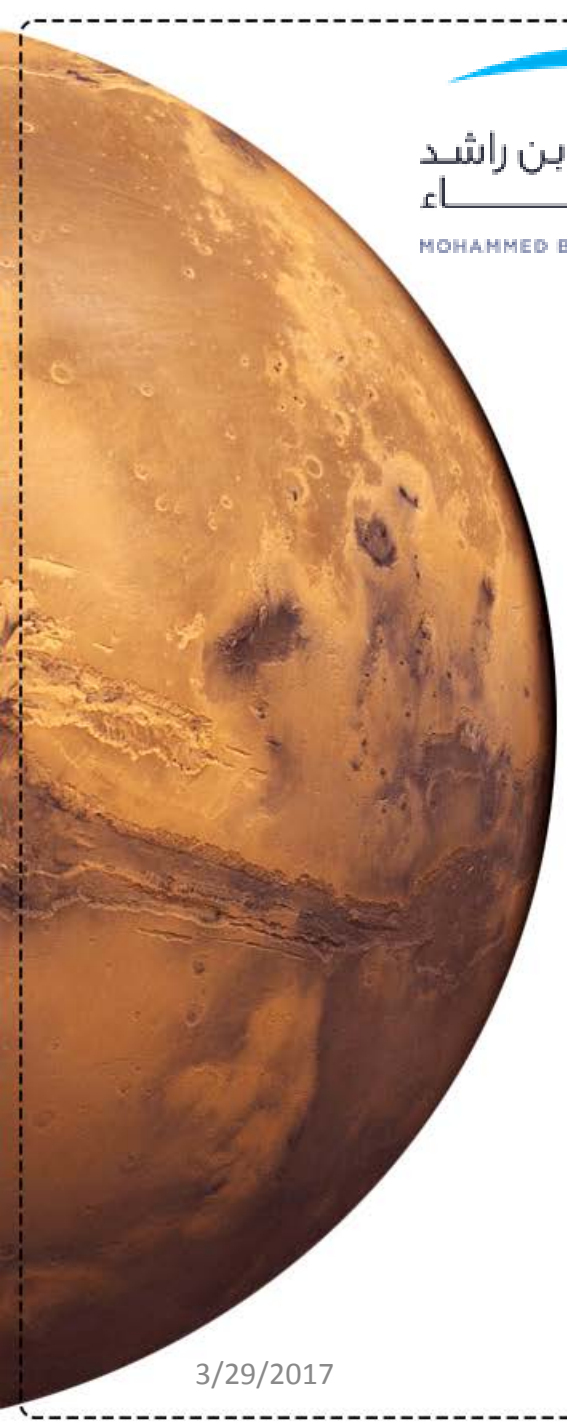


مركز محمد بن راشد للفضاء
MOHAMMED BIN RASHID SPACE CENTRE

Planetary Protection in Emirates Mars Mission

Omran Sharaf
EMM Project Manager

Program Objectives

- Program goals announced by UAE's Government on 16 July 2014:
  - Complete Mars orbiter insertion by the UAE's 50th anniversary in 2021
  - Contribute to the development of the Science and Technology Sector in the UAE
  - Develop UAE Scientific Capabilities
  - Increase UAE's Contribution to the Scientific Community

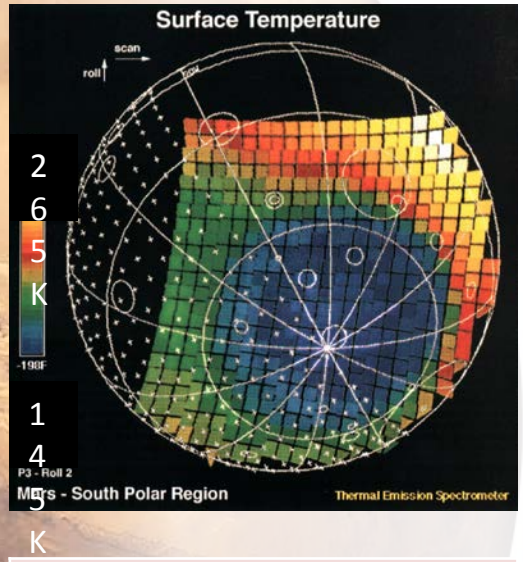
- Program Requirements
  - The mission should be unique, and should aim for significant discoveries.
  - The mission should have impactful contributions to the ongoing work of the global space science community, and should be of a great value to humanity.
  - The mission should help build a sustainable outer space exploration program in UAE.
  - The mission should include valuable contribution from UAE engineers and scientists.

