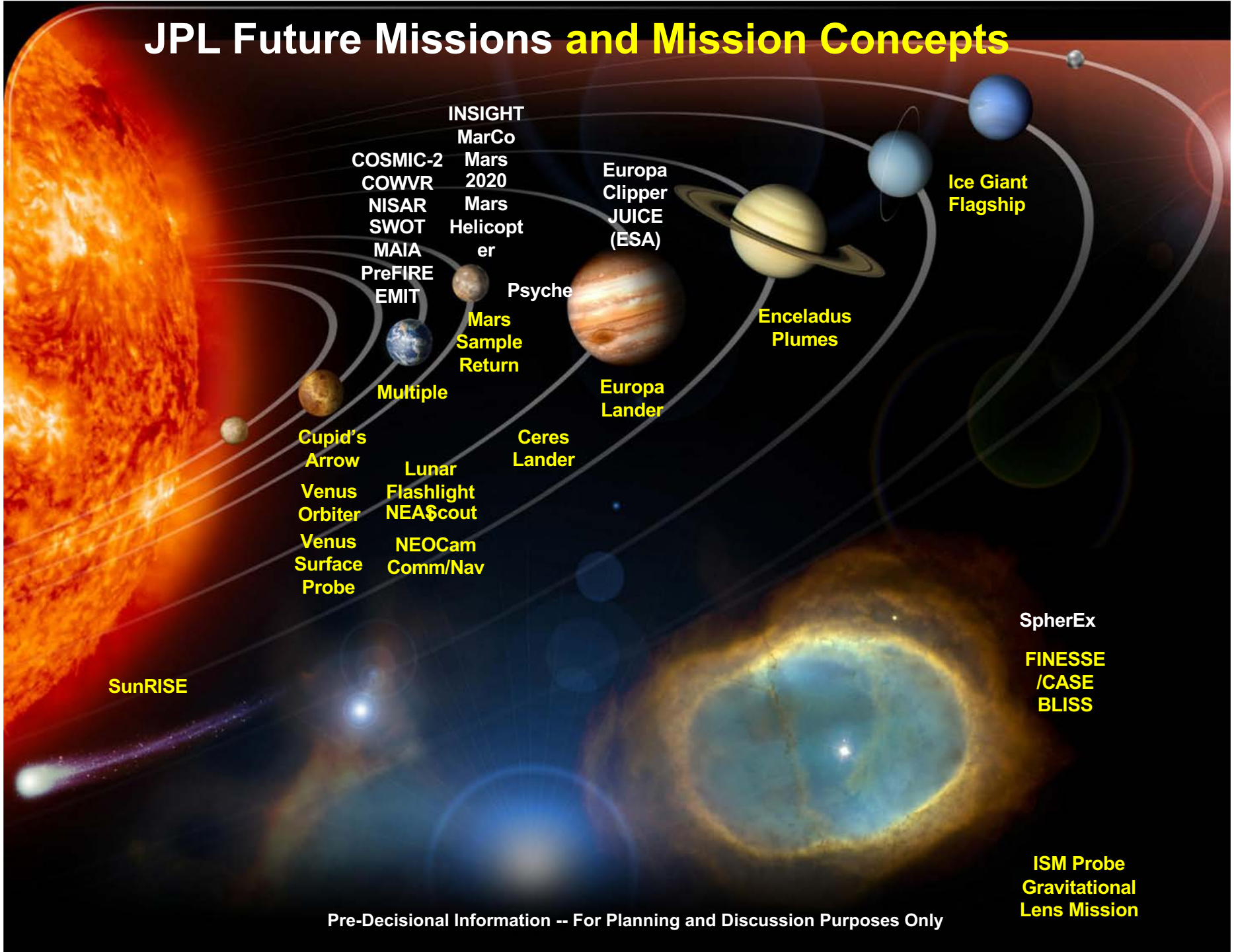
Jet Propulsion Laboratory
California Institute of Technology

Overview of JPL Future Missions
to
Future of space radiation assurance at JPL workshop

June 3, 2019

Tony Freeman, Innovation Foundry
NASA Jet Propulsion Laboratory
California Institute of Technology

JPL Future Missions and Mission Concepts



Pre-Decisional Information -- For Planning and Discussion Purposes Only

Next Mars Mission - Mars 2020

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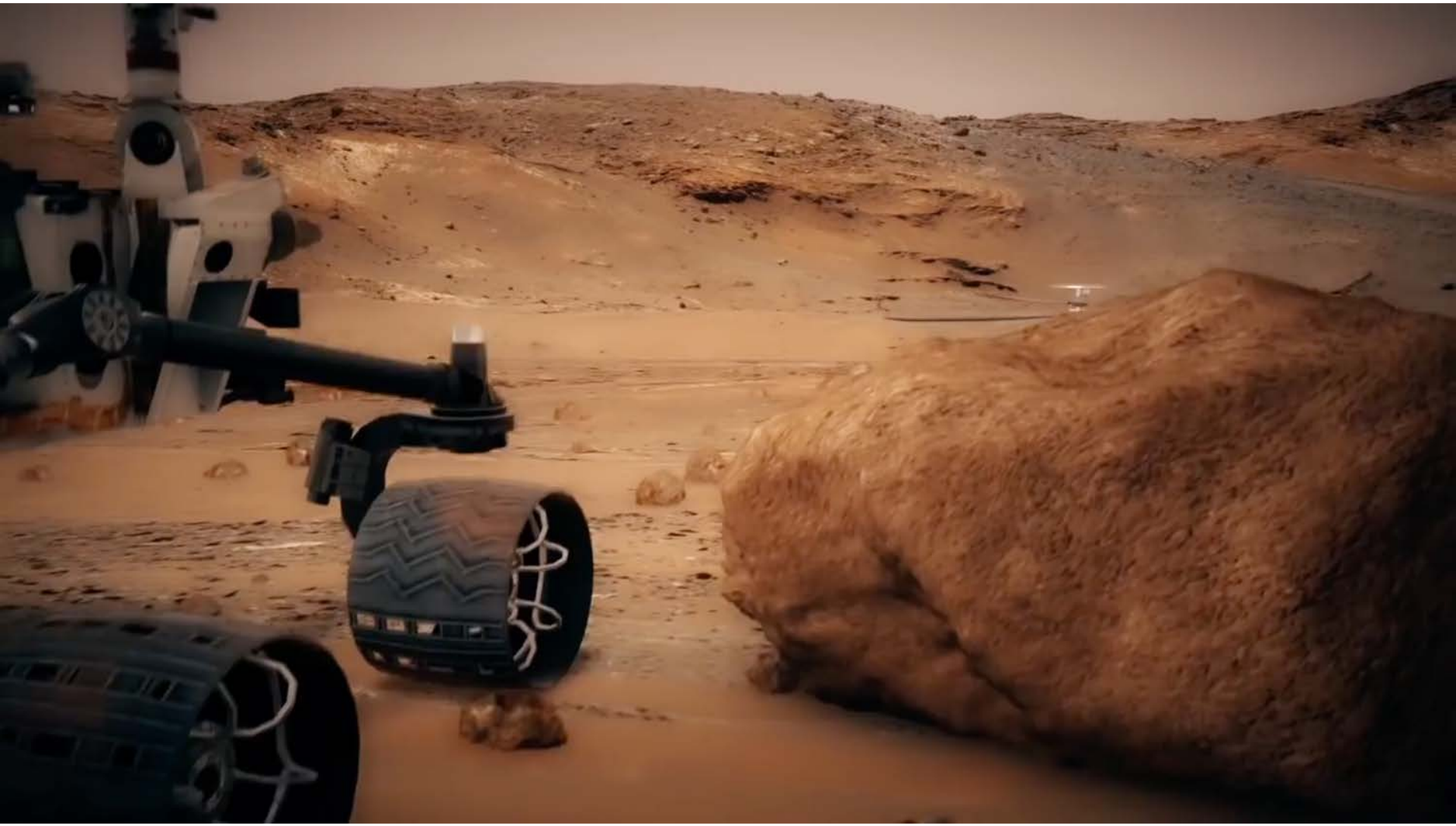
Mars Helicopter



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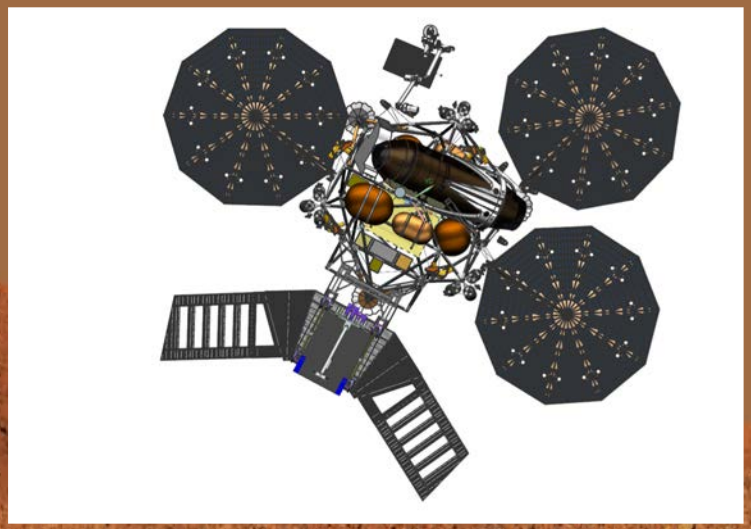
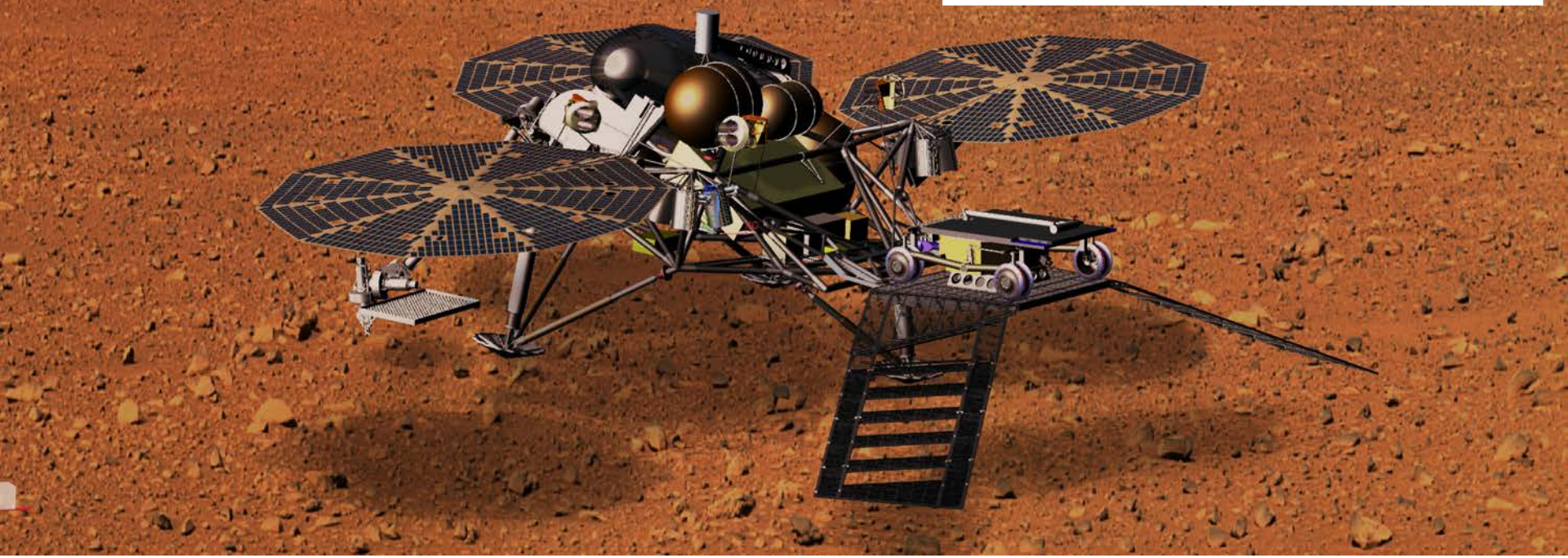
Mars Sample Return Lander Concept Study

