MarCO: Early Flight Status

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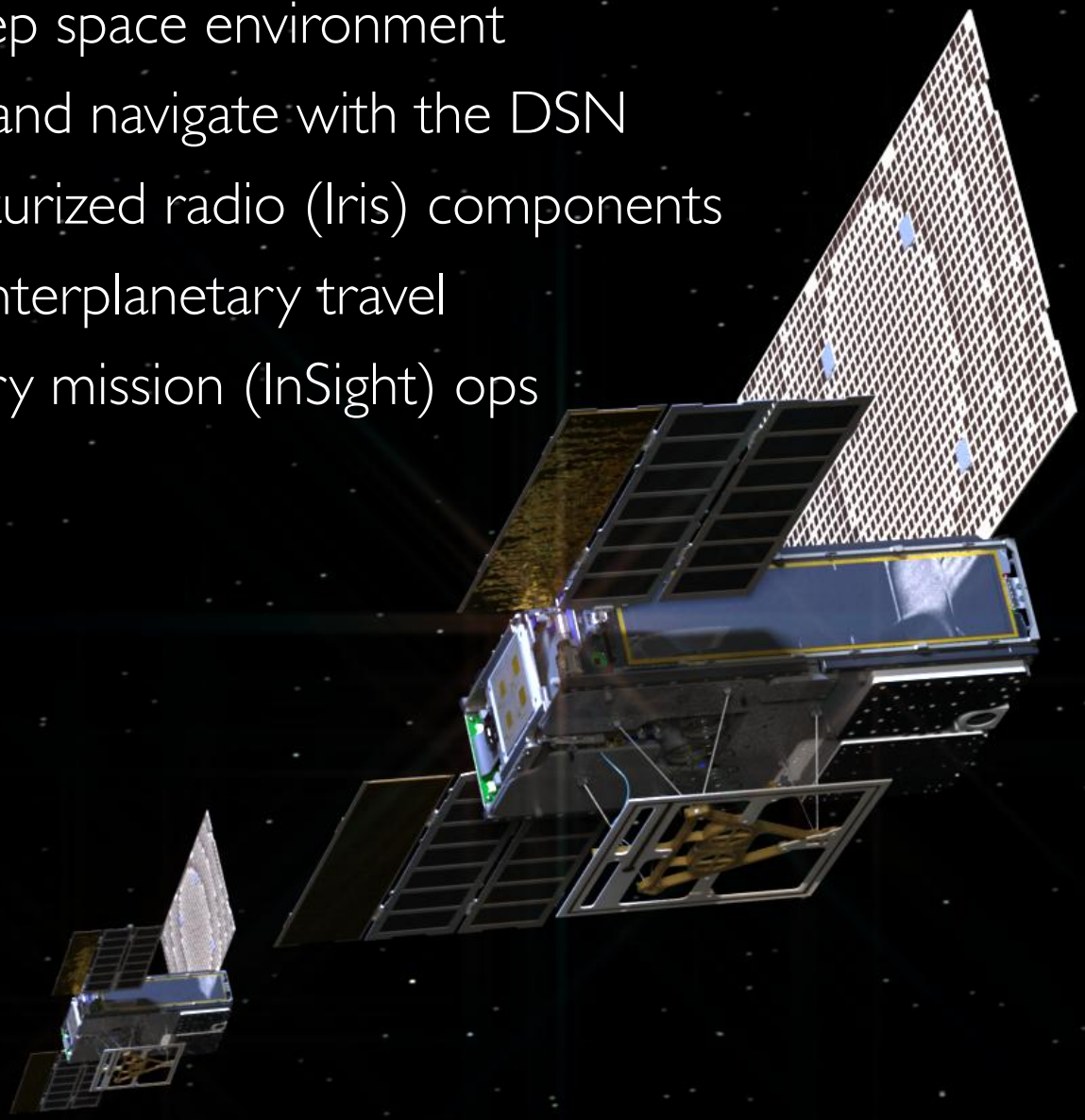
Dr. Andrew Klesh

- U. Michigan – BSE Aero / EE, MSE Aero, MEng Space Systems, PhD Aero
- RAX CubeSat – Postdoc / Chief Engineer
- JAXA Postdoc (Hayabusa / Ikaros)

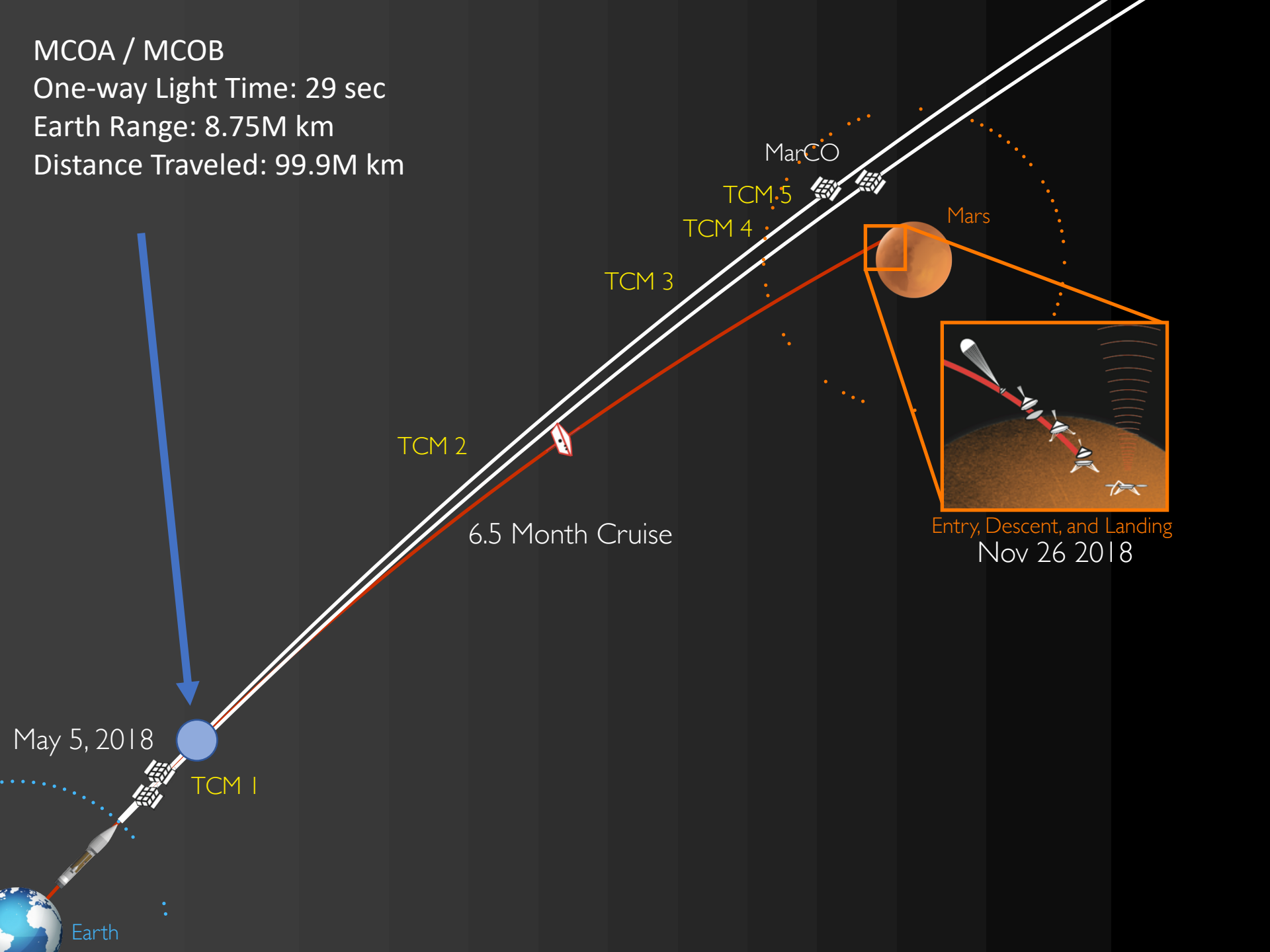
- NASA/JPL – Small Spacecraft and Ocean Worlds → Extreme Exploration
  - INSPIRE PI & MarCO Chief Engineer
  - Buoyant Rover Tech Lead
- Caltech Lecturer & ASU Adjunct Faculty

