

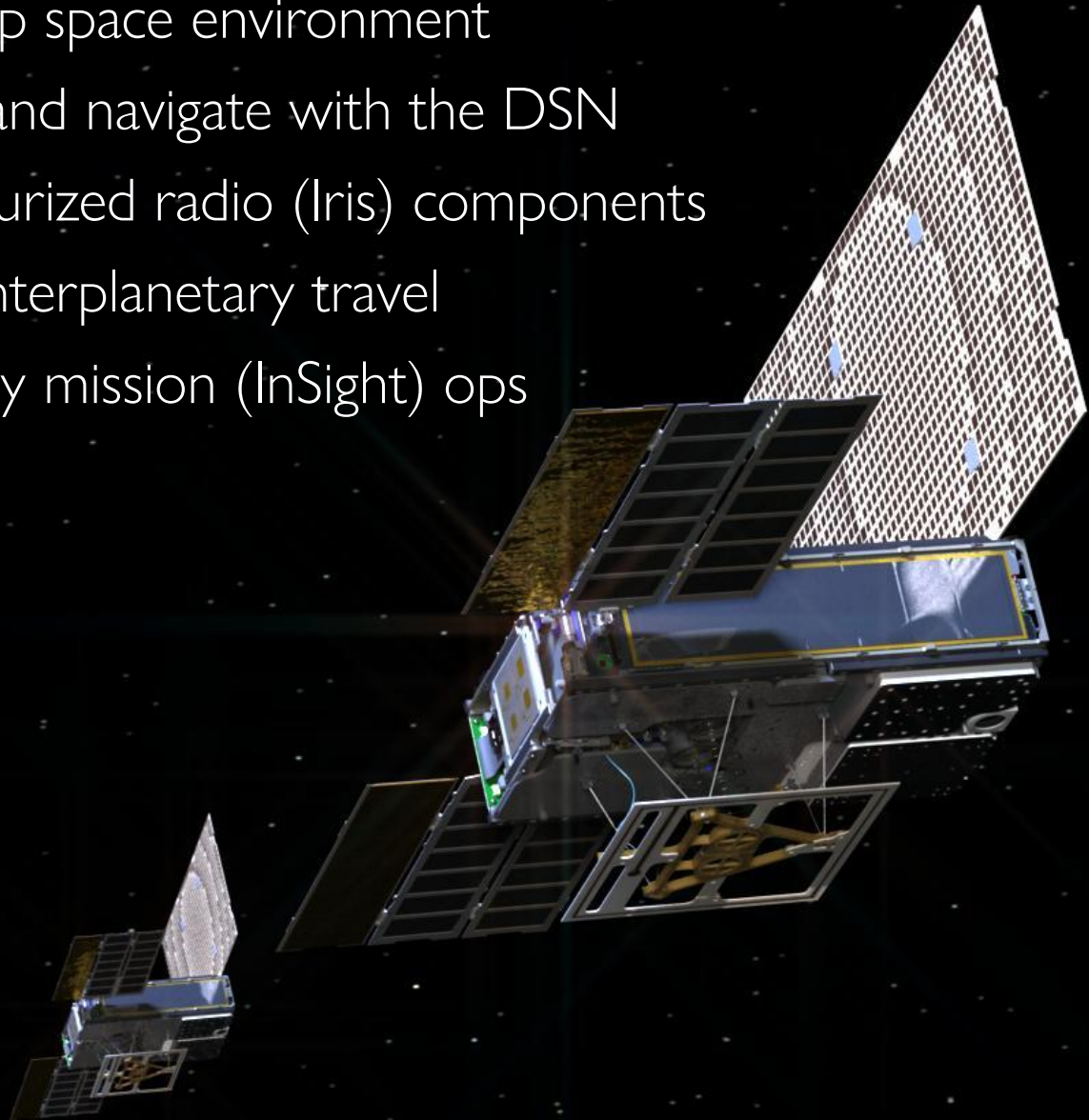


# MarCO: Ready for Launch

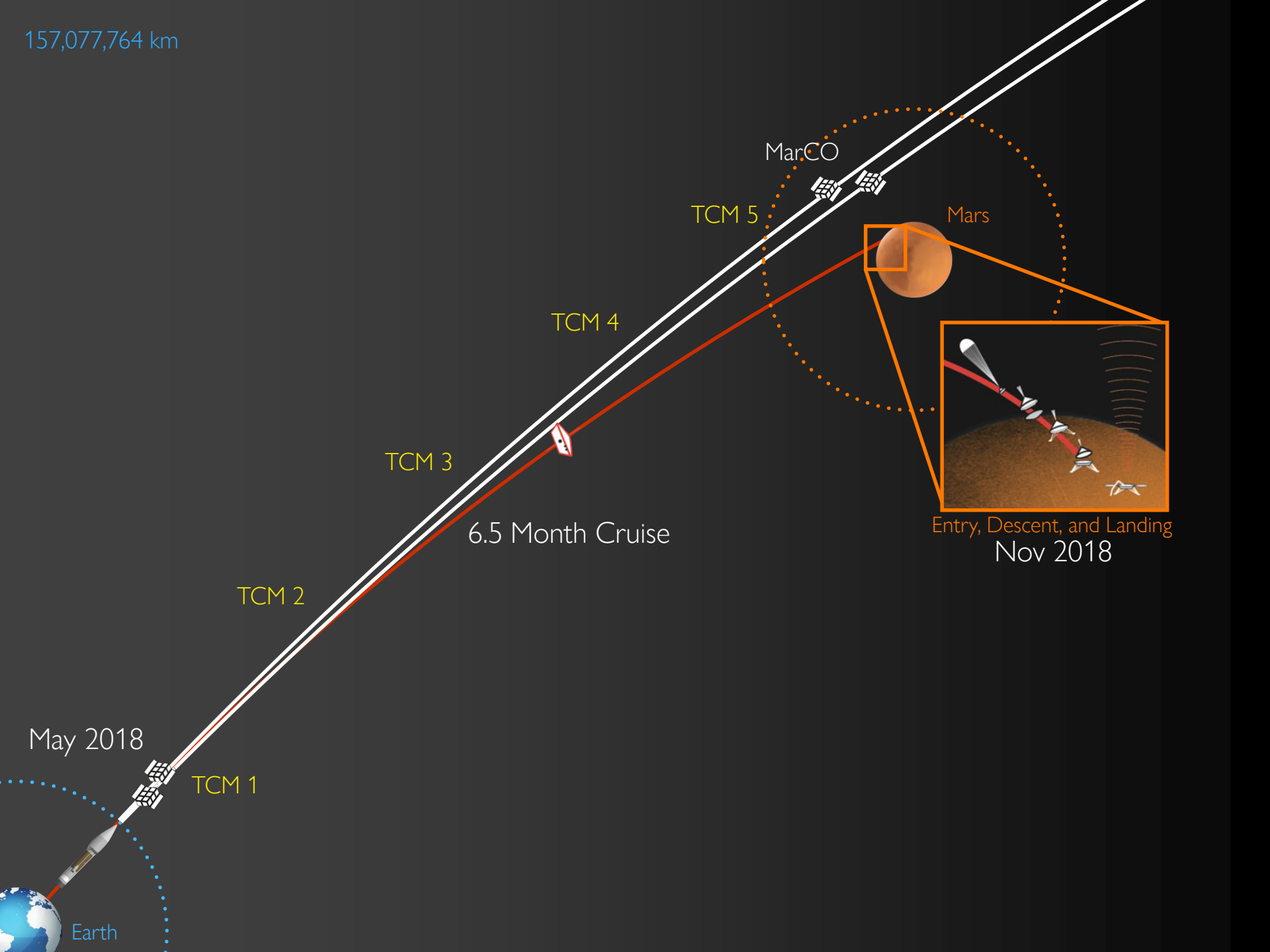
Andrew Klesh, Joel Krajewski

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



157,077,764 km



May 2018

TCM 1

TCM 2

TCM 3

TCM 4

TCM 5

MarCO

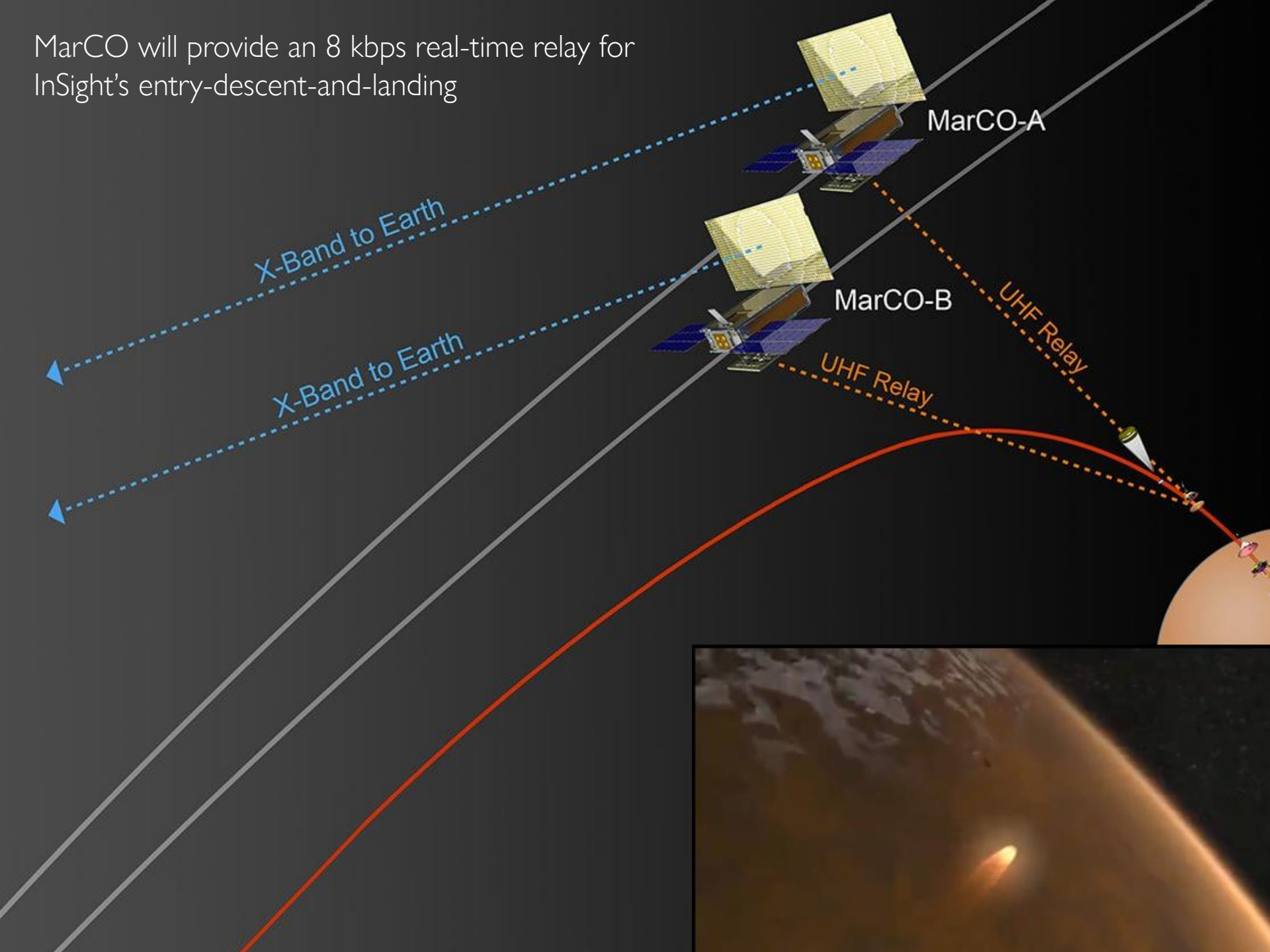
Mars

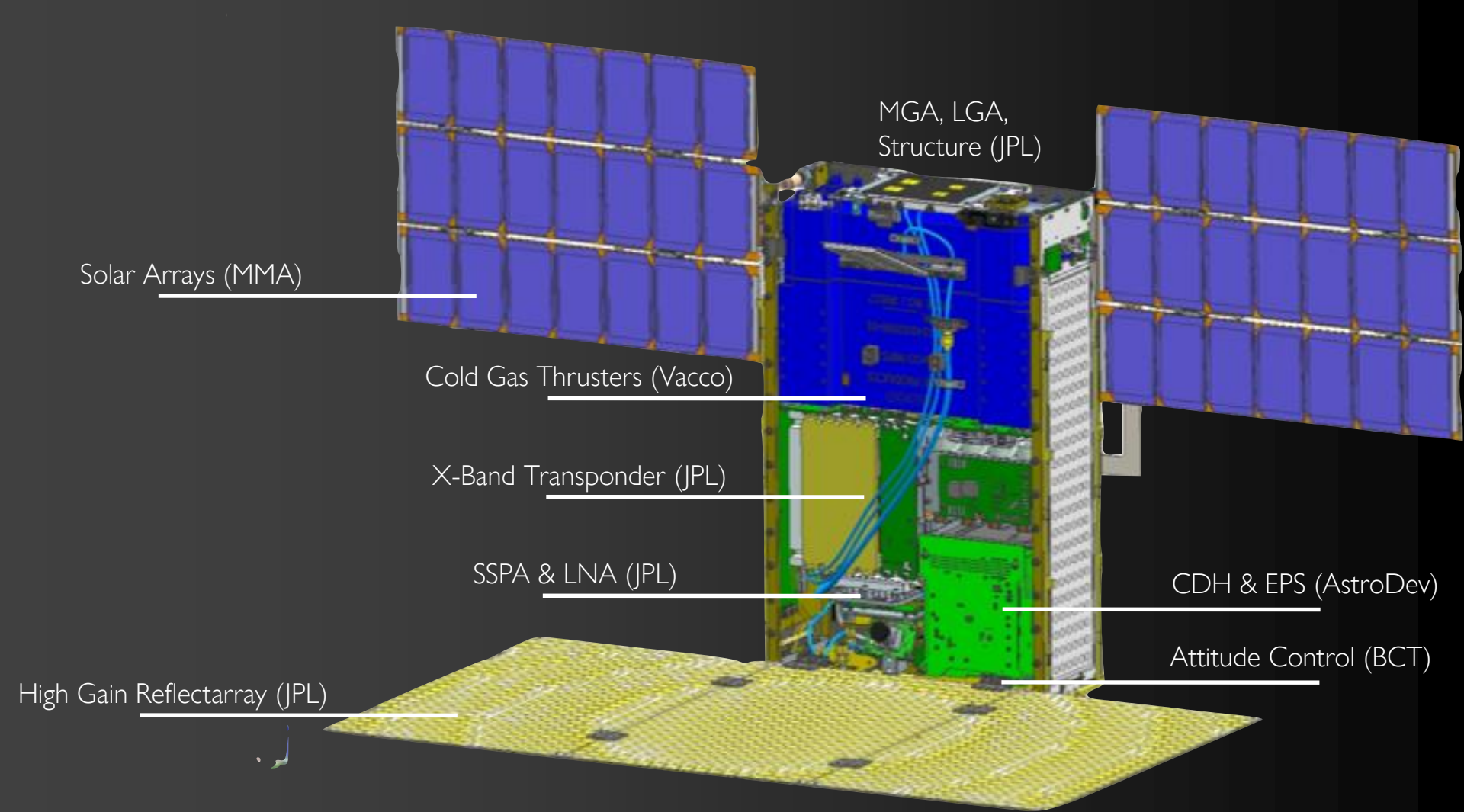
6.5 Month Cruise

Entry, Descent, and Landing  
Nov 2018

Earth

MarCO will provide an 8 kbps real-time relay for InSight's entry-descent-and-landing