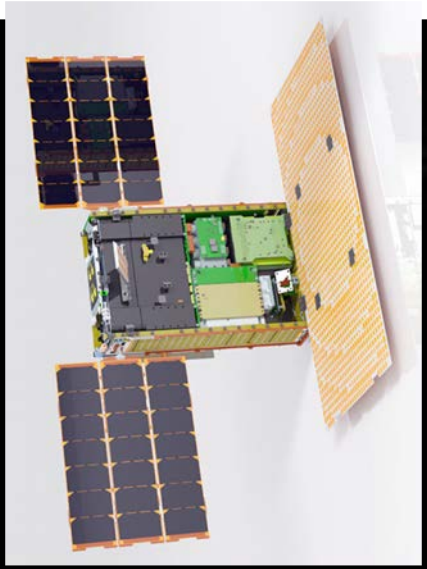
Concept of Operations:

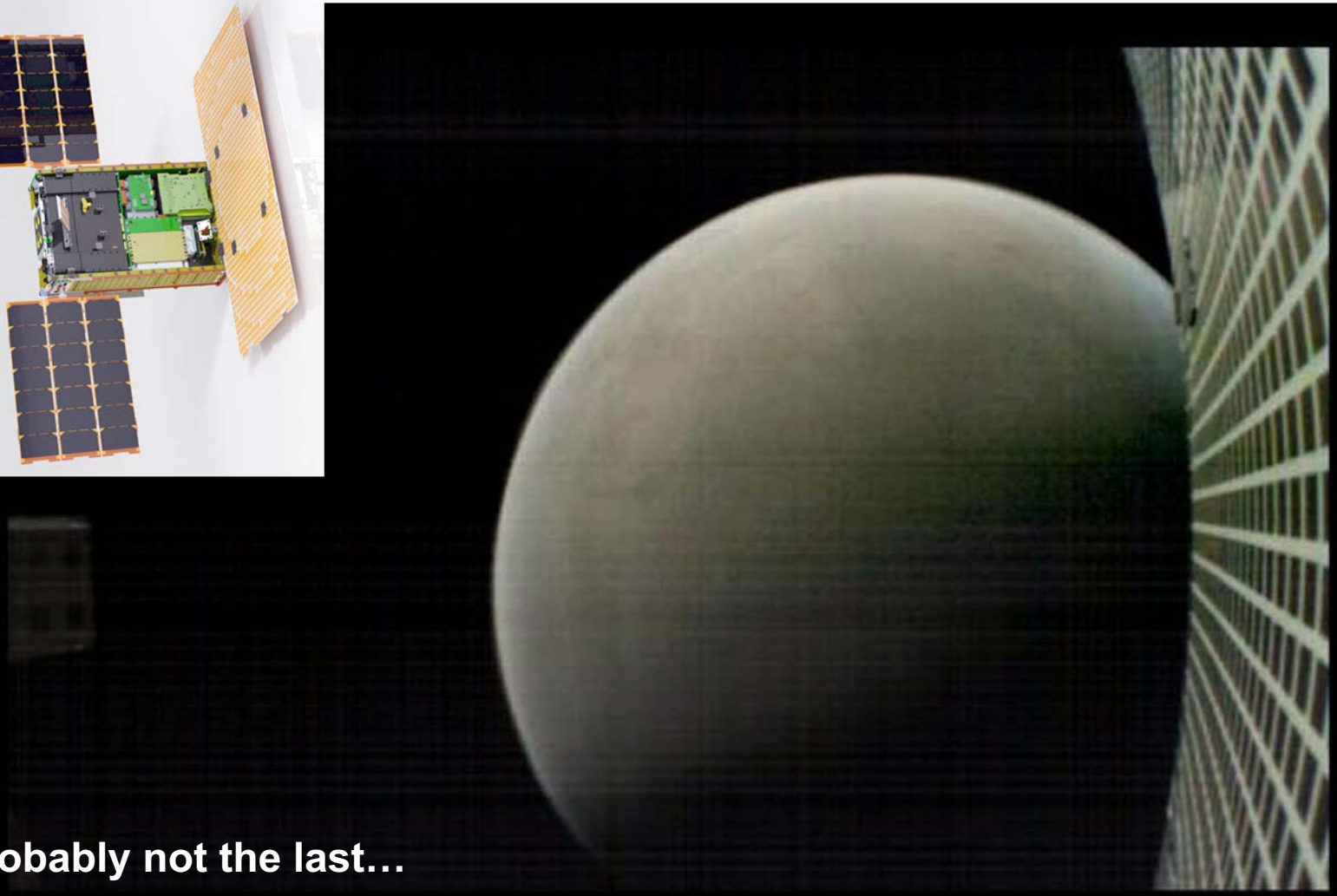
- Target launch date: 2026
- Cached samples from Mars 2020
- Retrieved by 'Fetch Rover'
- Sample is placed in Mars orbit by the MAV
- Sample captured on orbit by SEP orbiter
- Return to Earth
- Direct Entry Sample Return Vehicle





MarCO – the first Interplanetary Cubesats





But probably not the last…

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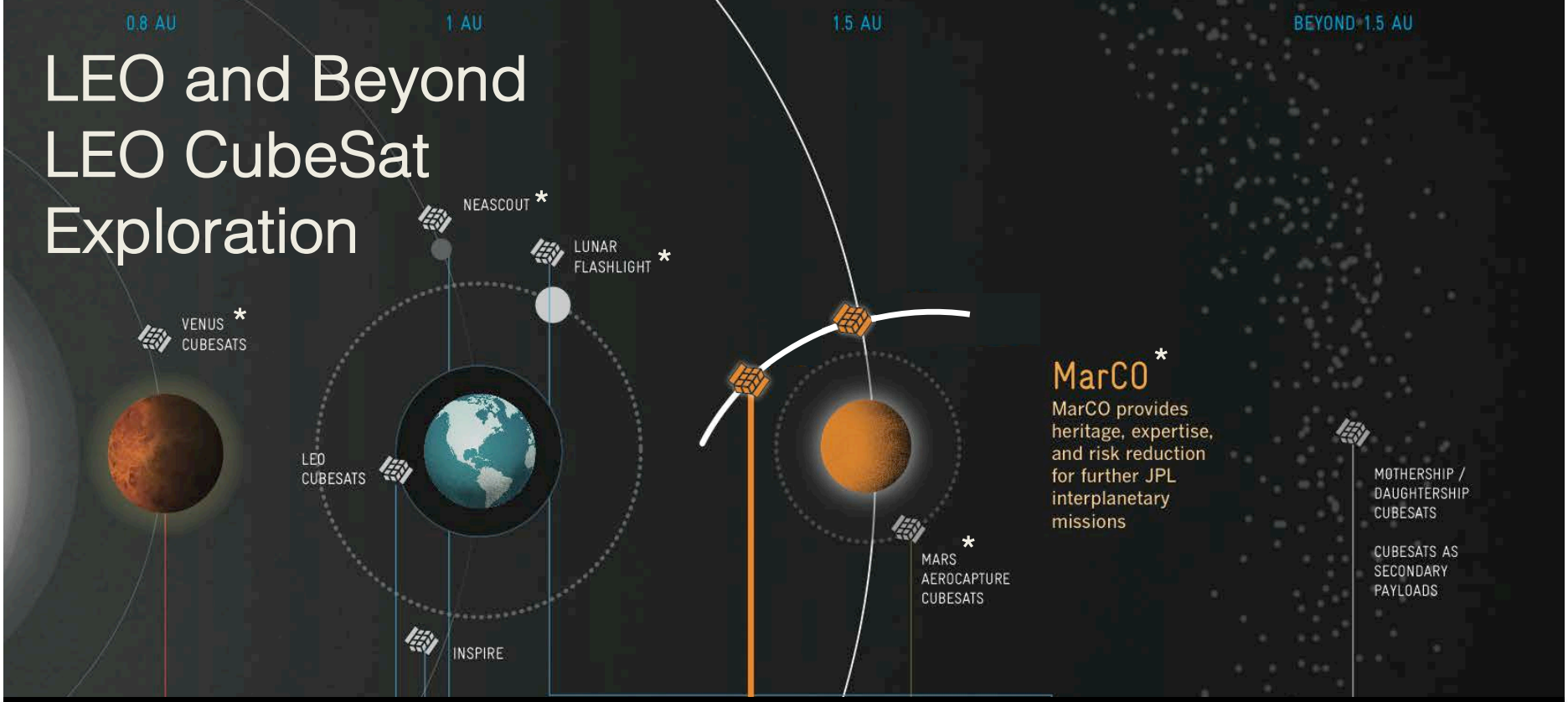
LEO and Beyond LEO CubeSat Exploration



Known Challenges

- Propulsion
- Communications and Navigation
- Environments, Power, ADACS
- Thermal, Energy storage
- Proximity operations and autonomy

Less Obvious Challenges

- Mission assurance and reliability (especially for COTS parts)
- Multi-mission ground operation systems
- Planetary protection, Hazard avoidance
- Flight software standards

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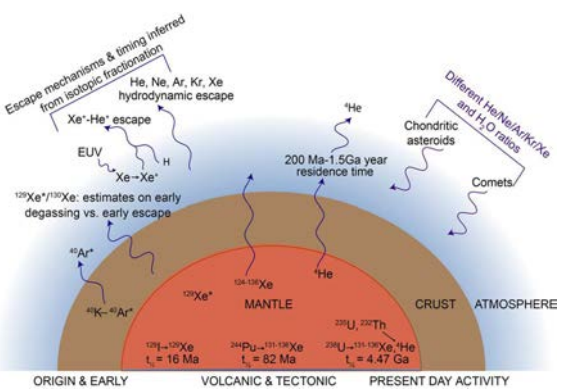
Looking Ahead: Cupid's Arrow Mission Concept

Decadal-Survey-Class Science

Address Planetary Decadal Survey Priority Q3: What governed the accretion, supply of water, chemistry, and internal differentiation of the inner planets and the evolution of their atmospheres, and what roles did bombardment by large projectiles play?'

#1 investigation of objective A of goal I of the VEXAG "Goals-Objectives-Investigation for Venus Exploration"

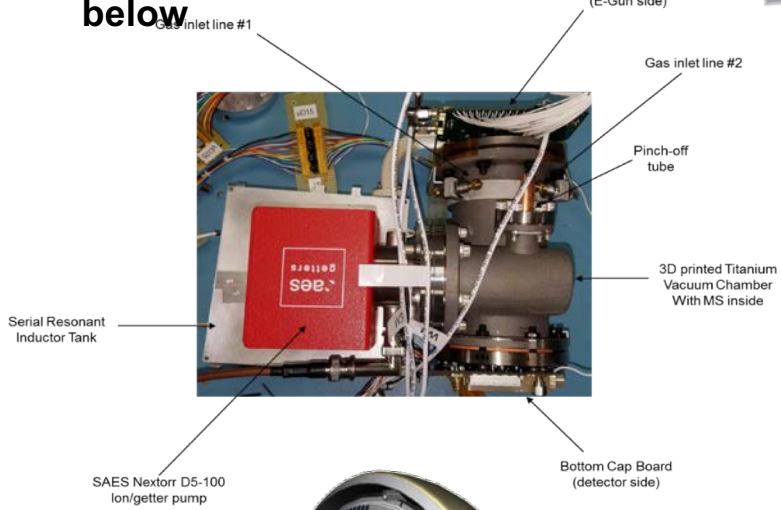
Measure concentrations of noble gases and isotope ratios in Venus atmosphere (below the homopause @110 km).

