



Summary of LEAG Virtual Town Hall on Decadal Survey

- **Streamed live on YouTube and Recording is available**
  - 85 live participants | 275+ views of recording (as of 20 June 2022)
  - https://www.youtube.com/watch?v=U1odBPj7g2E
- **Vigorous discussion, an engaged audience, and general support**
  - Many questions generated→ implications and some disagreement
- **Most questions received fell into a few categories** *[# Q | # total upvotes | Avg. # upvotes/Q]*
  - Endurance-A mission concept and implications *[6Q |94 ↑ | 11.75 ↑/Q]*
  - Artemis and broader lunar exploration and strategy *[4Q | 56 ↑ | 14 ↑/Q]*
  - Commercial Lunar Payload Services (CLPS) and implication to other programs *[3Q | 21 ↑ | 7 ↑/Q]*
  - Planetary protection and ISRU *[3Q | 11 ↑ | 3.7 ↑/Q]*
  - Plus "other/assorted" (e.g., when to expect report with final images)

The Decadal Survey strongly highlights the value of lunar exploration, both human and robotic, for <u>ALL</u> of planetary science.



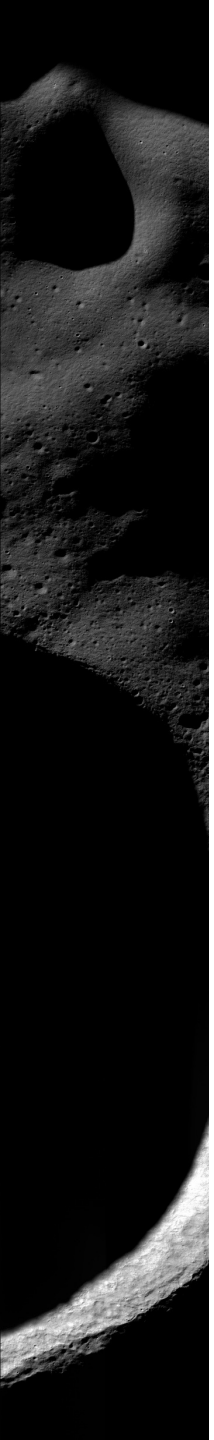
LEAG Findings and Action Requests to the PAC

Points of Concern and Opportunities to Maximize Science Return

Dr. Amy L. Fagan, on behalf of
Lunar Exploration Analysis Group

Given to NASA Planetary Science Advisory Committee

Tuesday, June 21, 2022



The Moon has value for exploration AND science objectives

- **Action Request to the PAC : Recommend the development of ”primers” or “modules” for science that can be achieved at the Moon (planetary science and lunar science) for use by the public and NASA administration and/or advocate for consistent, positive messaging for the value of the Moon from officials beyond a simple exploration stepping-stone.**
  - The Moon has rich scientific value demonstrated in numerous reports
    - e.g., Scientific Context for Exploration of the Moon; Artemis Science Definition Team; and Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032
  - NASA is planning a return to the Moon
    - e.g., National Space Policy; Moon to Mars Objectives; Artemis Plan
  - … BUT messaging from some of NASA Administration continues to **ignore** the scientific value of the Moon
    - e.g., “We don’t want to get stuck on the Moon” –AA Cabana @ LSIC May meeting
  - Concern that the continued omission of the value of lunar science (and planetary science achieved at the Moon) may be detrimental to the community

LEAG stands ready to support a positive message for the Moon’s scientific and exploration value

The Moon has value for exploration AND science objectives

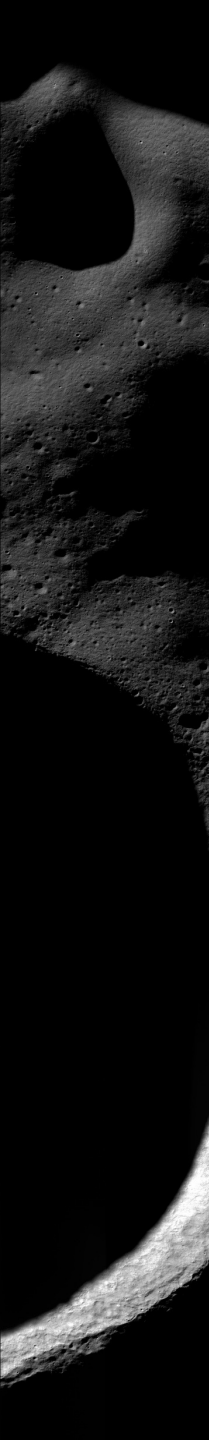
- **Action Request to the PAC : Establish a finding that the lunar community is broadly pleased with the wide-spread representation of the Moon in the Decadal Survey (D.S.) and the recognition that planetary science objectives can be achieved at the Moon.**
  - Pleased that the Moon is highlighted as a location to address scientific objectives in most chapters of the Survey → The Moon has great scientific value!
  - Findings/Recommendations about Artemis are in broad agreement with LEAG community

LEAG Examples

- See 2020 and 2021 LEAG annual meeting findings
- LEAG November 2021 Action Request to the PAC: Recommend the development of a broad lunar science and exploration strategy with clear hierarchy/authority, including advocating for PSD to have authority to develop science requirements for Artemis.

