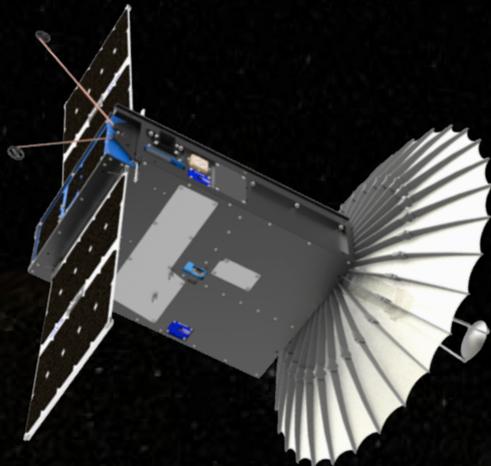




# RainCube and Its Initial Post-Launch Operations



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RainCube is a ***technology demonstration*** mission to enable ***Ka-band*** precipitation radar technologies on a low-cost, quick-turnaround platform.

- **InVEST-15 Selection, ESTO**

- Validate new Earth science technologies in space (TRL 4 to TRL 7)
- 6U CubeSat, deploy to LEO from ISS
- Three month primary mission (1 month payload demo phase)

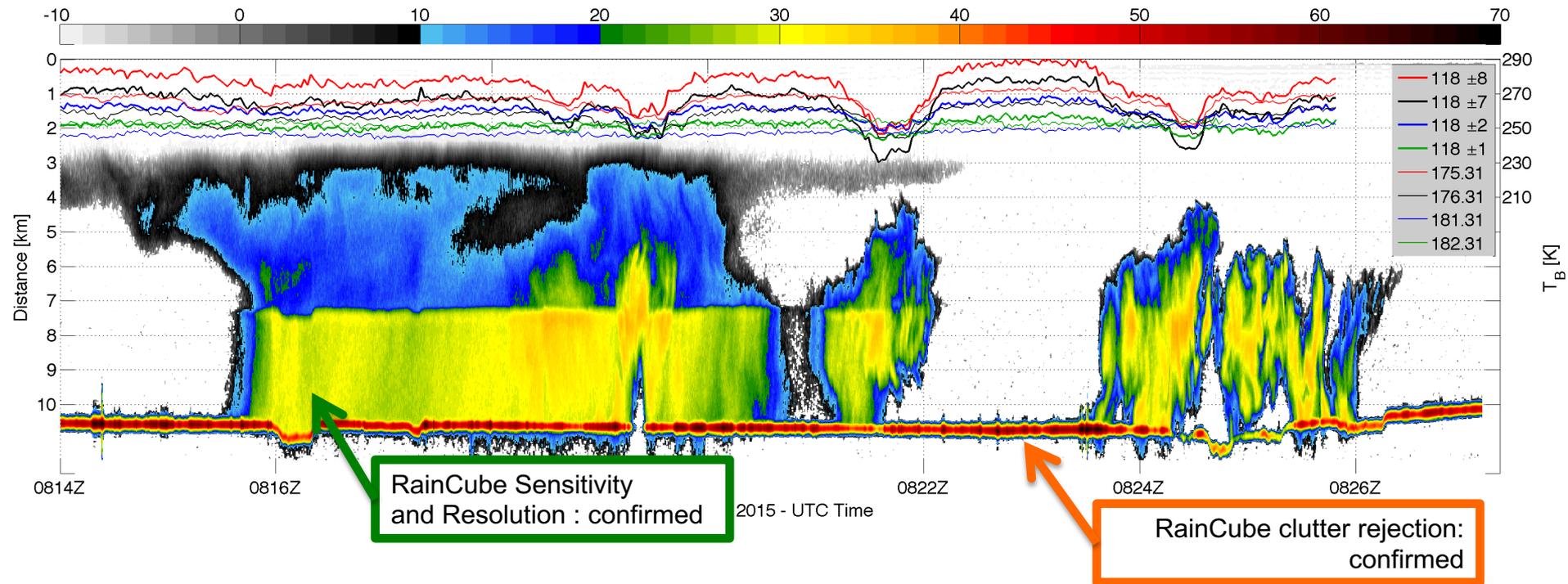
- **Two Key Mission Objectives**

- Demonstrate new technologies in Ka-band on a CubeSat platform
  - Miniaturized Ka-band Atmospheric Radar for CubeSats (miniKaAR-C)
  - Ka-band Radar Parabolic Deployable Antenna (KaRPDA)
- Enable precipitation profiling radar missions for Earth Science

- **Roles & Responsibilities**

- NASA ESTO: Sponsor
- JPL: Project Management, Mission Assurance, Radar Delivery
- Tyvak: Spacecraft Delivery, System I&T, Mission Operations

