

Introduction to SmallSats

California Space Grants Webinar

11 Dec 2020

Anh Nguyen

anh.n.nguyen@nasa.gov

About Me

- PhD in Aerospace Engineering, focus in Dynamics and Control of Precision Space Systems
 - *Small Satellite Technologies for Precision Drag-free Control and Drag Force Recovery*
- B.S. in Computer Engineering
- NASA Ames Research Center (2015 – Present)
 - Mission Design Division Subject Matter Expert (SME) in Guidance, Navigation and Control (GNC) & Attitude Determination and Control Systems (ADCS)
 - Earth Science Decadal Survey Designated Observables SmallSat Mission Architectures
 - Surface Biology and Geology Study
 - Surface Deformation and Change Study
 - Project Manager of CubeSat Technology Demonstrations
 - CubeSat Handing of Multisystem Precision Time Transfer (CHOMPTT) - 2018
 - Kicksat-2 - 2019
 - V-R3x - 2020
 - Payload Accelerator of CubeSat Endeavors (PACE) - 2020



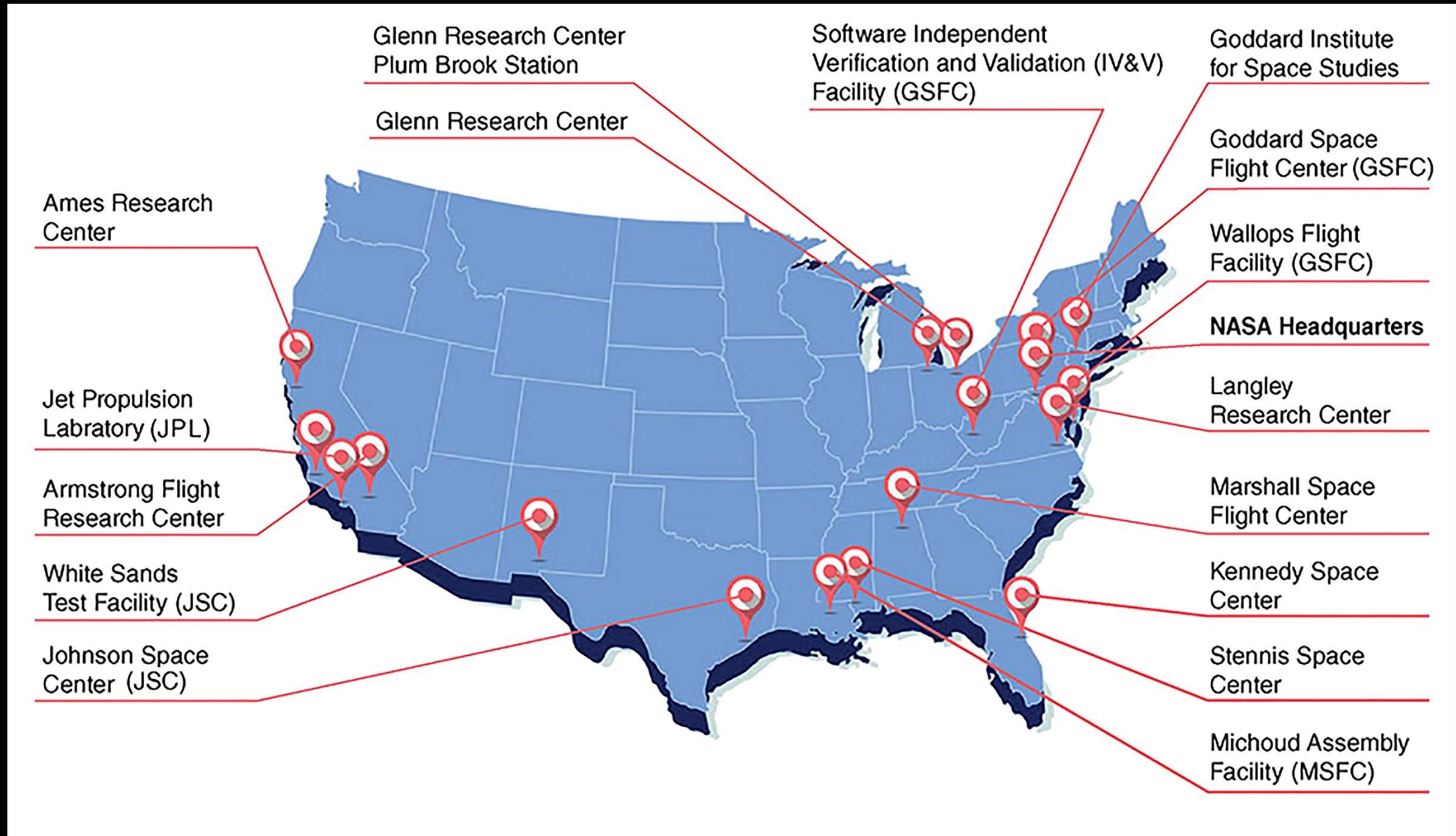


Image Credit: NASA

Spacecraft Classes



Large Satellite
2000-2500 kg



Medium Satellite
1000-1500 kg



Small Satellite
500-800 kg



Micro Satellite
100-300 kg



Cubesat+
<50 kg



Image Credit: NASA

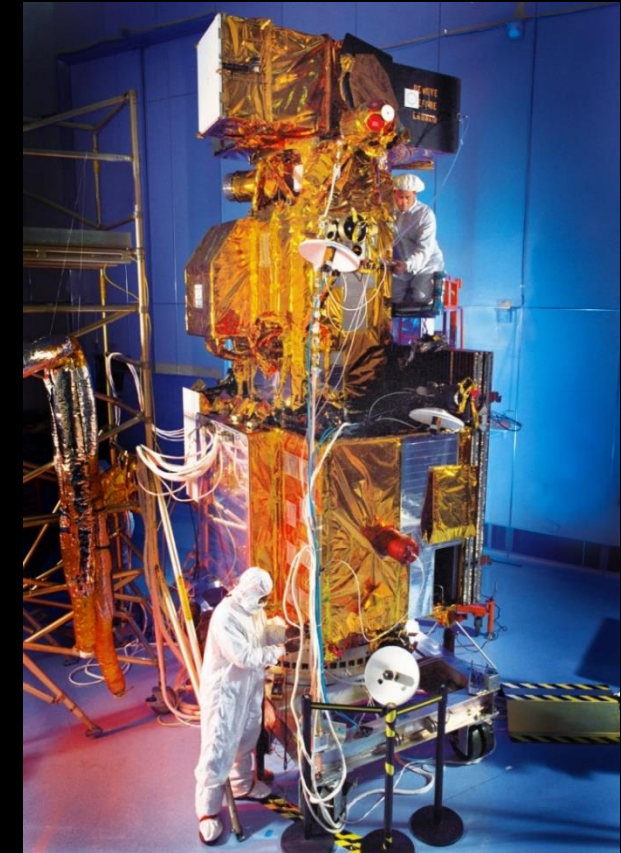


Image Credit: NASA

LandSat-7
13.25 x 9 ft
4850 lbs/2,200 kg

Spacecraft Classes



Large Satellite
2000-2500 kg



Medium Satellite
1000-1500 kg



Small Satellite
500-800 kg



Micro Satellite
100-300 kg



Cubesat+
<50 kg

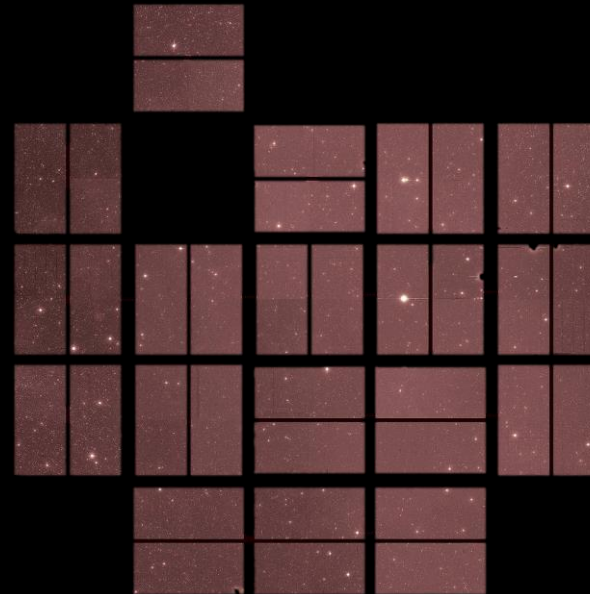


Image Credit: NASA



Image Credit: NASA

Kepler Space Telescope
15.4 × 8.9 ft
2,292 lbs./1,040.7 kg

Spacecraft Classes



Large Satellite
2000-2500 kg



Medium Satellite
1000-1500 kg



Small Satellite
500-800 kg



Micro Satellite
100-300 kg



Cubesat+
<50 kg

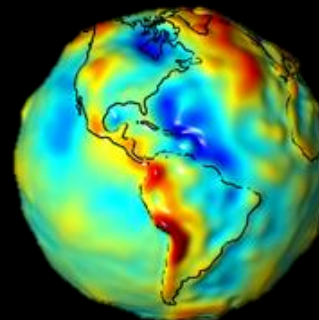
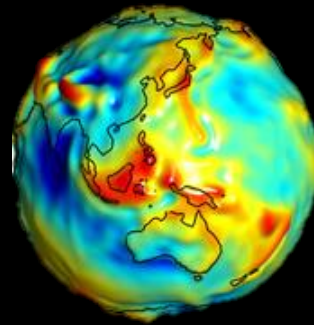


Image Credit: NASA



Image Credit: NASA

Gravity Recovery and Climate
Experiment (GRACE)
 $6.4 \times 10.2 \times 2.4$ ft
1,073 lbs./487 kg



Spacecraft Classes



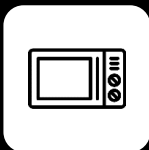
Large Satellite
2000-2500 kg



Medium Satellite
1000-1500 kg



Small Satellite
500-800 kg



Micro Satellite
100-300 kg



Cubesat+
<50 kg



Image Credit: NASA

Lunar Atmosphere and Dust Environment Explorer
(LADEE)

6.1 × 6.1 × 7.8 ft

546 lbs./248.2 kg



Spacecraft Classes



Large Satellite
2000-2500 kg



Medium Satellite
1000-1500 kg



Small Satellite
500-800 kg



Micro Satellite
100-300 kg



Cubesat+
<50 kg

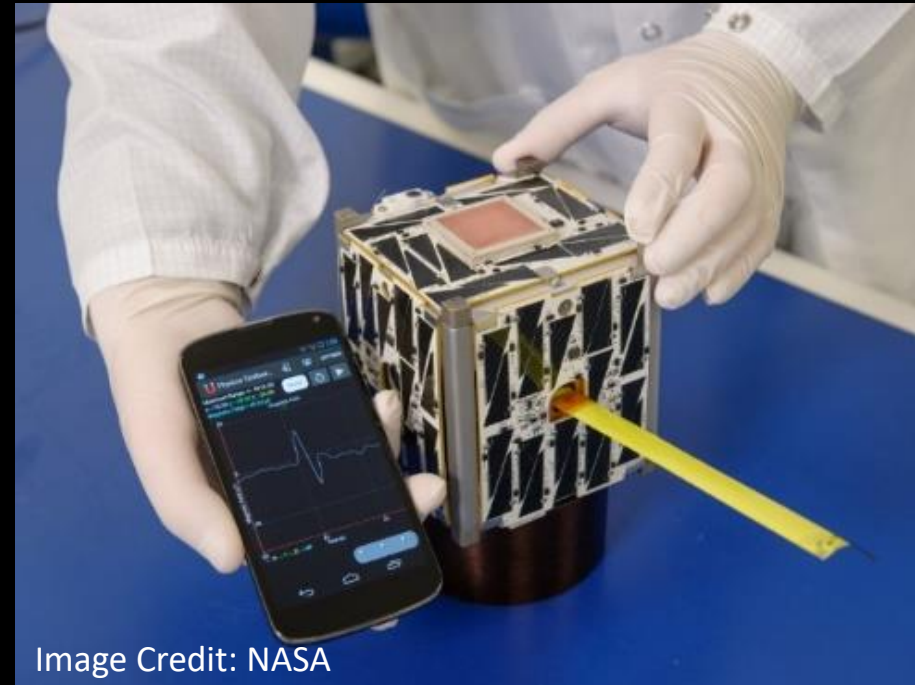
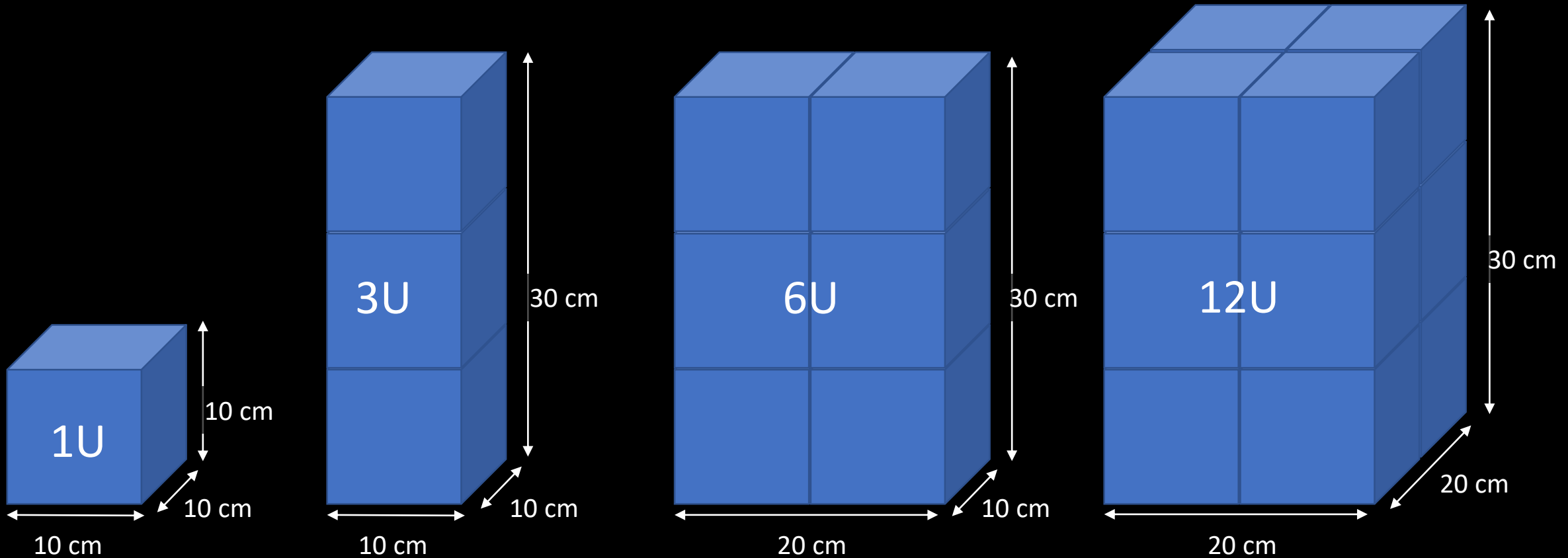


Image Credit: NASA

PhoneSat
3.93 x 3.93 x 3.93 in
2.86 lbs./1.3 kg

CubeSat Standard



Why SmallSats?

