National Aeronautics and Space Administration

2023 NASA SCIENCE

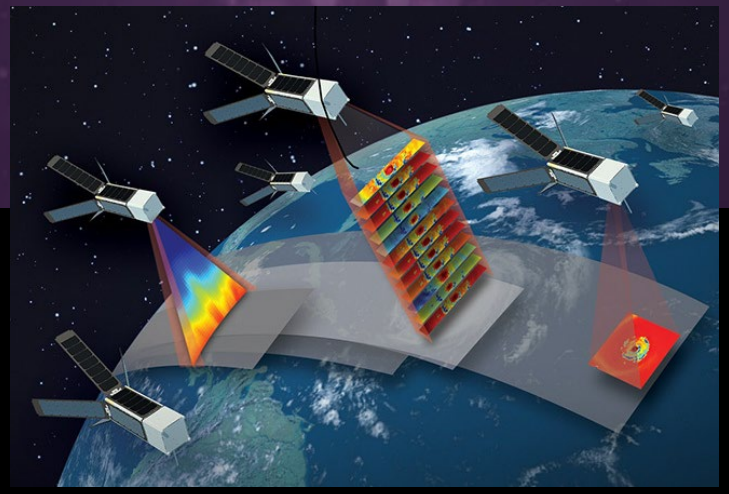
NASA SmallSats Missions for Science and Technology Demonstration

Florence Tan
Chair, Small Spacecraft Coordination Group NASA Headquarters

COSPAR 2023

April 2023

SCIENCE MISSION DIRECTORATE (SMD) & CUBESAT/SMALLSAT OVERVIEW



CUBESAT/SMALLSAT PROGRAM REVIEWS & HIGHLIGHTS

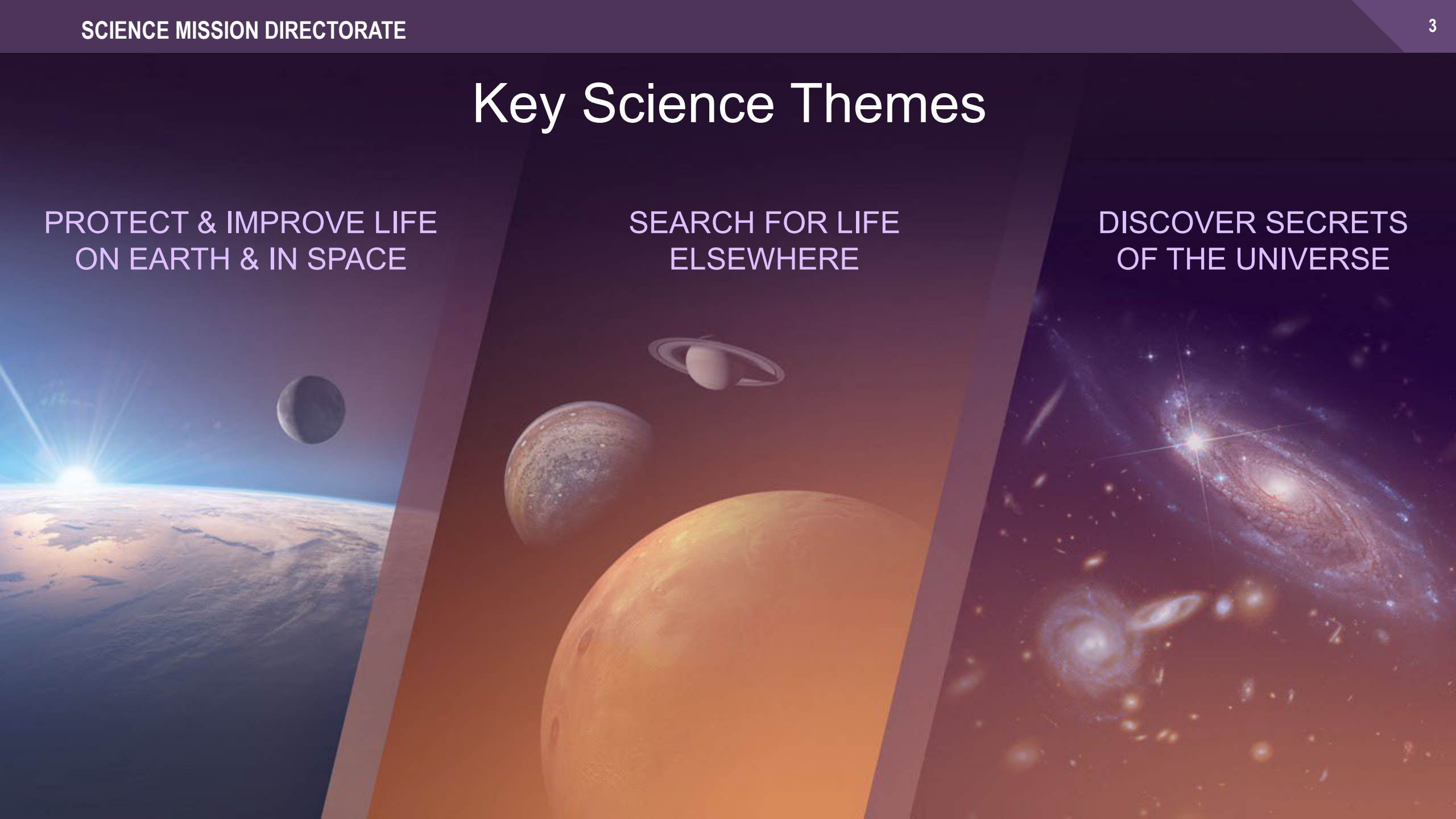
MISSION STRATEGY & OPPORTUNITES

Key Science Themes

PROTECT & IMPROVE LIFE ON EARTH & IN SPACE

SEARCH FOR LIFE ELSEWHERE

DISCOVER SECRETS OF THE UNIVERSE



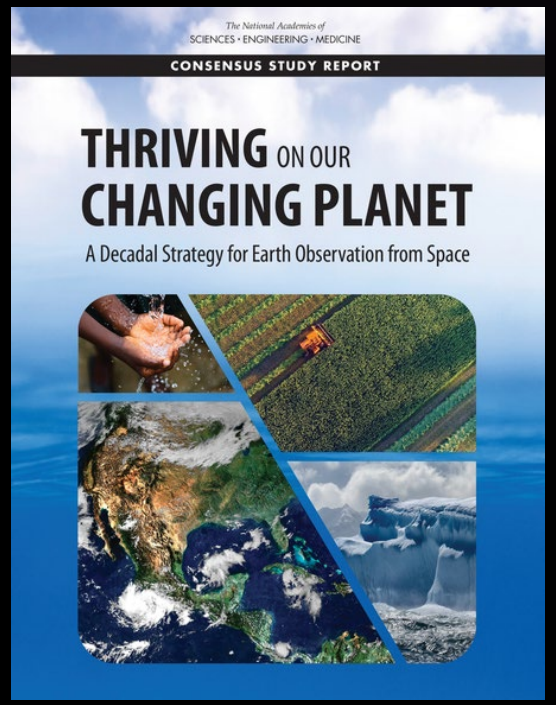
NASA SCIENCE

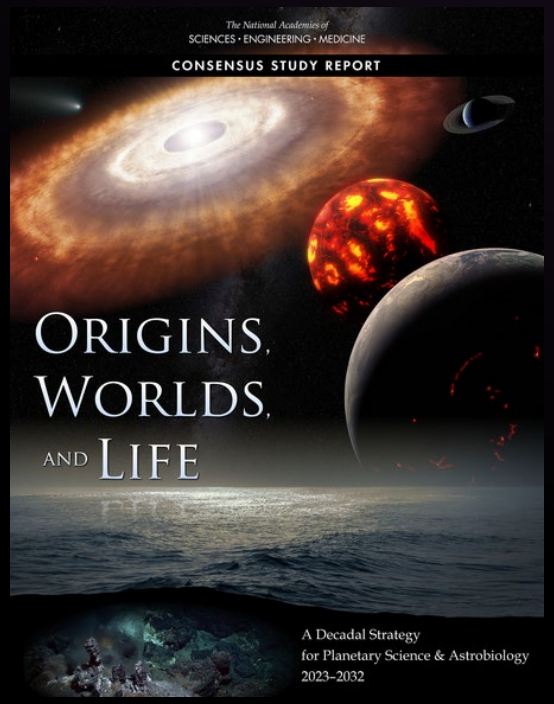
An Integrated Program

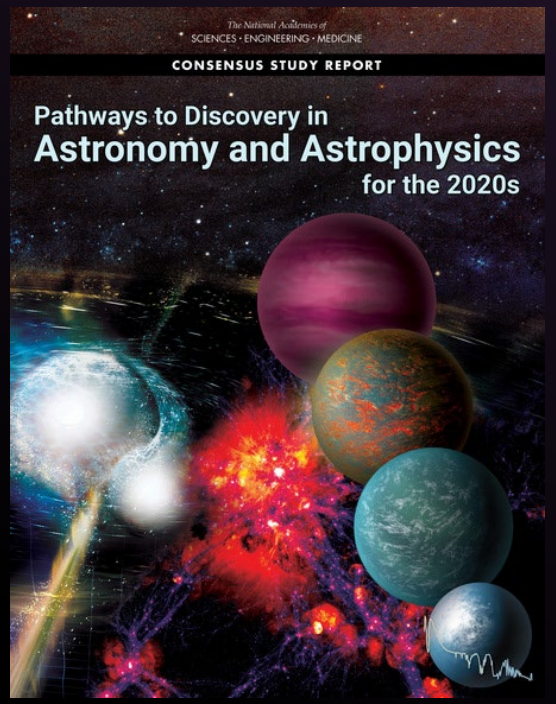
- Astrophysics
- Heliophysics
- Biological and Physical Science
- Joint agency Satellite
- Earth Science
- Planetary Science

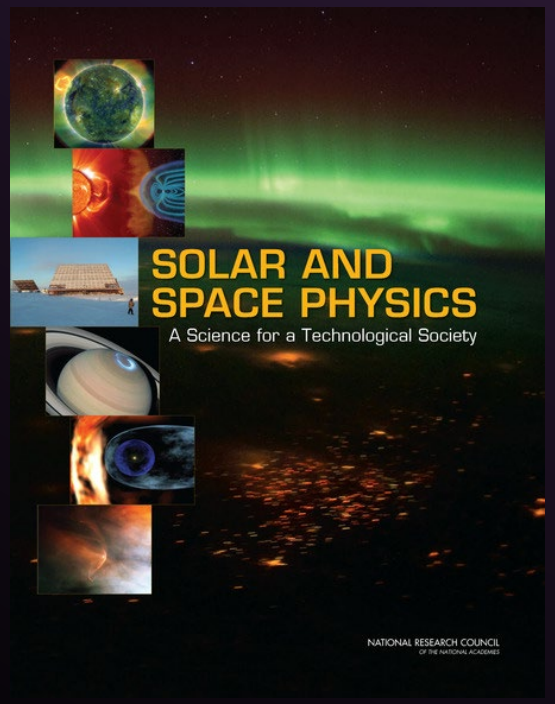
NASA SCIENCE

Guided by Decadal Studies



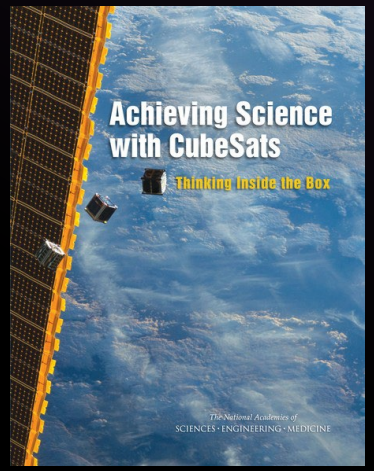


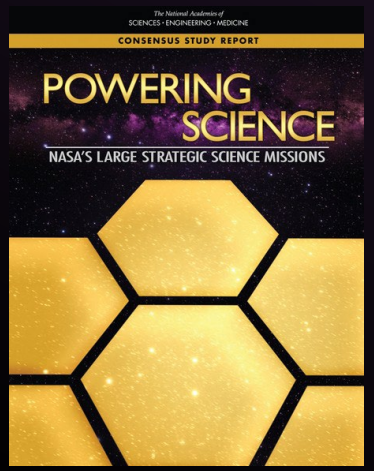




Establishing the Vision for Small Mission Science

Small satellite community can contribute to the scientific and technical rationale for a sustainable, productive, and relevant role within a balanced portfolio of strategic science missions



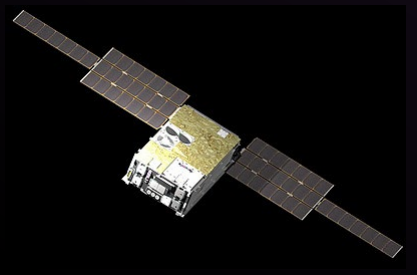


National Academies and NASA Reports Impact SmallSat/CubeSat Strategy

- NASA formed and chartered a Cross-Agency Coordination Group that Advises AAs on Strategy, Guidance, and Policy For Innovative Small Spacecraft Science and Technology Missions
- SMD, STMD, and SOMD's small spacecraft missions are actively pursuing science, space technology, and strategic knowledge gaps

Science
Hurricane observations via TROPICS constellation

New Observation Methods



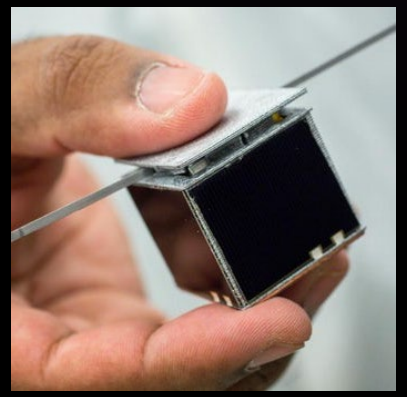
Exploration
Lunar imaging via Equuleus mission

Strategic Knowledge Gaps

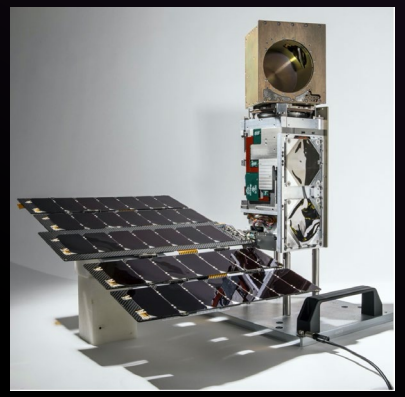
Technology maturation via CAPSTONE mission

Spacecraft Subsystems

Fundamentals of Small Spacecraft
Spectrum of Satellite Development

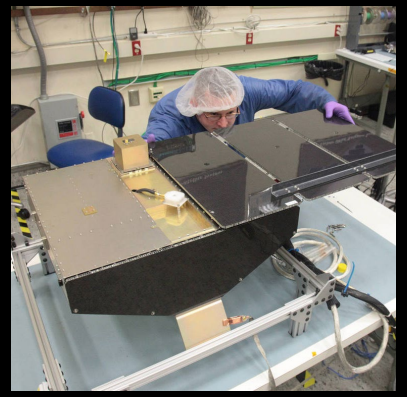


Picosatellite
PocketSat (0.1 – 1 kg)



CubeSat/Nanosatellite
TROPICS 3U/6U (1 – 10 kg)

SPA-Ring
Payload Port Limit (450 kg)



Microsatellite
CYGNSS (10 – 100 kg)

Small Satellite
ESCAPADE (100 – 500 kg)

