# SIG #3: Exoplanet / Solar System Synergies

## Stephen Kane (Co-chairs: Vikki Meadows & Kathy Mandt)

# For Researchers: NAC



## Planetary Science Analysis Groups

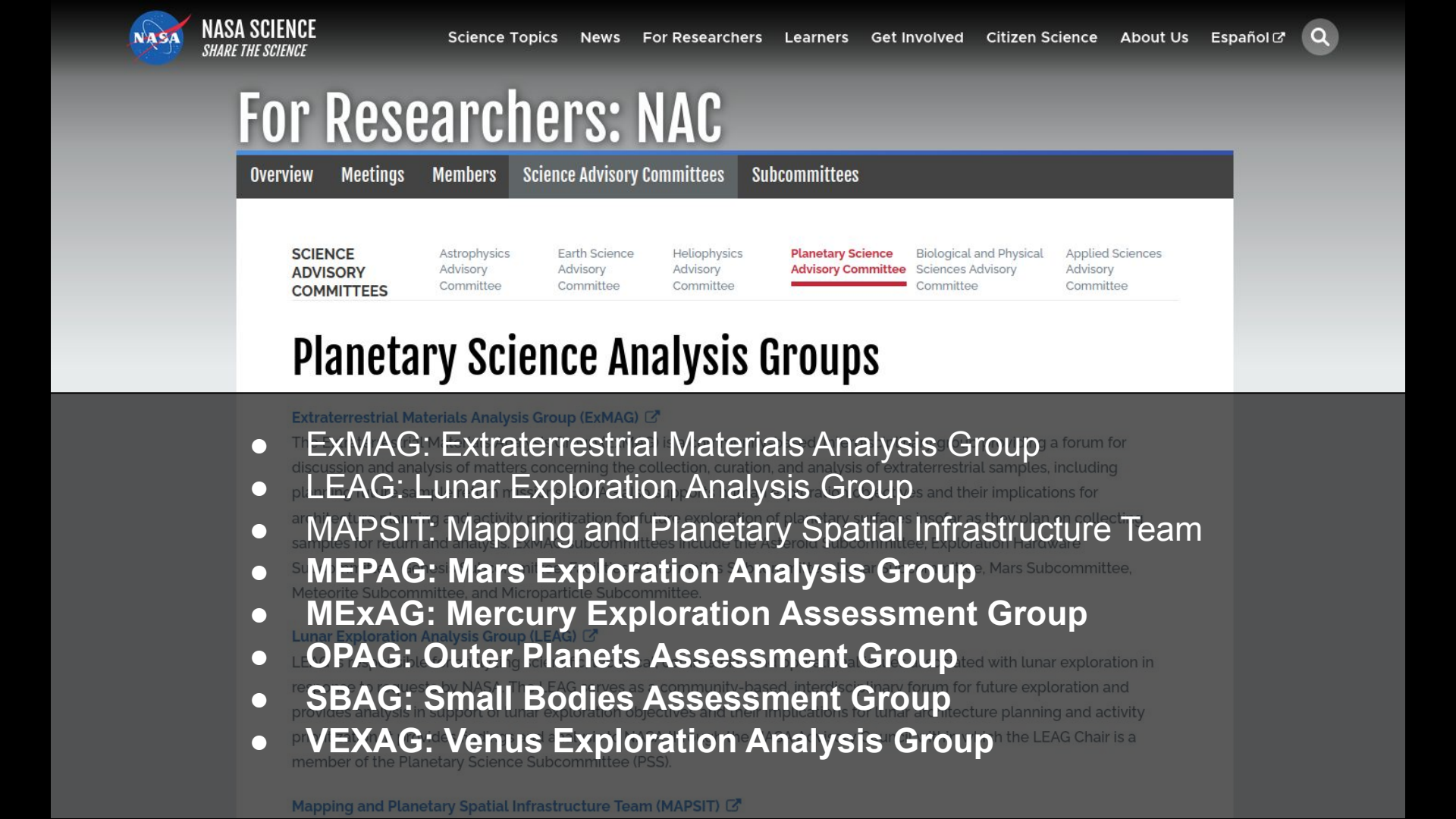
**Extraterrestrial Materials Analysis Group (ExMAG)**

The Extraterrestrial Materials Analysis Group (ExMAG) is a community-based, interdisciplinary group providing a forum for discussion and analysis of matters concerning the collection, curation, and analysis of extraterrestrial samples, including planning future sample return missions. ExMAG also supports human exploration objectives and their implications for architecture planning and activity prioritization for future exploration of planetary surfaces insofar as they plan on collecting samples for return and analysis. ExMAG subcommittees include the Asteroid Subcommittee, Exploration Hardware Subcommittee, Genesis Subcommittee, Facilities & Informatics Subcommittee, Lunar Subcommittee, Mars Subcommittee, Meteorite Subcommittee, and Microparticle Subcommittee.