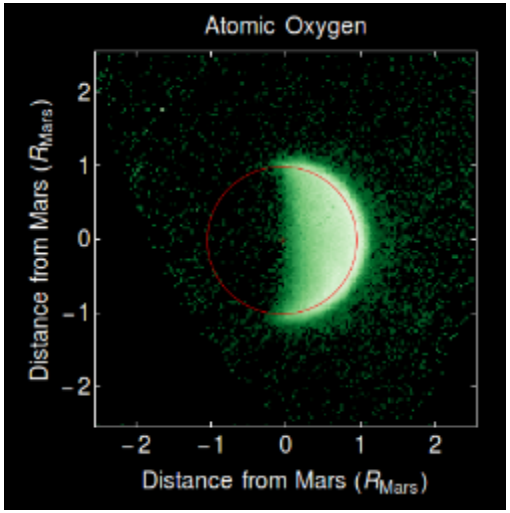
EMM Science Objectives

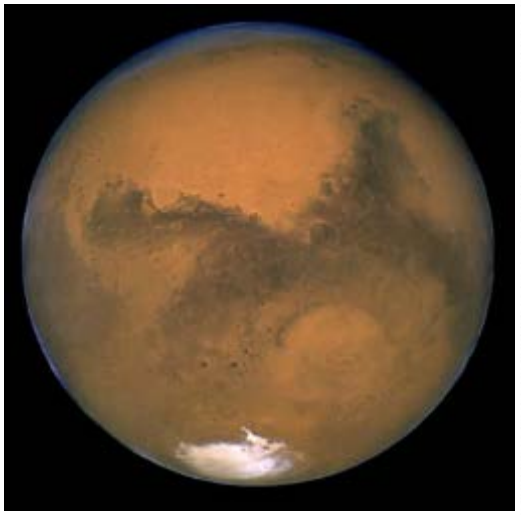
- **EMM Objectives**
  1. Characterize the state of the Martian lower atmosphere on global scales and its geographic, diurnal and seasonal variability.
  2. Correlate rates of thermal and photochemical atmospheric escape with conditions in the collisional Martian atmosphere.
  3. Characterize the spatial structure and variability of the Martian exosphere.

- **EMM Investigations**
  1. Determine the three-dimensional thermal state of the lower atmosphere and its diurnal variability, on sub-seasonal timescales.
  2. Determine the geographic and diurnal distribution of key constituents in the lower atmosphere on sub-seasonal timescales.
  3. Determine the abundances and spatial variability of key neutral species in the thermosphere on sub-seasonal timescales.
  4. Determine the three-dimensional structure and variability of key species in the exosphere and their variability on sub-seasonal timescales.

Hope Science Instruments







EMIRS (ASU/MBRSC)

Fourier Transform IR Spectrometer

EMUS (LASP/MBRSC)

