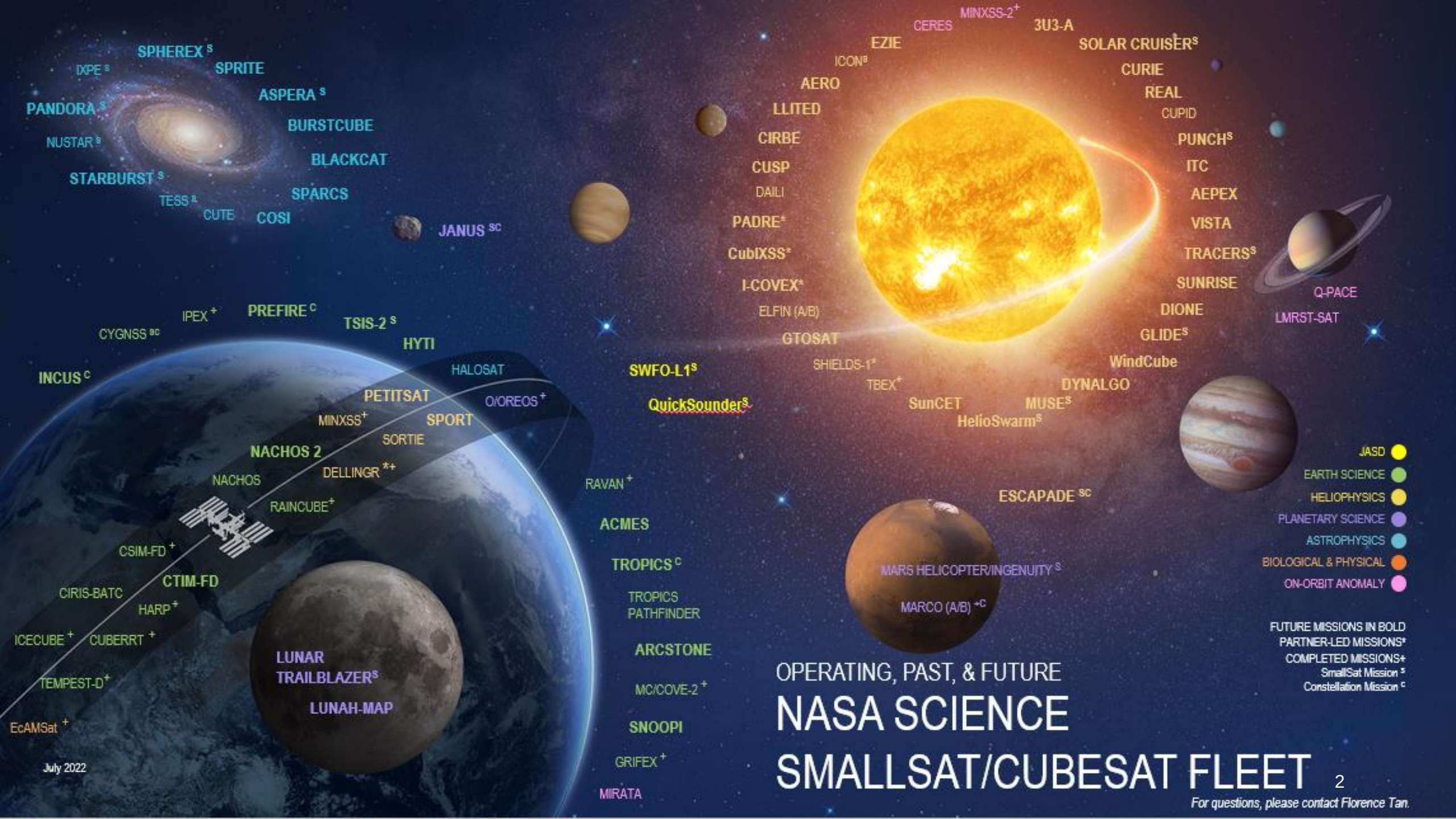


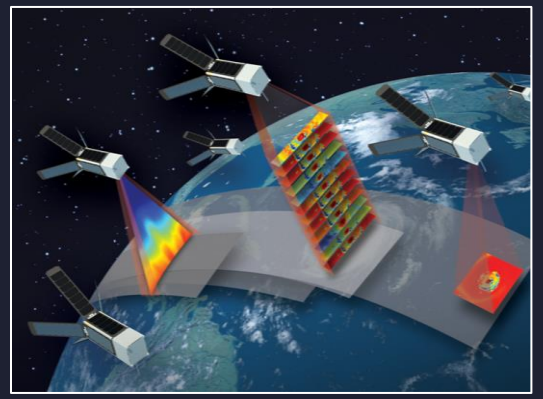
NASA Innovative Science SmallSat Missions

Florence Tan
Deputy Chief Technologist
Science Mission Directorate (SMD)
Chair, Small Spacecraft Coordination Group
NASA Headquarters
May 2022


SPHEREX S
IXPE S
SPRITE
ASPERA S
PANDORA S
BURSTCUBE
NUSTAR S
BLACKCAT
STARBURST S
SPARCS
TESS S
CUTE
COSI
JANUS SC
IPEX +
PREFIRE C
CYGNSS SC
TSIS-2 S
HYTI
INCUS C
HALOSAT
PETITSAT
O/OREOS +
MINXSS+
SPORT
SORTIE
NACHOS 2
DELLINGR *+
NACHOS
RAINCUBE+
CSIM-FD +
CTIM-FD
CIRIS-BATC
HARP +
ICECUBE +
CUBERRT +
TEMPEST-D+
EcAMSat +
LUNAR TRAILBLAZER S
LUNAH-MAP
July 2022
RAVAN +
ACMES
TROPICS C
TROPICS PATHFINDER
ARCSTONE
MC/COVE-2 +
SNOOPI
GRIFEX +
MIRATA
MINXSS-2+
CERES
3U3-A
EZIE
SOLAR CRUISER S
