Status of the Small Satellite developments at the Jet Propulsion Laboratory

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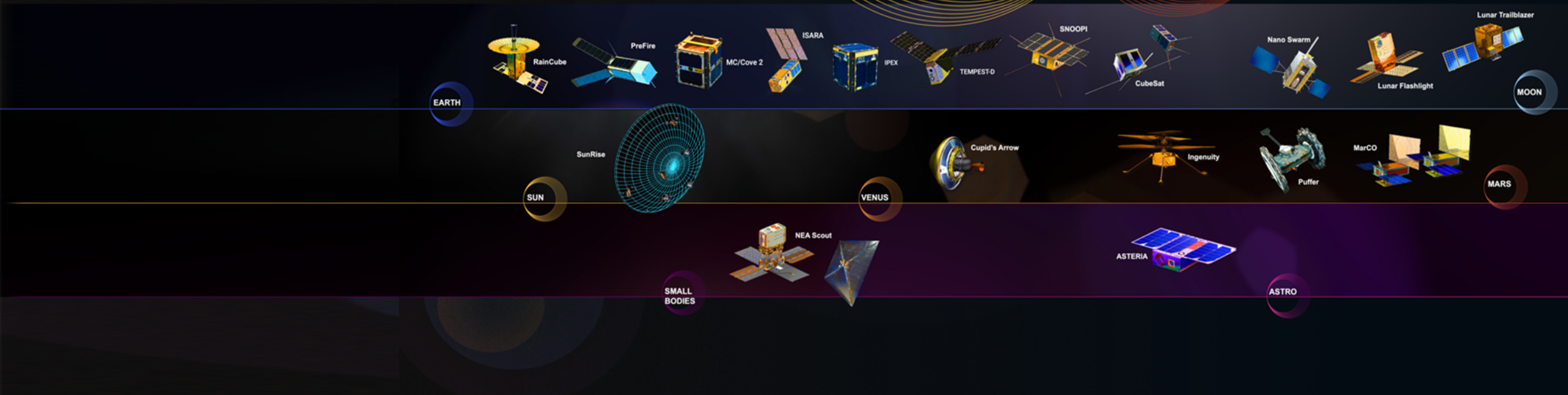
Jet Propulsion Laboratory
California Institute of Technology

JPL: At the Forefront of Finding New Capabilities

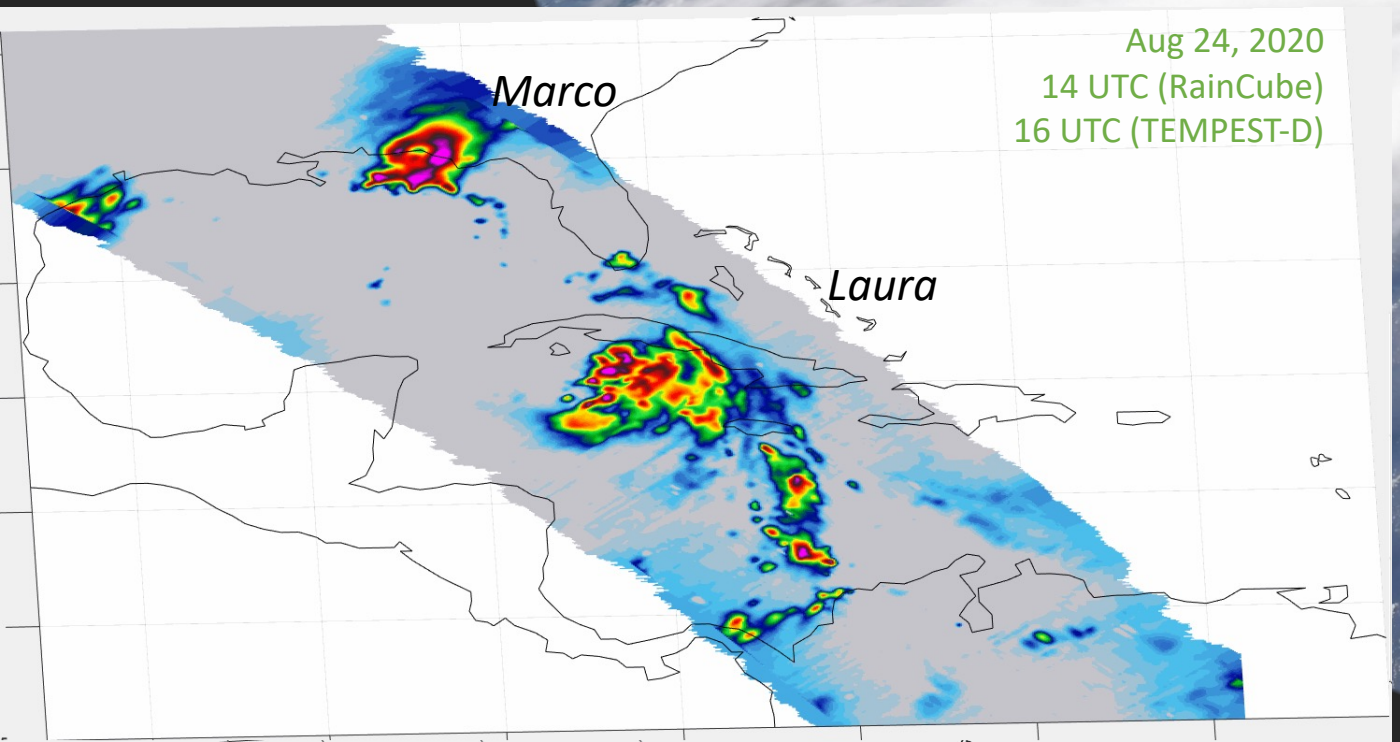
National Aeronautics and Space Administration

In delivering big science returns in smaller packages that are:

Small, modular, scalable, and less expensive to build rapidly and launch



SmallSats, offer a new world of possibilities and challenges for doing innovative science measurements



TEMPEST-D and RainCube joined forces after 2 years in space to observe Laura strengthening while Marco makes landfall

What do we consider a "SmallSat" at JPL?

- Typically, SmallSats are defined as spacecraft with a mass of ~250 kg or less
  - CubeSats are a subset of SmallSats that have a standard form factor made up of a number of "U's" (each "U" is 10 x 10 x 10 cm). Standard CubeSat form factors are 3U, 6U, and 12U.
- **But this definition doesn't fit all of the JPL use cases!**
- An expanded definition for JPL "SmallSats":
  - Has to have a mission aspect (i.e. not an instrument)
  - Includes small rovers (e.g. CADRE), helicopter, "flightless CubeSats" (e.g. Farside Seismic Suite), etc.
  - Generally under 250 kg mass, but if it is a Class D, Type II project, it's a "SmallSat"
  - Under 250 kg but higher risk class is a grey area

Example JPL SmallSats that span the definition

"Typical" SmallSat

"Over 250 kg" SmallSat (Class D)