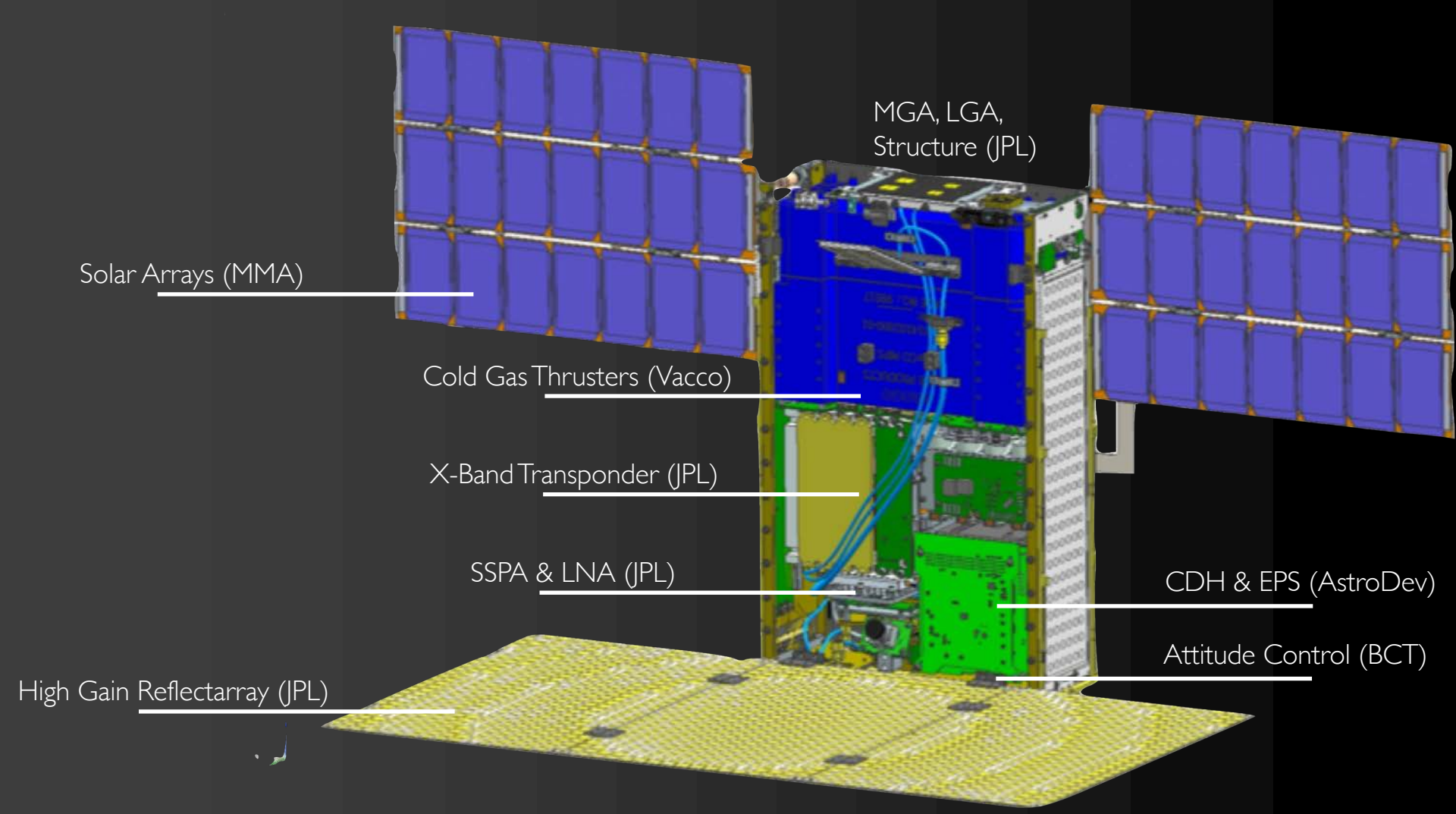
MarCO is a CubeSat technology demonstration to:

- Survive the deep space environment
- Communicate and navigate with the DSN
- Advance miniaturized radio (Iris) components
- Maneuver for interplanetary travel
- Support primary mission (InSight) ops



MCOA / MCOB
One-way Light Time: 29 sec
Earth Range: 8.75M km
Distance Traveled: 99.9M km





MarCO Overview:
Volume: 2 x 6U (10x10x30cm)
Mass: 14.0kg
Power: Earth 35 W / Mars 17W
Data Rates: 62-8000 bps
Delta-V: > 40 m/s