SmallSat Definition

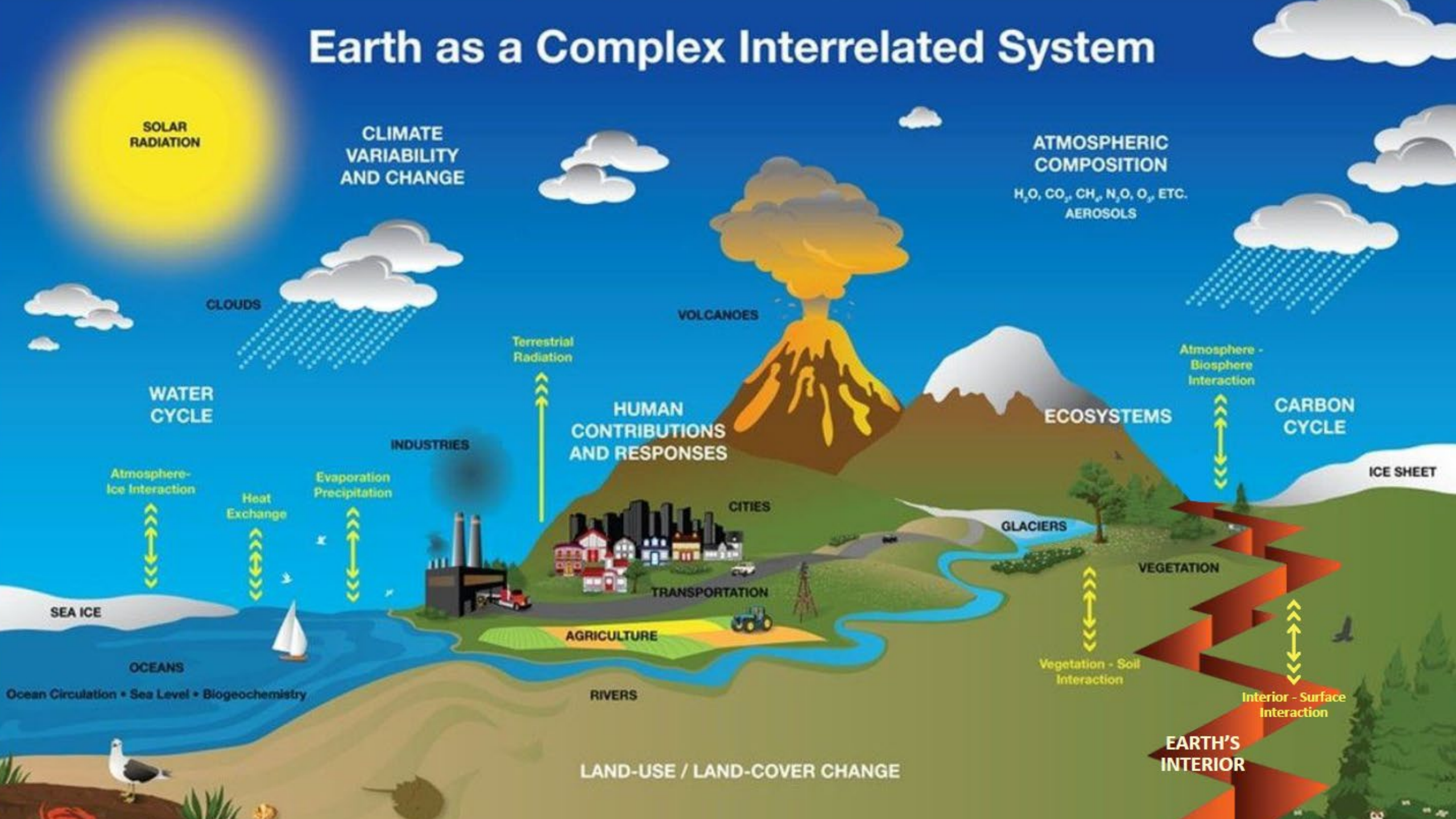
A spacecraft that is interface compatible with a SPA Ring, a dedicated small or medium-lift launch vehicle, or a containerized dispenser, and with an upper mass limit of approximately 500 kg

ISS

Rideshare

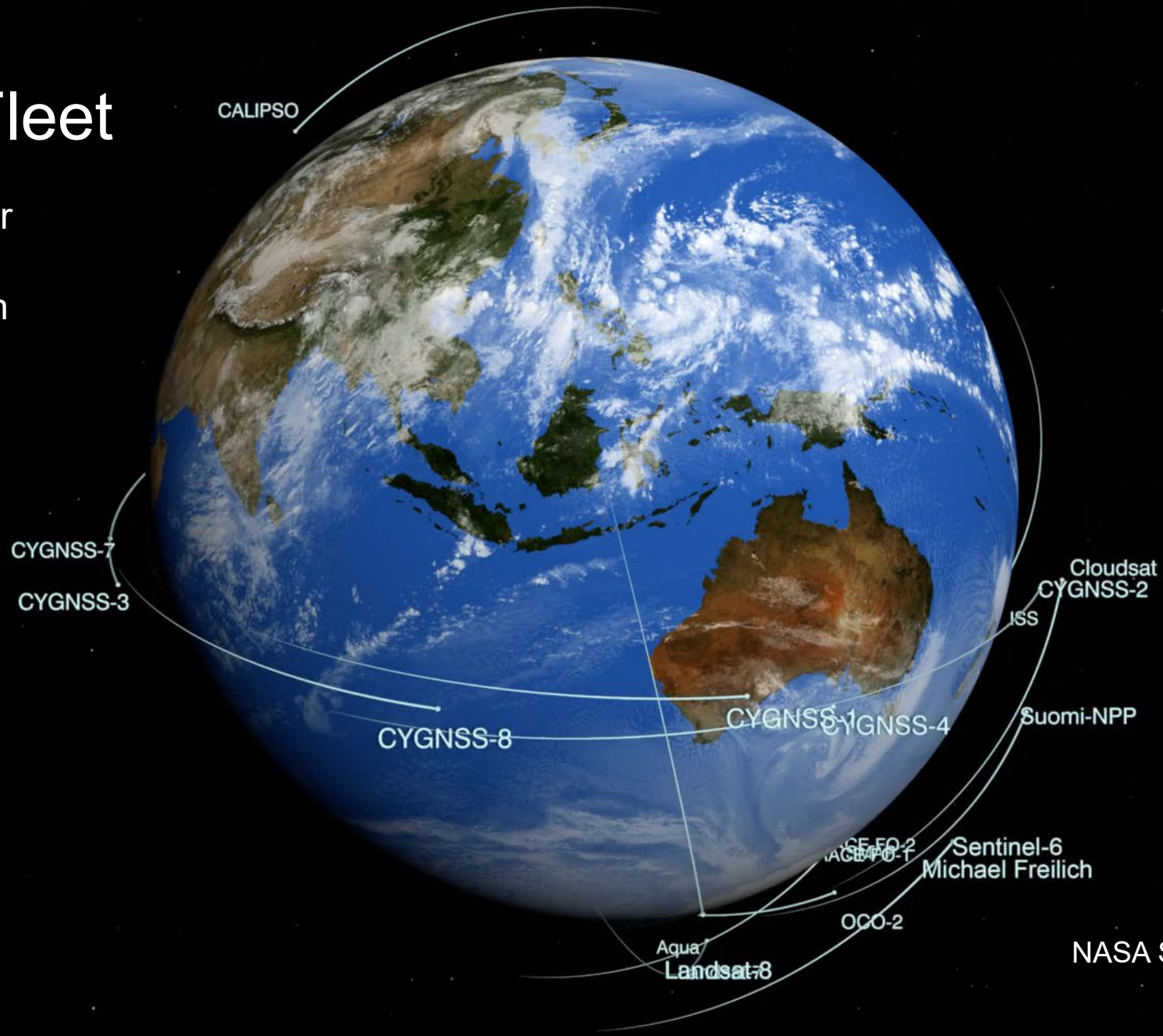
Dedicated


SPACE WEATHER
Researching Causes
Studying Impacts
Improving Predictions
EXOSPHERE
IONOSPHERE
STRATOSPHERE


Earth as a Complex Interrelated System
SOLAR RADIATION
CLIMATE VARIABILITY AND CHANGE
ATMOSPHERIC COMPOSITION
H_2O, CO_2, CH_4, N_2O, O_3, ETC.
AEROSOLS
CLOUDS
VOLCANOES
Terrestrial Radiation
WATER CYCLE
HUMAN CONTRIBUTIONS AND RESPONSES
ECOSYSTEMS
Atmosphere - Biosphere Interaction
CARBON CYCLE
INDUSTRIES
ICE SHEET
Atmosphere-Ice Interaction
Heat Exchange
Evaporation Precipitation
CITIES
GLACIERS
VEGETATION
TRANSPORTATION
SEA ICE
AGRICULTURE
OCEANS
Ocean Circulation • Sea Level • Biogeochemistry
Vegetation - Soil Interaction
Interior - Surface Interaction
RIVERS
EARTH'S INTERIOR
LAND-USE / LAND-COVER CHANGE

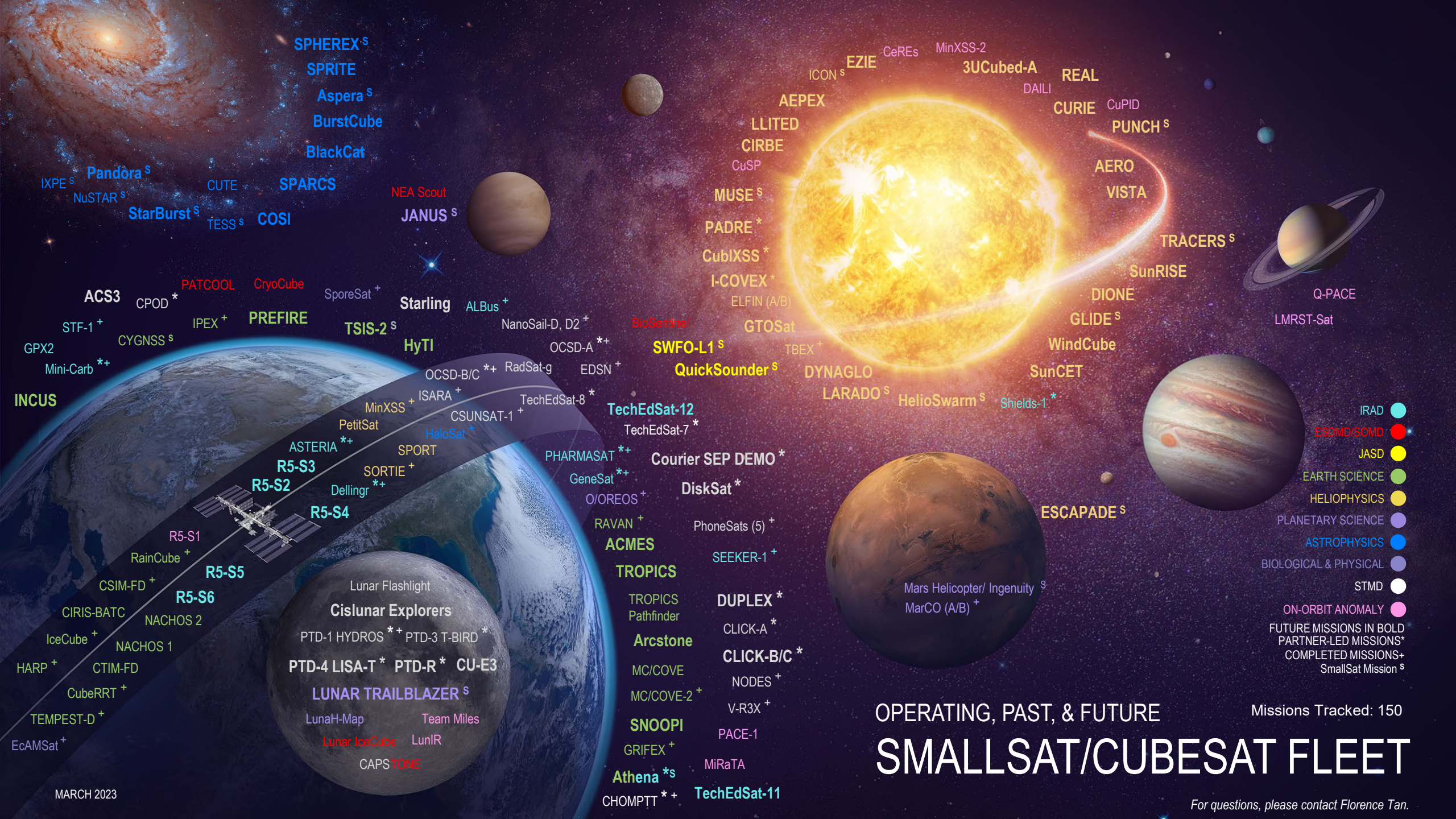
NASA Earth Observing Fleet

Active science partner with **134 nations,** engaged in more than **270 partnership activities (UPDATE)**



August 2021

NASA Scientific Visualization Studio
svs.gsfc.nasa.gov/4931


SPHEREX S
SPRITE
Aspera S
BurstCube
BlackCat
SPARCS
Pandora S
IXPE S
NuSTAR S
CUTE
StarBurst S
TESS S
COSI
NEA Scout
JANUS S
ACS3
CPOD *
PATCOOL
CryoCube
SporeSat +
Starling
ALBus +
STF-1 +
IPEX +
PREFIRE
TSIS-2 S
CYGNSS S
GPX2
Mini-Carb *+
HyTI
NanoSail-D, D2 +
OCSD-A *+
OCSD-B/C *+
RadSat-g
EDSN +
INCUS
ISARA +
MinXSS +
TechEdSat-8 *
CSUNSAT-1 +
PetitSat
HaloSat +
ASTERIA *+
SPORT
R5-S3
R5-S2
SORTIE +
Dellingr *+
R5-S4
R5-S1
RainCube +
R5-S5
CSIM-FD +
R5-S6
CIRIS-BATC
NACHOS 2
IceCube +
NACHOS 1
HARP +
CTIM-FD
CubeRRT +
TEMPEST-D +
EcAMSat +
Lunar Flashlight
Cislunar Explorers
PTD-1 HYDROS *+
PTD-3 T-BIRD *
PTD-4 LISA-T *
PTD-R *
CU-E3
LUNAR TRAILBLAZER S
LunaH-Map
Team Miles
Lunar IceCube
LunIR
CAPSTONE
MARCH 2023
ICON S
EZIE
CeREs
MinXSS-2
3UCubed-A
REAL
DAILI
AEPEX
CURIE
CuPID
LLITED
PUNCH S
CIRBE
CuSP
AERO
MUSE S
VISTA
PADRE *
TRACERS S
CubIXSS *
SunRISE
I-COVEX *
DIONE
Q-PACE
ELFIN (A/B)
GLIDE S
LMRST-Sat
BioSentinel
GTOSat
SWFO-L1 S
TBEX +
WindCube
QuickSounder S
DYNAGLO
SunCET
LARADO S
HelioSwarm S
Shields-1 *
TechEdSat-12
TechEdSat-7 *
PHARMASAT *+
Courier SEP DEMO *
GeneSat *+
DiskSat *
O/OREOS +
RAVAN +
PhoneSats (5) +
ACMES
SEEKER-1 +
TROPICS
TROPICS Pathfinder
DUPLEX *
CLICK-A *
Arcstone
CLICK-B/C *
MC/COVE
NODES +
MC/COVE-2 +
V-R3X +
SNOOPI
PACE-1
GRIFEX +
MiRaTA
Athena *S
CHOMPTT *+
TechEdSat-11
ESCAPADE S
Mars Helicopter/ Ingenuity S
MarCO (A/B) +
IRAD
ESDMD/SOMD
JASD
EARTH SCIENCE
HELIOPHYSICS
PLANETARY SCIENCE
ASTROPHYSICS
BIOLOGICAL & PHYSICAL
STMD
ON-ORBIT ANOMALY
FUTURE MISSIONS IN BOLD
PARTNER-LED MISSIONS*
COMPLETED MISSIONS+
SmallSat Mission S
OPERATING, PAST, & FUTURE
Missions Tracked: 150
SMALLSAT/CUBESAT FLEET
For questions, please contact Florence Tan.

