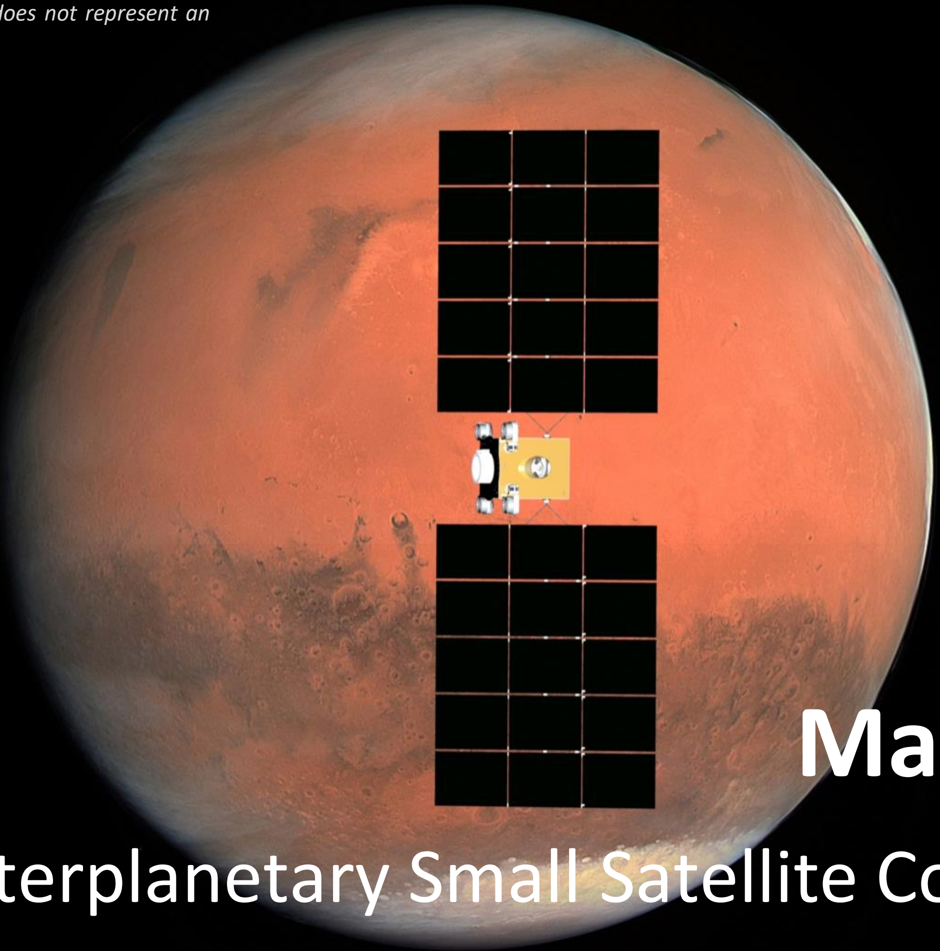
This presentation was created by students as an educational activity at the University of Michigan, and does not represent an actual mission.



Mars Areo TGL

Interplanetary Small Satellite Conference, 2019

Jet Propulsion Laboratory
California Institute of Technology

UNIVERSITY OF MICHIGAN

Collaboration Background

- This concept study was developed as an educational exercise for UM students, as part of a year-long SURP collaboration, with the goal of providing them exposure to a real-world mission concept. The mission concept was selected as the context for this study to provide boundary-conditions based on realistic scientific interests

- All allocations provided to the student team were based on reasonable assumptions by the JPL support team; they are pre-decisional and are for planning and discussion purposes only

- At JPL, the SURP effort was supported by Adrian Arteaga-Garcia, Nathan Barba, Serina Diniega, Danielle Marsh, Bogdan Oaida, Rick Redick, Vlada Stamenkovic, and Ryan Woolley