"Untraditional" SmallSat

Grey Area

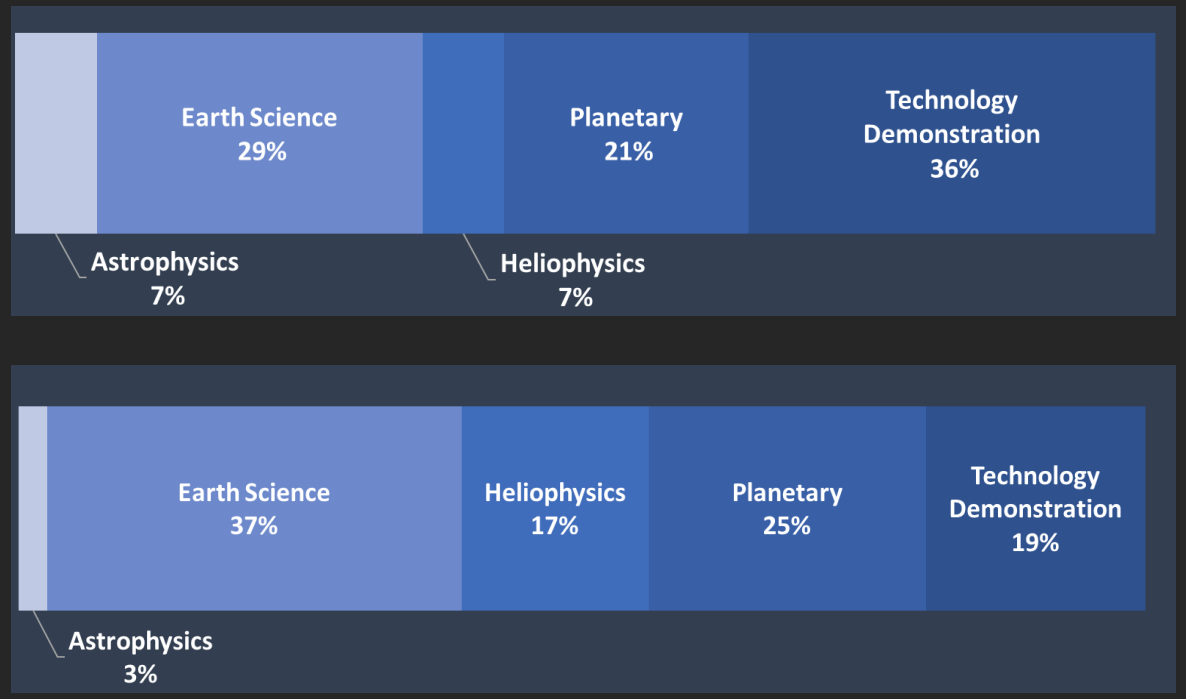
Mission Risk Class

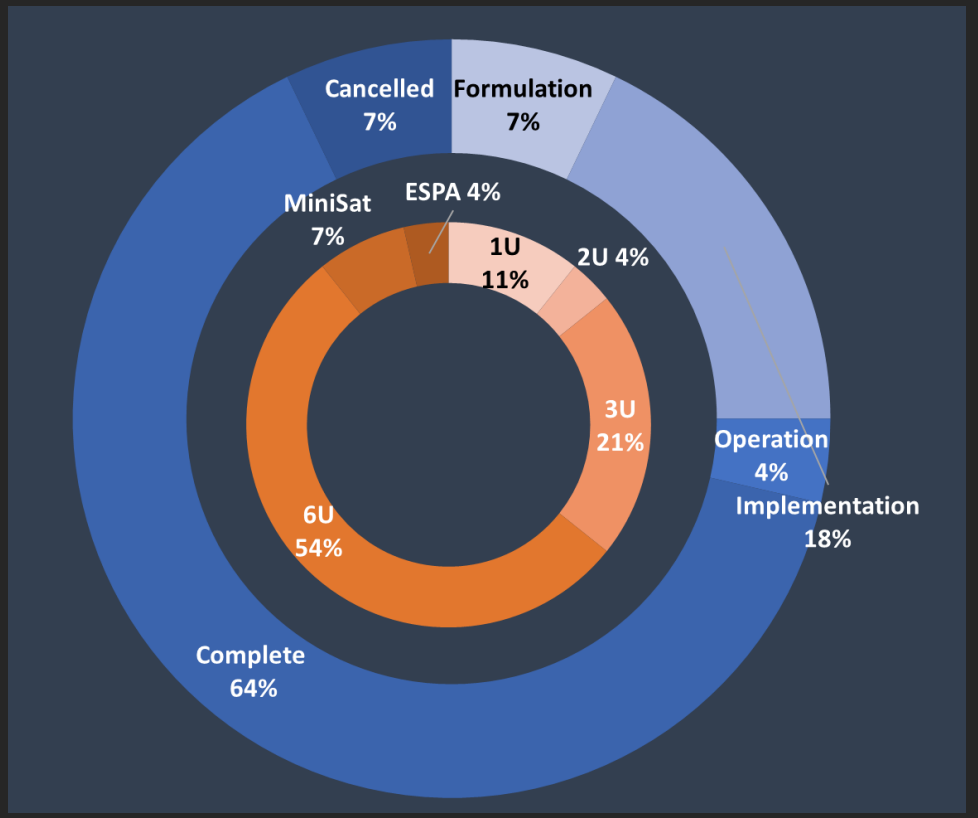
	Flight System Mass: Under 250 kg	Flight System Mass: Over 250 kg
Class A/B/C	Grey Area	Not SmallSat
Class D (or less)	SmallSat	SmallSat

- **Note: Type II payloads would NOT be considered a SmallSat (e.g. DSOC, DSAC, CGI)**