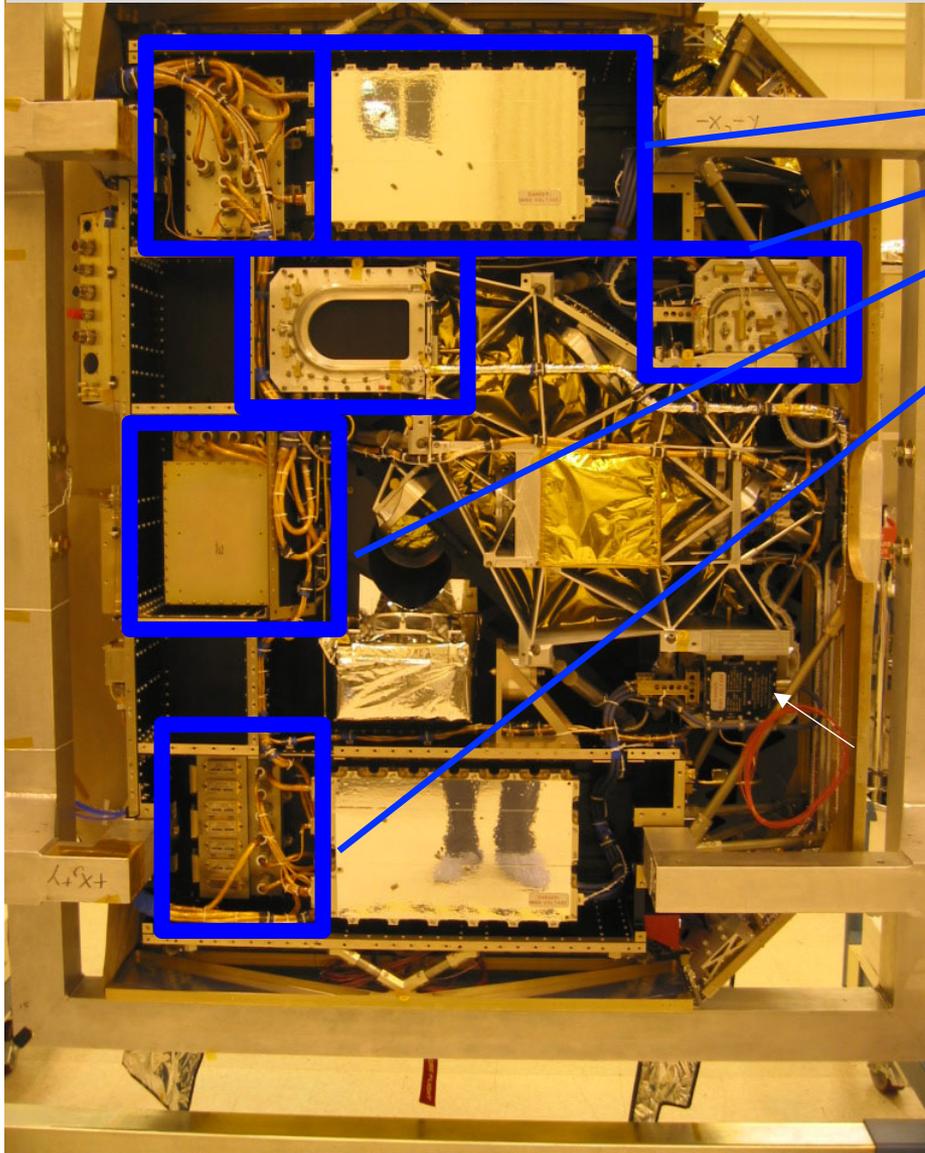
# RainCube measurement (from 2015 airborne demonstration)



