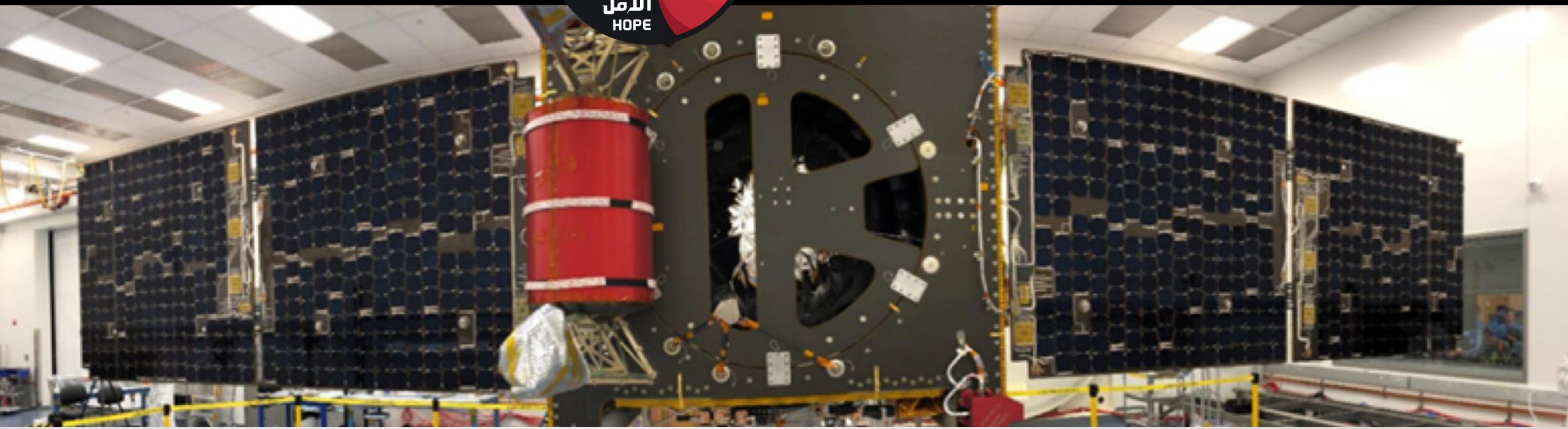


EMIRATES HOPE MARS MISSION (EMM) SCIENCE OVERVIEW

Presented by Sarah Amiri on behalf of the EMM Team

NOTE ADDED BY JPL WEBMASTER: This content has not been approved or adopted by NASA, JPL, or the California Institute of Technology. This document is being made available for information purposes only, and any views and opinions expressed herein do not necessarily state or reflect those of NASA, JPL, or the California Institute of Technology

AL AMAL

- The Emirates Mars Mission is the first planetary exploration mission for the UAE, announced in 2014.
- Hope Probe is developed through a partnership between Mohamed bin Rashid Space Centre (MBRSC), LASP at University of Colorado Boulder, and Arizona State University (ASU)
- Due to launch July 2020

PROGRAM OBJECTIVES

- Develop science and engineering capabilities
- Data from the mission should be beneficial to the global science community
- Arrive at Mars by the 50th anniversary of the formation of the UAE.

SCIENCE OBJECTIVES

EMM is a mission focused on atmospheric dynamics. It will explore the atmosphere of Mars globally while sampling both diurnal and seasonal timescales.

Science Questions	→	Science Objectives
How does the Martian lower atmosphere respond globally, diurnally and seasonally to solar forcing?	→	Characterize the state of the Martian lower atmosphere on global scales and its geographic, diurnal and seasonal variability
How do conditions throughout the Martian atmosphere affect rates of atmospheric escape?	→	Correlate rates of thermal and photochemical atmospheric escape with conditions in the collisional Martian atmosphere
How do key constituents in the Martian exosphere behave temporally and spatially?	→	Characterize the spatial structure and variability of key constituents in the Martian exosphere

EMM PARTNERSHIPS

مركز محمد بن راشد للفضاء
MOHAMMED BIN RASHID SPACE CENTRE

United Arab Emirates
وكالة الإمارات للفضاء
UAE SPACE AGENCY

Project Management & Development ← Fund

Science

مركز محمد بن راشد للفضاء
MOHAMMED BIN RASHID SPACE CENTRE

Arizona State University

SSL UC Berkeley

SPACE SCIENCE INSTITUTE

LASP Laboratory for Atmospheric and Space Physics University of Colorado Boulder

LMD

Spacecraft, Mission Operations, Observatory and Spacecraft I&T

مركز محمد بن راشد للفضاء
MOHAMMED BIN RASHID SPACE CENTRE

LASP Laboratory for Atmospheric and Space Physics University of Colorado Boulder

Instruments

مركز محمد بن راشد للفضاء
MOHAMMED BIN RASHID SPACE CENTRE

LASP Laboratory for Atmospheric and Space Physics University of Colorado Boulder

SSL UC Berkeley

ASU School of Earth & Space Exploration
ARIZONA STATE UNIVERSITY

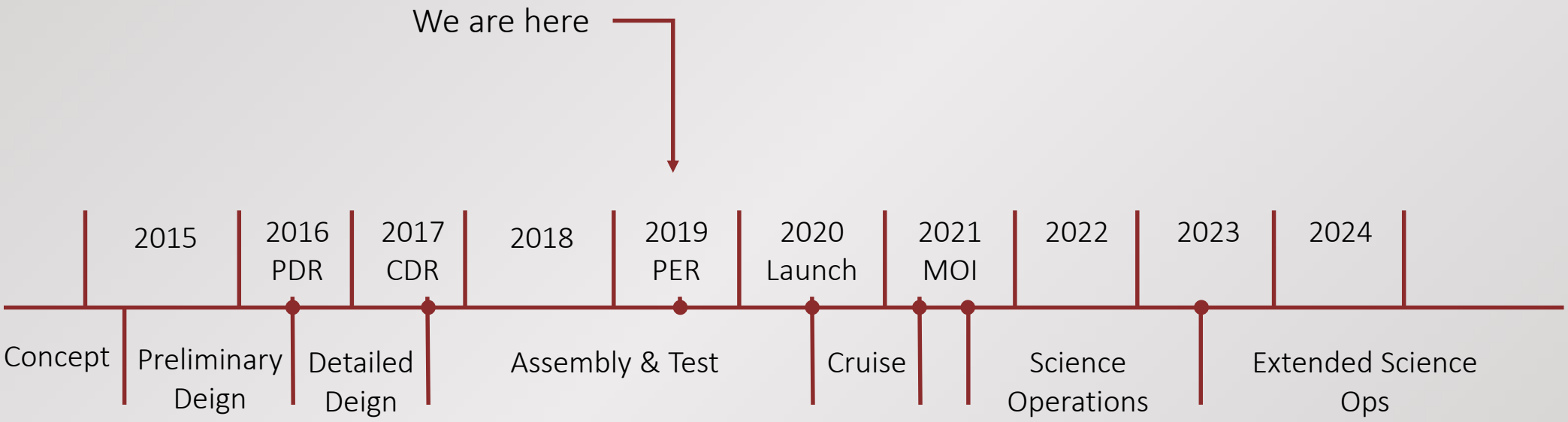
Navigation

KINETX AEROSPACE

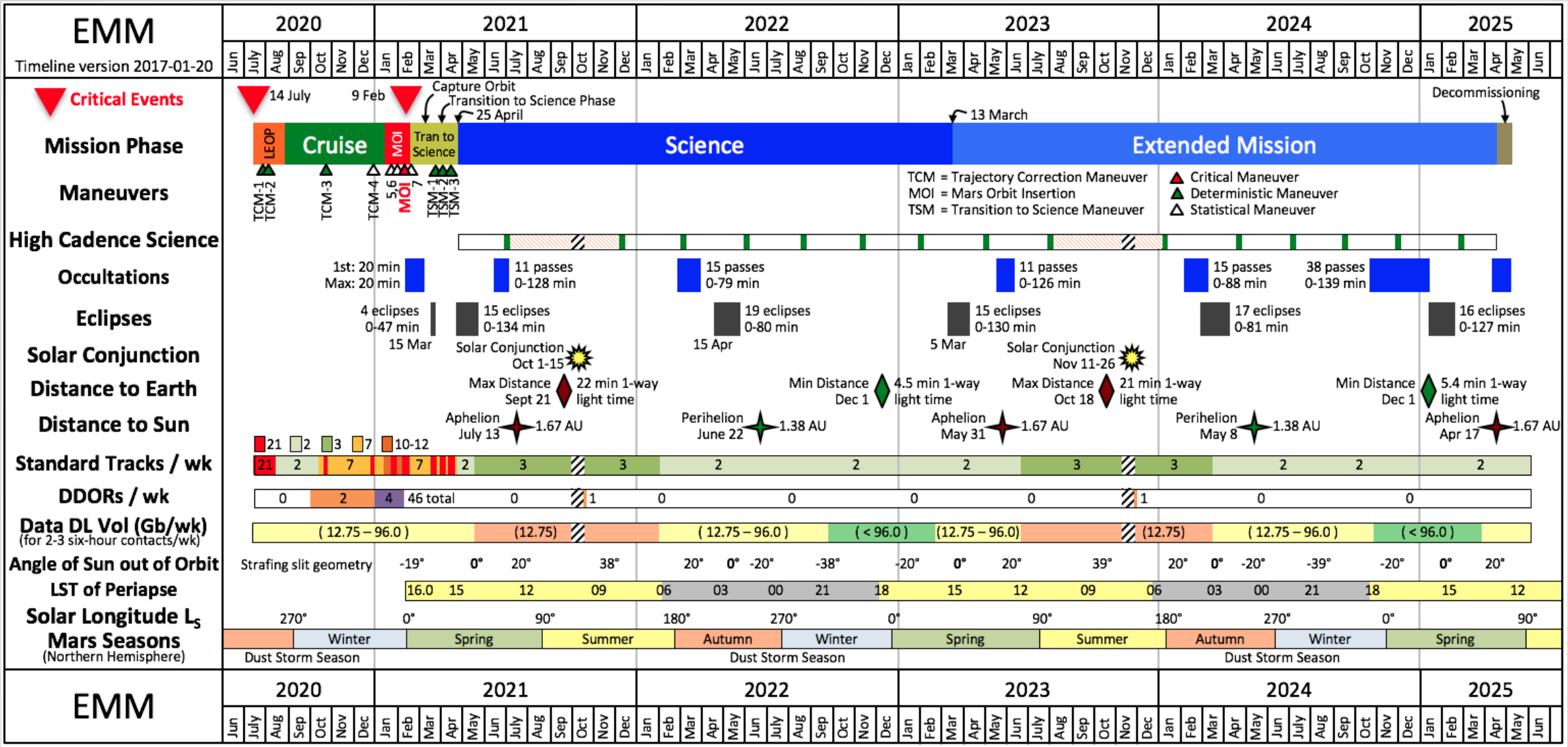
Launch Vehicle

MITSUBISHI HEAVY INDUSTRIES, LTD.