- Cost Effective
- Shorter development times
 - Capability for a quick response to targets of opportunity
- Replenishable
 - More opportunities for flight demonstration and maturation of new spacecraft and instrument design concepts and hardware
 - More opportunities to develop scientific research, engineering, and project management capabilities

CHOMPTT

CubeSat Handling of Multisystem Precision Time Transfer

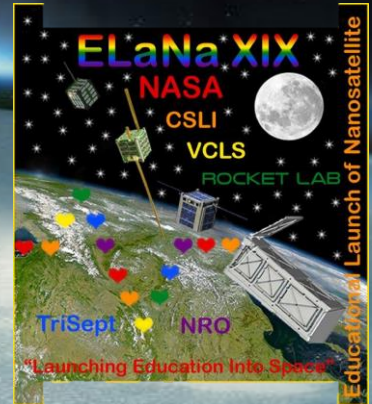
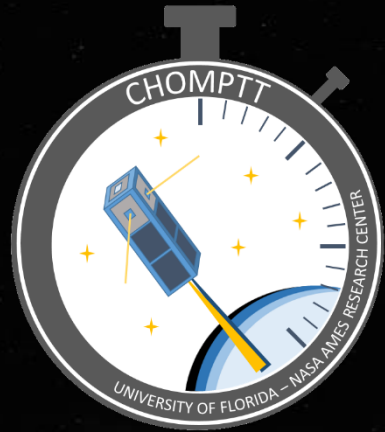
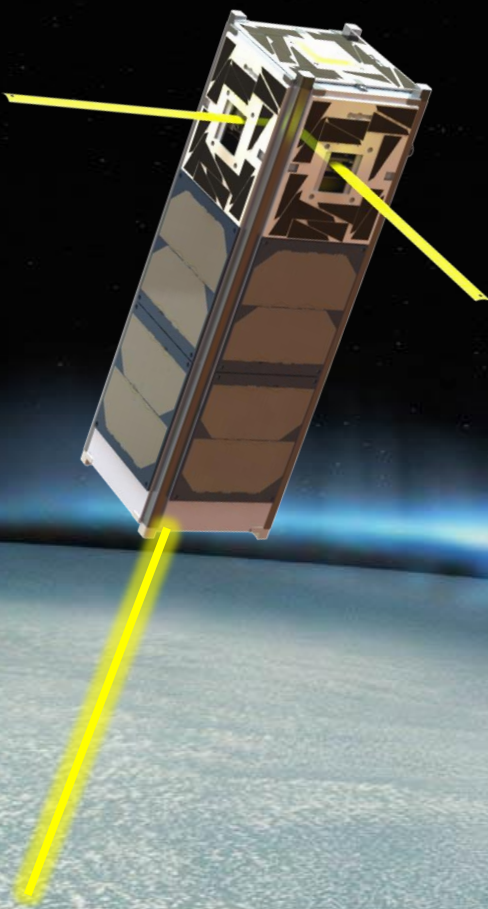
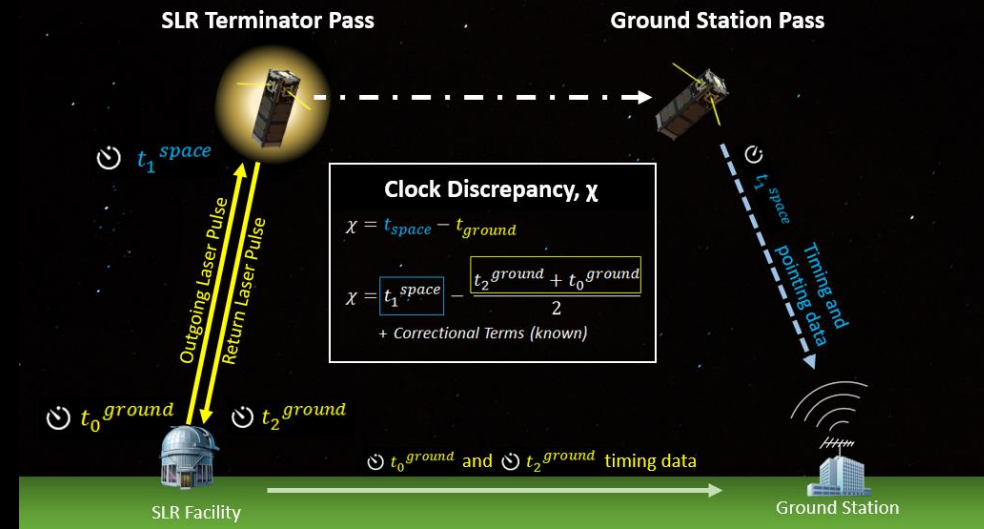


Image Credits: NASA



CHOMPTT Overview

NASA Stakeholders	HEOMD-AES, STMD-SSTP, AFRL
NASA COR	Belgacem Jaroux NASA Ames Research Center
University PI/PM	John W. Conklin University of Florida
Systems Engineer	Anh N. Nguyen NASA Ames Research Center
Project Description	The CHOMPTT mission will demonstrate technology for enhanced GPS and future disaggregated navigation systems
Launch	12/15/2018 ELaNa XIX, RocketLab Electron
Status	Mission Ops in progress



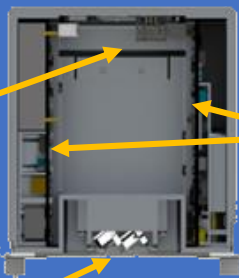
Spacecraft Overview

University of Florida 1U Optical Precision Time Transfer Payload

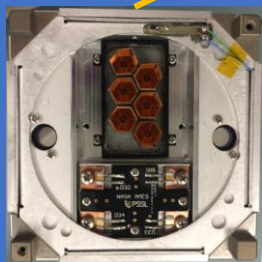
Power & Data
Mgt Board



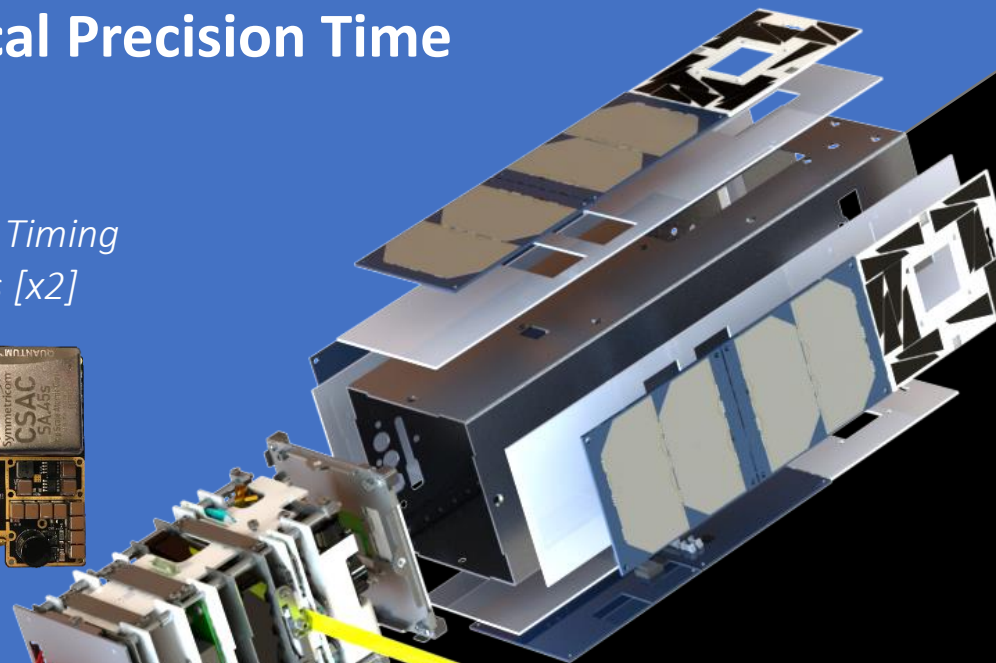
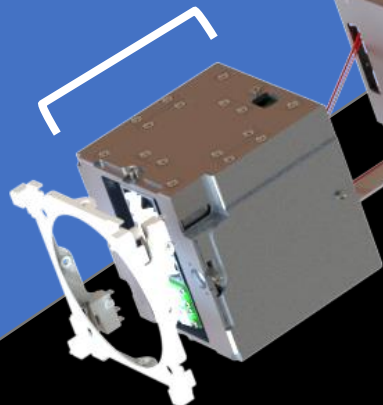
Cross-section
View



Precision Timing
Boards [x2]



Nadir Face Optics

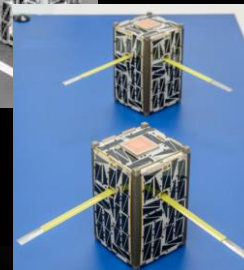


**NASA ARC NODES-derived
1.5U spacecraft bus**

CHOMPTT BUS Heritage from NODES



EDSN



NODES



Mission Success!



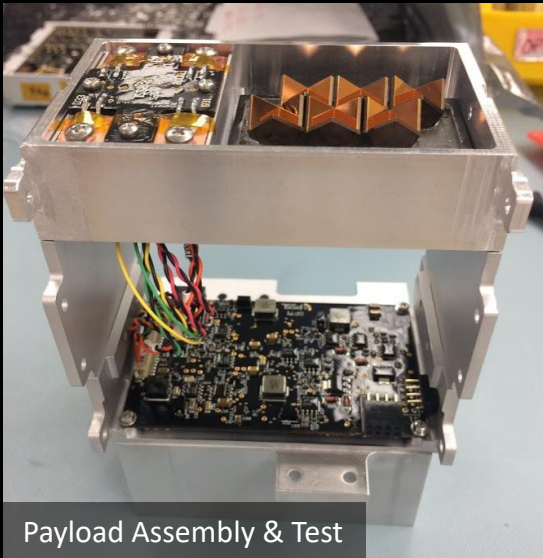
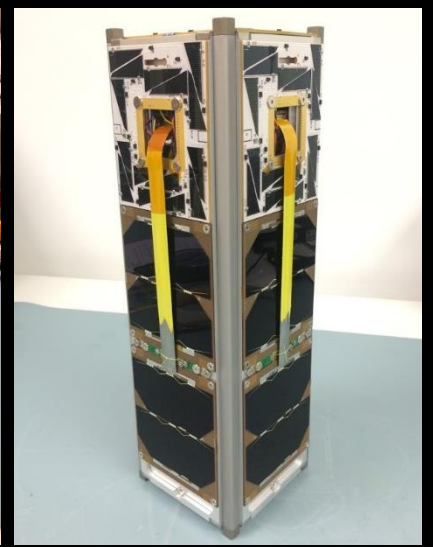
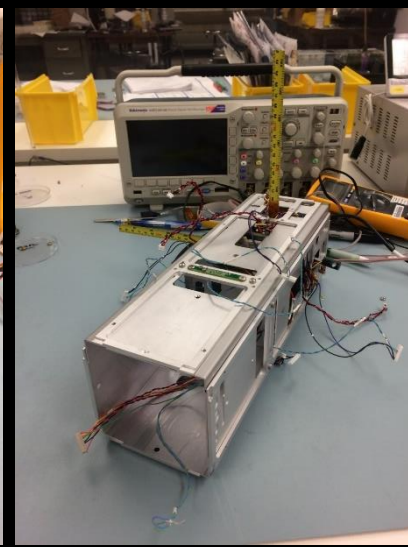
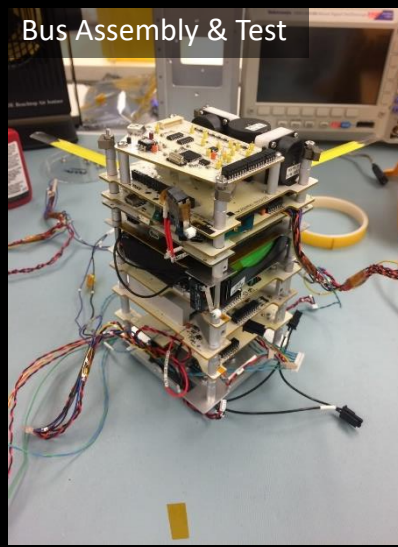
*NODES launched from ISS
March 2016*