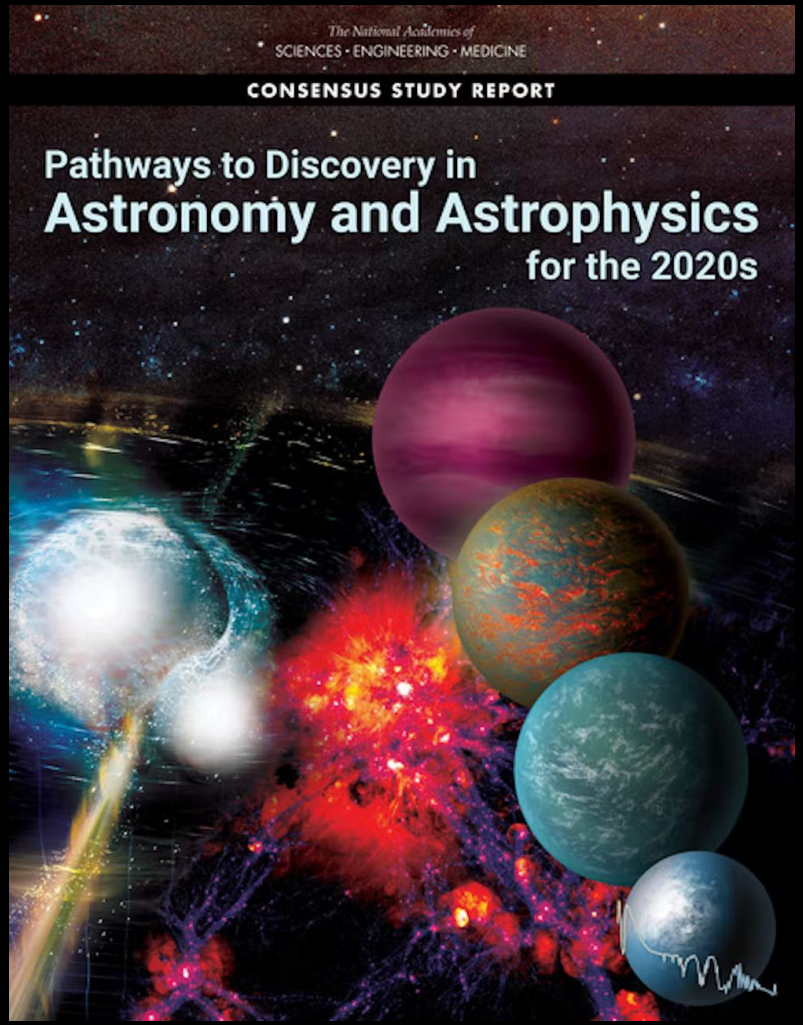
**Lunar Exploration Analysis Group (LEAG)**

LEAG is responsible for analyzing scientific, technical, commercial, and operational issues associated with lunar exploration in response to requests by NASA. The LEAG serves as a community-based, interdisciplinary forum for future exploration and provides analysis in support of lunar exploration objectives and their implications for lunar architecture planning and activity prioritization. It provides findings and analysis to NASA through the NASA Advisory Council within which the LEAG Chair is a member of the Planetary Science Subcommittee (PSS).