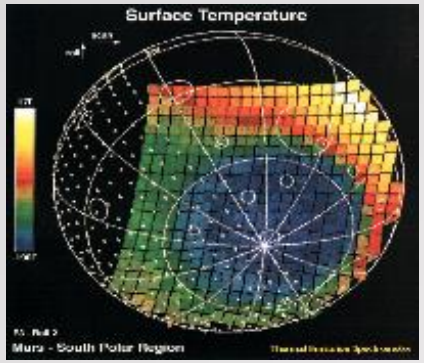
EMM PROJECT DEVELOPMENT TIMELINE



MISSION TIMELINE

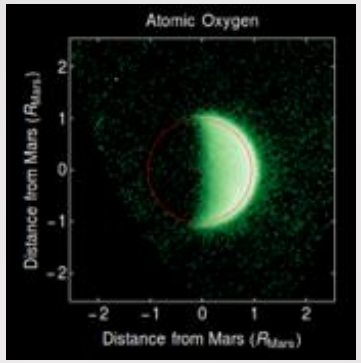


EMM INSTRUMENTS



EMIRS

Fourier Transform IR Spectrometer



EMUS

Ultra Violet Imaging Spectrometer

EXI

Imager with 12 MP camera with 6 bandpass filters (VIS/UV)

EMM Science Flow

Science Investigations	Physical Parameters	Observable Quantity	Instruments
Determine the three- dimensional thermal state of the lower atmosphere and its diurnal variability, on sub-seasonal timescales	Temperature Profiles <50 km	Absolute radiance of CO2 absorption band (7-8 µm and 14-16 µm)	EMIRS (IR)
Determine the geographic and diurnal distribution of key constituents in the lower atmosphere on sub-seasonal timescales	Surface Temperatures	Absolute radiance over a subset of the spectral range (7 - 12 µm)	
	H20 vapour column abundance	Relative radiance of H2O vapor absorption (25-40um)	
	Dust column integrated optical depth 9 µm	Relative radiance of dust absorption bands (8 -25 µm)	
	Ice column integrated optical depth at 12 µm and 320 nm	Relative radiance of H2O ice absorption bands (10-15 µm)	
	Ozone column integrated abundance	2D image of radiance in 320	EXI (VIS/UV)
		2D image of radiance in 260	

EMM Science Flow

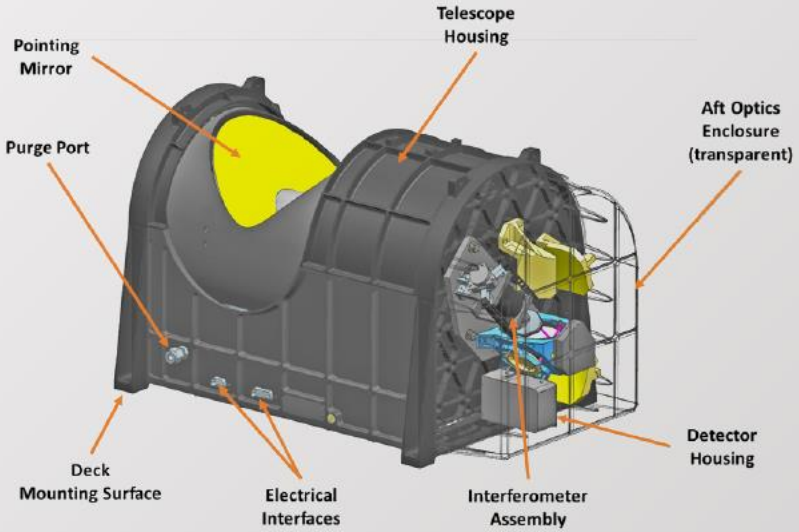
Science Investigations	Physical Parameters	Observable Quantity	Instruments
Determine the abundance and spatial variability of key neutral species in the thermosphere on sub-seasonal timescales	Carbon Monoxide Column Density	CO Emmistion (CO 4PG: 140–170 nm)	EMUS (FUV)
	Oxygen Column Density	Light intensity image at O (130.4 nm & 135.6nm)	
Determine the three-dimensional structure and variability of key species in the exosphere and their variability on sub-seasonal timescales	Density of Hydrogen Corona	Light intensity at H (121.6 nm and 102.6 nm)	
	Density of Oxygen Corona	Altitude profiles at H emission (121.6 nm and 102.6 nm)	
		Light intensity at O (130.4 nm)	
		Altitude profiles at O emission (130.4nm)	

EMIRS

Instrument Description

EMIRS is the 5th generation ASU built FTIR spectrometer with OTES, Mini-TES (2x), MGS-TES and MO-TES heritage

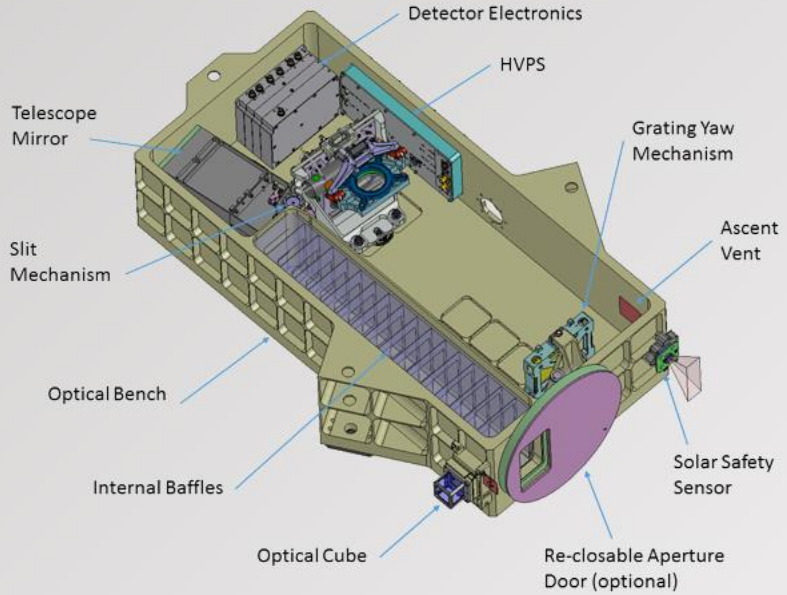
- Simple, FTIR spectrometer w/ pointing mirror
- Acquires interferograms every 4 seconds
- Space and internal blackbody provide 1.5% absolute calibration
- Electronics compress and packetize science and housekeeping data



SPECIFICATION	
Instantaneous Field of view	6 mrad
Spectral Resolution	5 cm-1 or 10 cm-1
Spectral Range	6-40+ µm
Spatial Resolution	<300 km resolution
Observation Capability	Observe ½ of Mars within ½ hour of observing ~60 observations per week (~20/orbit)

MEASUREMENT REQUIRED	SCIENCE NEED
Relative radiance of dust absorption bands	To characterize dust.
Relative radiance of ice absorption bands	To characterize water ice clouds.
Relative radiance of H_2O vapor absorption bands	To track the Martian water cycle.
Absolute radiance of CO_2 absorption band	Track the thermal state of the Martian atmosphere.
Radiance at 1300 cm^{-1}	Boundary condition for the lower atmosphere.

EMUS



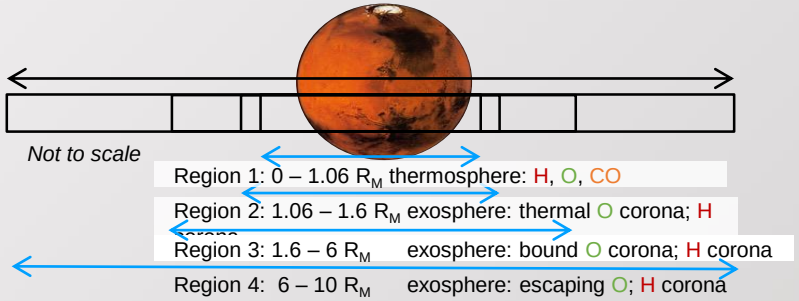
Instrument Description

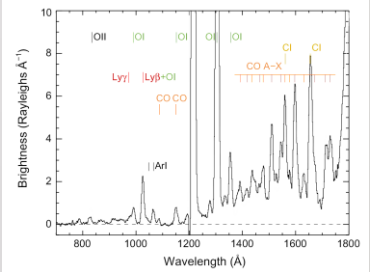
- Far ultraviolet imaging spectrograph that will characterize the escape of hydrogen and oxygen from Mars and the state of the Mars Thermosphere.
- It consists of a single telescope mirror feeding a Rowland circle imaging spectrograph with a photon-counting and locating detector.
- The EMUS spatial resolution of less than 300km on the disk is sufficient to characterize spatial variability in the Martian thermosphere (100-200 km altitude) and exosphere (>200 km altitude).