# How small is RainCube. . .



**CloudSat's Cloud Profiling Radar  
~200U**



**RainCube Radar in 6U  
CubeSat ~2.5U**

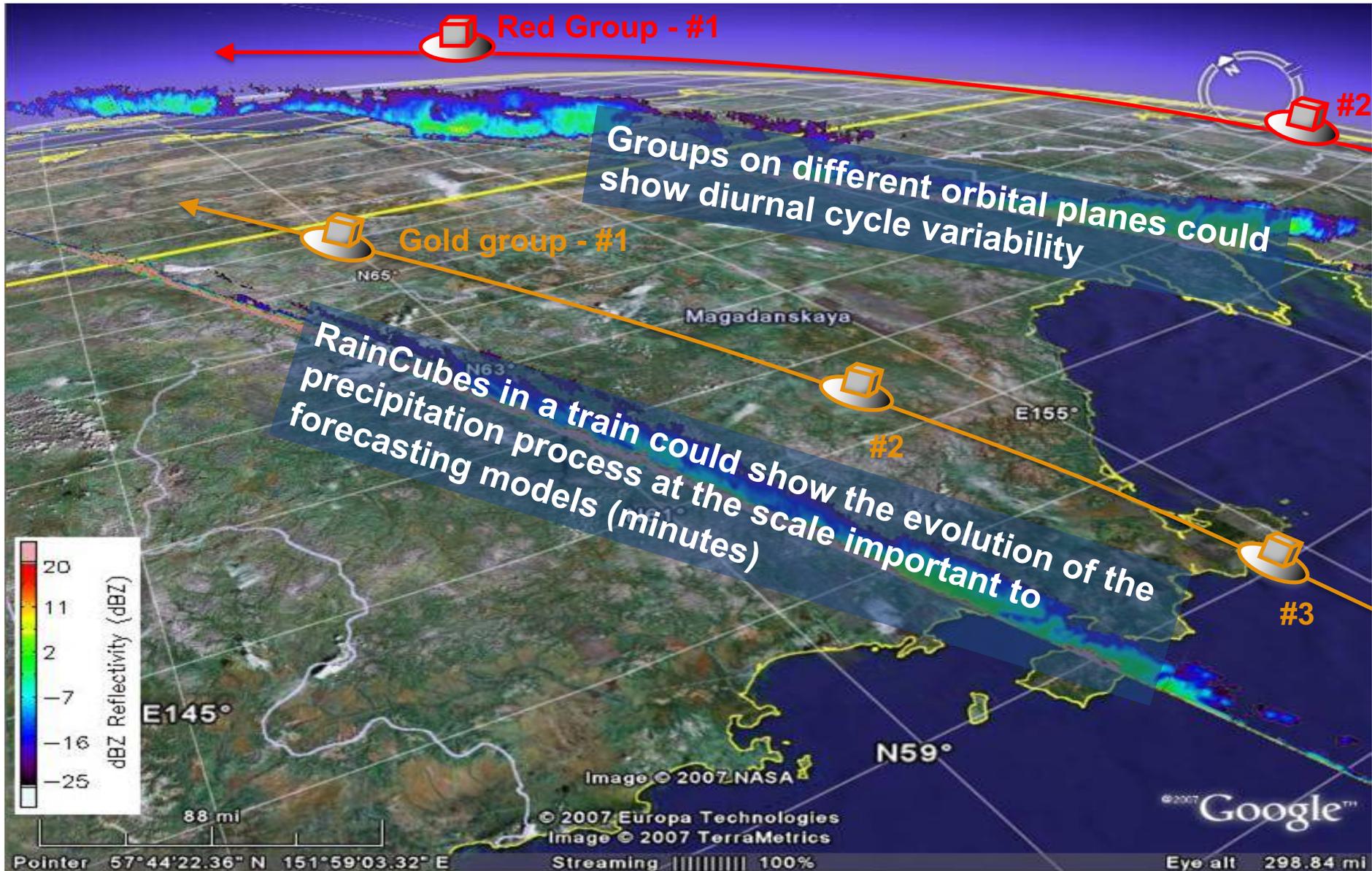


**1U  
10x10x10cm**



These two images are approximately to scale

# Science motivation



Red Group - #1

#2

Groups on different orbital planes could show diurnal cycle variability

Gold group - #1

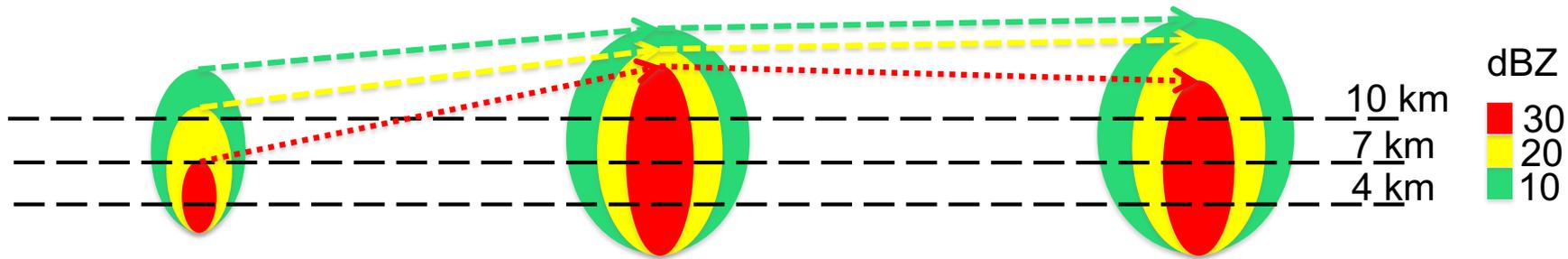
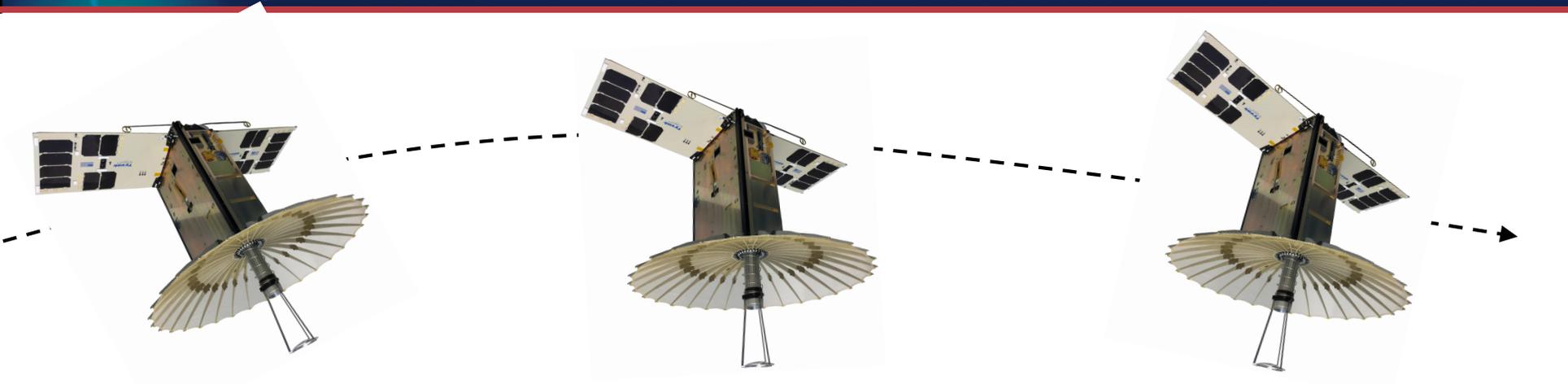
#2

RainCubes in a train could show the evolution of the precipitation process at the scale important to forecasting models (minutes)