ICON S
CURIE
AERO
REAL
LLITED
CUPID
CIRBE
PUNCH S
CUSP
ITC
DAILI
AEPEX
PADRE*
VISTA
CubIXSS*
TRACERS S
I-COVEX*
SUNRISE
ELFIN (A/B)
Q-PACE
DIONE
LMRST-SAT
GTOSAT
GLIDE S
SHIELDS-1*
WindCube
SWFO-L1 S
TBEX+
DYNALGO
QuickSounder S
SunCET
MUSE S
HelioSwarm S
ESCAPADE SC
MARS HELICOPTER/INGENUITY S
MARCO (A/B) +C
JASD
EARTH SCIENCE
HELIOPHYSICS
PLANETARY SCIENCE
ASTROPHYSICS
BIOLOGICAL & PHYSICAL
ON-ORBIT ANOMALY
FUTURE MISSIONS IN BOLD
PARTNER-LED MISSIONS*
COMPLETED MISSIONS+
SmallSat Mission S
Constellation Mission C
OPERATING, PAST, & FUTURE
NASA SCIENCE
SMALLSAT/CUBESAT FLEET
For questions, please contact Florence Tan.

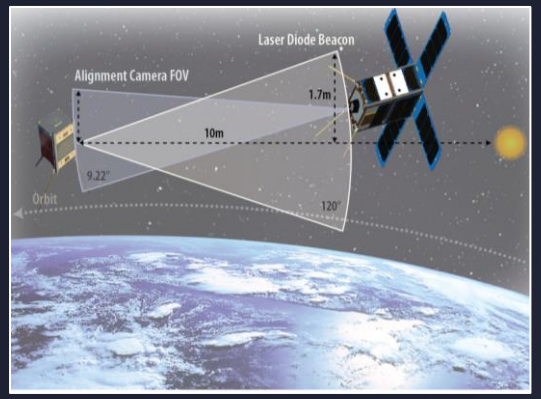
SmallSat Program Opportunities

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)

