STUDENT-SOURCING INNOVATION: MARS AREOSTATIONARY TRACE GAS LOCALIZER (MATGL) SMALL SATELLITE

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Program: Strategic University Research Partnerships

SURP SRI Project Objective

Graduate students at the University of Michigan, in conjunction with scientists and engineers at NASA JPL, have developed a conceptual mission with the objective of localizing methane sources and sinks on Mars. Augmenting JPL's technical knowledge with the Michigan Space Engineering department's systems engineering cultivation has yielded a mission concept demonstrating the prolific results of a collaboration between two established entities.

Scientific Background/Benefit to NASA & JPL

- As a biological byproduct, methane could suggest the existence of life on Mars
- In 2013, the MSL (Curiosity Rover) detected a seasonal shift in methane
- This detection was confirmed in 2019 using data from the Mars Express Orbiter

Primary Objective

Design a mission that shall:

- Transfer the payload to areostationary orbit
- Support a three Martian year observation of the Gale Crater Region

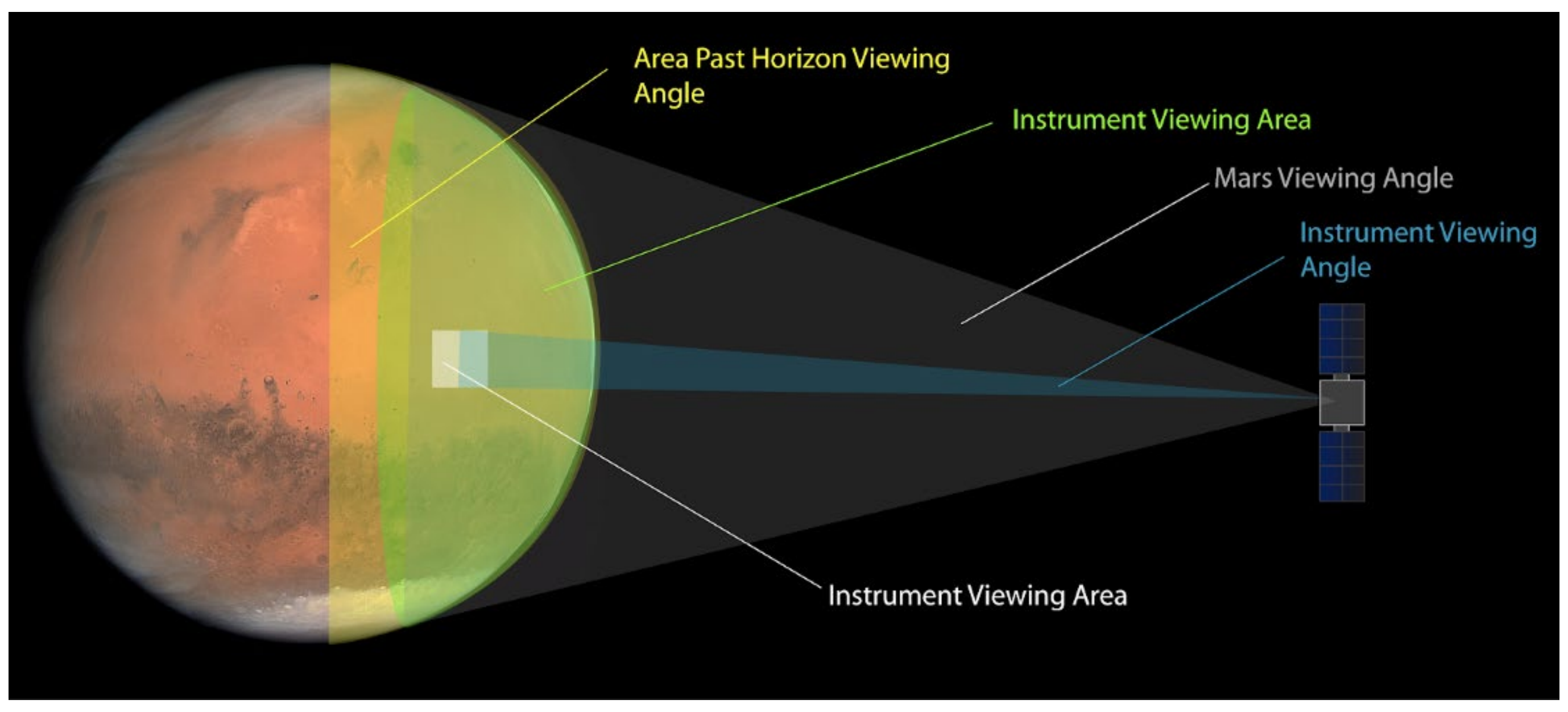
Payload

Ultra High Miniaturized Spectrometer with two modes of observation

- Coarse: more regularly used, 0.42 degree field of view (FOV)
- Fine: for regions of interest (ROIs), 0.06 degree FOV

Payload in observation mode for 8 hours per sol

- 8 hours to scan entire daylit surface until ROI appears
- ROI trigger leads to fine observation of ROI for remaining time



Observation Concept from Mars Areostationary Orbit

System Architecture

Propulsion and Trajectory

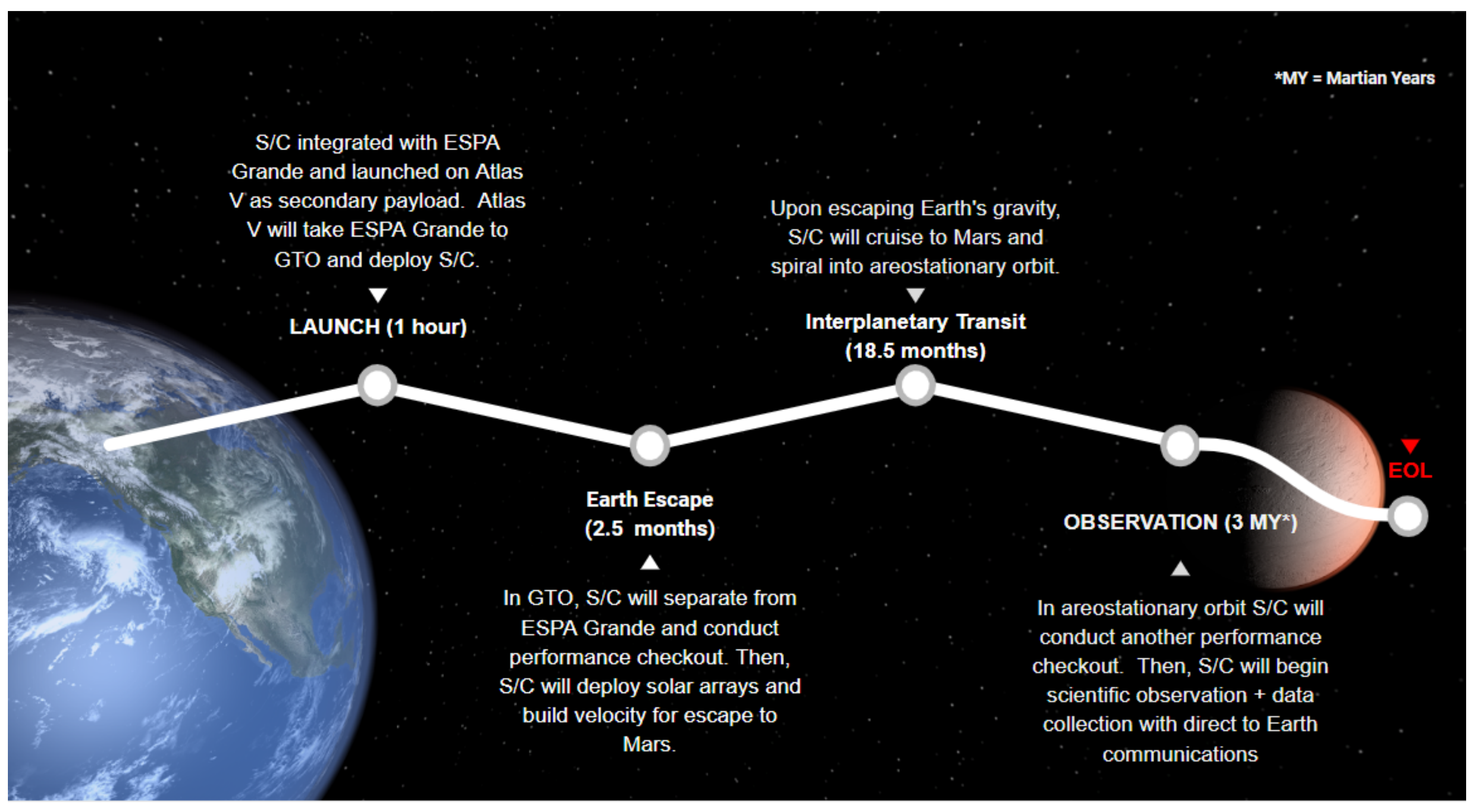
- 1 central EP thruster for Earth escape and interplanetary transit
- 4 smaller EP thrusters on each back corner for Mars capture and on-station operations