Instrument Specifications

SPECIFICATION	
Field of view	(0.18°, 0.25°, 0.7°) × 11.0°
Wavelength range	100 – 170 nm
Spectral resolution	1.3, 1.8, 5 nm
Spatial resolution with narrow slit	0.14° × 0.20°
Detector photocathode	CsI

Science Targets

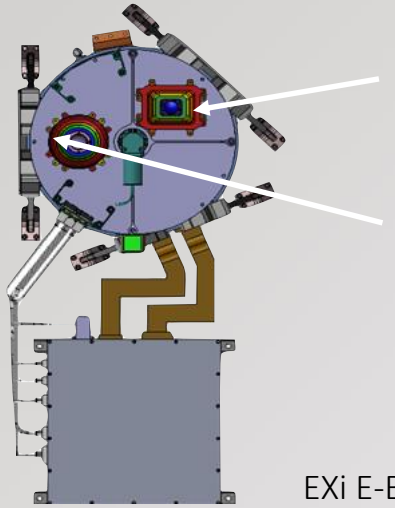




FUV spectrum of Mars
[Feldman. Icarus 214.2 (2011): 394-399]

TARGETS	WAVELENGTH
H	102.6, 121.6 nm
O	130.4, 135.6 nm
CO 4PG	140-170 nm

EXI



INSTRUMENT DESCRIPTION

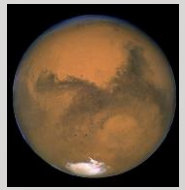
- 12 Mpix CMOS Imager with re-closeable door and filter wheel
- Filter band-pass targets
  - Blue: 437±5 nm CW, ≤20 nm FWHM
  - Green: 546±5 nm CW, ≤20 nm FWHM
  - Red: 635±5 nm CW, ≤20 nm FWHM
  - UV1: 260±5 nm CW, ≤30 nm FWHM
  - UV2: 320±5 nm CW, ≤30 nm FWHM

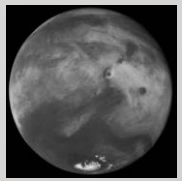
INSTRUMENT SPECIFICATIONS

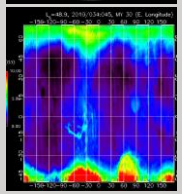
Specification	UV	VIS
Focal Plane Format	12.6 MP 4:3 format 4096x3072 @5.5 um	
Technology	CMOS	
Dynamic Range	12-bit, 13,500 e full well	
Lens System	48 mm, f/3.6	51 mm, f/4.25
Field of View	19.0°	25.8° by 19.2°
Pixel Angular View	23 arcsec per pixel	22 arcsec per pixel
Plate Scale	0.85 mm/°	0.9 mm/°
Distortion @9.35°	+6%	-2%
Ground coverage at apoapsis and priapsis	Full Disk	
Ground resolution at apoapsis / priapsis	4.9 /2.3 km per pixel	4.6 / 2.2 km per pixel
Filter Spectral Bands	UV1: 245-275 nm UV2: 305-335nm	Blue: 427-447 nm Green: 536-556 nm Red: 625-645 nm

SCIENCE TARGETS

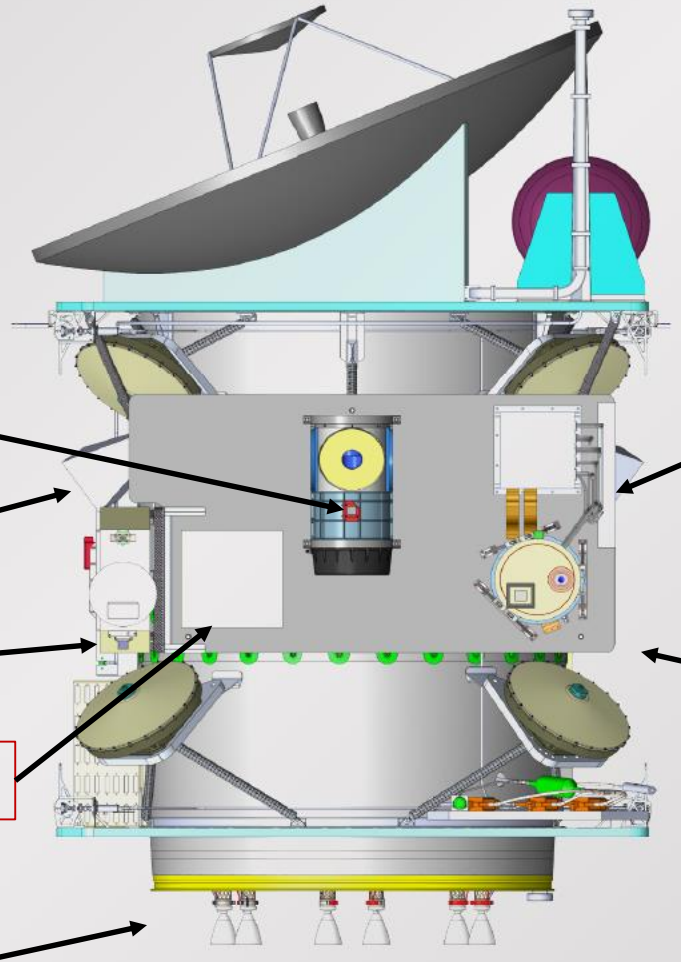
SCIENCE PRODUCT	SPATIAL RESOLUTION	IMAGE WAVELENGTHS
Dust Column-integrated optical Depth	≤ 10 km	635 nm
Water Ice cloud Column-integrated optical depth	≤ 10 km	320 nm
Ozone Column-integrated abundance	≤ 10 km	260 nm
Color images of Mars	≤ 10 km	437, 546, and 635 nm