JPL's Small Satellite Missions at a Glance

Includes missions that JPL has led and contributed to 2013 - 2022



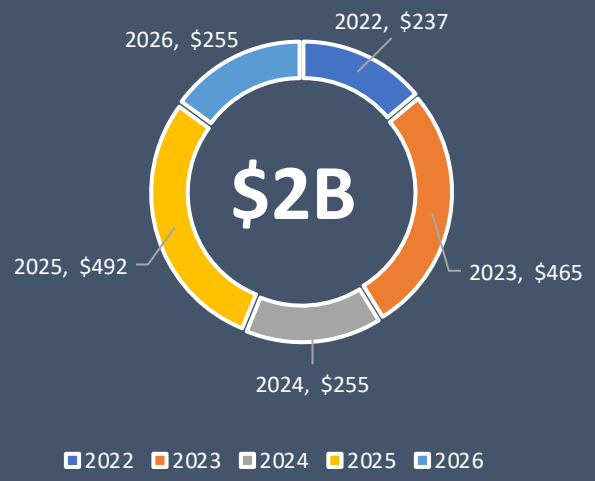


$663M
Total Investment

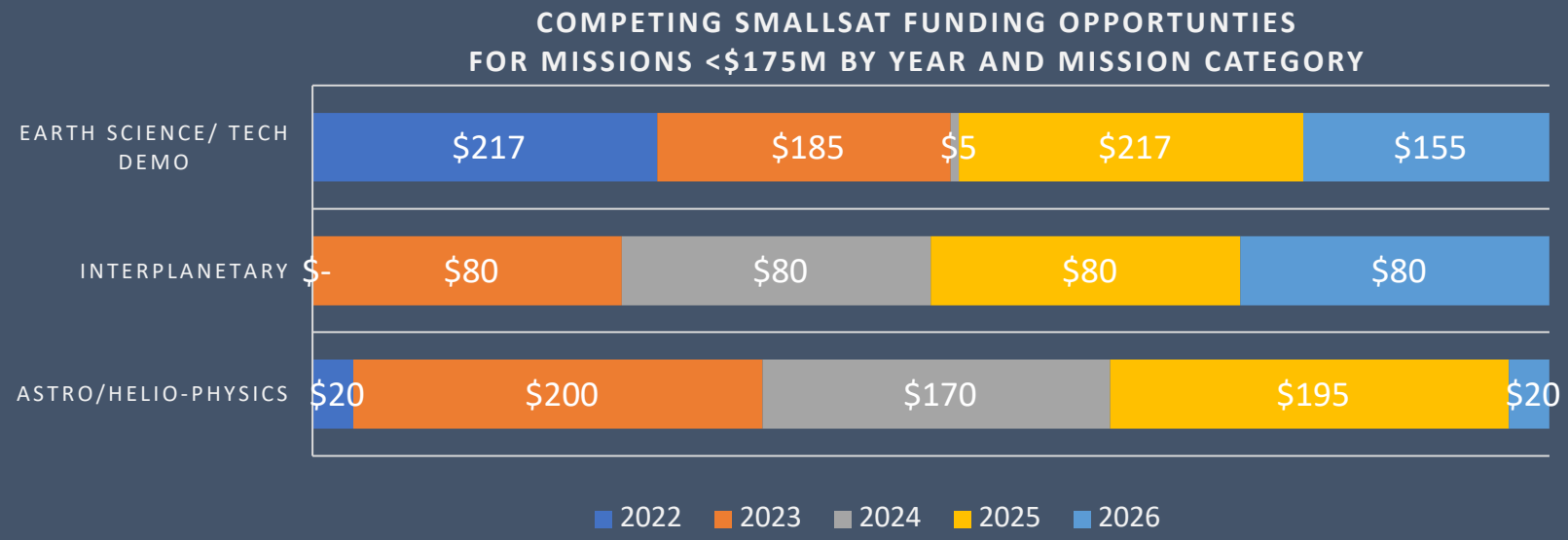
28 SmallSat Missions
(41 Spacecraft)

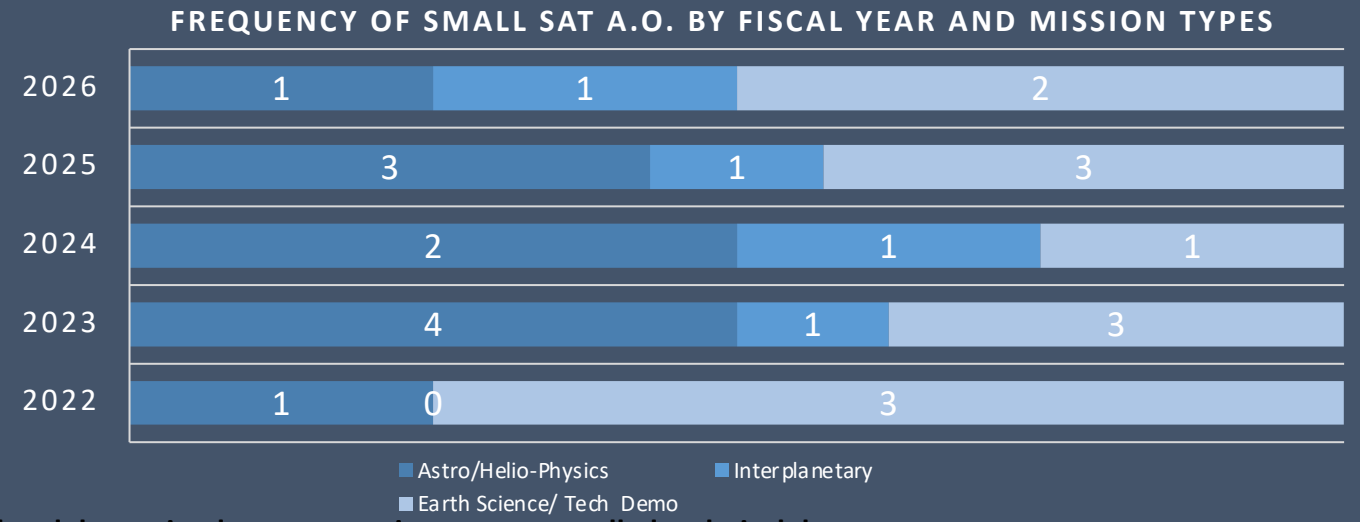
Small Satellite Missions at a Glance

Total NASA Small and Mid Sat Investment Opportunities



27 Missions In 5 Years

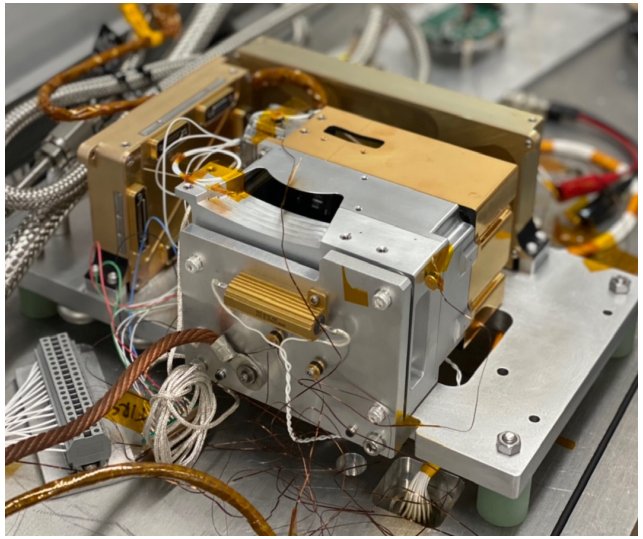




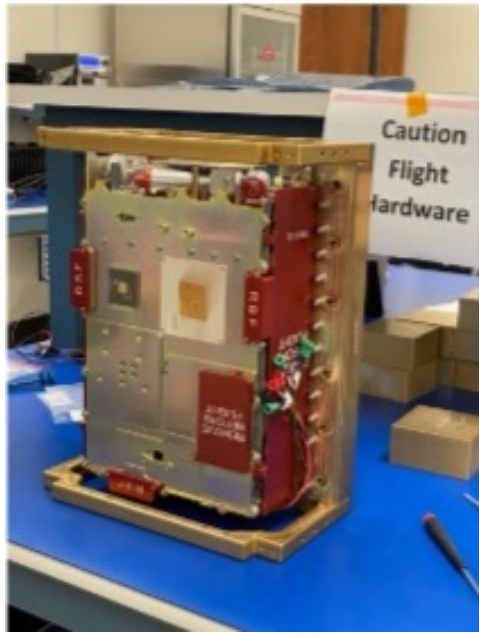
Institutional Approach to Handling Future SmallSat Missions

- Establishment of a dedicated JPL Center for SmallSat Development
  - To coordinate SmallSat activities across the project lifecycle and facilitate collaboration among stakeholders
  - Establishes a new implementation model
    - ***Innovative ways to execute multiple, simultaneous small missions***
  - Provides key services to handle multiple, simultaneous projects across Program Offices
  - Reaches out to other organizations/universities to help augment the development of our small missions
  - Helps enable JPL to take advantage of increasing SmallSat mission opportunities
  - Pathfinding ways to reduce paperwork and institutional process

