SCIENTIFIC PAYLOAD OF THE EMIRATES MARS MISSION: EMIRATES MARS ULTRAVIOLET SPECTROMETER (EMUS) OVERVIEW

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Emirates Mars Mission [EMM]

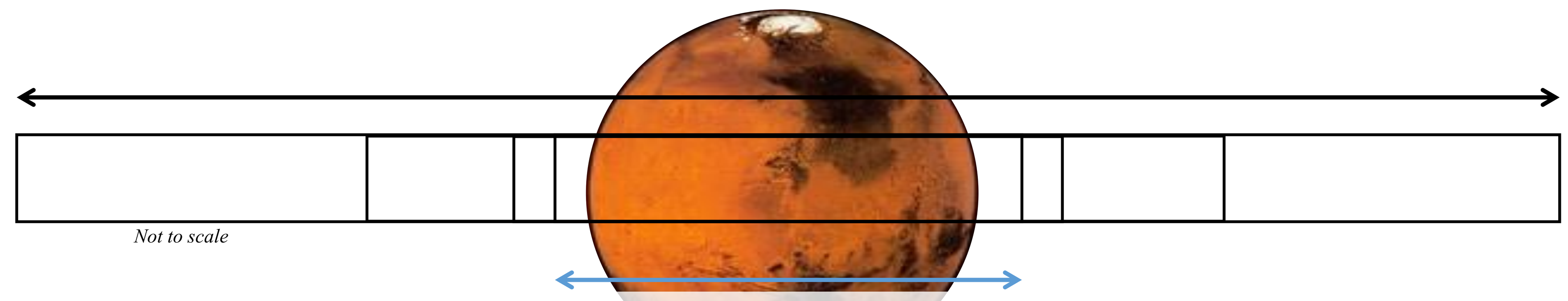
- EMM is the first outer-planetary Arab mission to be launched by 2020.
- The mission focuses on developing national capabilities in both science and engineering within the UAE, and on contributing with novel science to the human knowledge and civilizations.
- EMM has three instruments:
  - Emirates eXploration Imager (**EXI**) and Emirates Mars Infrared Spectrometer (**EMIRS**) which will focus on the lower atmosphere observing dust, ice clouds, water vapor and ozone.
  - Emirates Mars Ultraviolet Spectrometer (**EMUS**) will focus on both the thermosphere of the planet and its exosphere.

Table 1: EMM Science Questions And Objectives

Motivating Questions	EMM Science Objectives	EMM Science Investigations	EMM Instrument
How does the Martian lower atmosphere respond globally, diurnally and seasonally to solar forcing?	A. Characterize the state of the Martian lower atmosphere on global scales and its geographic, diurnal and seasonal variability	1. Determine the three-dimensional thermal state of the lower atmosphere and its diurnal variability on sub-seasonal timescales.	EMIRS
		2. Determine the geographic and diurnal distribution of key constituents in the lower atmosphere on sub-seasonal timescales.	EXI
How do conditions throughout the Martian atmosphere affect rates of atmospheric escape?	B. Correlate rates of thermal and photochemical atmospheric escape with conditions in the collisional Martian atmosphere.	3. Determine the abundance and spatial variability of key neutral species in the thermosphere on sub-seasonal timescales.	EMUS
How do key constituents in the Martian exosphere behave temporally and spatially?	C. Characterize the spatial structure and variability of key constituents in the Martian exosphere.	4. Determine the three-dimensional structure and variability of key species in the exosphere and their variability on sub-seasonal timescales.	

- EMUS data will enhance our understanding of the thermosphere and exosphere of Mars and their variability on sub-seasonal timescales & will measure changes in the structure of the corona with season, and lower atmosphere forcing.

EMUS Science Targets



Region 1: 0 – 1.06 R_M thermosphere: H, O, CO

Region 2: 1.06 – 1.6 R_M exosphere: thermal O corona; H corona

Region 3: 1.6 – 6 R_M exosphere: bound O corona; H corona

Region 4: 6 – 10 R_M exosphere: escaping O; H corona

Table 2: EMUS Science Targets

Targets	Wavelength
Hydrogen	102.6, 121.6 nm
Oxygen	130.4, 135.6 nm
Carbon Monoxide 4PG	140-170 nm