NASA SmallSat Status

Missions *as of Jan 2023*

Red: CSLI White: 3U or 6U units Orange: MiniSat Yellow: Multiple units
Blue: ESPA-Class Mission Green: 12U Mission

Formulation

ACMES (ESD)
Arcstone (ESD)
COSI (APD)
CubIXSS (HPD)
DiskSat (STMD)
HelioSwarm (HPD)
I-COVEX (HPD)
INCUS (ESD)
MoonBEAM (APD)
MUSE (HPD)
PADRE (HPD)
QuickSounder (JASD)
SunCET (HPD)
TSIS-2 (ESD)

Implementation

3U^3-A (HPD)
ACS3 (STMD)
AEPEX (HPD)
AERO/VISTA (HPD)
Aspera (APD)
Athena (ESD)
BlackCat (APD)
BurstCube (APD)
CIRBE (HPD)
Cislunar Explorers (STMD)
CLICK B/C (STMD)
Courier SEP DEMO (STMD)
CU-E3 (STMD)
CURIE (HPD)
DIONE (HPD)
DUPLEX (STMD)
DYNAGLO (HPD)
ESCAPADE (HPD)
EZIE (HPD)
GLIDE (HPD)
GTOSat (HPD)
HYTI (ESD)
JANUS (PSD)
LARADO (HPD)
LLITED (HPD)
Lunar Trailblazer (PSD)
PANDORA (APD)
PREFIRE (ESD)
PTD-4 LISA-T (STMD)
PTD-R (STMD)
PUNCH (HPD)
R5-S2,3,4,5,6 (IRAD)
REAL(HPD)
SNOOPI (ESD)
SPARCS (APD)
SPHEREx (APD)
SPRITE (APD)
StarBurst (APD)
Starling (STMD)
SunRISE (HPD)
SWFO-L1 (JASD)
TechEdSat-12 (IRAD)
TRACERS (HPD)
TROPICS (ESD)
WindCube (HPD)

Launched/Deployed

TECHEDSAT-7 (STMD)

Complete

ALBus (IRAD)
ASTERIA (IRAD)
CryoCube (SOMD/ESDMD)
CSIM-FD (ESD)
CSUNSat-1 (STMD)
CubeRRT (ESD)
Dellingr (IRAD)
EcAMSAT (BPS)
EDSN (STMD)
ELFIN (HPD)
GeneSat (IRAD)
GRIFEX (ESD)
HaloSat (APD)
HARP (ESD)
IceCube (ESD)
IPEX (ESD)
ISARA (STMD)
MarCO-A/B (PSD)
MC-COVE (ESD)
MC-COVE-2 (ESD)
MINICARB (IRAD)
MinXSS (HPD)
NanoSail-D, D2 (STMD)
NODES (STMD)
O/OREOS (PSD)
OCSD-A,2B,C (STMD)
PATCOOL (SOMD/ESDMD)
PharmaSat (IRAD)
PhoneSats (STMD)
PTD-1 HYDROS (STMD)
RadSat-G (STMD)
RainCube (ESD)
RAVAN (ESD)
SEEKER (IRAD)
SORTIE (HPD)
SporeSat (BPS)
STF -1(IRAD)
TBEx (HPD)
TechEdSat SERIES (STMD)
Tempest-D (ESD)
TILE DEMO (STMD)
V-R3X (STMD)

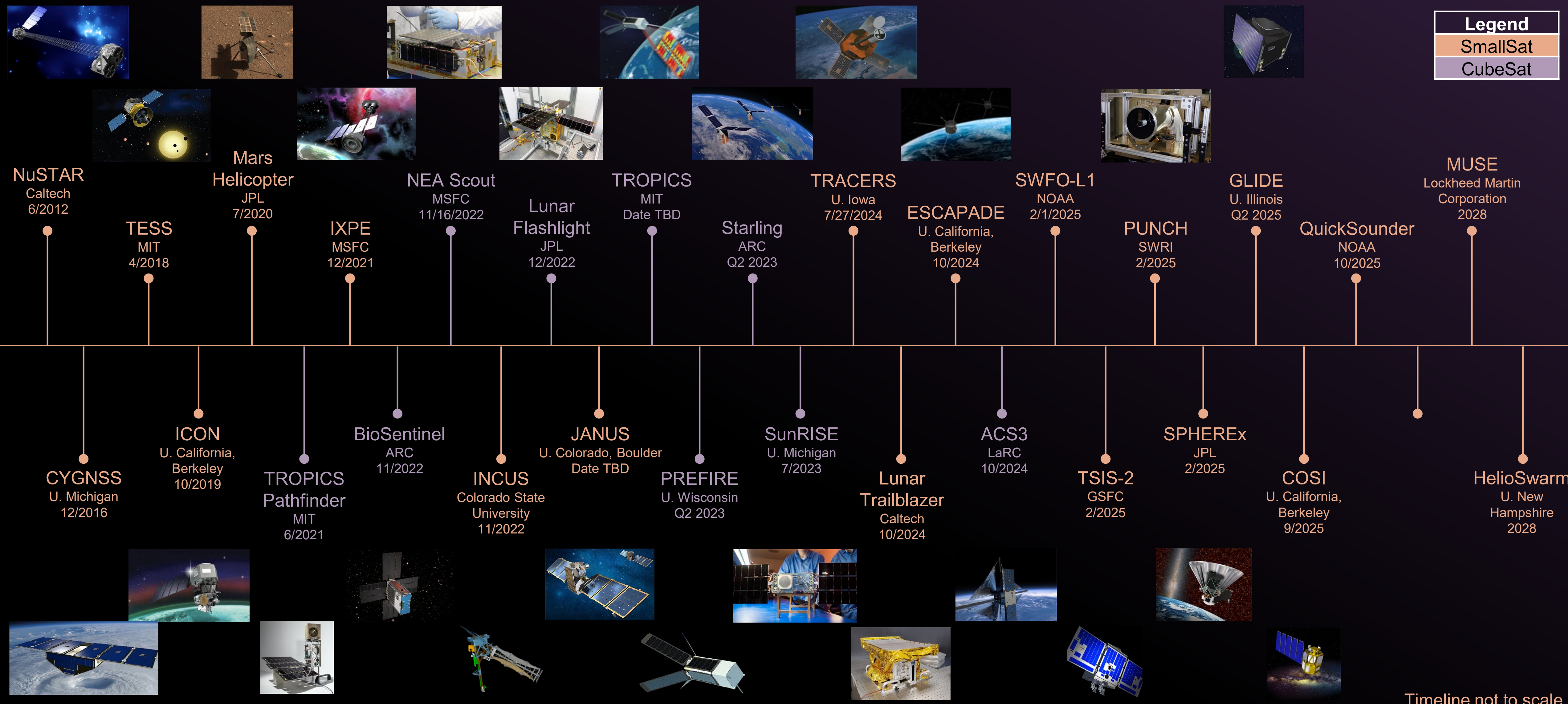
Orbit Anomaly

CeRES (HPD)
CuPID (HPD)
CuSP (HPD)
DAILI (HPD)
LMRST –Sat (IRAD)
MinXSS-2 (HPD)
MiRaTA (ESD)
PACE 1 (STMD)
Q-PACE (PSD)
R5-S1 (IRAD)

Operating

BioSentinel (SOMD/ESDMD)
CAPSTONE (STMD/ESDMD)
CHOMPTT (STMD)
CIRiS-BATC (ESD)
CLICK A (STMD)
CPOD (STMD)
CTIM-FD (ESD)
CUTE (APD)
CYGNSS (ESD)
GPX2 (IRAD)
ICON (HPD)
IXPE (APD)
LunaH-Map (PSD)
Lunar FlashLight (STMD)
Lunar IceCube (SOMD/ESDMD)
LunIR (SOMD/ESDMD)
Mars Helicopter (PSD)
NEA Scout (SOMD/ESDMD)
NACHOS/2 (ESD)
NuSTAR (APD)
PetitSat (HPD)
PTD-3 T-BIRD (STMD)
Shields (IRAD)
SPORT (HPD)
Team Miles (STMD)
TESS (APD)
TROPICS Pathfinder (ESD)

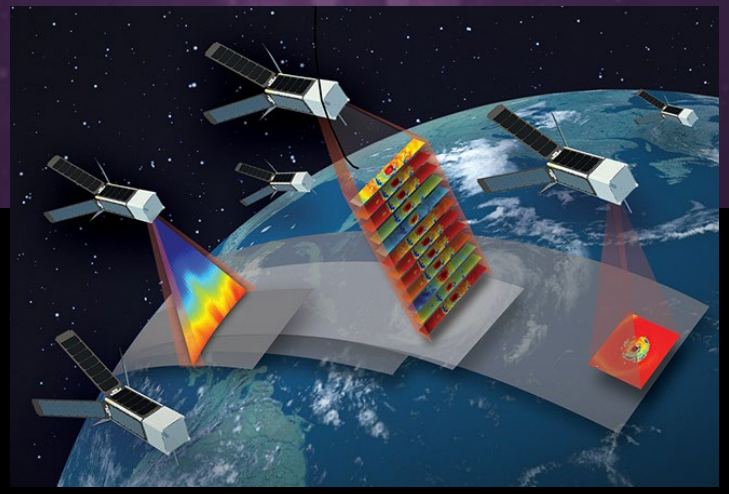
NASA's SmallSat Past and Future Launches



Images sourced from NASA or directly from Lead Institution.

Timeline not to scale
Calendar year used for quarterly launch estimates.

SCIENCE MISSION DIRECTORATE (SMD) & CUBESAT/SMALLSAT OVERVIEW



CUBESAT/SMALLSAT PROGRAM REVIEWS & HIGHLIGHTS

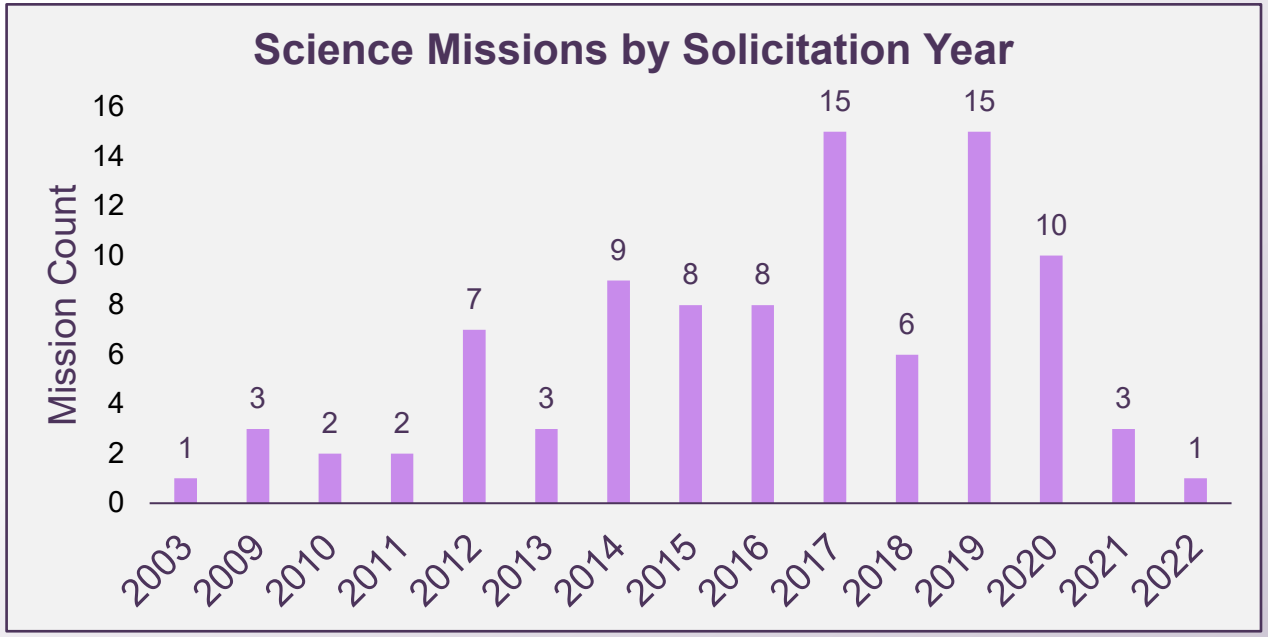
MISSION STRATEGY & OPPORTUNITES

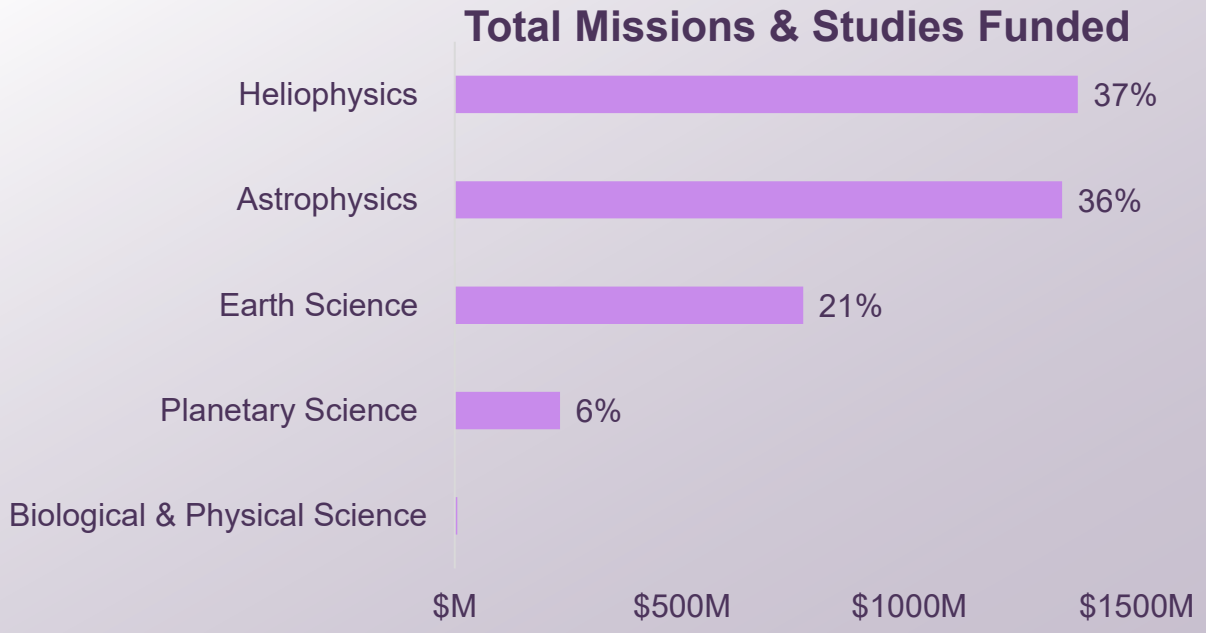
NASA Science SmallSat Missions at a Glance

138 **TOTAL** MISSIONS & STUDIES

$4.2B **TOTAL** INVESTED

- **20** COMPLETED
- **47** IN FORMULATION / IMPLEMENTATION
- **15** IN OPERATION
- **7** FAILURES
- **3** CANCELLED
- **46** STUDIES
- **1** CLOSED WITHOUT FLIGHT





Data as of Jan 2023

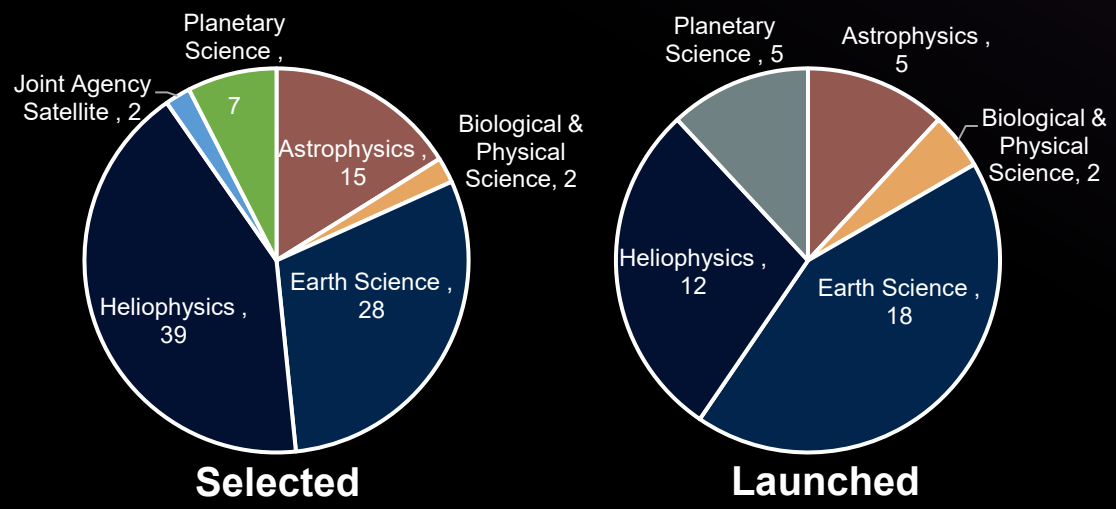
NASA's Science SmallSat Missions Division Comparison

Excludes Studies
Data as of Jan 2023

Earth and Heliophysics science missions are embracing SmallSat platforms for enabling science.