Decadal Survey Examples

- Recommendation: PSD should develop a strategic lunar program that includes human exploration as an additional option to robotic missions to achieve decadal-level science goals at the Moon. *[p19-10]*
- Recommendation: NASA should adopt an organizational approach in which SMD has the responsibility and authority for the development of Artemis lunar science requirements that are integrated with human exploration capabilities. *[p19-10]*



A need for big-picture plans for the Moon and clearly defined authority to better ensure success of lunar science objectives

- **Action Request to the PAC : Advocate that NASA follow the Chapter 22 finding and recommendation of the Decadal Survey (D.S.) regarding setting science goals and objectives at the Moon.**
  - Finding: A structured approach to setting science goals and measurement objectives at the Moon, led by the lunar science community in a manner similar to that led by the Mars community, would allow for scientific prioritization and coordination of lunar missions, instrumentation, landing site selections, and other activities performed within LDEP. [p22-14]
  - Recommendation: The advancement of high priority lunar science objectives, as defined by PSD based on inputs from this report and groups representing the scientific community, should be a key requirement of the Artemis human exploration program. Design and implementation of an integrated plan responsive to both NASA's human exploration and science directorates, with separately appropriated funding lines, presents management challenges; however, overcoming these is strongly justified by the value of human-scientific and human-robotic partnerships to the agency and the nation. [p22-14]

LEAG stands ready to support and enable this endeavor through updates to the Lunar Exploration Roadmap and/or an additional guiding document.

June 2022 LEAG Summary

We request that the PAC:

1. Recommend the development of ”primers” or “modules” for science that can be achieved at the Moon (planetary science and lunar science) for use by the public and NASA administration and/or advocate for consistent, positive messaging for the value of the Moon from officials beyond a simple exploration stepping-stone.
2. Establish a finding that the lunar community is broadly pleased with the wide-spread representation of the Moon in the Decadal Survey (D.S.) and the recognition that planetary science objectives can be achieved at the Moon.
3. Advocate that NASA follow the Chapter 22 finding and recommendation of the Decadal Survey (D.S.) regarding setting science goals and objectives at the Moon.
4. Pass along our gratitude to NASA for reaching out to the broader community for feedback and responding to that feedback (e.g., CLPS/PRISM, Moon to Mars draft Objectives). Compiling feedback from the community with their diverse backgrounds will strengthen science.

Dr. Amy L. Fagan, on behalf of
Lunar Exploration Analysis Group

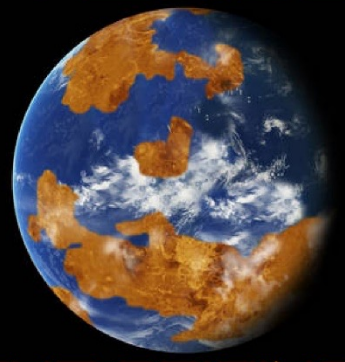
VEXAG

VEXAG update June 21, 2022

VENUS EXPLORATION VEXAG ANALYSIS GROUP

Noam Izenberg	*Applied Physics Laboratory*, Chair
Debra Buczkowski	*Applied Physics Laboratory,* Deputy Chair
Darby Dyar	*PSI, Mount Holyoke College*, Past Chair
Jeff Balcerski	*Ohio Aerospace Institute*
Paul Byrne	*North Carolina State University*
Chuanfe Dong	*Princeton University,* Early-Career Representative
Eric Grosfils	*Pomona College,* Onboard July 2022
Natasha Johnson	*NASA GSFC*
Stephen Kane	*University of California at Riverside*
Erika Kohler	*NASA GSFC,* Early-Career Representative, Onboard July 2022
Siddarth Krishnamoorthy	*Jet Propulsion Laboratory*, Early-Career Representative
Molly McCanta	*University of Tennessee*
Sara Port	*Glenn Research Center*, Early-Career Representative
Jason Rabinovich	*Stevens Institute of Technology*
Jennifer Whitten	*Tulane*, Early-Career Representative
Megan Ansdell	*NASA HQ*, ex officio