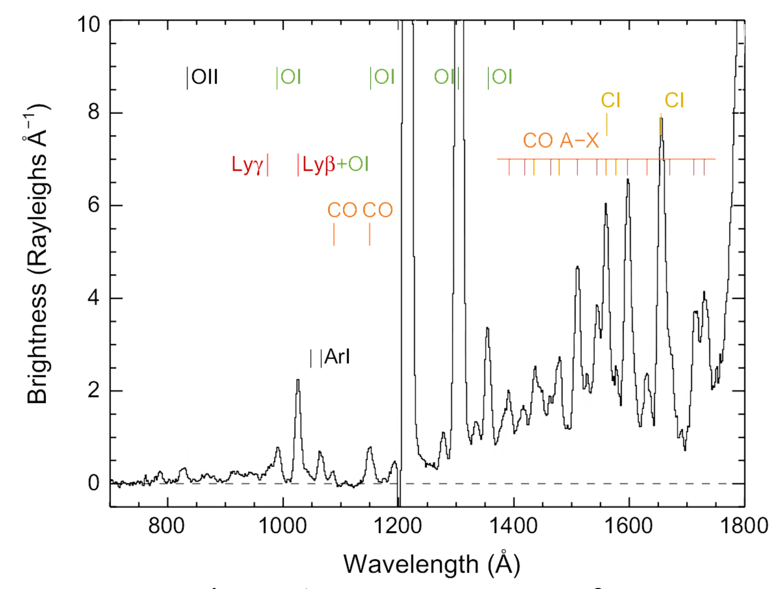


Figure 1: FUV spectrum of Mars [Feldman. Icarus 214.2 (2011): 394-399]

EMUS Overview

- The EMUS instrument is a 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).

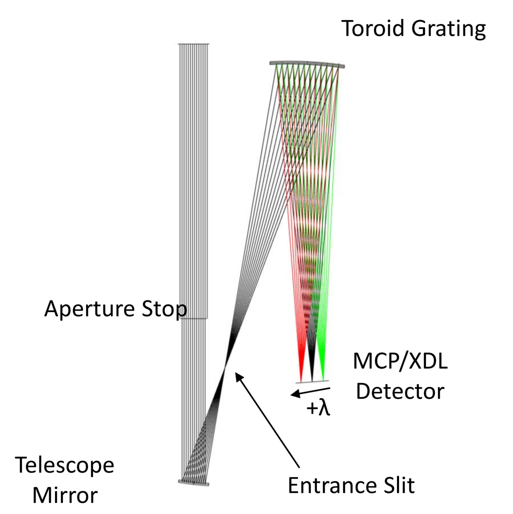


Figure 2: EMUS Optical Layout

- The instrument and the mission is managed by MBRSC.
- The instrument development is led by LASP with a detector from SSL.
- The EMUS science team compromises from people from MBRSC, LASP, and SSL.