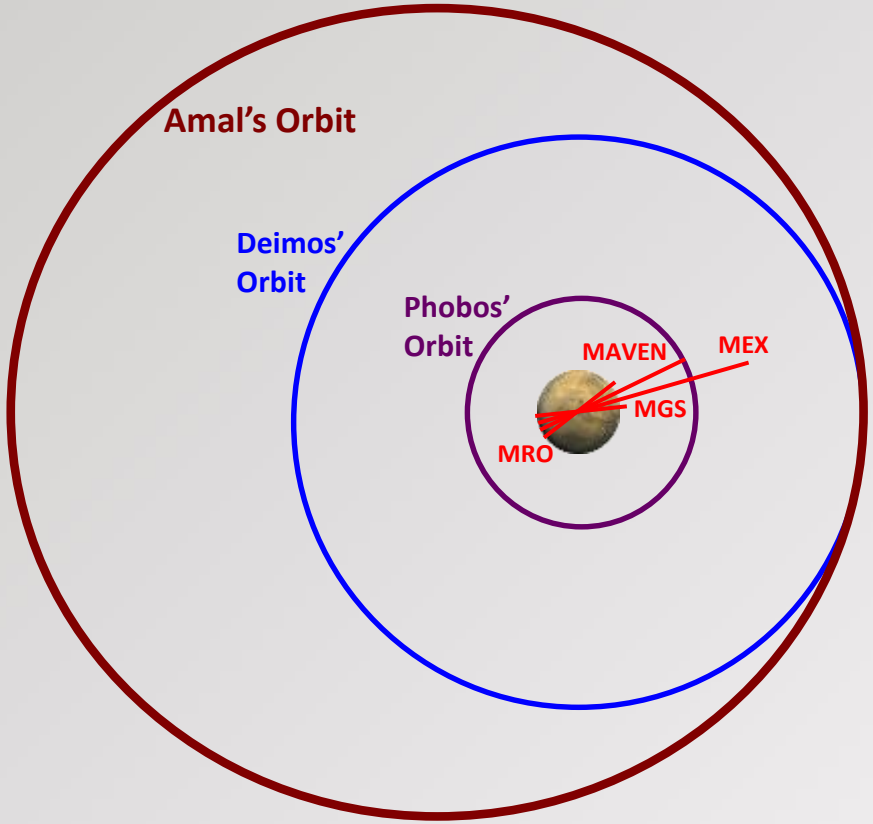




INSTRUMENT PAYLOAD ON THE OBSERVATORY

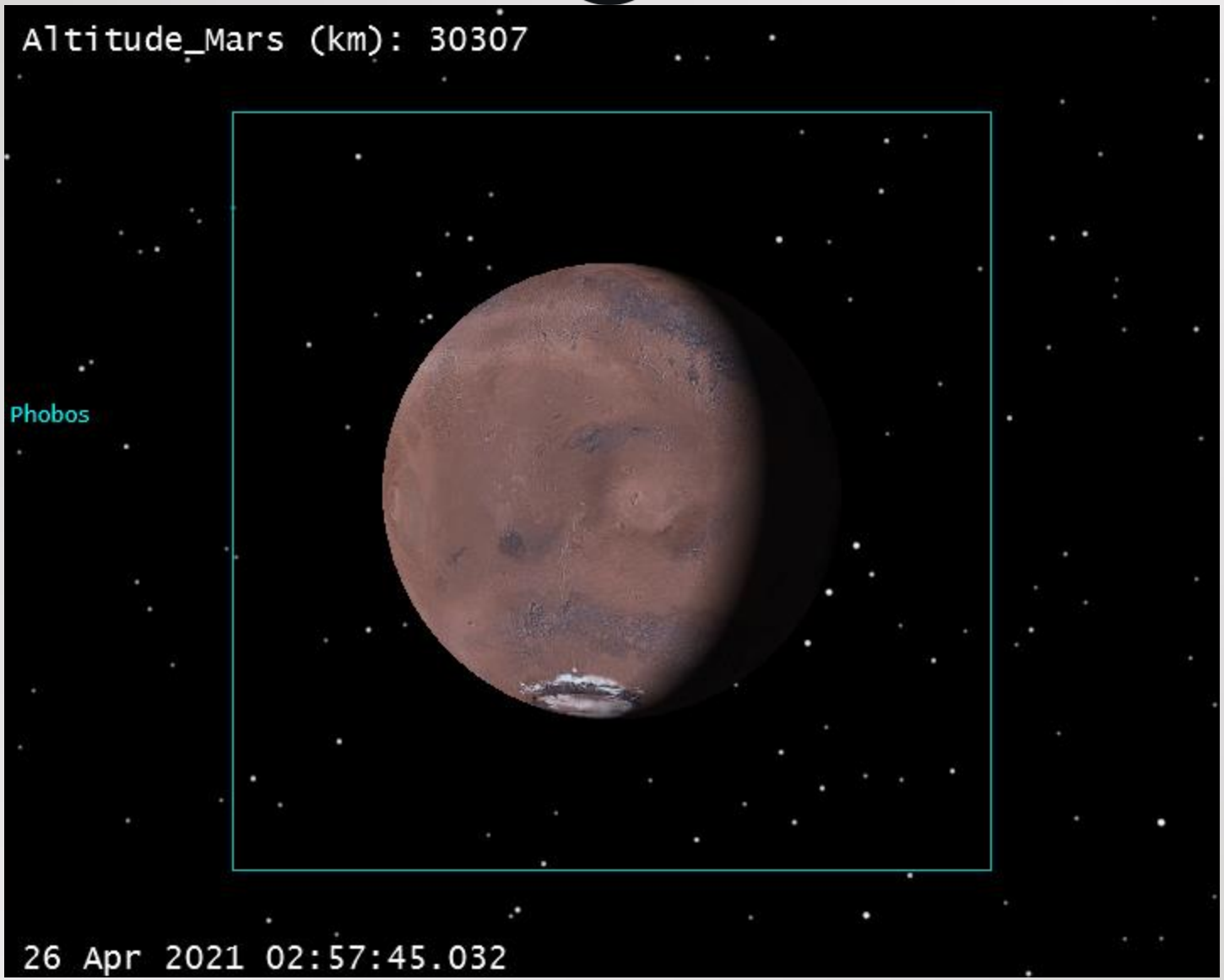


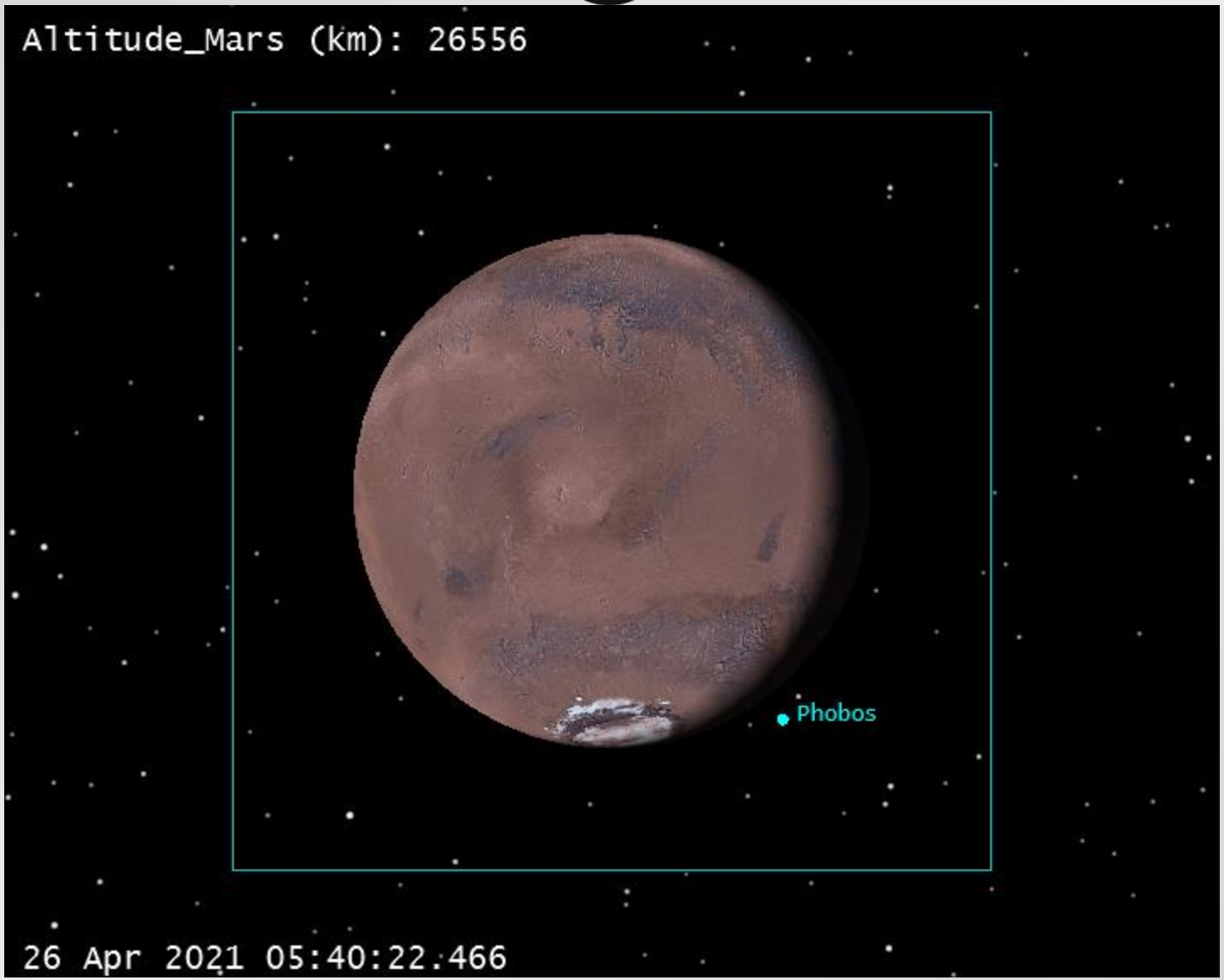
EMM'S SCIENCE ORBIT

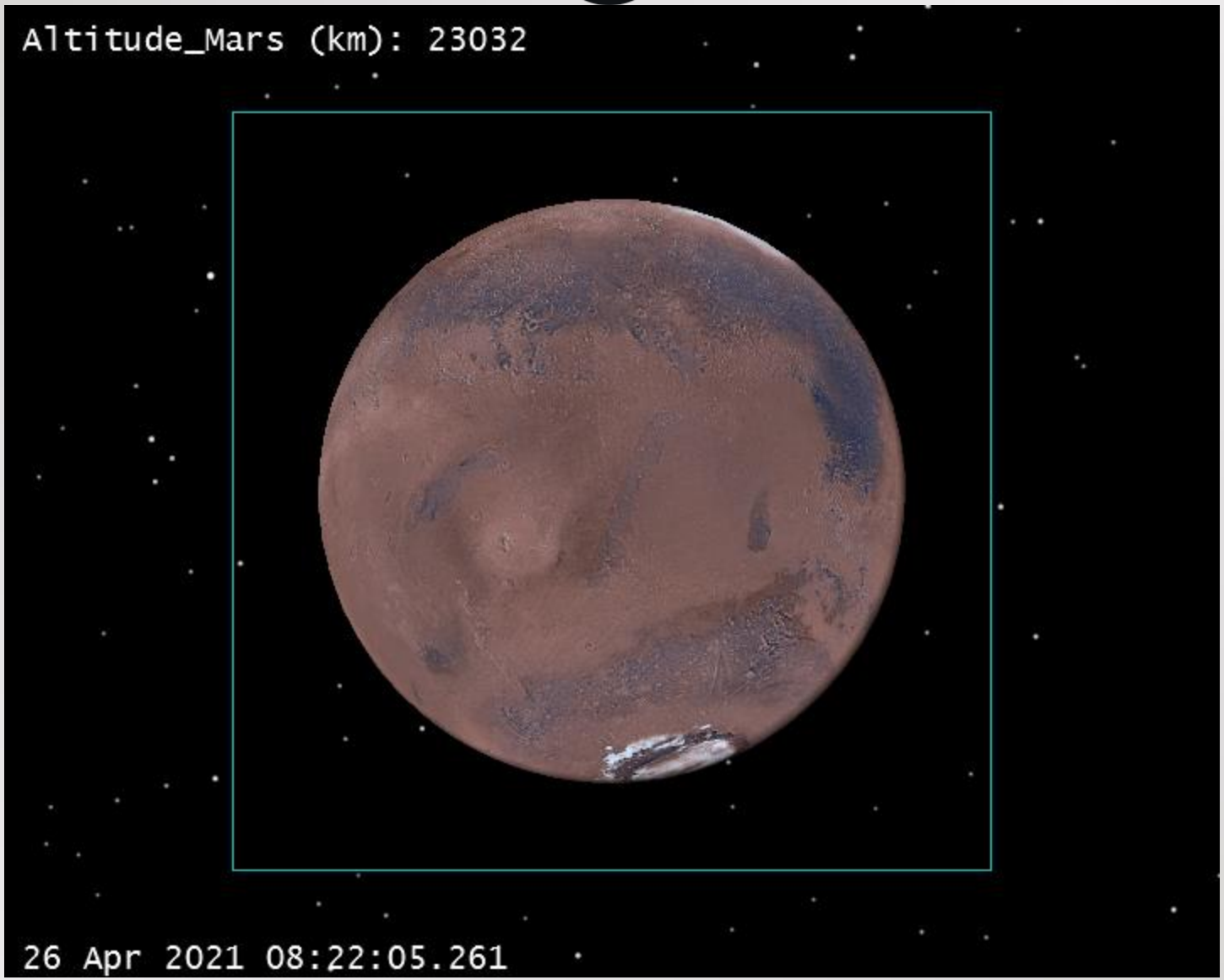


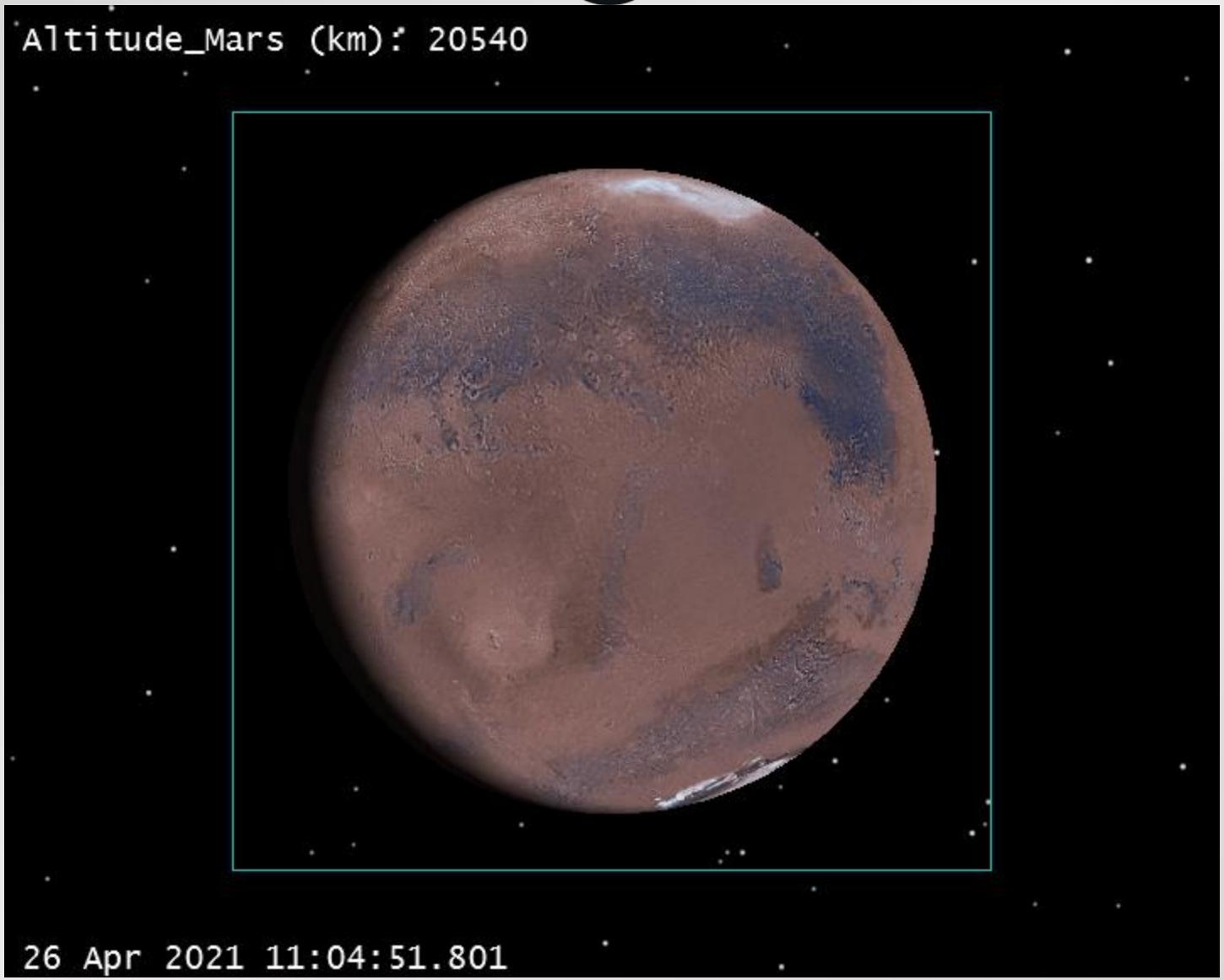
- **High altitude**: 20,000 km x 43,000 km altitude.
  - Each observation covers the majority the Martian disk, providing substantial coverage of several local solar time ranges.
- **At periapse**, the orbit is ~synchronous with Mars' motion. During this time, the spacecraft observes a large part of Mars at various lighting conditions.