**Mapping and Planetary Spatial Infrastructure Team (MAPSIT)**




- ExMAG: Extraterrestrial Materials Analysis Group
- LEAG: Lunar Exploration Analysis Group
- MAPSIT: Mapping and Planetary Spatial Infrastructure Team
- **MEPAG: Mars Exploration Analysis Group**
- **MExAG: Mercury Exploration Assessment Group**
- **OPAG: Outer Planets Assessment Group**
- **SBAG: Small Bodies Assessment Group**
- **VEXAG: Venus Exploration Analysis Group**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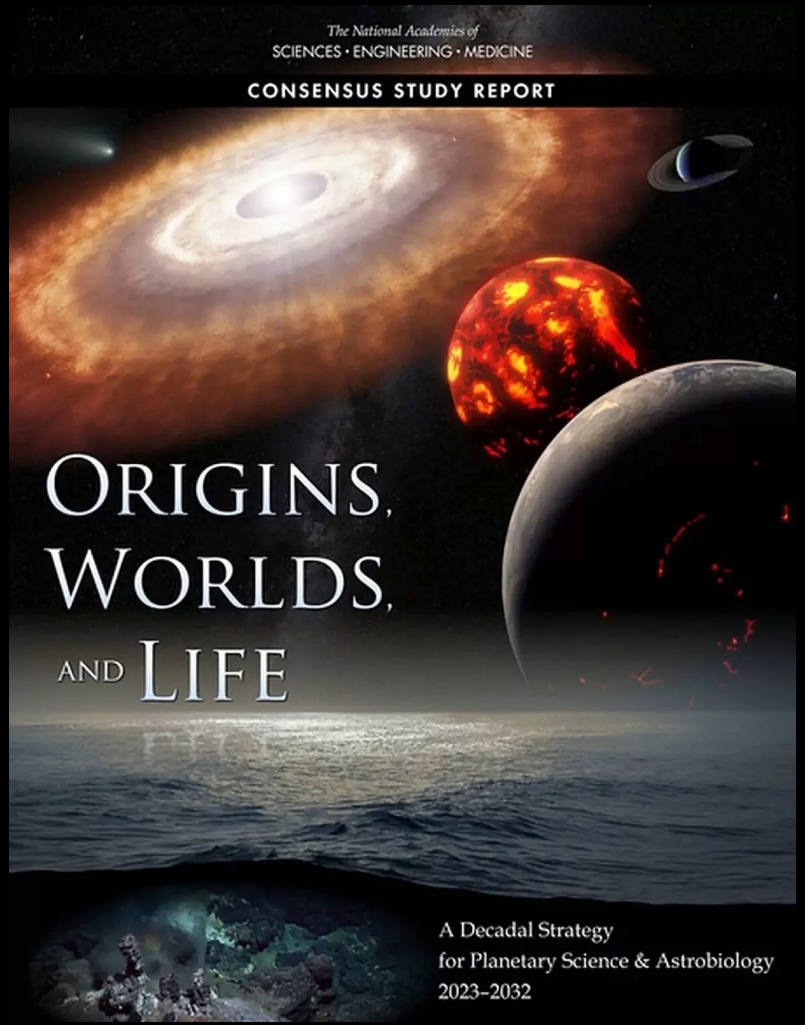
