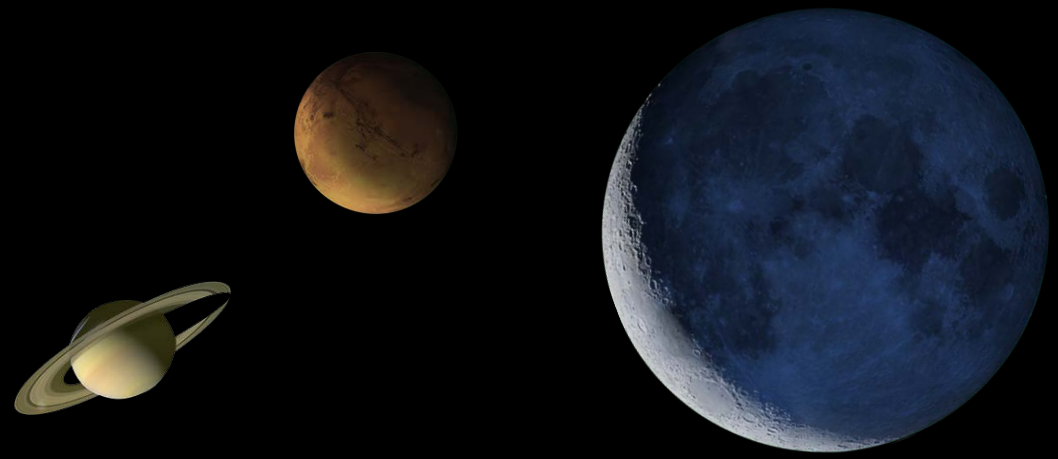
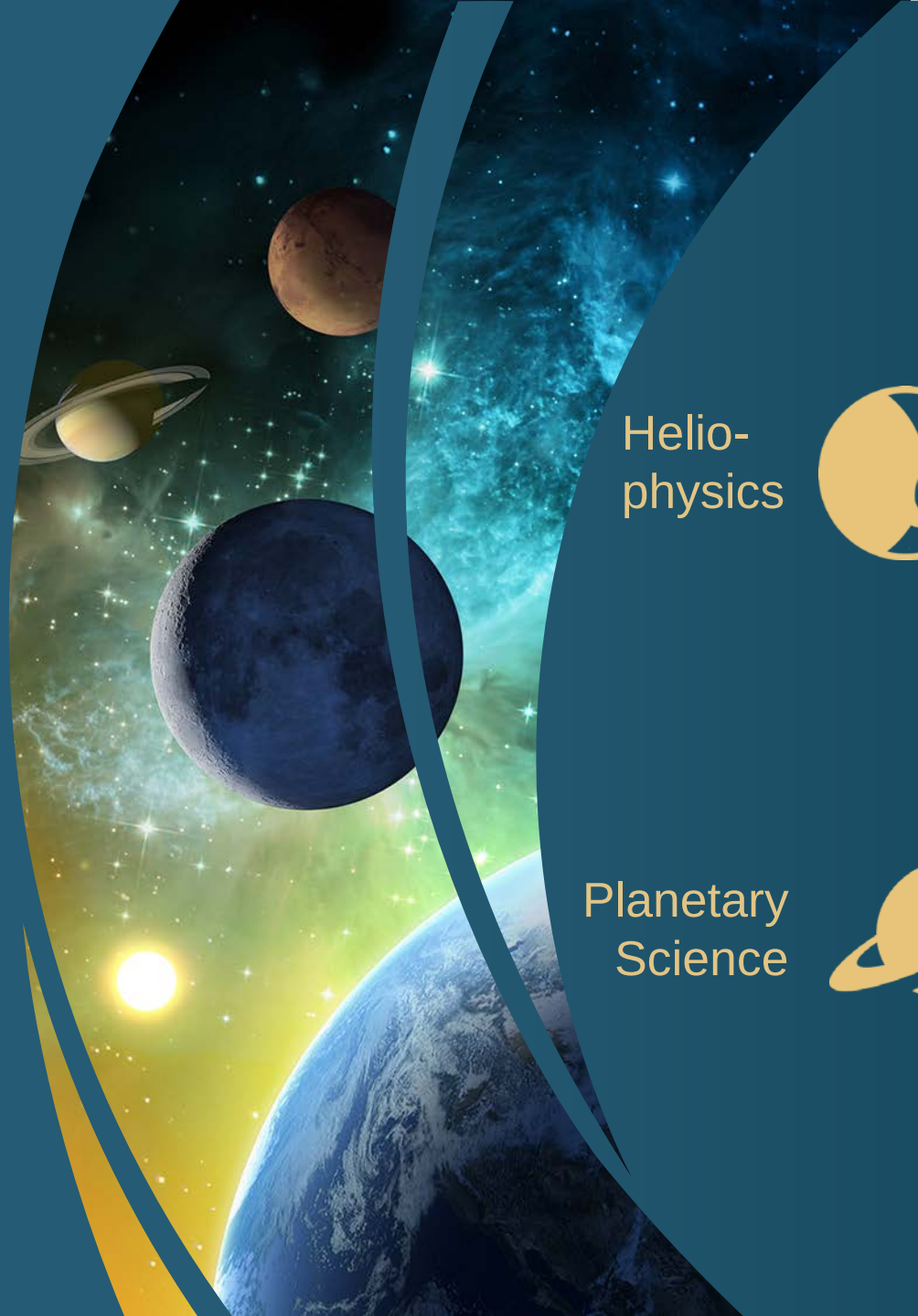
National Aeronautics and Space Administration