#3

RainCube, a Ka-band precipitation radar in a 6U CubeSat

# RainCube in a train



RainCube, a Ka-band precipitation radar in a 6U CubeSat

# System Architecture

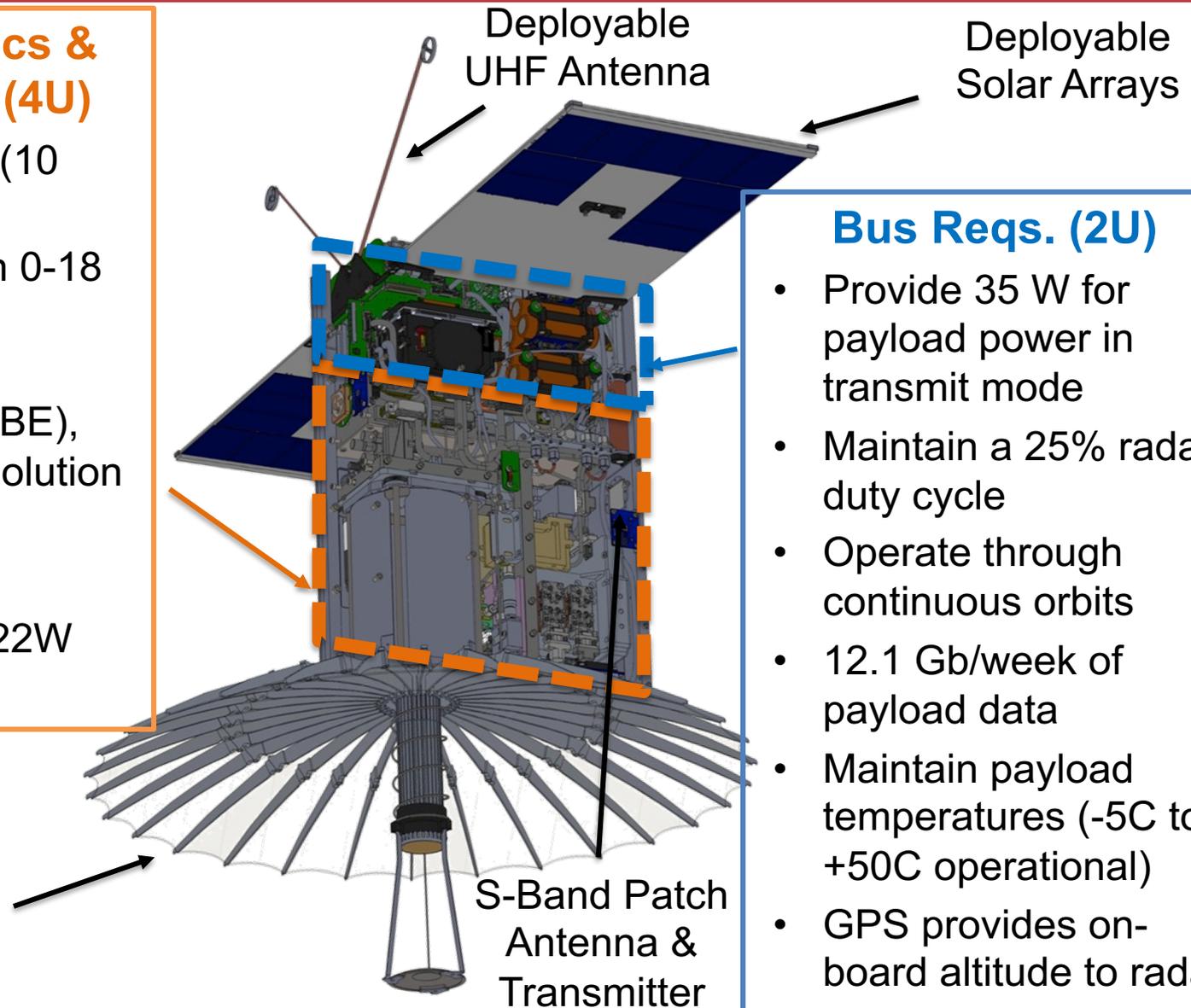


## Radar Electronics & Antenna Reqs. (4U)

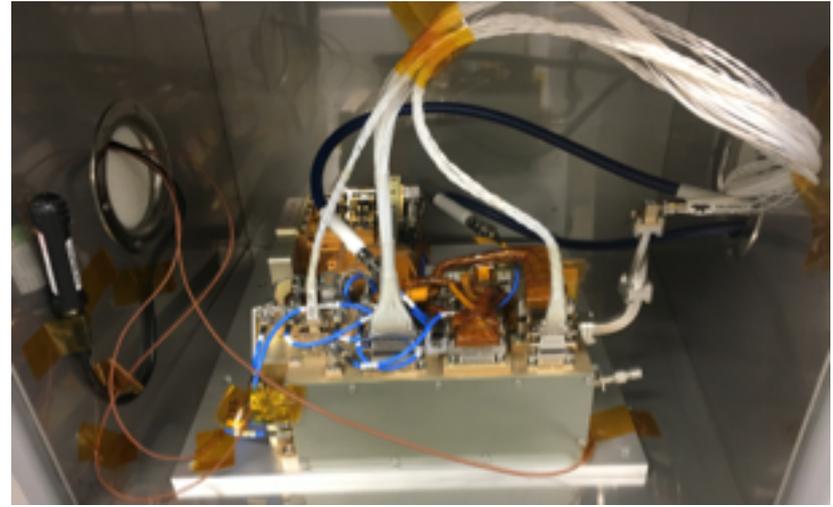
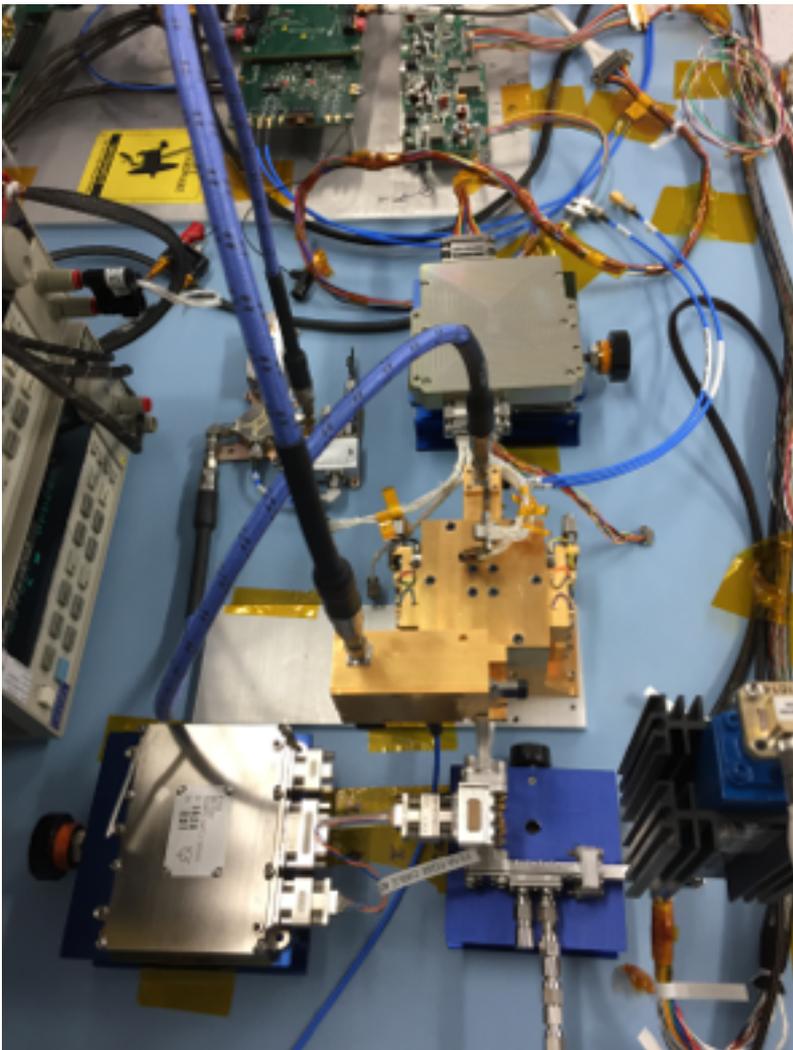
- 20dBZ sensitivity (10 dBZ CBE)
- Vertically profile in 0-18 km altitudes
- 10 km horizontal resolution (8km CBE), 250 m vertical resolution
- 0.5m deployable antenna
- 35W in transmit (22W CBE)

## Bus Reqs. (2U)

- Provide 35 W for payload power in transmit mode
- Maintain a 25% radar duty cycle
- Operate through continuous orbits
- 12.1 Gb/week of payload data
- Maintain payload temperatures (-5C to +50C operational)
- GPS provides on-board altitude to radar