SCIENCES · ENGINEERING · MEDICINE
CONSENSUS STUDY REPORT
Pathways to Discovery in
Astronomy and Astrophysics
for the 2020s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ORIGINS,
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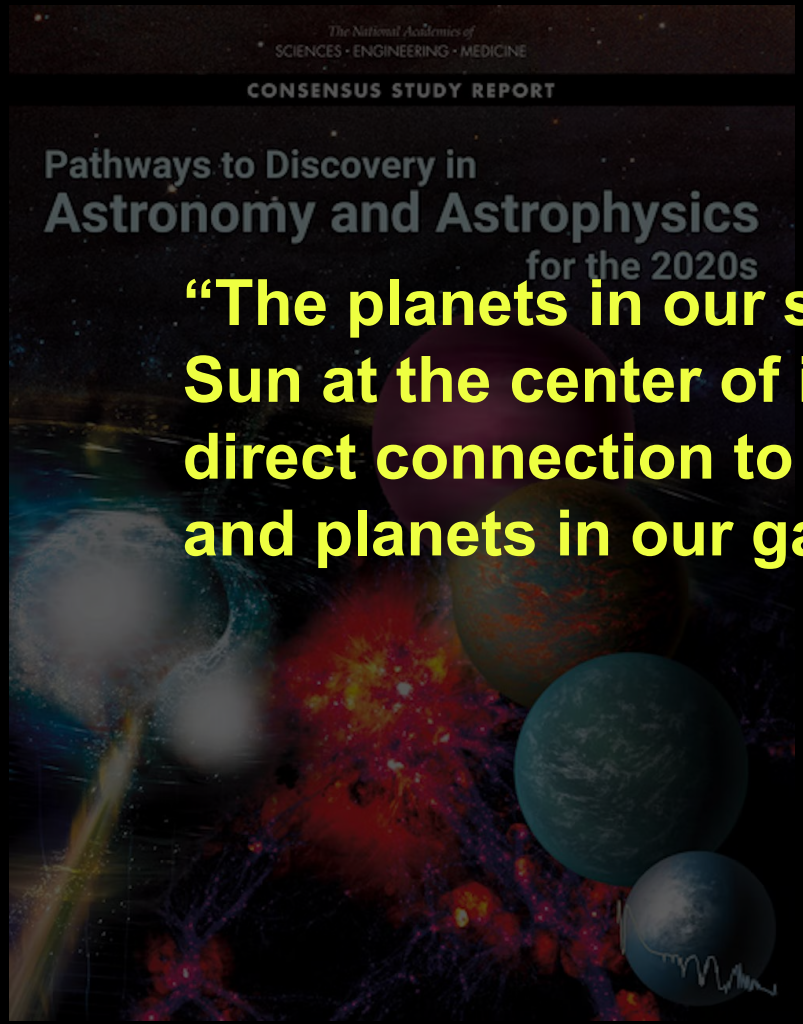
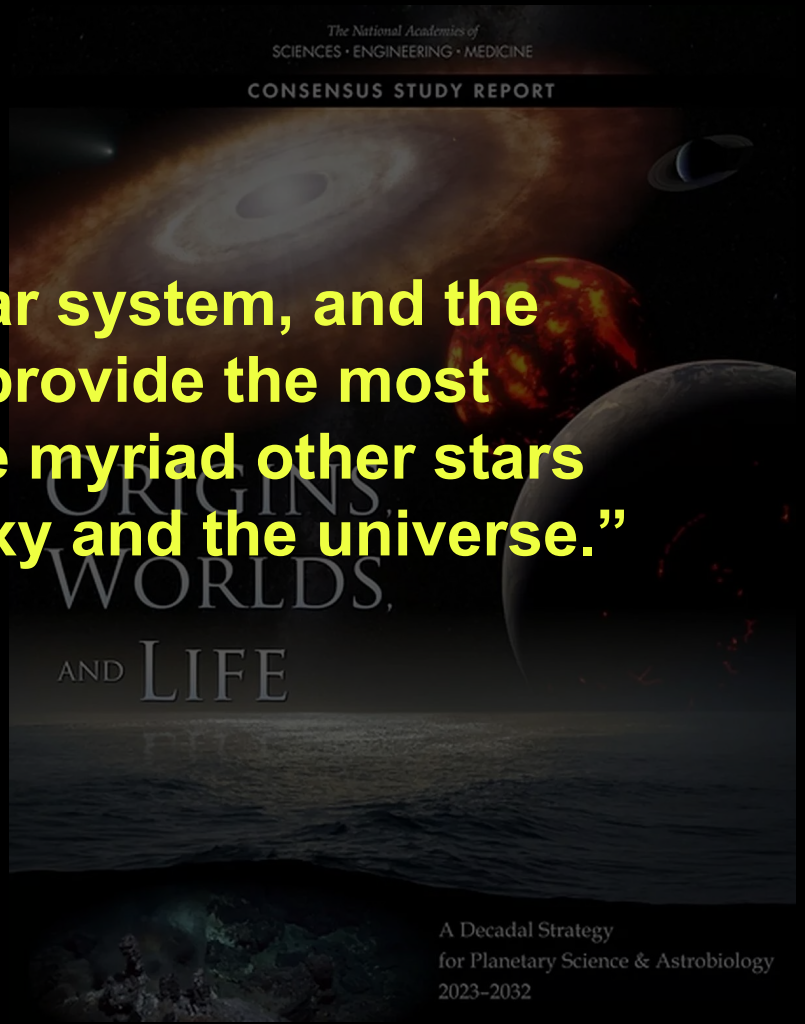
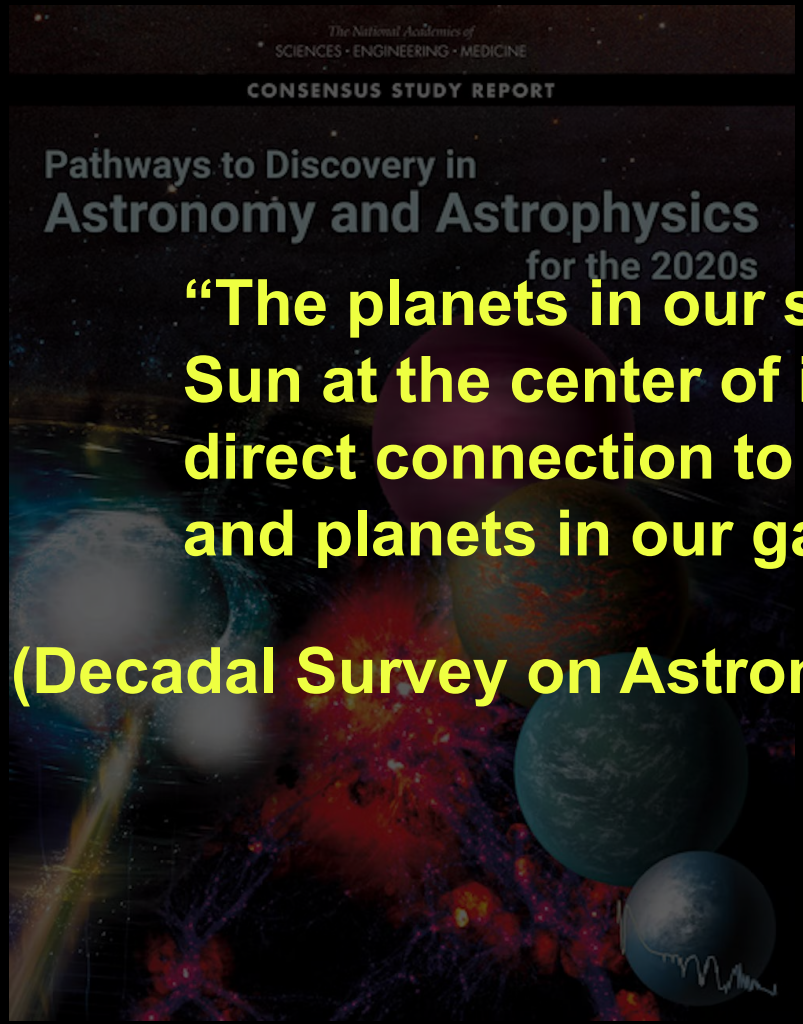
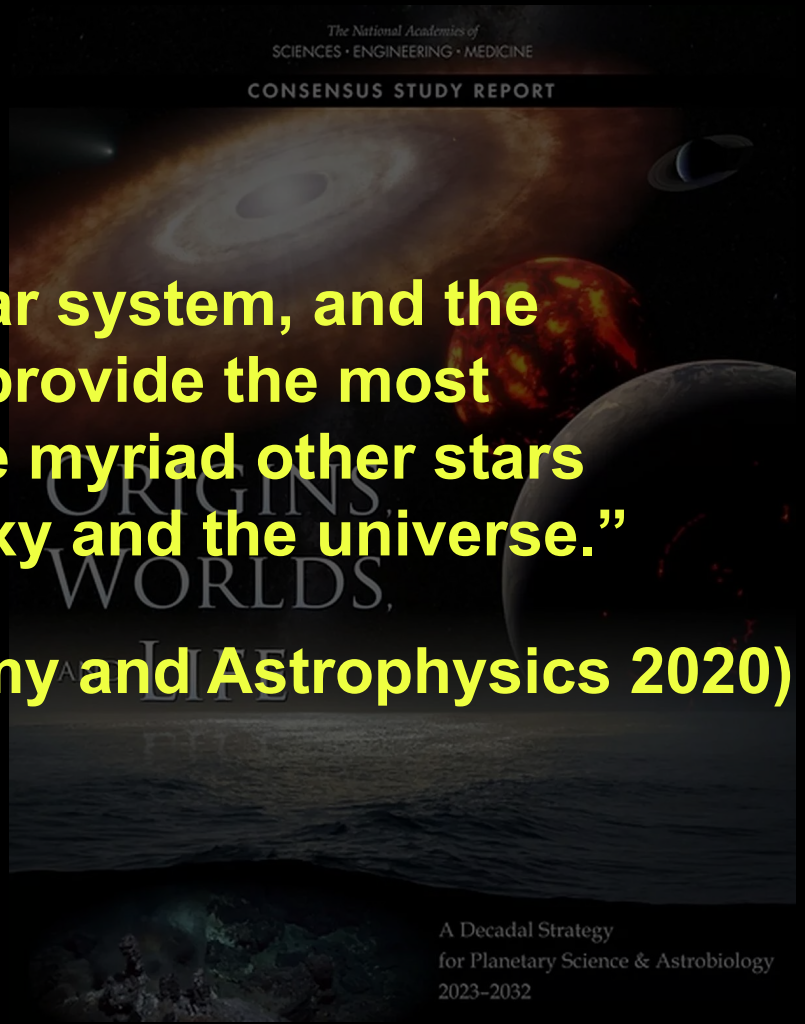
AND LIFE
A Decadal Strategy
for Planetary Science & Astrobiology
2023–2032