- **At apoapse**, Mars rotates quickly beneath the observatory, giving EMM opportunities to survey the globe.
- **Period**: 2.25 sols.
  - From one periapse to the next, Mars rotates 360+360+90 deg. That last 90 deg is key. At each periapse, the spacecraft observes the next quadrant of Mars.
  - Every 4 orbits fills in a full map. 2.25 sols * 4 = 9 sols
- **Inclination**: 25 deg.
  - The orbit is inclined enough to see each pole
- **Argument of periapse**: ~180 deg. This balances the time we spend over each of Mars' hemispheres.

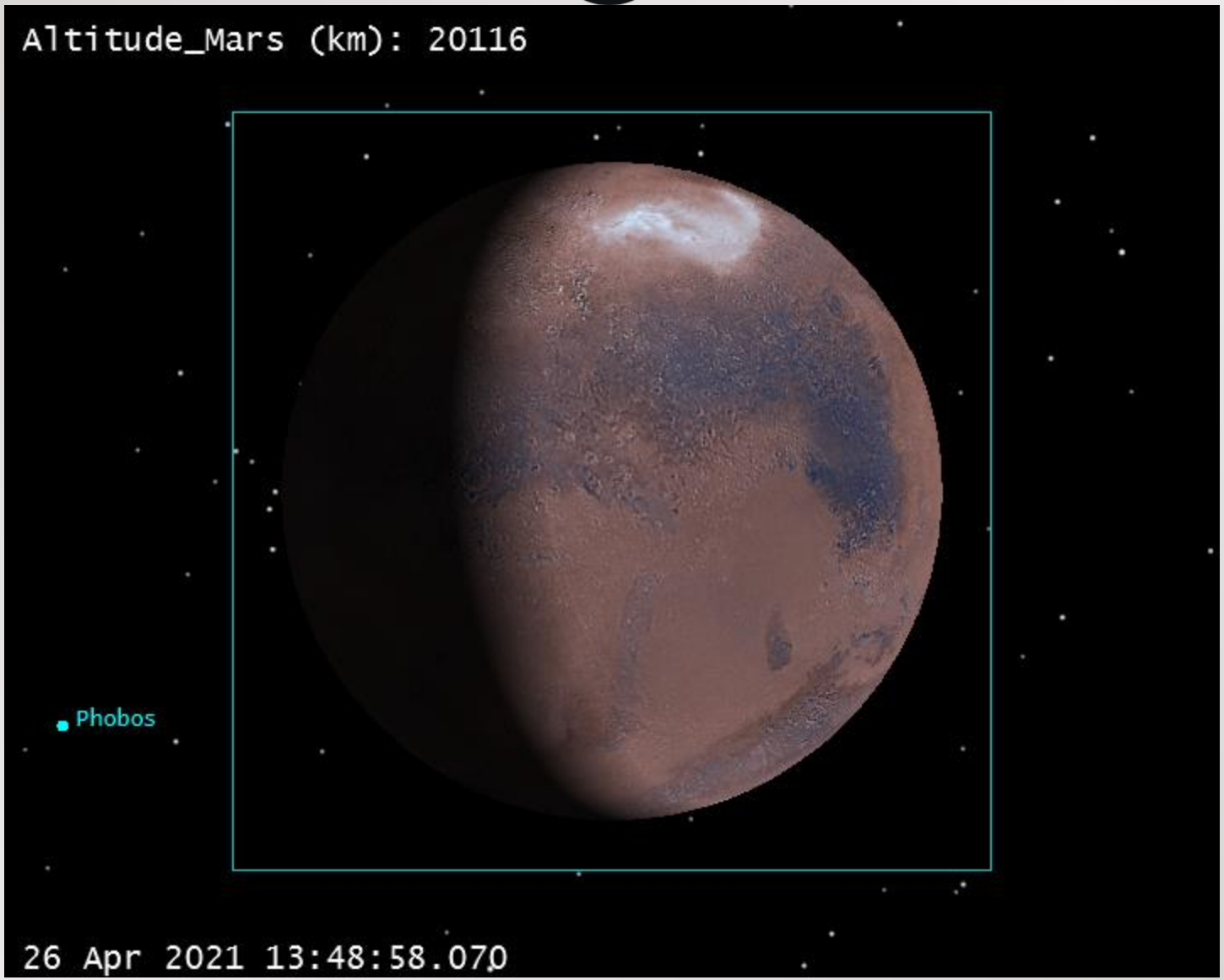
Altitude_Mars (km): 33816
Phobos
26 Apr 2021 00:14:21.136