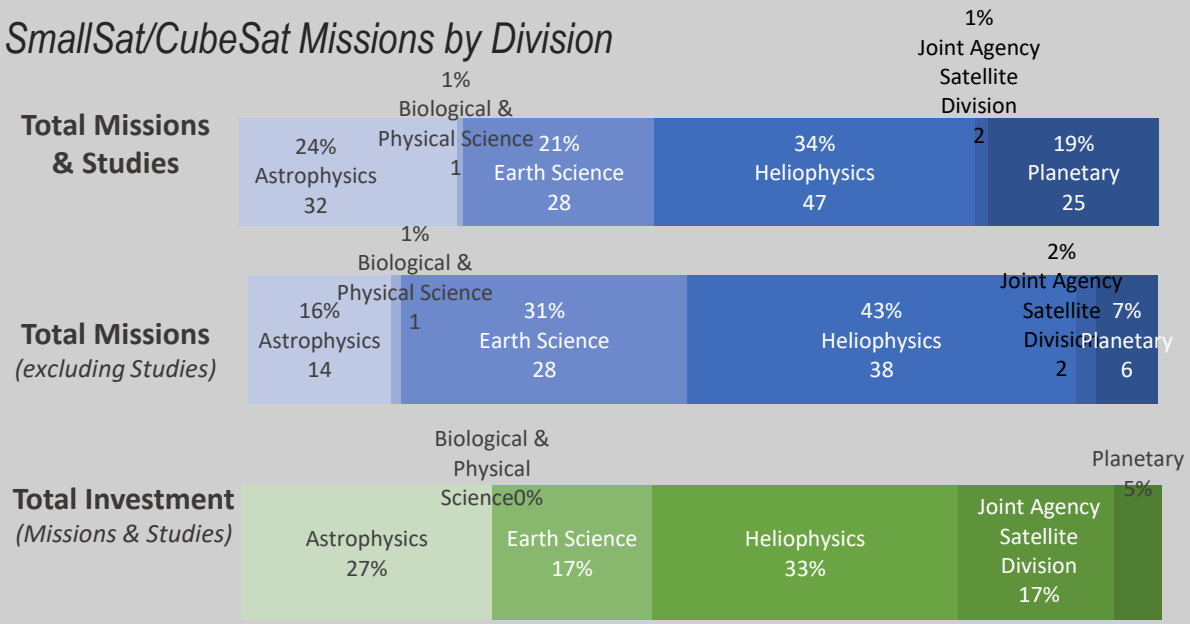
SmallSat/CubeSat commercial engagement opportunities are essential to NASA Science's balanced portfolio, achieving distinct science objectives