The current state of JPL SmallSat Projects and Capabilities

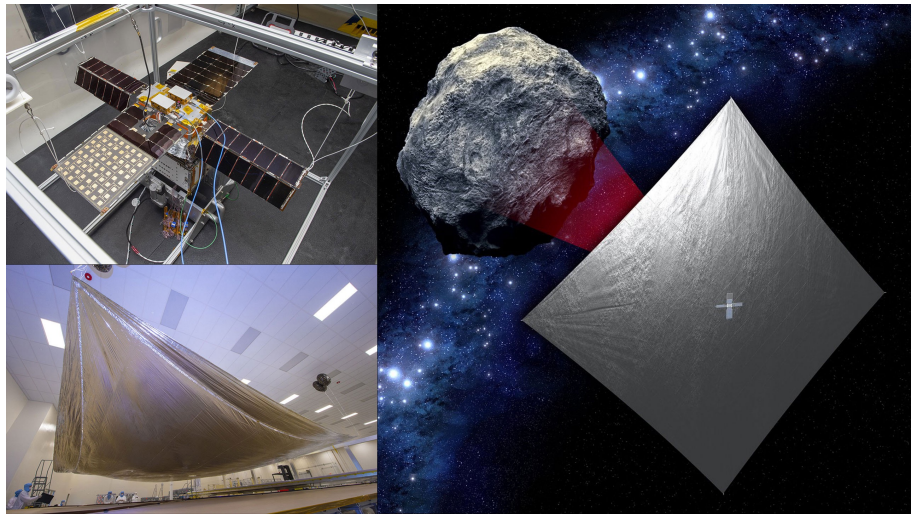


PREFIRE electronics and Pointing Mirror Assembly in the TVAC chamber. Launch TBD. Approaching Systems Integration Review (SIR)



Lunar Trailblazer (SIMPLEx) launching with Intuitive Machines (IM-2); Approaching Systems Integration Review (SIR)

The SunRISE EM payload and spacecraft. Rideshare. Negotiating for opportunities too “near GEO”. Passed its System Requirements Review (SIR)



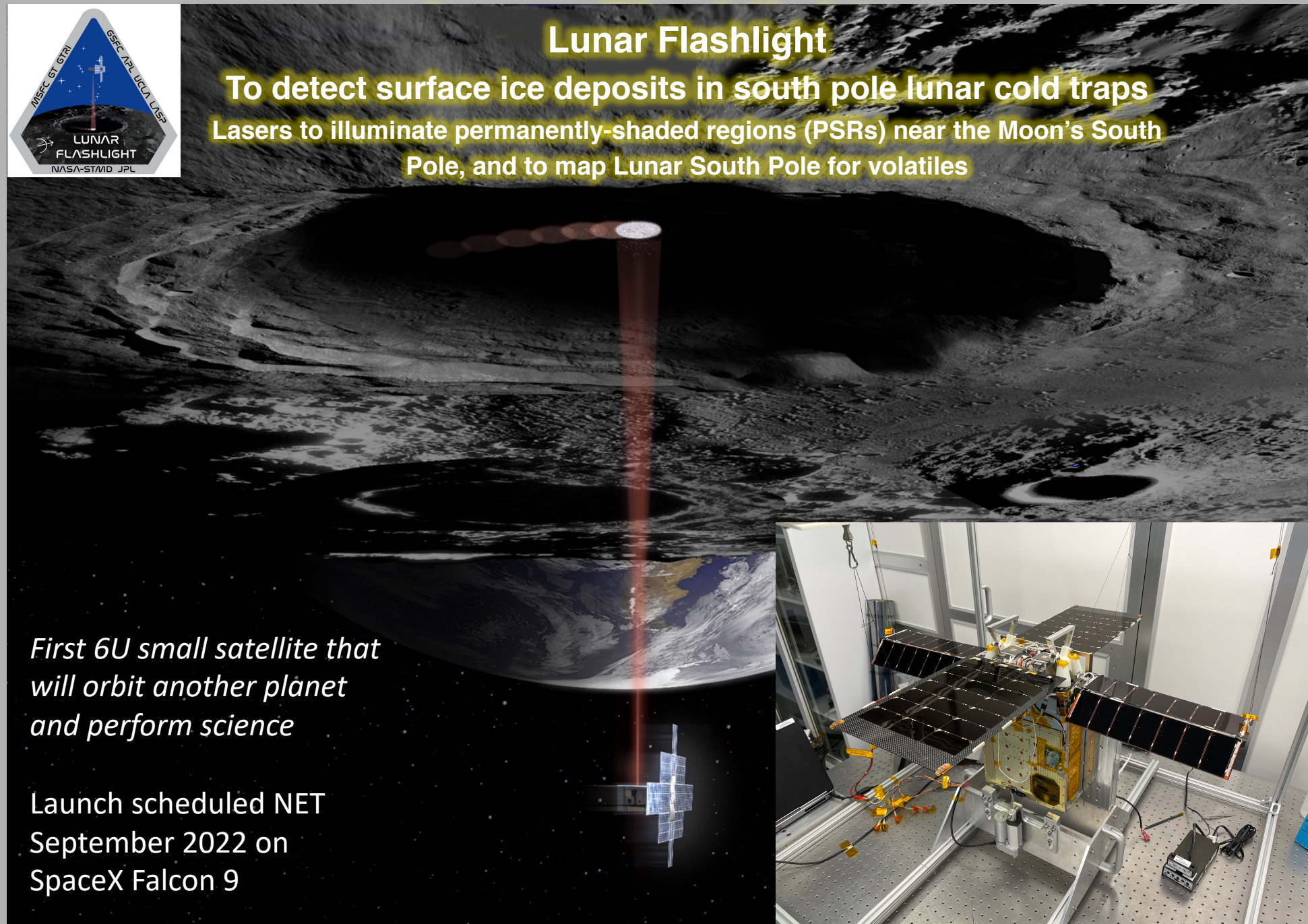
NEA Scout (Near Earth Asteroid Scout - JPL & NASA MSFC Collaboration. Launch on Artemis-1

Lunar Trailblazer (SIMPLEx) Highlights

- Lunar Trailblazer has been directed by HQ and the flight planning board to launch with Intuitive Machines (IM-2) in January of 2023.
- The project has planned multiple mitigations to address schedule-risk and is now looking to execute those.

- Both instruments are working toward integration and testing with delivery to the flight system in early summer.

Next Major Project Events: 05/04/22 - Lifecycle review (SIR).