**“The planets in our solar system, and the Sun at the center of it, provide the most direct connection to the myriad other stars and planets in our galaxy and the universe.”**

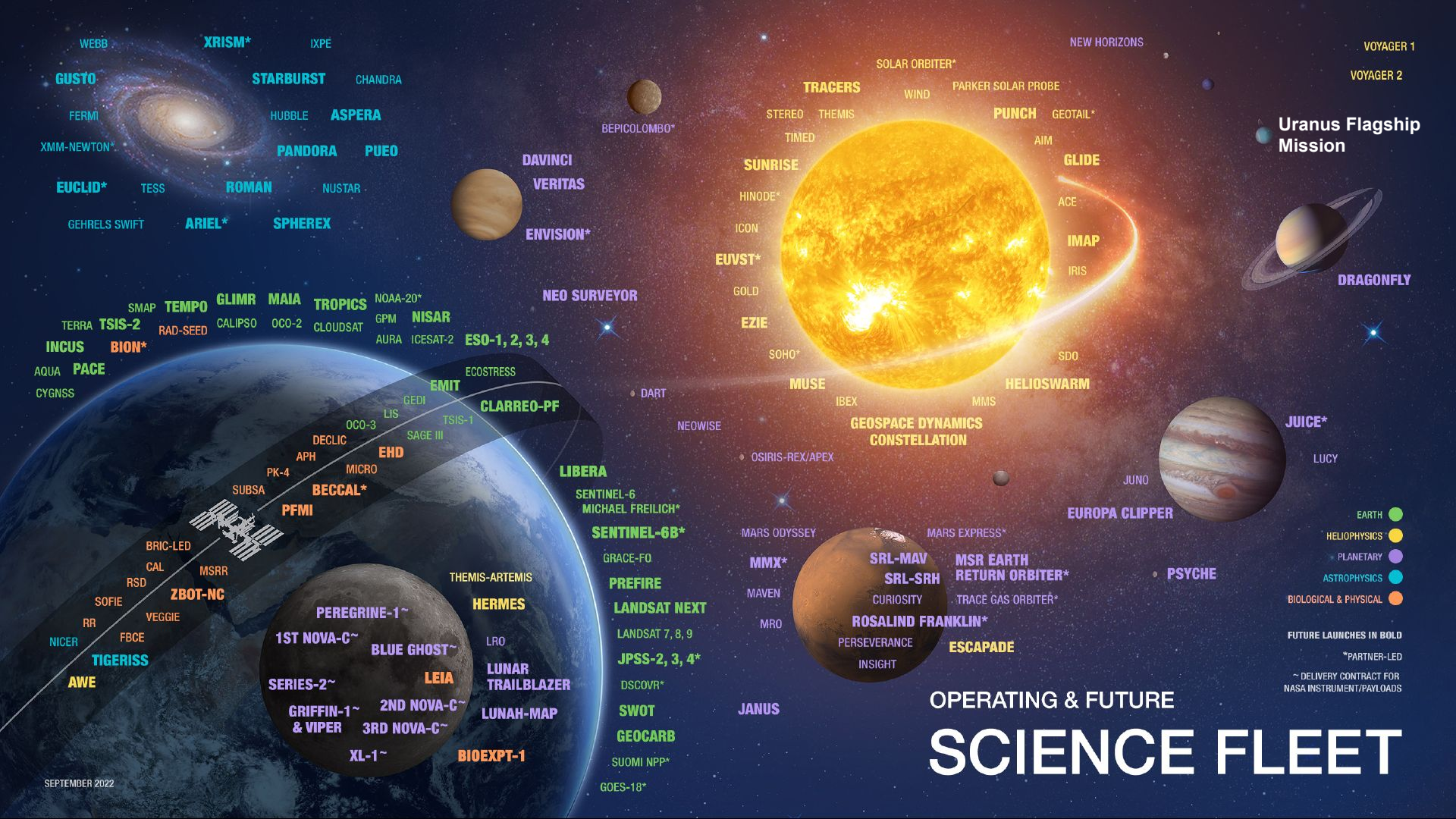



**"The planets in our solar system, and the Sun at the center of it, provide the most direct connection to the myriad other stars and planets in our galaxy and the universe."**