Communications

- Transmit 4.1 Gbits per sol
- Direct-to-Earth
- High gain X-band/Ka-band deployable antenna

Power

- Deployable solar cells
- Solar cell total area = 14.3 m^2
- Small-sat battery packs



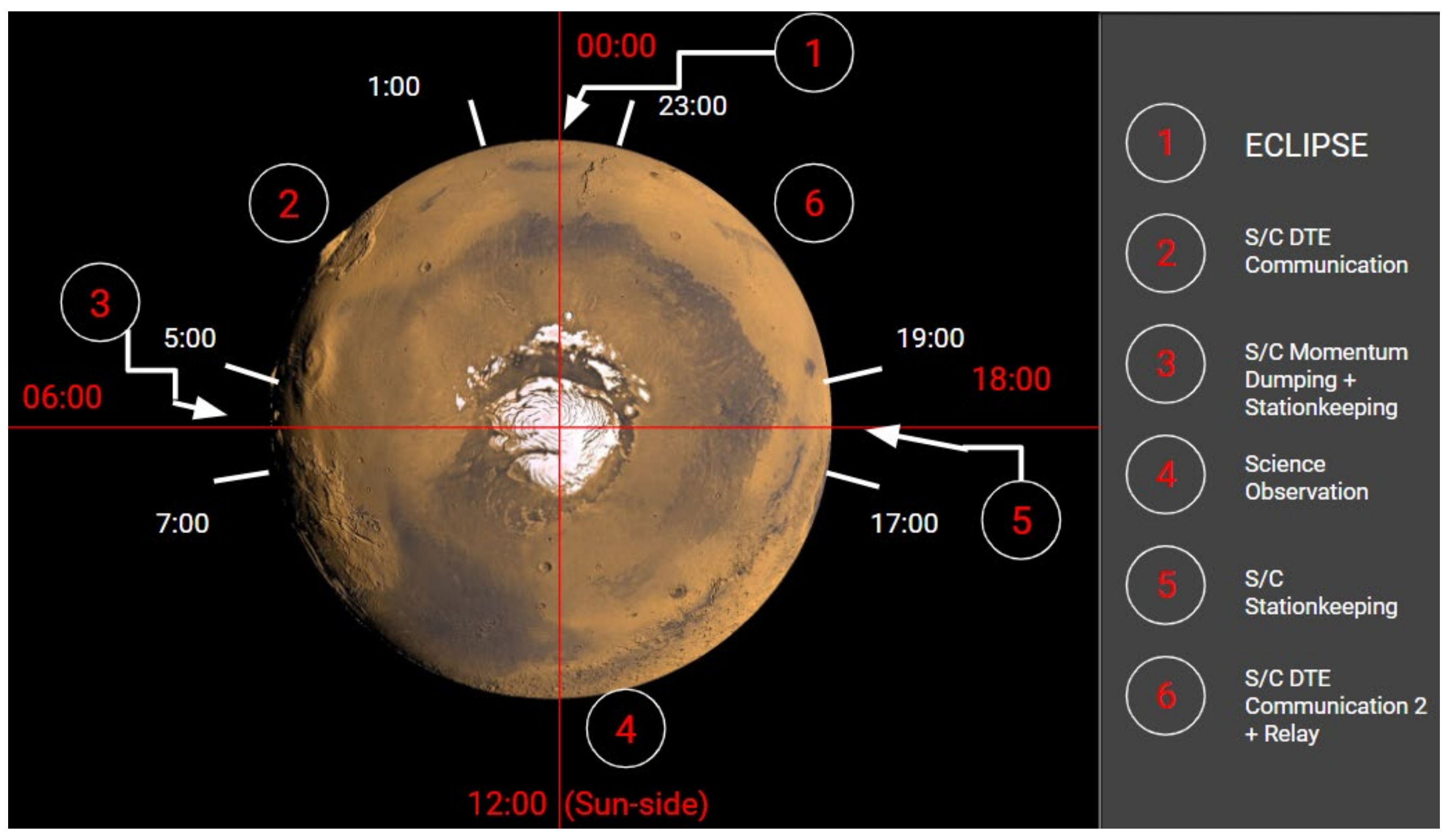
S/C integrated with ESPA Grande and launched on Atlas V as secondary payload. Atlas V will take ESPA Grande to GTO and deploy S/C.