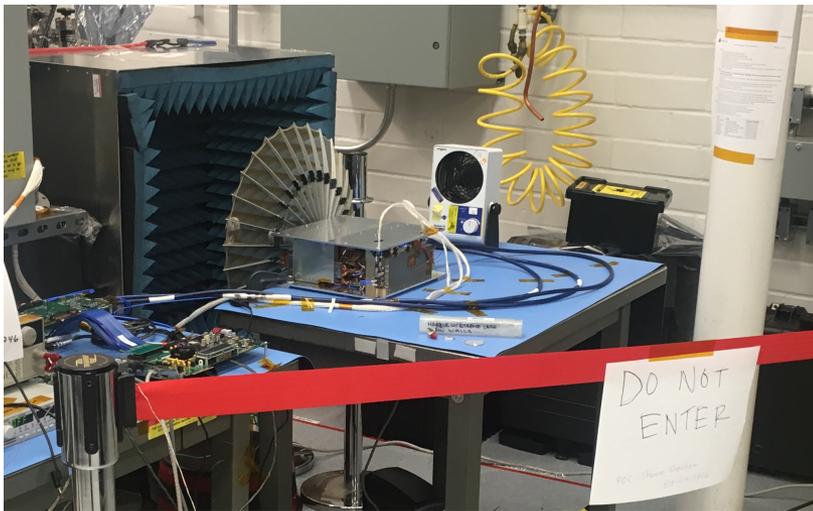
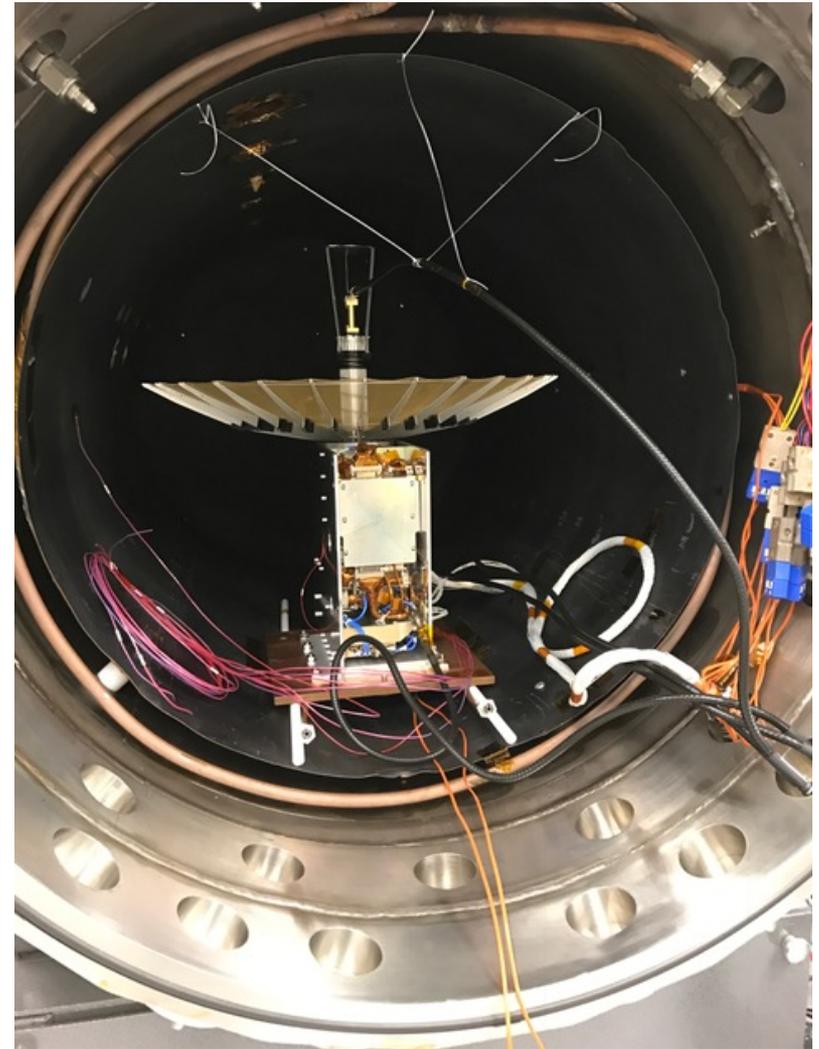
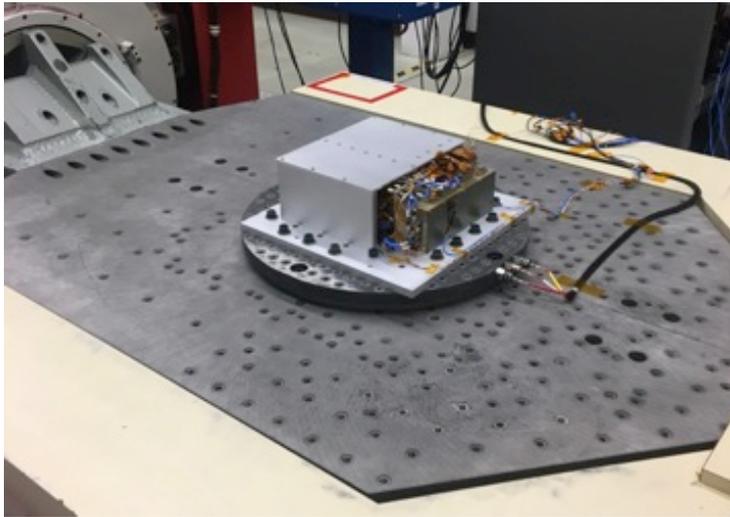