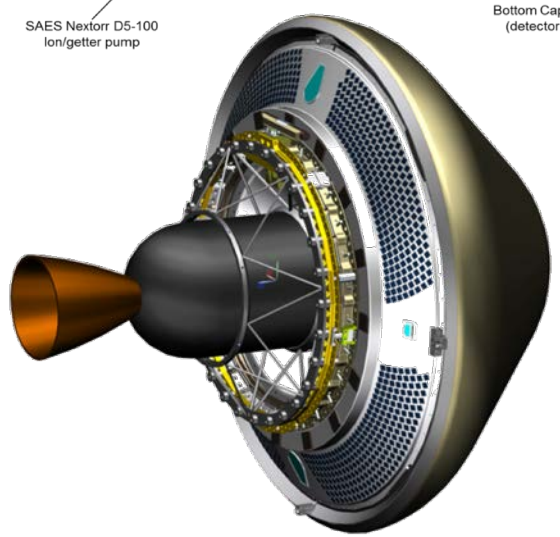


Instrument

JPL Mini-QITMS to analyze 4 samples/pass

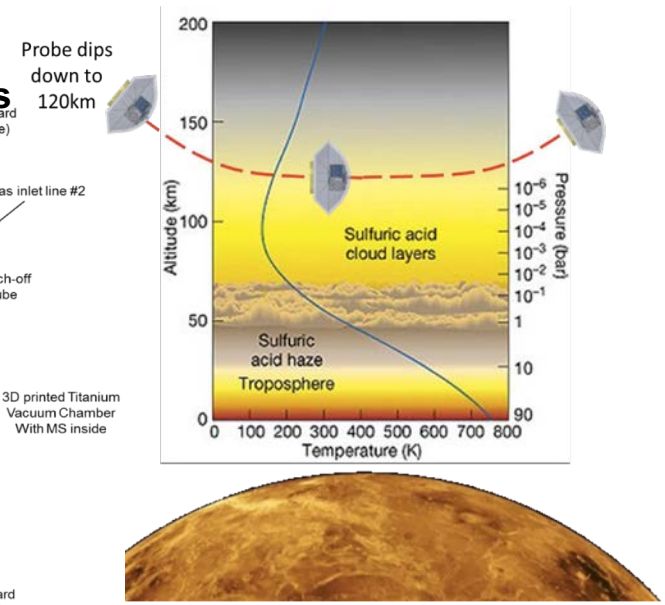
Sample chamber and electronics below





Skimmer Vehicle Concept

Ops Concept



Study Team:

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John Baker (JPL)
Tony Freeman (JPL)
Glenn Lightsey (GATech)
Terry Stevenson(GATech)
Murray Darrach (JPL)
Bernard Marty (CRPG, FR)

Pre-Decisional Information -- For Planning and Discussion Purposes Only

Psyche Mission

- **Discovery Main Belt Asteroid mission to a new metal world(2022)**

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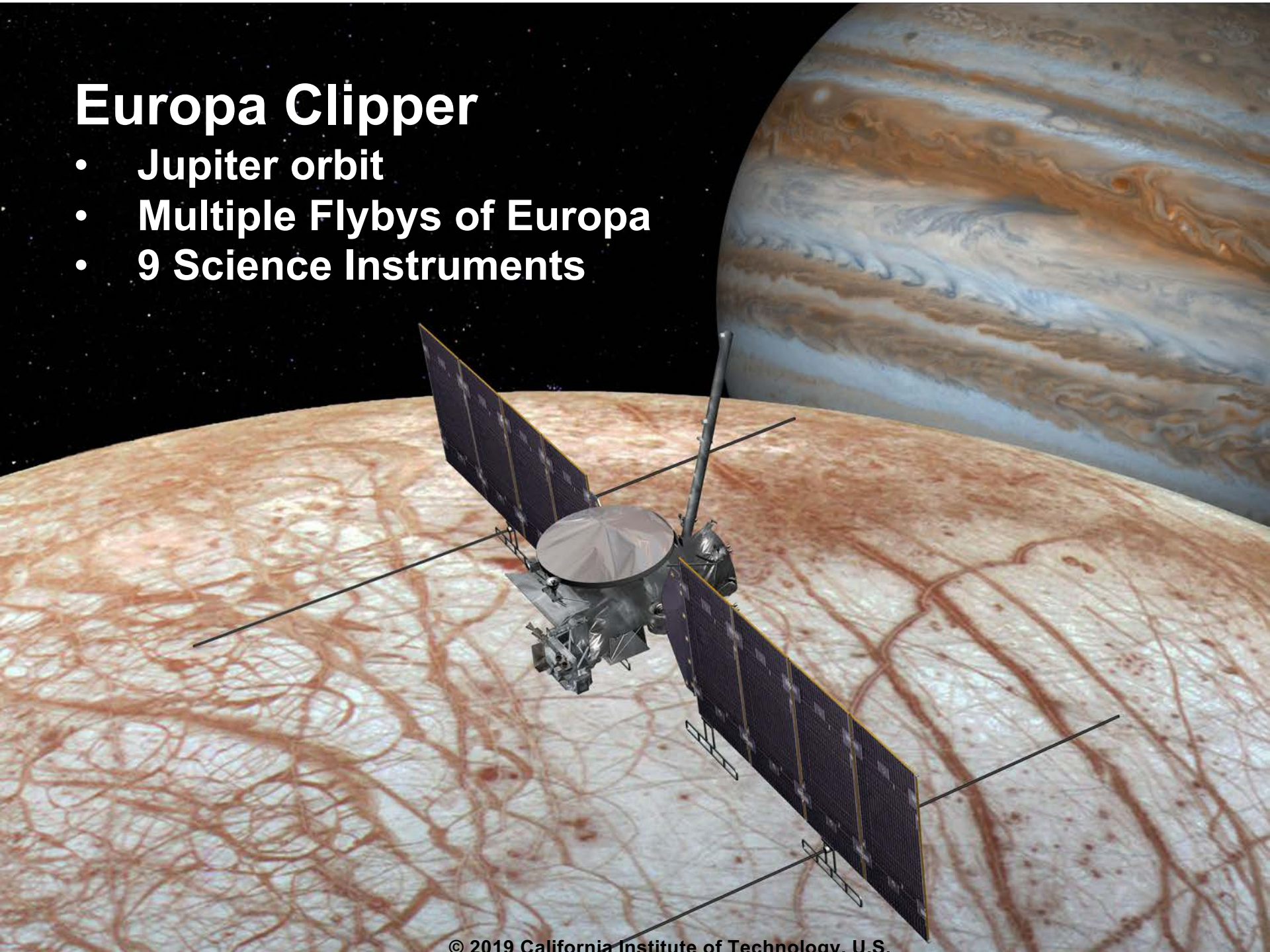
Europa Clipper

- Jupiter orbit
- Multiple Flybys of Europa
- 9 Science Instruments



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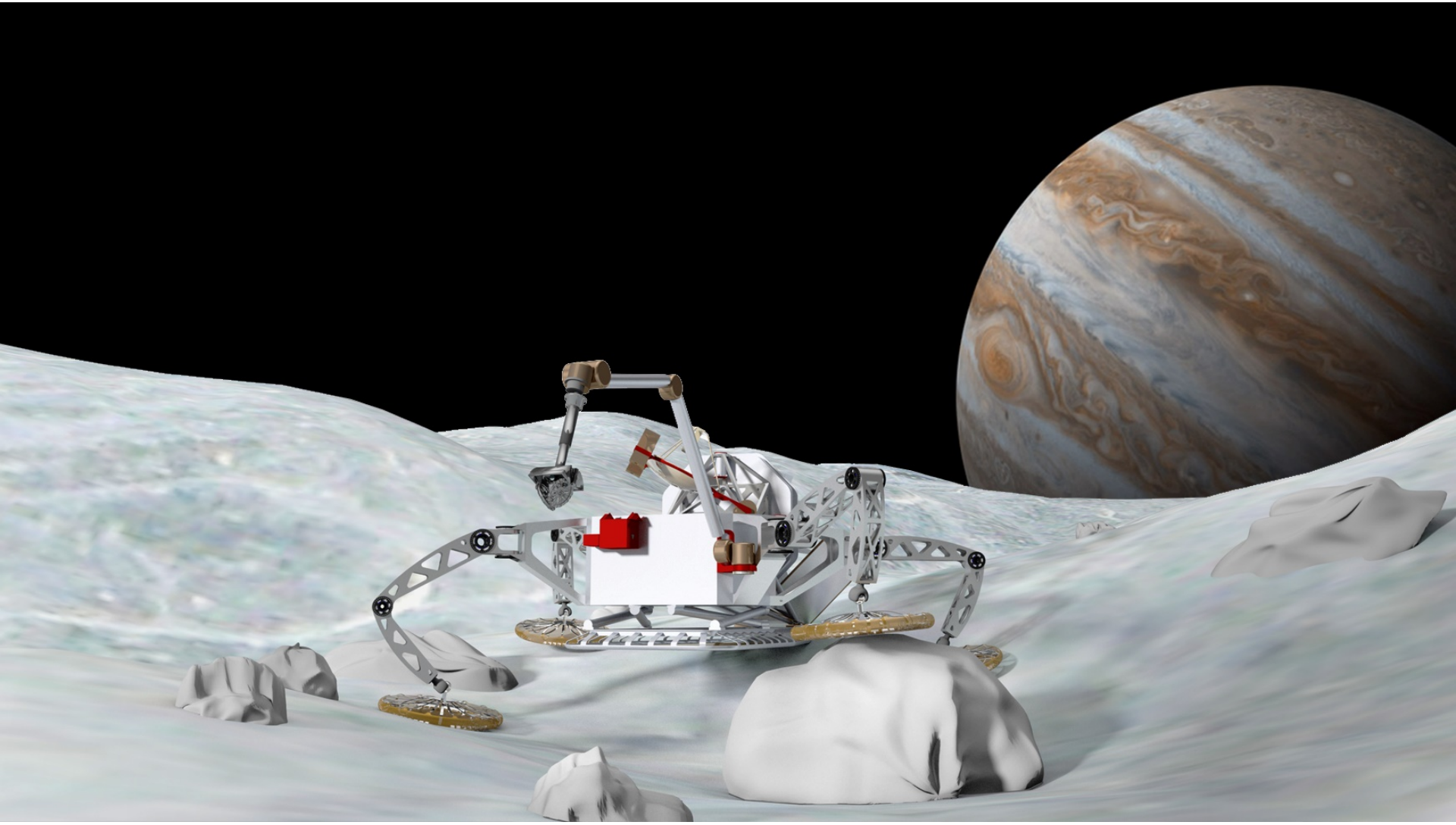
Europa Lander Concept Study



