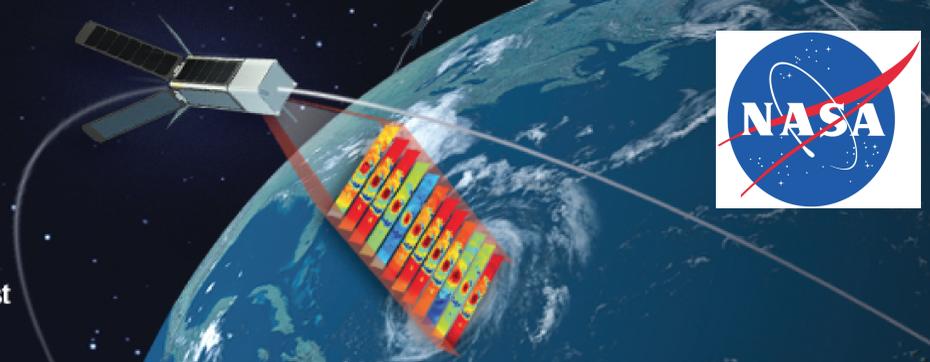




Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

MIT Lincoln Laboratory (proposing organization)

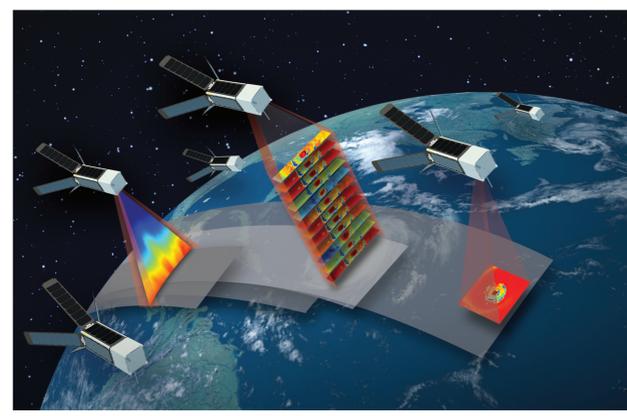
William J. Blackwell, Principal Investigator. Scott Braun (NASA GSFC), Project Scientist



Overview

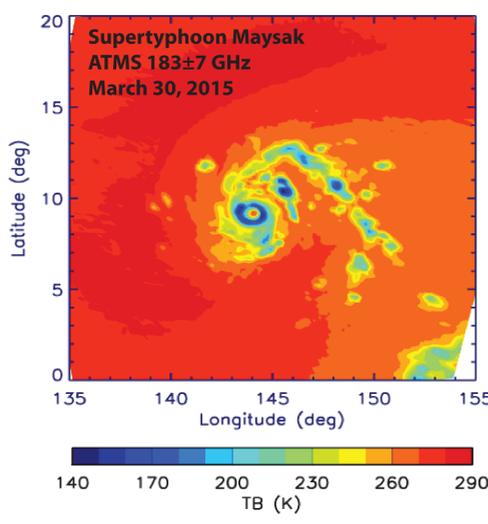
The TROPICS goal is to obtain observations critical to improved understanding of genesis and intensification processes in tropical cyclones and to assessing the impact of SmallSat remote sensing technologies on modeling and analysis. TROPICS will use a constellation of 12 Cubesats each carrying a 12-channel microwave radiometer for three-dimensional temperature and moisture sounding and imaging of storm precipitation structure as measured by brightness temperature proxies that are sensitive to the scattering by precipitation ice within storms. The currently scheduled launch is mid 2019. Mission lifetime will be one year. The TROPICS mission is funded by NASA's Earth Venture-Instrument (EV-I3) program.

- TROPICS will meet key PATH (Precision and All-weather Temperature and Humidity, 2007 NASA Decadal Survey) requirements for temperature and moisture sounding
- TROPICS will quantify warm-core strength and provide storm intensity estimates
- TROPICS will provide precipitation structure information that VIS/IR cannot reveal
- TROPICS will provide ~21-min median refresh rates at all longitudes and ±40° latitude



Science Objectives

- Relate precipitation structure evolution, including diurnal cycle, to the evolution of the upper-level warm core and associated intensity changes
- Relate the occurrence of intense precipitation cores (convective bursts) to storm intensity evolution
- Relate retrieved environmental moisture measurements to coincident measures of storm structure (including size) and intensity
- Assimilate microwave radiances and/or retrievals in mesoscale and global numerical weather prediction models to assess impacts on storm track and intensity