# Radar assembly

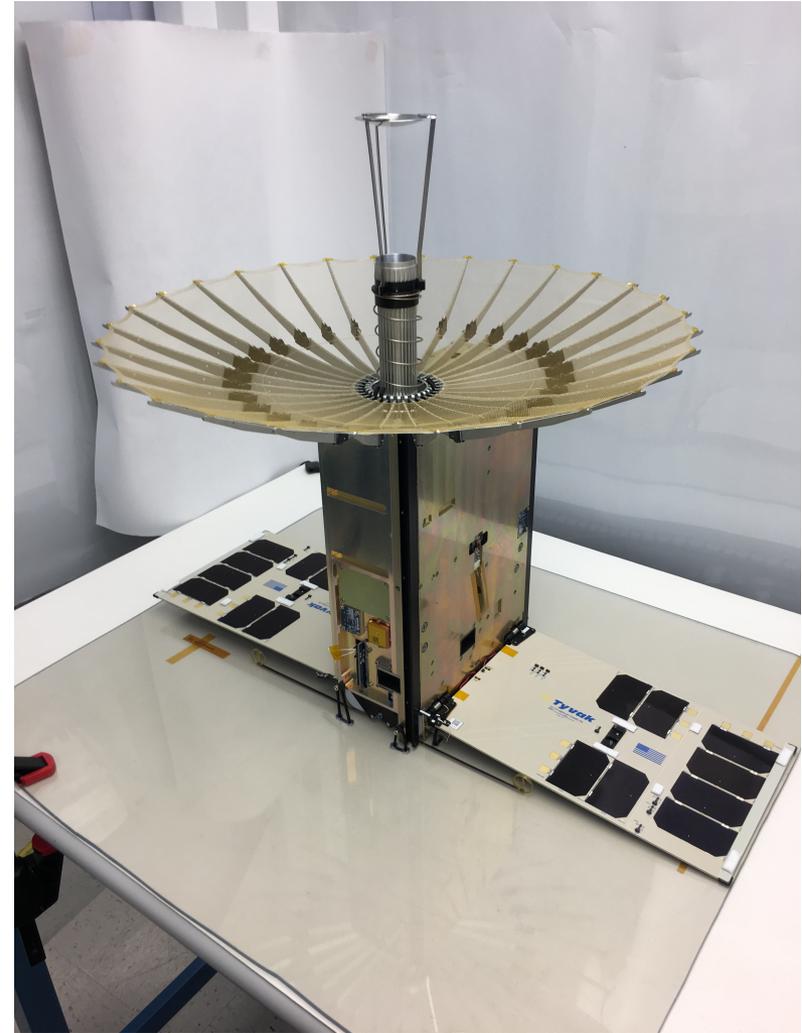
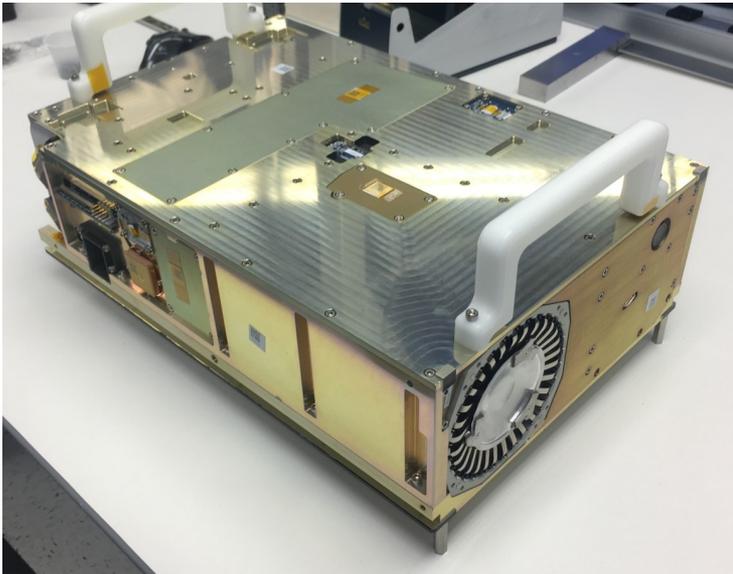