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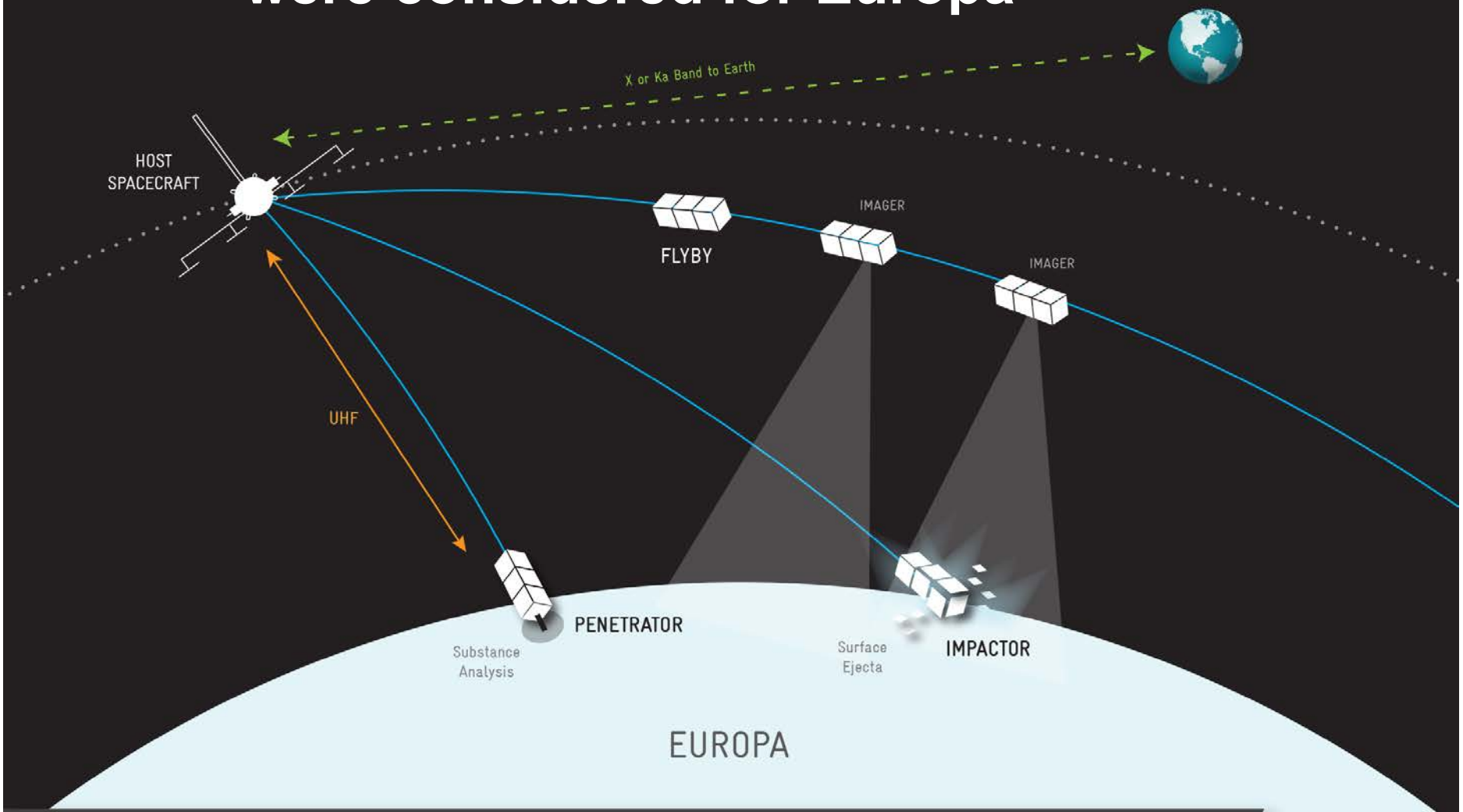
ExCSITE

11 Cubesat "ride-alongs" were considered for Europa



SPACECRAFT FORMATION	12 CUBESATS	FLYBY	DEPLOYMENT TRAJECTORY	HOST DEPLOYMENT	JOVIAN ENVIRONMENT	MISSION LIFETIME GOAL	3 YEARS

*Proposed Mission - Pre-Decisional – for Planning and Discussion Purposes Only

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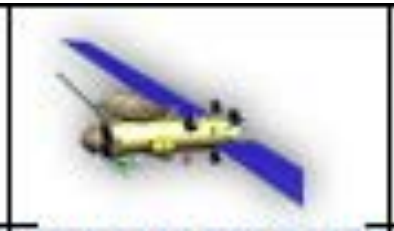
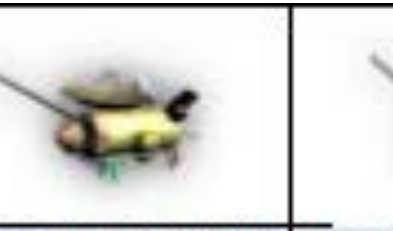
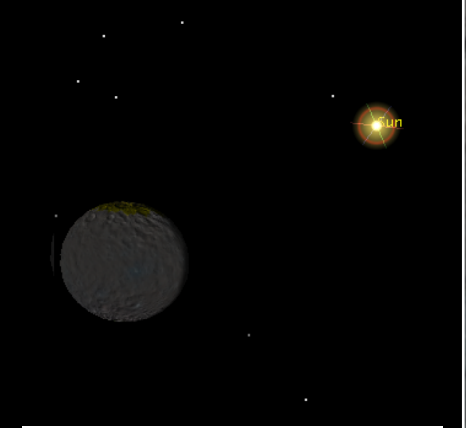
Ice Giants Flagship Mission Concepts

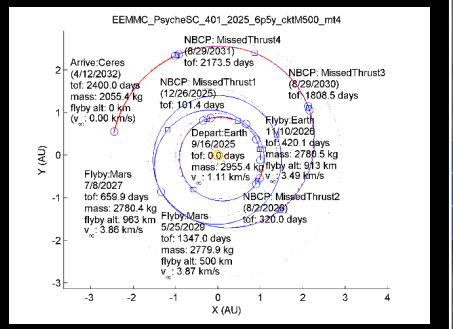
Ice Giants Pre-Decadal Survey Mission Study Report, 2017

				
Case Description	Neptune Orbiter with probe and ~50 kg science payload. Includes SEP stage for inner solar system thrusting.	Uranus Flyby with probe and ~50 kg science payload. Chemical only mission.	Uranus Orbiter with probe and ~50 kg science payload. Chemical only mission.	Uranus Orbiter without a probe, but with ~150 kg science payload. Chemical only mission.
Science	Highest priority plus additional system science (rings, sats, magnetospheres)	Highest priority science (interior structure and composition)	Highest priority plus additional system science (rings, sats, magnetospheres)	All remote sensing objectives
Payload	3 instruments* + atmospheric probe	3 instruments* + atmospheric probe	3 instruments* + atmospheric probe	15 instruments**
Payload Mass MEV (kg)	45	45	45	170
Launch Mass (kg)	7365	1524	4345	4717
Launch Year	2030	2030	2031	2031
Flight Time (yr)	13	10	12	12
Time in Orbit (yr)	2	Flyby	3	3
Total Mission Length (yr)	15	10	15	15
RPS use/ EOM Power	4 eMMRTGs/ 376W	4 eMMRTGs/ 425W	4 eMMRTGs/ 376W	5 eMMRTGs/ 470W
LV	Delta IVH + 25 kW SEP	Atlas V 541	Atlas V 551	Atlas V 551
Prop System	Dual Mode/NEXT EP	Monopropellant	Dual Mode	Dual Mode

Ceres Lander Mission Concept

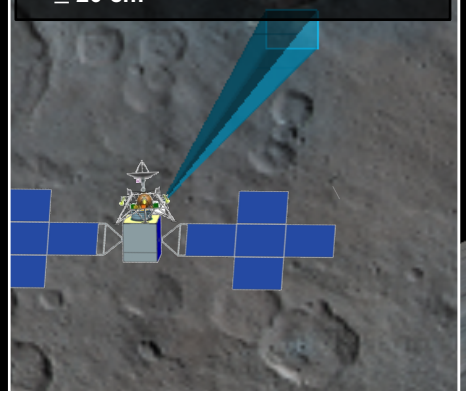
Cruise to Ceres (ΔV = 6 km/s)



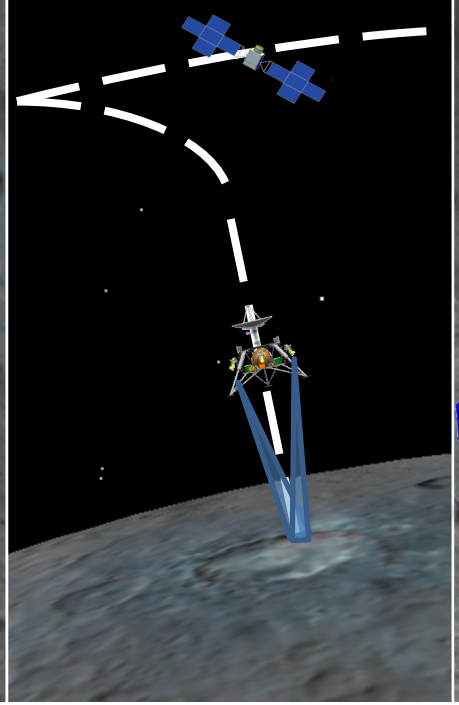


Perform geology investigation, landing site reconnaissance, and site certification from orbit

- Geology: Image Ahuna Mons and Occator Crater with a GSD of $\leq$ 5 m
- Reconnaissance: Obtain topology & color maps of Haulani and Occator Craters with a GSD of $\leq$ 5 m
- Certification: Obtain topological greyscale maps of 10 down-selected candidate sites at Haulani or Occator with a GSD of $\leq$ 20 cm

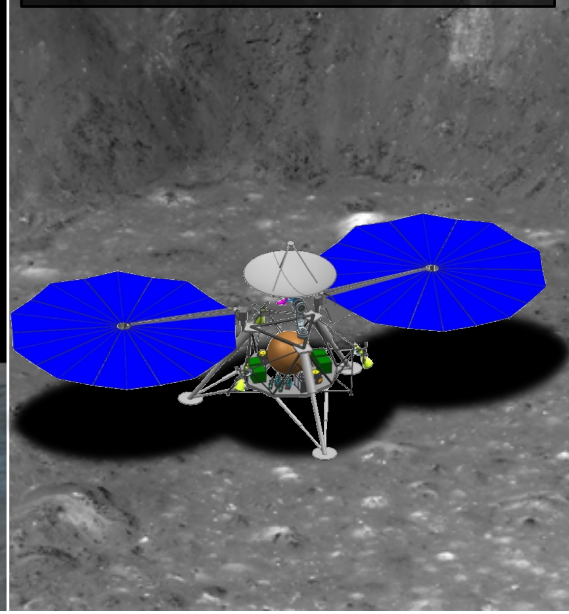


Separate Lander from SEP chassis and land at chosen location with an error ellipse of < 10 m



Perform surface science investigation

- Obtain an in-situ NIR spectrographic panorama of surrounding crater walls
- Obtain in-situ APXS measurements for at least three spots



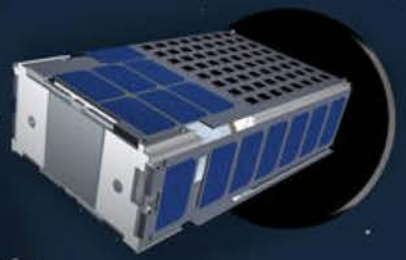
Slide courtesy Julie Castillo-Rogez, JPL

Pre-Decisional Information -- For Planning and Discussion Purposes Only

EXPLORATION MISSION-1: LAUNCHING SCIENCE & TECHNOLOGY SECONDARY PAYLOADS

13 CUBESAT EXPLORERS

GOING TO DEEP SPACE WHERE FEW CUBESATS HAVE EVER GONE BEFORE.