Integration

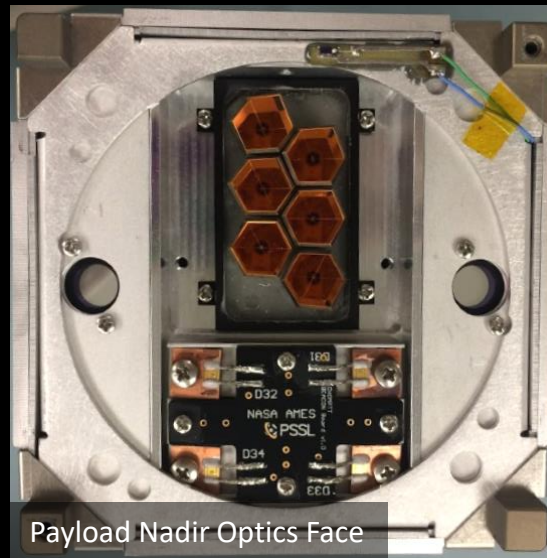
Conformal Coat



Bus Assembly & Test



Payload Assembly & Test



Payload Nadir Optics Face



Final Assembly

Test

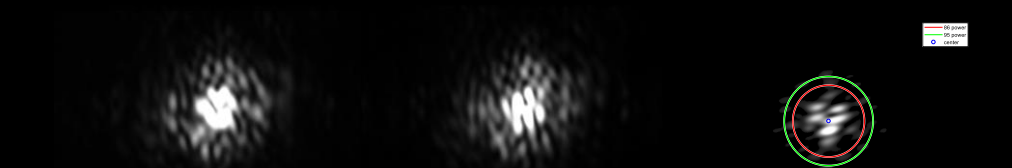
Antenna Trim



Laser Interferometer Testing



Far-field Testing @ SPAWAR



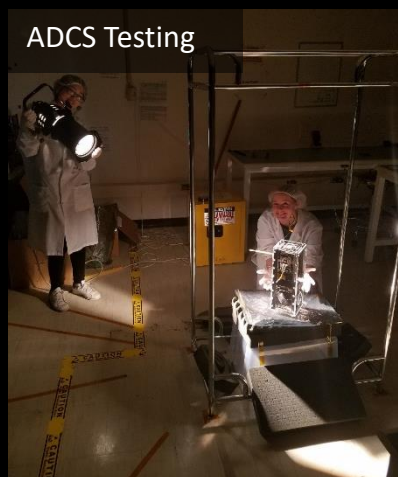
GPS Test



Random Vibration Testing



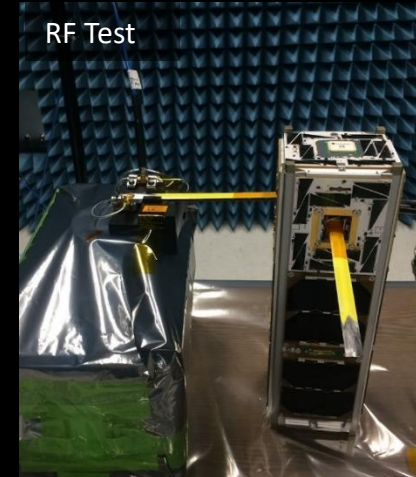
ADCS Testing



Thermal Vacuum Testing

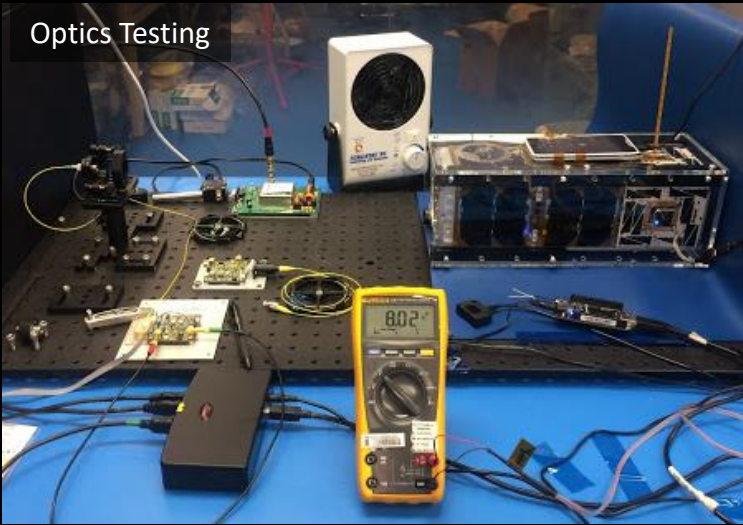


RF Test



More testing

Optics Testing



Mission Simulation Testing



Solar Charging and Safe Mode Testing



Satellite Laser Ranging Station Testing @ KSC



Dispenser Integration at RocketLab USA

Unpacking



CubeSat Acceptance Checklist



Last touch



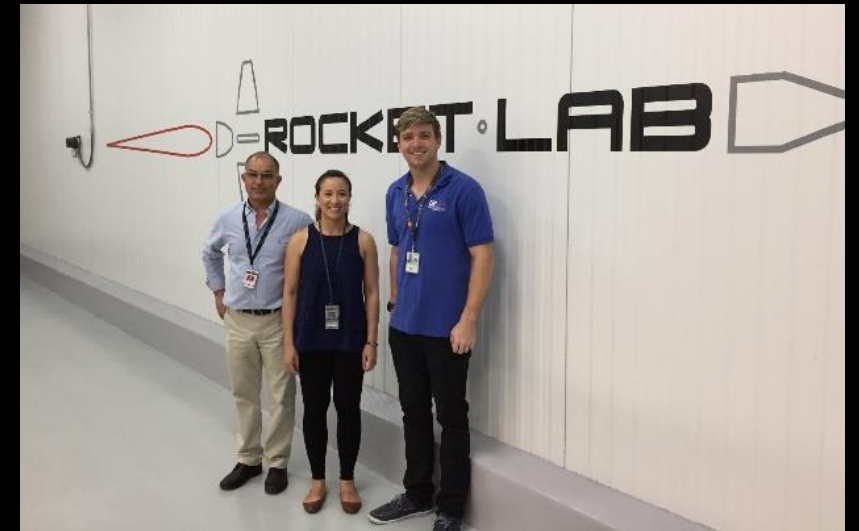
Antenna Tie-down



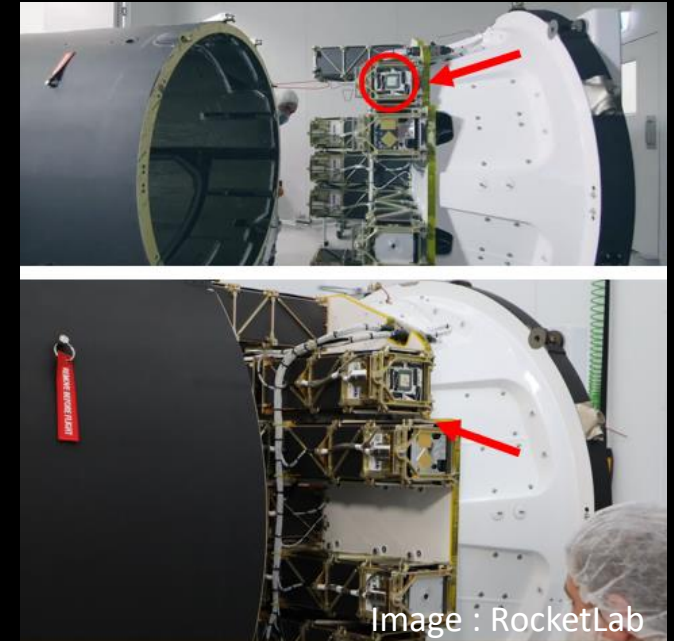
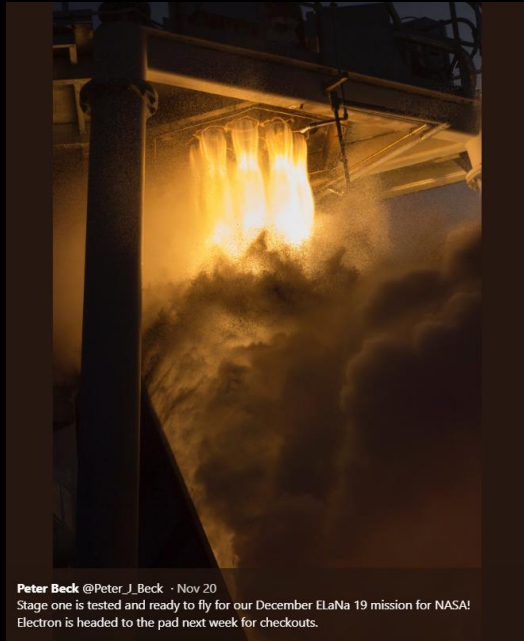
RailPOD Integration



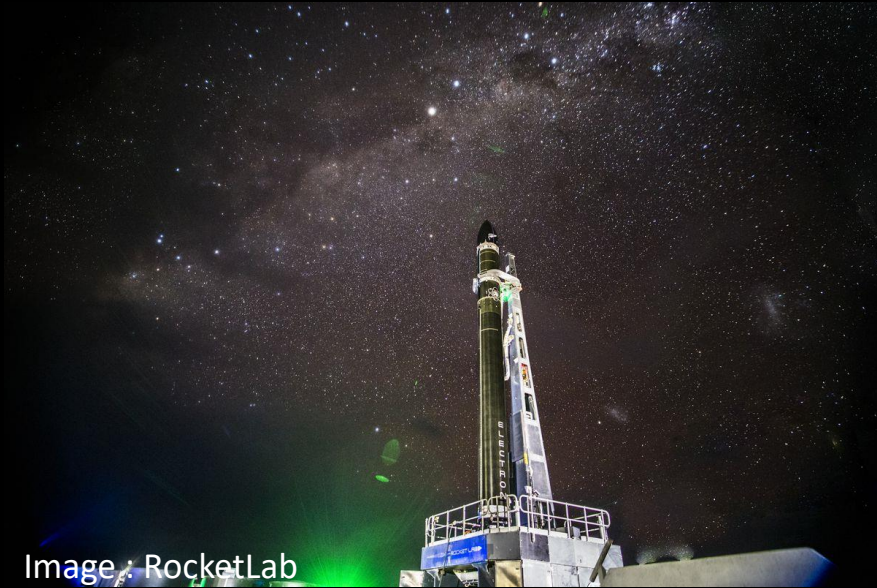
Final Check-out



RocketLab Development



Launch 12/15/2018



RocketLab 4: ELaNa XIX



Mission Ops – In progress!



Image : NASA



TISTEF Satellite Laser Ranging Station



Image : TISTEF



Image : UF



EOS Satellite Laser Ranging Station



Image : EOS

KickSat-2

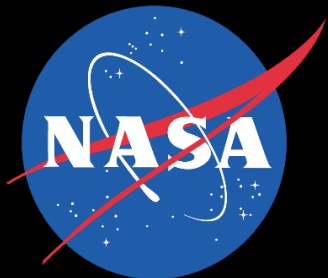
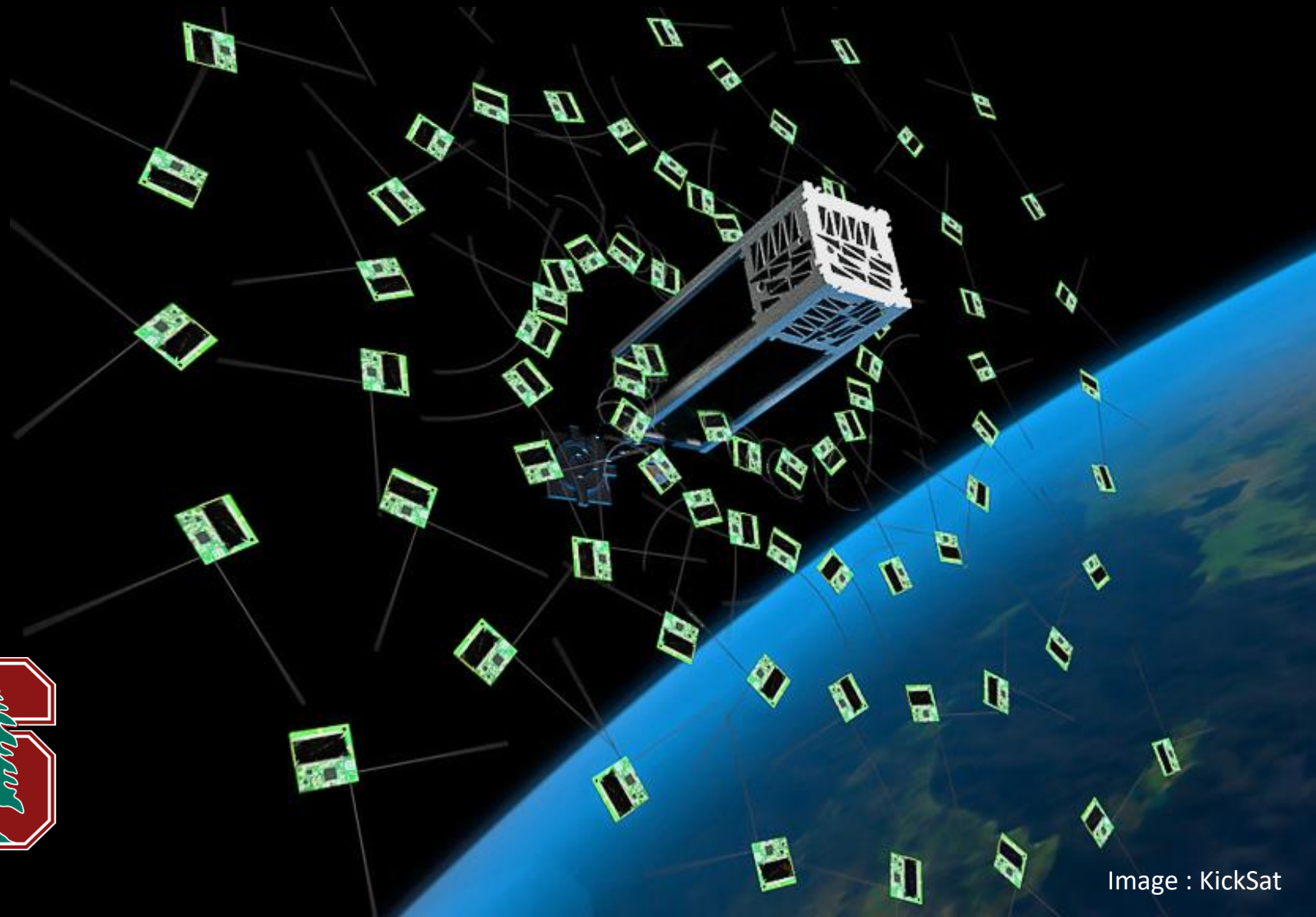


Image : KickSat

Kicksat-2 Overview

NASA Stakeholders NASA, DoD

NASA COR Belgacem Jaroux
NASA Ames Research Center

University PI/PM Zachary Manchester
Stanford University

Systems Engineer Anh N. Nguyen
NASA Ames Research Center

Project Description The KickSat-2 mission tests 105 Sprite ChipSats demonstrating that tiny, massively distributed satellites using commercial off-the-shelf technology can work in space.

Launch 11/17/2018 Cygnus NG-10 Antares

KickSat-2 Deployment 2/13/2019

Sprites Deployed 3/19/2019 – Mission Success!