VENUS



THE ORIGINAL OCEAN WORLD

VEXAG 2022

The 20th Meeting of the Venus Exploration Analysis Group

- Currently being planned
- November 7-9 in Pasadena, CA (live/hybrid)
- Expecting 150+ in attendance over 2 ½ days
  - Primers, flash talks, posters
  - Presentations by 3 New Venus Missions

SAW 1: Organization Documentation
SAW 2: VEXAG 2022 Meeting
SAW 3: Exoplanets in our Backyard (2022)
SAW 4: Venus Flyby & Opportunistic Science
SAW 5: Venus Science Nuggets
~~SAW 6: Surface Platform Study~~ Retired
SAW 7: Technology & Laboratory studies
SAW 8: Outreach/Advocacy
SAW 9: Social Media
SAW 10:VEXAG Website
SAW 11: IDEA
SAW 12: Aerial Platform Science and Technology
SAW 13: "Next Gen" Liaison

Moon to Mars Initiative

- The Moon to Mars Pathway is a “first humans to Mars” expedition, a “short stay” opposition-class mission the baseline of which includes ~30 days at Mars and a Venus flyby on the return or outbound leg
- The Venus Exploration Analysis Group (VEXAG) sent a letter of support and appreciation
- Having Venus flybys as an integral part of the Moon to Mars pathway can enable significant new Venus science, training, practice for astronauts on long space missions.
- VEXAG also provided an initial evaluation of the 50 Moon to Mars Objectives from the Venus community perspective and detailed how potential Venus flybys either benefit the objective, or are naturally enhanced or enabled by the objective.

VEXAG 2022 Calendar

- KISS Science Enabled By Crewed Flybys of Venus (July 20-21)
- LPI Venus Initiative, Ancient Venus July 25-27, 2022
- Exoplanets in our Backyard 2: live/hybrid at Caltech, November 2-4 2022
- VEXAG 2022: live/hybrid at Caltech, November 7-9 2022

Abbreviated Findings

- Establish a Venus Program
- Support LLISSE maturation and offer as a capability for New Frontiers
- Request STMD to restart support of long-duration power systems
- Augment SSO program to support Venus observations and support new suborbital and ground-based capabilities
- Encourage specific language for Venus-appropriate R&A in Habitable Worlds and Exobiology programs
- Encourage a new solicitation of aerial platform capabilities, similar to HOTTECH and COLDTECH
- Continue support for EDL thermal protection systems
- Create joint Astrophysics and Planetary opportunities to address cross-disciplinary recommendations of the Decadal Survey

MExAG

Mercury Exploration Assessment Group (MExAG)

June 21, 2022

Carolyn Ernst, MExAG Vice-Chair

JHU APL

MExAG Steering Committee

Steven A. Hauck, II
Case Western Reserve U.
Chair

Carolyn Ernst
JHU APL
Vice-Chair

Ronald J. Vervack, Jr.
JHU APL
Exosphere Discipline Member

Stephen Parman
Brown University
Geochemistry Discipline Member

Christian Klimczak
U. of Georgia
Geology Discipline Member

Catherine L. Johnson
UBC & PSI
Geophysics Discipline Member

Gina DiBraccio
NASA GSFC
Magnetosphere Discipline Member

Ariel Deutsch
NASA ARC
Early Career Member

Gang Kai Poh
Catholic U./ NASA GSFC
Early Career Member

Suzanne Imber
U. of Leicester
International Liaison

Shoshana Weider
NASA HQ
NASA Liaison

Recent MExAG and Mercury Activities

- Collected MExAG comments on SPD-41 and submitted a response to the RFI.
- MExAG Town Hall
  - May 10, 2022 [virtual]
  - Focused on MExAG community discussion of the Decadal Survey
- Goals Document Development
- Search for new Steering Committee member
- Mercury 2022 (originally Mercury 2020) – held 7–10 June 2022 in Orléans, France

Decadal Survey

- The MExAG community is extraordinarily thankful for the incredible efforts of everyone who served on the Decadal Survey and produced such a detailed and comprehensive strategy for astrobiology and planetary science in the coming decade.

Decadal Survey – Notable Mercury

- Decadal level Mercury science was highlighted throughout *Origins, Worlds, and Life,* indeed in most of the priority question topics.
- Technological challenges, and the to address them, of Mercury's extreme environment were highlighted as well.
- Dozens of mentions of the need for samples and *in situ* measurements of Mercury underscore the importance of landing a spacecraft on the planet.