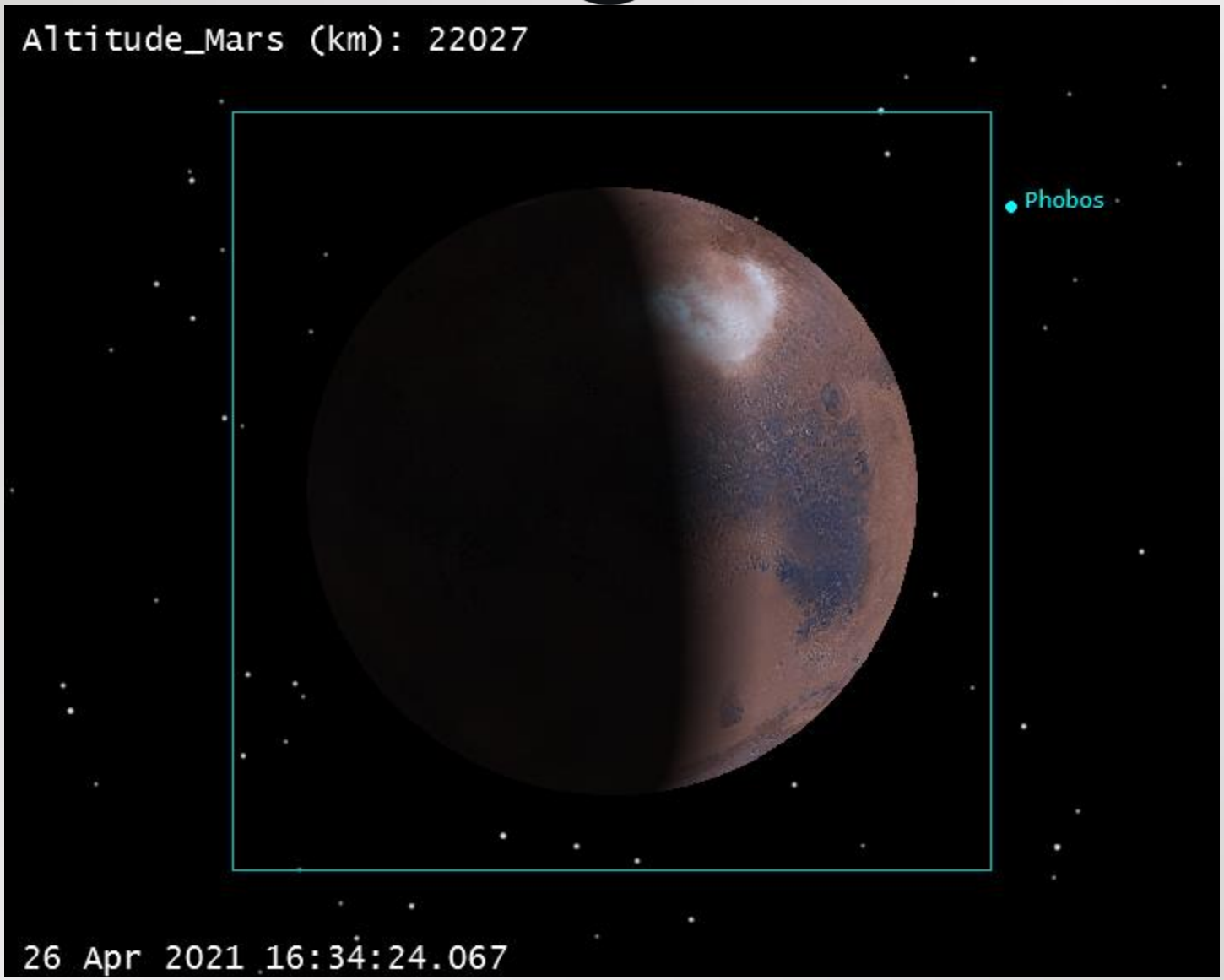

Altitude_Mars (km): 30307
Phobos
26 Apr 2021 02:57:45.032


Altitude_Mars (km): 26556
Phobos
26 Apr 2021 05:40:22.466


Altitude_Mars (km): 23032
26 Apr 2021 08:22:05.261


Altitude_Mars (km): 20540
26 Apr 2021 11:04:51.801


Altitude_Mars (km): 20116
Phobos
26 Apr 2021 13:48:58.070


Altitude_Mars (km): 22027
Phobos
26 Apr 2021 16:34:24.067

Altitude_Mars (km): 25420
26 Apr 2021 19:20:53.809

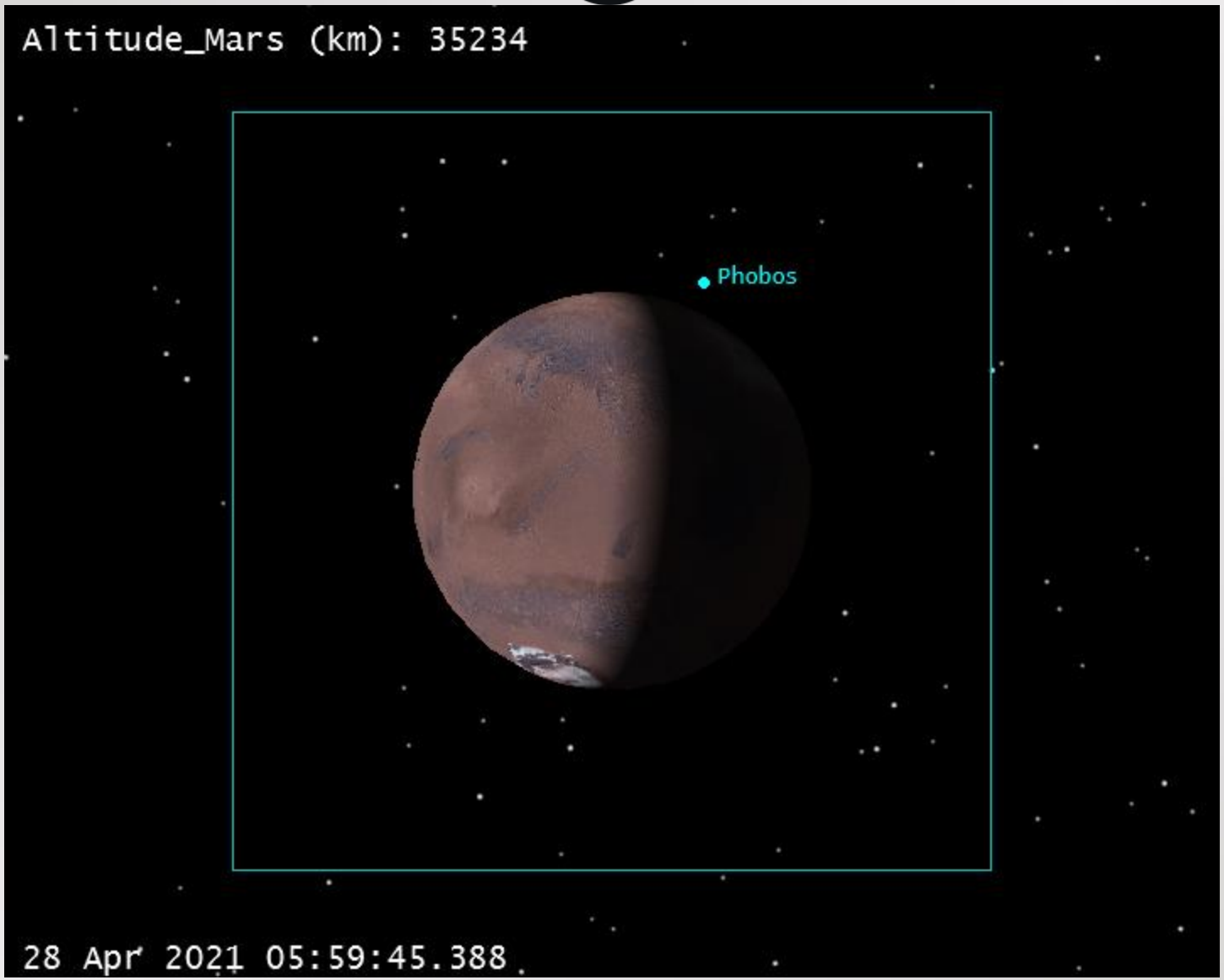
Altitude_Mars (km): 42987
27 Apr 2021 17:11:44.656

Altitude_Mars (km): 42534
Phobos
27 Apr 2021 19:46:10.461

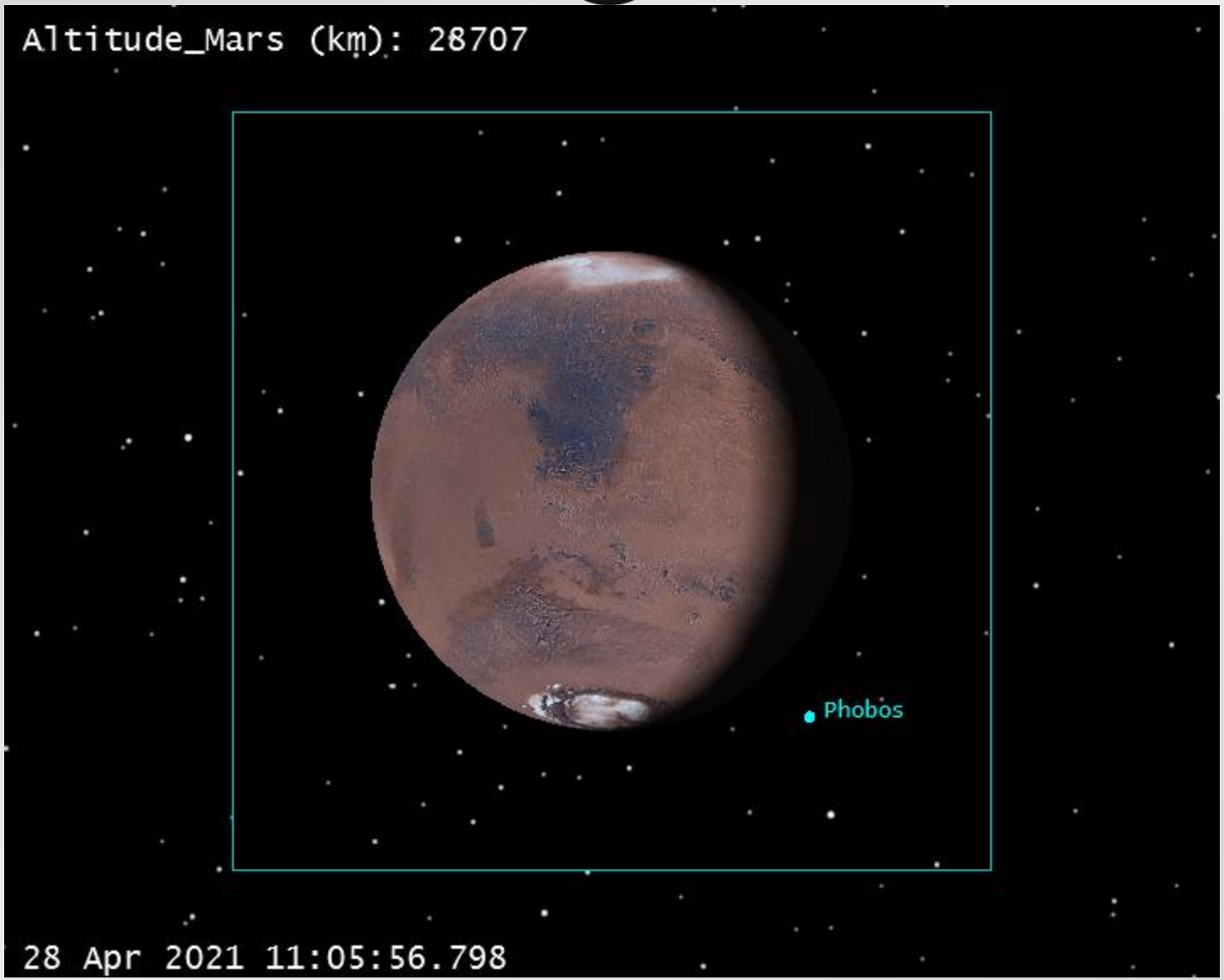
Altitude_Mars (km): 41518
Phobos
27 Apr 2021 22:20:36.265