Mission End 4/2/2019 S/C Re-entry

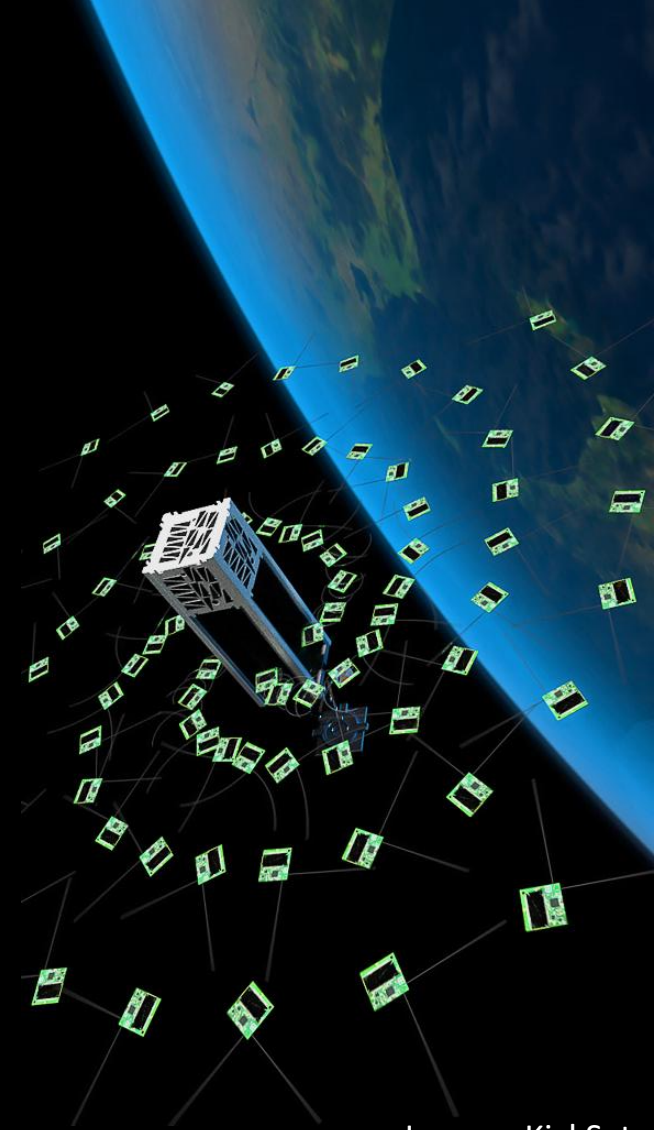


Image : KickSat

Spacecraft Overview

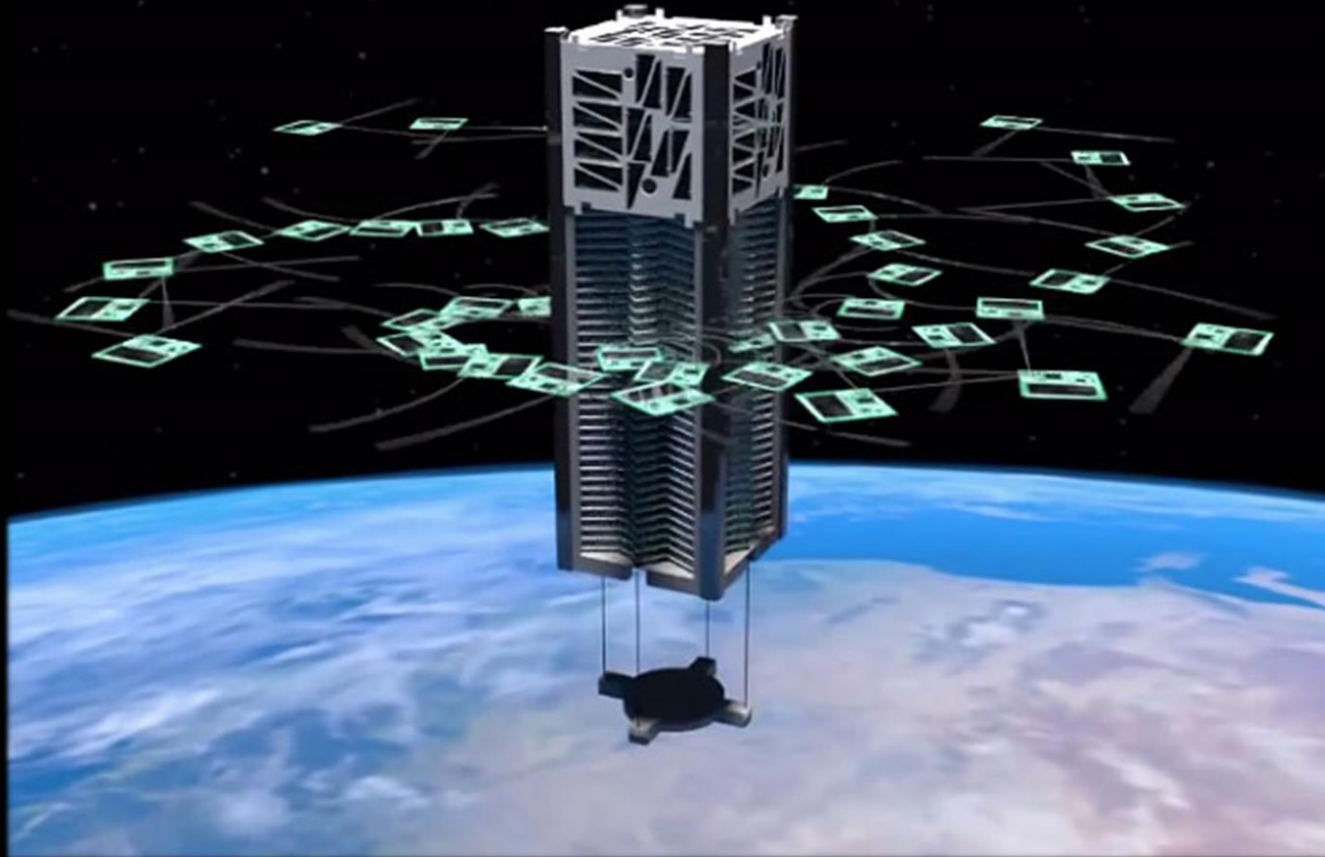


Image : KickSat

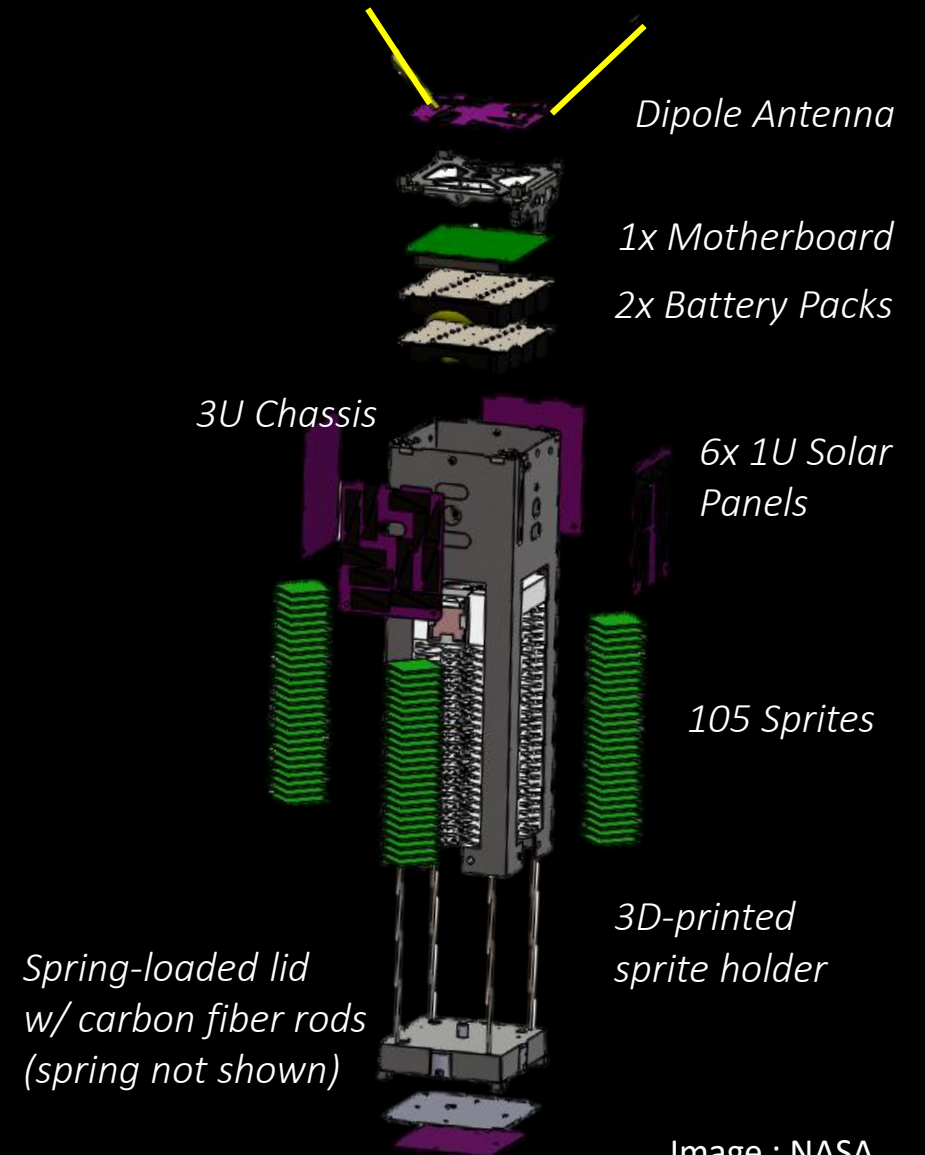
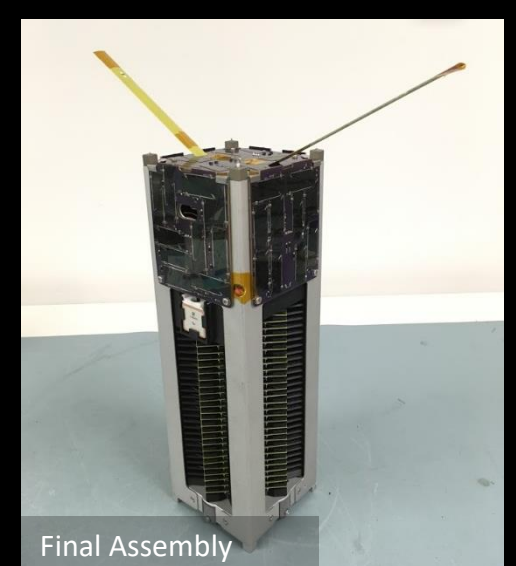
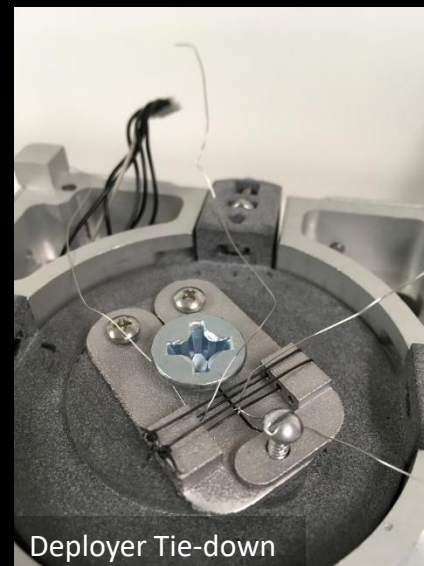
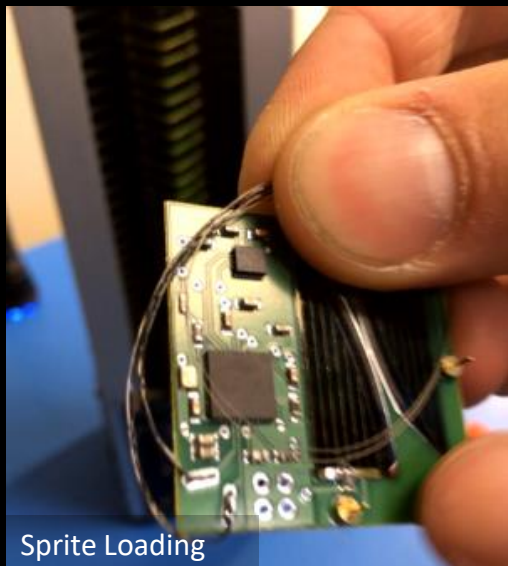
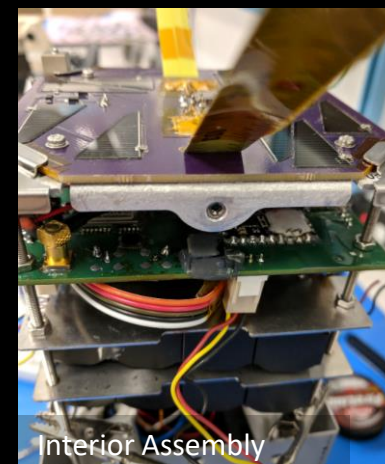
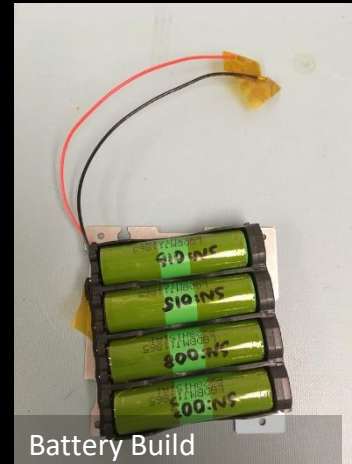
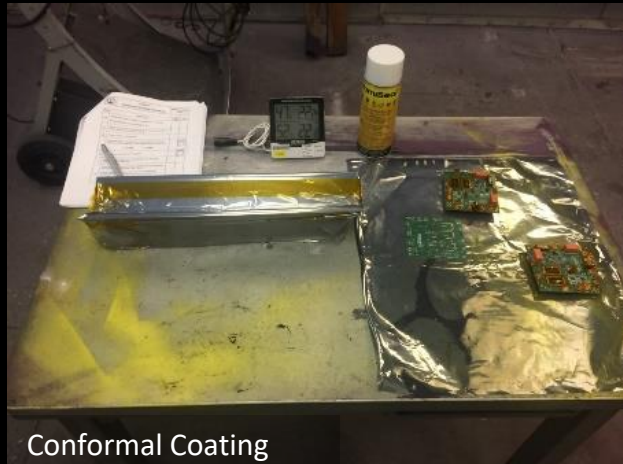
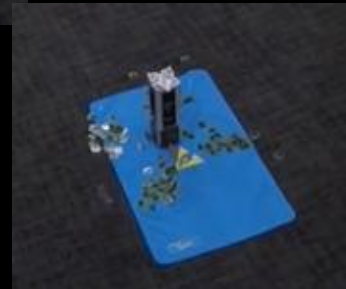
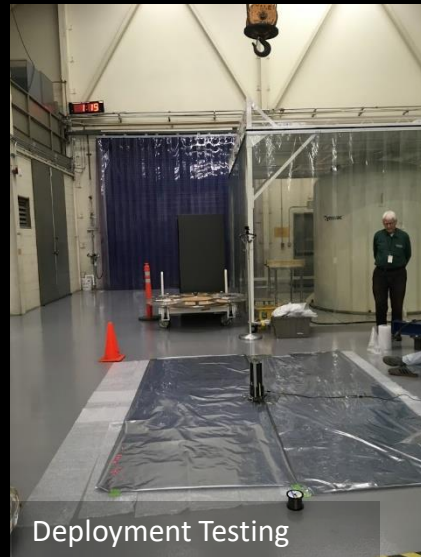
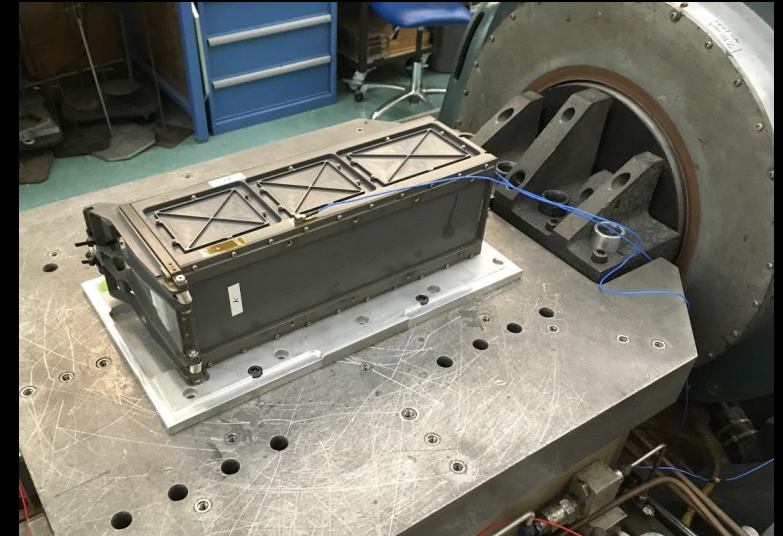