In GTO, S/C will separate from ESPA Grande and conduct performance checkout. Then, S/C will deploy solar arrays and build velocity for escape to Mars.

Upon escaping Earth's gravity, S/C will cruise to Mars and spiral into areostationary orbit.

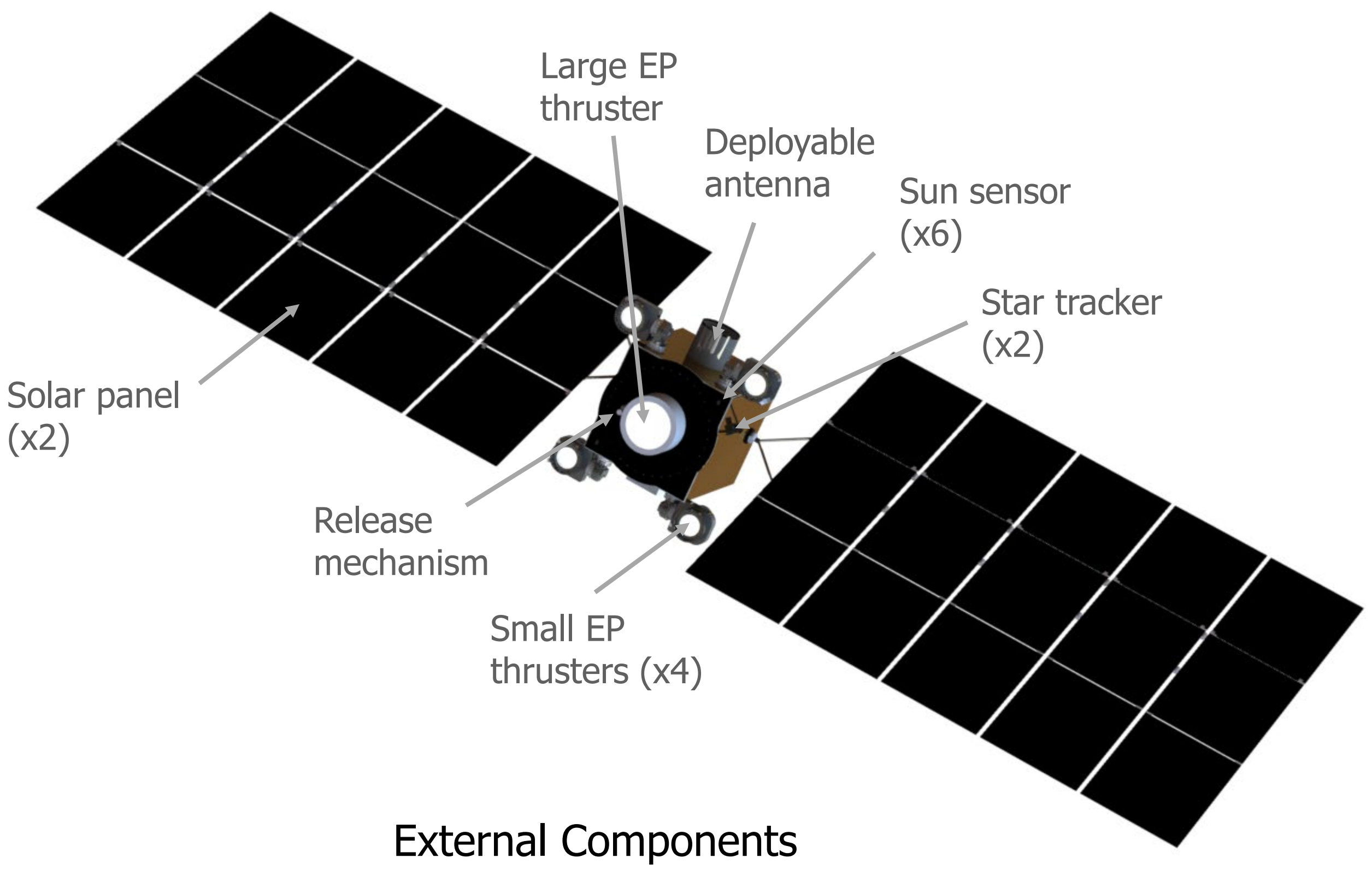
In areostationary orbit S/C will conduct another performance checkout. Then, S/C will begin scientific observation + data collection with direct to Earth communications