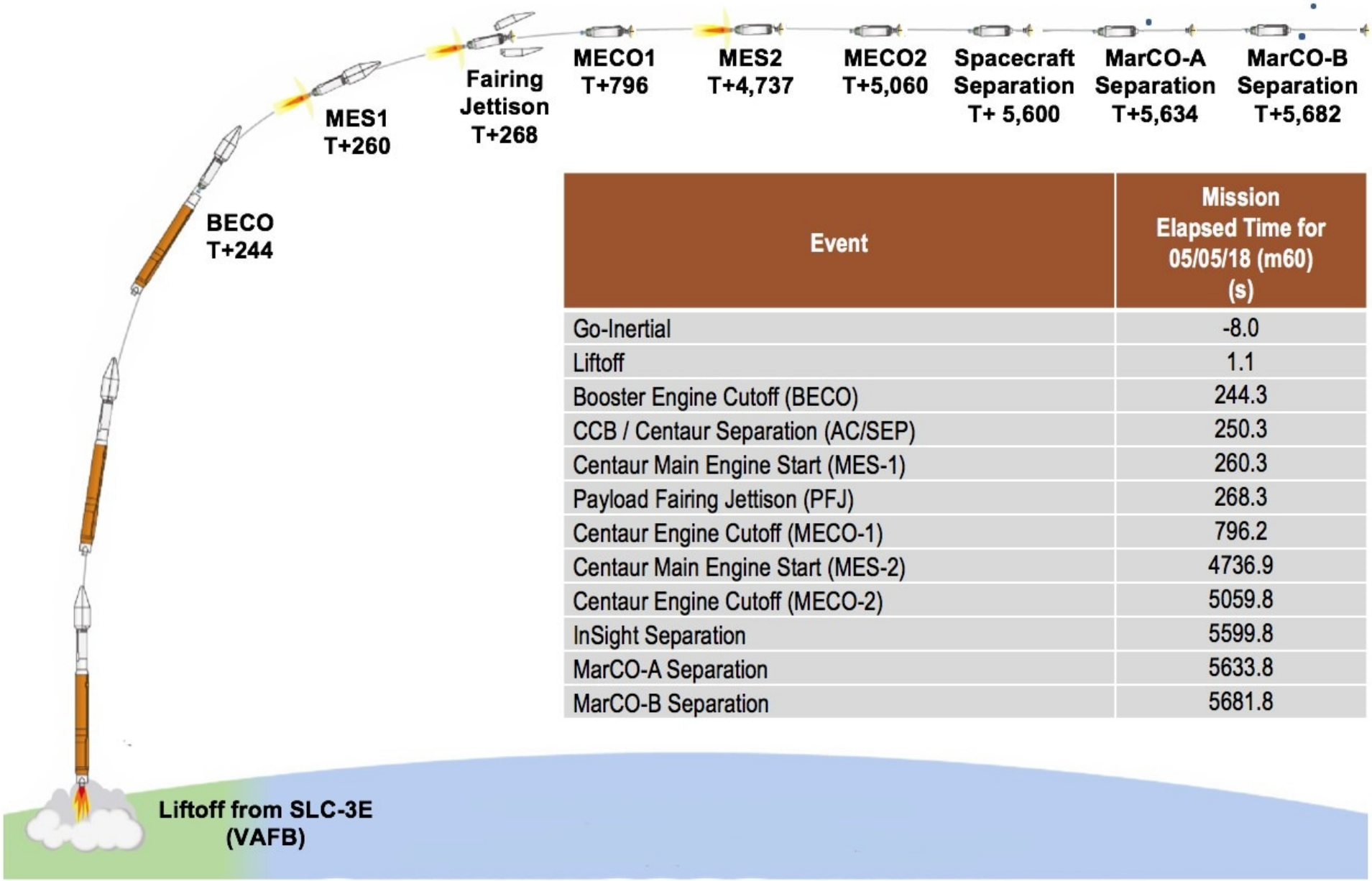
Software:
FSW: protos (JPL)
GSW: AMPCS (NASA/JPL)

I&T:
In-house S/C I&T, testing, Tyvak
NLAS/Launch Integration

Operations:
Primary: DSN (34 & 70m)
EDL: Madrid 70m
In-Flight Relay Demo: Morehead State

Primary Ops: JPL
Ops Support: CalPoly-SLO

Insight Launch Events

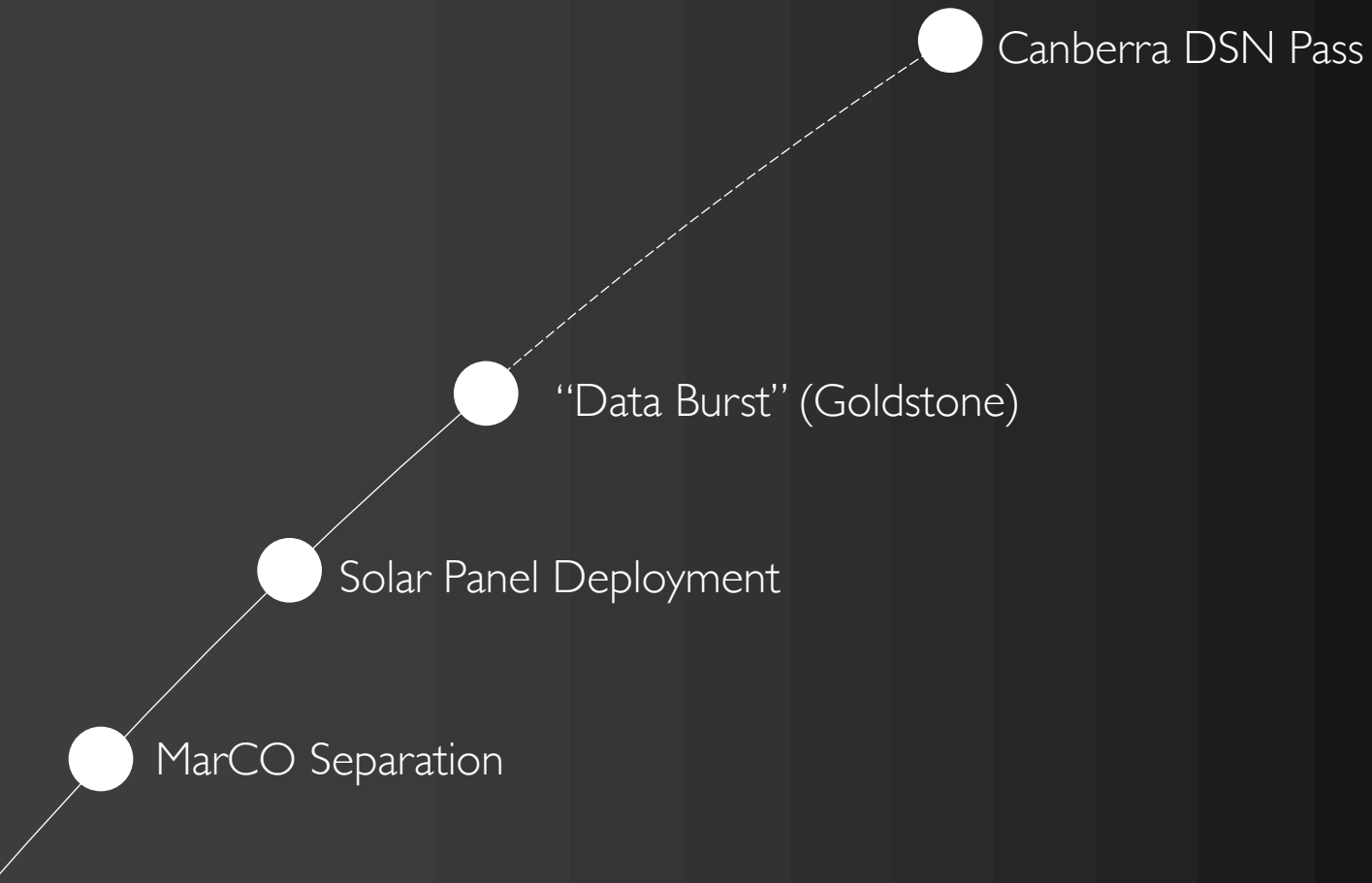


Event	Mission Elapsed Time for 05/05/18 (m60) (s)
Go-Inertial	-8.0
Liftoff	1.1
Booster Engine Cutoff (BECO)	244.3
CCB / Centaur Separation (AC/SEP)	250.3
Centaur Main Engine Start (MES-1)	260.3
Payload Fairing Jettison (PFJ)	268.3
Centaur Engine Cutoff (MECO-1)	796.2
Centaur Main Engine Start (MES-2)	4736.9
Centaur Engine Cutoff (MECO-2)	5059.8
InSight Separation	5599.8
MarCO-A Separation	5633.8
MarCO-B Separation	5681.8