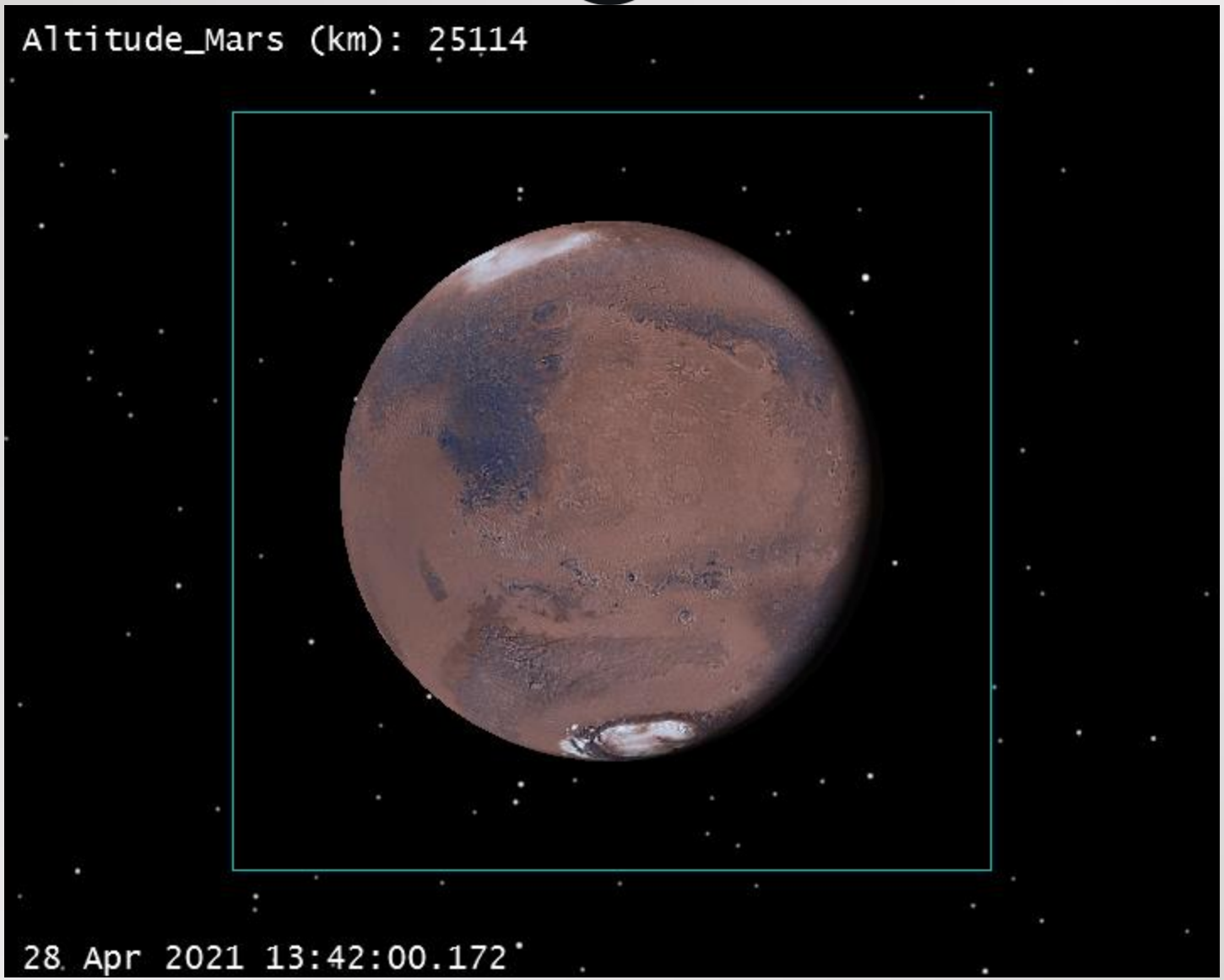
Altitude_Mars (km): 39975
Phobos
28 Apr 2021 00:52:18.525

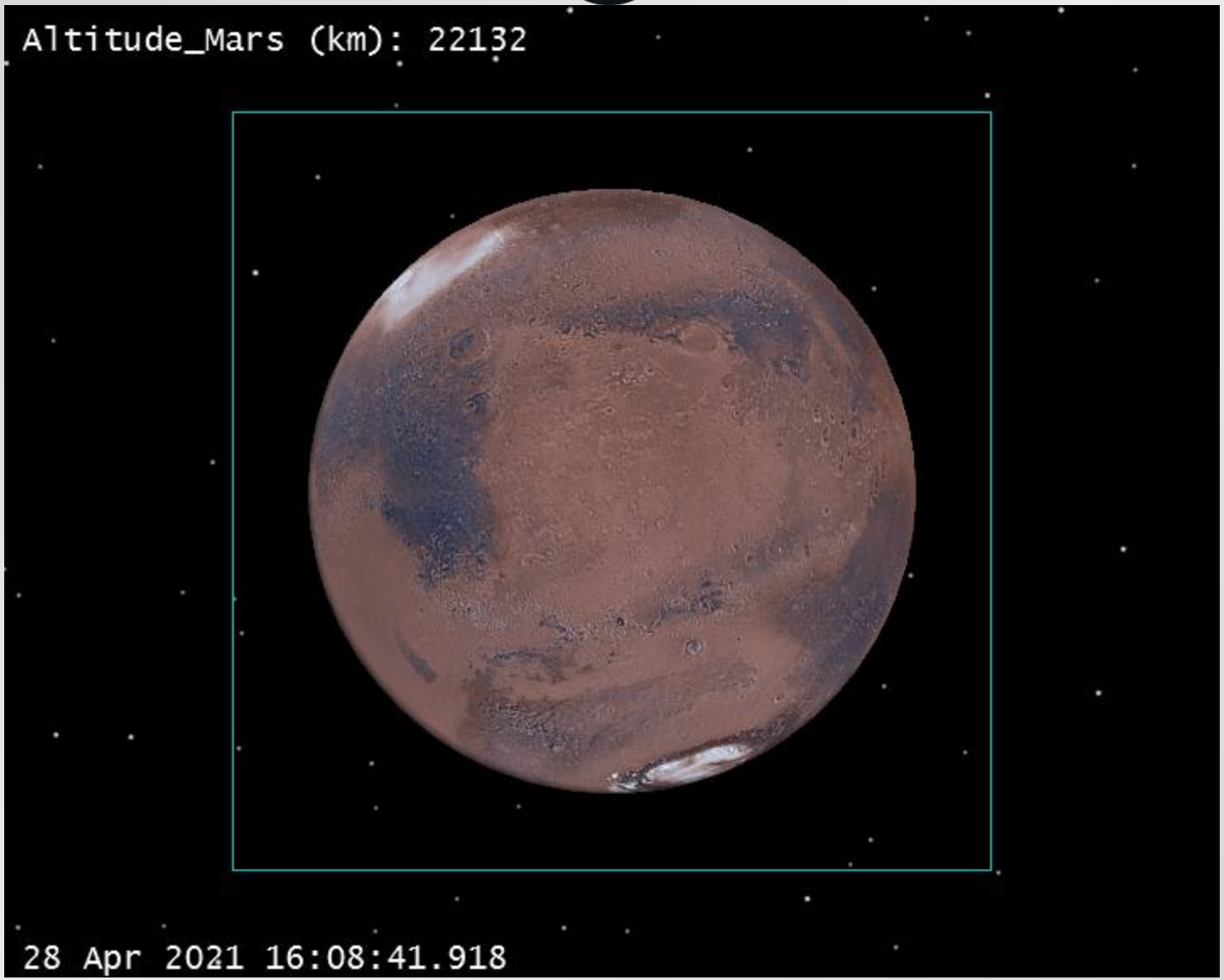
Altitude_Mars (km): 37827
Phobos
28 Apr 2021 03:28:35.466