Solar Arrays (MMA)

MGA, LGA,  
Structure (JPL)

Cold Gas Thrusters (Vacco)

X-Band Transponder (JPL)

SSPA & LNA (JPL)

CDH & EPS (AstroDev)

Attitude Control (BCT)

High Gain Reflectarray (JPL)

**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:**

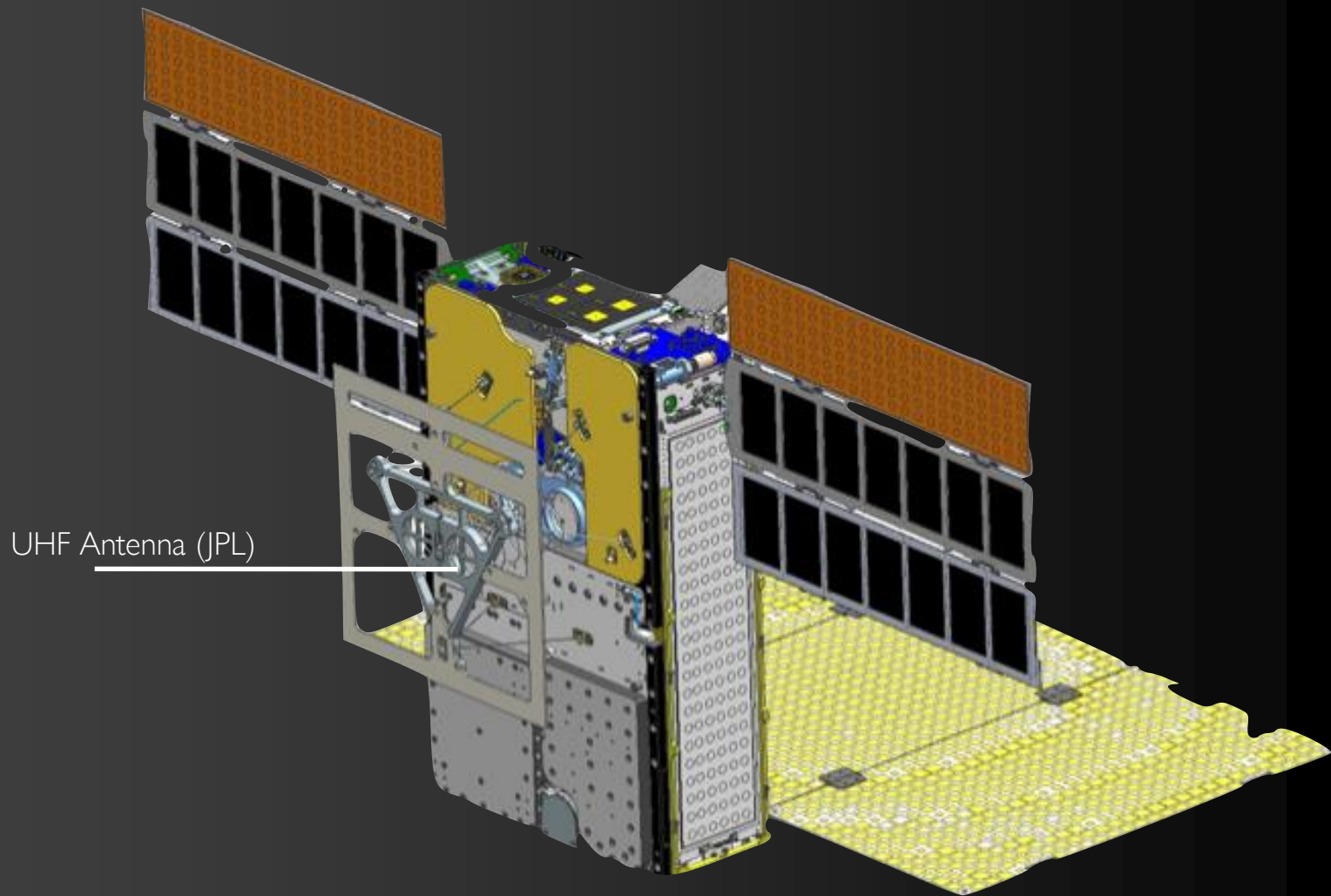
FSW: protos (JPL)  
 GSW: AMPCS (NASA/JPL)

**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



UHF Antenna (JPL)

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EDL: Madrid 70m  
In-Flight Relay Demo: Morehead State

Primary Ops: JPL  
Ops Support: CalPoly-SLO



## MarCO Collaborators:

NASA / JPL (Lead)

Astrodev (CDH / EPS)

Blue Canyon Technologies (ADCS)

CalPoly – SLO (Ops Support)

InSight Project (Primary S/C)

Kempke Engineering (Radio Sims)

MMA (Solar Panels)

Morehead State (Relay Demo)

NASA / Deep Space Network

NASA / HQ (Planetary Protection)

NASA / KSC (Launch Services)

Tyvak (Launch Integrators)