NASA's Science SmallSat Missions at a Glance

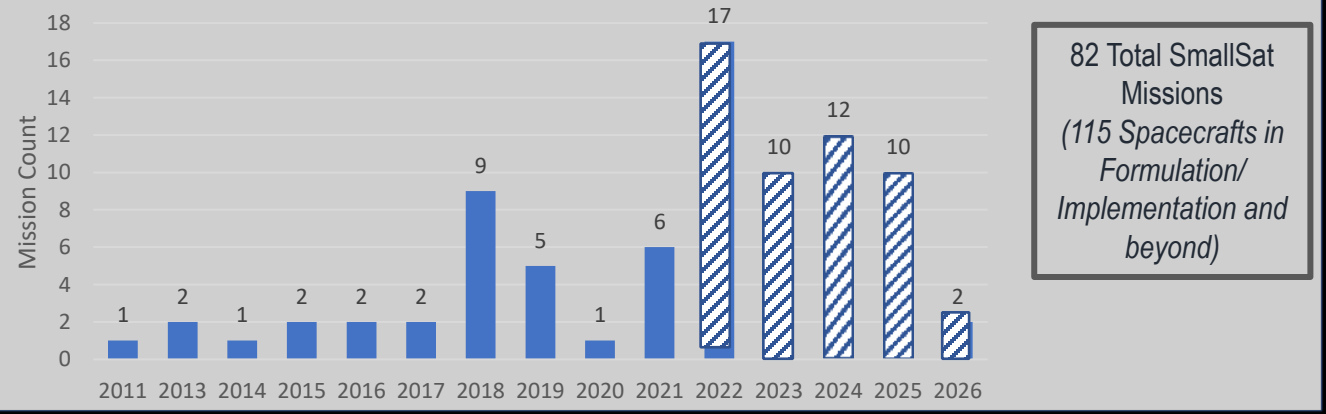
Inclusive Missions and Studies

Data as of July 12 2022

SmallSat/CubeSat Missions by Division

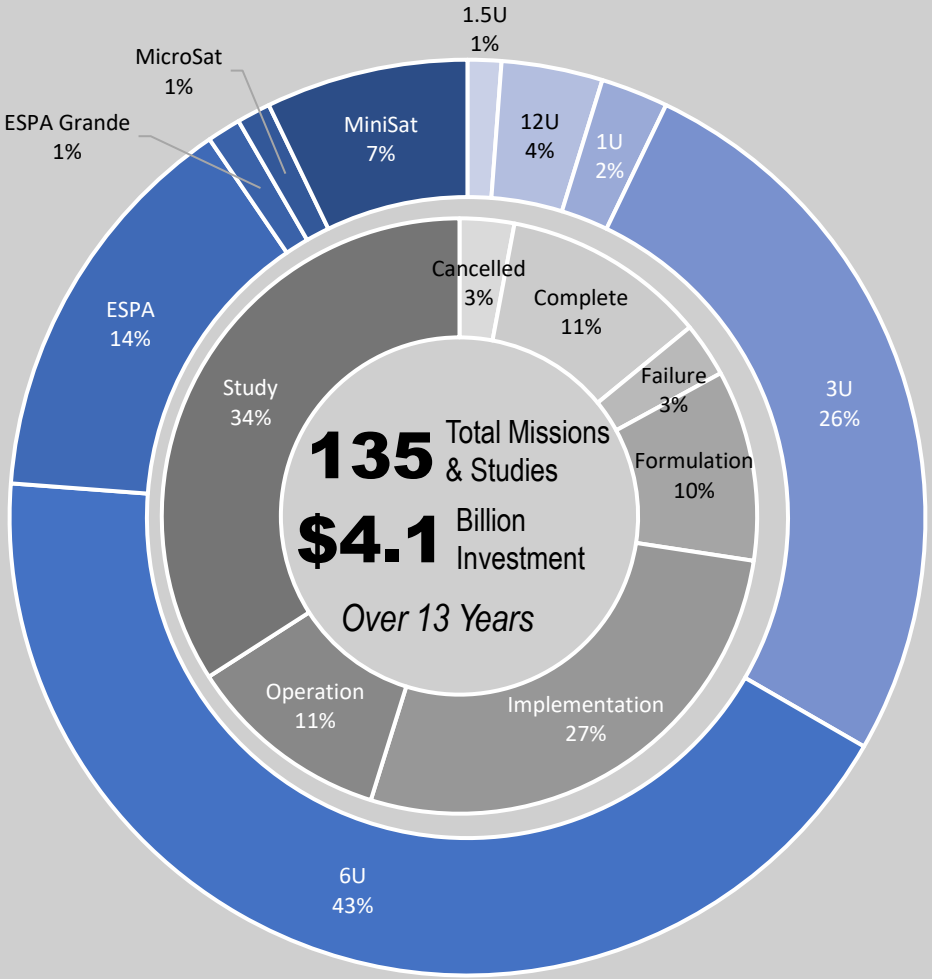


NASA Science SmallSat & Cubesat Launches Per Year



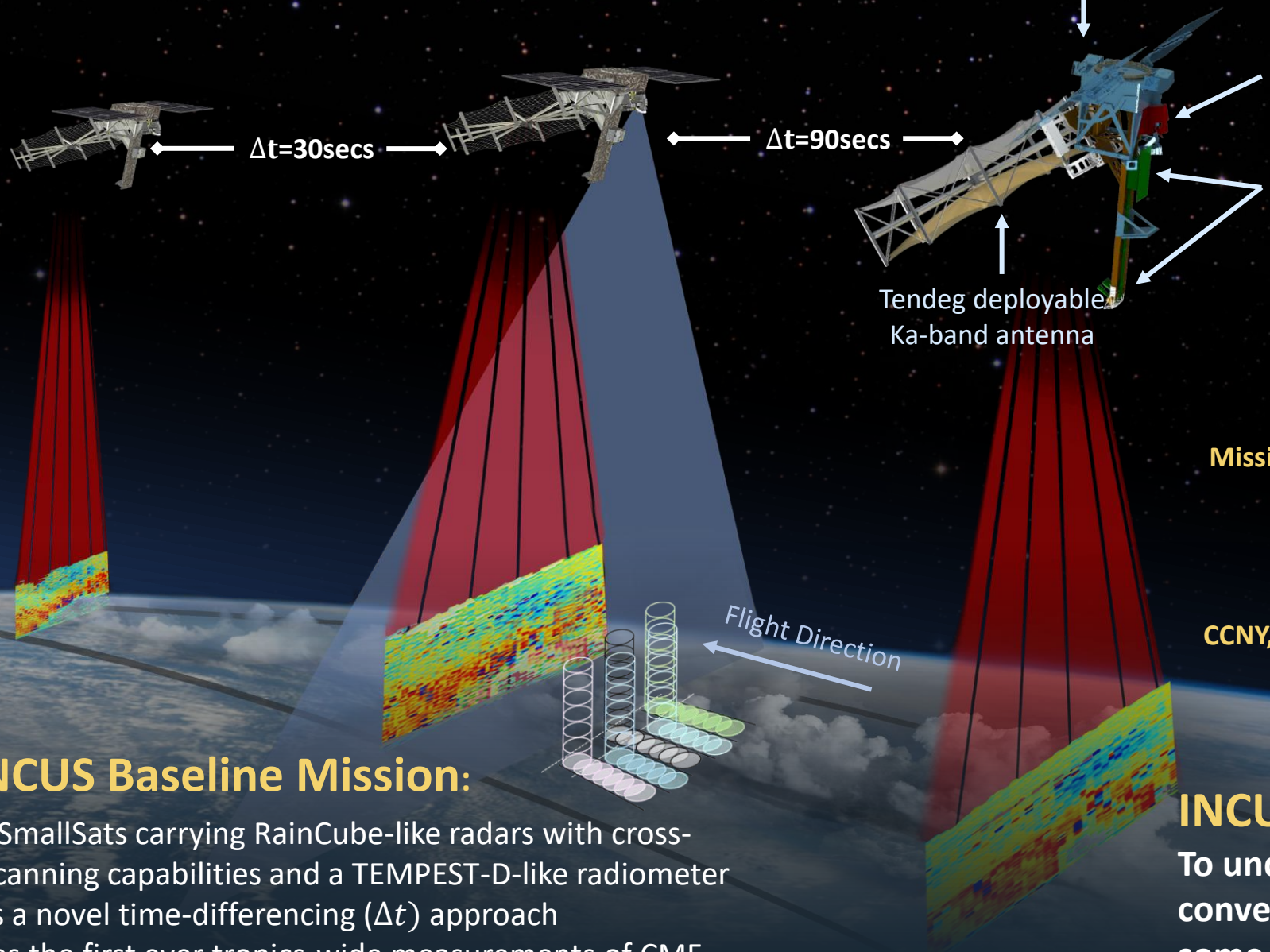
82 Total SmallSat Missions *(115 Spacecrafts in Formulation/ Implementation and beyond)*

Total Missions by Phase and Satellite Size *(excluding studies)*



**Data inclusive of missions solicited or directed from 2010-2021.*

INCUS Investigation of Convective Updrafts



Blue Canyon Technologies X-SAT
Venus commercial bus

JPL cross-track scanning microwave radiometer (middle spacecraft only) (TEMPEST-D heritage)

JPL Ka-band radar with 5 beams (RainCube heritage)

Tendeg deployable Ka-band antenna

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

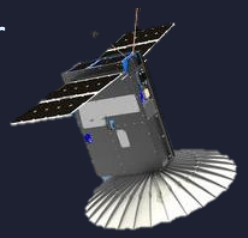
The INCUS Baseline Mission:

- 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

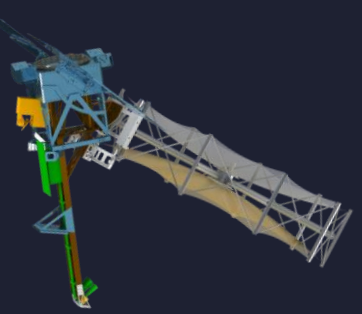
INCUS Goal

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

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







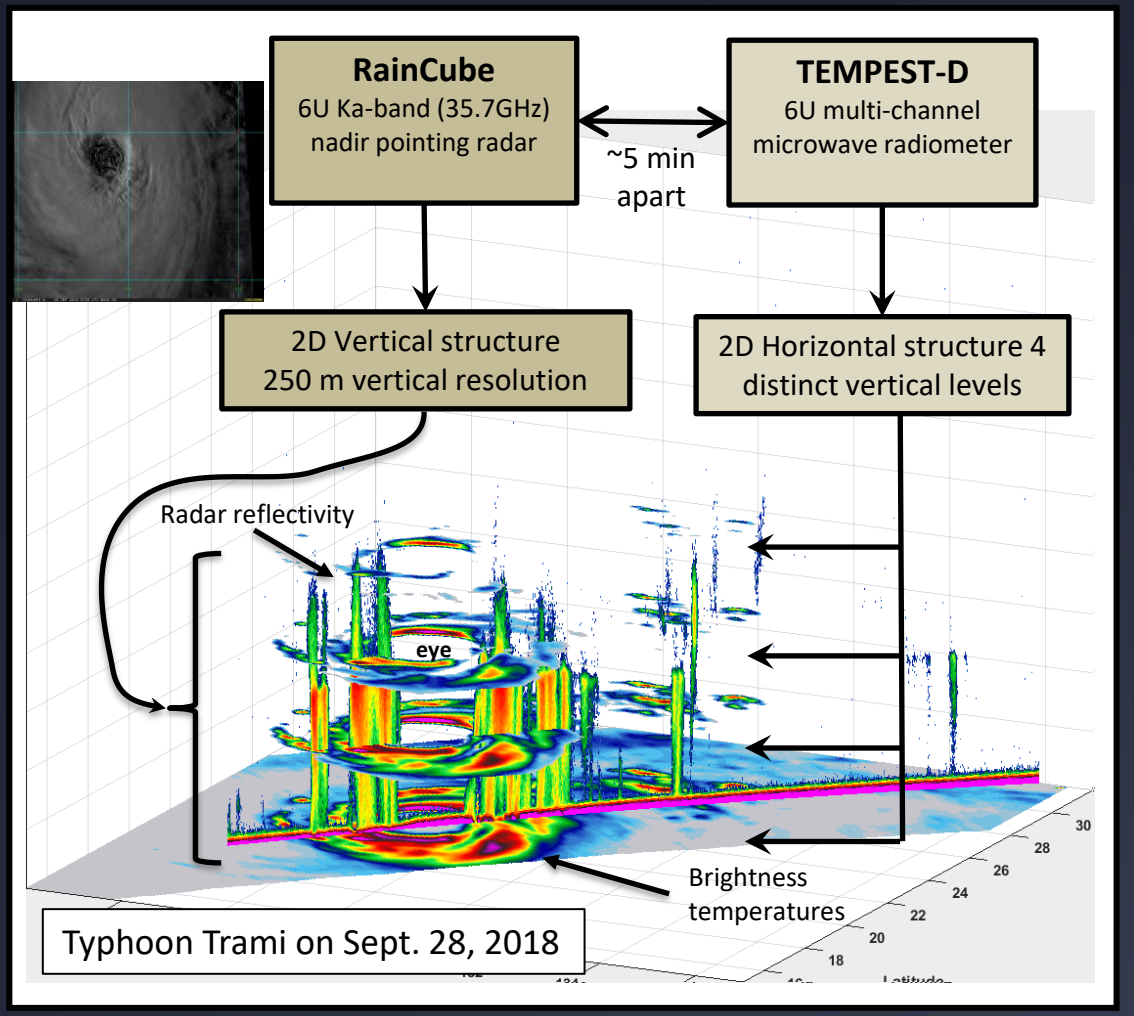
INCUS

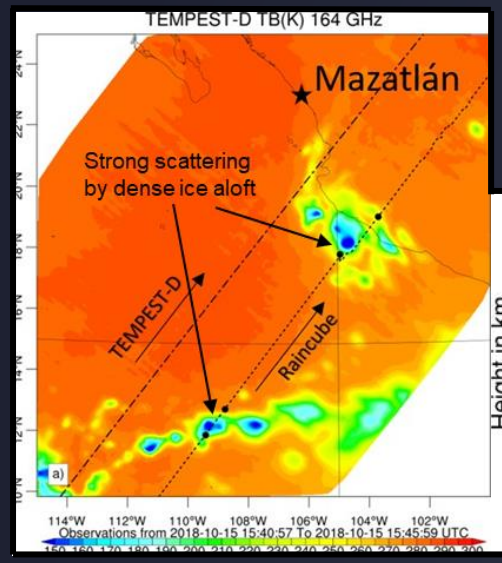
INCUS draws on the strengths of BOTH RainCube and TEMPEST-D to provide unprecedented vertical and horizontal views of storm structure and processes.

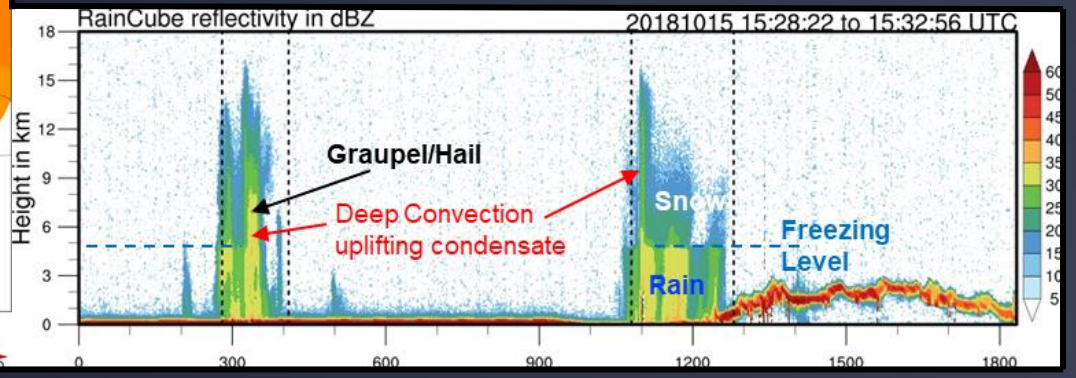
Figures and animations by Simone Tanelli, Shannon Brown and Steve Reising

(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








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Science Mission Directorate (SMD) SmallSat and CubeSat Programs

SMD Division or Office	Programs that fund CubeSats	Example CubeSat Missions	Programs that fund SmallSats	Example SmallSat Missions