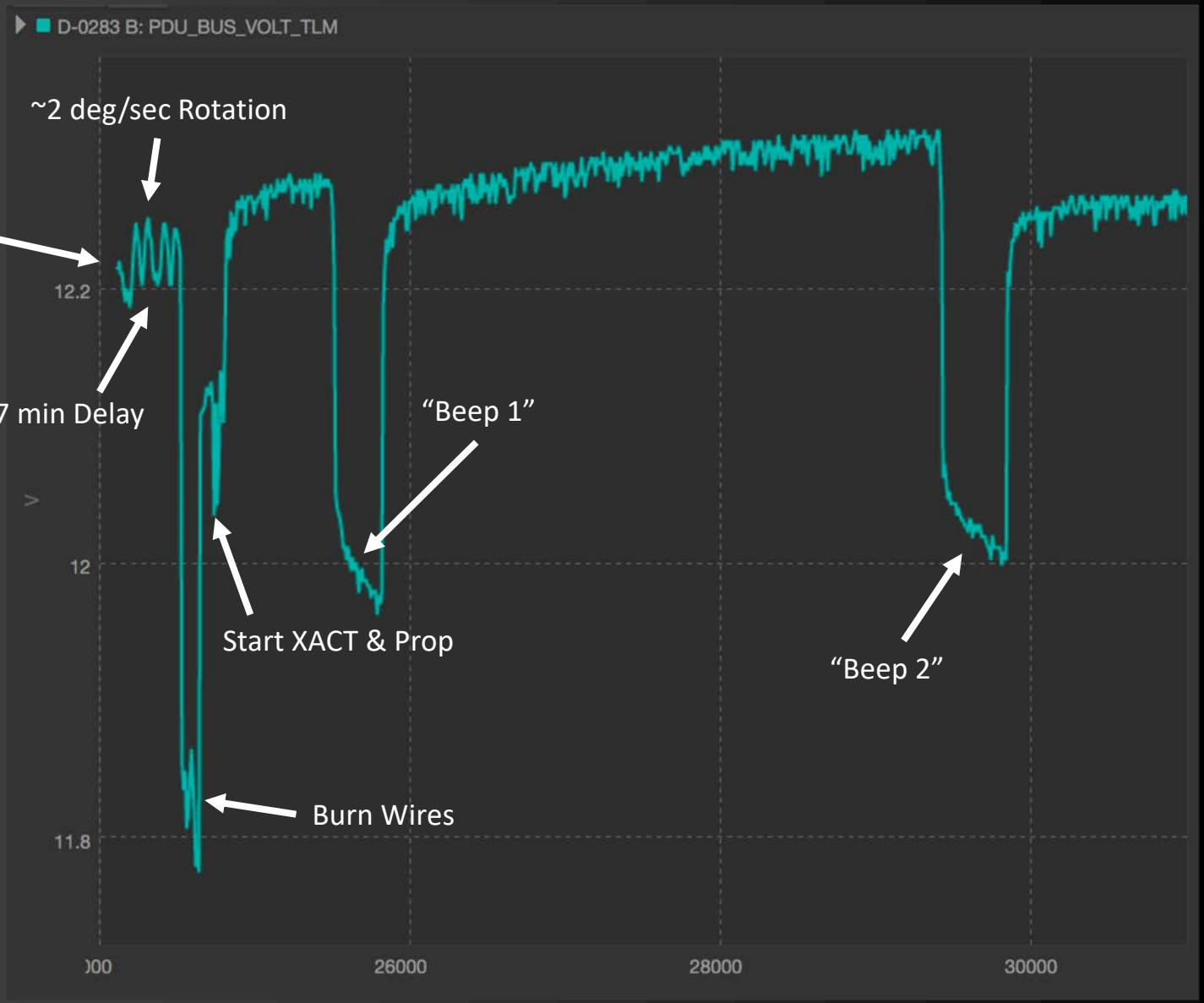
MarCO Launch Events

- Solar Panel Deployment
- MarCO Separation

MarCO Launch Events



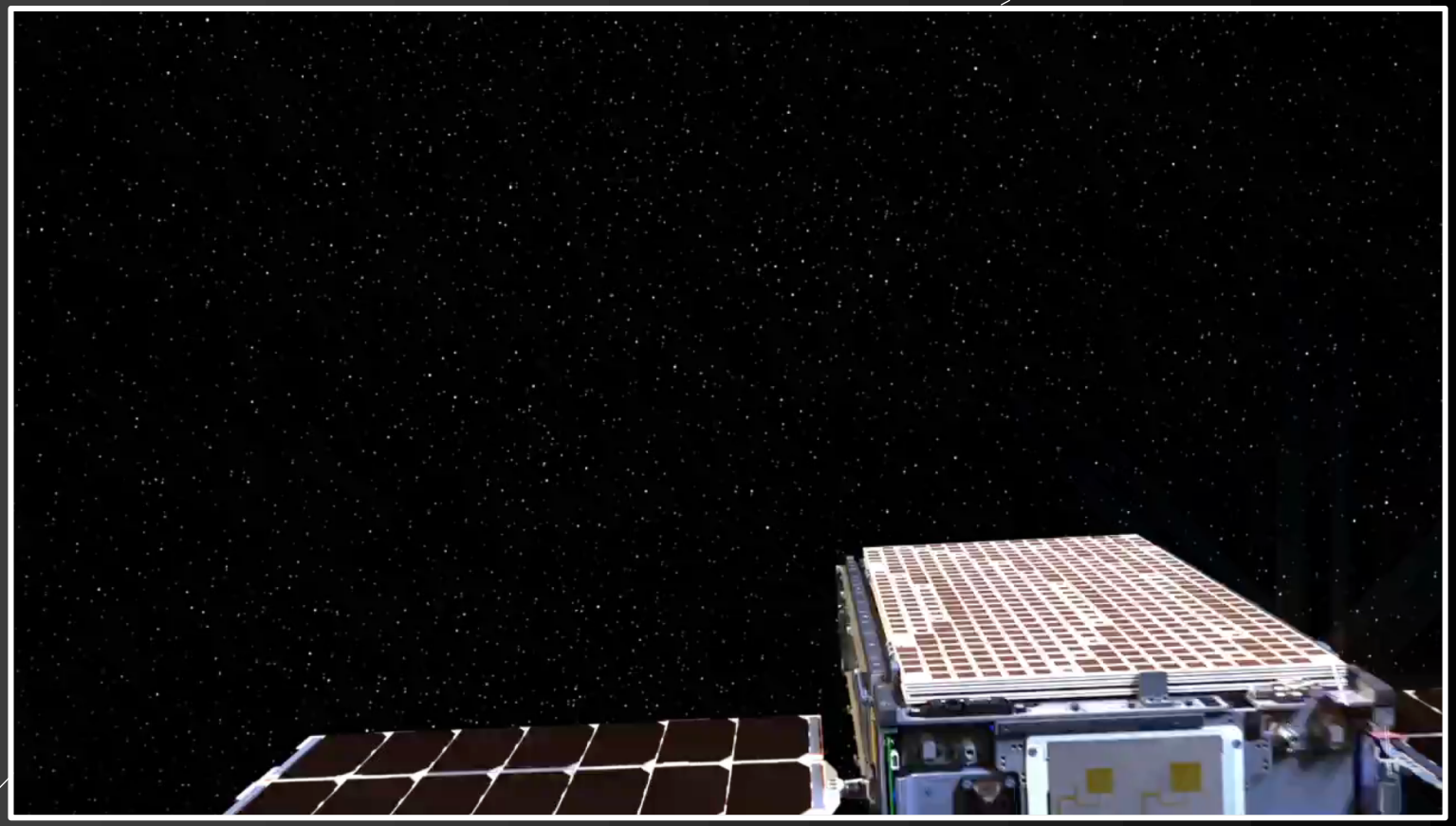
MarCO B Launch Events – As Told by Bus Voltage