- At UM, the SURP effort was supported by Prof. Nilton Renno, and the SPACE 582/583 students: Ryan Whitney, Vishnu Saravanan, James Apfel, Taylor Morton, James Cooney, Shawn Lu, Sotirios Dedes, Nirmal Patel

Science Objectives

- MSL (Curiosity) found seasonal shifts in background levels of methane near Gale Crater over three Martian years
  - Methane observation confirmed by Mars Express one day after MSL
  - Column abundance (15.5±2.5 ppbv) greater than that predicted from either UV degradation of impact-delivered organics on surface or annual surface pressure cycle
- ExoMars mission was sent to investigate the atmospheric composition of Mars, but has yet to find evidence
- Mars Areo TGL would be capable of localizing the sources and sinks of any methane observations

Mission Objectives

1. Determine diurnal and seasonal variations of methane and its isotopologues

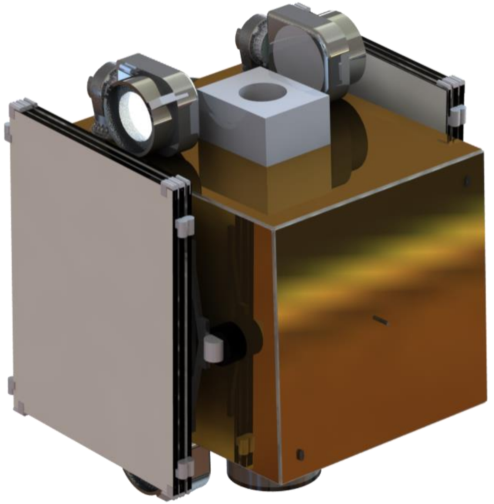
1. Demonstrate feasibility of electric propulsion (EP) for interplanetary small satellites

1. Make a case for Direct-to-Earth (DTE) communication at Mars for small satellites

Mission Concept

SmallSat launched as a secondary payload with the ESPA Grande Ring Interface.

- Mass:
  - 270 kg wet
  - 185 kg dry
- Form Factor: less than 1m x 1m x 1m stowed
- Payload: Ultra-High Sensitive (UHS) Miniaturized Spectrometer



Stowed Spacecraft Configuration

Payload - UHS Miniaturized Spectrometer

Surface Scan (Coarse Mode)

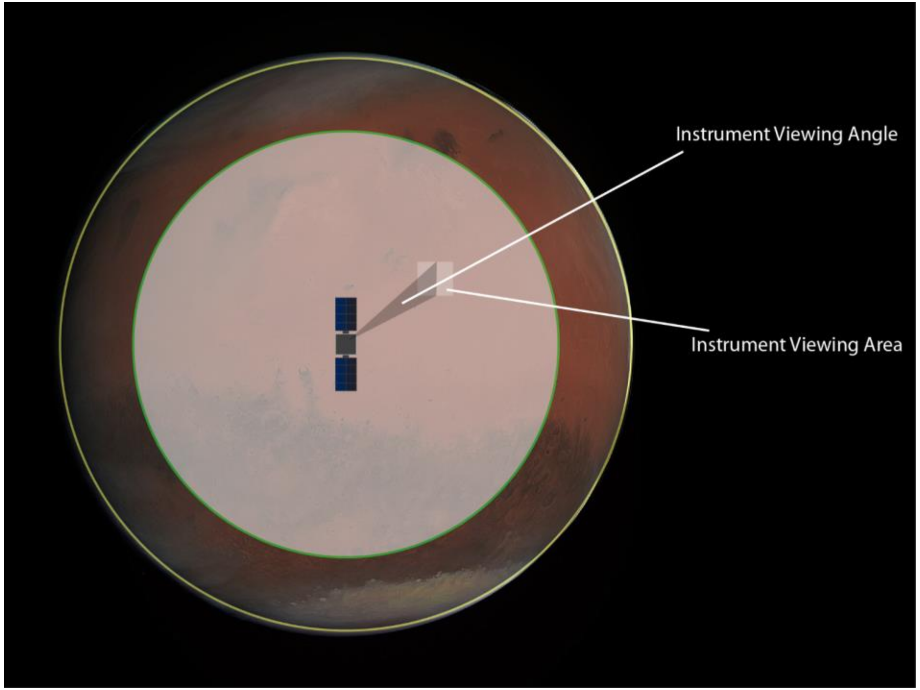
Target area	57.2x10^6 km^2
Pixel Resolution	30 m^2/pixel
Max Image Resolution	166 km^2
# of Images	2069
Time to image	10 sec
Slew Rate	0.15 deg/sec
Time to scan target area	~ 7.4 hours