**(Decadal Survey on Astronomy and Astrophysics 2020)**

| Themes | Priority Science Question Topic and Scope |
|---|---|
| Origins | **Q1. Evolution of the protoplanetary disk** What were the initial conditions in the Solar System? What processes led to the production of planetary building blocks, and what was the nature and evolution of these materials? |
| | **Q2. Accretion in the outer solar system** How and when did the giant planets and their satellite systems originate, and did their orbits migrate early in their history? How and when did dwarf planets and cometary bodies orbiting beyond the giant planets form, and how were they affected by the early evolution of the solar system? |
| | **Q3. Origin of Earth and inner solar system bodies** How and when did the terrestrial planets, their moons, and the asteroids accrete, and what processes determined their initial properties? To what extent were outer Solar System materials incorporated? |
| Worlds & Processes | **Q4. Impacts and dynamics** How has the population of Solar System bodies changed through time, and how has bombardment varied across the Solar System? How have collisions affected the evolution of planetary bodies? |
| | **Q5. Solid body interiors and surfaces** How do the interiors of solid bodies evolve, and how is this evolution recorded in a body's physical and chemical properties? How are solid surfaces shaped by subsurface, surface, and external processes? |
| | **Q6. Solid body atmospheres, exospheres, magnetospheres, and climate evolution** What establishes the properties and dynamics of solid body atmospheres and exospheres, and what governs material loss to space and exchange between the atmosphere and the surface and interior? Why did planetary climates evolve to their current varied states? |
| | **Q7. Giant planet structure and evolution** What processes influence the structure, evolution, and dynamics of giant planet interiors, atmospheres, and magnetospheres? |
| | **Q8. Circumplanetary systems** What processes and interactions establish the diverse properties of satellite and ring systems, and how do these systems interact with the host planet and the external environment? |
| Life & Habitability | **Q9. Insights from Terrestrial Life** What conditions and processes led to the emergence and evolution of life on Earth, what is the range of possible metabolisms in the surface, subsurface and/or atmosphere, and how can this inform our understanding of the likelihood of life elsewhere? |
| | **Q10. Dynamic Habitability** Where in the solar system do potentially habitable environments exist, what processes led to their formation, and how do planetary environments and habitable conditions co-evolve over time? |
| | **Q11. Search for life elsewhere** Is there evidence of past or present life in the solar system beyond Earth and how do we detect it? |
| All Themes | **Q12. Exoplanets** What does our planetary system and its circumplanetary systems of satellites and rings reveal about exoplanetary systems, and what can circumstellar disks and exoplanetary systems teach us about the solar system? |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ROMAN
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DAVINCI
VERITAS
ENVISION*
NEO SURVEYOR
SOLAR ORBITER*
TRACERS
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PARKER SOLAR PROBE
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SDO
MUSE
HELIOSWARM
IBEX
MMS
GEOSPACE DYNAMICS CONSTELLATION
NEW HORIZONS
VOYAGER 1
VOYAGER 2
Uranus Flagship Mission
DRAGONFLY
SMAP
TEMPO
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CALIPSO
OCO-2
CLOUDSAT
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ICESAT-2
ESO-1, 2, 3, 4
INCUS
BION*
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PACE
CYGNSS
ECOSTRESS
EMIT
GEDI
CLARREO-PF
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TIGERISS
AWE
PEREGRINE-1~
1ST NOVA-C~
BLUE GHOST~
SERIES-2~
LEIA
GRIFFIN-1~
& VIPER
2ND NOVA-C~
3RD NOVA-C~
XL-1~
THEMIS-ARTEMIS
HERMES
LRO
LUNAR TRAILBLAZER
LUNAH-MAP
BIOEXPT-1
DART
NEOWISE
LIBERA
SENTINEL-6
MICHAEL FREILICH*
SENTINEL-6B*
GRACE-FO
PREFIRE
LANDSAT NEXT
LANDSAT 7, 8, 9
JPSS-2, 3, 4*
DSCOVR*
SWOT
GEOCARB
SUOMI NPP*
GOES-18*
OSIRIS-REX/APEX
MARS ODYSSEY
MARS EXPRESS*
MMX*
MAVEN
MRO
SRL-MAV
SRL-SRH
MSR EARTH RETURN ORBITER*
CURIOSITY
TRACE GAS ORBITER*
ROSALIND FRANKLIN*
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PLANETARY
ASTROPHYSICS
BIOLOGICAL & PHYSICAL
FUTURE LAUNCHES IN BOLD
*PARTNER-LED
~ DELIVERY CONTRACT FOR NASA INSTRUMENT/PAYLOADS
SEPTEMBER 2022
OPERATING & FUTURE
SCIENCE FLEET