PLANNING FOR FUTURE PLANETARY SCIENCE MISSIONS USING SMALL SATELLITES

Carolyn R. Mercer, Ph.D.
NASA Glenn Research Center
Program Executive, Small Innovative Missions for Planetary Exploration (SIMPLEx)

IAA Low Cost Planetary Missions Conference
June 3, 2019
Toulouse, France



NASA SCIENCE

AN INTEGRATED PROGRAM

Helio-physics

Earth Science

KEY SCIENCE THEMES

Protect & Improve Life on Earth

Search for Life Elsewhere

Discover Secrets of the Universe

Planetary Science

Astrophysics

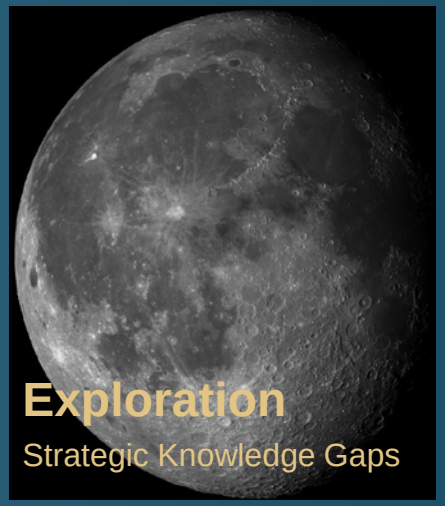
Joint Agency Satellite Division

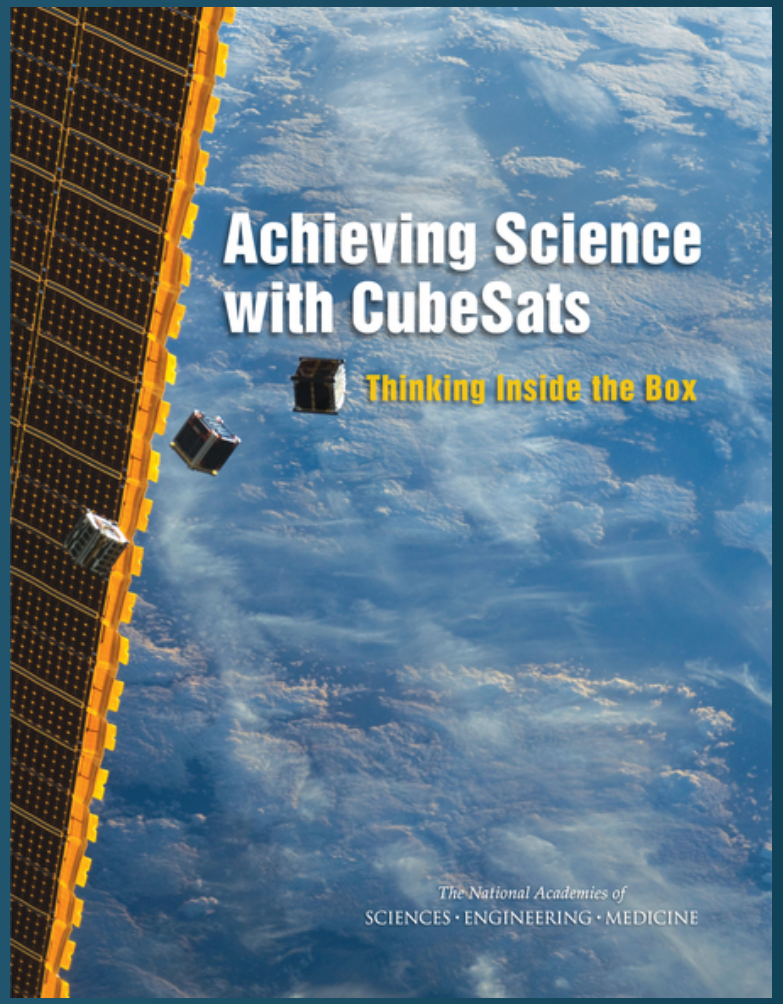
Planetary Science Division

Science

Planetary Defense

Exploration



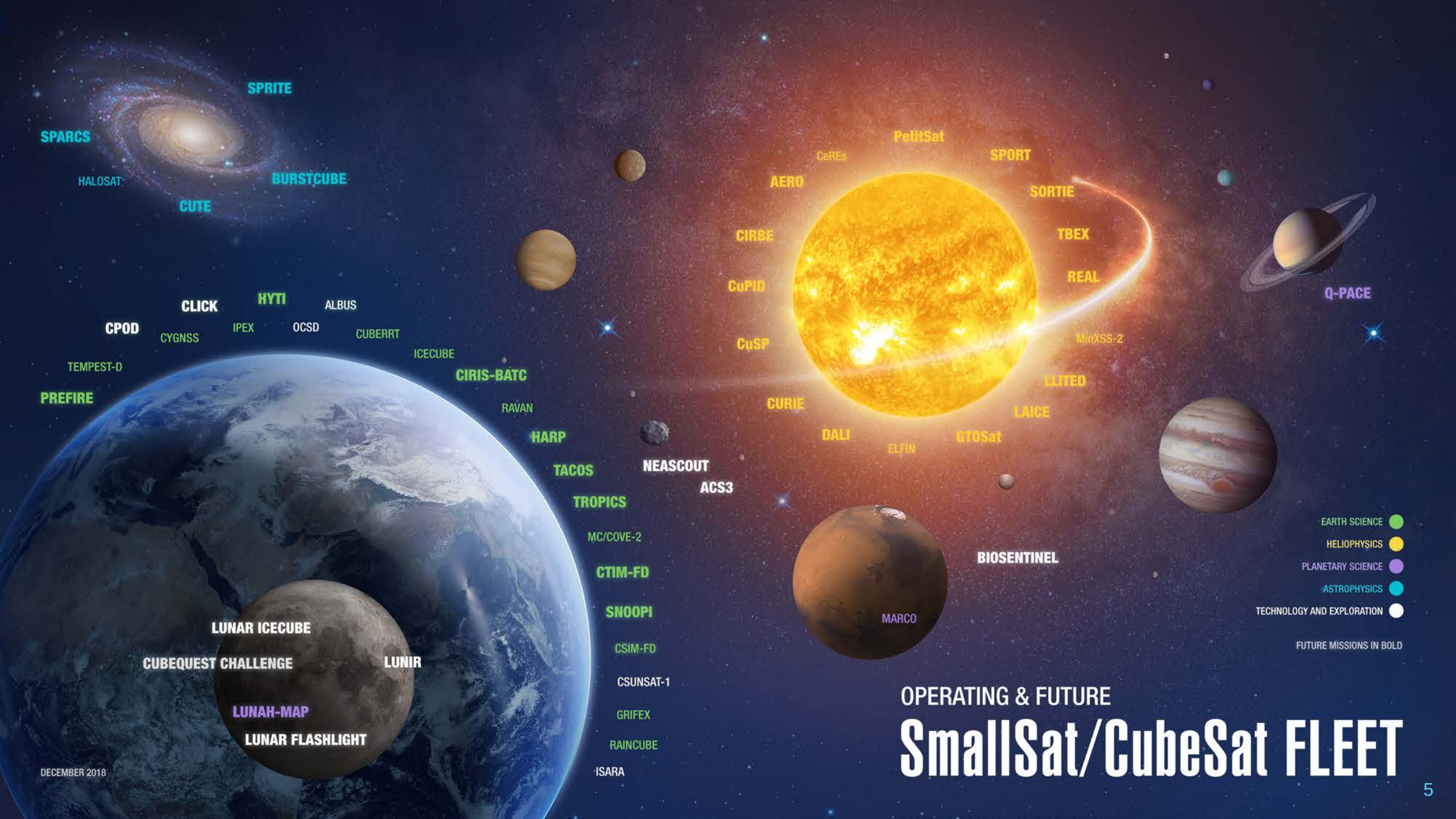


U.S. National Academies Report (2016)