ORION STAGE ADAPTER

SUPPORTS BOTH PRIMARY MISSION AND SECONDARY PAYLOADS

1 PRIMARY MISSION

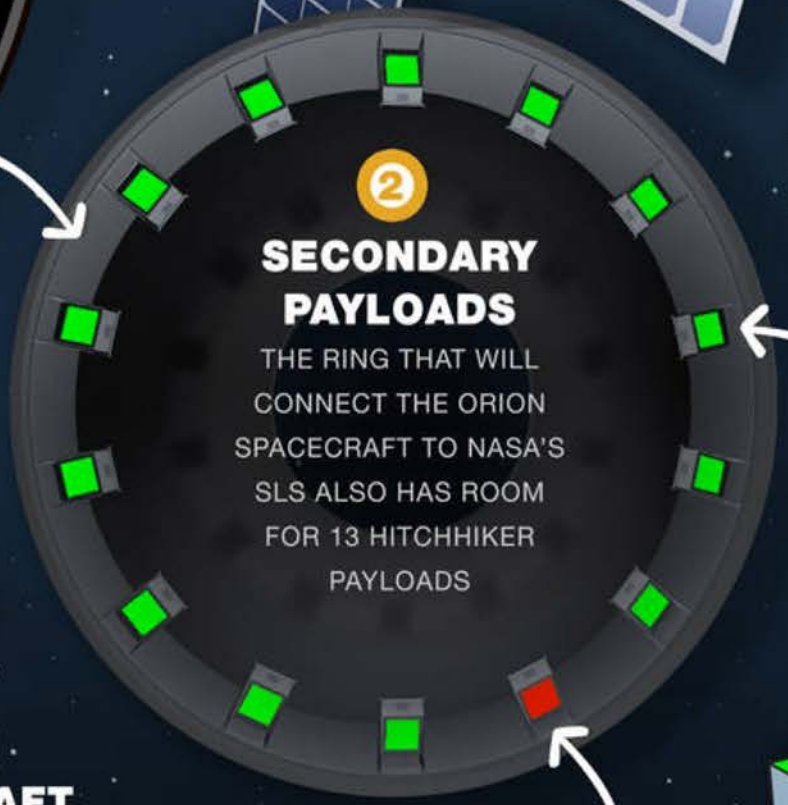
TESTING SLS AND ORION

SPACE LAUNCH SYSTEM (SLS)

LIFTS MORE THAN ANY EXISTING LAUNCH VEHICLE

ORION SPACECRAFT

TRAVELING THOUSANDS OF MILES BEYOND THE MOON, WHERE NO CREW VEHICLE HAS GONE BEFORE



2 SECONDARY PAYLOADS

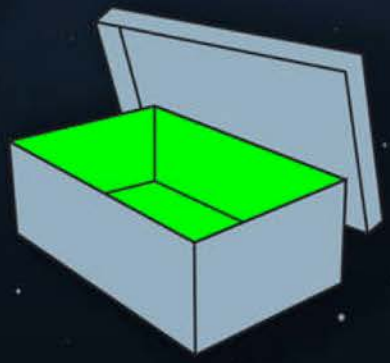
THE RING THAT WILL CONNECT THE ORION SPACECRAFT TO NASA'S SLS ALSO HAS ROOM FOR 13 HITCHHIKER PAYLOADS

SHOEBOX SIZE

PAYLOADS EXPAND OUR KNOWLEDGE FOR THE JOURNEY TO MARS

AVIONICS

(SELF-CONTAINED AND INDEPENDENT FROM THE PRIMARY MISSION) SEND CUBESATS ON THEIR WAY



#RIDEONSLS

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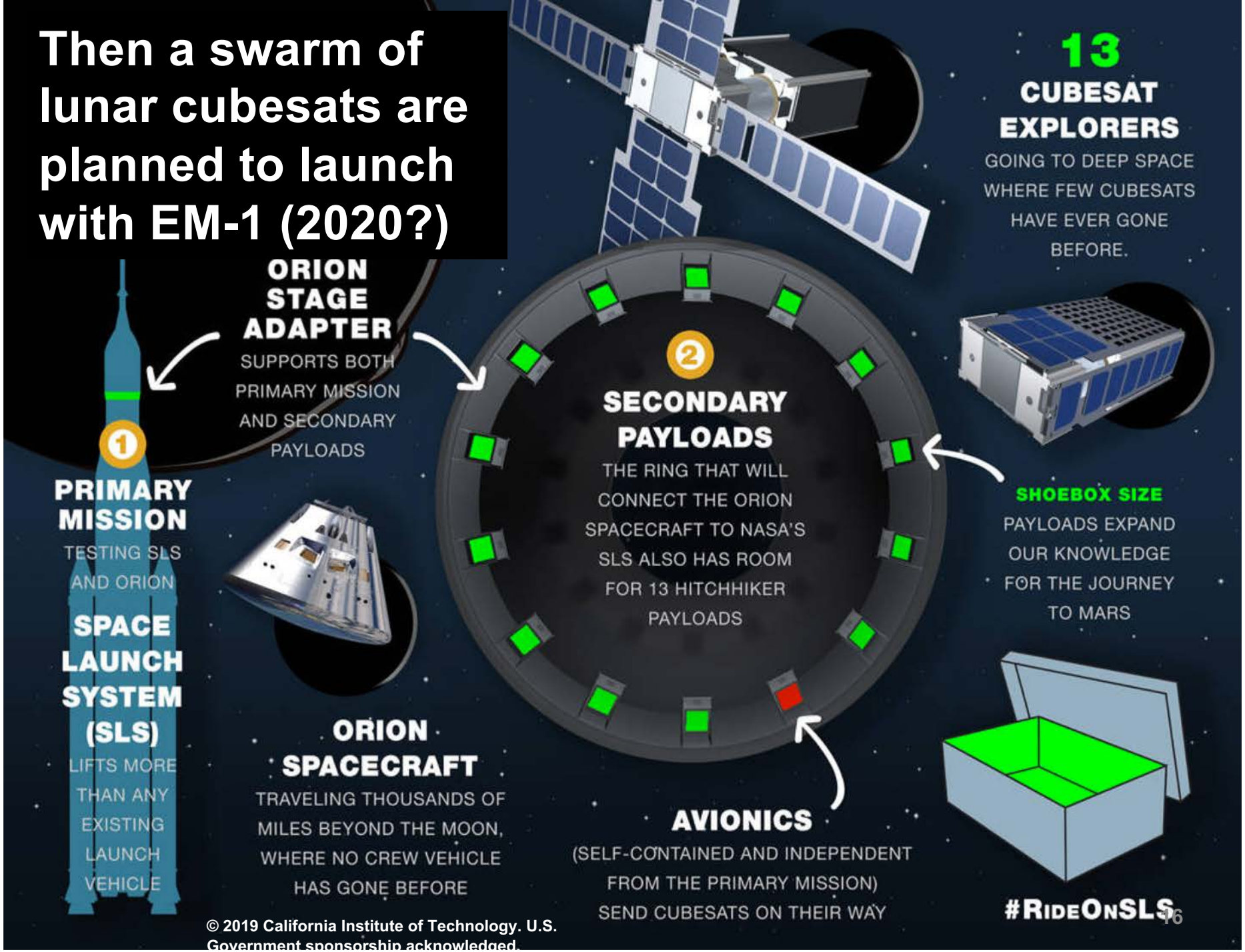
Then a swarm of lunar cubesats are planned to launch with EM-1 (2020?)



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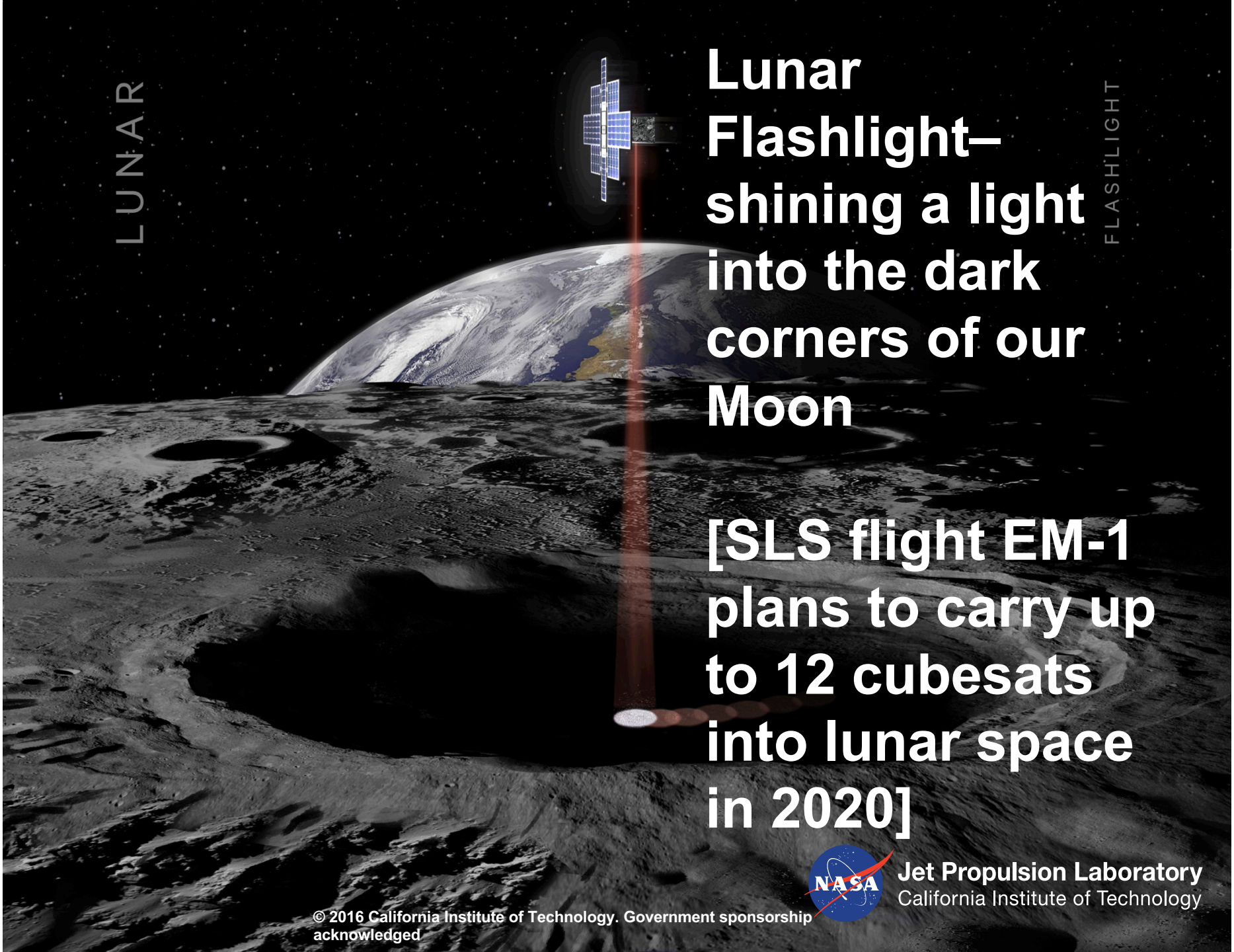

Lunar Flashlight– shining a light into the dark corners of our Moon

[SLS flight EM-1 plans to carry up to 12 cubesats into lunar space in 2020]