Lunar Flashlight

To detect surface ice deposits in south pole lunar cold traps

Lasers to illuminate permanently-shaded regions (PSRs) near the Moon's South Pole, and to map Lunar South Pole for volatiles

First 6U small satellite that will orbit another planet and perform science

Launch scheduled NET September 2022 on SpaceX Falcon 9

Ingenuity as of 4/15/22: 25 flights, 5821 m, 2793 sec

Heli Flight #11 RTE Image: Exploring Mars with both Ingenuity and Perseverance (Sol 163)

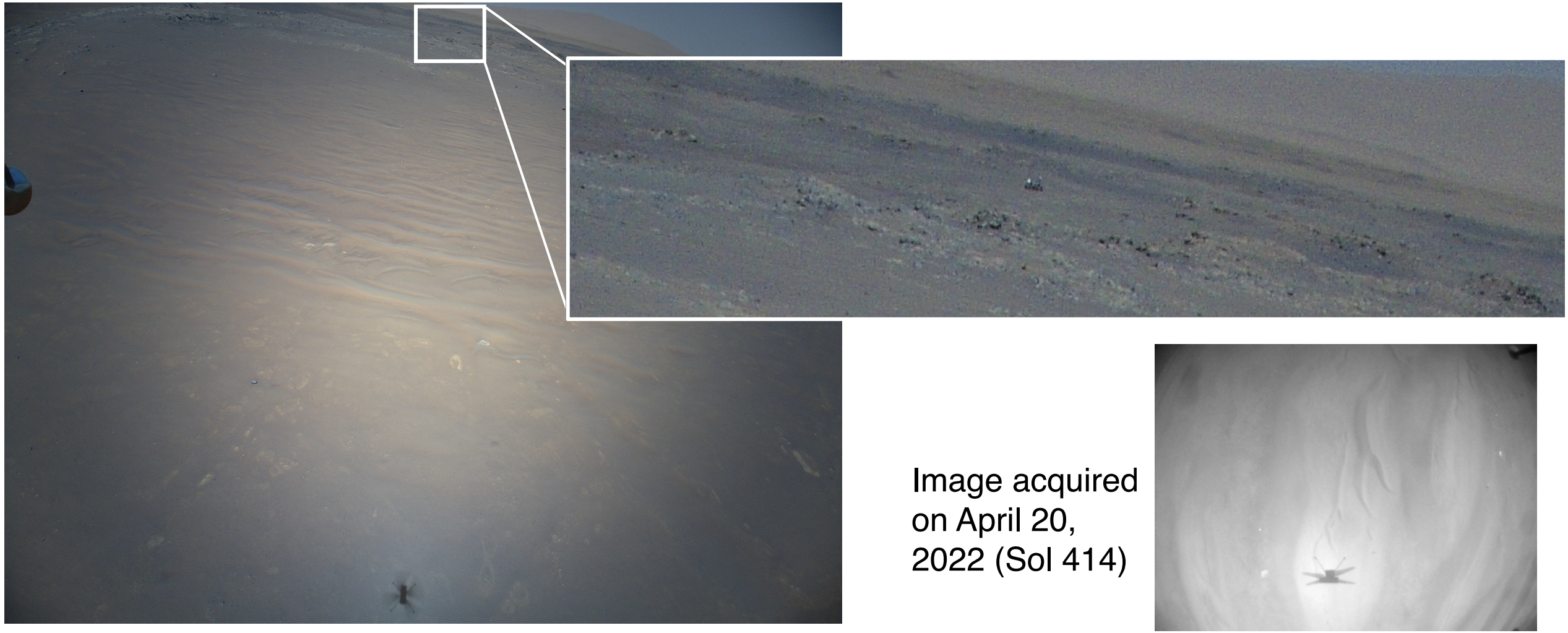
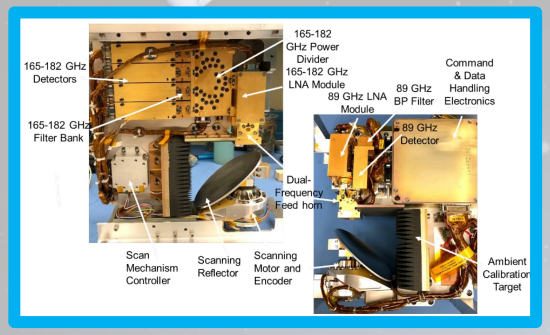


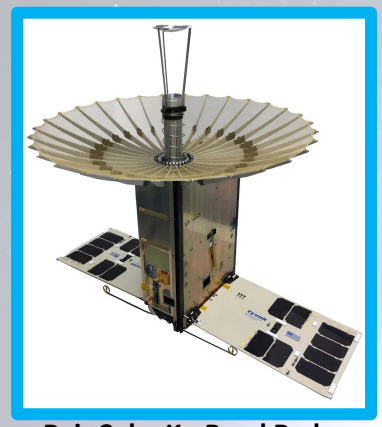
Image acquired on April 20, 2022 (Sol 414)