*Launched missions are in operation, complete, or failed

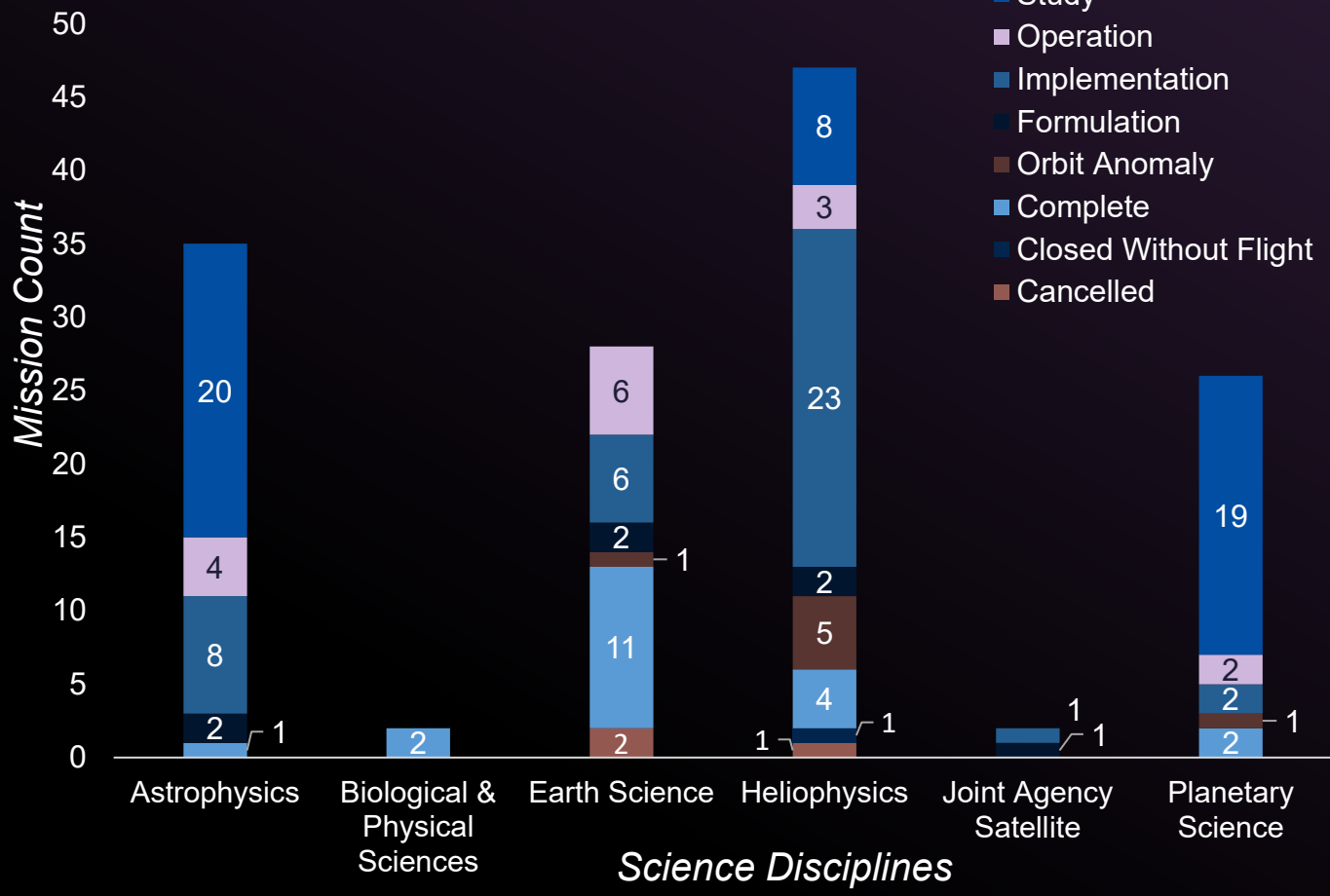
All Selected & Launched Missions* Since 2010



Of NASA science disciplines

- Heliophysics selected the most number of missions
- Earth Science launched the most number of missions
- More than 50% of missions are still in development with 25% complete

Mission Status

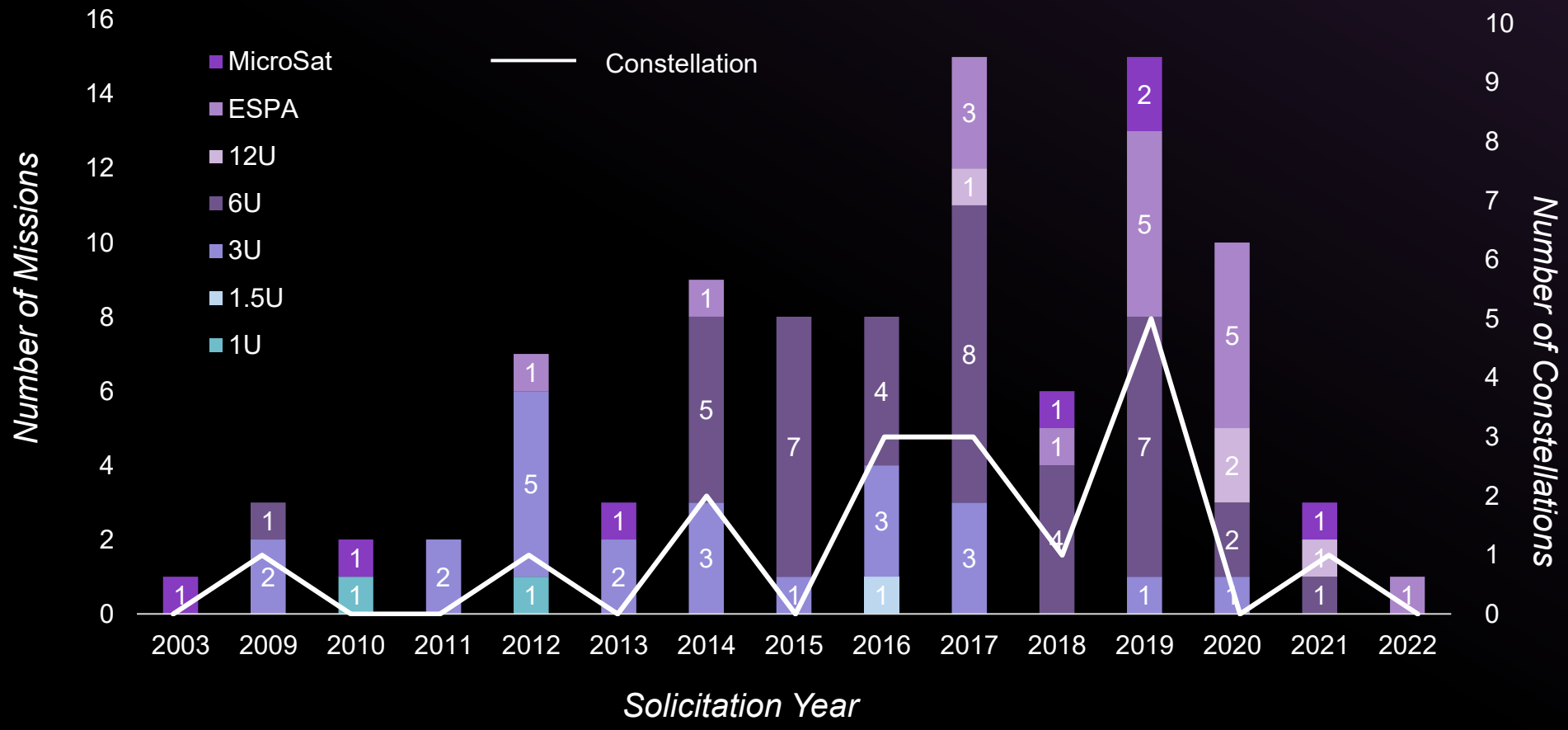


NASA SMD SmallSat Mission Trends

Excluding Studies

Data as of Jan 2023

Mission Size & Constellation Trends

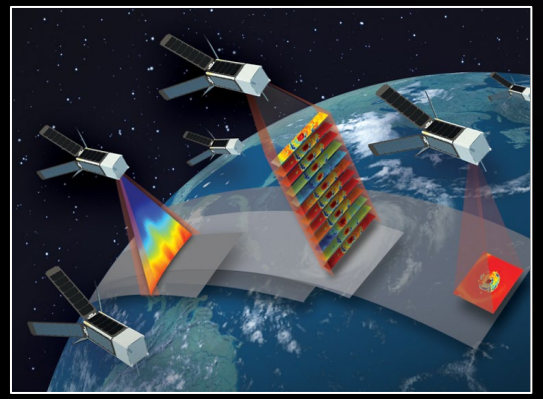


Missions Trends

- Progressively growing larger
- Trending towards constellations
- Continuing to produce more results in science collection and technology development

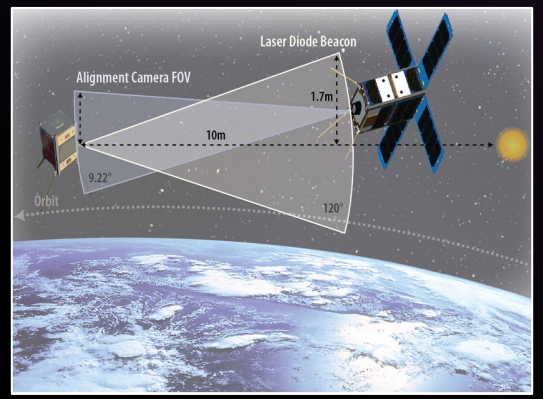
SmallSat Program Opportunities

Investing in Earth Science Constellations



Earth Venture Missions (EVM/EVI) and In-Space Validation of Earth Science Technologies (InVEST)

Major Investment in Astro SmallSat Missions



Astrophysics APRA CubeSat and PIONEERS program, Small Explorer (SMEX) Astrophysics Science SmallSat Studies

Investing in SmallSat Constellations and ESPA Class Missions

Heliophysics Technology and Science Mission of Opportunity (MoO), Small Explorer (SMEX), Medium Explorer (MIDEX), Flight Research and Technology (H-FORT) programs

Investing in Deep Space SmallSat Missions

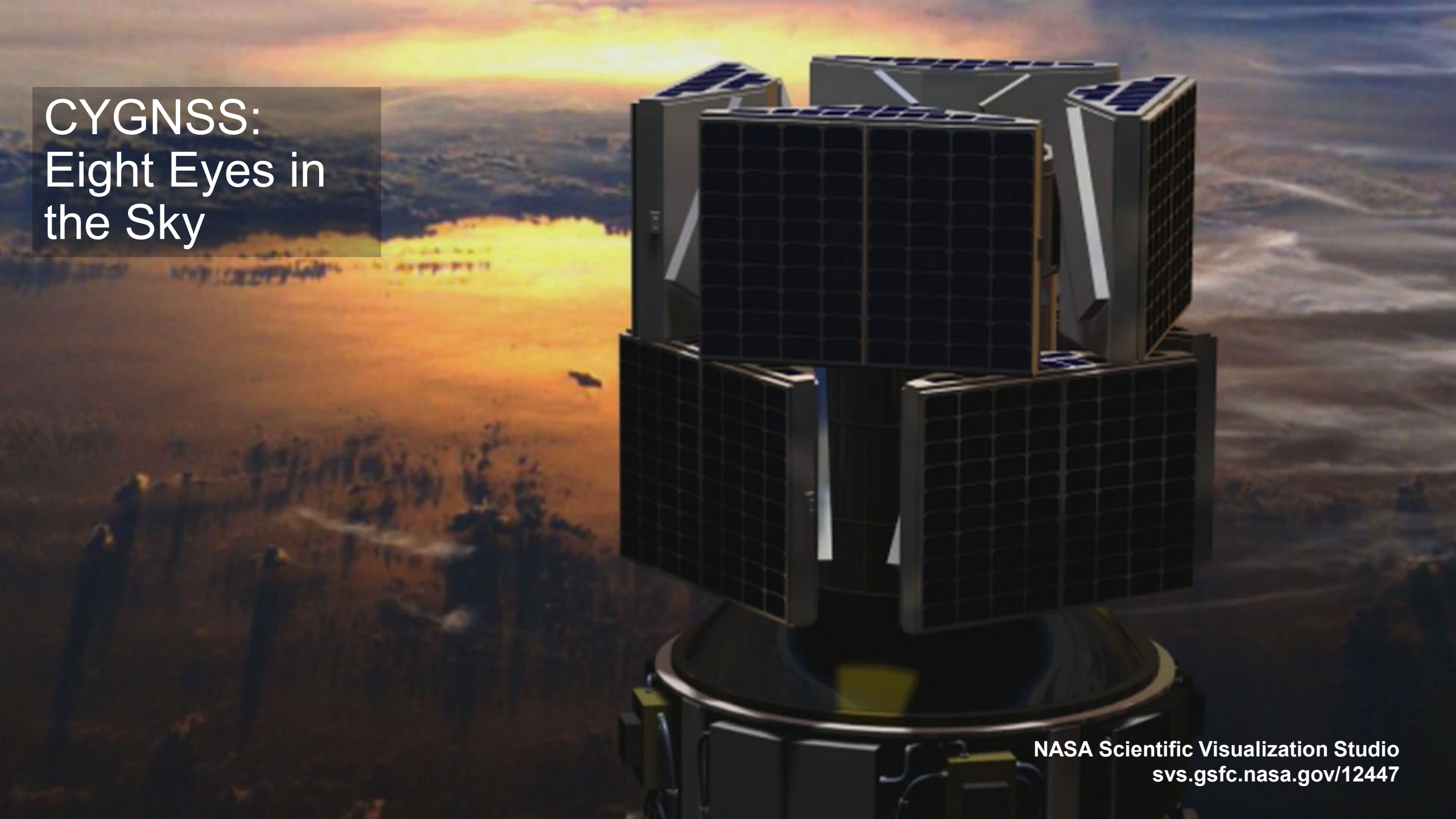
Small Innovative Missions for Planetary Exploration (SIMPLEx)

SmallSat/CubeSat commercial engagement opportunities are essential to NASA Science's balanced portfolio, achieving distinct science objectives

SMD SmallSat and CubeSat Programs

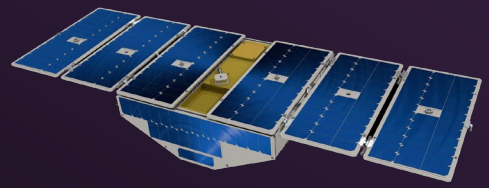
SMD Directorate	Funding Program: CubeSats	Example Missions: CubeSat	Funding Program: SmallSats	Example Missions: SmallSats
Astrophysics	APRA	SPRITE, BLACKCAT, CUTE, BURSTCUBE	PIONEERS	Starburst, Aspera, PANDORA
Astrophysics			Explorer Small Explorer (SMEX) Program	IXPE
Astrophysics			Explorer Medium Explorer (MIDEX) Program	SPHEREx
Earth Science	INVEST	ACMES, SNOOPI, HyTI, CTIM-FD, NACHOS, RainCube	Earth Venture / SMEX	CYGNSS, TROPICS, PREFIRE, INCUS, TEMPEST-D
Heliophysics	H-FORT	GTOSAT, AERO / VISTA, CURIE, REAL, CUSP	SIMPLEX-2 / SMEX / MIDEX	ESCAPADE
Heliophysics	Explorer Mission of Opportunity	SunRise, EZIE	SMEX	TRACERS, PUNCH
Heliophysics	MIDEX		STP Explorer Mission of Opportunity	GLIDE
Heliophysics			STP Explorer Mission of Opportunity	Solar Cruiser
Heliophysics			MIDEX	Helioswarm
Planetary Science	SIMPLEX-1	Q-PACE, LunaH-Map	SIMPLEX-2	JANUS
Exploration Science Strategy & Integration Office			SIMPLEX-2	Lunar Trailblazer

CYGNSS: Eight Eyes in the Sky

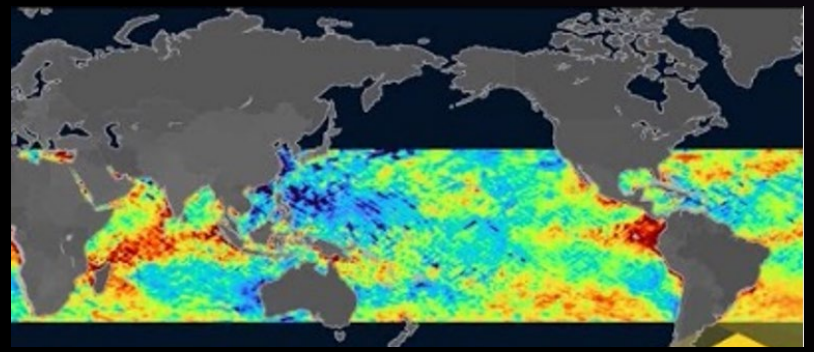


NASA Scientific Visualization Studio
svs.gsfc.nasa.gov/12447

CYGNSS Scientific Results and Applications



Observations of sources of ocean microplastic from space 2021

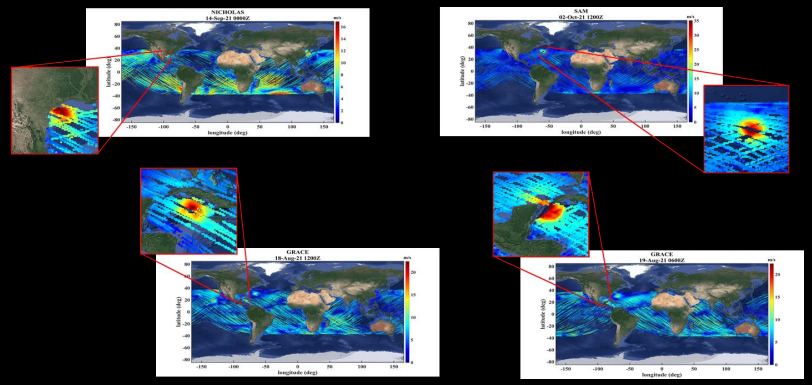


Map flood inundation after hurricane landfall

- Reflectivity before and after Hurricane Isaias landfall, July-August 2020

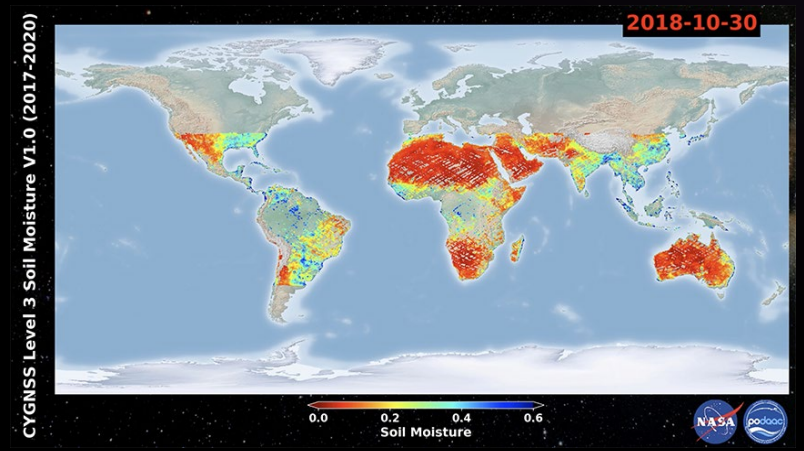
Measure winds in tropical cyclones

- CYGNSS L3 Merged Wind Speed Data Product - Nicholas, Sam and Grace (2021)