Table 3: EMUS Instrument Parameters

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

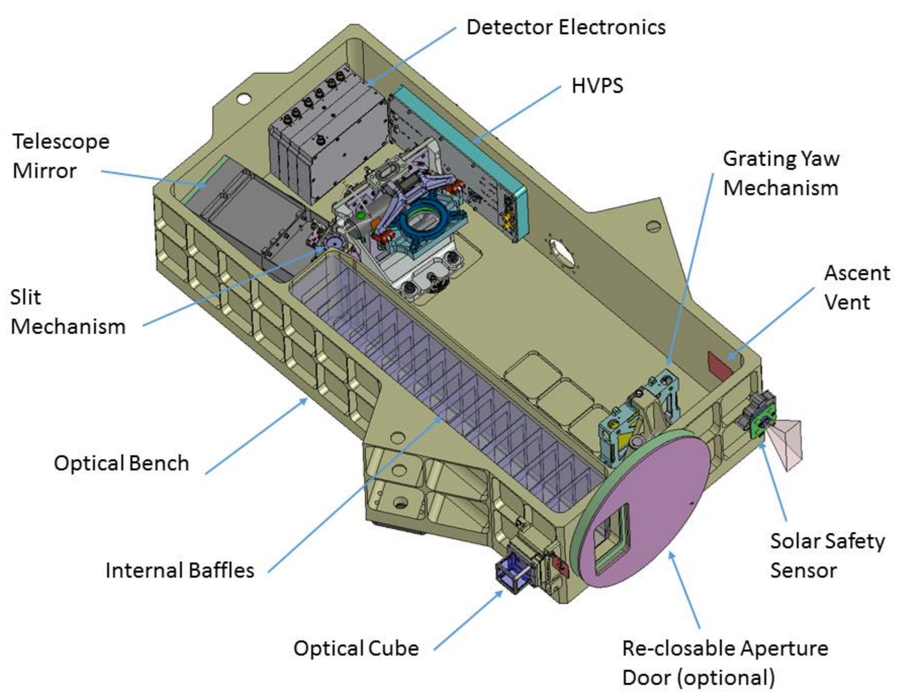


Figure 3: EMUS Schematic

EMUS Science Operations

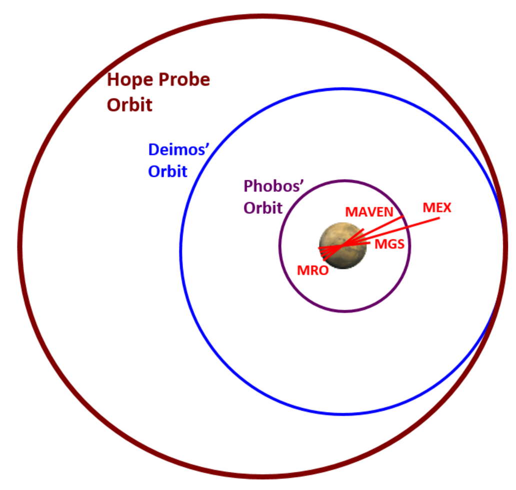
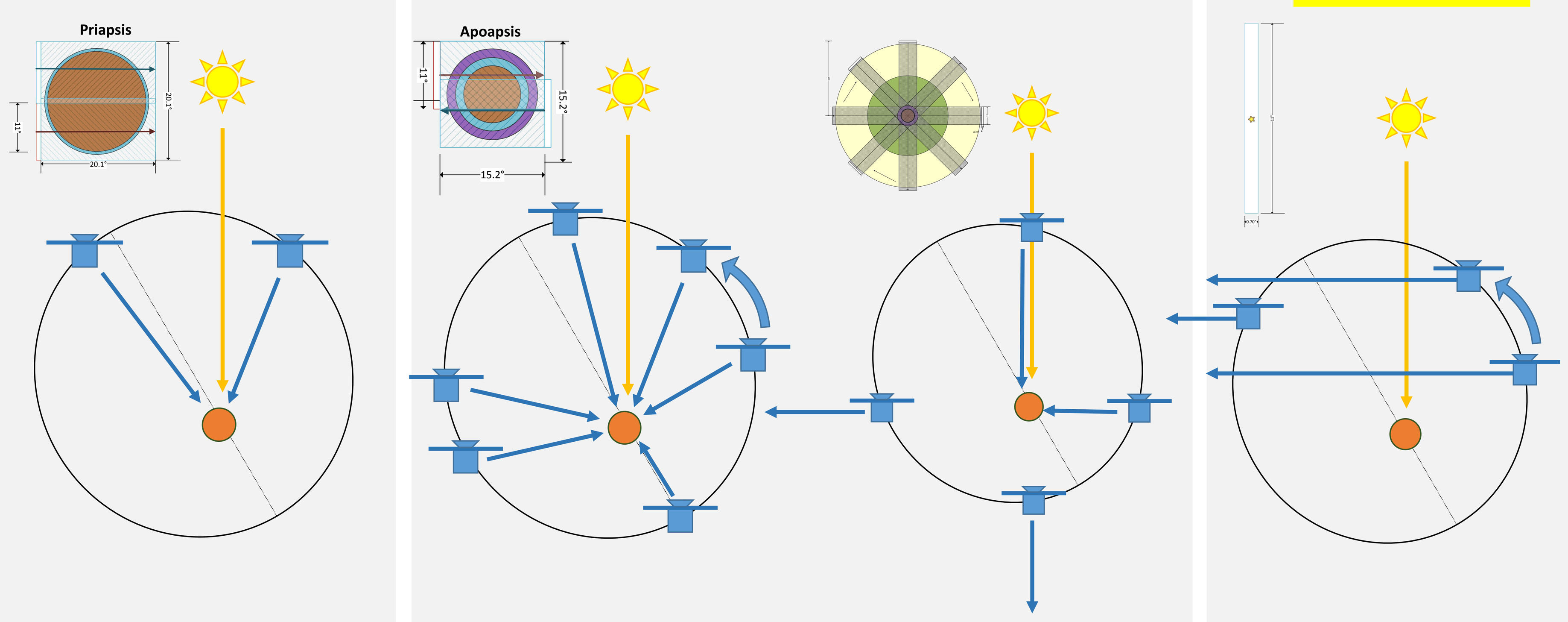


Figure 4: EMM Target Science Orbit

- EMM science orbit enables comprehensive observations of the exosphere, and full sampling of latitude, longitude, and local time.
  - 20,000km x 43,000
  - 25° inclination
  - 55 hour orbital period
- The Science Phase is planned for 2 Earth years (just over 1 Mars year long) to cover all the seasonal variations in the atmosphere.