JPL SmallSat Instruments – Delivering Scince

Flown Instruments



Tempest-D Radiometer



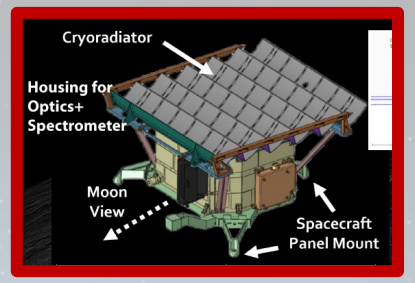
RainCube Ka-Band Radar

Earth Science

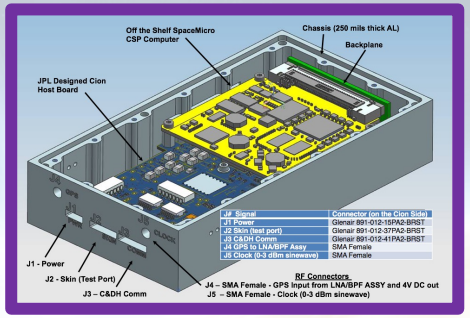
Planetary Science

Astrophysics and Heliophysics

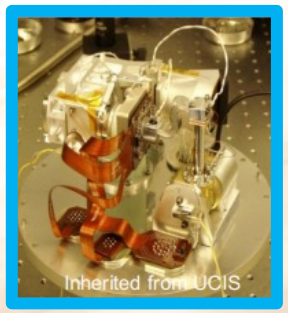
Instruments in Development



Lunar Trailblazer Volatiles Mapper



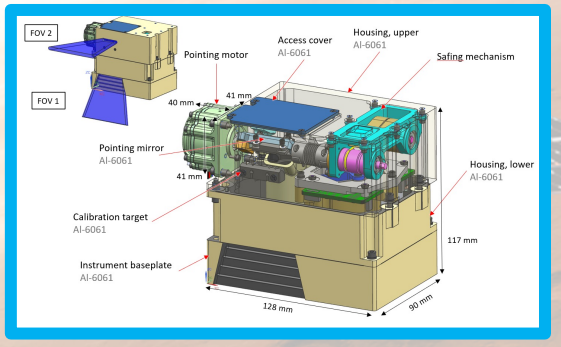
CION Receiver



Snow and Water Imaging Spectrometer

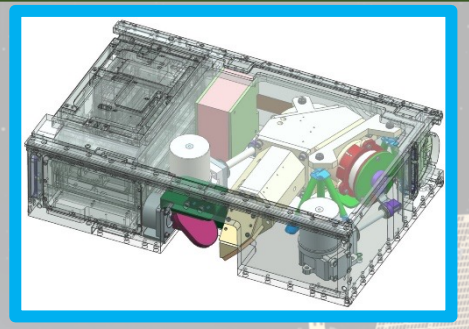
Vector Helium Magnetometer

NEAScout Camera

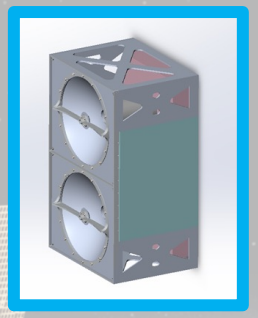


PreFire Thermal IR Spectrometer

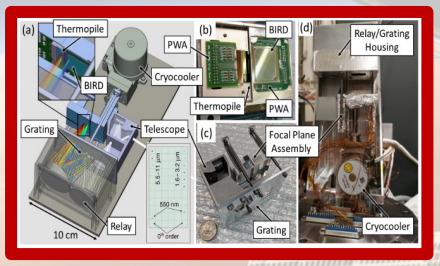
Future Instruments



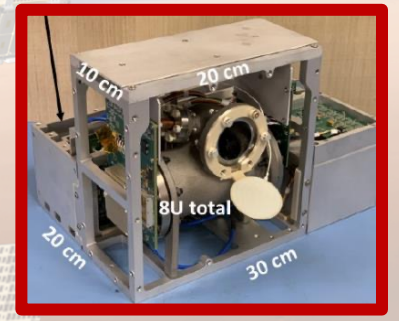