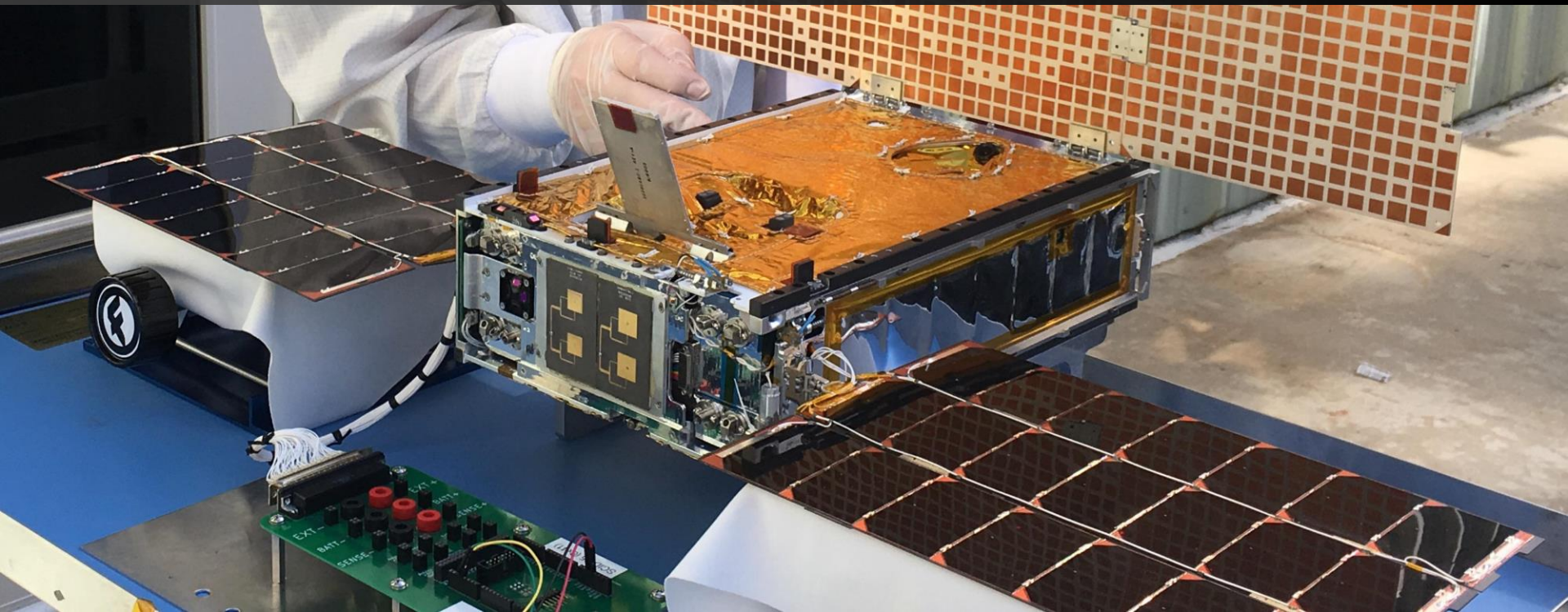
ULA (Launch Operations)

Vacco Industries (Prop)



Lesson #1: End-to-End system testing is required

- Work with the DSN for compatibility testing and ground data system checkouts
- Utilize available software resources to begin ops training early
- Create a end-to-end RF testbed in your lab

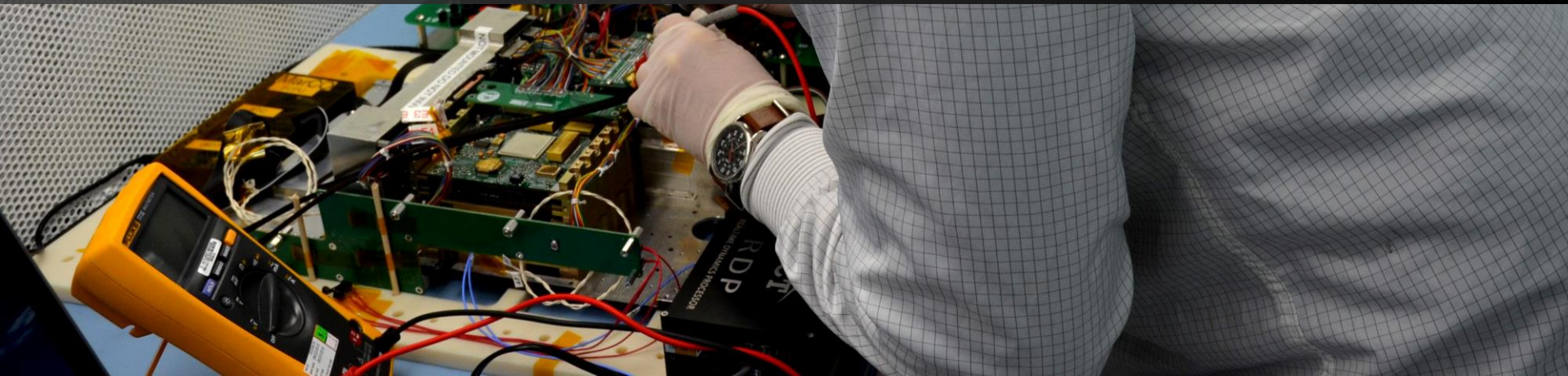






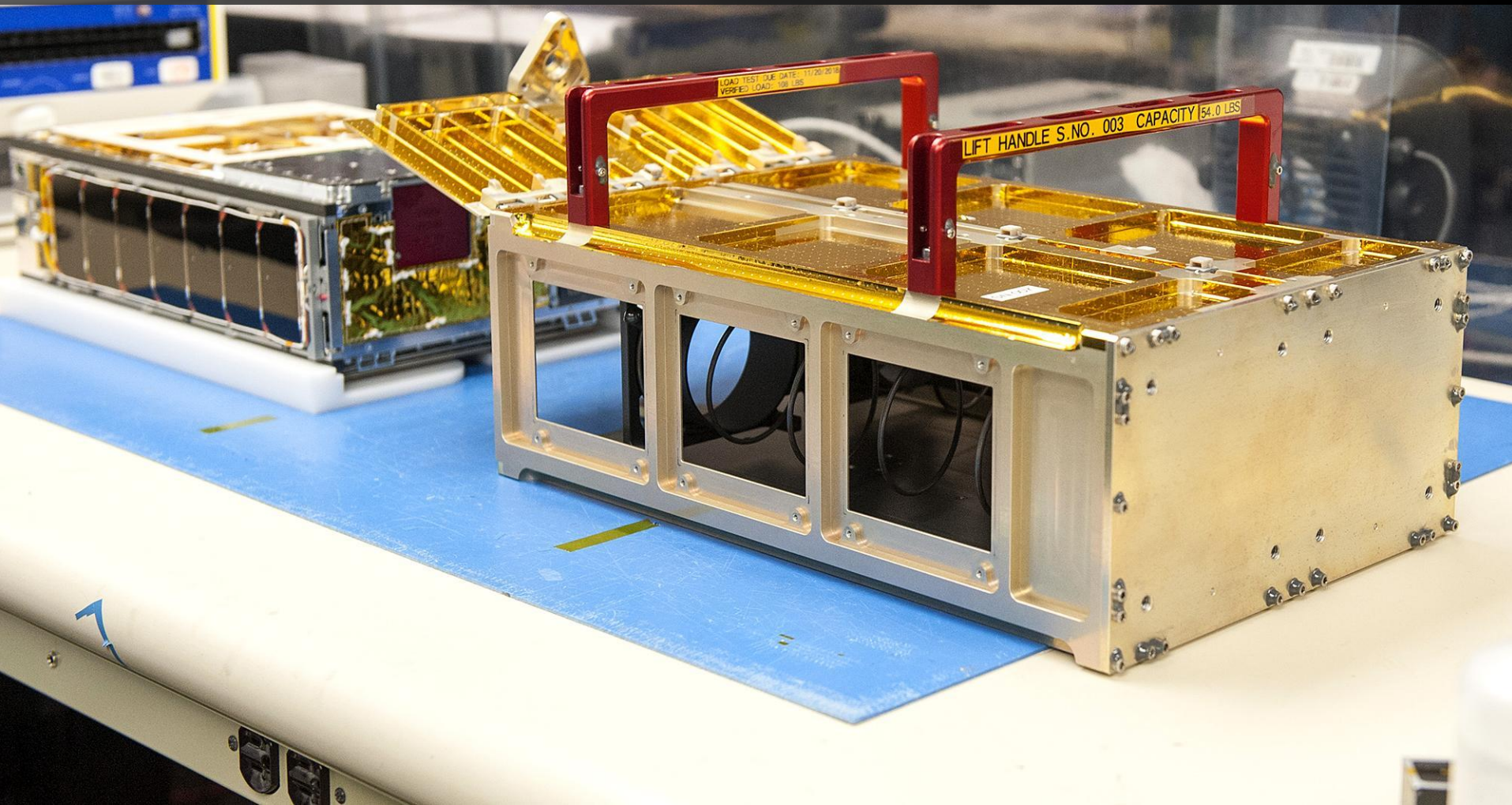
Lesson #2: Discuss with HQ Planetary Protection throughout development and integration/test