RainCube, a Ka-band precipitation radar in a 6U CubeSat

# Radar environmental testing

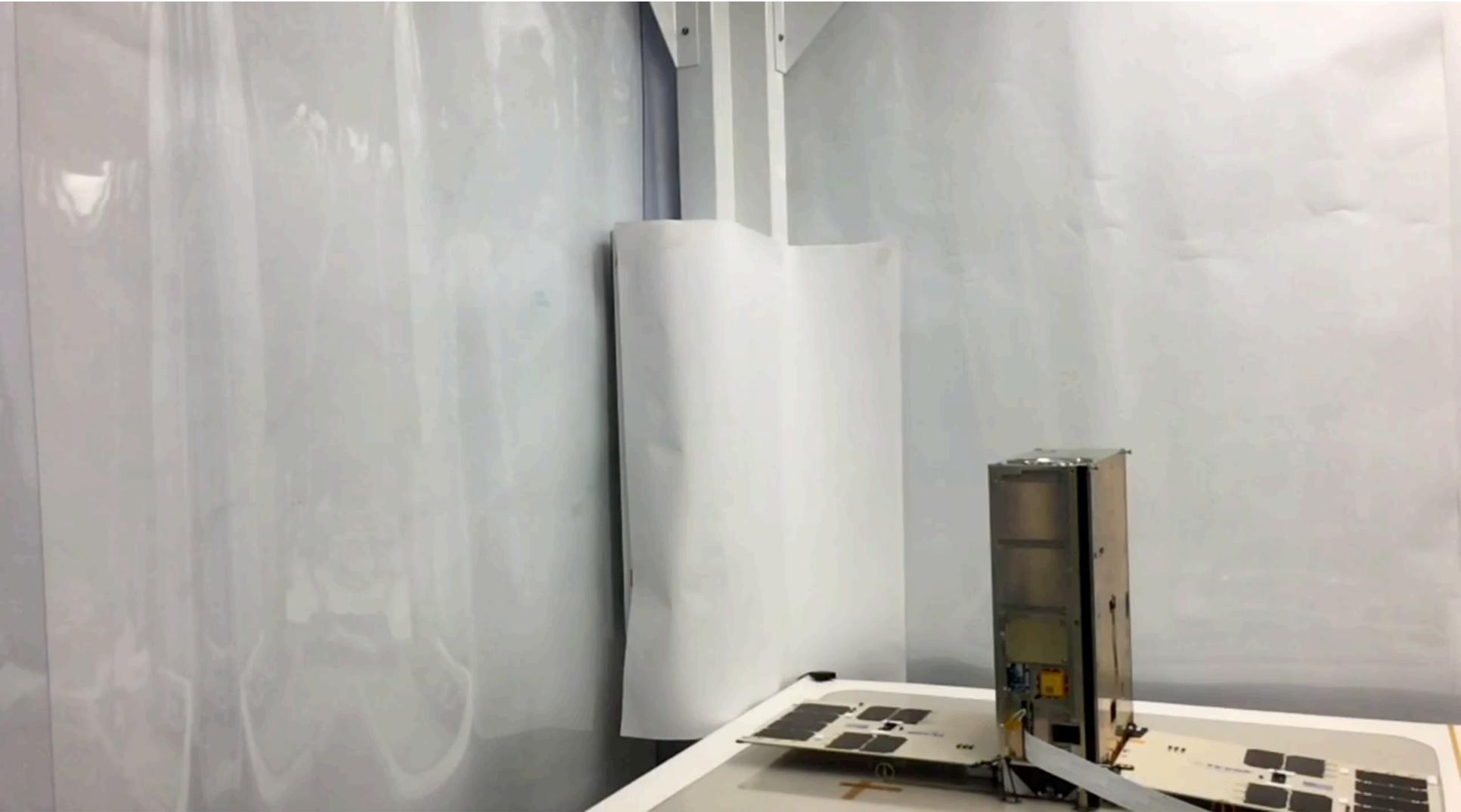


RainCube, a Ka-band precipitation radar in a 6U CubeSat



RainCube, a Ka-band precipitation radar in a 6U CubeSat

# Antenna deployment



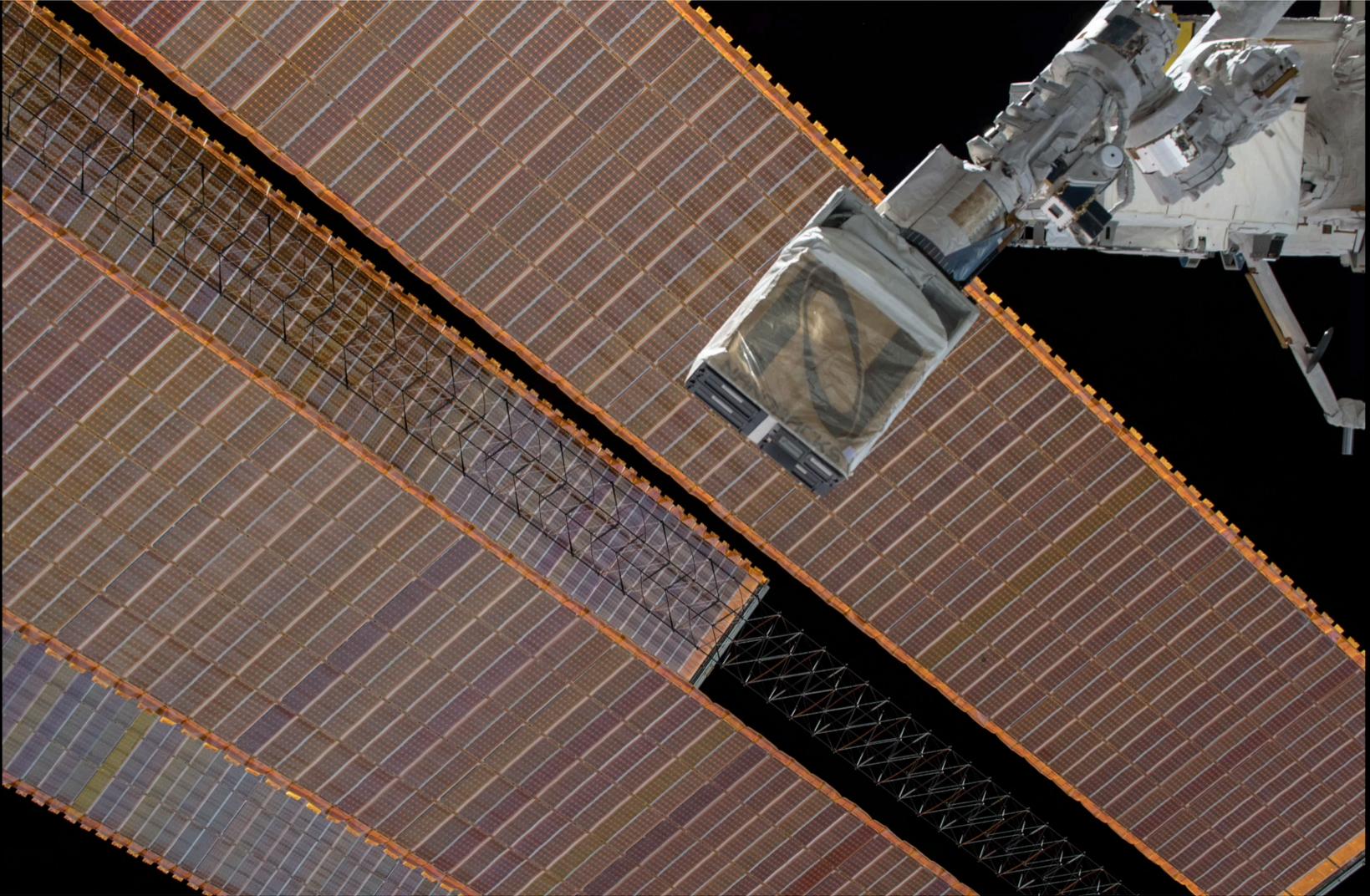
RainCube, a Ka-band precipitation radar in a 6U CubeSat

# Cygnus OA-9 Launch to ISS, 5/21/2018



RainCube, a Ka-band precipitation radar in

# RainCube Deployment from ISS, 7/13/2018



# Antenna Deployment, 7/28/2018



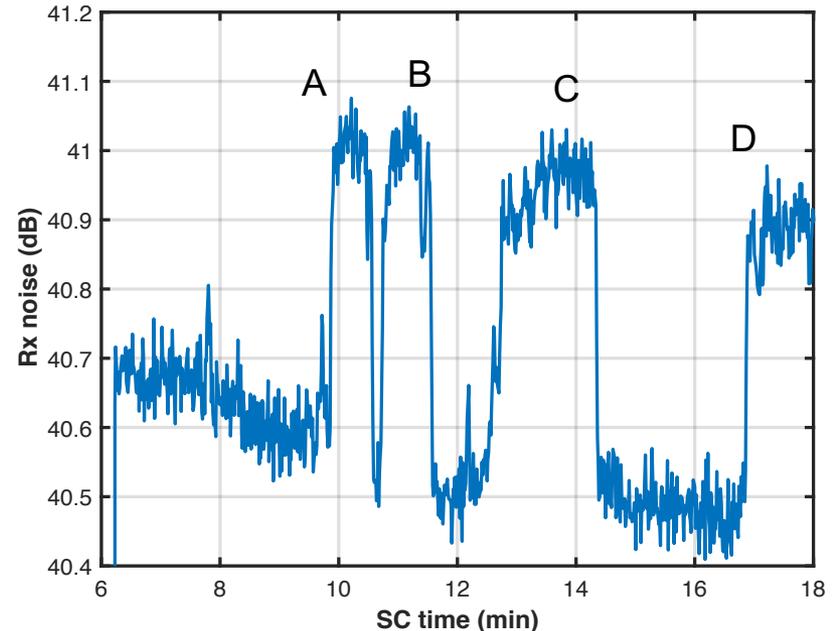
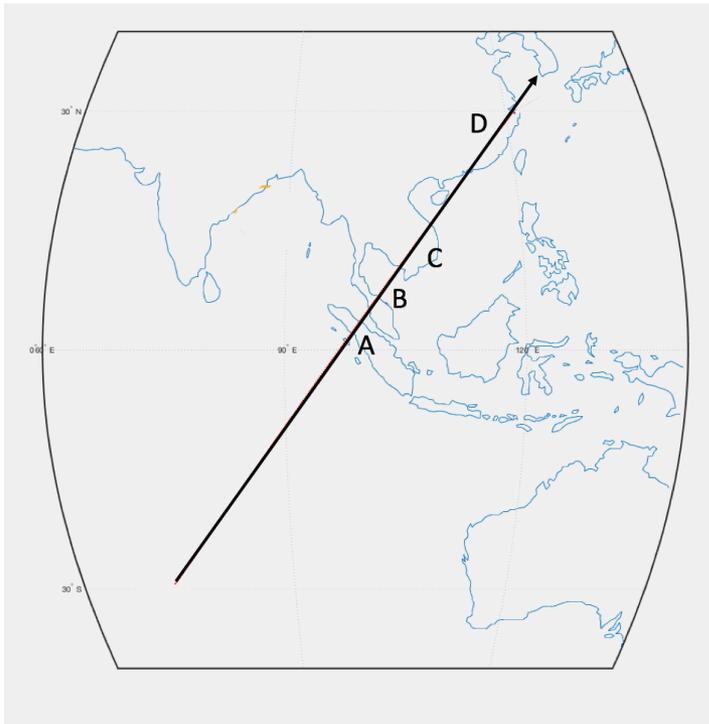
RainCube, a Ka-band precipitation radar in a 6U CubeSat