Daily soil moisture data product

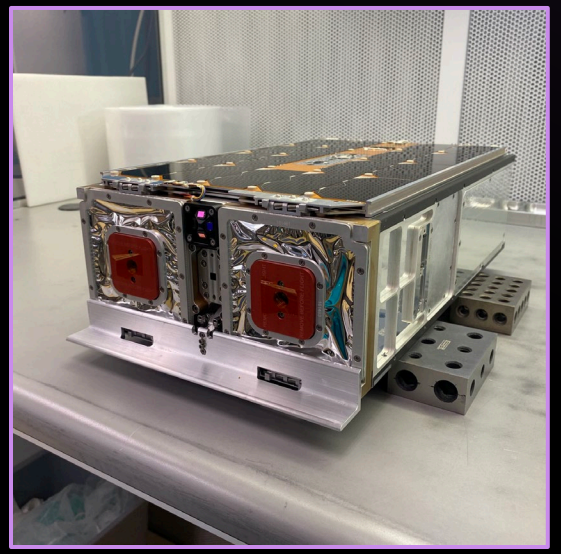
- Oct. 30, 2018



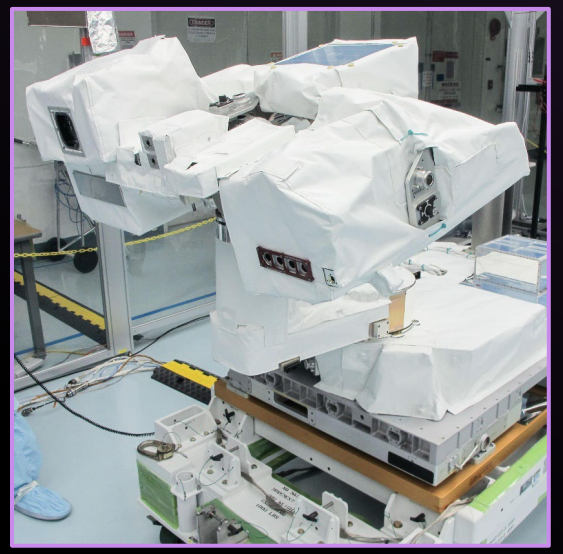
Compact Solar Irradiance Monitor-Flight Demo (CSIM-FD) / Compact Total Irradiance Monitor-Flight Demo (CTIM-FD)

Measures solar spectral irradiance (SSI), and monitoring Total Solar Irradiance (TSI) to explore how solar variability impacts the Earth's climate, contributing to long-term continuity measurements from TSIS SIM/TIM and SOURCE SIM/TIM

CSIM: 11kg CubeSat
- Built by LASP



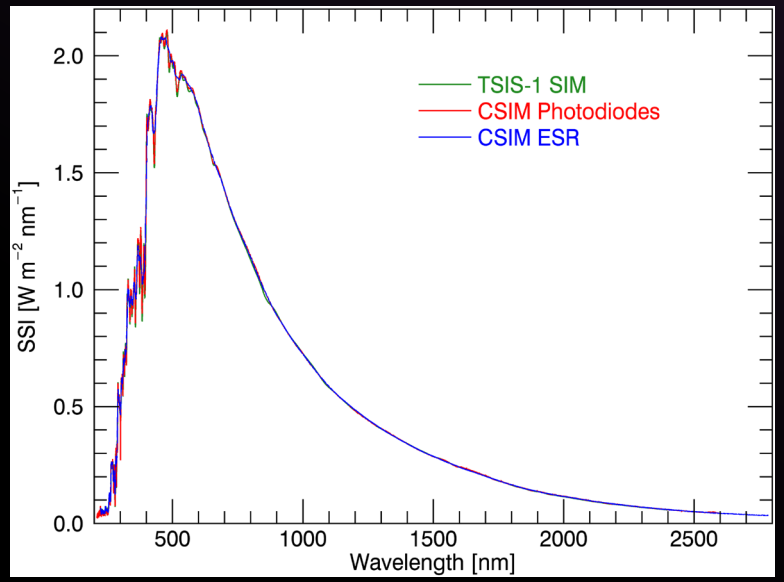
CTIM: 11kg CubeSat
- Built by LASP

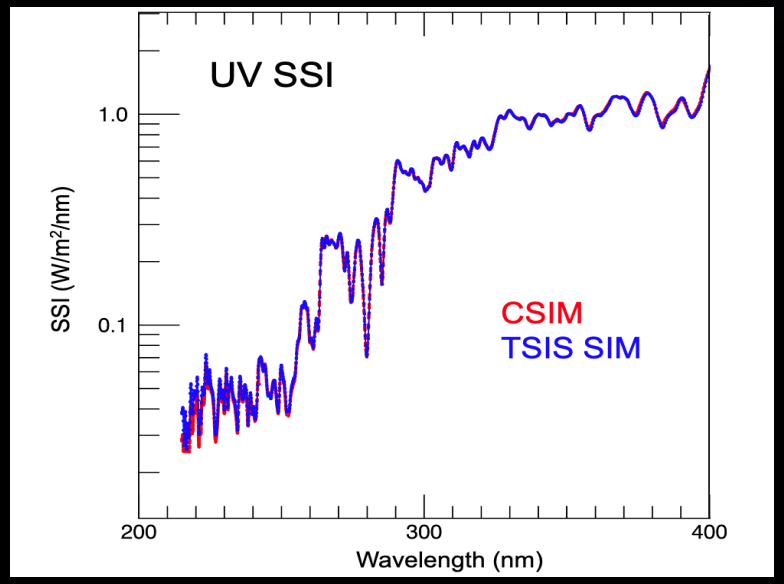


TSIS-1: 363kg
- Built by LASP
- Mounted to the ISS

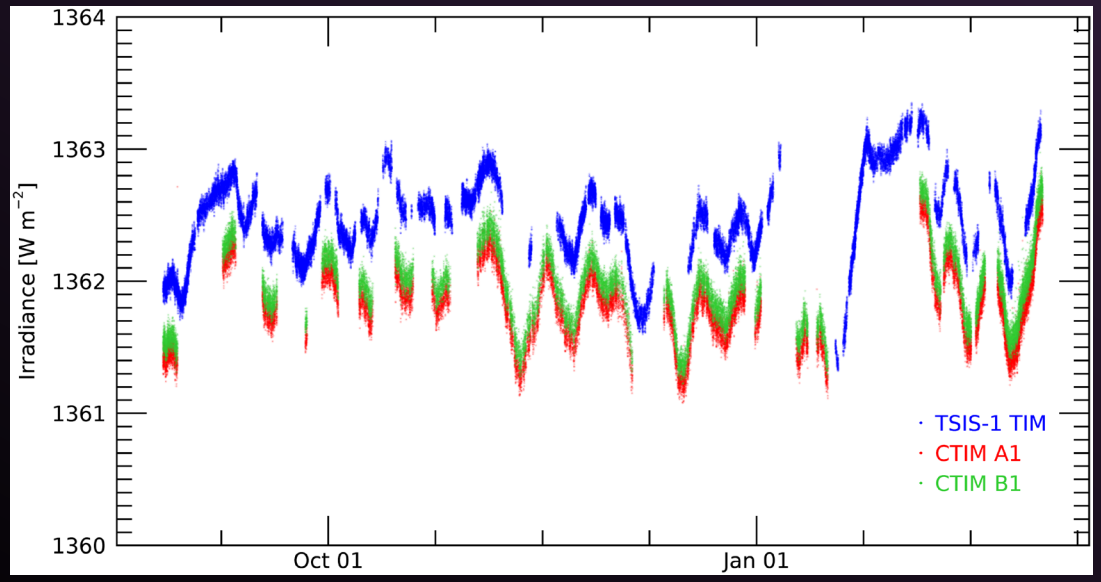
SORCE: 290kg
- On an Orbital LEOStar-2 bus

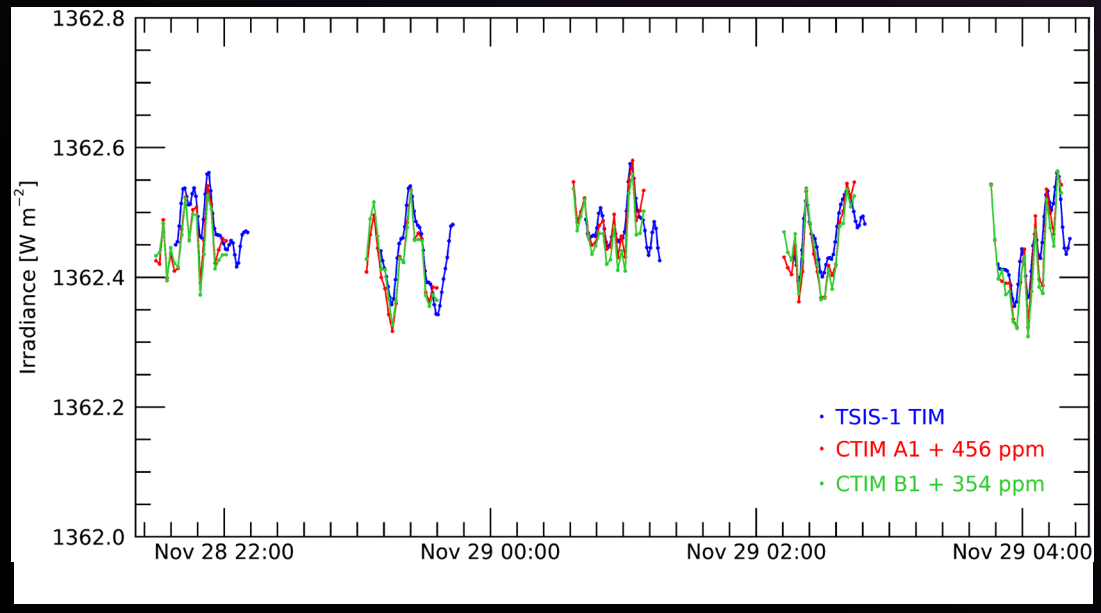
CSIM spectrum compared to TSIS spectrum





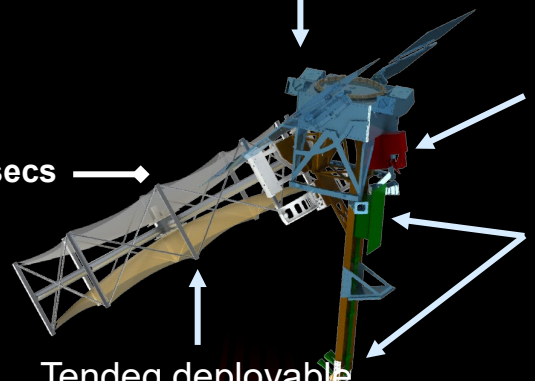
CTIM TSI measurements compared to TSIS TIM

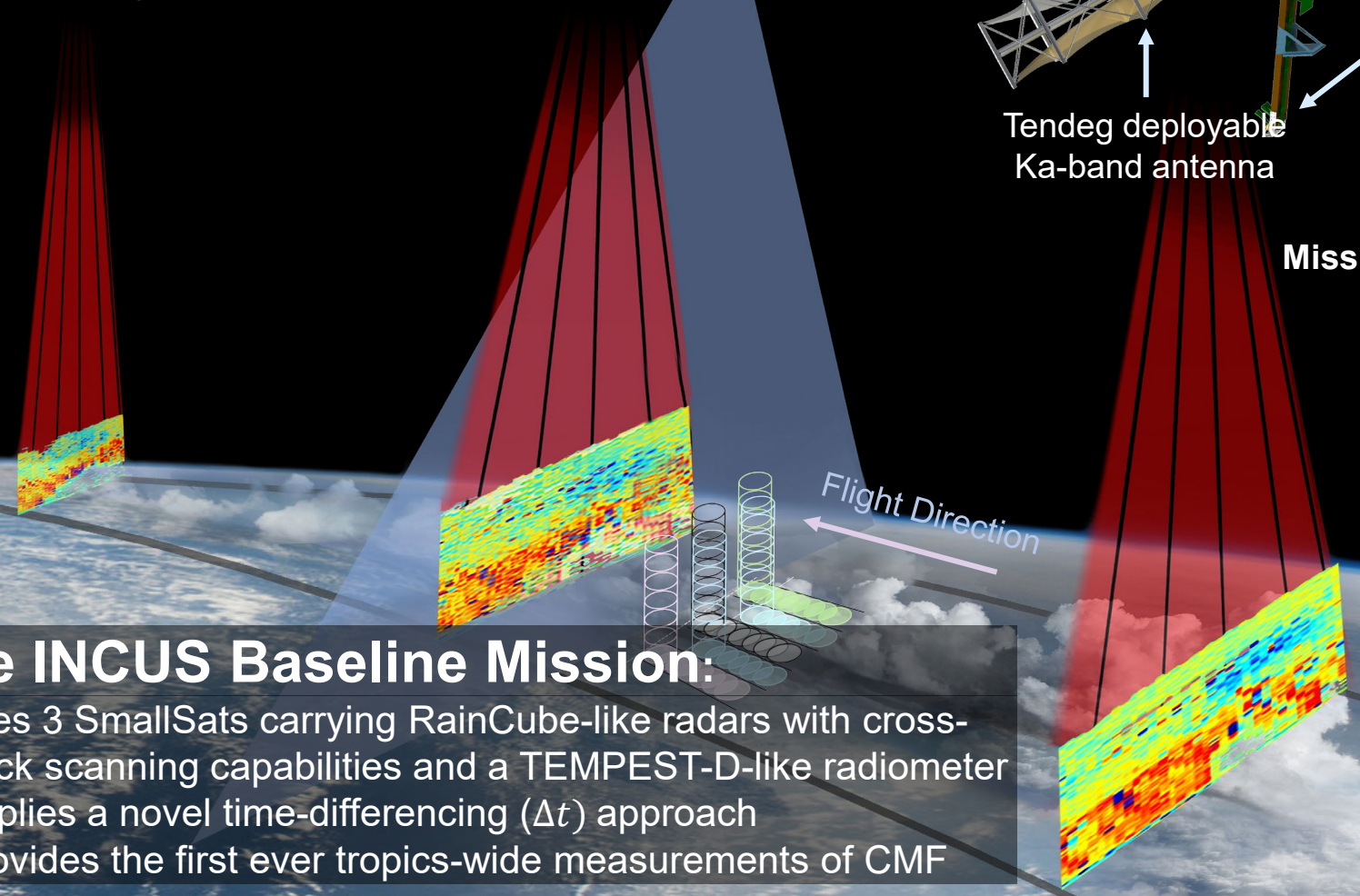




INCUS

Investigation of Convective Updrafts





PI: Susan van den Heever, CSU
Deputy PI: Ziad Haddad, JPL
Project Scientist: Simone Tanelli, JPL

Mission Management & Participating Organizations
CSU: PI Org, Science Data Processing
JPL: Instruments & Mission Management
Tendeg: Deployable Antennas
BCT: Spacecraft, Mission Ops
CCNY, GSFC, MSFC, NOAA, SBU, TAMU: Science Co-Is

Colorado State University

NASA Jet Propulsion Laboratory, California Institute of Technology

The INCUS Baseline Mission:

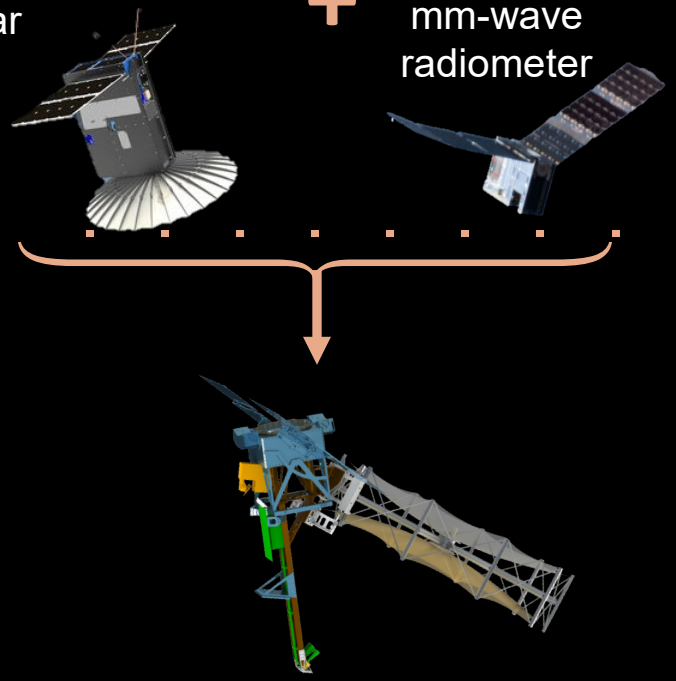
- Flies 3 SmallSats carrying RainCube-like radars with cross-track scanning capabilities and a TEMPEST-D-like radiometer
- Applies a novel time-differencing (Δt) approach
- Provides the first ever tropics-wide measurements of CMF

INCUS Goal:

To understand why, when, where tropical convective storms form, and why only some storms produce extreme weather.