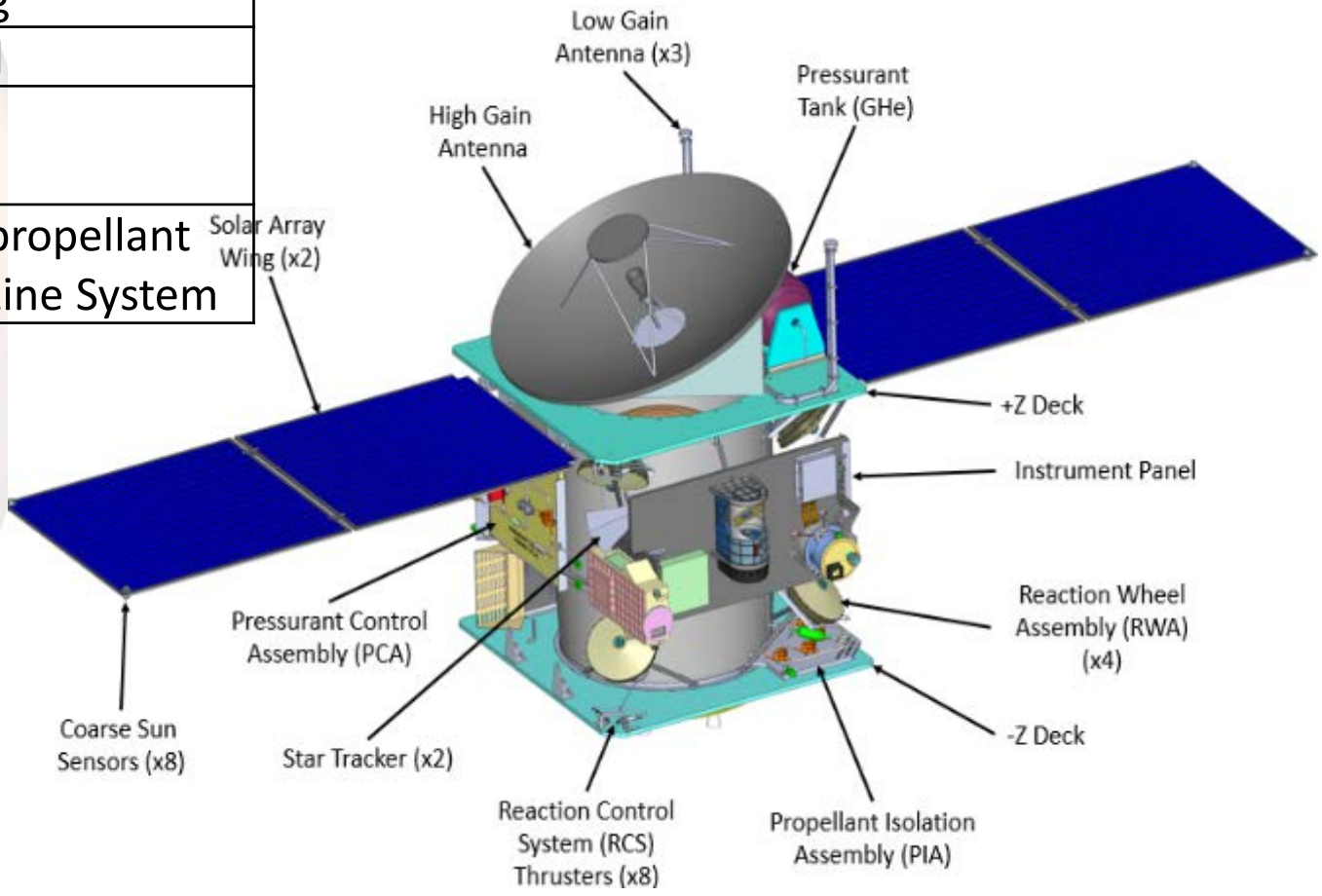
Ultra Violet Imaging Spectrometer

EXI (LASP/MBRSC)