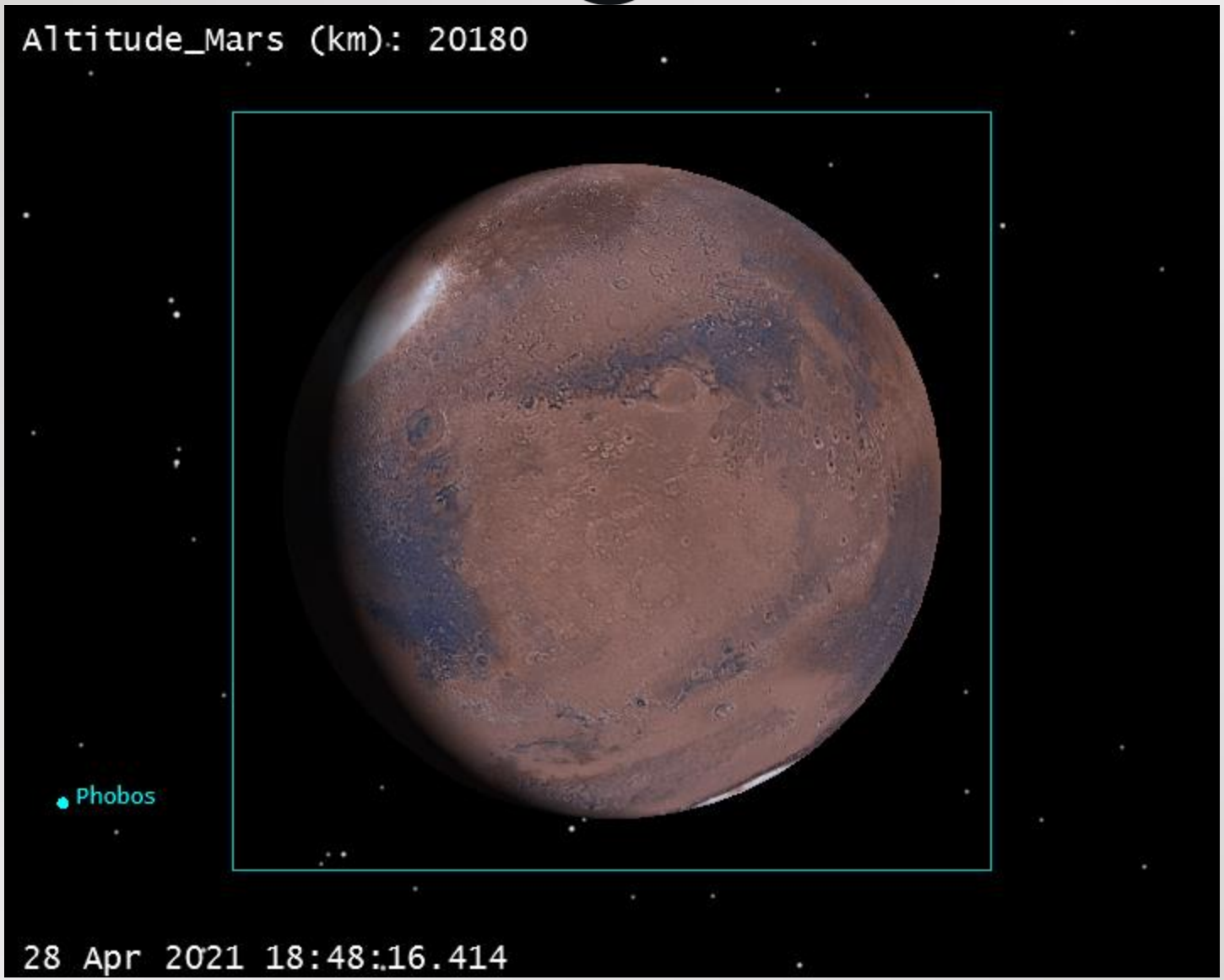

Altitude_Mars (km): 35234
Phobos
28 Apr 2021 05:59:45.388

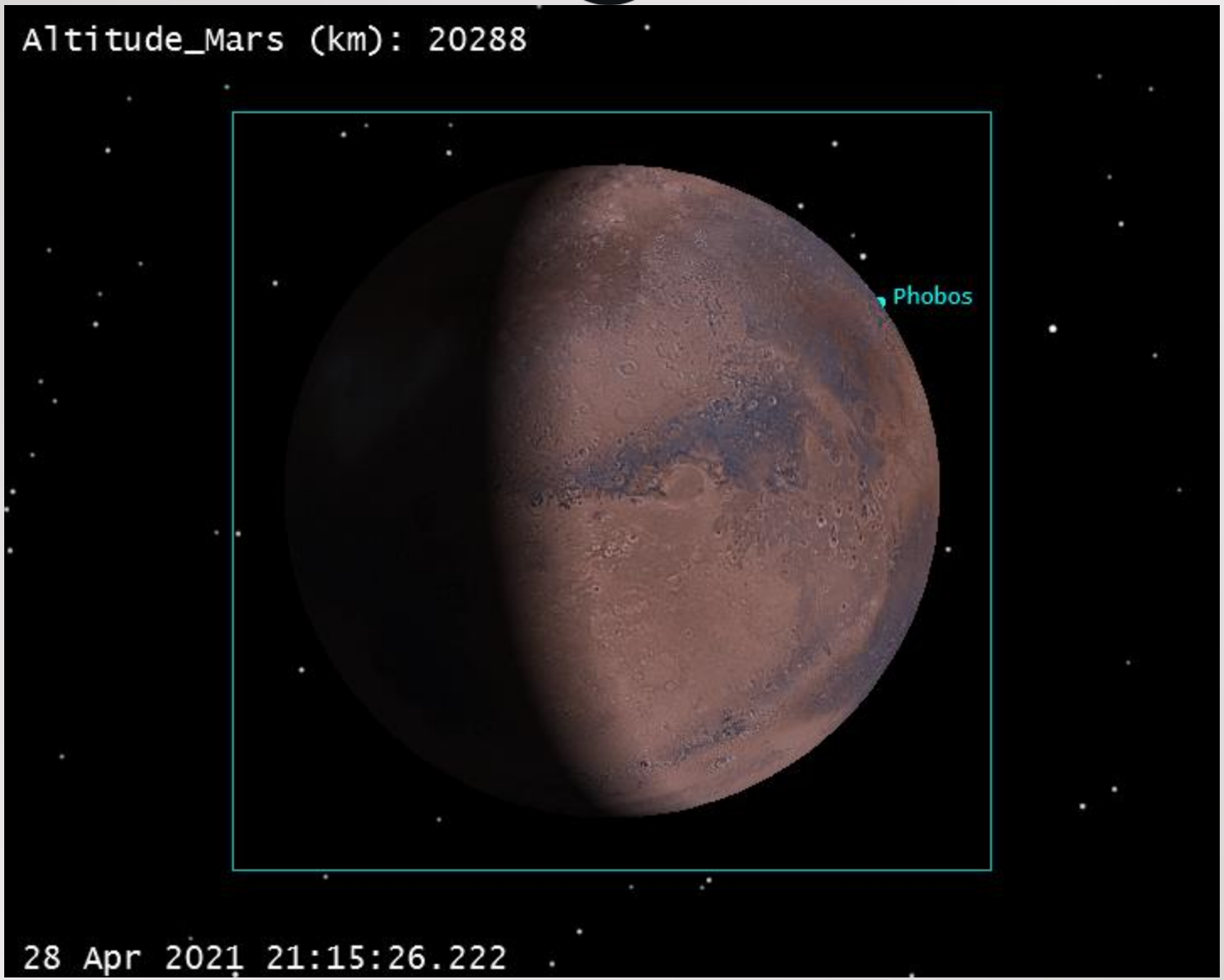
Altitude_Mars (km): 32067
Phobos
28 Apr 2021 08:36:27.605


Altitude_Mars (km): 28707
Phobos
28 Apr 2021 11:05:56.798


Altitude_Mars (km): 25114
28 Apr 2021 13:42:00.172

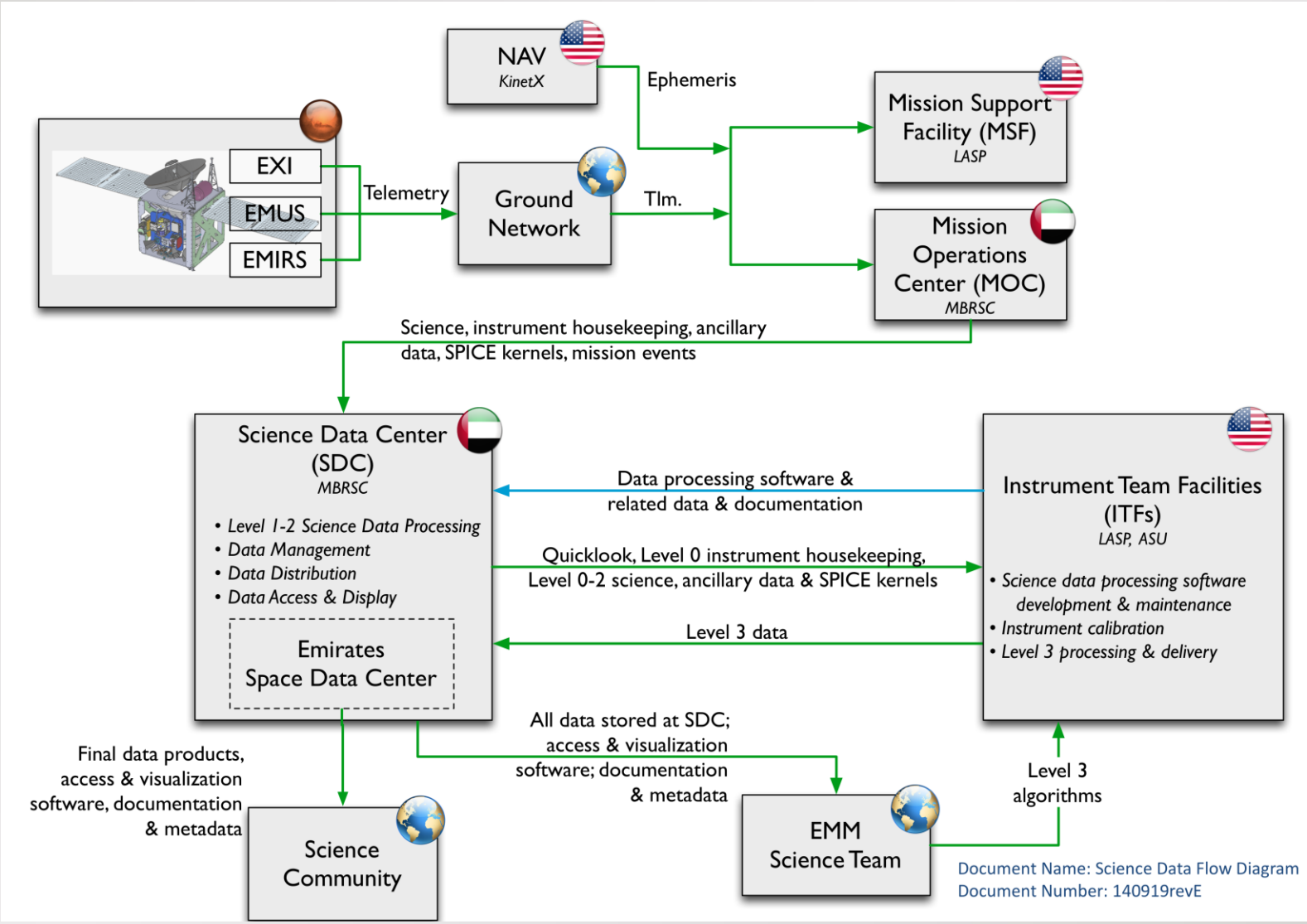

Altitude_Mars (km): 22132
28 Apr 2021 16:08:41.918


Altitude_Mars (km): 20180
Phobos
28 Apr 2021 18:48:16.414


Altitude_Mars (km): 20288
Phobos
28 Apr 2021 21:15:26.222

Altitude_Mars (km): 22483
28 Apr 2021 23:58:27.752

GROUND SEGMENT



DATA RELEASE POLICY

Release Date	Contents
Aug 2021	Quicklook plots from first month of mission; release earlier if possible. After initial release, will be released on a regular basis with a 2-week delay.
Sept 2021	Level 2 data products, February - April 2021 (MOI + 3 months)
Dec 2021	Level 2 data products, May - July 2021 Level 3 data products, February - April 2021
Mar 2022	Level 2 data products, August - October 2021 Level 3 data products, May - July 2021
Jun 2022	Level 2 data products, November 2021 - January 2022 Level 3 data products, August - October 2021
and so on through end of nominal mission, until all data is released.	
Apr 2026	Final release of all products from mission, including any needed updates to earlier releases, and the radiometric tracking data from NAV.