INCUS

RainCube Ka-band radar + TEMPEST-D mm-wave radiometer

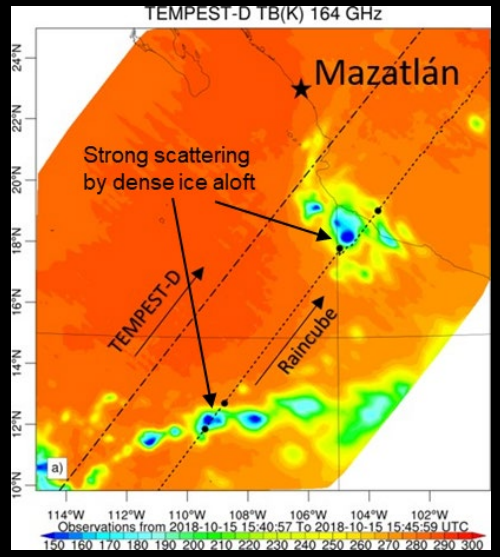


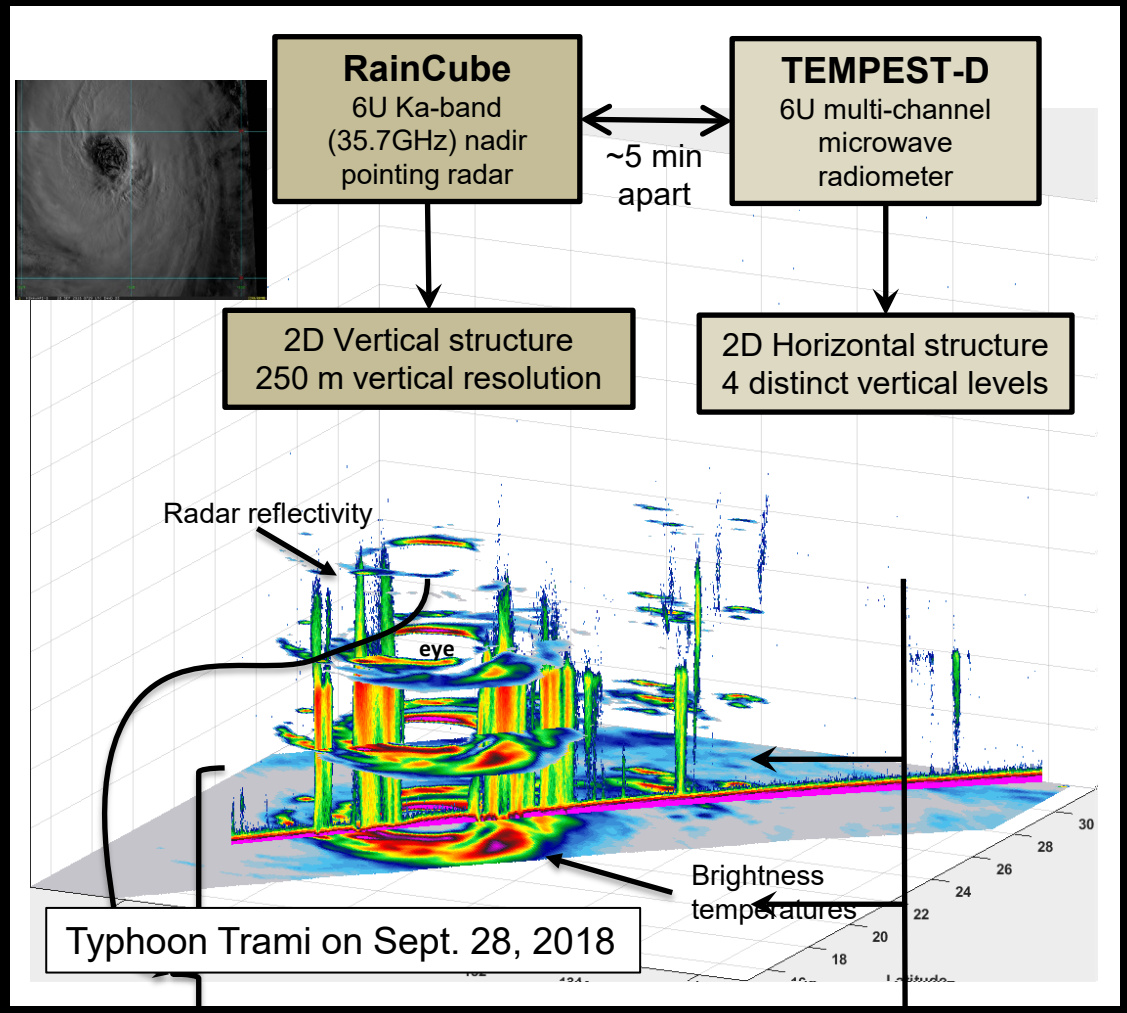
INCUS draws on the strengths of BOTH RainCube and TEMPEST-D to provide unprecedented vertical and horizontal views of storm structure and processes.

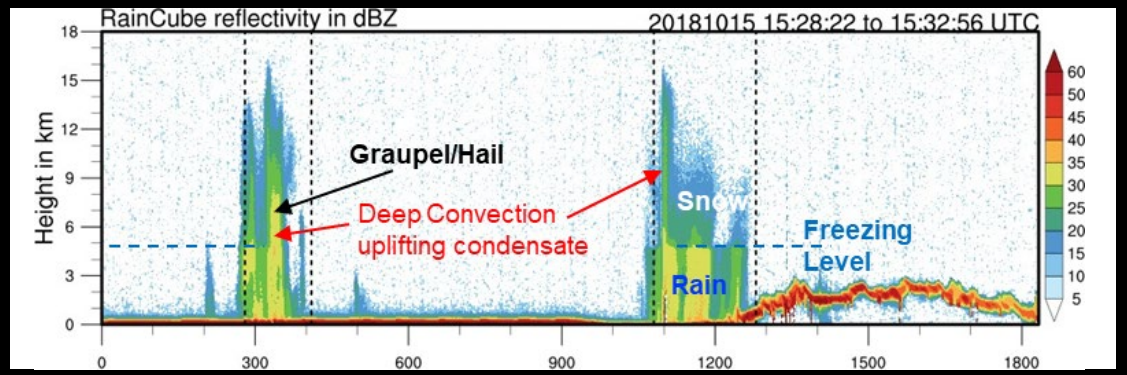
Figures and animations by Simone Tanelli, Shannon Brown and Steve Reising

(Right) On September 28, 2018, TEMPEST-D and RainCube overflew Typhoon Trami < 5 minutes apart

(Bottom) Correlated storm measurements from RainCube radar and TEMPEST-D radiometer over Texas, Mexico and Pacific Ocean







SunRISE

Sun Radio Interferometer Space Experiment

PI: Justin C. Kasper

U of Michigan

- Smallsat constellation acts as a single radio telescope to observe radio images of low-frequency solar activity blocked by Earth's atmosphere

Science Impact:

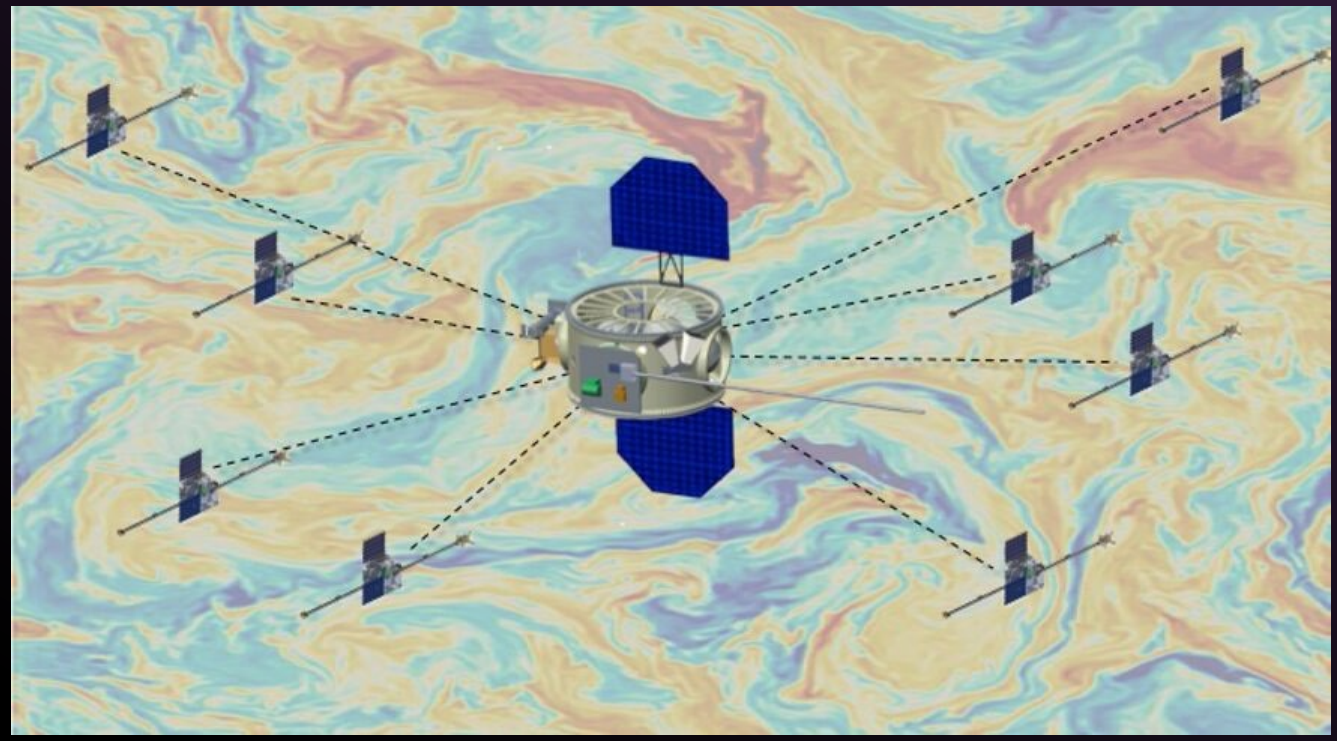
- Study how the Sun generates and releases solar radio bursts – eruptions of radio waves in the Sun's hot and magnetic atmosphere, the corona.
- Create detailed 3D maps of energetic radio emissions in the corona

Technology Impact:

- Six SmallSats operating together as one very large aperture radio telescope

HelioSwarm

- HelioSwarm mission will help improve our understanding of the dynamics of the Sun, the Sun-Earth connection, and the constantly changing space environment.
- Constellation or “swarm” of nine spacecraft that will capture the first multiscale in-space measurements of fluctuations in the magnetic field



SPORT

Science Goals

A science mission to understand the preconditions leading to equatorial plasma bubbles and scintillation

- What is the state of the ionosphere that gives rise to the growth of the plasma bubbles that extend into and above the F- peak at different longitudes?
- How are plasma irregularities at satellite altitudes related to the radio scintillations observed passing through these regions?

November 26, 2022

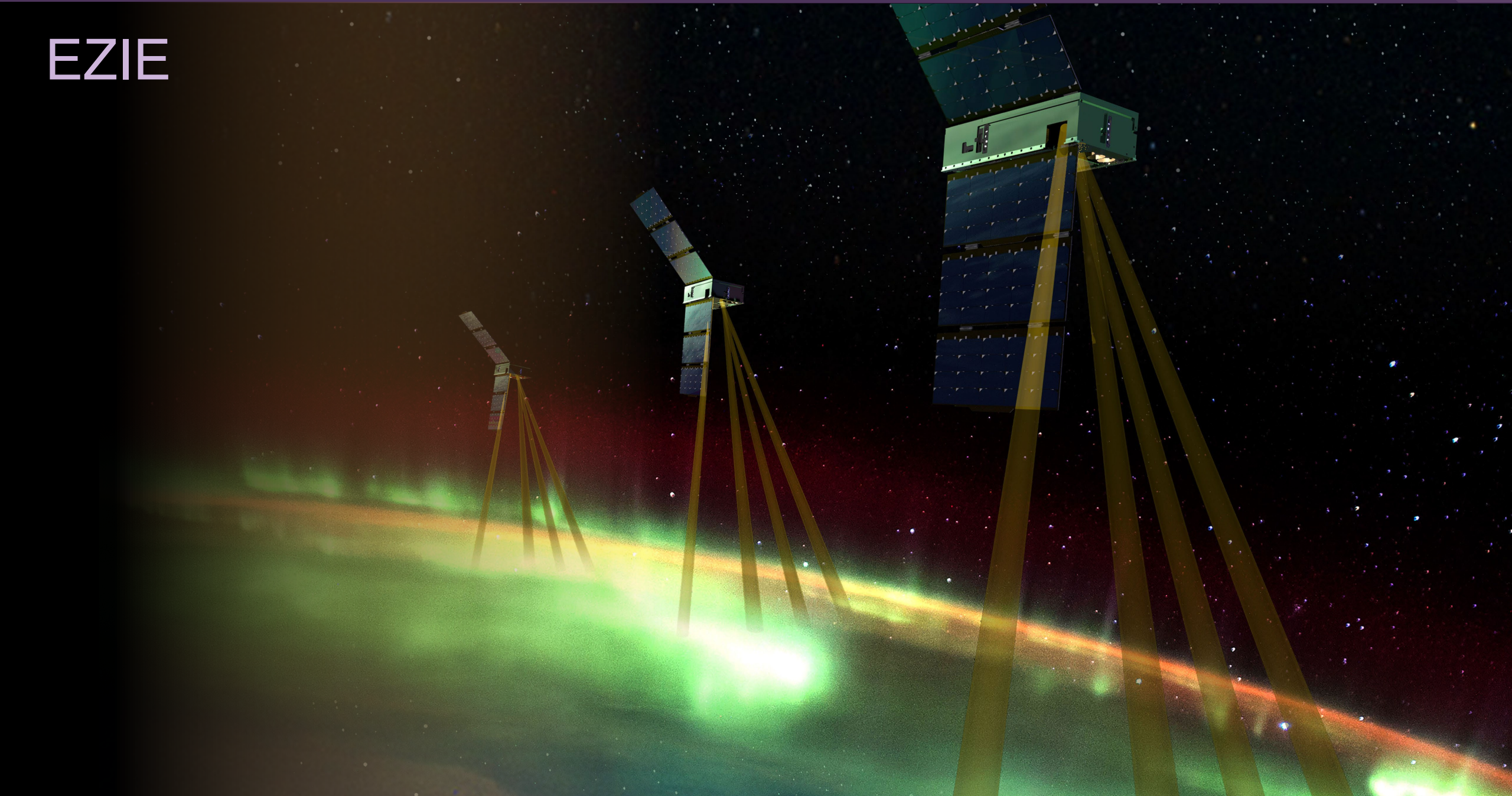
SPORT (Scintillation Prediction Observations Research Task) is a joint US/Brazil (NASA/AEB) mission. Brazil is providing CubeSat spacecraft and operations, US is providing instruments and launch.

petitSat

SPORT

December 29, 2022
Courtesy of NanoRacks and the ISS crew, especially Japanese astronaut asdl;jfasdjf

EZIE



EZIE-Mag

EZIE-Mag is a key component of the EZIE Outreach Program ready for launch in 2024

- Community development program designed using human centered design methodologies
- The EZIE Mag kit is a low-cost (~$200USD), science-quality magnetometer based on a single-board computer (SBC) that can be deployed anywhere
- The kits will form a global network of magnetometer data accessible through the EZIE-Mag Gateway (https://eziegw.jhuapl.edu/eziemag/)
- The kit will be open source, anyone can download the hardware designs and the operating software
- The program has been developed to build upon the success of the SuperMAG project and actively encourages international collaboration

Outcomes

- Create an international community of citizen scientists
- Inspire the next generation of scientists and engineers and grow a more diverse/inclusive workforce
- Promote cross-cultural understanding and greater social equity
- Provide a product, a program and a template for future missions

Small Spacecraft Technology – Capstone

The Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) is first U.S. commercial mission to the Moon and the first spacecraft to demonstrate the unique lunar orbit intended for NASA's Gateway. The 12U CubeSat was the first spacecraft to enter into this near rectilinear halo orbit (NRHO) and verify its dynamics.

Objectives

- Validate and demonstrate NRHO / three-body orbit Earth-Moon operations. ✓
- Inform future lunar exploration operations for the Artemis program and Gateway. ✓
- Demonstrate and accelerate infusion of the Cislunar Autonomous Positioning System (CAPS) and help lay a foundation for commercial support of missions beyond Earth.