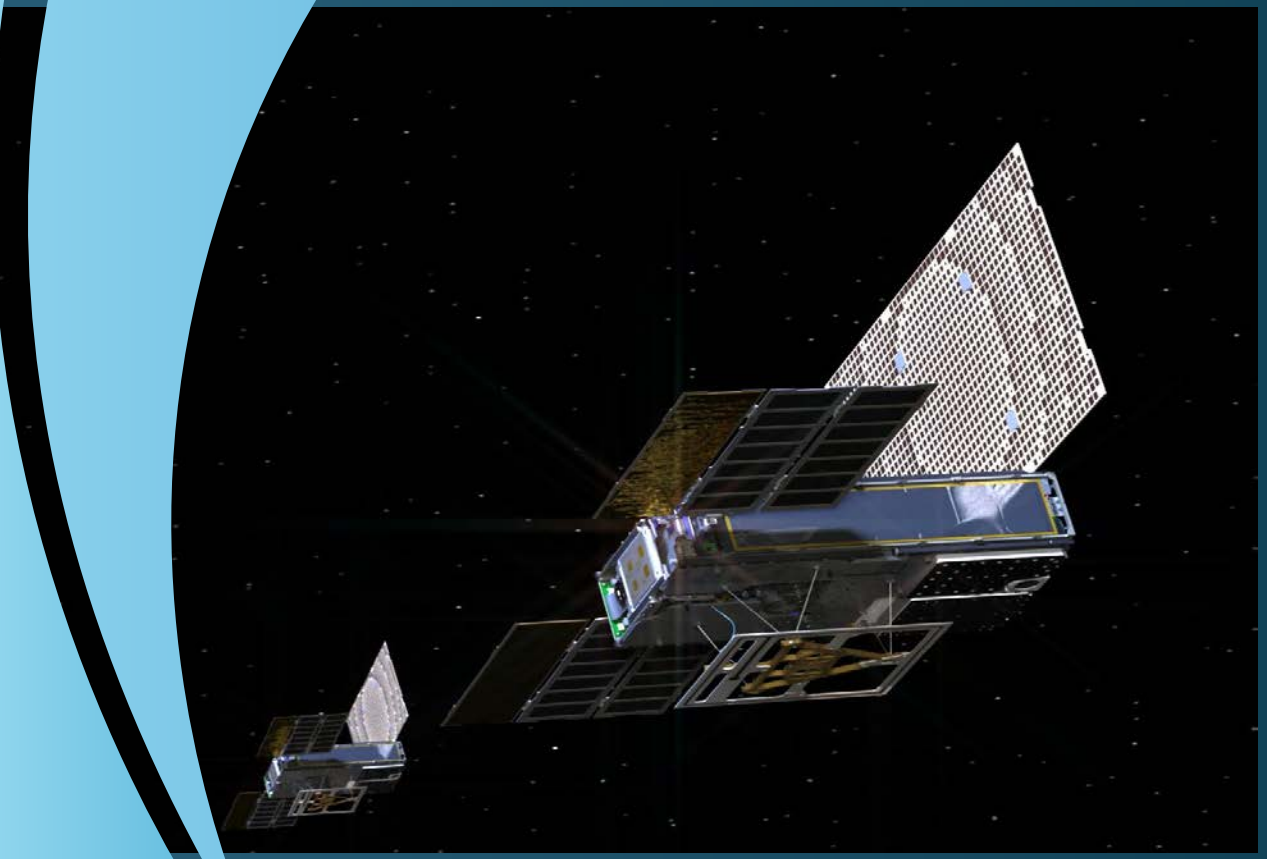
Small Spacecraft Approach: NASA Science

NASA's Science Mission Directorate (SMD) is committed to flying small spacecraft as secondary payloads on all appropriate SMD missions

- Target high-priority science that can be conducted using small spacecraft
- Manage programs with appropriate cost and risk
- Foster multi-discipline collaboration
- Leverage and partner with a growing commercial sector to collaboratively drive instrument and sensor innovation


SPRITE
SPARCS
HALOSAT
BURSTCUBE
CUTE
CLICK
HYTI
ALBUS
CPOD
CYGNSS
IPEX
OCSD
CUBERRT
ICECUBE
TEMPEST-D
CIRIS-BATC
PREFIRE
RAVAN
HARP
TACOS
NEASCOUT
ACS3
TROPICS
MC/COVE-2
CTIM-FD
SNOOPI
CSIM-FD
CSUNSAT-1
GRIFEX
RAINCUBE
ISARA
LUNAR ICECUBE
CUBEQUEST CHALLENGE
LUNIR
LUNAH-MAP
LUNAR FLASHLIGHT
DECEMBER 2018
PetitSat
CeREs
SPORT
AERO
SORTIE
CIRBE
TBEX
CuPID
REAL
Q-PACE
CuSP
MinXSS-2
LLITED
CURIE
LAICE
DALI
GTOSat
ELFIN
BIOSENTINEL
MARCO
EARTH SCIENCE
HELIOPHYSICS
PLANETARY SCIENCE
ASTROPHYSICS
TECHNOLOGY AND EXPLORATION
FUTURE MISSIONS IN BOLD
OPERATING & FUTURE
SmallSat/CubeSat FLEET