- Identify where manufacturing bioburden reductions might be applicable
- Consider both trajectory mitigation as well as contamination limitations
- Partner with an experienced team

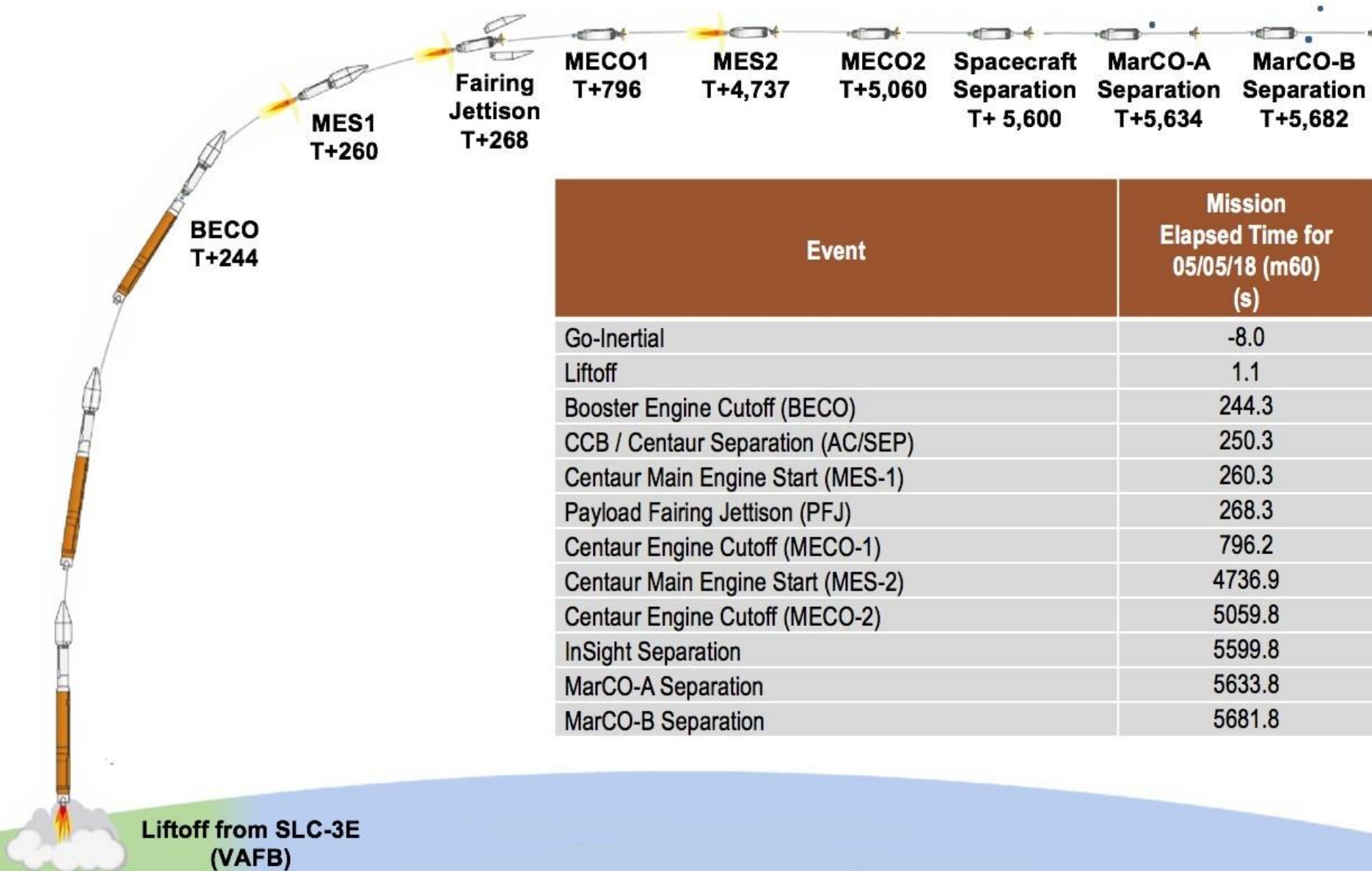


### Lesson #3: Consider implications of operations in deep space early

- Uplink / downlink times may need to be negotiated months in advance
- Short passes may be further reduced by light-time delay
- Early discussion of detailed conops with the DSN will provide valuable feedback



# Insight Launch Events



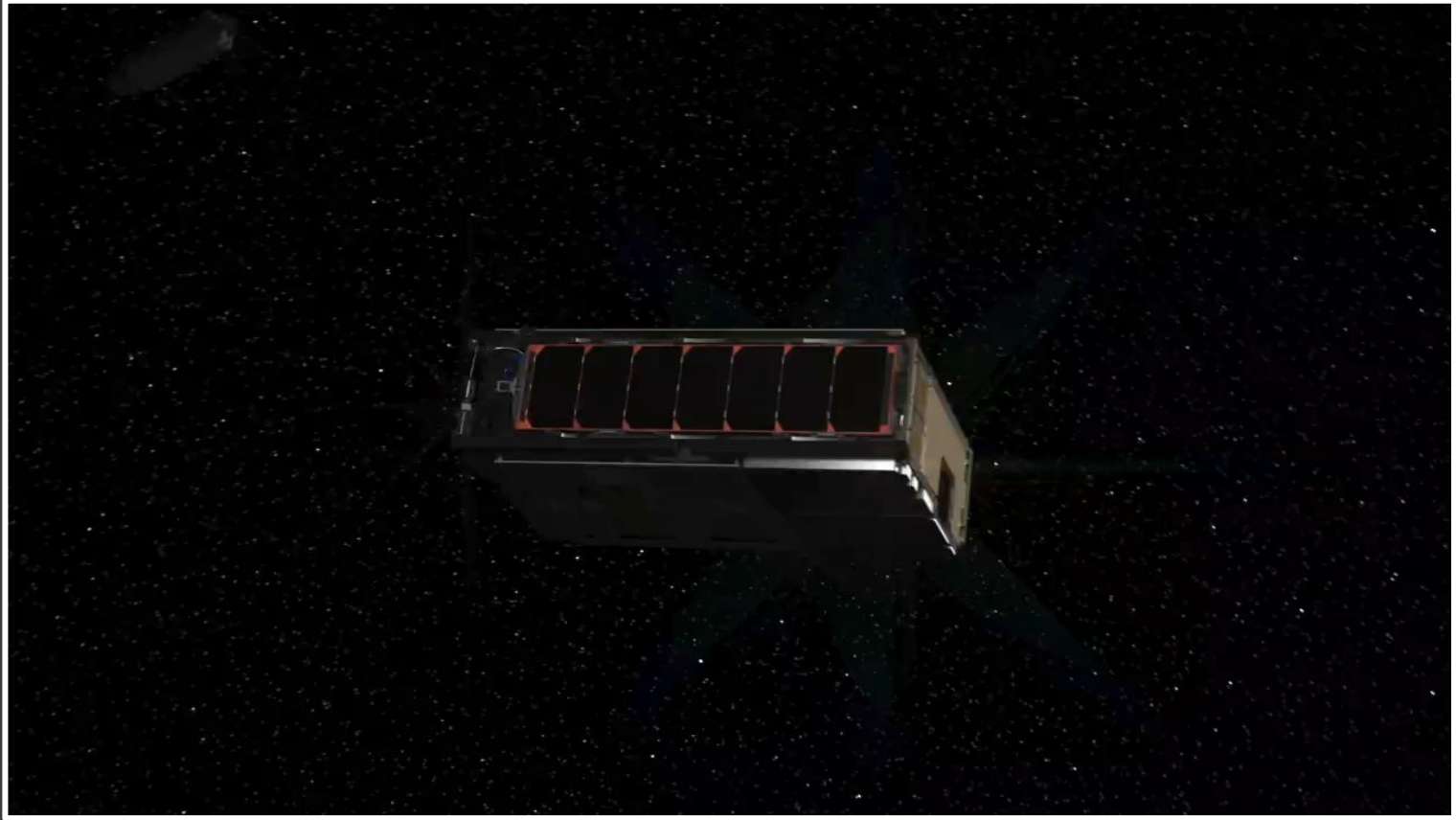
Event	Mission Elapsed Time for 05/05/18 (m60) (s)
Go-Inertial	-8.0
Liftoff	1.1
Booster Engine Cutoff (BECO)	244.3
CCB / Centaur Separation (AC/SEP)	250.3
Centaur Main Engine Start (MES-1)	260.3
Payload Fairing Jettison (PFJ)	268.3
Centaur Engine Cutoff (MECO-1)	796.2
Centaur Main Engine Start (MES-2)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