Current Status

- Launched June 28, 2022
- Arrived in NRHO on November 13, 2022

Deliverables / Schedule

- Ongoing Crosslink Demonstrations with LRO
- End of Primary Mission: L+10 Months
- Potential Extended Mission

CAPSTONE Spacecraft

CAPSTONE 12U lunar CubeSat prior to shipping
Credit: *Terran Orbital Corporation*

ESCAPADE

ESCAPADE is comprised of two small ESPA Grande-class spacecraft

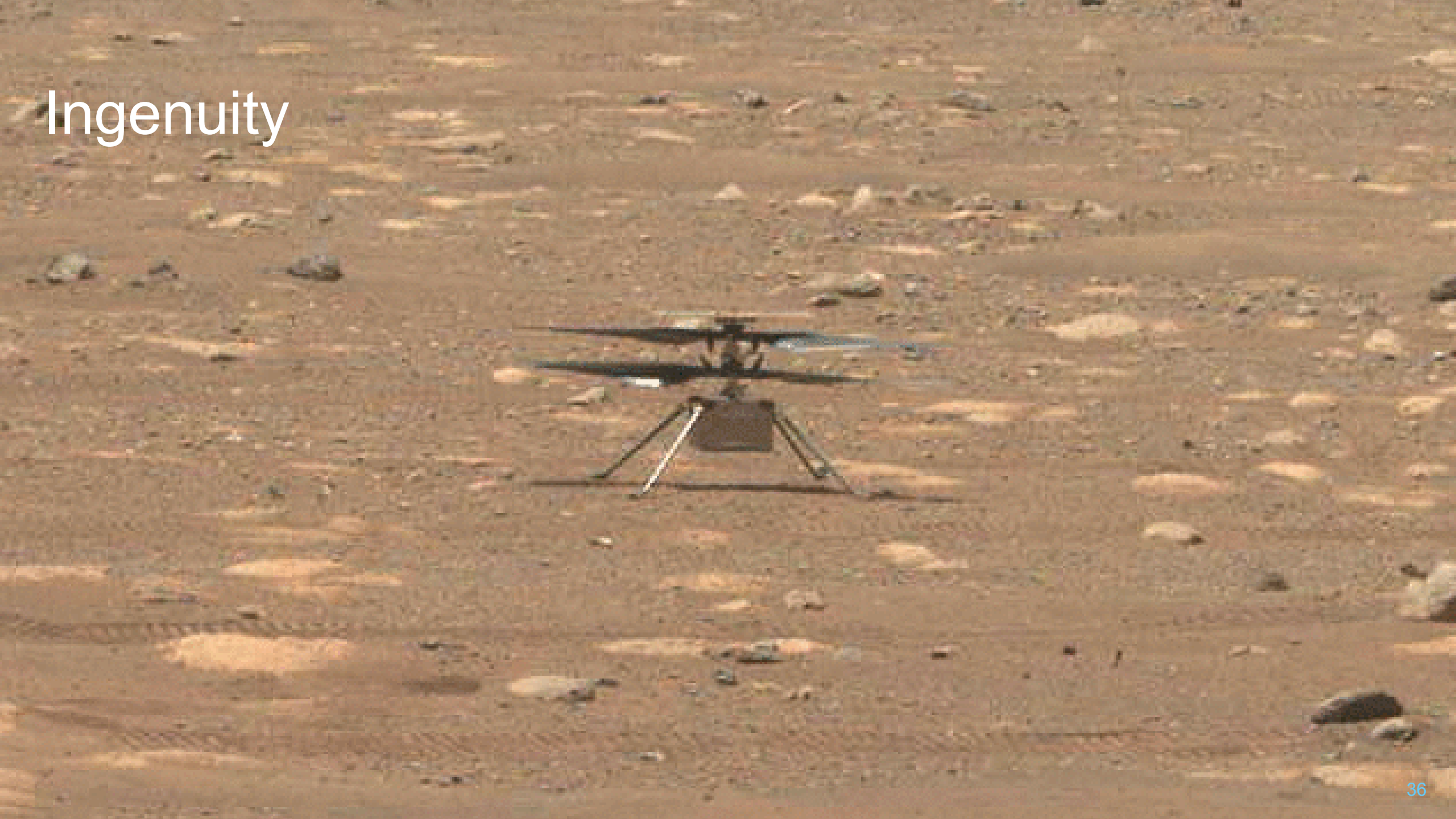
To be launched as secondary payloads on in 2024

Arrives at Mars science orbit April 2026 for 11-month science mission

Using instruments to measure magnetic fields, ions, and electrons, the ESCAPADE spacecraft will

- Analyze how Mars' magnetic field guides particle flows around the planet;
- Observe how energy and momentum are transported from the solar wind through Mars' magnetosphere;
- Study what processes control the flow of energy and matter into and out of the atmosphere.

Ingenuity



LICIACube

LICIACube was hosted as secondary spacecraft during DART's interplanetary cruise.

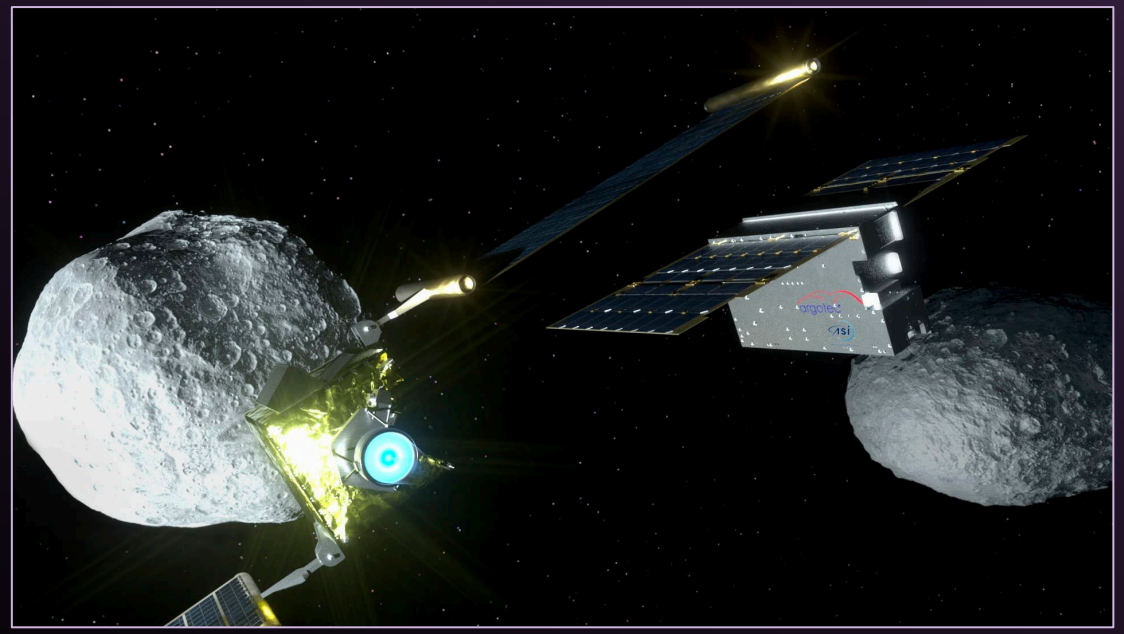
Released by its dispenser ~10 days before the impact

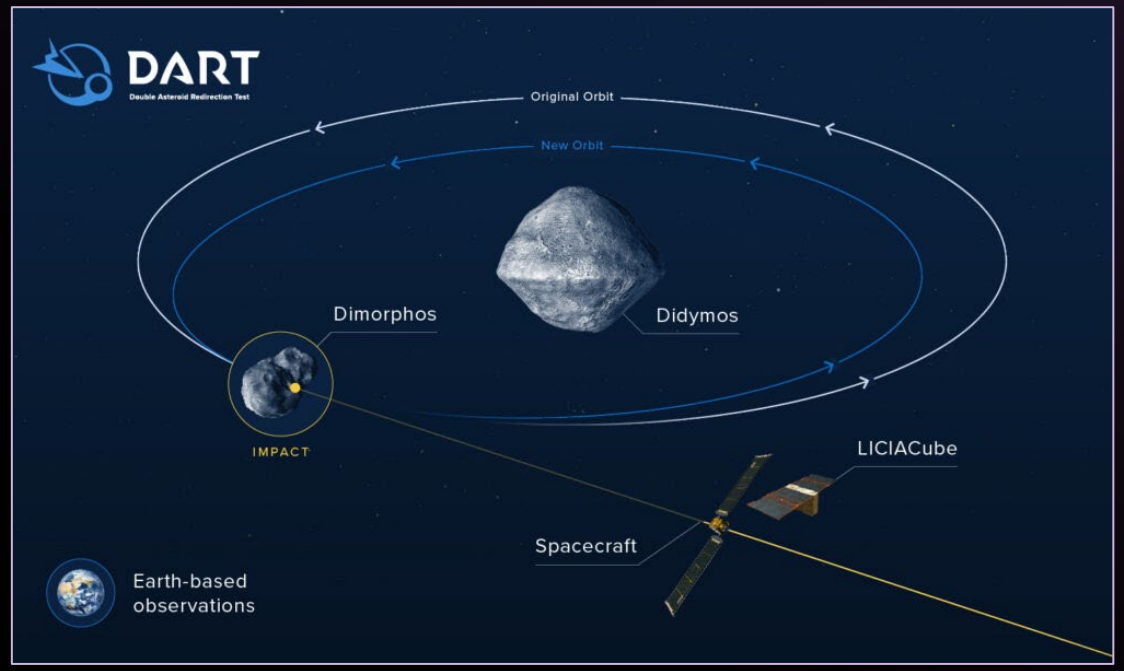
Goal:

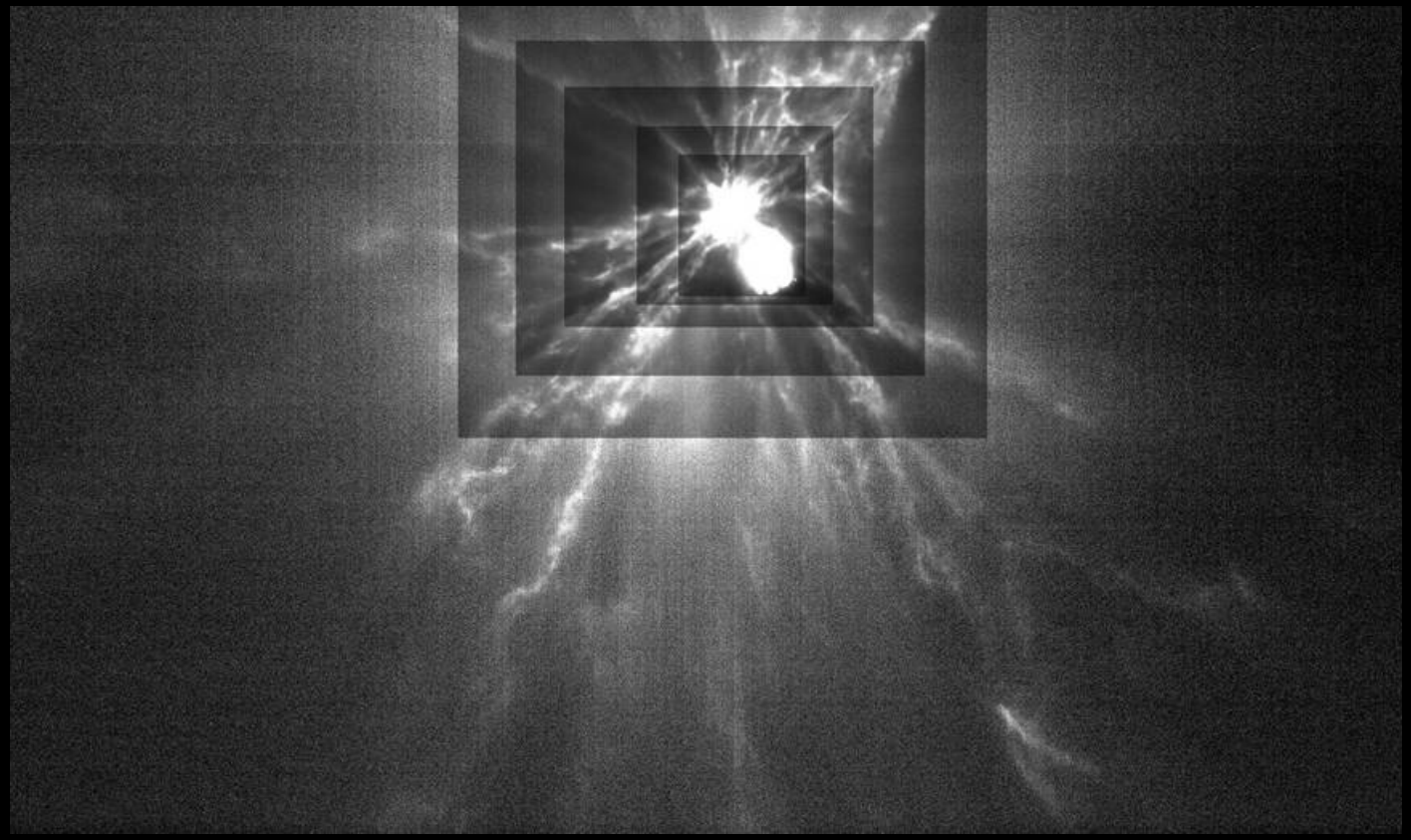
- Witness the DART impact on Dimorphos and acquire images of the target in the post-impact scenario.

Instruments:

- LEIA (LICIACube Explorer Imaging for Asteroid), a narrow field panchromatic camera to acquire images from long distance with a high spatial resolution.
- LUKE (LICIACube Unit Key Explorer), a wide field RGB camera, allowing a multicolor analysis of the asteroidal environment.







This image from ASI's LICIACube show the plumes of ejecta streaming from the Dimorphos asteroid after NASA's Double Asteroid Redirect Test, or DART, mission, made impact with it on Sept. 26, 2022. Each rectangle represents a different level of contrast in order to better see fine structure in the plumes. By studying these streams of material, we will be able to learn more about the asteroid and the impact process.

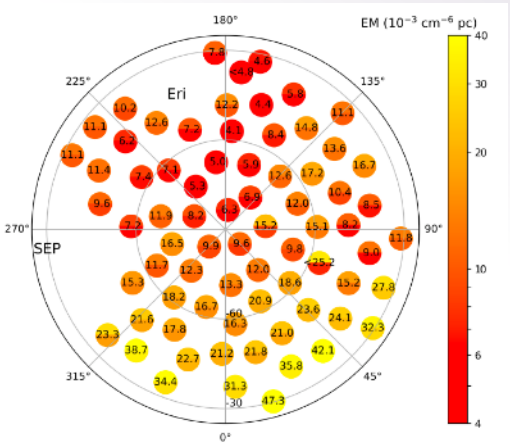
Credit: ASI/NASA/APL

ASI's LICIACube satellite acquired this image just after its closest approach to the Dimorphos asteroid, after the Double Asteroid Redirect Test, or DART mission, made impact on Sep. 26, 2022. In this image, it is possible to observe the Didymos and Dimorphos from a different perspective, which can be useful to determine the shapes of the asteroids.