Thermosphere	Corona		Strafe
U-OS1: Raster scanned images of the disk of Mars	**U-OS2:** Raster scanned images of the disk and the inner corona of Mars	**U-OS3:** Spacecraft will slew out to ±50 degrees in an asterisk pattern performed in 4 swaths	**U-OS4:** Long exposure times for mid and outer corona when instrument is not imaging / during charging
Thermospheric Emissions	H and O corona	H-Lyman alpha	H and O corona



R1, 1.3nm slit

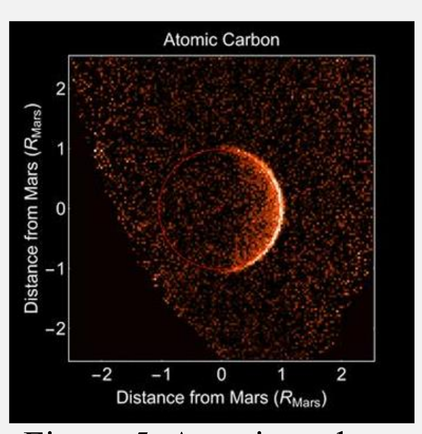


Figure 5: Atomic carbon image from MAVEN IUVS

At least 2 times per orbit in one orbit per week

R1-R2, 1.8nm slit

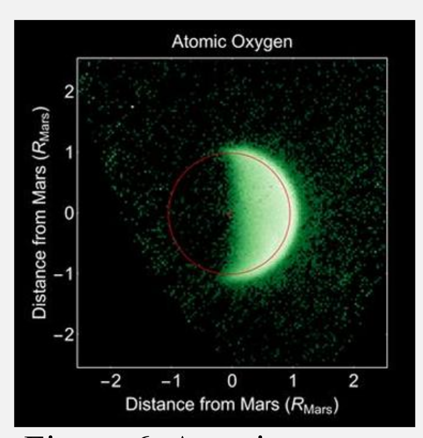


Figure 6: Atomic oxygen image from MAVEN IUVS

At least 6 times in one orbit per week

R1-R4, 5nm slit

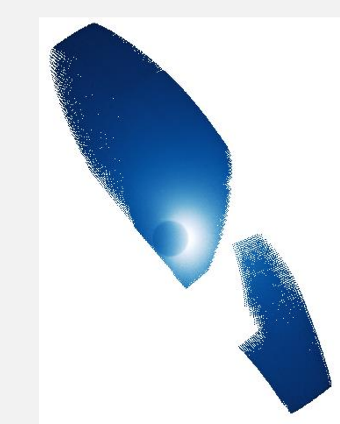


Figure 7: Atomic hydrogen image from MAVEN IUVS

At least 4 times in one orbit every other week

R2-R4, 1.8nm slit

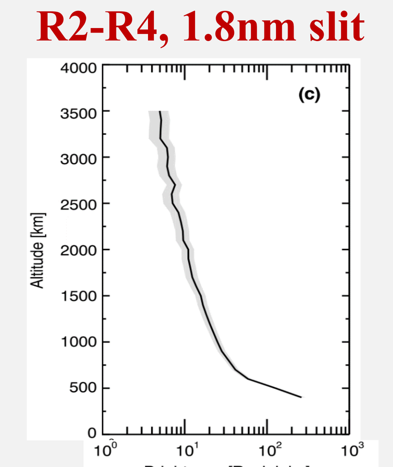


Figure 8: Oxygen Altitude Profile from MAVEN IUVS

Observe lines of sight in each 500km bin in one orbit per month

EMUS Data Sets

- Standard Cadence will sample sub-seasonal variation; High Cadence will sample shorter timescale variation (e.g., solar rotation)

Data Sets:	Standard Cadence	High Cadence
Thermospheric Measurements:	At least 6 images (OS1) taken on the dayside within 1 orbit (55 hours)	At least 12 images (OS1 or OS2) taken on the dayside within 1 orbit (55 hours)
Coronal Measurements:	At least 5 images (OS2) taken within 1 orbit At least 4 images (2 coronal, 2 background) (OS3) taken within 1 orbit	
Cadence:	At least 1 image set taken per week (3 orbits) (For OS3, at least 1 image set taken every other week)	At least 3 image sets taken within 1 week (3 consecutive orbits)
Seasonal Coverage:	At least 20 times per Martian year	At least 7 times per Martian year
Coronal Strafe:	Two profiles (1 coronal, 1 background) (OS4) from 1.06 to ≥ 6 Mars radii taken at least once per month	