MarCO Separation

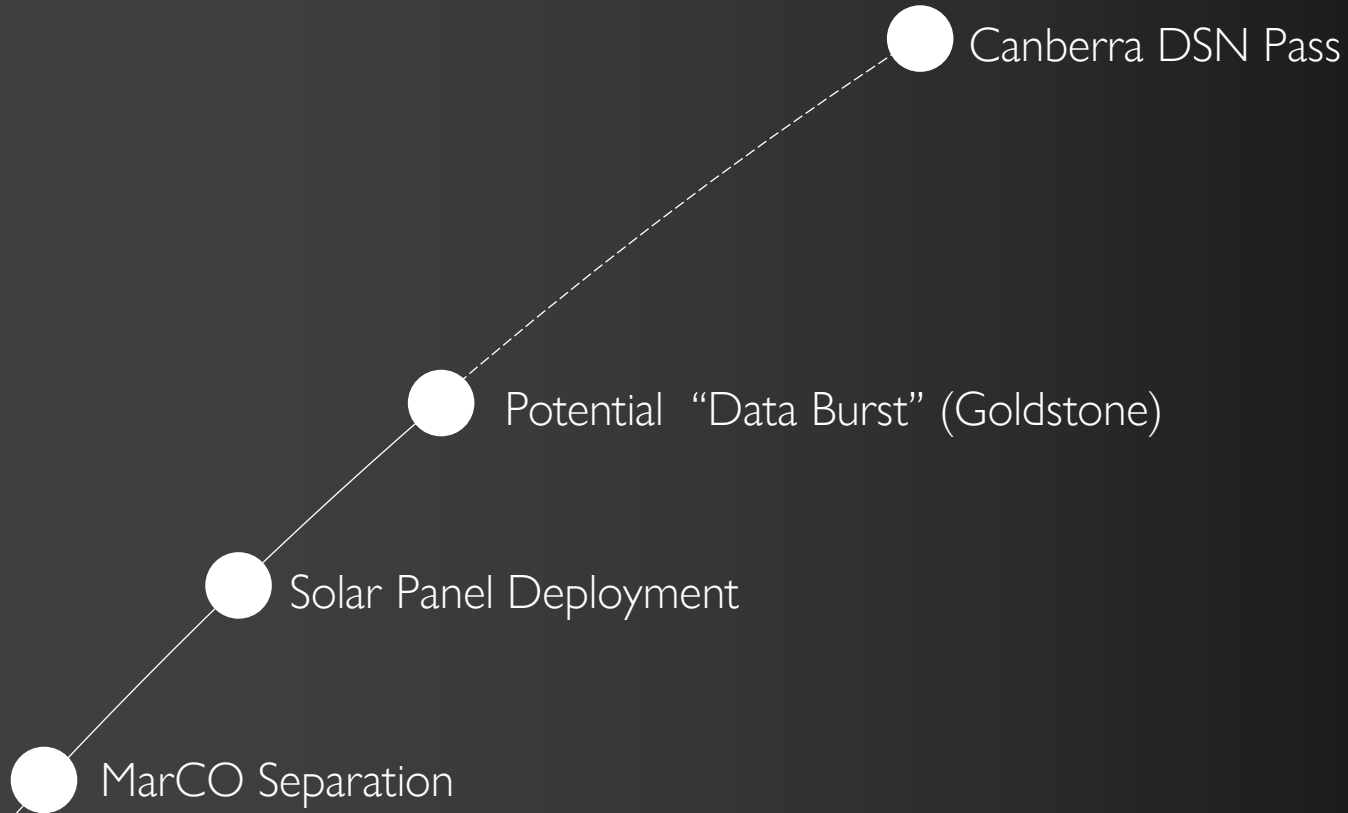
# MarCO Launch Events



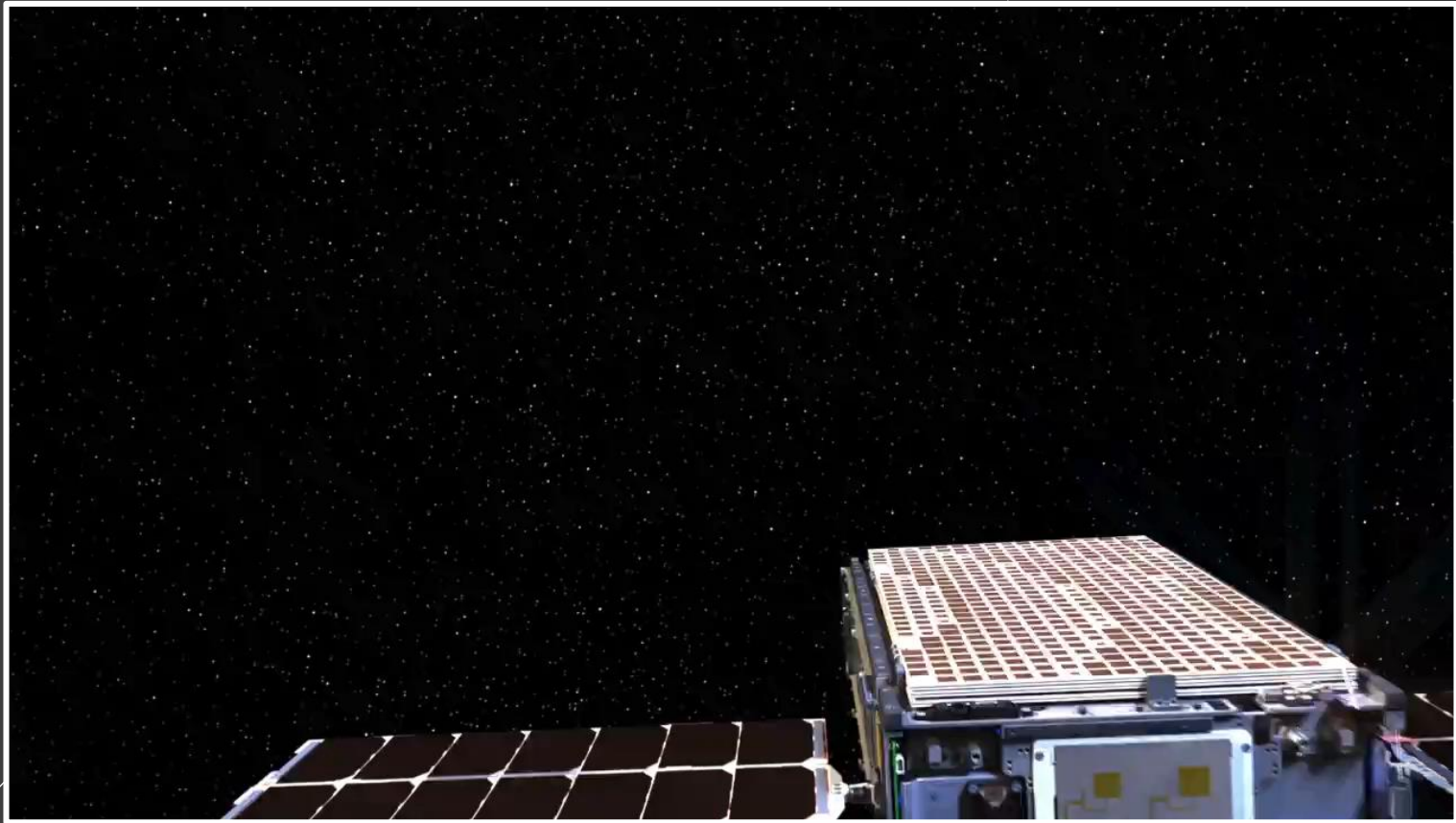
● Solar Panel Deployment

● MarCO Separation

# MarCO Launch Events



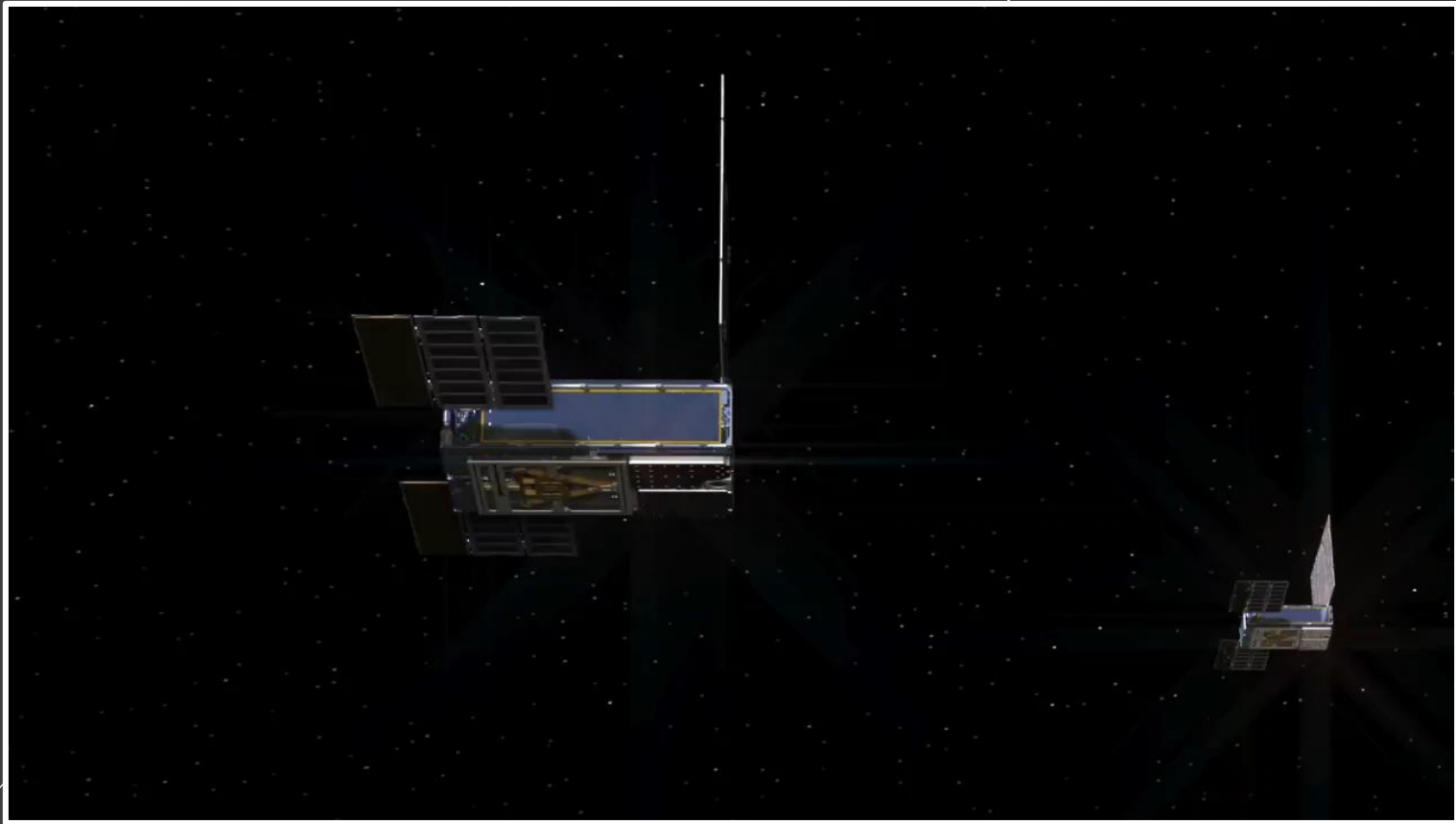
● HGA / UHF  
Deployment



● MarCO Separation

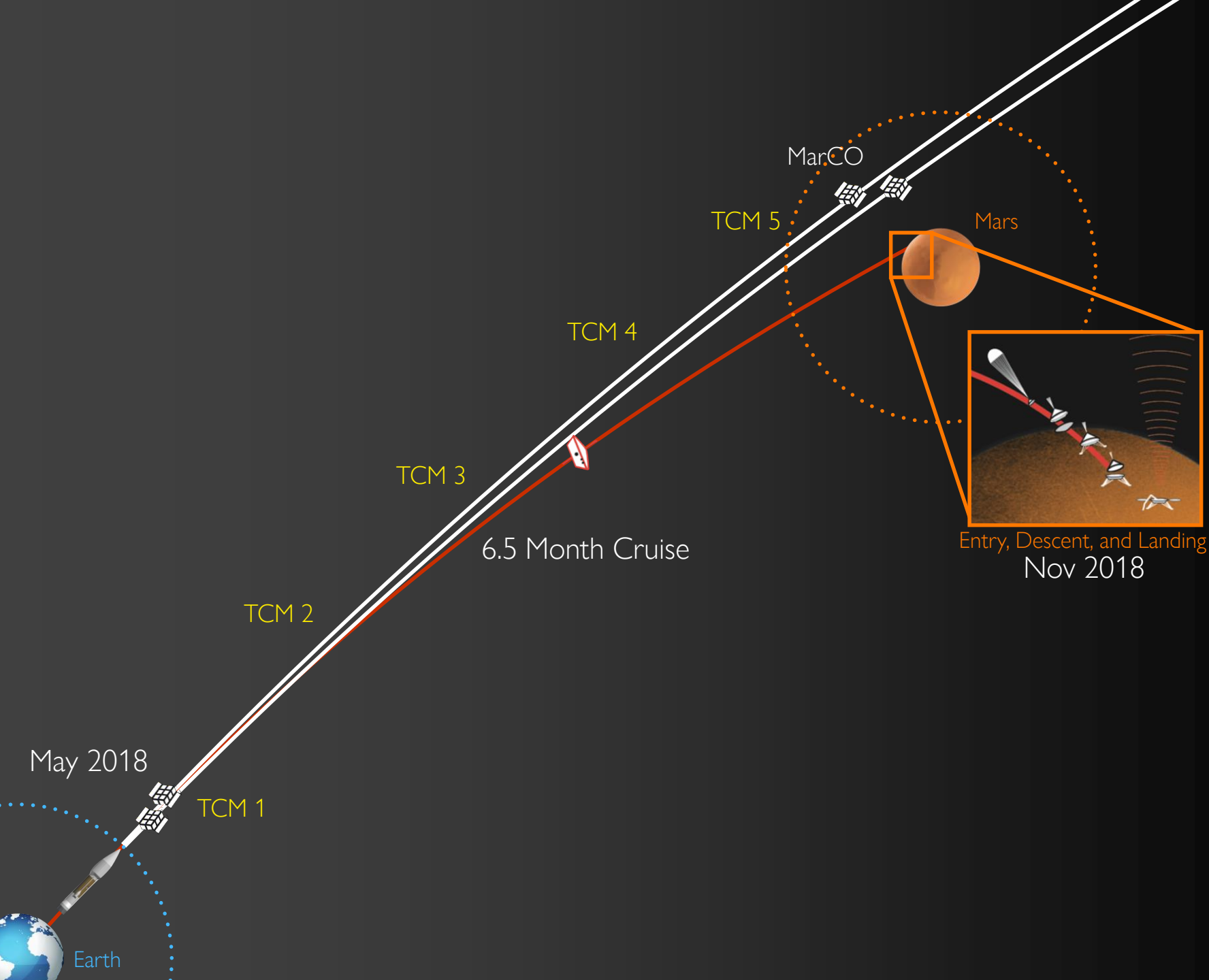
# MarCO Launch Events

● HGA / UHF  
Deployment



● MarCO Separation





May 2018

Earth