MarCO Separation

MarCO Launch Events

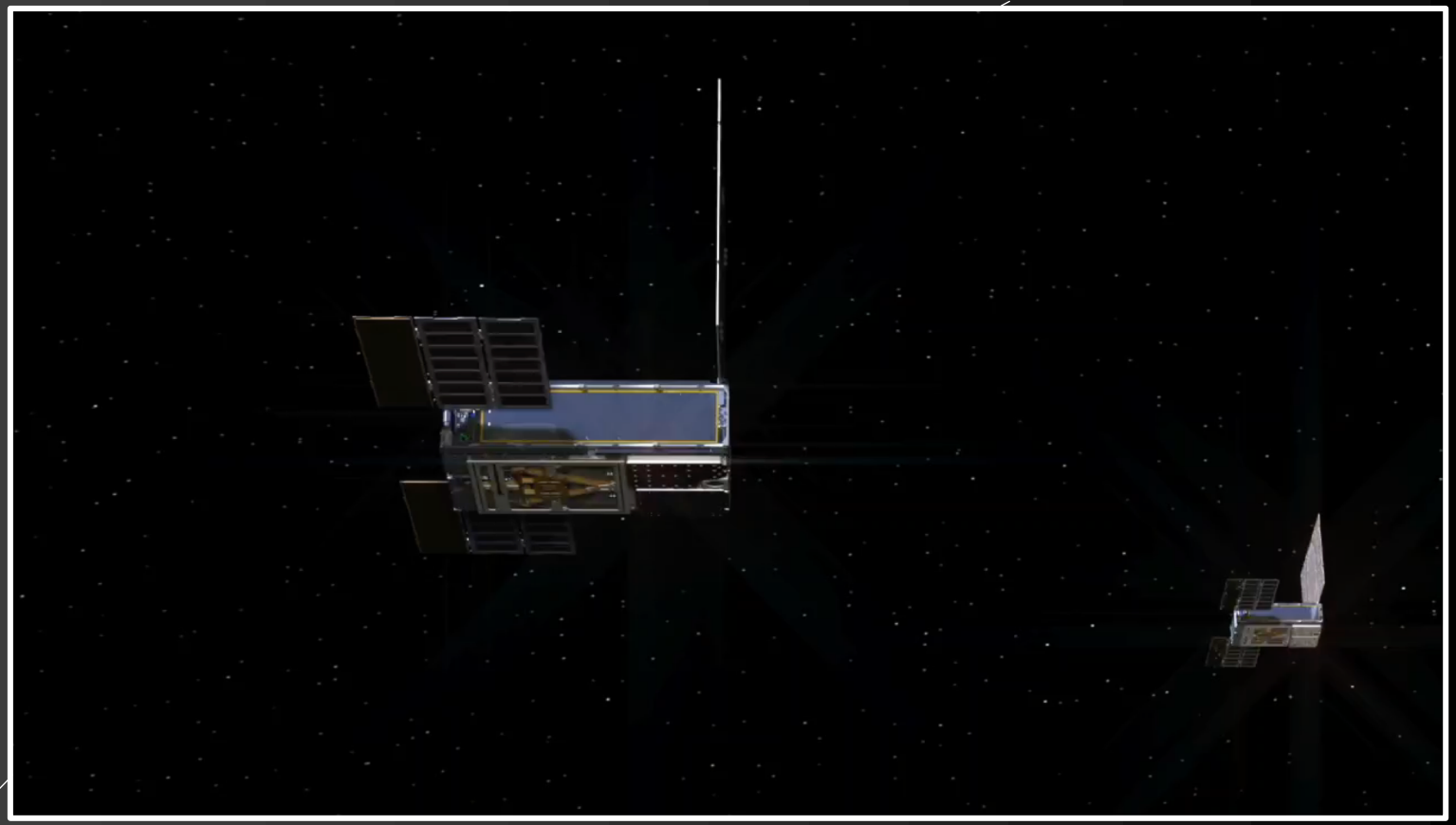
HGA / UHF Deployment



MarCO Separation

MarCO Launch Events

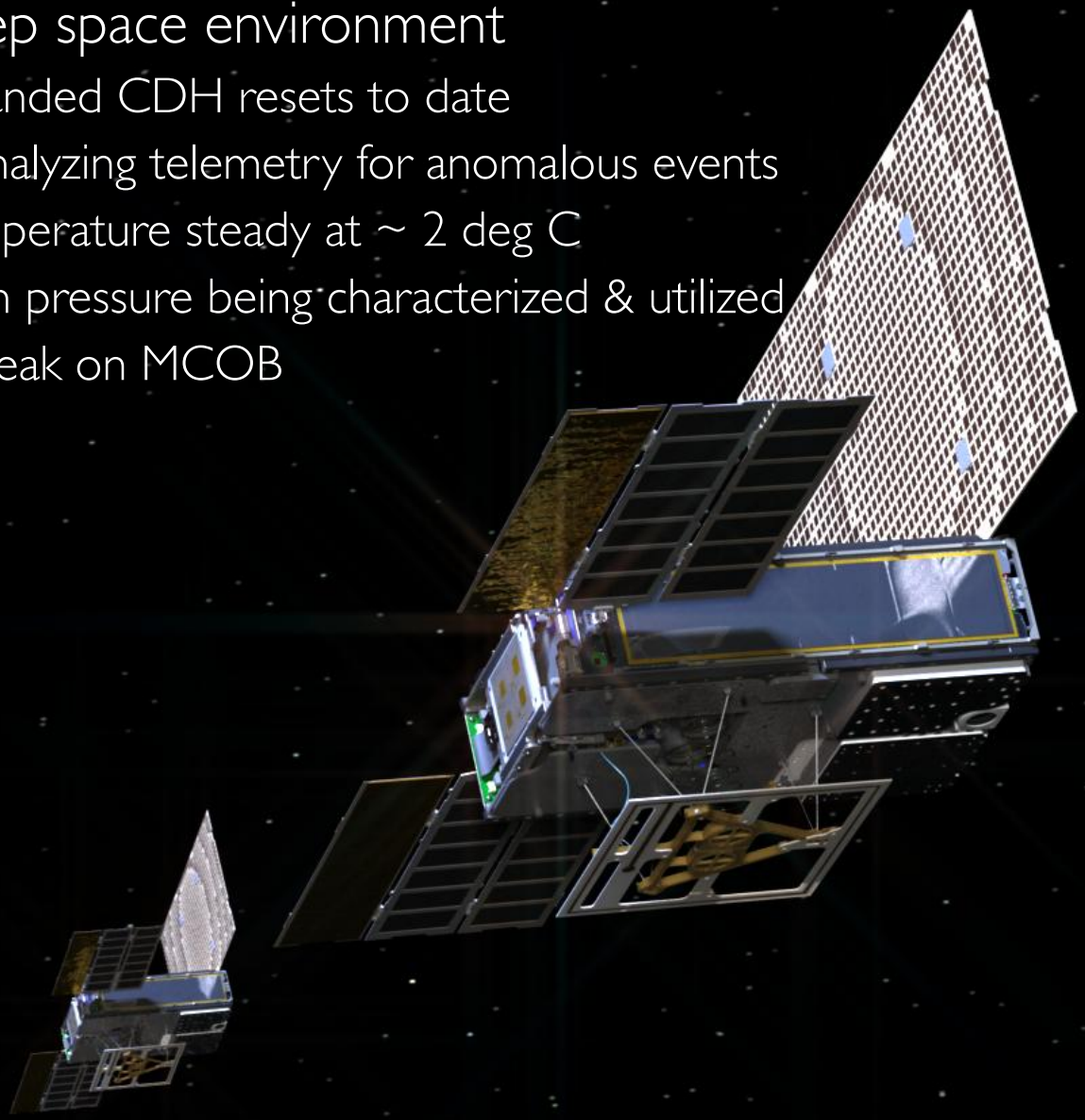
HGA / UHF Deployment



MarCO Separation

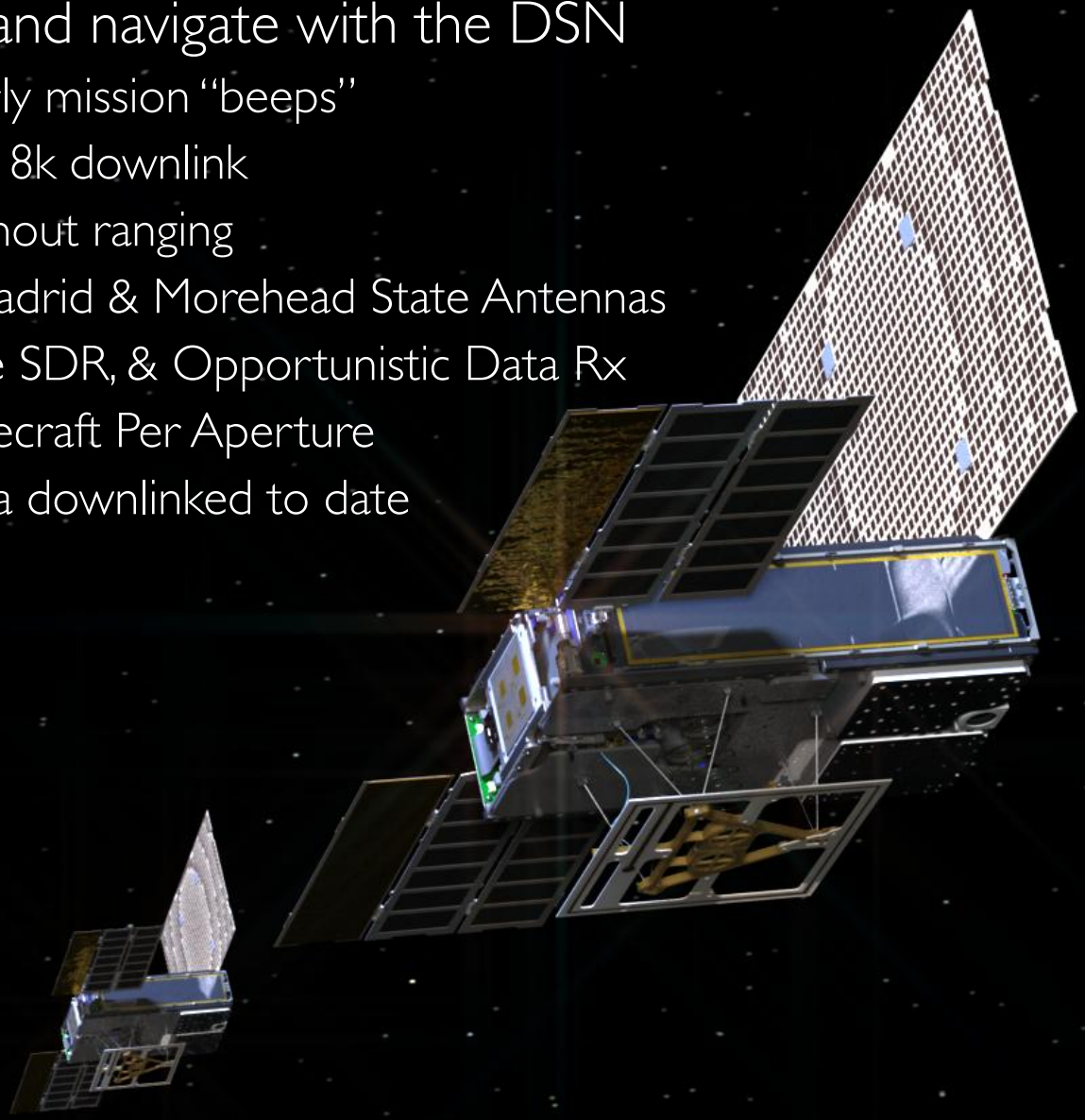
MarCO is a CubeSat technology demonstration to:

- Survive the deep space environment