Astrophysics	APRA	SPRITE, BLACKCAT, CUTE, BURSTCUBE, HaloSat	PIONEERS	Starburst, Aspera, PANDORA
Astrophysics			Explorer SMEX	IXPE
Astrophysics			Explorer MIDEX	SPHEREx
Earth Science	INVEST	ACMES, SNOOPI, HyTI, CTIM-FD, NACHOS, RainCube, RAVAN, CubeRRT	Earth Venture/SMEX	CYGNSS, TROPICS, PREFIRE, INCUS, TEMPEST-D
Heliophysics	H-FORT	GTOSAT, AEPEX, AERO/VISTA, CURIE, REAL, DAILI, LLITED, CUSP	SIMPLEX-2 /SMEX/MIDEX	ESCAPADE
Heliophysics	Explorer Mission of Opportunity	SunRISE, EZIE	Small Explorer (SMEX) Program	TRACERS, PUNCH
Heliophysics	MIDEX	CubeSat Constellations such as ARCS Phase A 2019 MIDEX	STP Science Mission of Opportunity	GLIDE
Heliophysics			STP Technology Mission of Opportunity	Solar Cruiser
Heliophysics			Medium Explorer (MIDEX) Program	Helioswarm
Planetary Science	SIMPLEX-1	Q-PACE, LunaH-Map	SIMPLEX-2	Janus
Exploration Science Strategy and Integration Office			SIMPLEX-2	Lunar Trailblazer