Fine Mode

Pixel Resolution	4.6 m^2/pixel
Max Image Resolution	27 km^2

Other Specifications

Duty Cycle	78%
Max Image Resolution	3.45 Gb/sol



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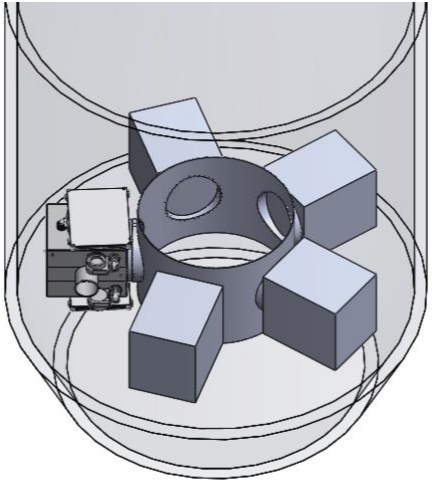
Bus Subsystem Design

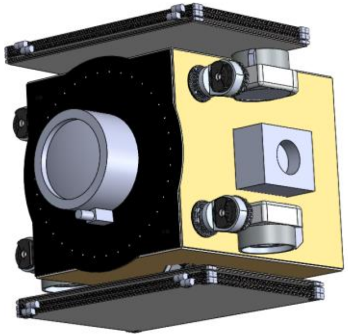
ADCS	C&DH
- 2x Star Trackers - 4x Gyros - 6x Sun Sensors - 4x RWAs - 0.003 deg Pointing Accuracy	- 2x BAE RAD 5545 flight computer
Mechanical	**Propulsion**
- Aluminum frame (7075) - Honeycomb panels	- 1x RIT 2X - 4X RIT 10 EVO - 105 Kg Capacity Xenon Tank - PPU



Spacecraft within 4m fairing

Bus Subsystem Design

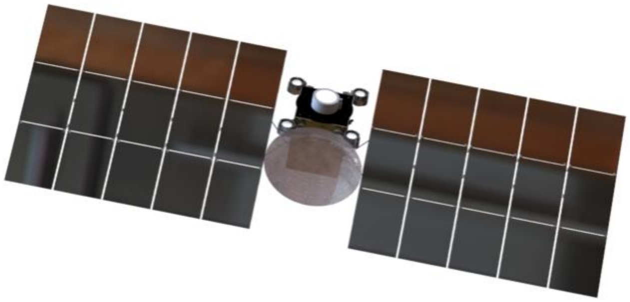
Thermal	**EPS**
- Z93 white paint - Internal zone heaters - No radiators required	- 2x deployable articulated solar arrays (14.3 m^2 total) - 8x Li-ion battery cells with total capacity of 312 W-Hr



Stowed configuration

Communications

- Ka-band 1.2 m deployable high gain antenna
- TWTA
- Small Deep Space Transponder