Significance to NASA

- Achieves the first high-revisit near-global microwave observations of precipitation, temperature, and humidity
- Fulfills most of NASA's PATH mission objectives using a low-cost, easy-to-launch CubeSat constellation
- Complements GPM, CYGNSS, and GOES-R missions with high refresh, near-all-weather measurements of precipitation and thermodynamic structure
- Increases understanding of critical processes driving significant and rapid changes in storm structure/intensity

Product Horizontal Resolution vs. ATMS

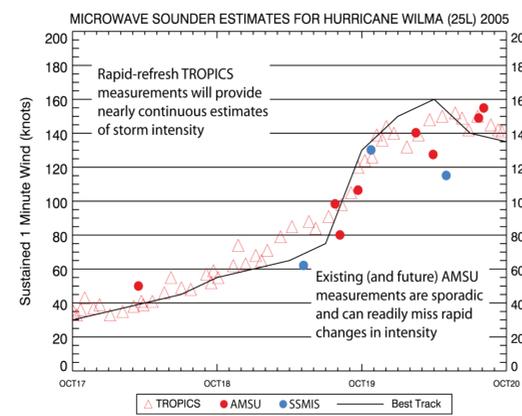
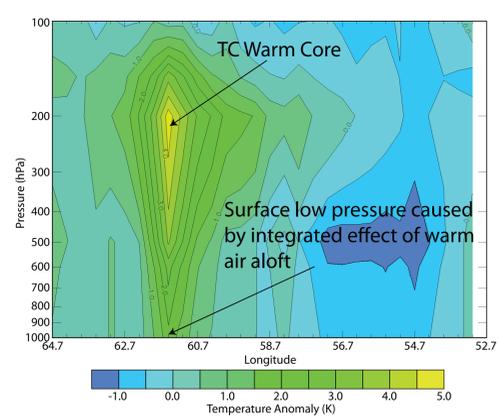
	ATMS Nadir/Avg (km)	TROPICS Nadir/Avg (km)
Temperature	33/44	27/40
Moisture & Precipitation	17/24	17/24
Swath width	2250 (±50.5°)	2025 (±56°)

Revisit time for baseline and threshold missions

	Average (min)	Median (min)	Frequency of gaps <2 hr
Baseline 12 satellites	31	21	67%
Threshold 8 satellites	47	31	65%

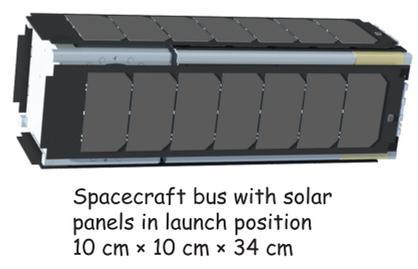
Data Products

- Retrieved 3-D temperature and humidity profiles (2-3 km vertical resolution)
- Precipitation/convection indicators via brightness temperatures, scattering index, rainfall rates
- Storm intensity estimates
- Data latency: <2 hours 70% of the time, <1 day most of the time. Add one hour for data processing.

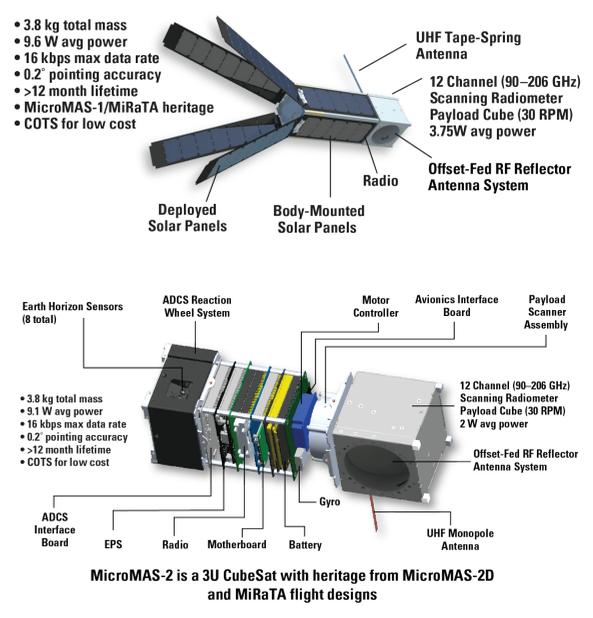


Spacecraft and Instrument Characteristics

- 3U CubeSat (2U spacecraft bus, 1U radiometer)
- 12-channel passive microwave radiometer
- 90 & 206 GHz imaging channels
- Temperature sounding with 7 channels near 118 GHz (114.9, 115.5, 116.1, 116.7, 117.3, 118.0 GHz)
- Moisture sounding with 3 channels near 183 GHz (183.31±1, ±3, ±7 GHz)