TCM 1

TCM 2

TCM 3

TCM 4

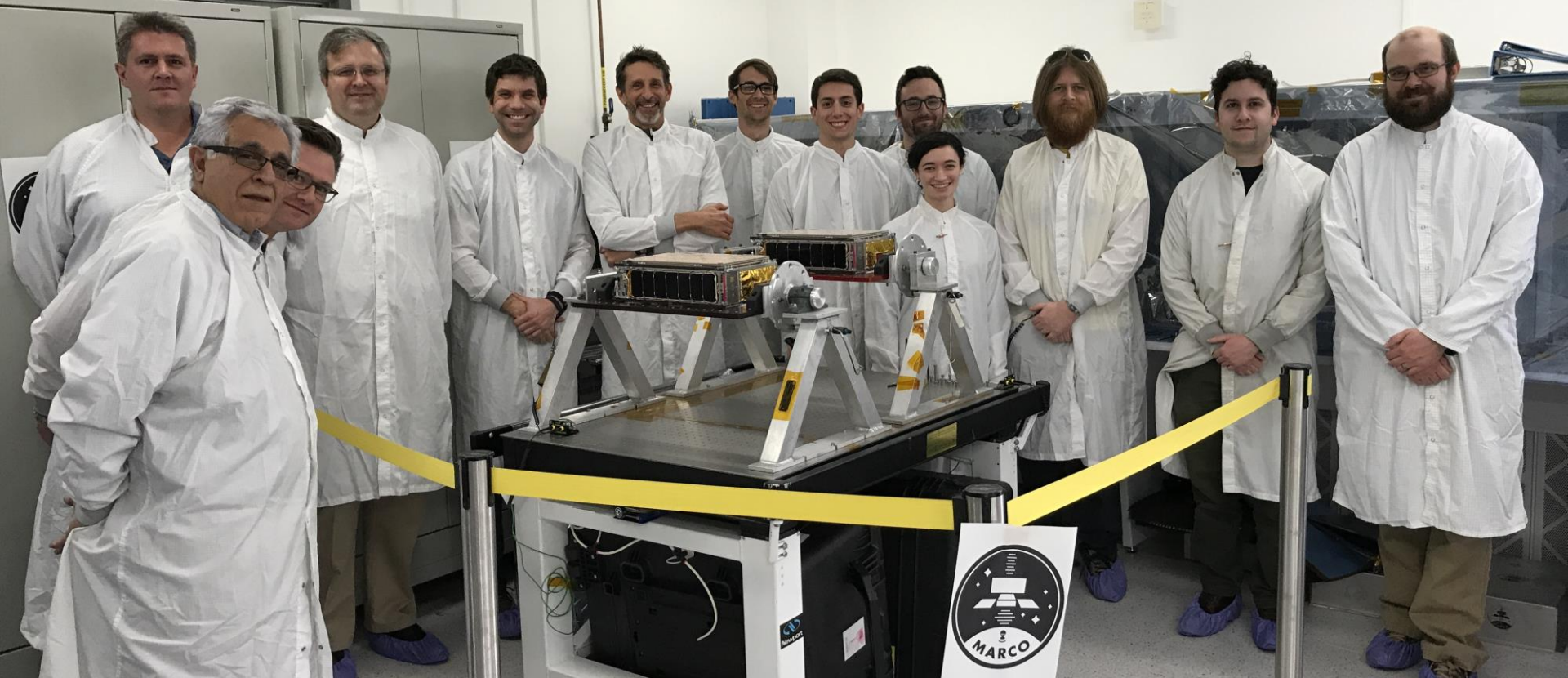
TCM 5

MarCO

6.5 Month Cruise

Mars

Entry, Descent, and Landing  
Nov 2018



- MarCO is a technology demonstration mission – the first CubeSat to travel interplanetary
- The successful development was a product of the entire CubeSat community
- Consider planetary protection, extensive communication planning / testing, and early end-to-end testing
- 30 day launch window opens May 5<sup>th</sup> from Vandenberg Air Force Base



Launch Window Opens

3d 17h 22m 59s



Launch Window Opens

3d 17h 22m 58s



Launch Window Opens

3d 17h 22m 57s



Launch Window Opens

3d 17h 22m 56s



Launch Window Opens

3d 17h 22m 55s



Launch Window Opens

3d 17h 22m 54s



# Dare Mighty Things



**Jet Propulsion Laboratory**  
California Institute of Technology