Image : NASA

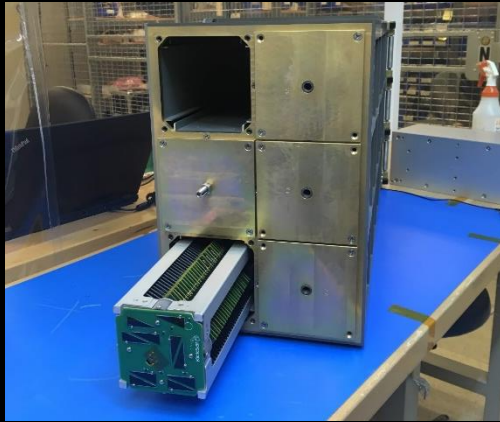
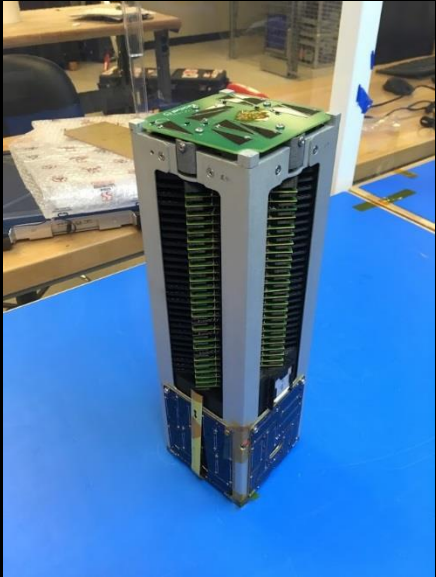
Integration



Test

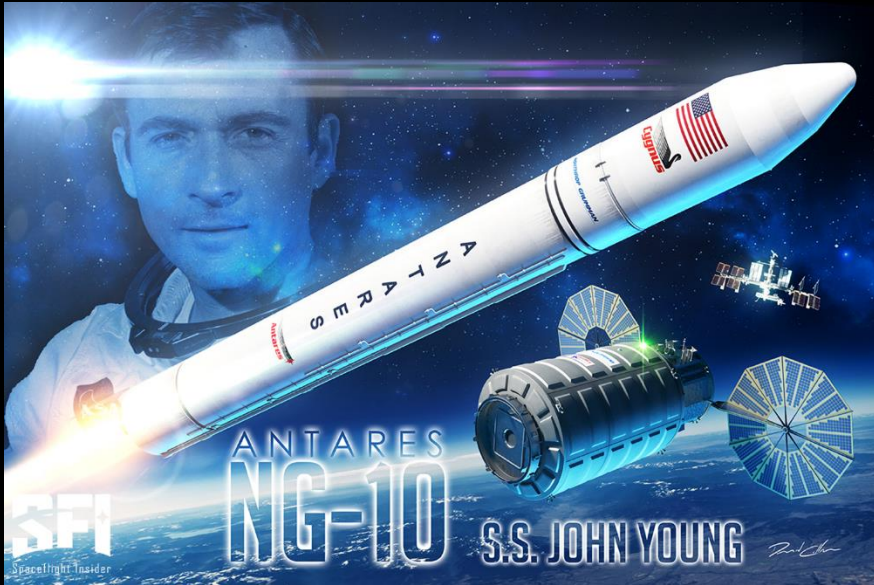


Integration @ NanoRacks



Signatures on the KickSat-2 NCRSD deployer door

Cygnus NG-10 Development



Launch 11/17/2018

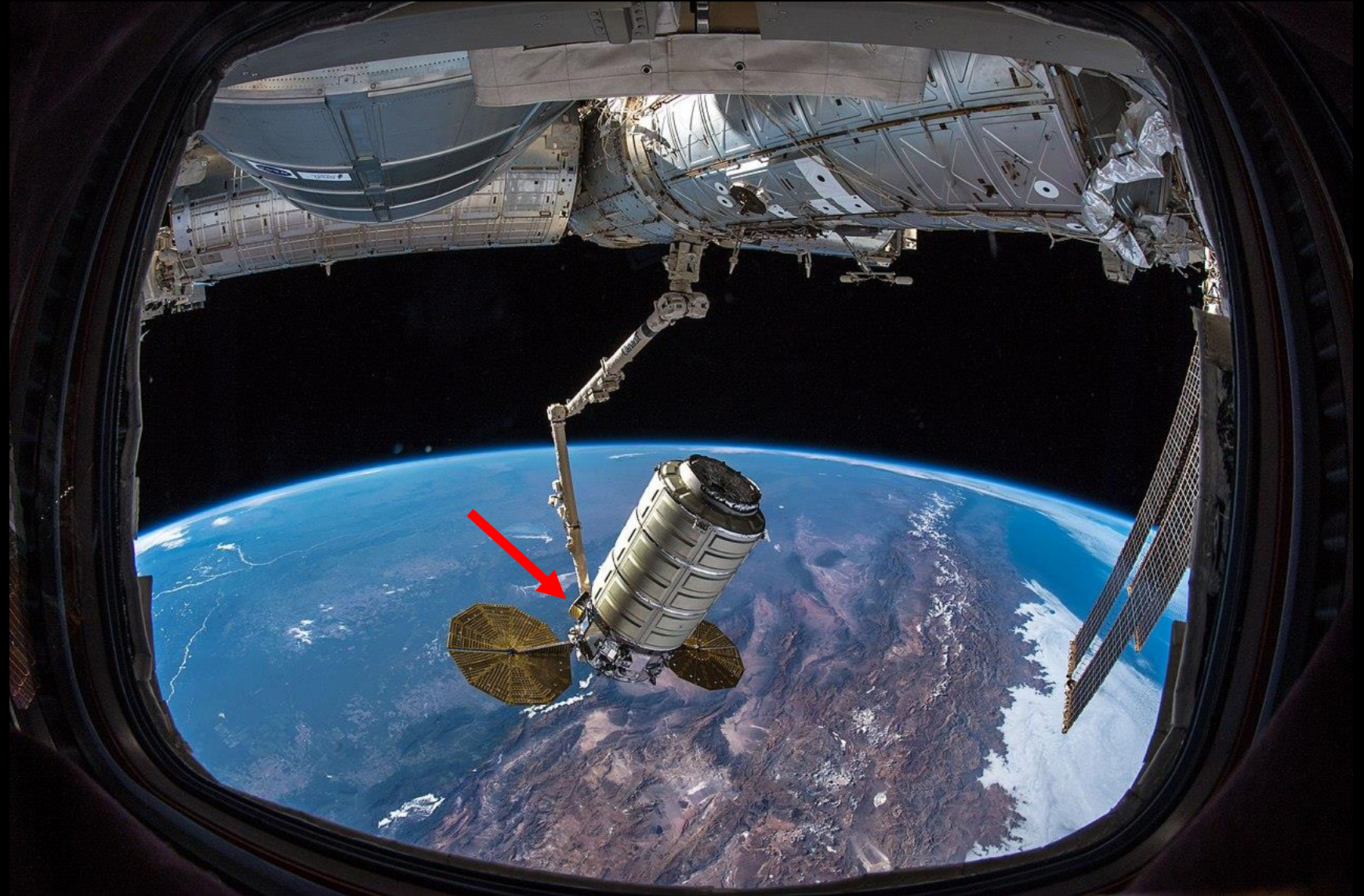


ISS Docking

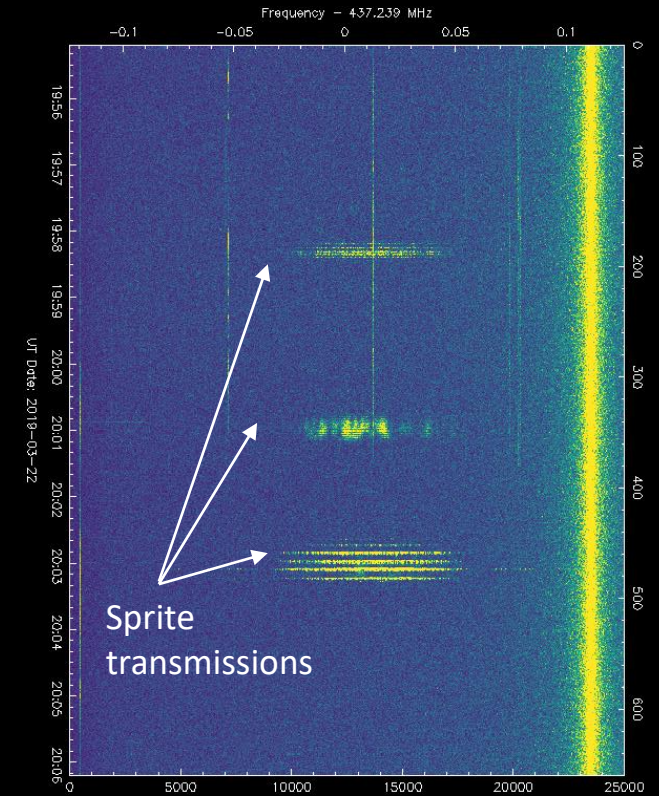
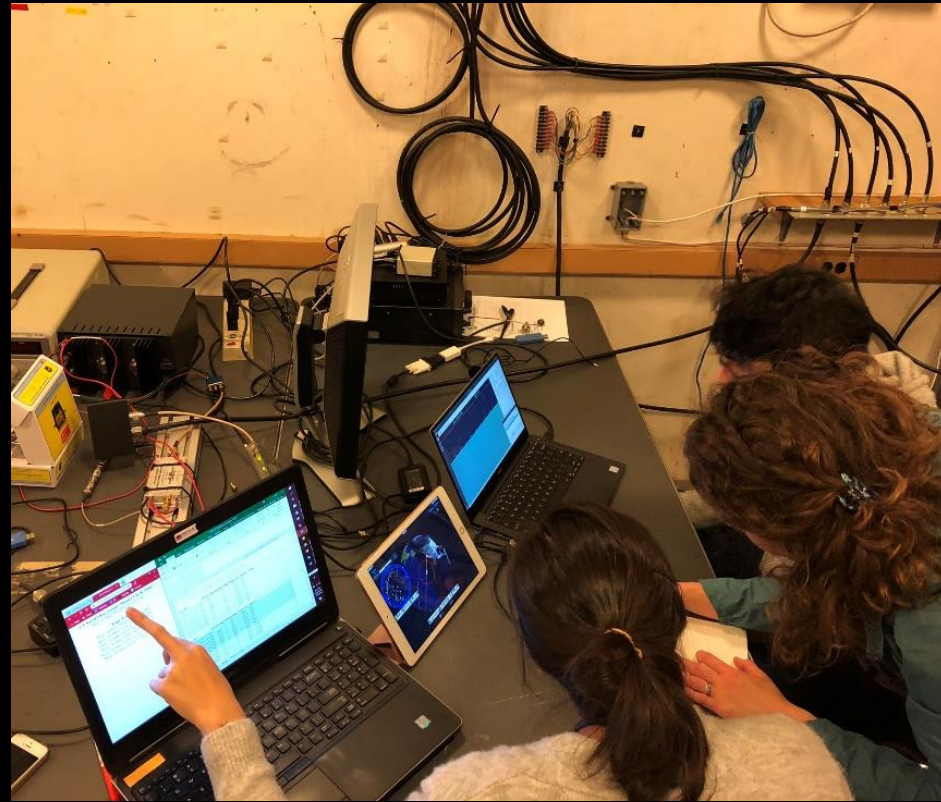
11/19/2018: Capture at ISS