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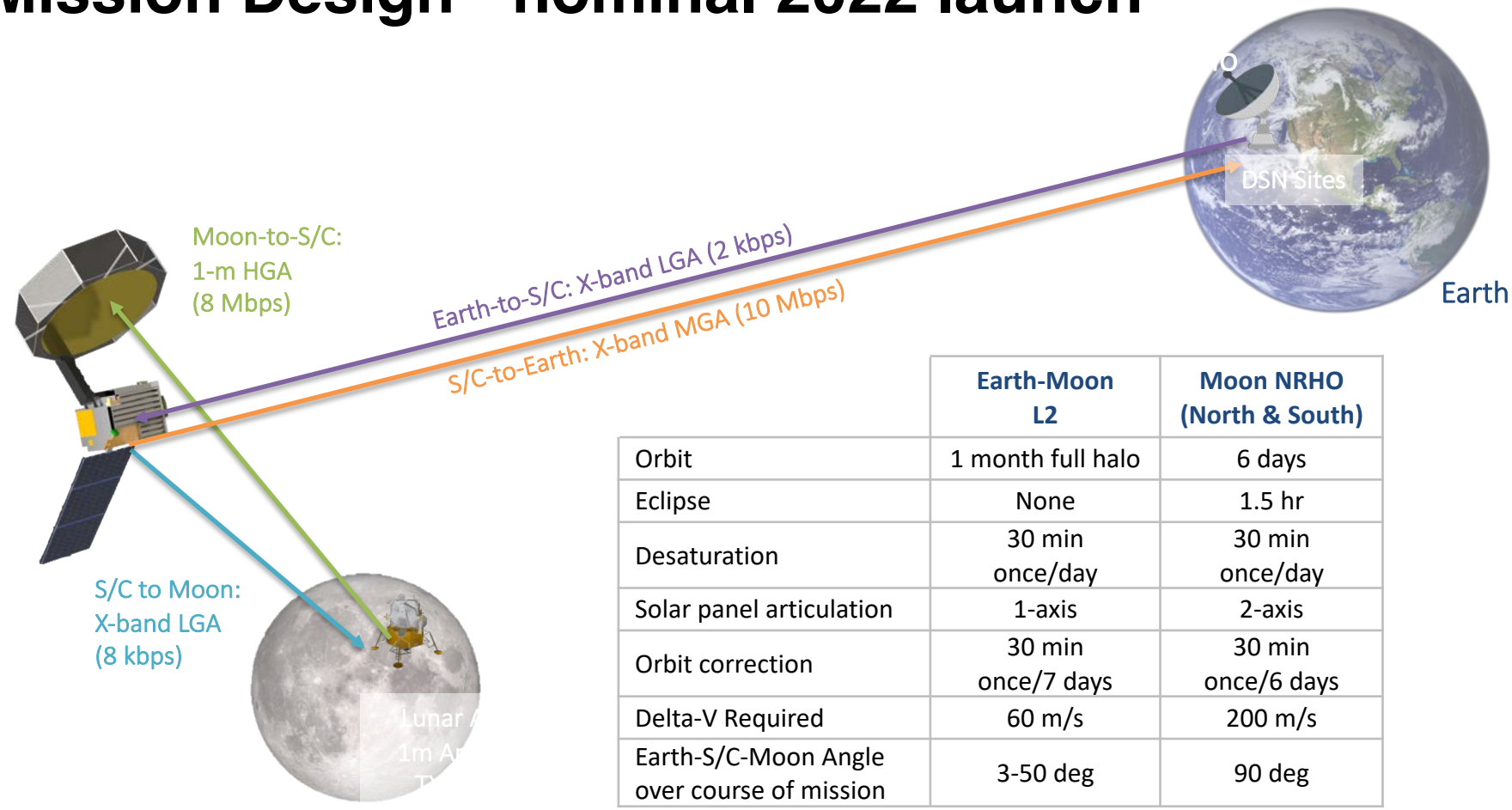
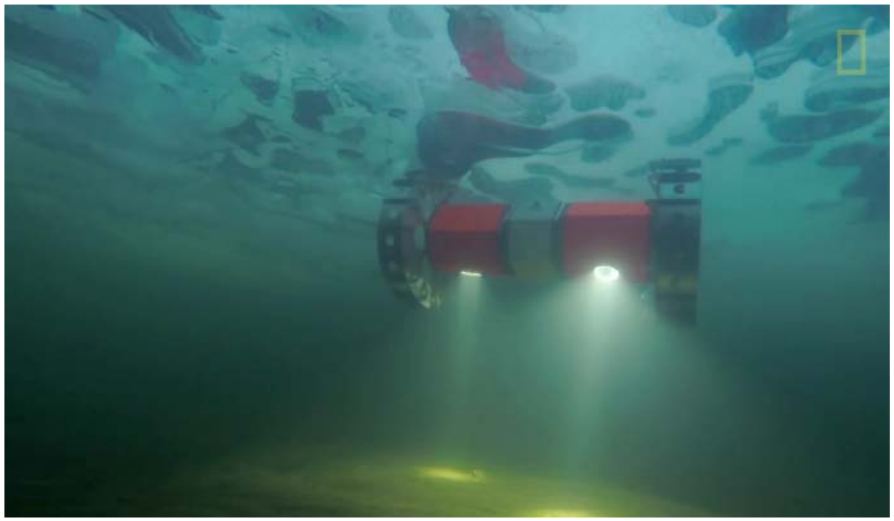
Lunar Comm/Nav Mission Concept (ARC/JPL)

Mission Design - nominal 2022 launch



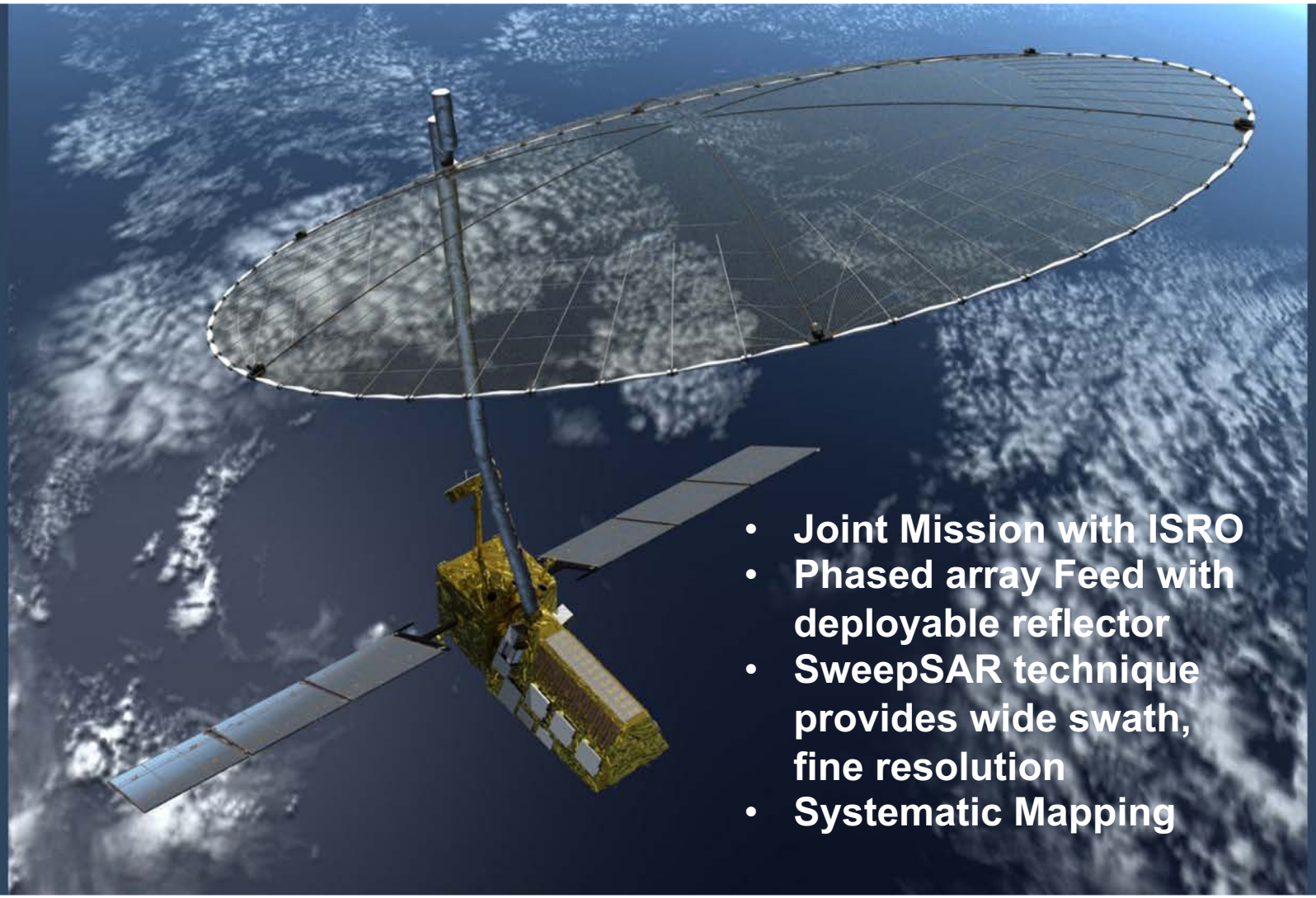
	Earth-Moon L2	Moon NRHO (North & South)
Orbit	1 month full halo	6 days
Eclipse	None	1.5 hr
Desaturation	30 min once/day	30 min once/day
Solar panel articulation	1-axis	2-axis
Orbit correction	30 min once/7 days	30 min once/6 days
Delta-V Required	60 m/s	200 m/s
Earth-S/C-Moon Angle over course of mission	3-50 deg	90 deg



Clip + still courtesy Andrew Shapiro-Scharlotta, JPL

Gecko Clip courtesy Aaron Parness, JPL

NISAR (Earth Science)



- Joint Mission with ISRO
- Phased array Feed with deployable reflector
- SweepSAR technique provides wide swath, fine resolution
- Systematic Mapping

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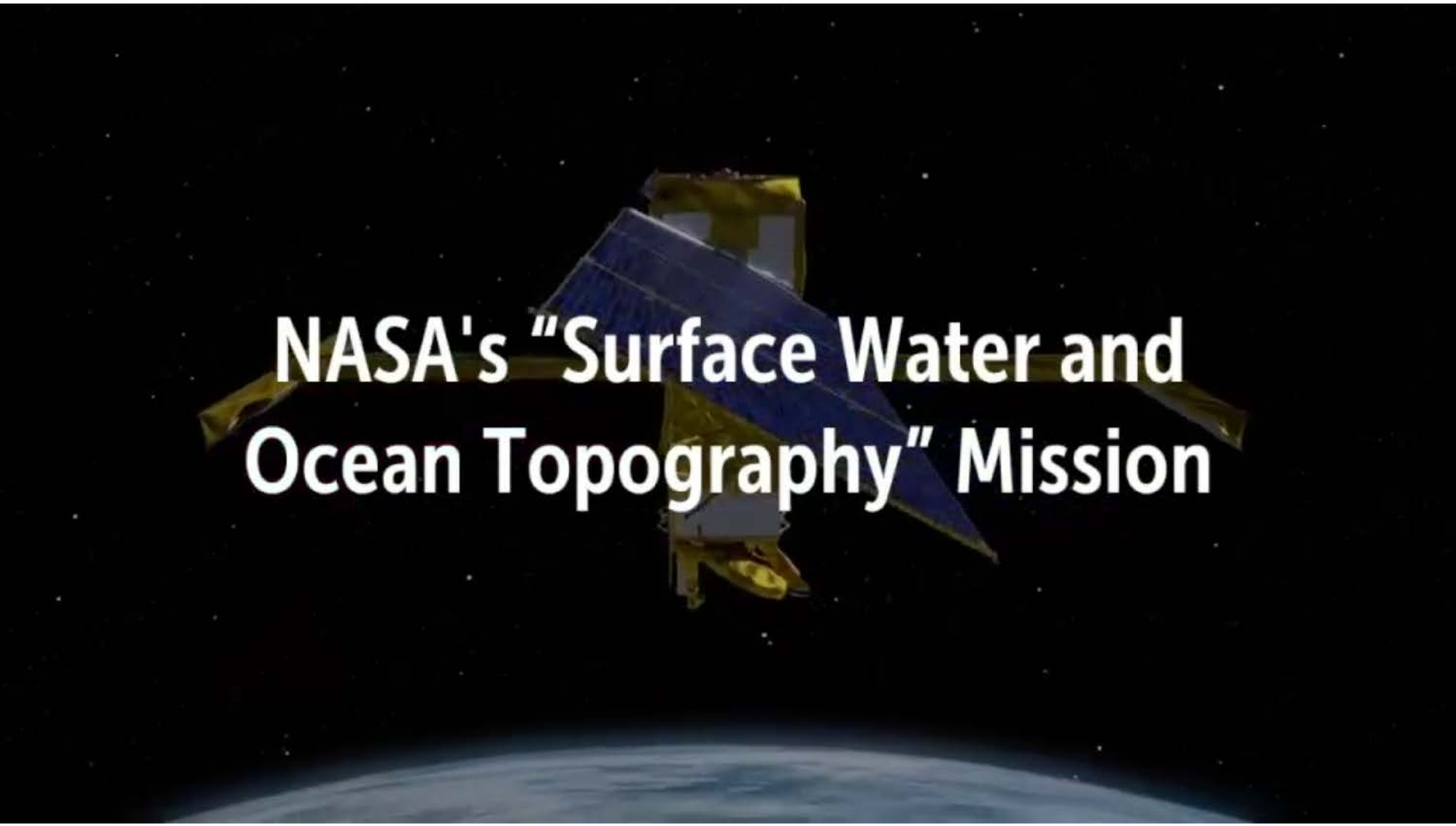
Surface Water Ocean Topography Mission
SWOT (2022)