Credit: ASI/NASA

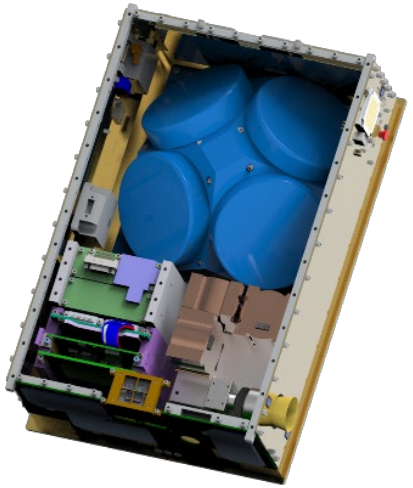
Astrophysics CubeSats

Solicited annually in ROSES/APRA, ~1 new start per year, ~<$5M each total cost

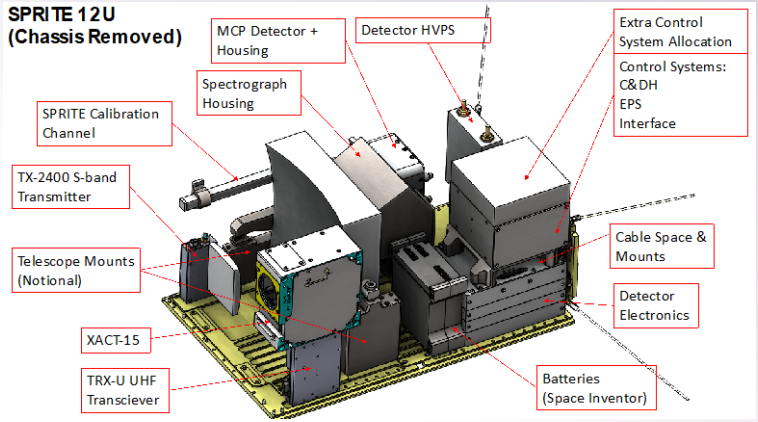


HaloSat:
PI Phil Kaaret (U of Iowa),
Launch May 2018,
Reentered Jan 2021,
OVII/OVIII lines in Galaxy halo, determine mass and structure of Galaxy halo

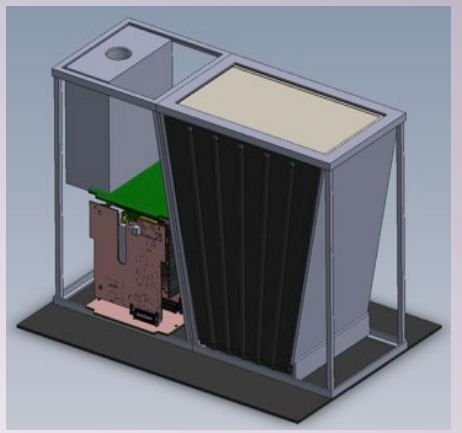
CUTE:
PI Kevin France (CU),
Launch Sep 2021,
UV Imaging of hot Jupiter ablation,
(Arika Egan & Ambily Suresh in lab)



BurstCube:
PI Jeremy Perkins (NASA GSFC),
Launch NET Dec 2021,
GRB monitor w/ TDRSS real-time event notification



SPRITE:
PI Brian Fleming (CU),
Launch NET Jan 2023,
UV spectra of ionizing radiation from star forming galaxies



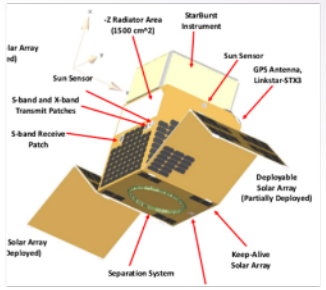
BlackCat:
PI Abe Falcone (Penn St U),
Launch NET Mar 2024,
2-20 KeV wide FOV localization of X-ray transients, real-time ‘cell phone’ downlink

Astrophysics Pioneers

- A new class of small missions solicited annually. Includes SmallSats, CubeSats >6U, major balloon payloads, modest ISS attached payloads, and cis-lunar payloads; $20M maximum PI cost cap
- Fills in the gap between existing investigations (<$10M for Astrophysics Research and Analysis program) and existing Explorers Missions of Opportunity investigations (~$35M for SmallSats)
  - 2020: 24 Proposals, 4 selected, all 4 passed gate review
  - 2021: 18 proposals received, review completed, selections soon
  - 2022: proposals due March 16, 2023

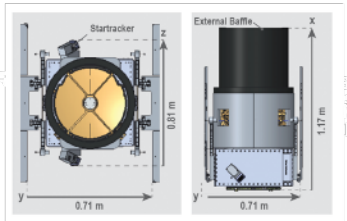
Astrophysics Pioneers – Cycle 1 Selections

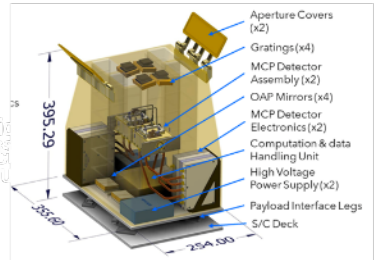
PUEO: A Long-duration Balloon-borne Instrument for Particle Astrophysics at the Highest Energies (PI Abigail Vieregg, U. Chicago) APPROVED for DEVELOPMENT



StarBurst: Gamma-ray ASM, Simultaneous detection of NS/NS mergers with LIGO (PI Daniel Kocevski, NASA MSFC) APPROVED for DEVELOPMENT

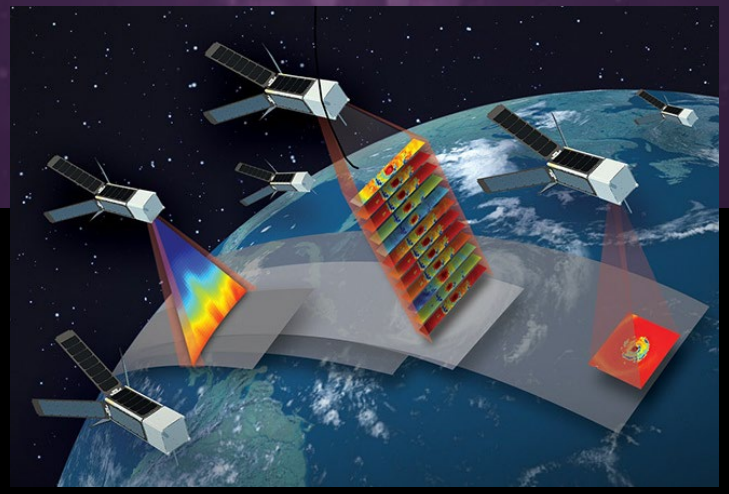
Pandora: Multiwavelength Characterization of Exoplanets and their Host Stars (PI Elisa Quintana, NASA GSFC) APPROVED for DEVELOPMENT





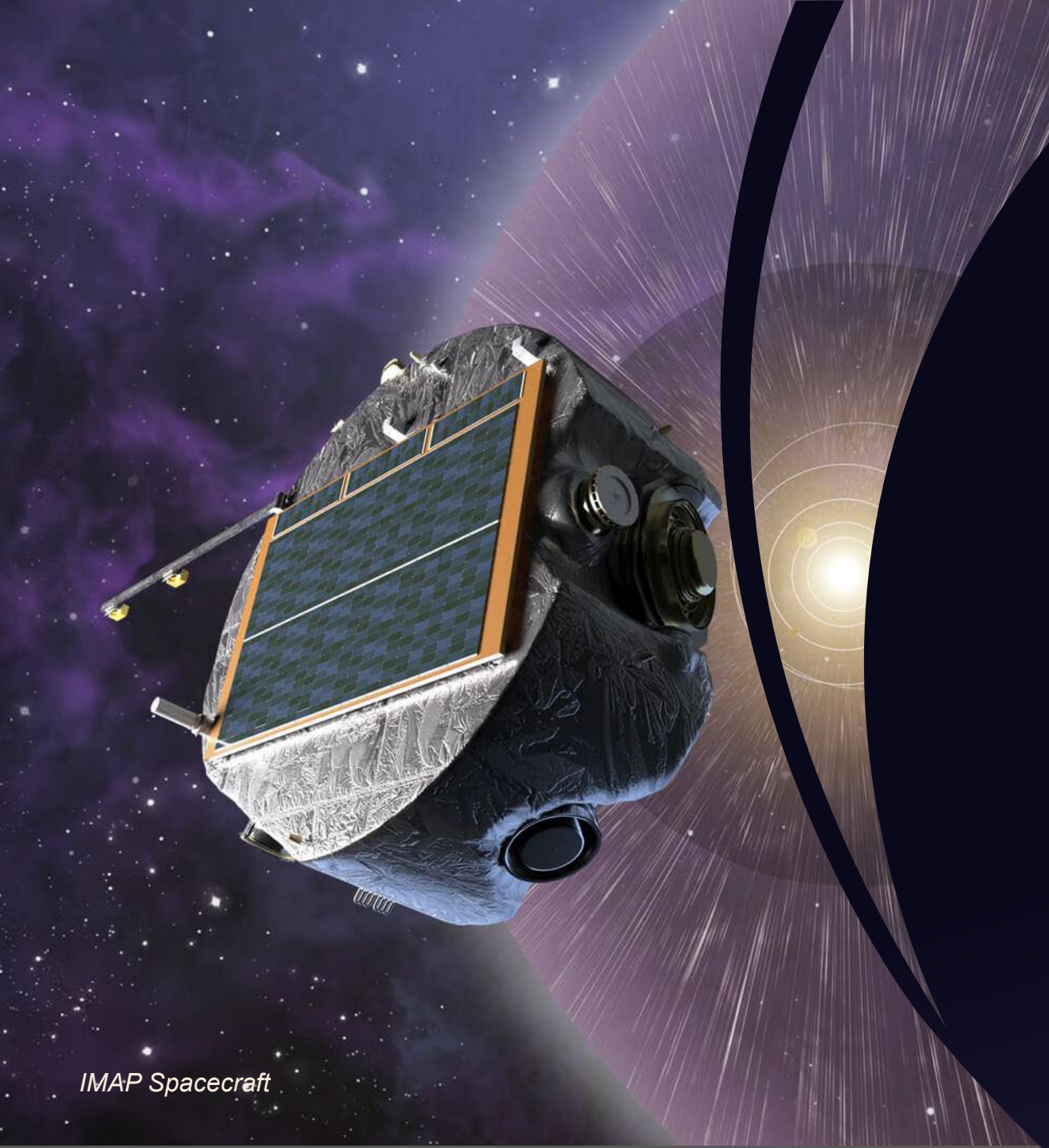
Aspera: IGM Inflow/outflow from galaxies via OVI 10^5K emission line imaging (PI Carlos Vargas, U. Arizona) APPROVED for DEVELOPMENT

SCIENCE MISSION DIRECTORATE (SMD) & CUBESAT/SMALLSAT OVERVIEW



CUBESAT/SMALLSAT PROGRAM REVIEWS & HIGHLIGHTS

MISSION STRATEGY & OPPORTUNITES



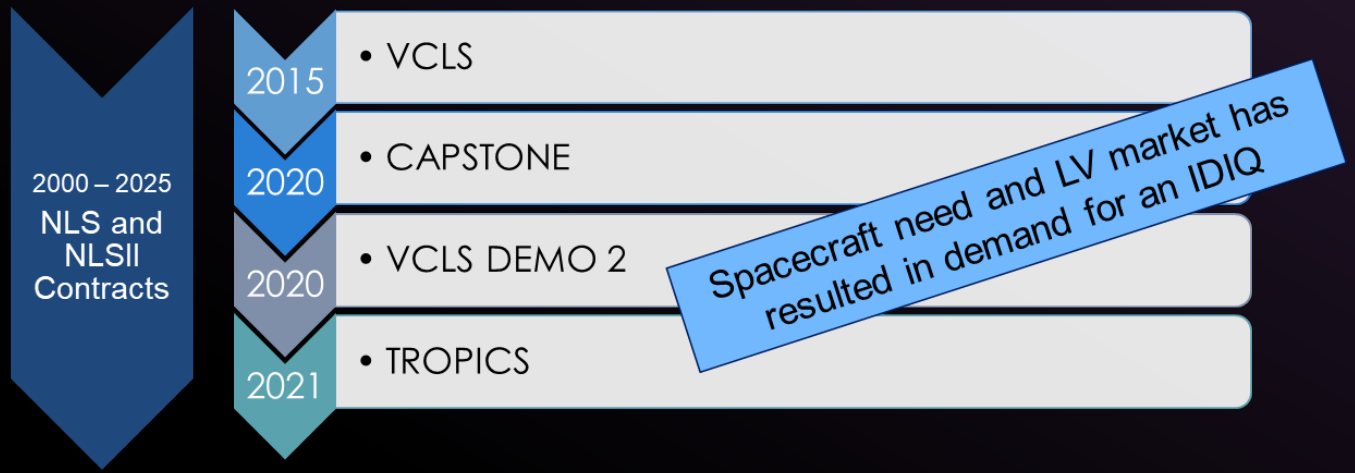
IMAP Spacecraft

SMD Rideshare Strategy

Access to Space For SmallSats on ESPA-Rings

- **SPD-32 Policy Impacts**
- NASA's Science Mission Directorate (SMD) Rideshare Policy SPD-32 provides ESPA-rings for SmallSats to utilize excess lift capacity on SMD-procured launch vehicles
- The SMD Rideshare Office manages SPD-32 implementation
- The Carruthers selection was assigned to the IMAP mission launch vehicle under the SPD-32 policy
- SMD's rideshare strategy has accelerated the frequency and diversity of science returned while maximizing launch vehicle performance

Venture-Class Acquisition of Dedicated and Rideshare (VADR)



- New Contract Structure to foster the vibrant launch vehicle market for higher risk missions
- Ability to access and on-ramp multiple providers and launch vehicles for our missions
- Launches under the VADR contract will align with commercial practices to achieve lower launch costs

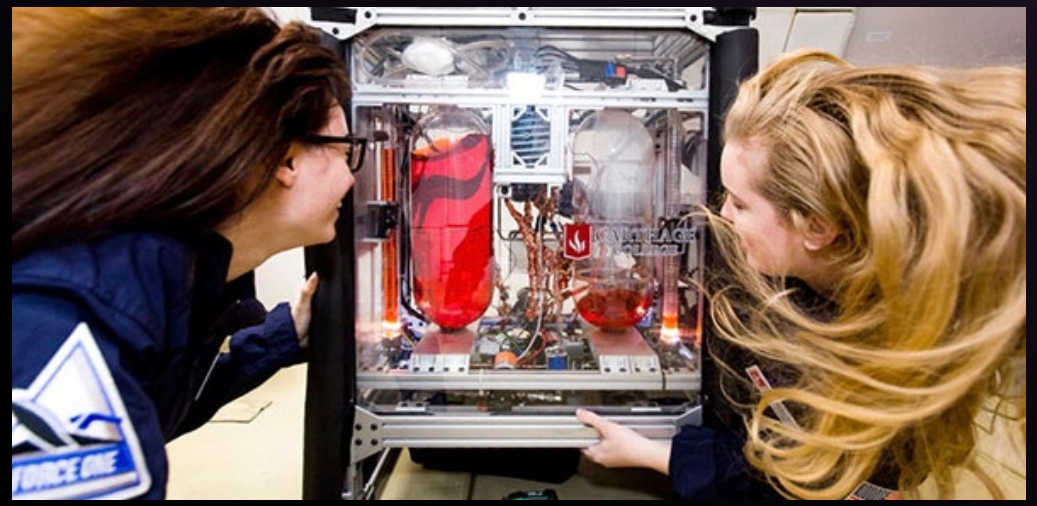
CubeSat Launch Initiative (CSLI)

NASA's CubeSat Launch Initiative (CSLI) provides launch opportunities to a variety of U.S. CubeSat developers who build small satellite payloads that fly as auxiliary payloads on previously planned launches or commercial missions to low Earth orbit and deep space destinations as well as International Space Station deployments.

https://www.nasa.gov/content/about-cubesat-launch-initiative

Flight Opportunities Mission

The Flight Opportunities program facilitates **rapid demonstration** of technologies for space exploration, discovery, and the expansion of space commerce through **suborbital testing with industry flight providers**.



www.nasa.gov/directorates/spacetech/flightopportunities

Space Technology Mission Directorate: Flight Opportunities

NASA TECHFLIGHTS

Includes topic areas that address agency and mission goals; up to $750K to purchase flights on suborbital or hosted orbital platforms directly from any eligible U.S. commercial flight provider

NASA TechLeap PRIZE

Challenges addressing specific NASA technology needs; previous awards have been up to $650K to build payloads, plus access to a suborbital flight test

NASA TECHRISE STUDENT CHALLENGE

Competition to inspire the next generation of space researchers; offers hands-on insight into the design and test process used by NASA-supported researchers

FLIGHTS OF OPPORTUNITY

Through collaborative internal and external relationships, the program takes advantage of opportunities to flight test valuable space technologies

Agency Initiatives

To increase access to test opportunities in relevant environments, Flight Opportunities collaborates with other NASA initiatives like **SMD's ROSES and SOMD's SubC** to help them leverage the commercial flight ecosystem

Flights of Opportunity Examples:

- In-Space Manufacturing/ ISS Program Office
- SBIR/STTR
- Intergovernmental support (Department of Defense, USDA)
- TechFlights Reflights

Small Spacecraft Systems Virtual Institute (S3VI)

The Small Spacecraft Systems Virtual Institute (S3VI) is chartered to perform the following:

- Establish effective conduits for collaboration and the dissemination of information to increase overall awareness of NASA small spacecraft programs, opportunities and activities;
- Capture and share best practices, emerging technology opportunities, and data; facilitate and execute special studies; and
- Conduct external workshops and public events to share mission-enabling information with the small spacecraft community.

PSYCHE

Challenges

Increasing popularity on LEO destinations

Orbital Debris

Spectrum Licensing

Cybersecurity

Access to space to the “hard” destination Secondaries are beholden to primary’s launch schedule, cleanliness, C3 e.g. Janus targets not accessible because Psyche delayed

Supply Chain issues

subsystems and parts

Training the next generation

Reliability of key components

especially deep space, GEO, cis-lunar

Lessons Learned for mission success

- **Active management** of gate reviews, adequate staffing, robust documentation process, and proper funding levels, experience mentors essential to provide guidance for Test Planning and Good systems engineering are keys to mission success, provide effective balance of insight vs oversight, flexibility in baseline vs threshold requirements
- **Access to Space policies** provide rapid access to space
- **Coordination of Intentional investments** in key low SWaP technologies accelerate science discoveries with SmallSats
- **Community of Practice** to build a robust and vibrant community of SmallSat practitioners to keep abreast of industry services/offerings for science investigations and technology demonstrations
- **Supportive policies** to provide "**institutional scaffolding**" such as policy guidance on spectrum licensing, conjunction analysis, cybersecurity planning are critical for small teams

The Future is Bright with SmallSats

SmallSats are now an integral part of NASA science strategy

"Destination drives the Science" and the "Science determines the platforms"

We continue to invest in technologies and partner with industry to develop reliable flight systems while maintaining a culture of innovation

SmallSats is a a way of growing science community and is an innovation that broadens thought horizons of the science community


EXPLORE
With Us

Backup