Spacecraft deployed configuration

Previous Mars Missions

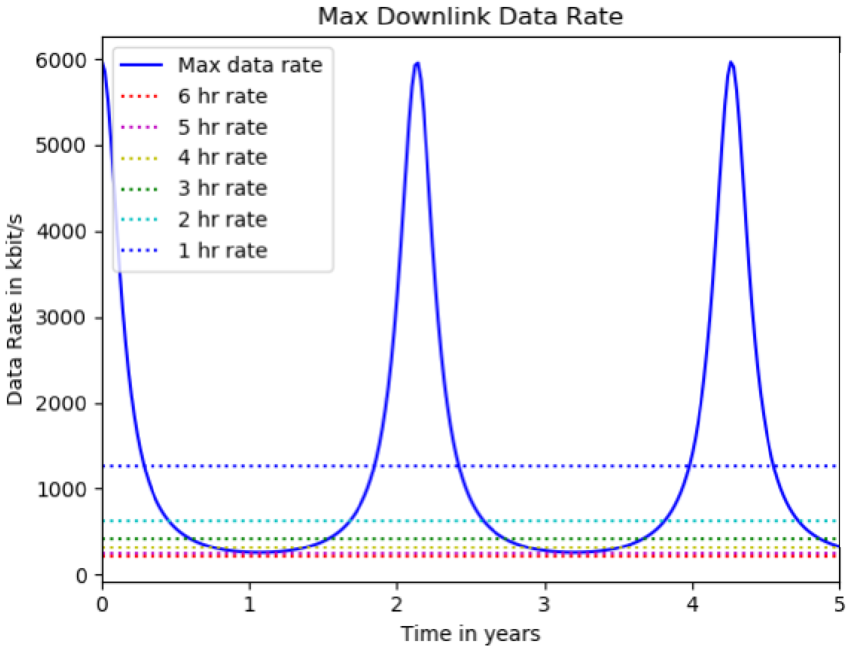
Mission	Mass (kg)	Communications	Propulsion
Mars Odyssey	758	DTE	Chemical
Mars Express	1120	DTE	Chemical
Mars Reconnaissance Orbiter	2180	DTE	Chemical
Mangalyaan	1337	DTE	Chemical
MAVEN	2454	DTE	Chemical
ExoMars	3755	DTE	Chemical
Mars Areo TGL	350	DTE	Electric

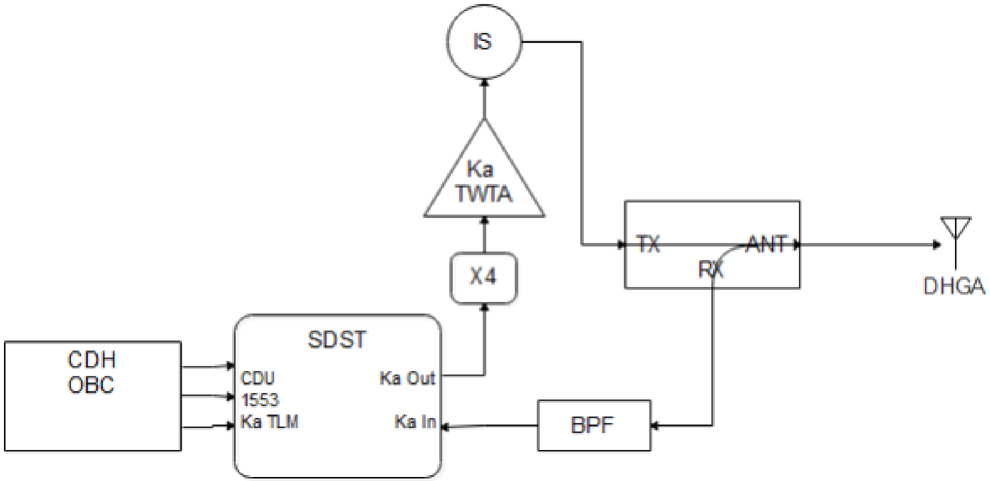
Communications: Direct-To-Earth

- Current communication options from Mars to Earth:
  - Relay via MAVEN/MRO
  - DTE