Small Spacecraft Approach: Planetary Science Division



Small Innovative Missions for Planetary Exploration (SIMPLEx-1) 2014

- LunaH-Map
- Q-PACE

Directed and *Partnered* Secondary Payloads

- MarCO (2018)
- *LICIA Cube (2021) – potential ASI contribution*

Planetary Science Deep Space SmallSat Studies (PSDS3) 2017

- 19 Studies – Presented March 2018

Small Innovative Missions for Planetary Exploration (SIMPLEx-2) 2018

- Step-1 selections expected soon

Technology Development

Planetary Science Deep Space SmallSat Studies

Solicitation Requirements

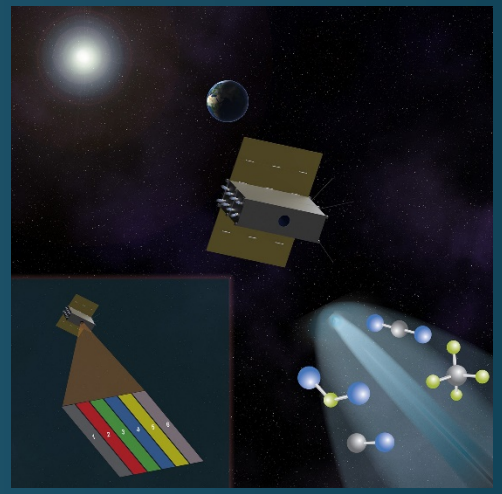
- Concepts for planetary science missions
- CubeSat up to 180 kg
- $100M USD cost cap
- No constraints on rides, infrastructure, etc.

Solicitation Objectives

- Can deep space missions be credibly done using small spacecraft?
- What science might be accomplished?
- What technology development is needed?
- What are credible mission costs?

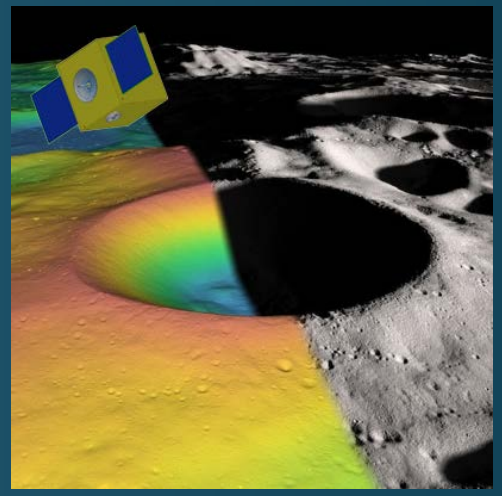
Planetary Science Deep Space SmallSat Studies

Tilak Hewagama
University of Maryland
College Park



PrOVE

Noah Edward Petro
NASA
Goddard Space Flight Center



MiLuV

19 Studies Funded

- Study destinations were to Mars, Venus, the Moon, the Outer Planets, and small Solar System bodies.
- Science questions …

Conclusions:

- Excellent planetary science *can* credibly be done using small spacecraft
- Critical enabling technology includes high delta-V propulsion, high bandwidth communications, low-volume power systems, radiation-tolerant flight computers, and aerocapture.
- Small spacecraft can carry large price tags. Several concepts had difficulty staying within the $100M cap.

https://www.hou.usra.edu/meetings/smallsat2018/smallsat_program.pdf

Small Innovative Missions for Planetary Exploration (SIMPLEx)

Primary Mission	SIMPLEx Proposal Cut-off Date	Launch Readiness Dates
LEO or GTO	On-going	On-going
Lucy	24 July 2018	October 2021
Psyche	24 July 2018	August 2022
IMAP	NET Oct 2019	Dec 2024
EM-x	TBA	TBD
New launch opportunities to be added as available		

Solicitation Requirements

- Missions to conduct planetary science
- CubeSat up to 180 kg
- $15M - $55M USD cost cap
- Must propose to ride as a secondary for a specific launch opportunity

Solicitation Structure

- Continuously open call, with deadlines for specific launch opportunities
  - Last deadline was July 24, 2018
  - Next deadline will be no earlier than Oct 1, 2019
- **Up to 50% of the total mission cost may be from non-U.S. contributions**

Small Spacecraft Selection for Planetary Science: Target Specific Launch Opportunity

Launch minus 4-5 years	**Solicit small spacecraft for specific launch opportunities**	• Select and award ~1 year Phase A/B design studies • Expected product is PDR-level design • Launch trajectory is known
Launch minus 3-4 years	**Phase A/B design studies and Technology readiness demonstration**	• Launch Vehicle procurement includes ESPA ring and/or CubeSat dispenser options based on selections
Launch minus 2-3 years	**Select secondary mission in accordance with expected launch capacity** **Procure Launch Vehicle for Primary and Secondary**	• Selection determined in coordination with launch vehicle selection • Provided for Phase C design/build: More detailed Launch Vehicle trajectory, environments, and interfaces


EXPLORE
with us