Decadal Survey – Highlighted Recommendations

- R&A constitute 10% of PSD budget.
- Technology be 6–8 % of PSD budget.
- New NF concepts due to new discoveries be evaluated before NF-7.[a]
- Plutonium-238 needs be evaluated against mission portfolio and increased as needed.[a]
- Expanding support for ground-based telescope observations and planetary astronomers.[a]
- Reviewing current radar infrastructure to meet community needs, including replacing capabilities lost with Arecibo.[a]

[a] MExAG has presented findings to the PAC in 2021 & 2022 consistent with these recommendations.

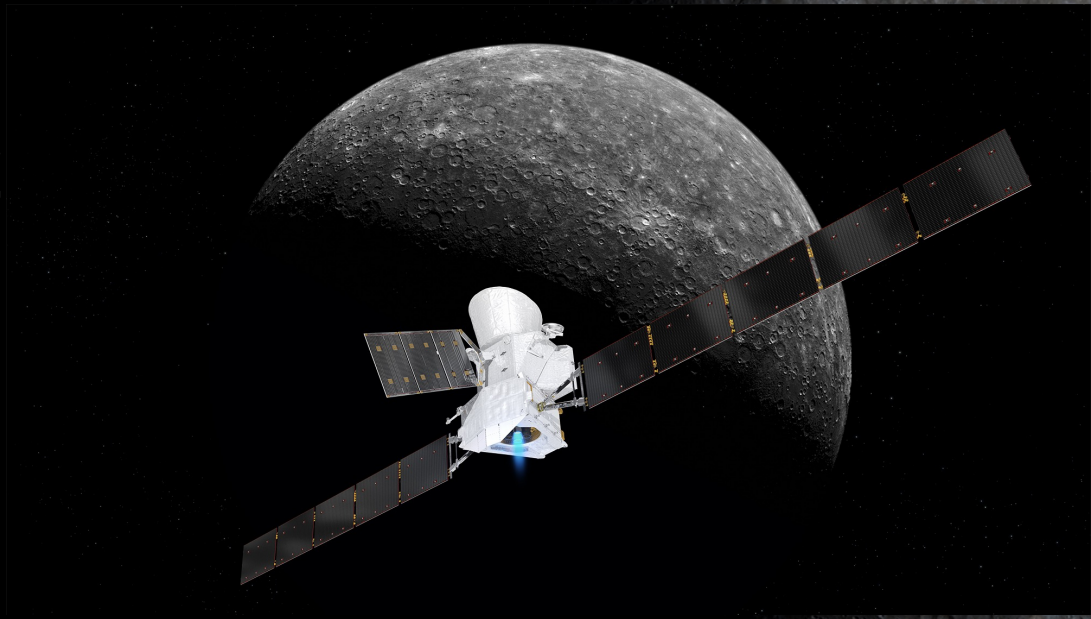
Finding – Documentation of TRACE results

- The Decadal Survey applied independent cost and risk (TRACE) assessments of the mission concepts. However, the extraordinarily brief TRACE outcomes presented in Appendix C of Origins, Worlds, and Life lacks documentation of the specific drivers of cost and risk in their assessments. These drivers are vital for NASA and the planetary science community to identify technologies in need of investment.
- MExAG requests that the complete TRACE outcomes be released to the public in a level of detail and fashion consistent with the input to these assessments, the reports of the Planetary Mission Concept Studies.

Upcoming Mercury Meetings and Events

- EPSC 2022, 18–23 September 2023 – Mercury session
- AGU Fall Meeting, 12–16 December 2023
- Mercury 2024 – To be held in Japan