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

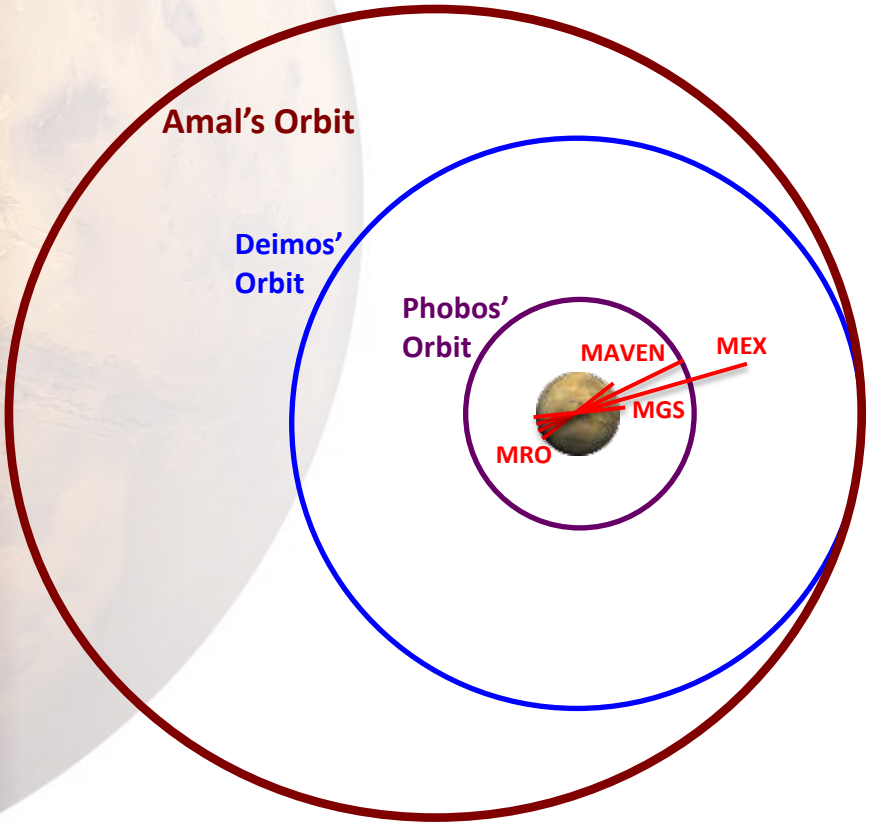
Hope Spacecraft

Technical Specifications	
S/C Dimension	3m x 7.9m
Wet Mass	1500kg
RF Band	X Band
Power Requirement	477 W
Propulsion Type	Monopropellant Hydrazine System



Science Orbit

- EMM's target orbit is exciting! No spacecraft has flown an orbit like it. Further, it is low-risk, simple to fly, and produces excellent opportunities to collect EMM's science.



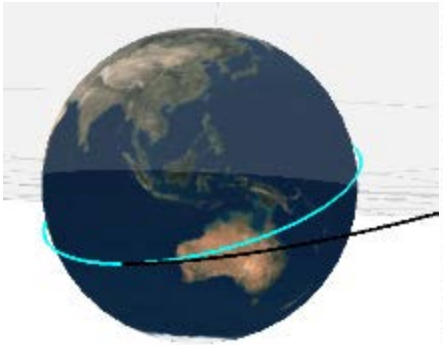
Key Features:

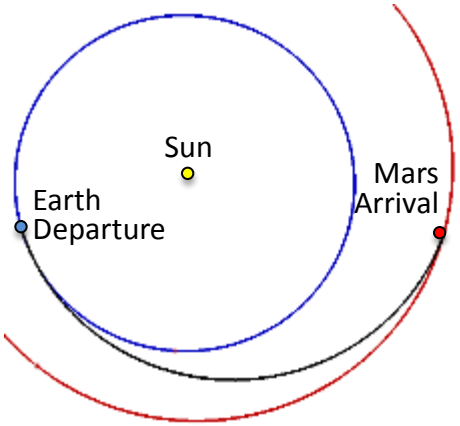
- Periapse altitude: 20,000 km
- Apoapse altitude: 43,300 km
- Orbital period: 55 hours
  3 orbits per week
  ~2.24 sols
- Inclination: 25 deg
- Periapse placed near equator
- Primary science collection starts ~May 2021

Mission Concept

1. Launch in July/Aug 2020.
   21+ day launch period

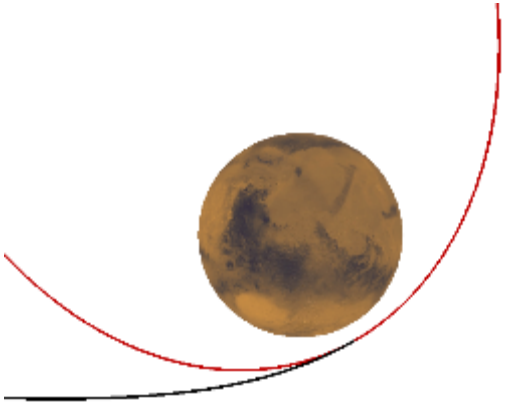
2. Brief coast in low Earth orbit.
   Upper stage re-ignites to send spacecraft towards Mars.