- MRO and Maven considerations
  - MRO on fourth extension of mission lifetime (to 2021)
  - MAVEN on first extension of mission lifetime (to Sept 2019)

Communications: Ka-band Architecture





Communications Architecture Block Diagram

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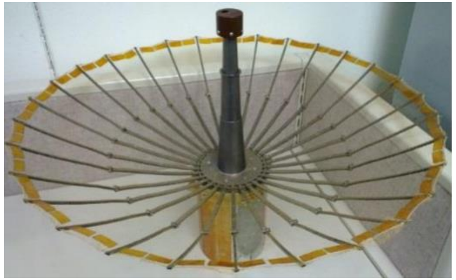
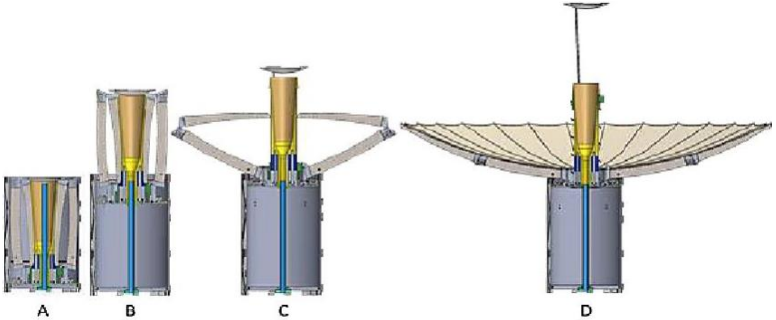
Communications: Antenna

- Deployable Ka-Band High Gain Antenna
- Mass: 5 kg
- Vol (stowed): 2.5 x 2.5 x 3.5 U
- Diameter: (deployed): 1.2m
- Data Rate: 0.2-5.9 Mbit/s
- Input Power: 400 W
- RainCube DHGA Heritage

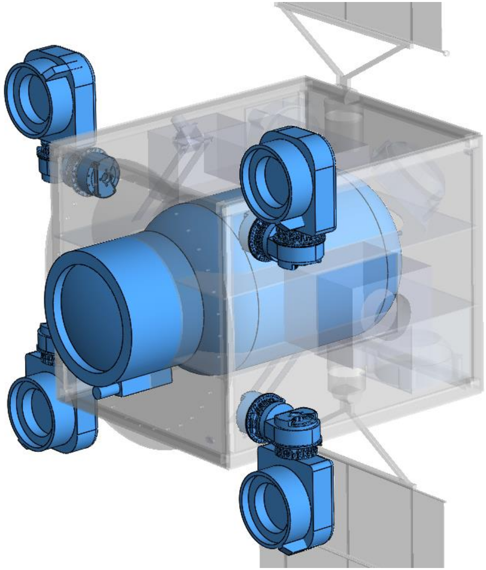




Images: Sauder, J. F., and Thomson, M. W., “The Mechanical Design of a Mesh Ka-band Parabolic Deployable Antenna (KaPDA) for CubeSats,” *2nd AIAA Spacecraft Structures Conference*, 2015.

Propulsion Architecture

- 1 RIT 2X
  - Earth Escape
  - Interplanetary Transit
- 4 RIT 10 Evos
  - 2 burn at a time
  - Mars Capture
  - Stationkeeping
  - Momentum Dumping