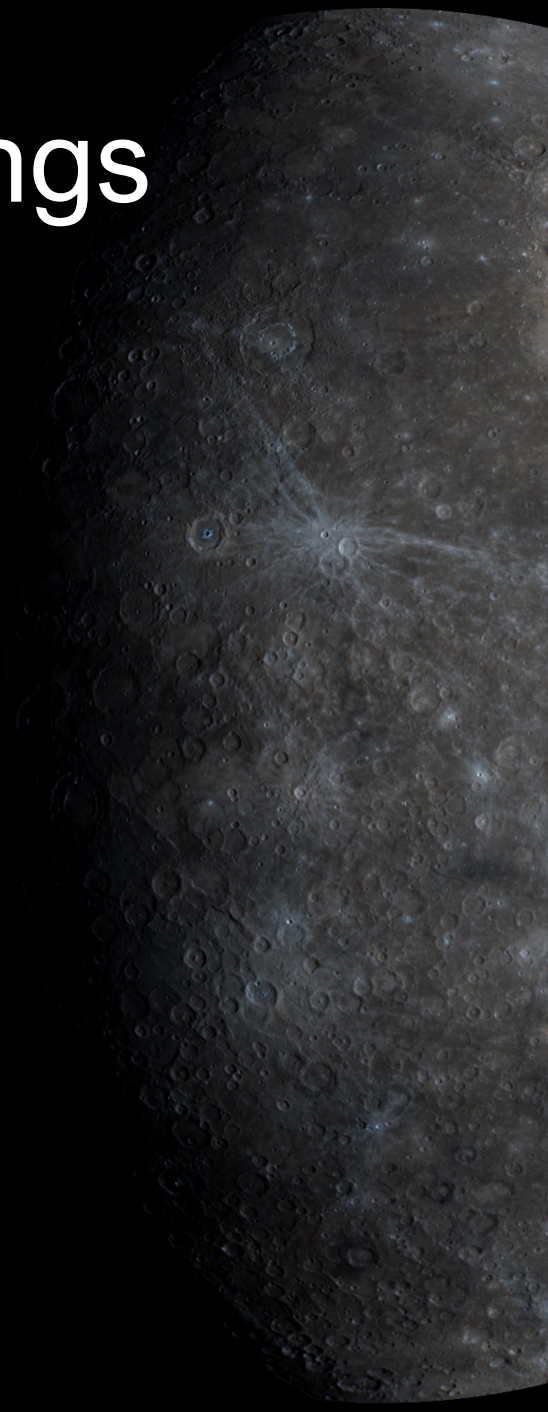
- BepiColombo:
  - Mercury Flyby 2, 23 June 2022



MExAG: https://www.lpi.usra.edu/mexag

Twitter: @ExploreMercury

Backup – Recent MExAG Findings



New Frontiers

- MExAG is concerned that the delay in the New Frontiers 5 (NF-5) call, especially without the scope to update the NF-5 destination list in the upcoming Decadal survey, substantially hinders NASA's ability to respond to outcomes of its own missions (both NASA-led missions and missions led by partner agencies) and other mission-enabling activities. By maintaining the NF destination list defined in *Vision and Voyages* (2011), MExAG highlights that NASA is relying on guidance written **more than 10 years** before the upcoming NF-5 call. For Mercury science, specifically, this means that the guidance was provided before the MESSENGER orbital mission and the subsequent revolution in the study and understanding of the innermost planet. This situation, however, is not unique to the study and exploration of Mercury. In addition, MExAG recognizes that the NF-4 call created a precedent for including themes responsive to new discoveries. This approach, therefore, could be used again to mitigate the challenges posed by the NF and Decadal cadences.
- MExAG encourages NASA to develop a defined and transparent mechanism for re-evaluating, and considering additional, NF destinations, especially when more than five years have elapsed since the recommended destinations were originally published.

MExAG Finding: February 2022

Radioisotope Power Systems

- Radioisotope power systems (RPS) are crucial tools for exploring the solar system, particularly in its most extreme environments, such as the surface of Mercury. An RPS system would be an essential element of a future Mercury lander (e.g., as demonstrated in the PMCS study of the NF-class Mercury Lander for the Decadal Survey process), which would likely operate during the Mercury night or within permanently shadowed regions where solar power is not possible.

- The RPS Program currently only follows the guidance of the Decadal Survey, which explicitly excludes Discovery-class missions and cannot foresee the mid-decade inclusion of RPS-enabling NF destinations, such as the Ocean Worlds theme that NASA added to (and selected from) the NF-4 call. MExAG, therefore, encourages NASA to ensure a sufficient supply of RPS and fuel to adequately meet the needs of exploration in the Flagship, New Frontiers (NF), and Discovery lines throughout the solar system – including Mercury.

MExAG Finding: February 2022

Ground-based Observatories

- Ground-based optical, infrared, and radio/radar observations play a critical role in the study of Mercury. MExAG encourages NASA to work with key facilities to address procedural/logistical obstacles that create serious challenges for proposals to observe Mercury, particularly during the coming years when support for – and coordinated science with – the BepiColombo mission is vital to provide increased science context.
- MExAG encourages NASA to:
  - Work with optical telescope facilities on which NASA acquires time (e.g., Keck Observatory) and their Telescope Allocation Committees (TACs) to ease the scheduling of twilight-time observations for Mercury. Many telescopes require half-night or even full night proposals; however, Mercury is only available for 1-2 hours at the beginning or end of the night, substantially disadvantaging observers of the innermost planet.
  - Engage with Goldstone and Green Bank Telescope, to ensure that there are equitable opportunities for planetary science observations, particularly now that Arecibo is no longer an option.
  - Allow observers to obtain letters of endorsement from NASA for Mercury observations in support of the BepiColombo mission during the upcoming flybys and orbital mission.