02/08/2019: Cygnus NG-10
Undocking from ISS

02/13/2019: KickSat-2
Deployment from Cygnus
NG-10



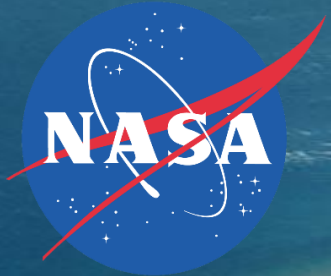
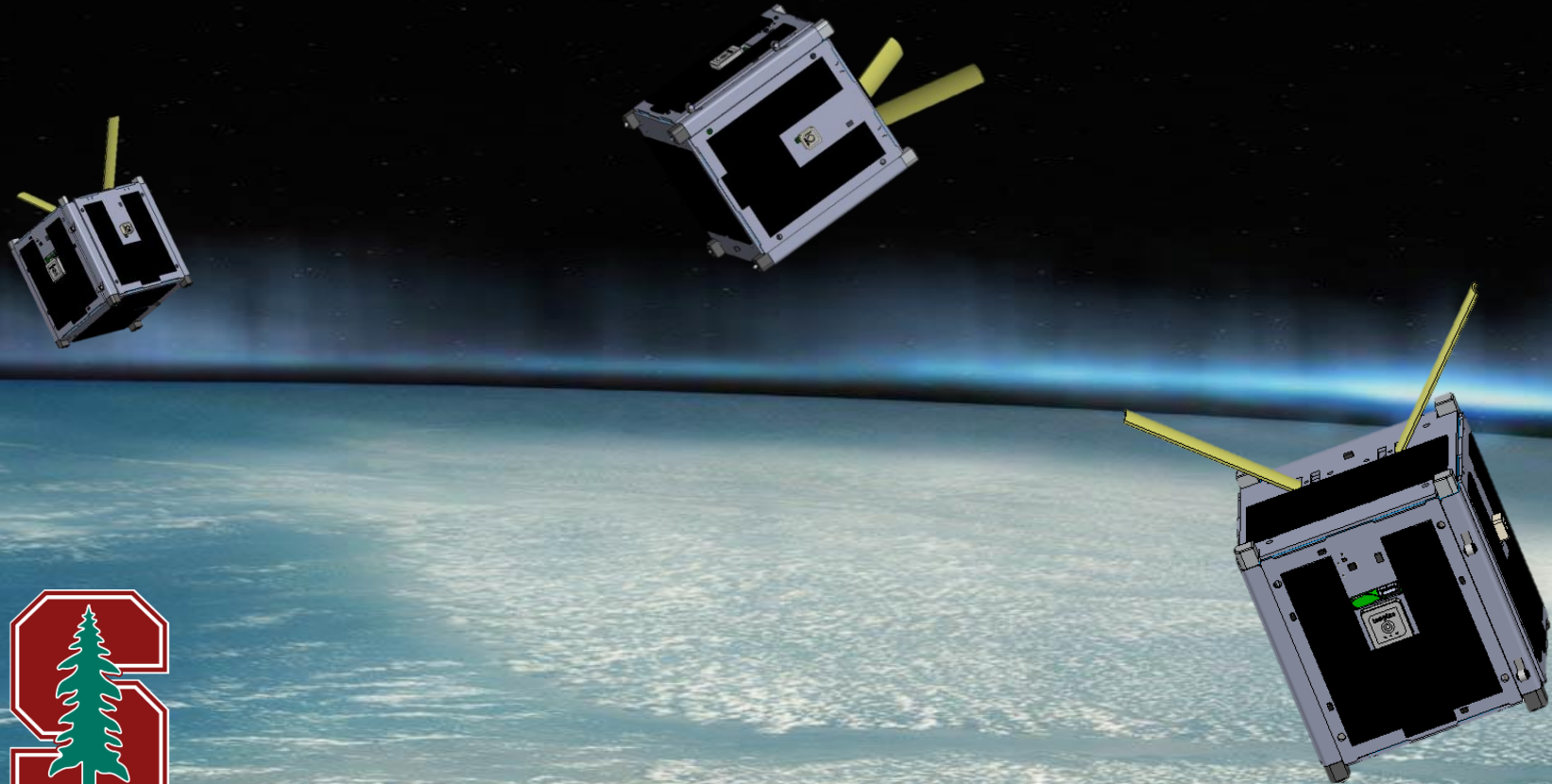
Mission Ops



03/15/2019 – 04/01/2019: Sprite Deployment Window 2

- **03/18/2019: Sprite Deployment**
- **03/19/2019 – 03/20/2019: Sprite Communications!**
- 03/21/2019: Sprite Re-entry
- 04/02/2019: KickSat-2 Re-entry

V-R3x



V-R3x Overview

NASA Stakeholders STMD-SSTP

PM Anh N. Nguyen
NASA Ames Research Center

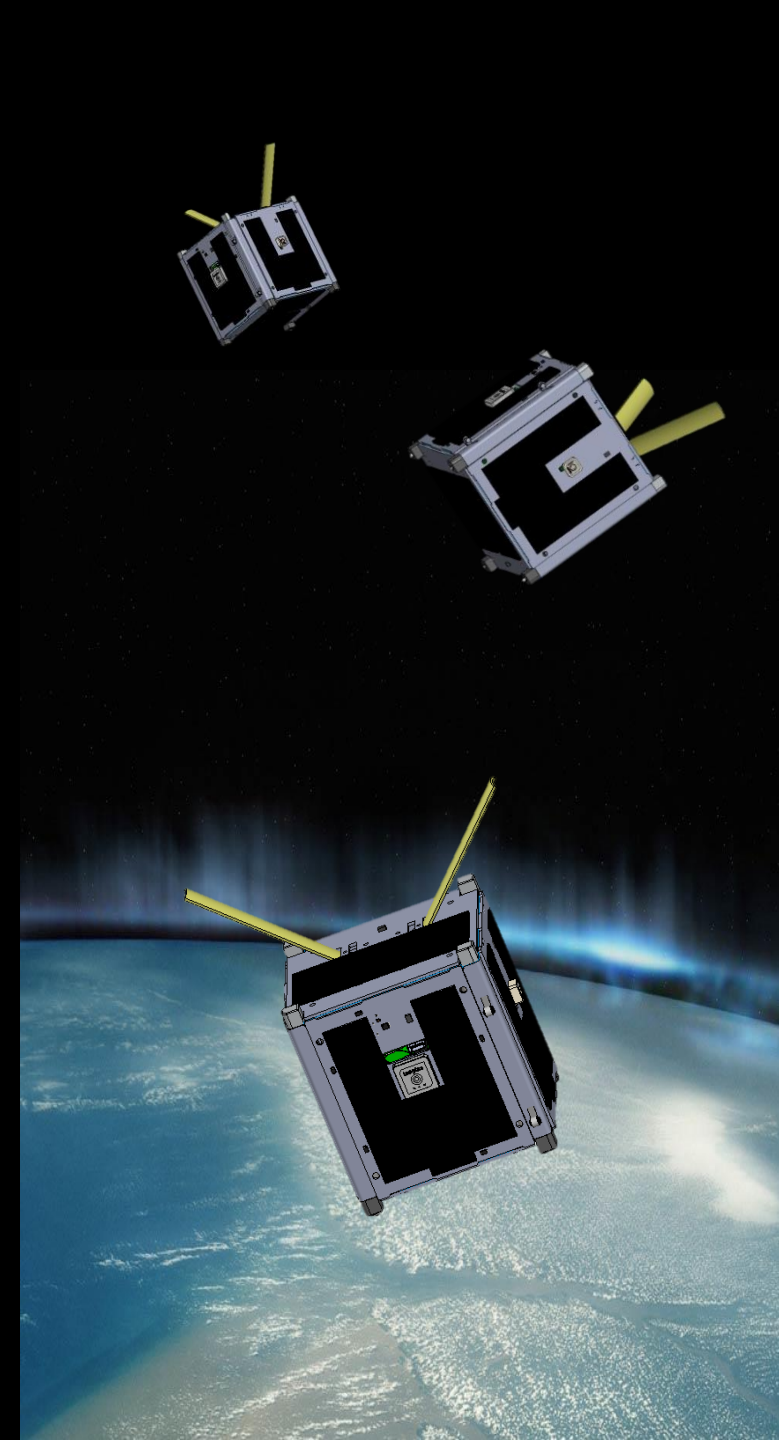
University PI Zachary Manchester
Carnegie Mellon University (Formerly Stanford)

NASA Systems Engineer Adam Zufall
NASA Ames Research Center – Millennium Engineering

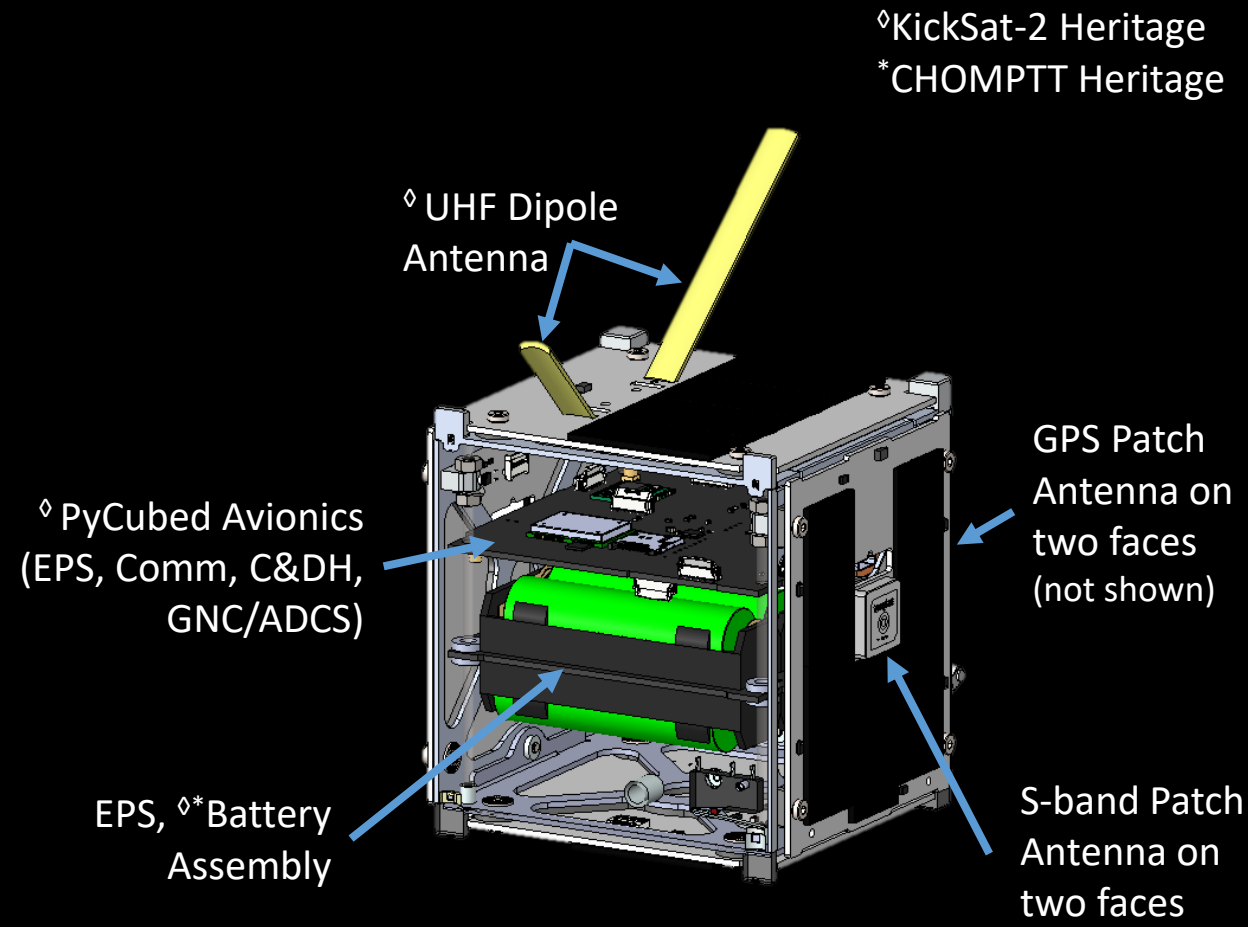
Stanford Systems Engineer Max Holliday
Stanford University

Project Description V-R3x is a STMD-SSTP technology demonstration utilizing a system of three 1U CubeSats that will advance small satellite swarm technologies through low-cost, low-complexity, and low-SWaP advanced communication and navigation capabilities.

Launch 1/14/2021 Space-X Falcon 9 Transporter-1 Mission
Mission Ops 11 mo.