4 RIT 10 Evo Thrusters
1 RIT 2X Thruster
1 DS400 Xenon Tank

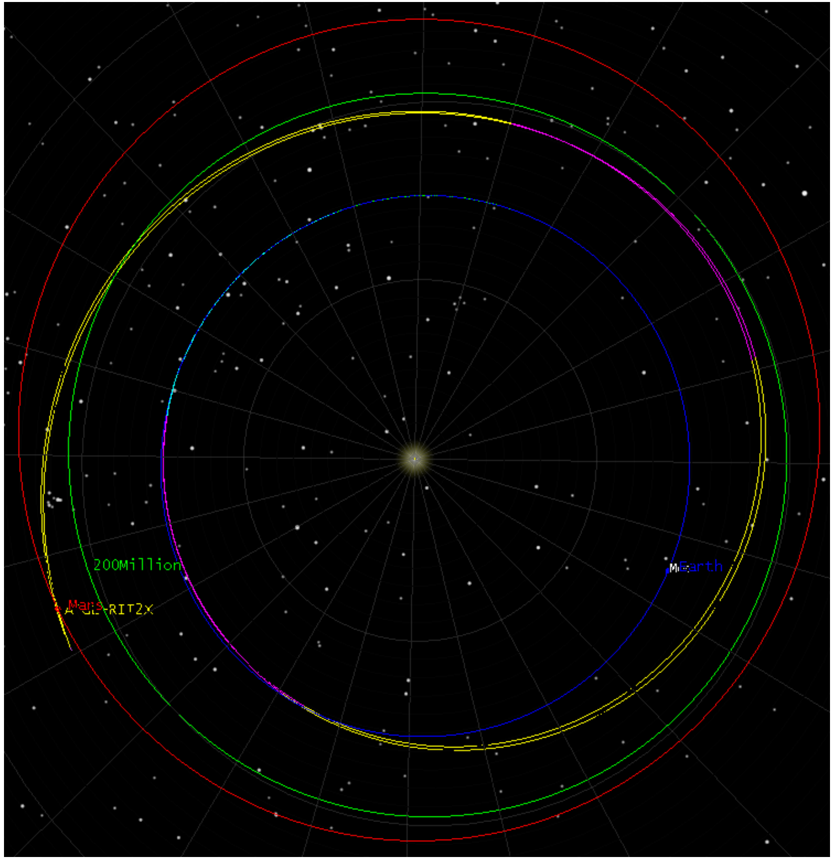
Thruster Parameters

RIT 2X Specifications		
	Low Power	High Power
Power (W)	2000 - 2500	4000 - 4500
Thrust (mN)	70 - 88	151 - 171
ISP (s)	3400 - 3500	3300 - 3500
Throughput		~350 Kg
Fuel		Xenon
Mass		< 10 Kg

RIT 10 Evo Specifications		
	Low Power	High Power
Power (W)	435	760
Thrust (mN)	15	25
ISP (s)	> 3000	> 3200
Throughput		~35 Kg
Fuel		Xenon
Mass		1.8 Kg

Orbital Maneuvers

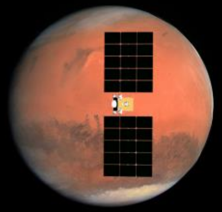
Orbit Phase	Prop Mass (kg)	Time (days)
Earth Escape	26.5	61
Interplanetary Transit	33.0	544
Mars Capture	8.0	38
Total	**67.5**	**643**



Summary

- Localization of methane could be conducive to delineating between biotic and abiotic sources
- Electric propulsion has great utility and should be further developed for interplanetary missions
- Deployable antenna technology will become increasingly significant for small satellite missions

Questions?



Backup Slides

Concept of Operations

*MY = Martian Years

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.

LAUNCH (1 hour)

Earth Escape (2.5 months)

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.