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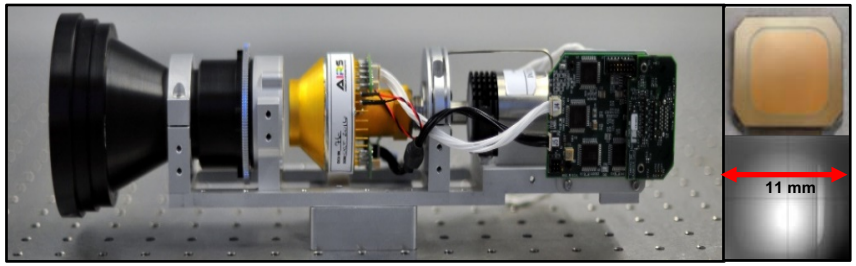
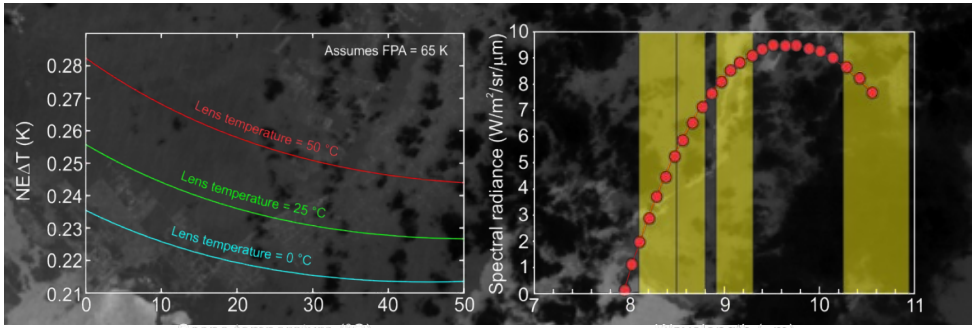
HyTI

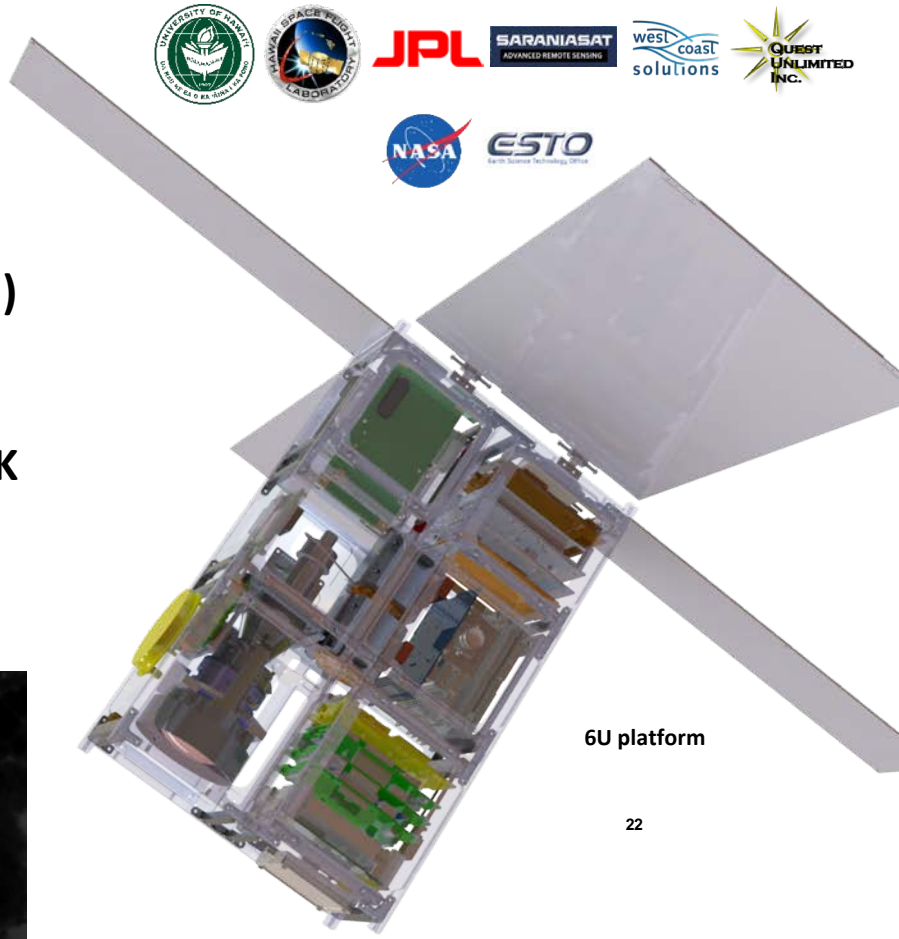
Hyperspectral Thermal Imager

Slide courtesy PI Rob Wright, UHI



- High spectral resolution (25 bands, 8-10.5 μm)
- 70 m spatial resolution; 30 km swath
- Fabry-Perot interferometer (inset, top)
- JPL's BIRD FPA inside the dewar, cooled to 67 K
- Single multi-element refractive lens (f#/3.44)
- Data acquired at 157 frames per second
- Delivery for launch Oct 2020





6U platform

22

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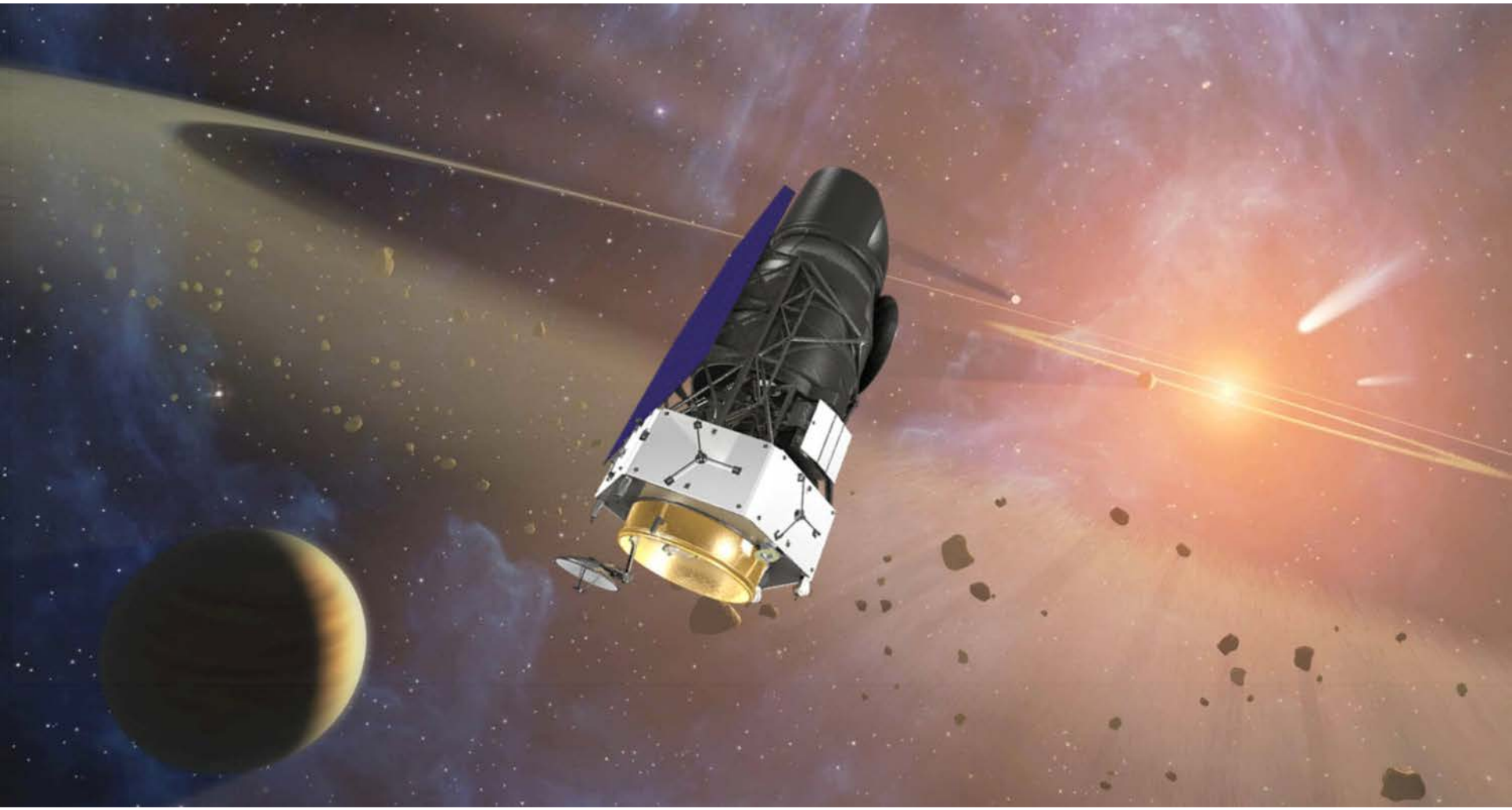
WFIRST Space Telescope

- **GSFC-led L2 Mission**
- **JPL Coronograph**



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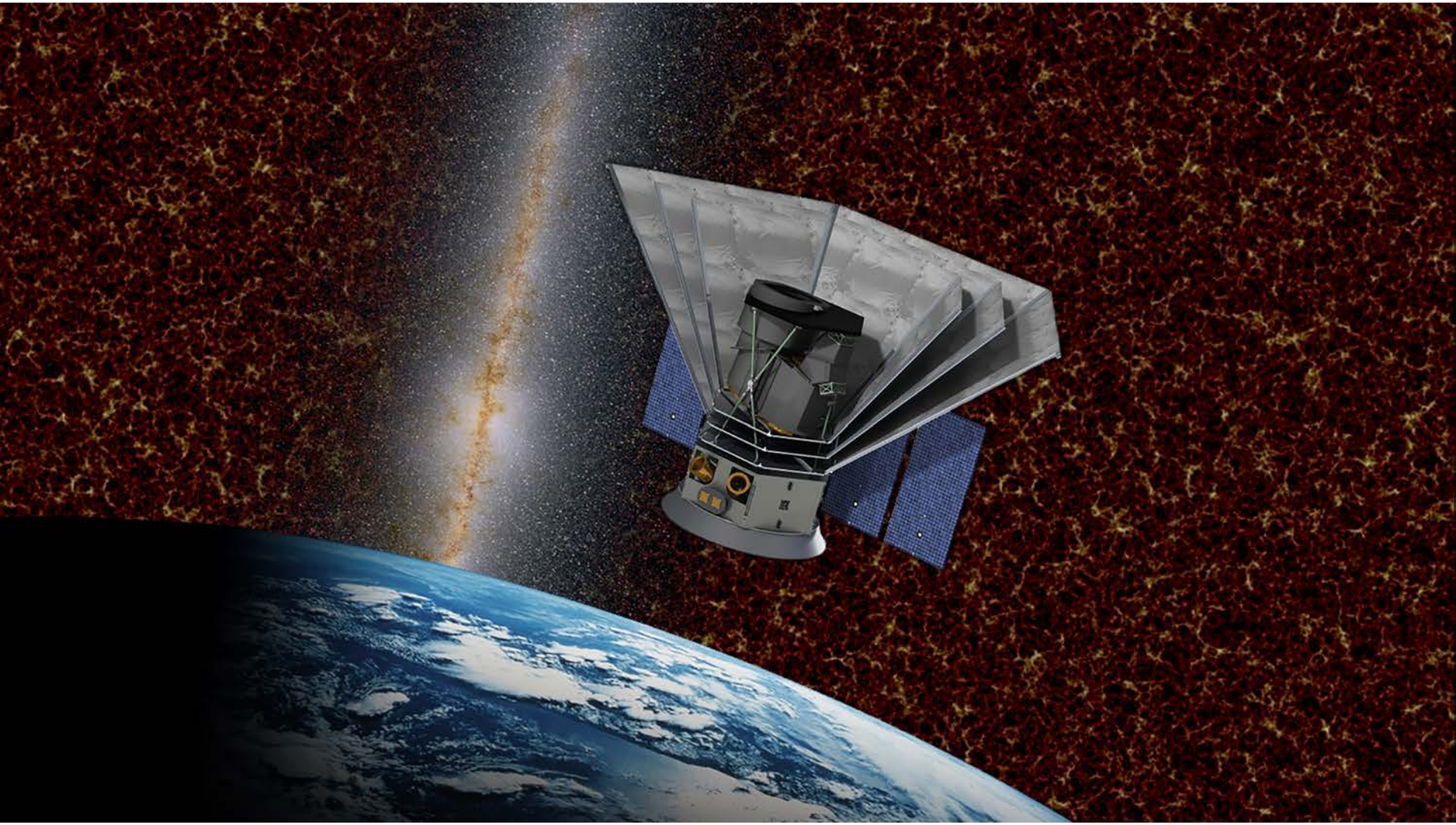
SPHEREx Mission