# Satellite Bus Commissioning Status



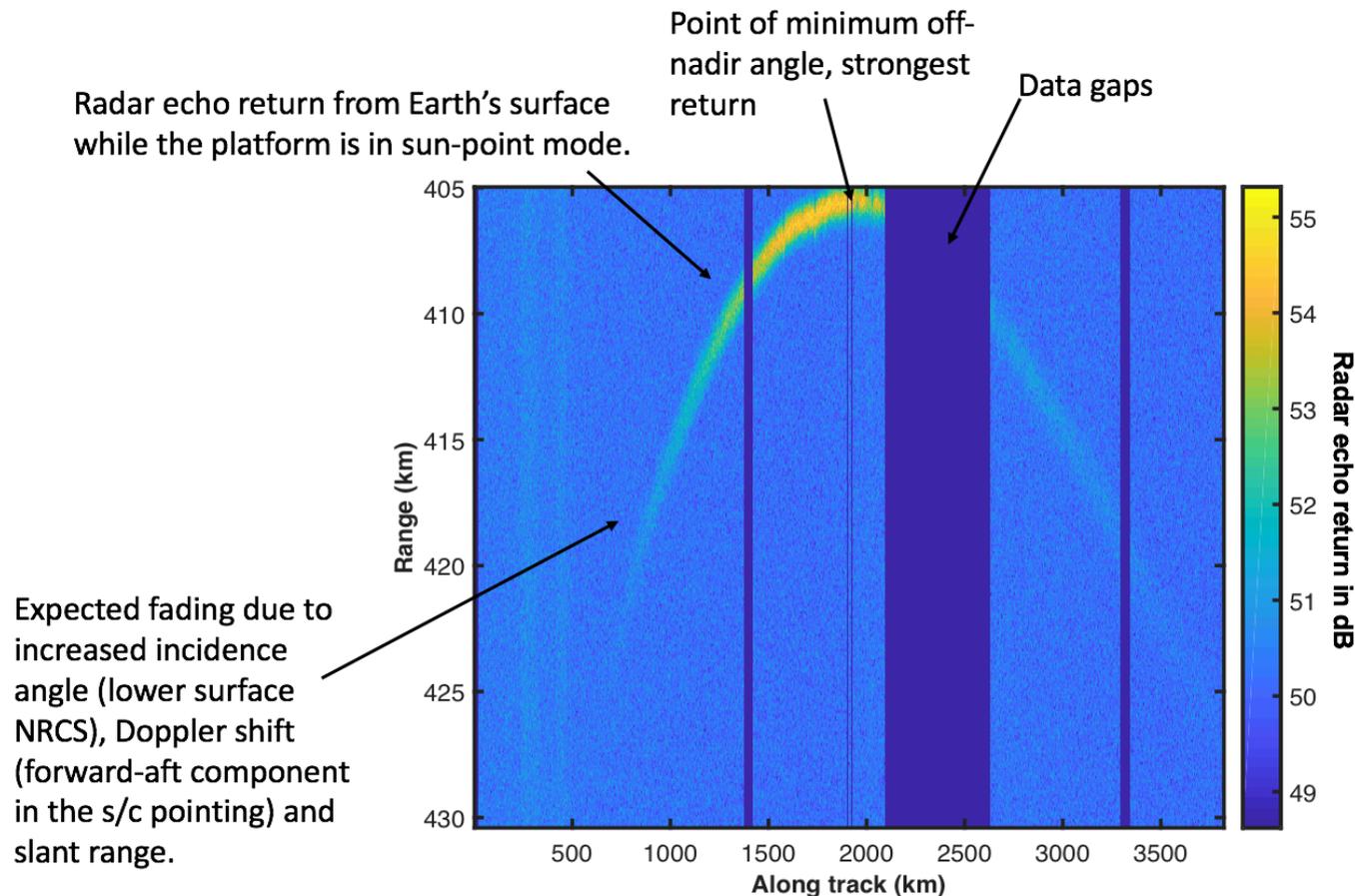
- RainCube satellite bus commissioning phase is on-going
- Achievements so far:
  - UHF communication and S-band downlinks are reliable
  - Solar array deployed
  - Vehicle state of charge is nominal
  - Reaction wheels are active
  - Torque rods are active and managing momentum
  - Star trackers and sun sensors are operational
  - GPS has achieved lock
  - GNC calibration on-going
- Issue being worked:
  - Frequent C&DH subsystem reboots
    - They usually, but not always, occur during eclipse or shortly after exiting eclipse
    - Root cause investigation is on-going

- RainCube radar instrument was successfully commanded to receive mode
  - receiver gain was nominal
  - changes in the measured (uncalibrated) receive noise variations were qualitatively consistent with the expected changes in ocean/land brightness temperature



Higher receive noise corresponds to regions of land with higher brightness temperature

- RainCube radar instrument was subsequently commanded to transmit mode and it successfully acquired surface backscattered measurements in clear air.



- **June '17:** Radar delivery to Tyvak and begin of system I&T
- **Feb. '18:** Mission readiness review and delivery to Nanoracks
- **May '18:** Launch to ISS
- **July '18:** ISS deployment!
- **Oct '18 (est.):** Primary mission complete