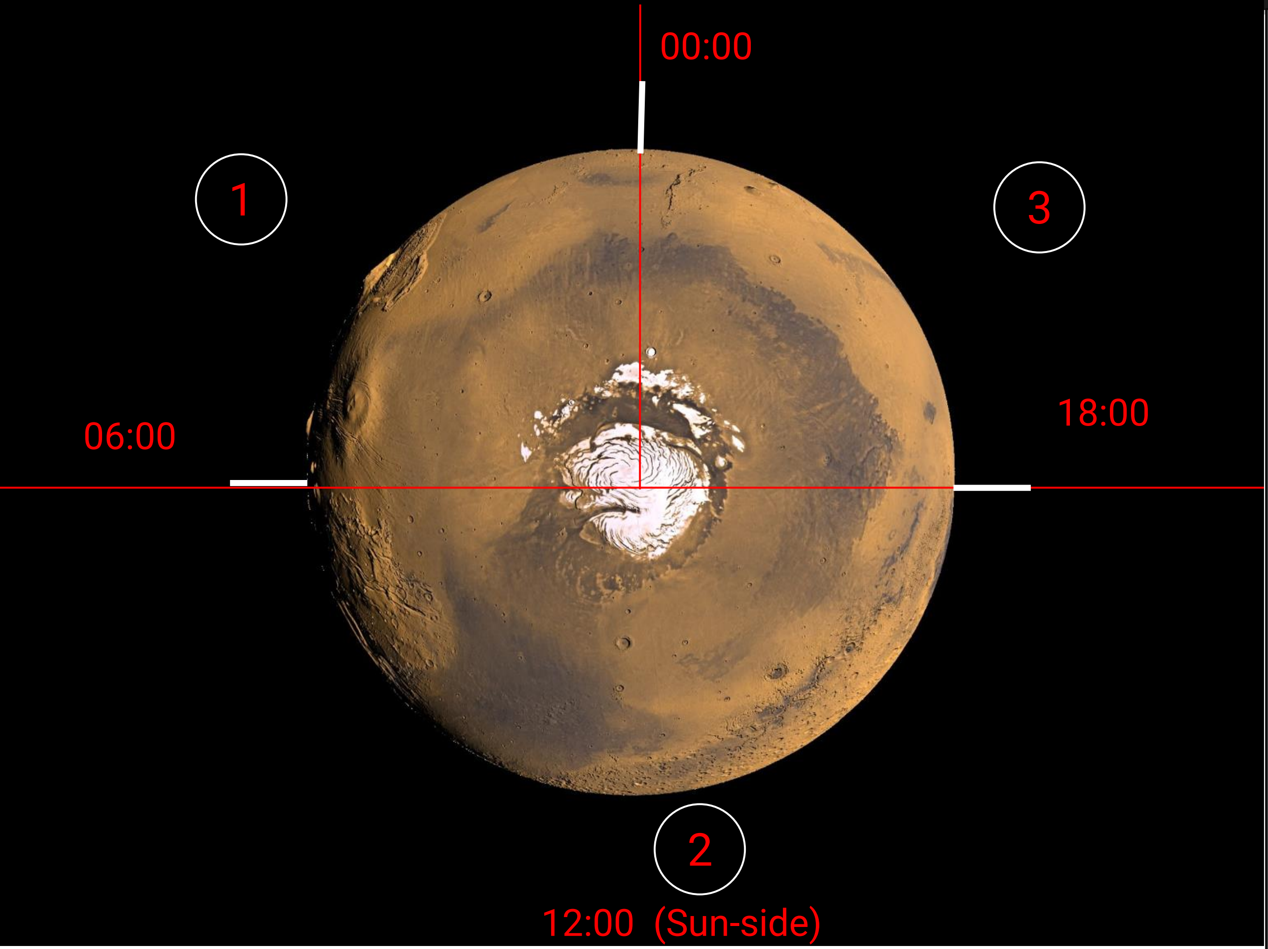
Interplanetary Transit (18.5 months)

OBSERVATION (3 MY*)