- **MIDEX LEO mission (2023)**
- **All Sky NIR Spectroscopy**



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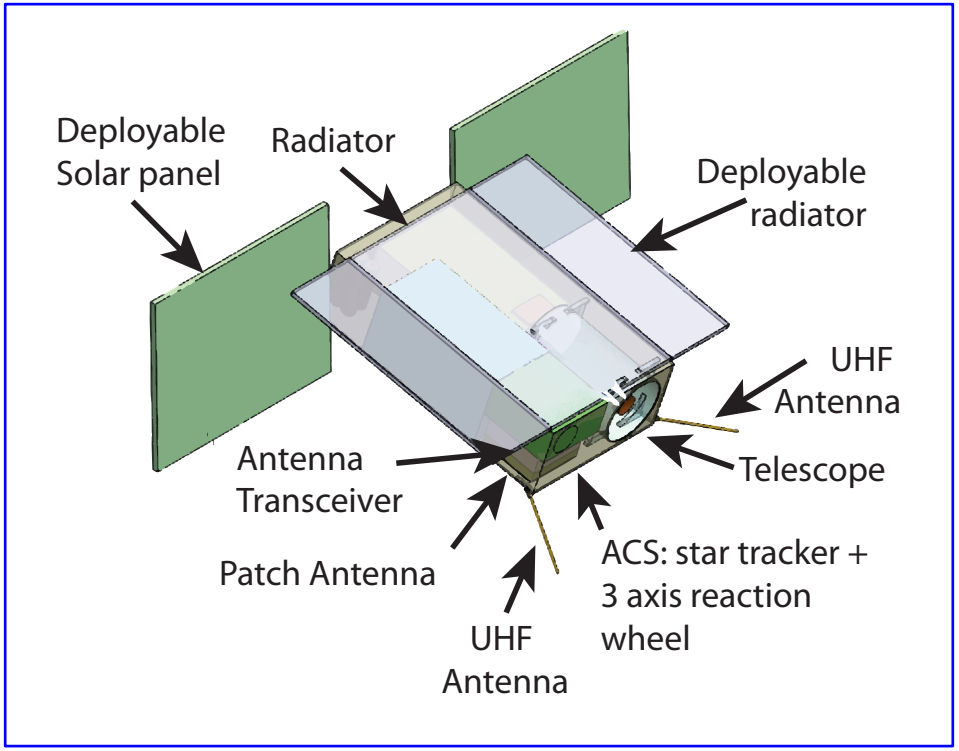
SPARCS 6U cubesat mission

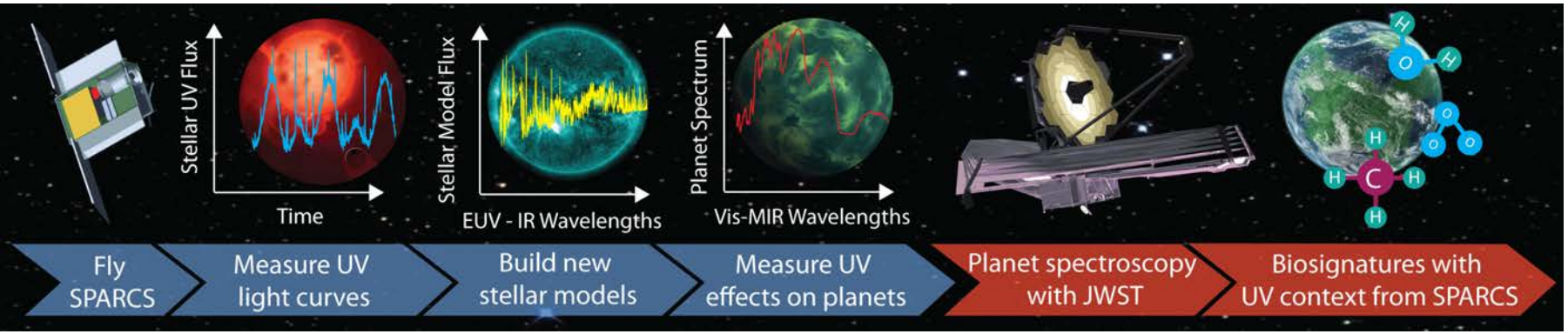
Study UV environment of exoplanets around M dwarf stars

Slide courtesy of David Ardila, JPL

Planned launch in late 2021

- 9 cm aperture
- 2-mirror telescope
- Dichroic + Two detectors
- Simultaneous observations FUV/NUV
- 1 day to 3 mth 'staring' mode

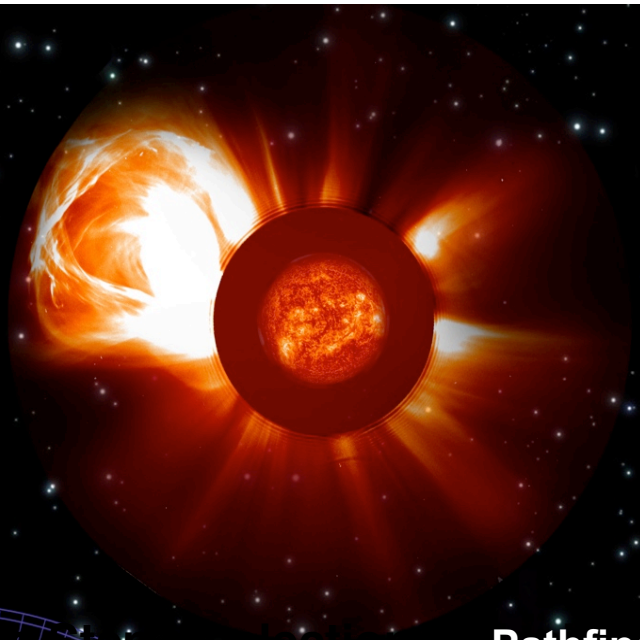


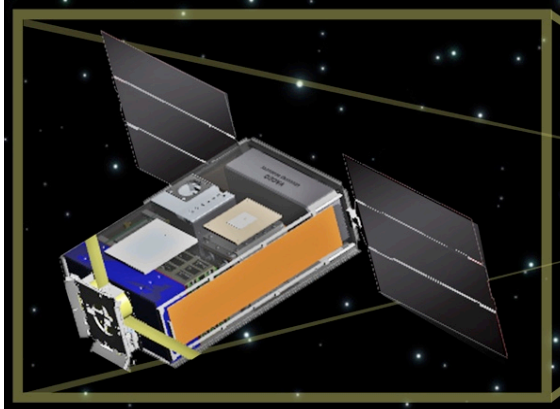


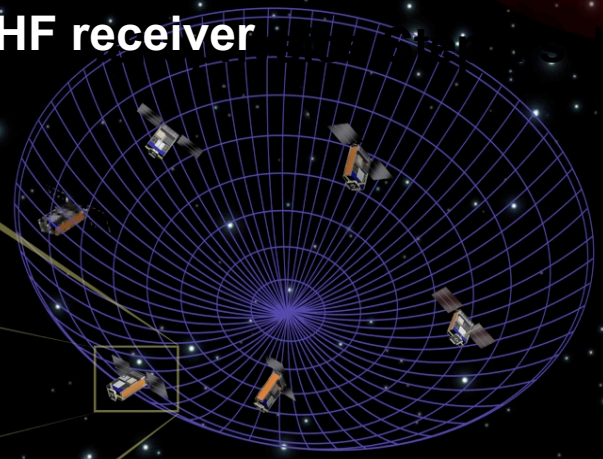
SunRISE is in extended Phase A

Sun Radio Imaging Space Experiment (SunRISE)

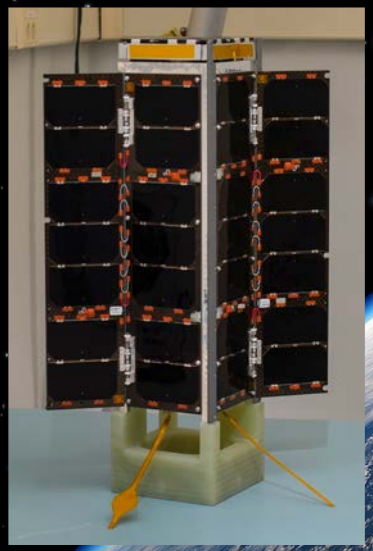
- ✓ Use radio emissions to track solar CME particle acceleration and transport
- ✓ Proposed science swarm to form an RF Interferometer
- ✓ 6 spacecraft synthetic aperture
- ✓ Combined GPS + HF receiver
- ✓ 6U Spacecraft







Pathfinder (2017/18)



Pre-Decisional Information -- For Planning and Discussion Purposes Only

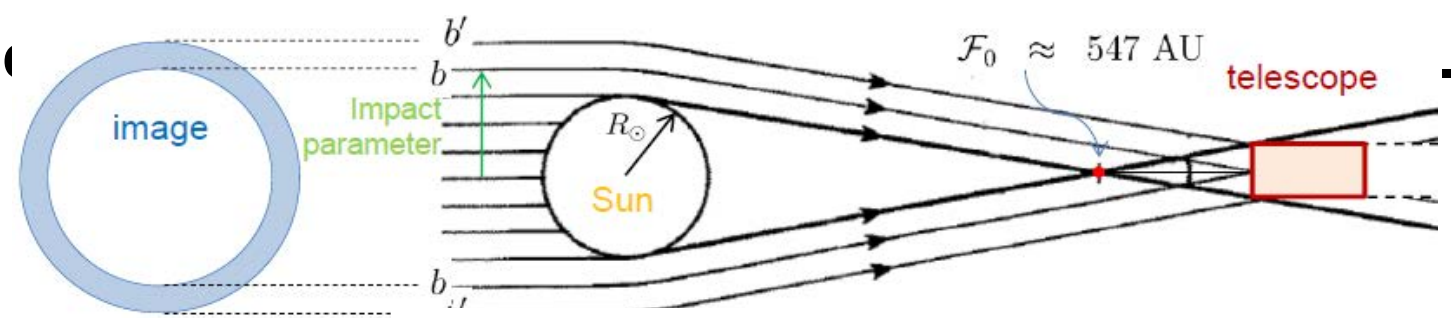
Solar Gravity Lens Mission Concept

Leon Alkalai, Nitin Arora NASA-JPL

- **A line in space starting at ~550AU from the Sun, from where we can use Sun as a lens to image planetary bodies on the other "side" of the Sun, light years away!**

- **A 1m telescope at the SGL can take a 1000 x 1000 pixel image of an Earth size exoplanet up to planet up to 30 parsecs**
  - **Only practical way for multi-pixel imaging of an exoplanet.**
  - **10 km or better resolution !**

- **Ne**



Pre-Decisional Information -- For Planning and Discussion Purposes Only

Wrap-up

- JPL has a wide variety of missions ”On the Books” and in the Concept Study Phase
- Missions cover all of NASA’s Science Mission Directorate interests:
  - Solar System Exploration
  - Earth Science
  - Astrophysics
  - Heliophysics
- Mission set includes flybys, orbiters, landers, surface explorers, sample return
- Missions will experience a wide range of space environments