Spacecraft Overview



Concept of Operations

Eject from Dispenser

- SC untethered
- Dipole antenna not tied down

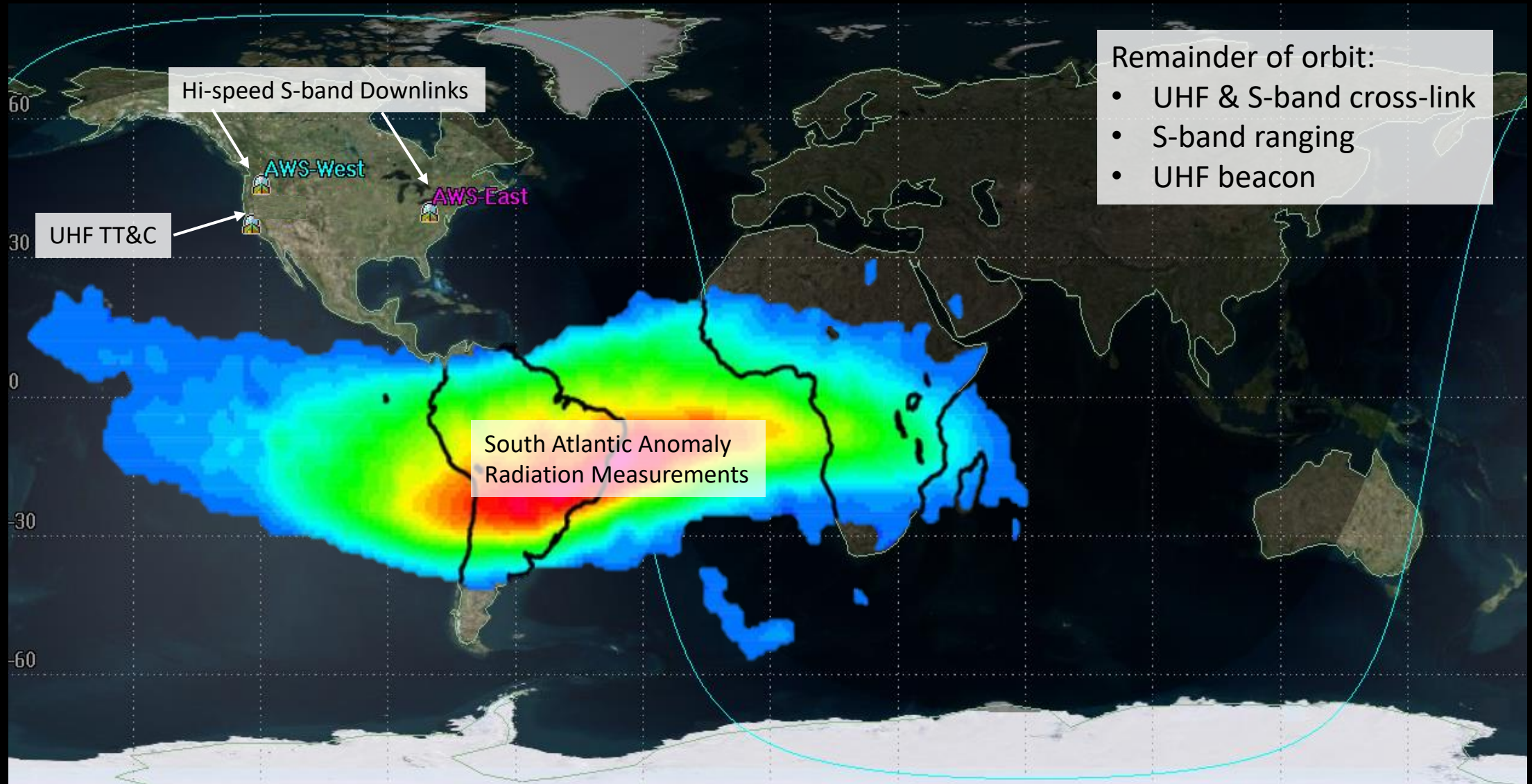
Separation & Deployment

- Wait 5 sec
- Power spacecraft
- Begin RF Transmissions

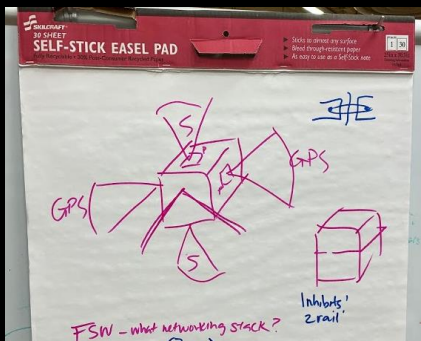
Nominal Operations



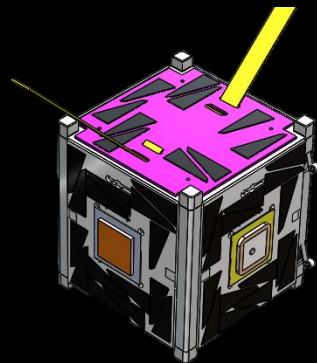
Concept of Operations



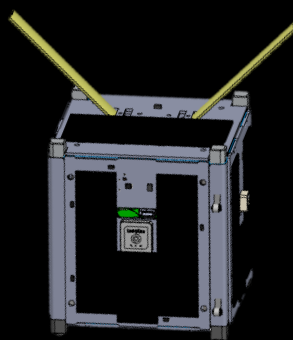
Concept of Operations



Brainstorm
12/03/2019



Project Proposal
12/16/2019



PDR/CDR
05/18/2020



EDU
08/31/2020



FM 09/27/2020



12/3/2020

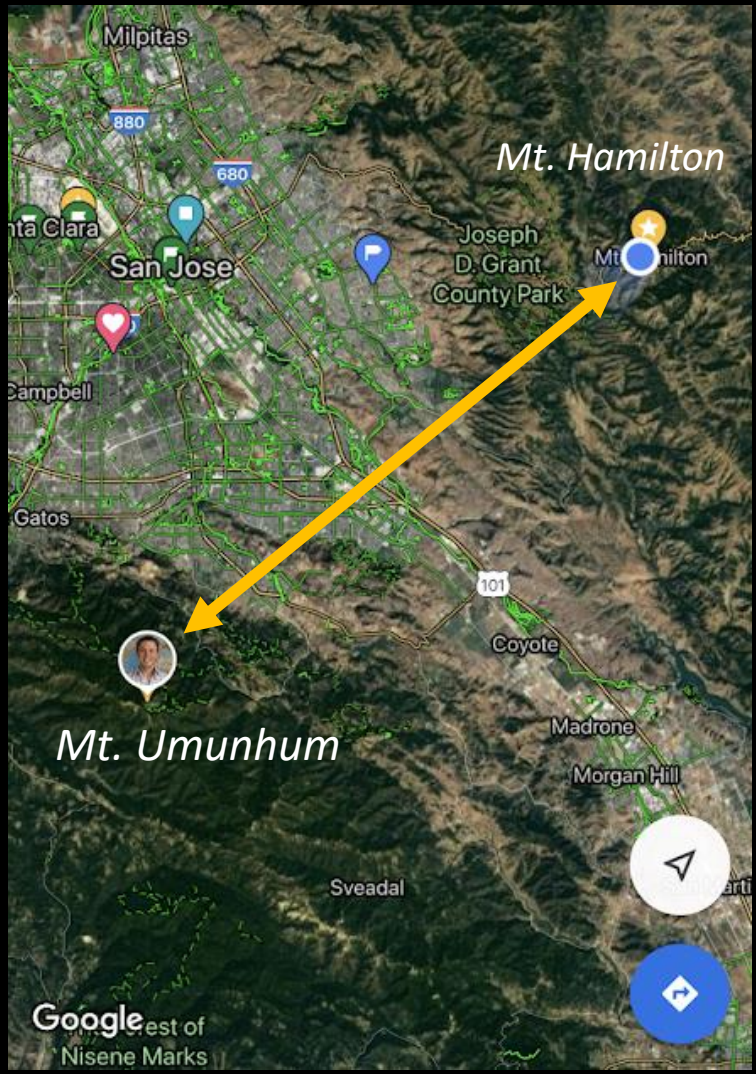


V-R3x Tech Demo



36

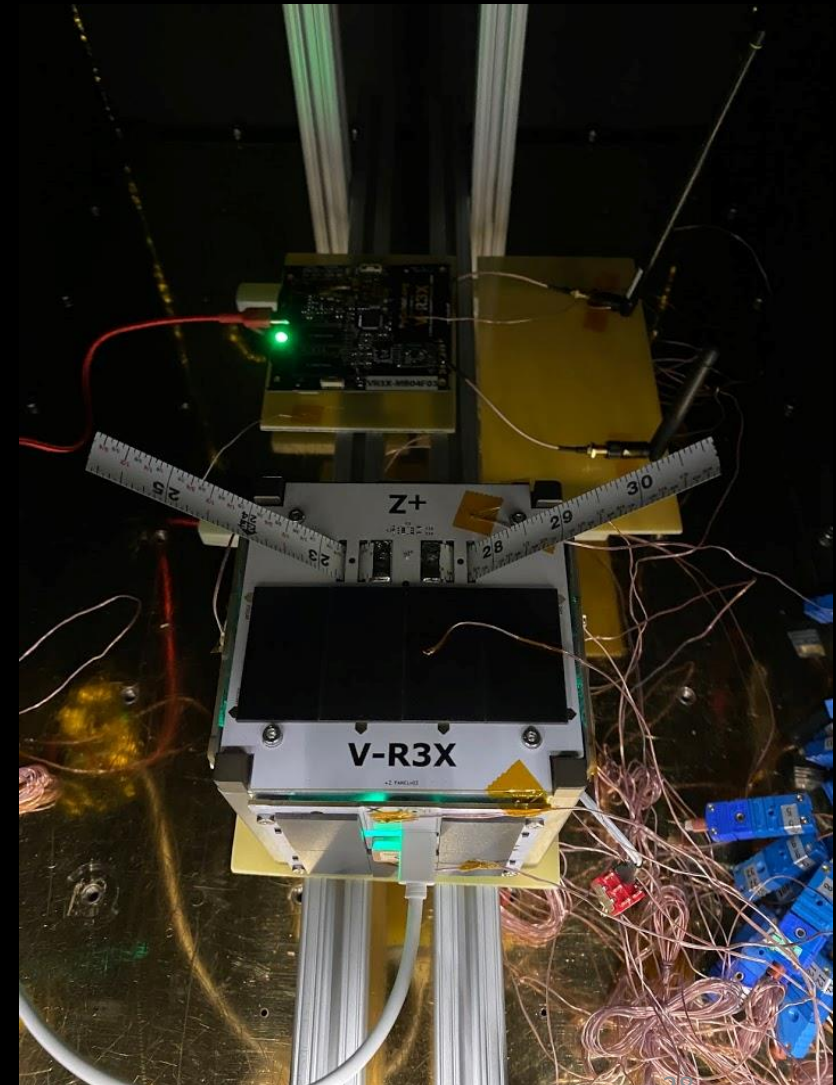
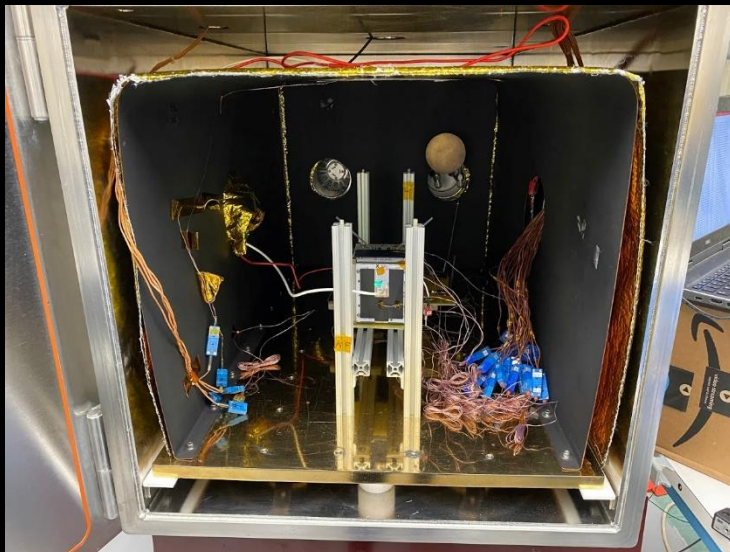
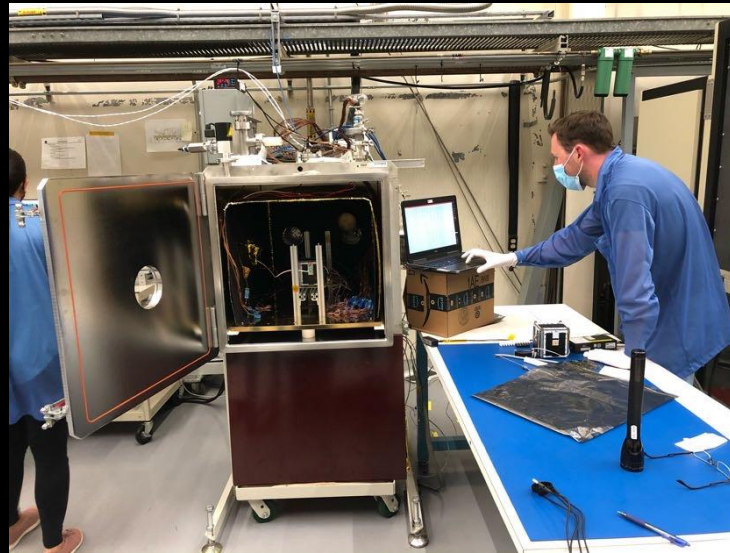
07/19/2020 – Ridge Testing #1