Concept of Operations

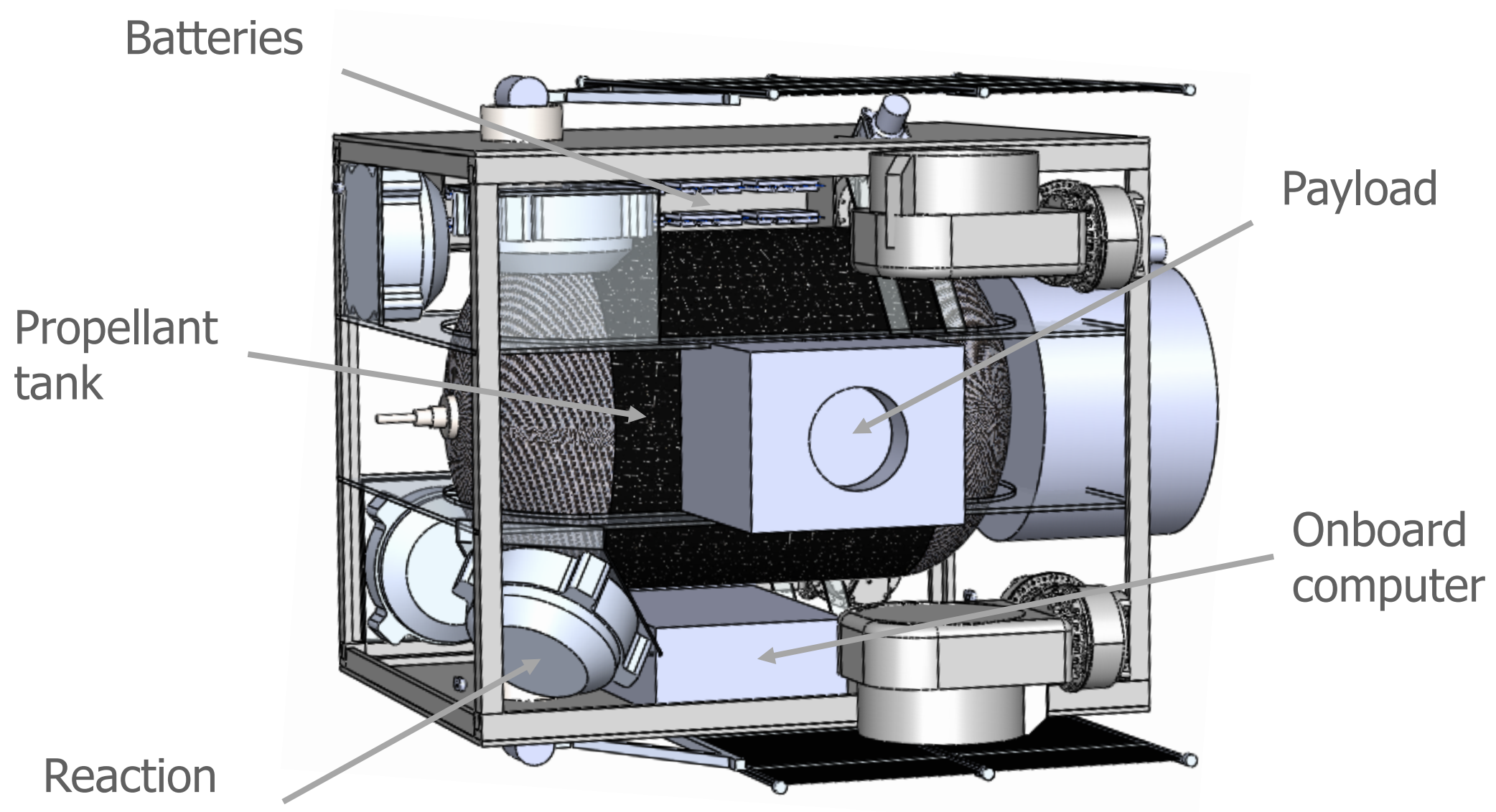


Day in the Life (Worst Case)

Satellite Design



External Components

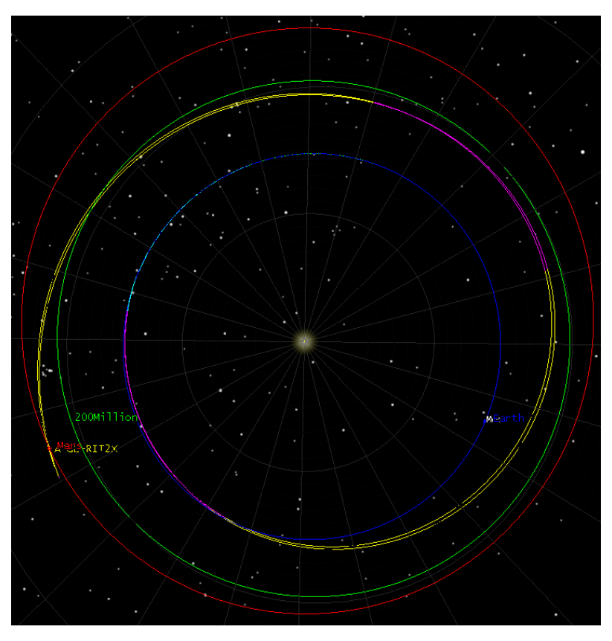


Internal Components

BUDGET SUMMARY	
Mass (kg)	350
Peak Power Required (W)	1650
Peak Power Provided (W)	2100
Volume/Form Factor	ESPA Grande Payload (24" port)

Lessons Learned

- Deployable antennas are needed to optimize mass and form factor for DTE communication at Mars
- Large power requirement of DTE leads to increased significance of subsystem duty cycles
- Electric propulsion requires multiple stages during interplanetary transit to close trajectory
- Escape from Earth is achievable but capture at Mars is much more difficult with the reduced thrust of EP
- Gravitational perturbations in areostationary orbit require additional momentum compensation in control system



STK Model of Trajectory

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

PUBLICATIONS AND PRESENTATIONS

[A] "Mars Areostationary Trace Gas Localizer," submitted to 2019 Interplanetary Small Satellite Conference, San Luis Obispo, CA, April 29-30 2019

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