CubeSat Infrared Atmospheric Sounder



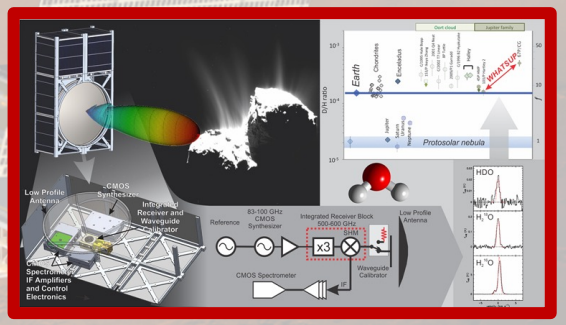
Vapor Inside-cloud Profiling Radar



Midwave- and Longwave-Infrared Point Spectrometer

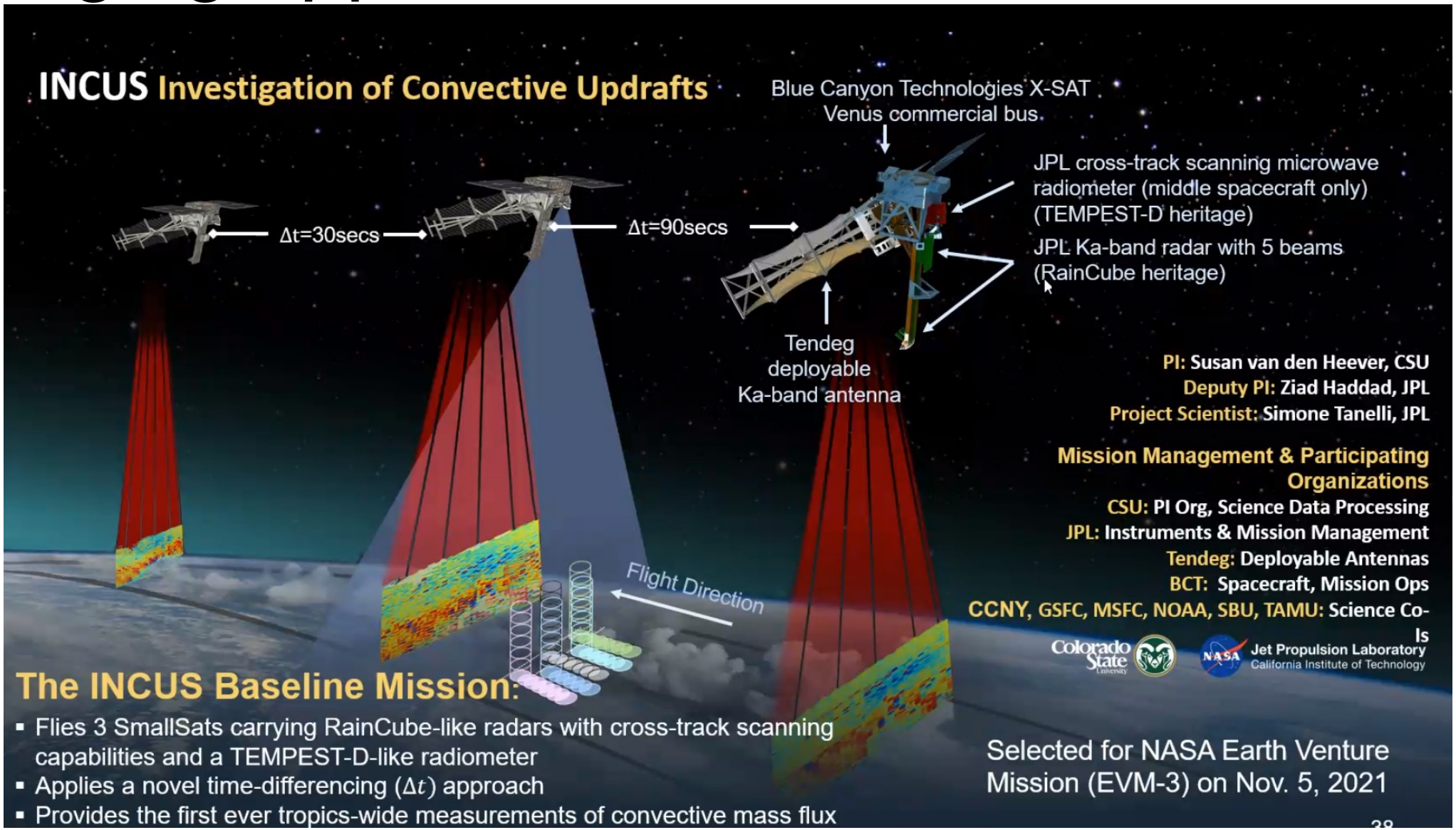


Compact Mass Spectrometer

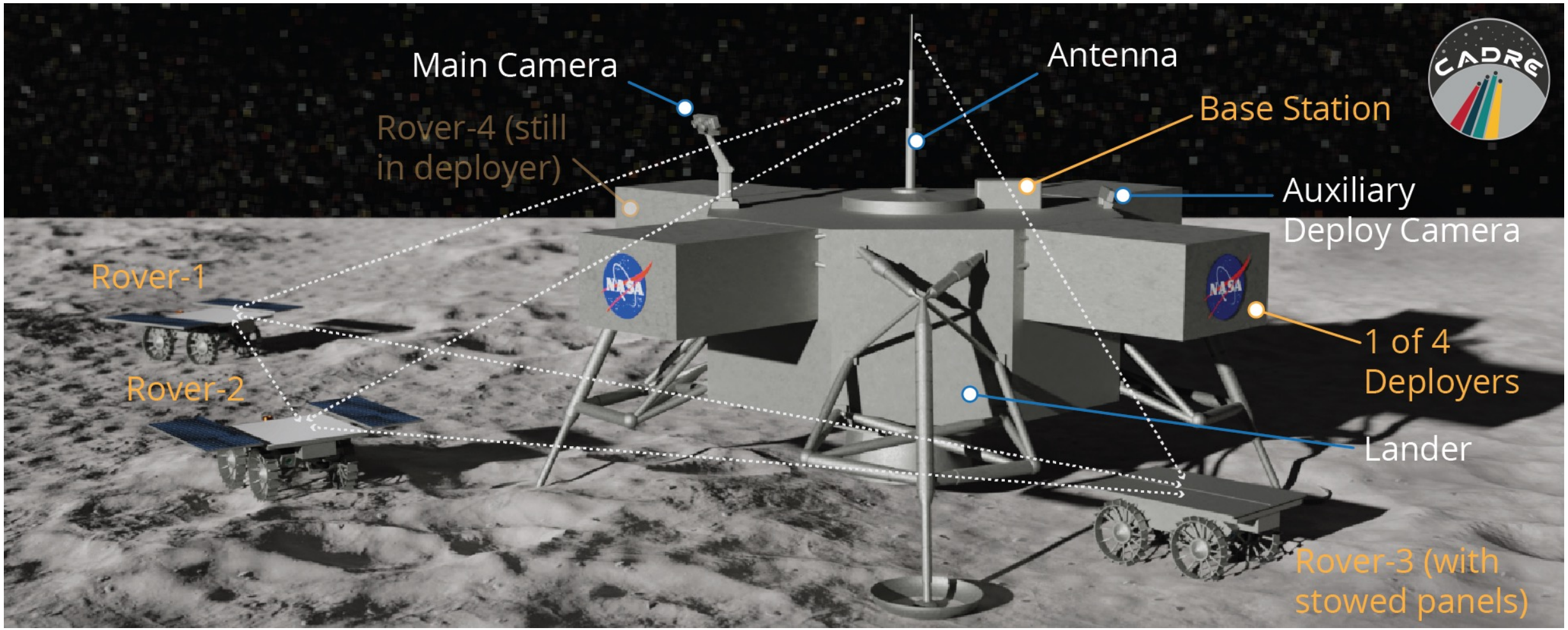


Water Hunting Advanced Terahertz Spectrometer

Emerging opportunities for SmallSat science



CADRE – Lunar Surface Technology Demo

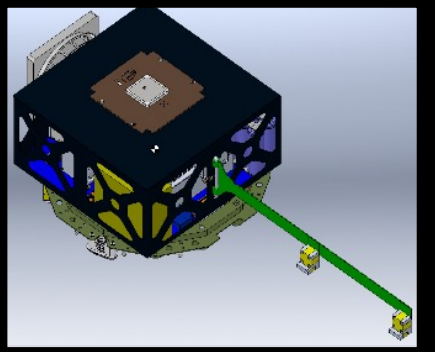


NanoSWARM – Discovery 2019

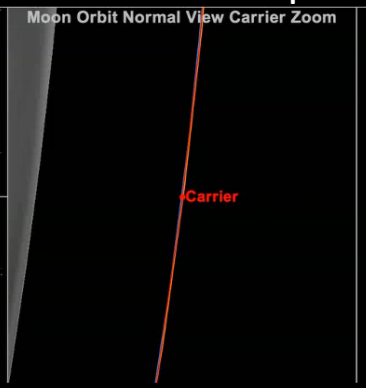
- Space Weathering
- Solar Wind
- Surface Water and
- Remament Magnetism

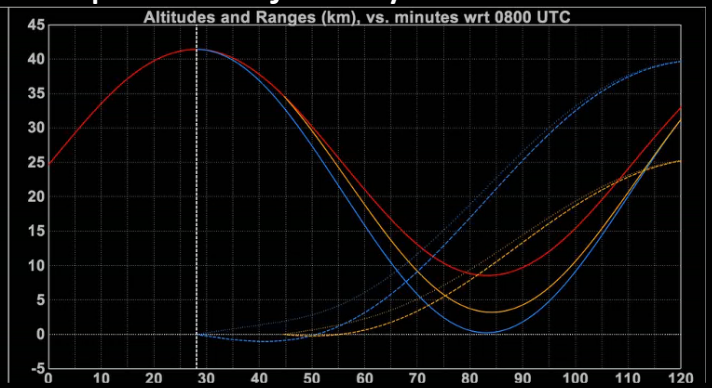
Category I
Ian Garrick-Bethell PI

Unique science enabled by 24 probes sampling particles and fields over lunar anomalies.