12/3/2020



07/21/2020 TVAC Testing



08/20/2020 – Ridge Testing #2 postponed due to wildfires

Testing @ Mt. Hamilton on 7/19/2020

Lick Observatory

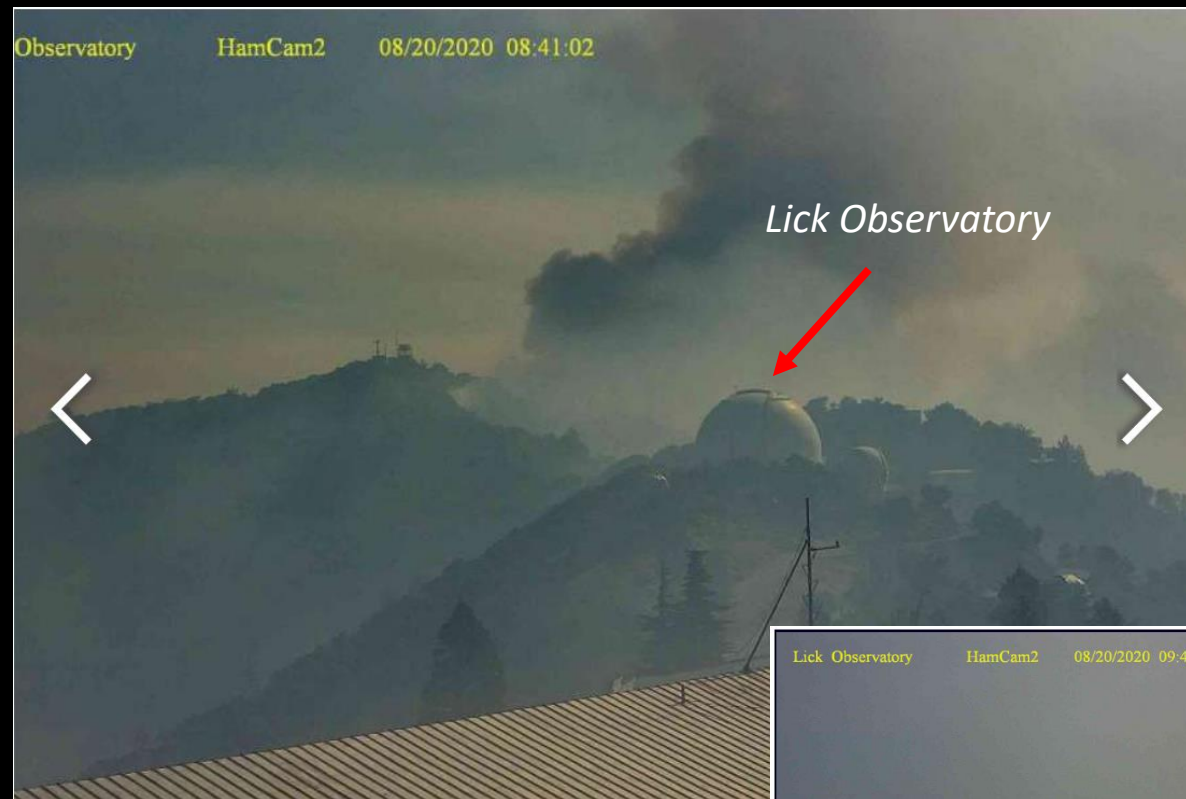


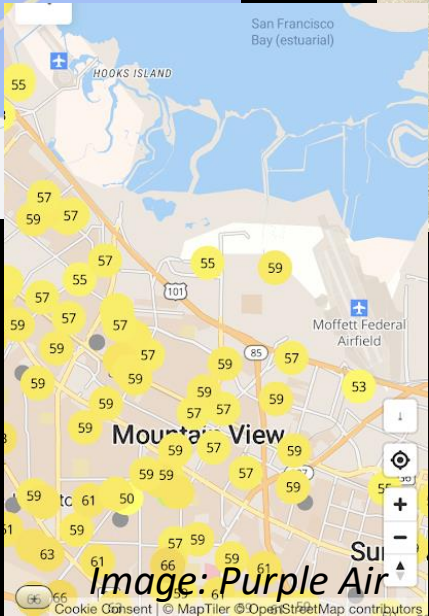
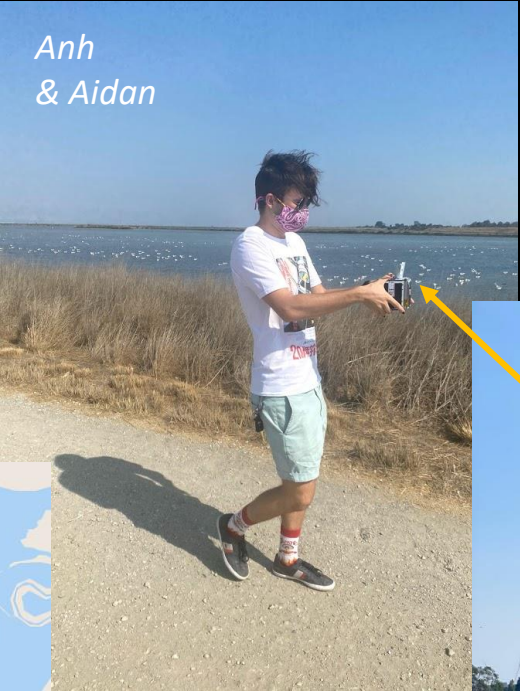
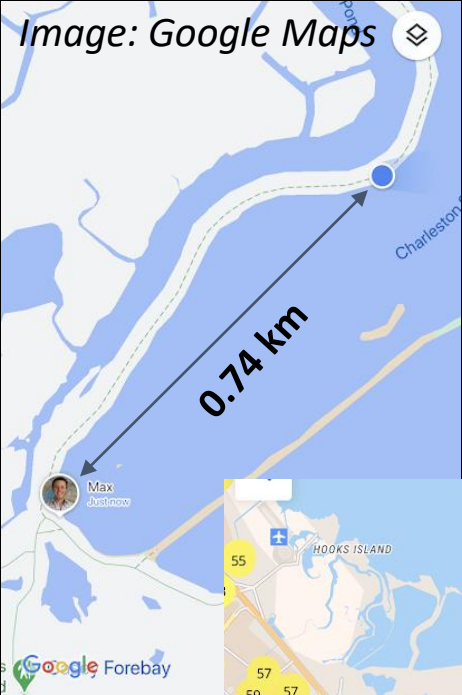
Image (top, right): University of California
Observatories/Lick Observatory



Looking East by Northeast

12/3/2020

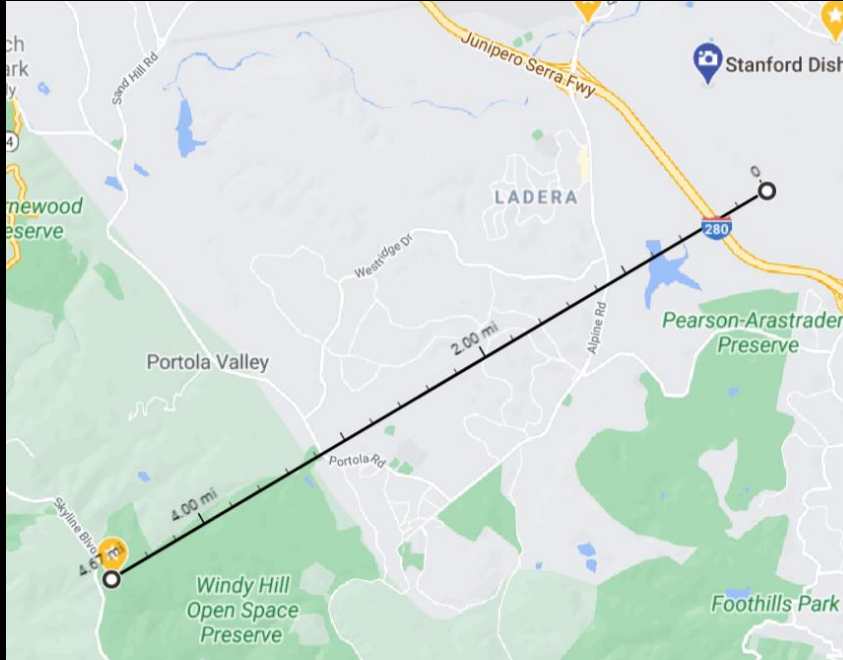
9/20/2020 - V-R3x Range Testing



9/26/2020 Ridge Testing



Setup at Windy Hill



9/27/2020 FM Build Day



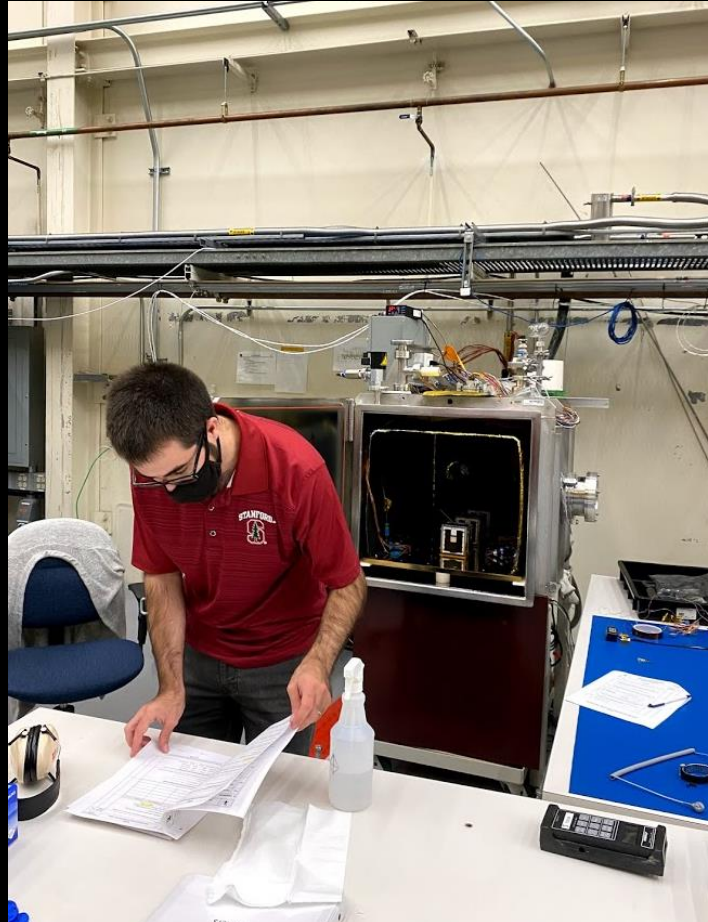
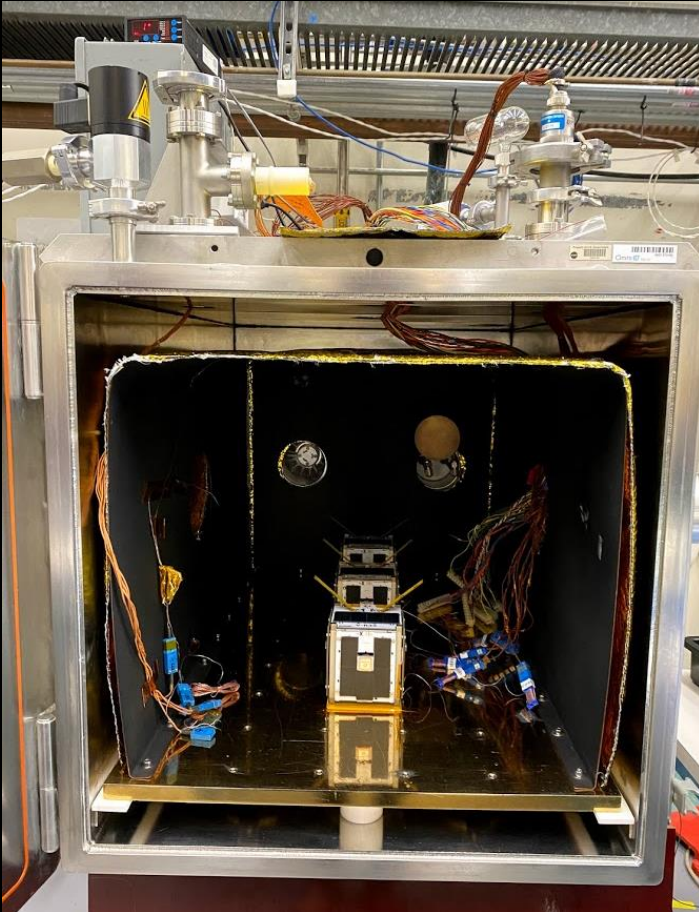
9/27/2020 FM Build Day



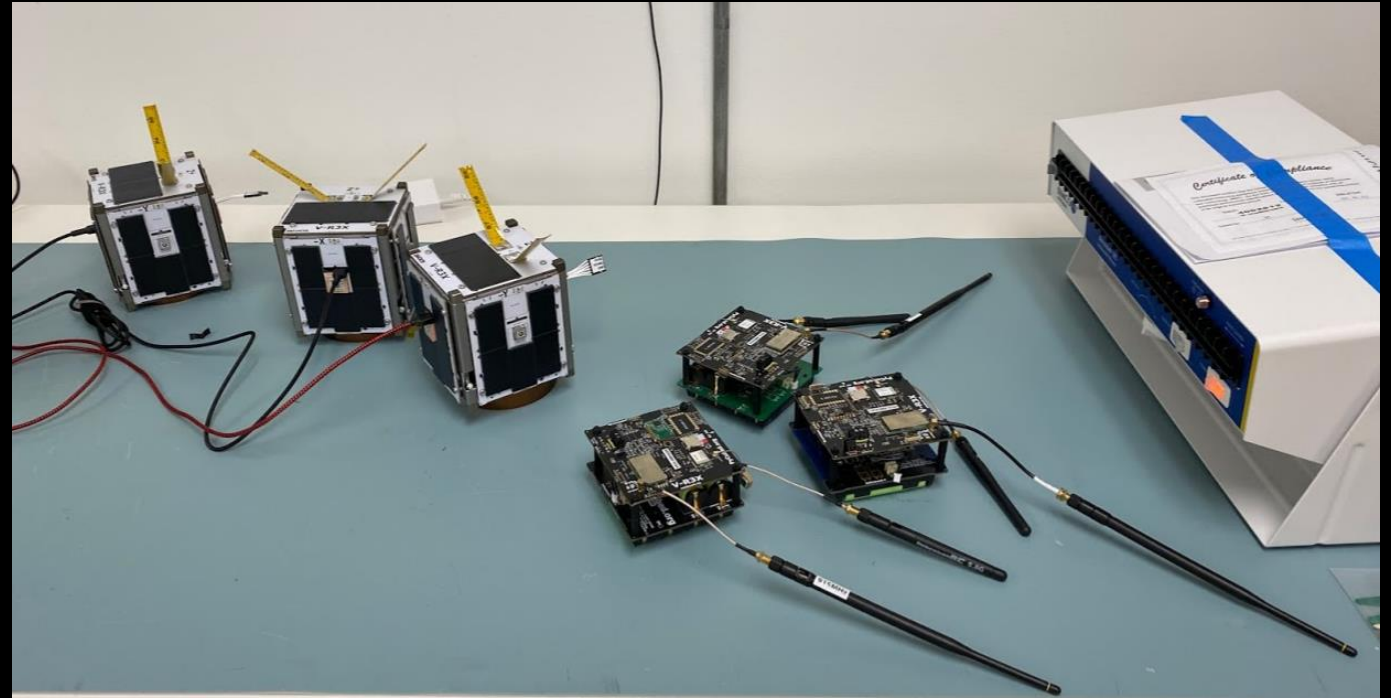
9/30/2020 Random Vibration Test Day



10/14/2020 Bakeout

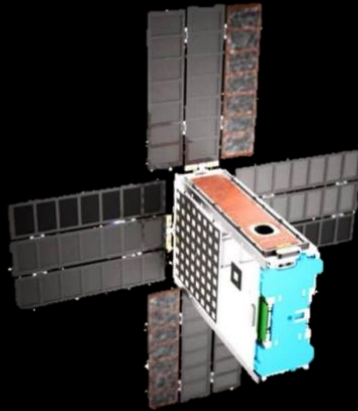


Ready for Launch Jan 14, 2021!



Other Upcoming NASA Ames Projects

- Pathfinder Technology Demonstrators
- CubeSat Laser Infrared Crosslink (CLICK)
- Starling
- BioSentinel
- TechEdSat



Questions

- Interested in working at NASA?
 - Careers: <https://nasai.usajobs.gov/>
 - Internships: <https://intern.nasa.gov/>
- Learn more about NASA STMD: Small Spacecraft Technology Directorate here
 - https://www.nasa.gov/directorates/spacetech/small_spacecraft/index.html