  - No uncommanded CDH resets to date
  - Team is still analyzing telemetry for anomalous events
  - Onboard temperature steady at ~ 2 deg C
  - Solar radiation pressure being characterized & utilized
  - Prop system leak on MCOB



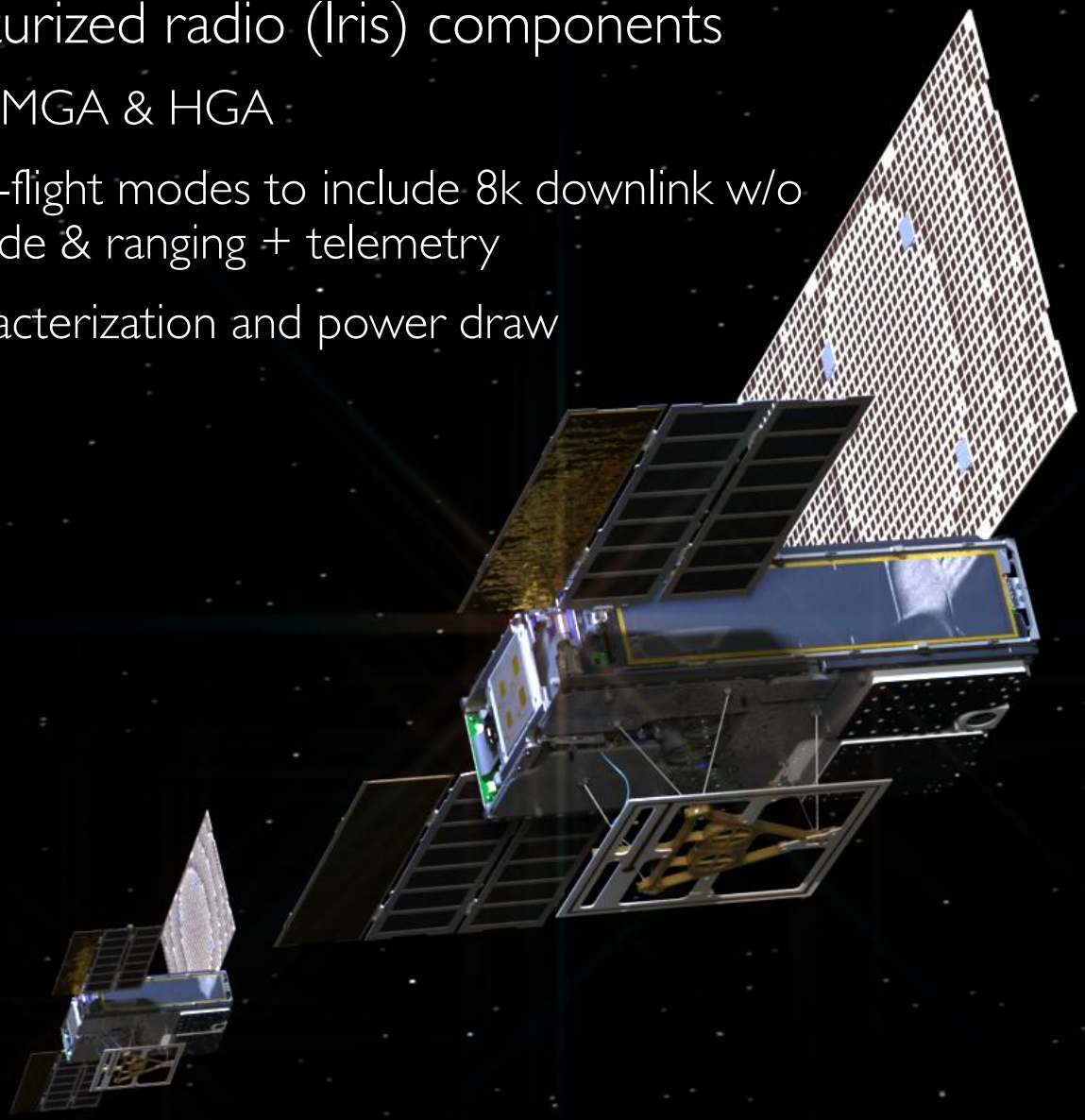
MarCO is a CubeSat technology demonstration to:

- Communicate and navigate with the DSN
  - Successful early mission "beeps"
  - 1k uplink, 1k / 8k downlink
  - With and without ranging
  - Goldstone, Madrid & Morehead State Antennas
  - DSN, Kempke SDR, & Opportunistic Data Rx
  - Multiple Spacecraft Per Aperture
  - ~120 MB data downlinked to date



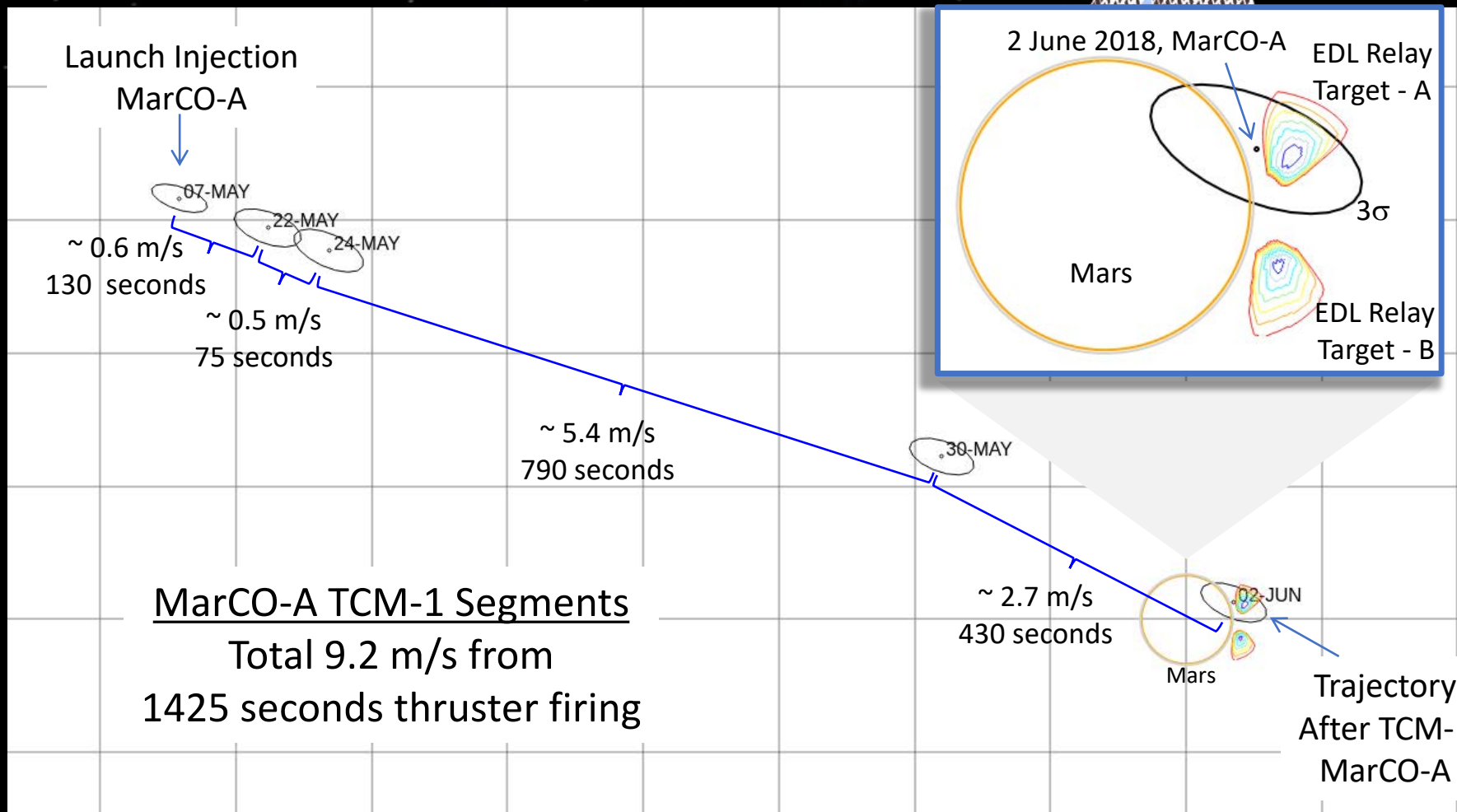
MarCO is a CubeSat technology demonstration to:

- Advance miniaturized radio (Iris) components
  - Utilized LGA, MGA & HGA
  - Extended pre-flight modes to include 8k downlink w/o Bent Pipe Mode & ranging + telemetry
  - Thermal characterization and power draw



MarCO is a CubeSat technology demonstration to:

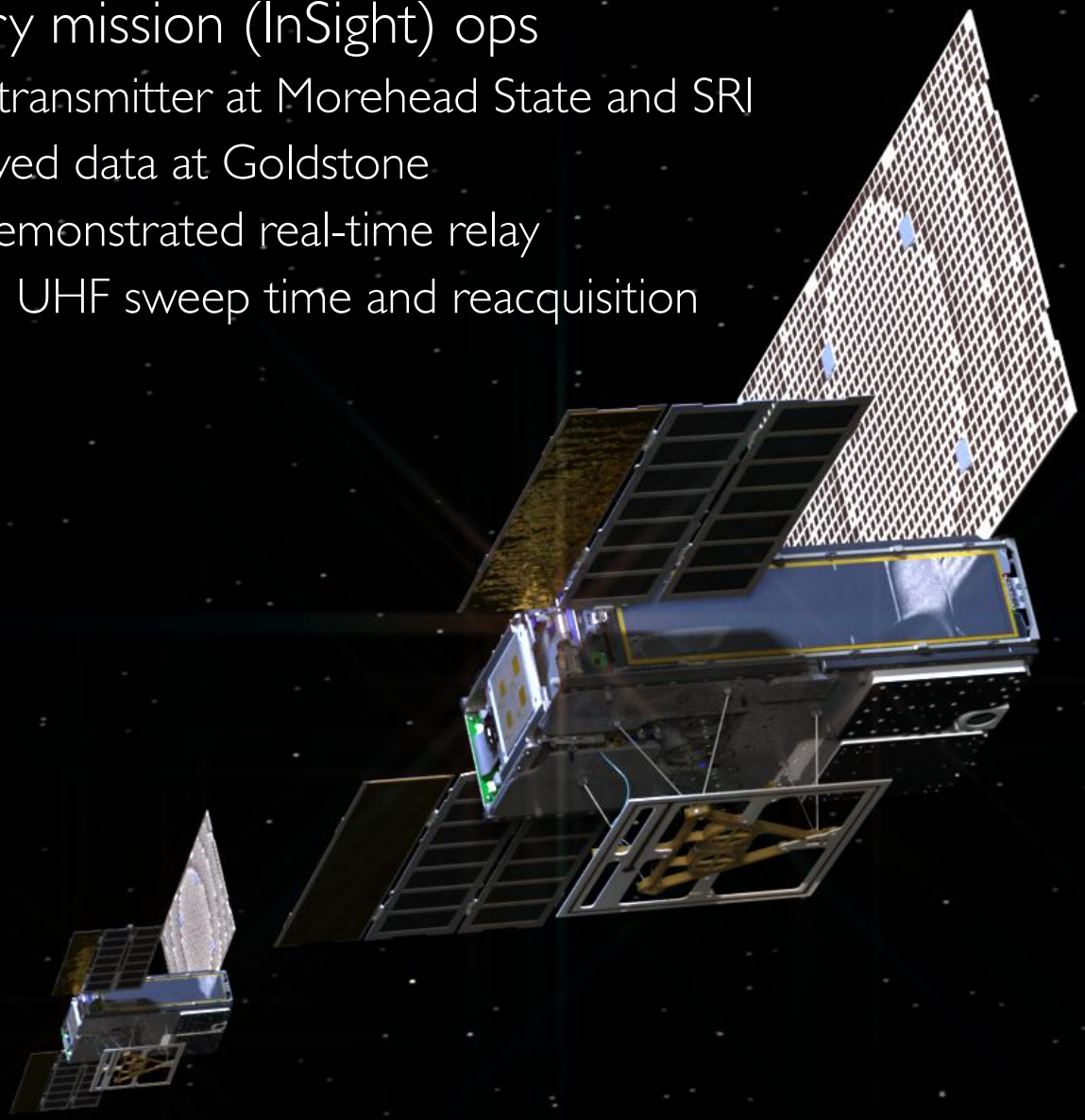
- Maneuver for interplanetary travel
  - Both spacecraft completed TCM-1
  - MCOB using SRP to desaturate wheels

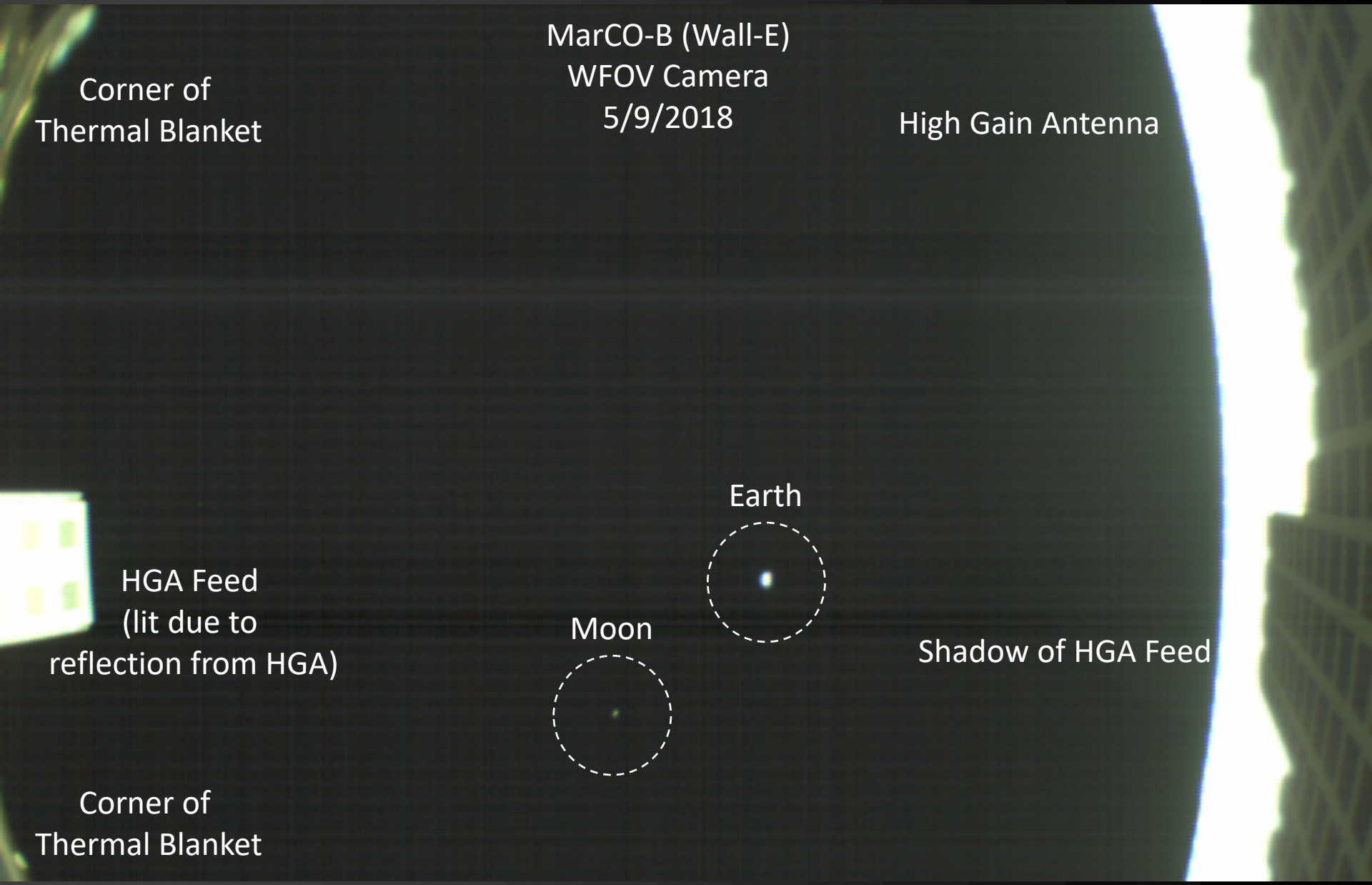


MarCO-A TCM-1 Segments
Total 9.2 m/s from
1425 seconds thruster firing

MarCO is a CubeSat technology demonstration to:

- Support primary mission (InSight) ops
  - Utilized UHF transmitter at Morehead State and SRI
  - Received relayed data at Goldstone
  - Successfully demonstrated real-time relay
  - Characterized UHF sweep time and reacquisition




MarCO-B (Wall-E)
WFOV Camera
5/9/2018
Corner of
Thermal Blanket
High Gain Antenna
Earth
HGA Feed
(lit due to
reflection from HGA)
Moon
Shadow of HGA Feed
Corner of
Thermal Blanket

Dare Mighty Things

Jet Propulsion Laboratory
California Institute of Technology