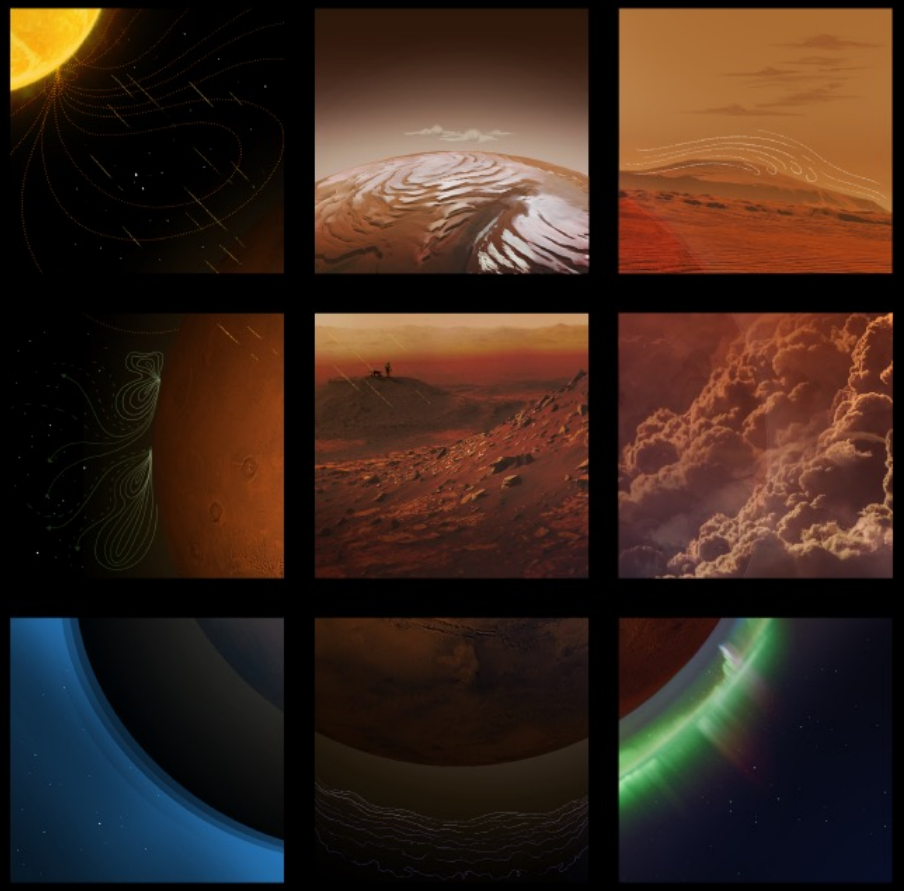


Class B mothership responsible for communications and precise probe trajectory



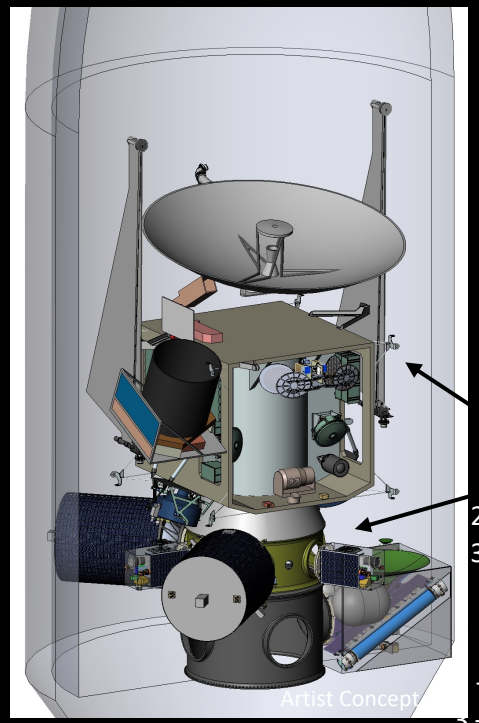


MOSAIC - Discovery 2019



A Planetary Mission Concept Study

Mars Orbiters for Surface-Atmosphere-Ionosphere Connections



10 Spacecraft

49 Science Instruments

3 Orbital Perspectives

1 Launch Vehicle

1 – Large Orbiter

2 - Elliptical ESPA-Class S/C
3 - Polar ESPA-Class S/C

- Areostationary ESPA Class
3 – Small Areostationary S/C

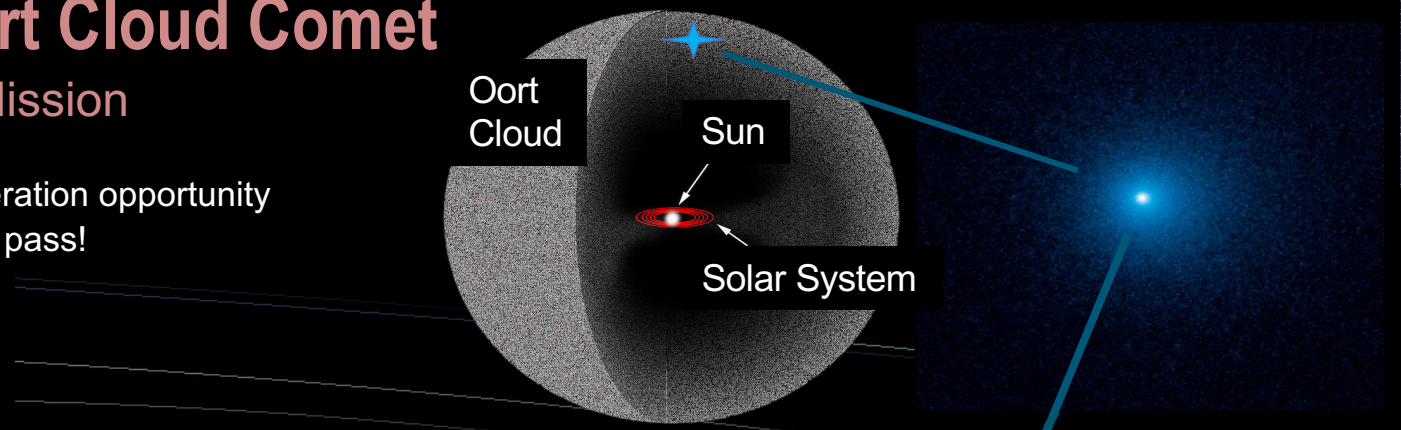
Rob Lillis & the MOSAIC team

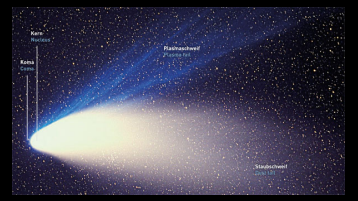
Credit: PMCS study PI Rob Lillis Cal Berkley SSL and Steve Matousek et al. JPL

Rapid Response to an Oort Cloud Comet

Opportunistic Close Comet Flyby Mission

Concept Xenia: A Once in a generation opportunity to visit a unique Oort Cloud comet on its first sun pass!

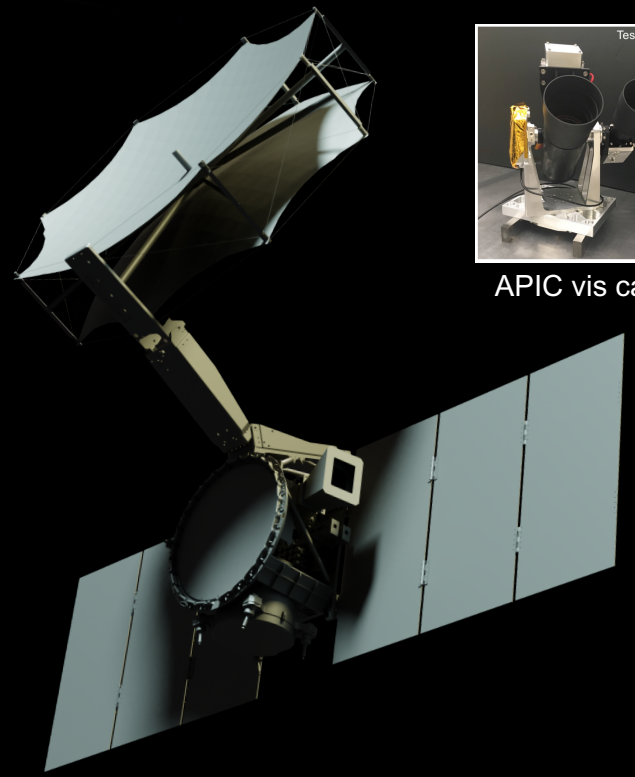




Hale-Bopp, 1995. (Similar comet)

Basic Facts:

- 2017 discovery at ~2.5 Billion km, coming from the edge of our Solar System, ¾ light years away!
- Builds on MarCO and Near-Earth Asteroid Scout.
- Assess the capabilities and limitations of flyby characterization methods to better prepare for a short-warning-time NEO threat



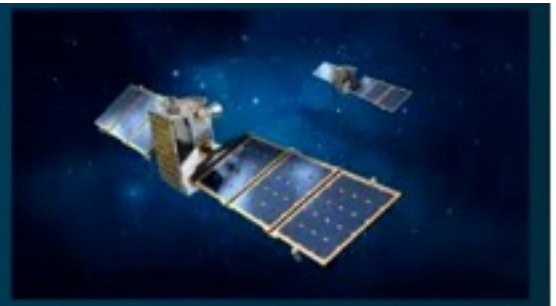
APIC vis camera

Recently announced in the Planetary Decadal Survey

SIMPLEx

- Very small missions managed within Discovery program that can be flexibly accommodated as budgets and ride-share opportunities allow
- Higher risk tolerance → infusion of new technologies and launch strategies
- Recent cost cap was $55M
- Modest dollar increase in cap warranted for continued high science value

SIMPLEx cost cap should be increased to ~ $80M



SMALL SATS

DARE MIGHTY THINGS

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