The MicroMAS-2 CubeSat (3U)



Pre-mission:

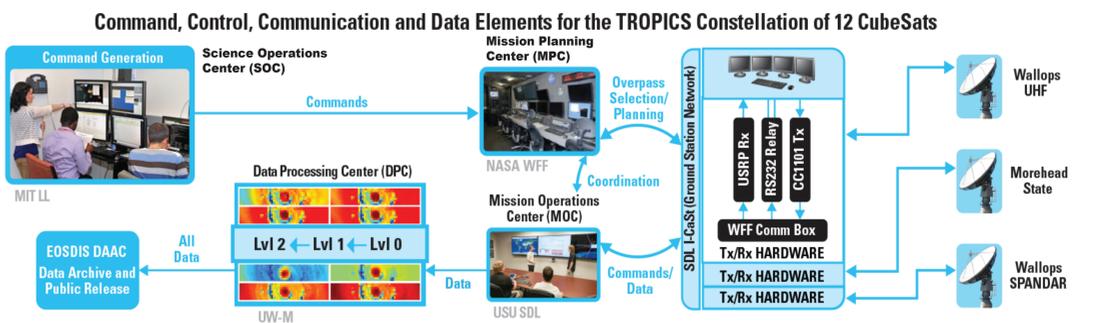
- Test launch #1 in March-June 2017. Similar design but different solar panels
- Test launch #2 in December 2017. Similar design but with new payload assembly and lighter weight solar panels (if needed).

Mission phase:

- 4 CubeSats in each of 3 orbital planes
- Orbit altitude of 600 km, 30° inclination
- 1 year mission lifetime

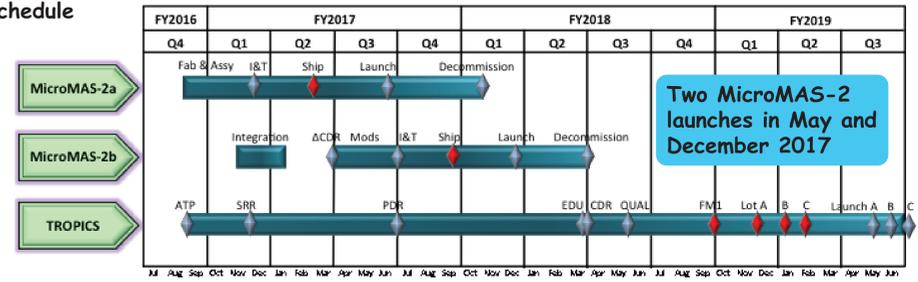


Mission Operations



Science Operations Center (LL/MIT): Generates commanding for early orbit activation and checkout for each CubeSat. Monitors the health and status of CubeSats and takes appropriate actions on any anomalies.
Mission Planning Center (WFF): Operates the TROPICS ground stations and ensures maximum contact time with the constellation.
Mission Operations Center (Utah State Univ./Space Dynamics Lab): Coordinates with the SOC and MPC for daily operations. Provides command and control for the constellation as directed by the SOC. Receives and stores telemetry from each satellite.

Schedule



Participating Organizations		
MIT Lincoln Laboratory	PI institution, CubeSat development, calibration and testing, Level 1 data product lead, Level 2 algorithm developer, Science Operations Center	NASA Wallops FM CubeSat assembly and test, ground stations, Mission Planning Center
University of Wisconsin - Madison	Data Processing Center, Level 2 data product lead and algorithm developer, science relating warm-core evolution to storm structure and intensity	USU Space Dynamics Laboratory Mission Operations Center, Ground Station Network
NASA Goddard Space Flight Facility	Project Scientist, data assimilation, study of moisture impacts on structure and intensity	University of Massachusetts Amherst Receiver front end
NOAA National Weather Service National Hurricane Center	Study precipitation structure evolution and microwave parameters in statistical storm intensity models	NOAA Atlantic Oceanographic Meteorological Laboratory Regional assimilation leadership; intensity and track forecasting; operations calibration and validation
MIT Space Systems Laboratory	Validation of on-orbit radiometric and spacecraft telemetry data; orbital dynamics analysis and optimization	Cornell University Optimize constellation architecture; orbital analysis to maintain constellation revisit rates
CIMAS University of MIAMI (Cooperative Institute of Marine and Atmospheric Studies)	Study relationship between moisture and precipitation to the storm's structure and intensity, diurnal cycle of hurricane structure	Tufts University Geolocation and calibration