JGR Planets

REVIEW ARTICLE

10.1029/2020JE006643

# The Fundamental Connections between the Solar System and Exoplanetary Science

**Stephen R. Kane[1], Giada N. Arney[2], Paul K. Byrne[3], Paul A. Dalba[1,†], Steven J. Desch[4], Jonti Horner[5], Noam R. Izenberg[6], Kathleen E. Mandt[6], Victoria S. Meadows[7], and Lynnae C. Quick[8]**

[1]Department of Earth and Planetary Sciences, University of California, Riverside, CA, USA, [2]Planetary Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA, [3]Department of Marine, Earth, and Atmospheric Sciences, Planetary Research Group, North Carolina State University, Raleigh, NC, USA, [4]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, [5]Centre for Astrophysics, University of Southern Queensland, Toowoomba, QLD, Australia, [6]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [7]Department of Astronomy, University of Washington, Seattle, WA, USA, [8]Planetary Geology, Geophysics and Geochemistry Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA

**Abstract** Over the past several decades, thousands of planets have been discovered outside our Solar System. These planets exhibit enormous diversity, and their large numbers provide a statistical opportunity to place our Solar System within the broader context of planetary structure, atmospheres, architectures, formation, and evolution. Meanwhile, the field of exoplanetary science is rapidly forging onward toward a goal of atmospheric characterization, inferring surface conditions and interiors, and assessing the potential for habitability. However, the interpretation of exoplanet data requires the development and validation of exoplanet models that depend on in situ data that, in the foreseeable future, are only obtainable from our Solar System. Thus, planetary and exoplanetary science would both greatly benefit from a symbiotic relationship with a two-way flow of information. Here, we describe the critical lessons and outstanding questions from planetary science, the study of which are essential for addressing fundamental aspects for a variety of exoplanetary topics. We outline these lessons and questions for the major categories of Solar System bodies, including the terrestrial planets, the giant planets, moons, and minor bodies. We provide a discussion of how many of these planetary science issues may be translated into exoplanet observables that will yield critical insight into current and future exoplanet discoveries.

**Special Section:**
Exoplanets: The Nexus of Astronomy and Geoscience

[†]NSF Astronomy and Astrophysics Postdoctoral Fellow.

**Key Points:**

- Exoplanetary science is rapidly expanding toward characterization of atmospheres and interiors
- Planetary science has similarly undergone rapid expansion of understanding planetary processes and evolution
- Effective studies of exoplanets require models and in situ data derived from planetary science observations and exploration

**Correspondence to:**
S. R. Kane,
skane@ucr.edu

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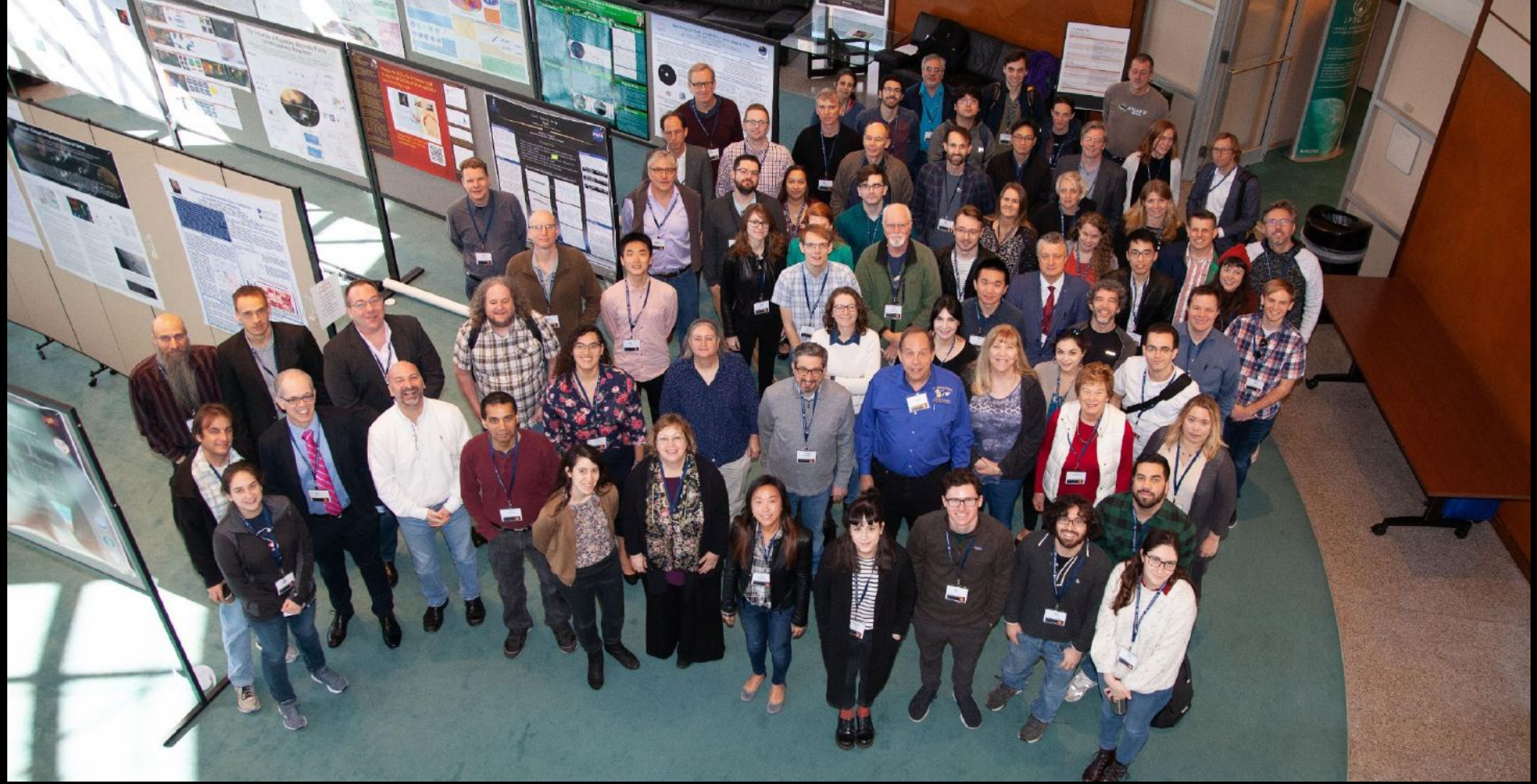
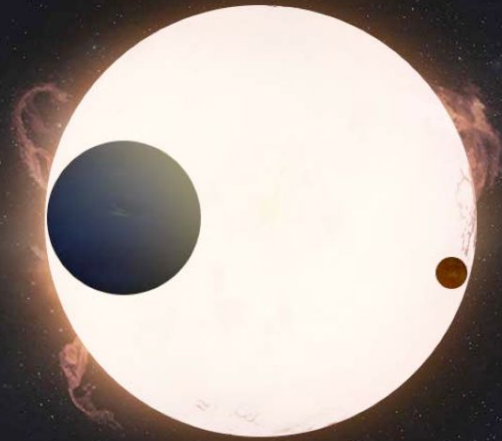
# Solar System Synergy Talks