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

EOL

Day in the Life - Nominal Ops

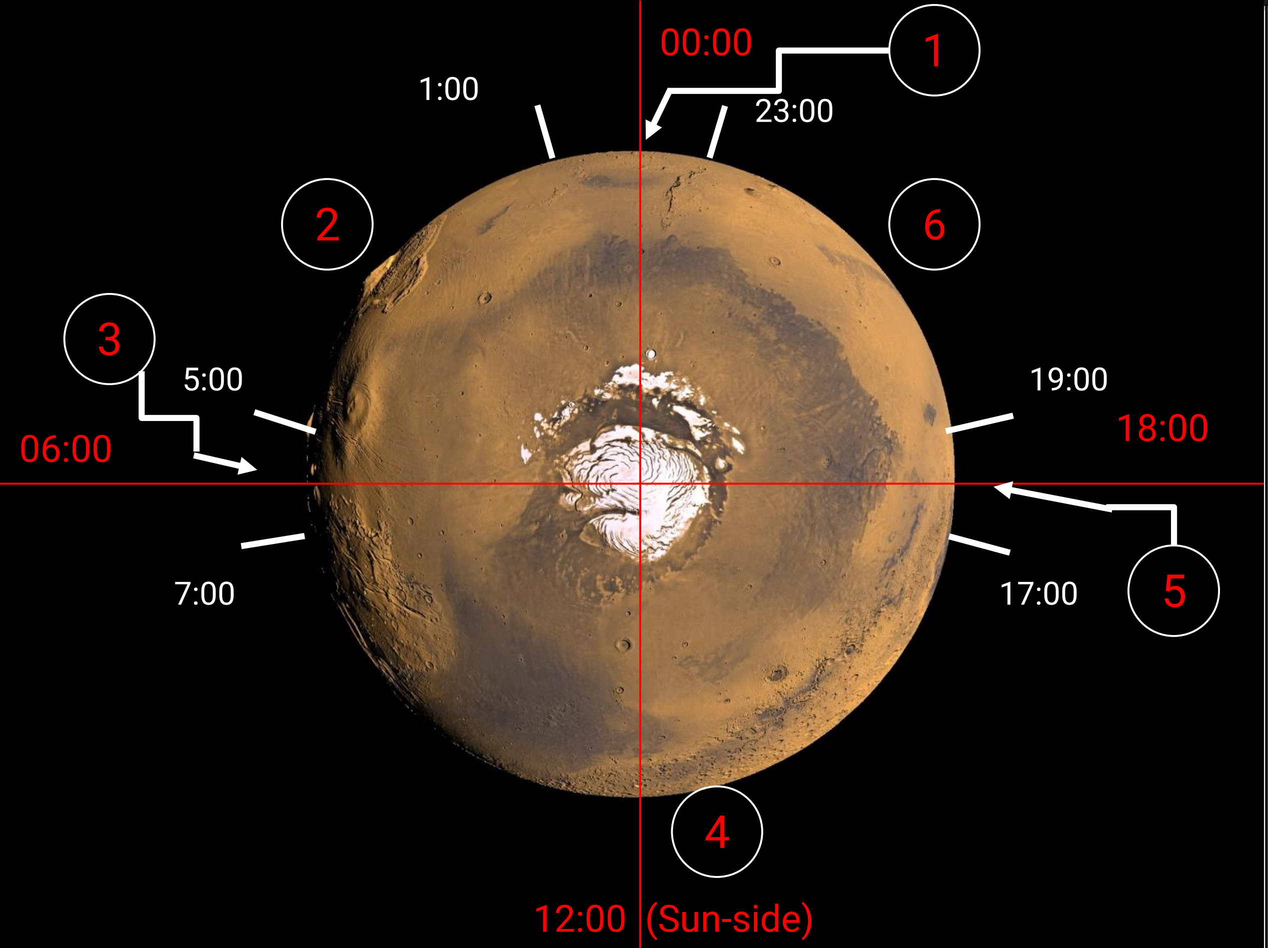


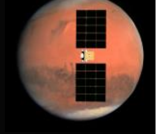
1 S/C DTE Communication

2 Science Observation

3 S/C DTE Relay

Day in the Life - Worst Case





1	ECLIPSE
2	S/C DTE Communication
3	S/C Momentum Dumping + Stationkeeping
4	Science Observation
5	S/C Stationkeeping
6	S/C DTE Communication 2 + Relay