- August 2020: *“Volatile Solubilities in Rocks”* – Laura Schaefer
- September 2020: *“How to Leverage NASA’s Planetary Data System Atmospheres Node for Exoplanet Science”* – Nancy Chanover
- October 2020: *“The advantages and Challenges of M Dwarfs as Planet Hosts”* – Elisabeth Newton
- November 2020: *“Spectra of Solar System Planets for Exoplanet Scientists”* – Mark Marley & Victoria Meadows
- January 2021: *“Formation, Evolution, and Structure of Giant Planets”* – Ravit Helled / *“Fuzzy Cores in our Prototypical Gas Giants: Evidence from Juno and Cassini”* – Chris Mankovich
- February 2021: *“How to “See” the Atmosphere of a Transiting Exoplanet”* – Laura Kreidberg
- April 2021: *“What We Learn from the Clouds on Giant Planets”* – Amy Simon / *“Clouds and Hazes in the Atmospheres of Terrestrial Exoplanets”* – David Crisp
- May 2021: *“Round-up of Exoplanets and Disks: JWST Cycle 1 GO Programs”* – Johanna Teske
- June 2021: *“Titan and Solar System Science with the James Webb Space Telescope”* – Conor Nixon
- December 9, 2021: *“Convective Cooling of Planetary Interiors”* – Johnny Seales
- March 17, 2022: *“Solar System Studies of Atmospheric Escape”* – Shannon Curry



White paper from first Exoplanets in our Backyard meeting:
https://ui.adsabs.harvard.edu/abs/2021BAAS...53d.231A/abstract

# Exoplanets in Our Backyard 2



Nov 2–4
2022 **ALBUQUERQUE, NEW MEXICO/VIRTUAL**

A joint Assessment Group meeting by VEXAG, OPAG, ExoPAG, MEPAG, and MExAG


# Exoplanets in our Backyard 2

**Co-Conveners**

- Stephen Kane (University of California, Riverside)
- Ravi Kumar Kopparapu (NASA Goddard Space Flight Center)

**Science Organizing Committee**

- Giada Arney (NASA Goddard Space Flight Center)
- Gina DiBraccio (NASA Goddard Space Flight Center)
- Terry Hurford (NASA Goddard Space Flight Center)
- Noam Izenberg (APL/JHU)
- Abigail Rymer (APL/JHU))
- Laura Schaefer (Stanford University)
- Johanna Teske (Earth and Planets Lab, Carnegie Institution for Science)
- Robin Wordsworth (Harvard University)

**Institutional Support**

- Lunar and Planetary Institute
- Universities Space Research Association
- NASA Exoplanet Science Institute

# Science Themes

- Overview Talks
- Formation and Evolution of Planets
- Interior and Surface Processes
- Planetary Atmospheres, Thin and Thick
- Star-Planet Interactions
- Habitability and Astrobiology, Near and Far
- Missions and Laboratory Work

**Coming soon: Exoplanets in our Backyard 3!**

# Planetary Science Meetings

- Lunar and Planetary Science Conference (LPSC)
  The Woodlands, TX, March 13-17, 2023.
- Division for Planetary Sciences (DPS)
  San Antonio, TX, October 1-6, 2023.
- American Geophysical Union (AGU)
  San Francisco, CA, December 11-15, 2023.

- PI Launchpad Workshop
  Ann Arbor, MI, July 24-28, 2023.
- Astrobiology Science Conference (AbSciCon)
  Providence, RI, May 5-10, 2024.