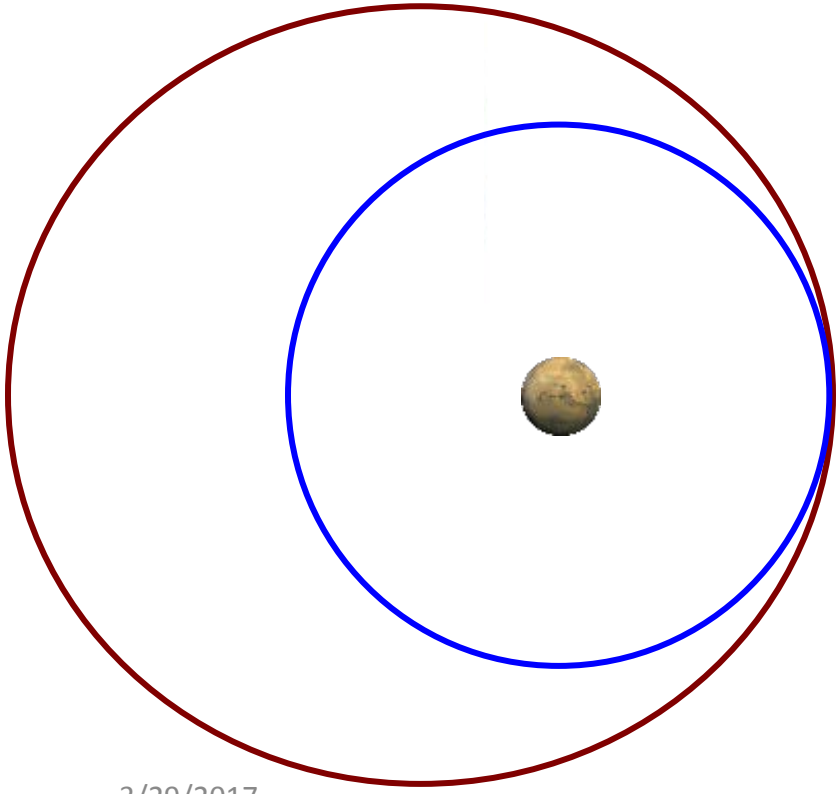


3. Interplanetary cruise.
   3-4 Trajectory Correction Maneuvers (TCMs)

4. Mars Orbit Insertion (MOI)
   Jan/Feb/Mar 2021
   Capture Orbit



Mission Concept

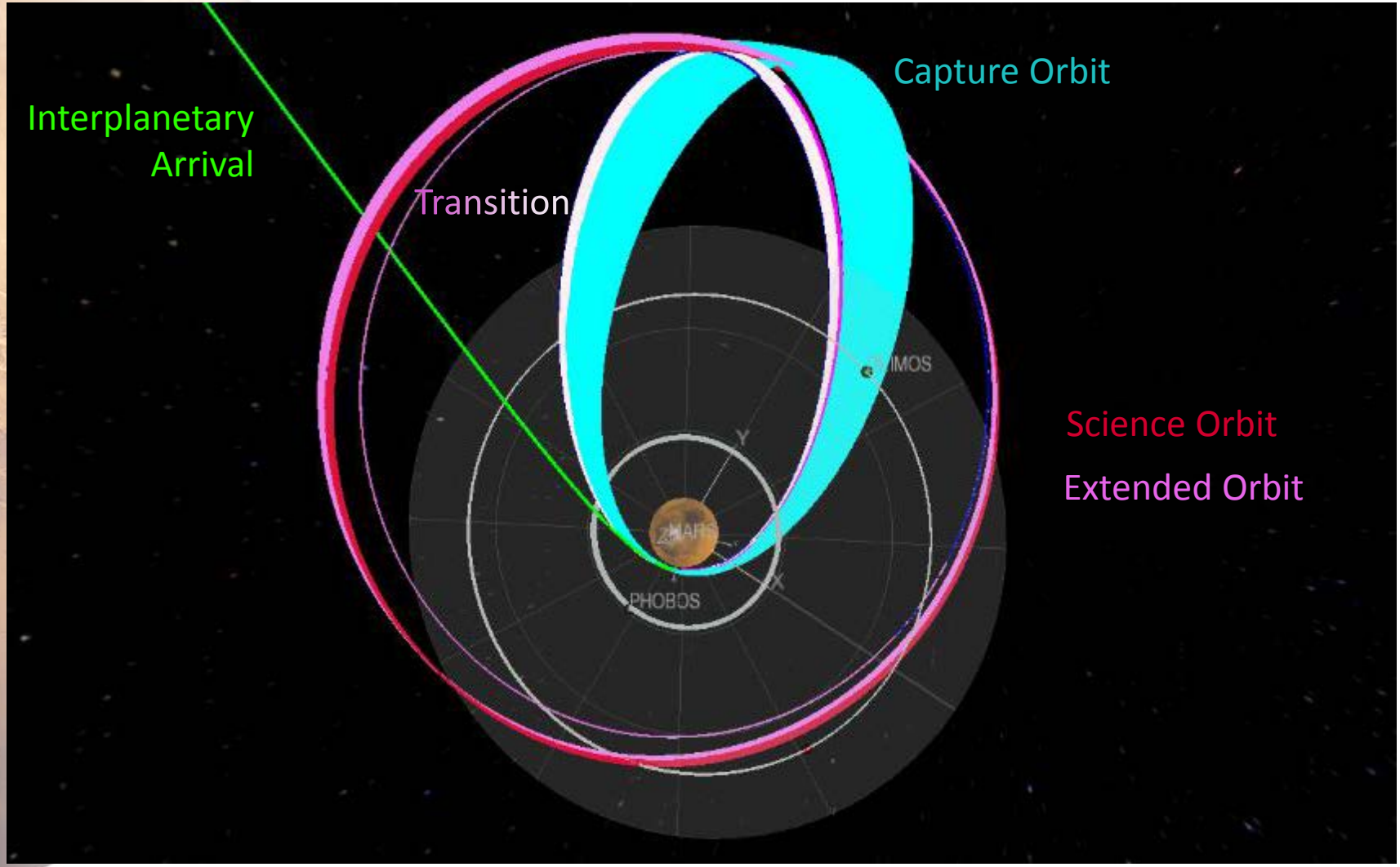


5. <u>Capture Orbit Operations</u>
   Collect early science

6. <u>Transition to Science</u>
   Raise orbit and inclination

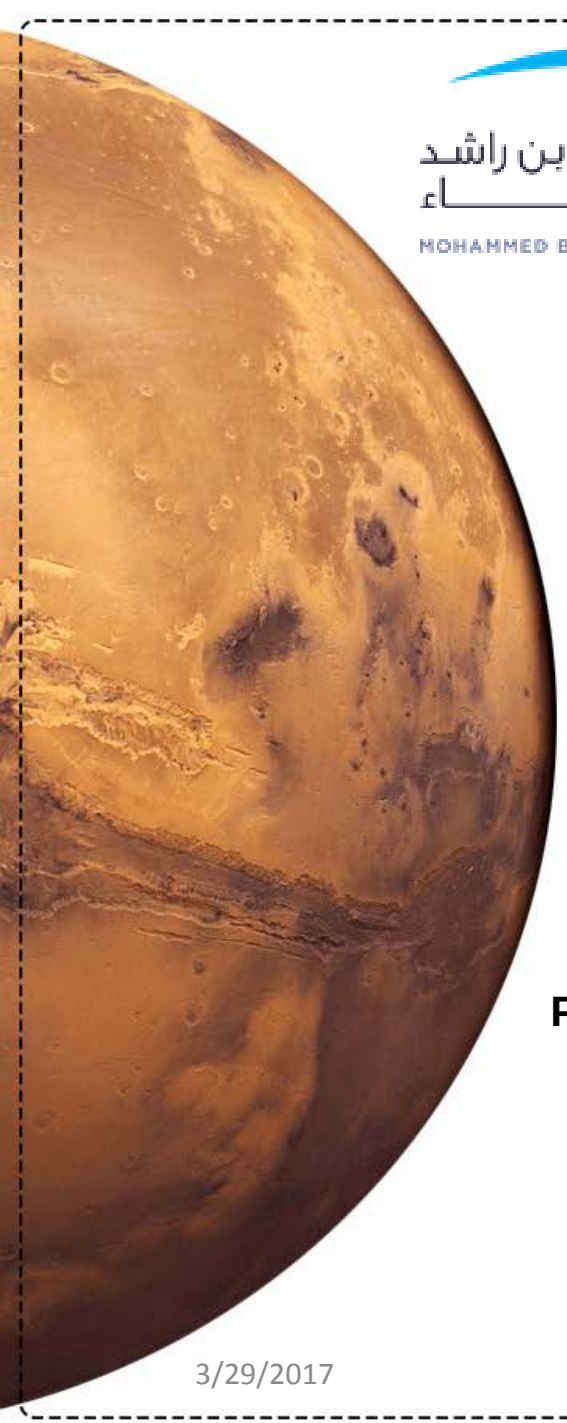
7. <u>Science Orbit</u>
   Global, diurnal, temporal science
   Several additional opportunities

Mission Illustration



View from the Capture Apoapse

View from the Capture Periapse



مـــــركز محمد بن راشد
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MOHAMMED BIN RASHID SPACE CENTRE

Planetary Protection

Planetary Protection

Description
TCM Strategy, Launch Vehicle Disposal
Capture Orbit
End of Mission

Planetary Protection Description

- COSPAR Planetary Protection Policy
  - We are a Category III orbiter

Trajectory Biasing

The probability of impact on Mars by any part of the launch vehicle shall be $\leq 1 \times 10^{-4}$ for a time period of 50 years after launch.

Missions to Mars

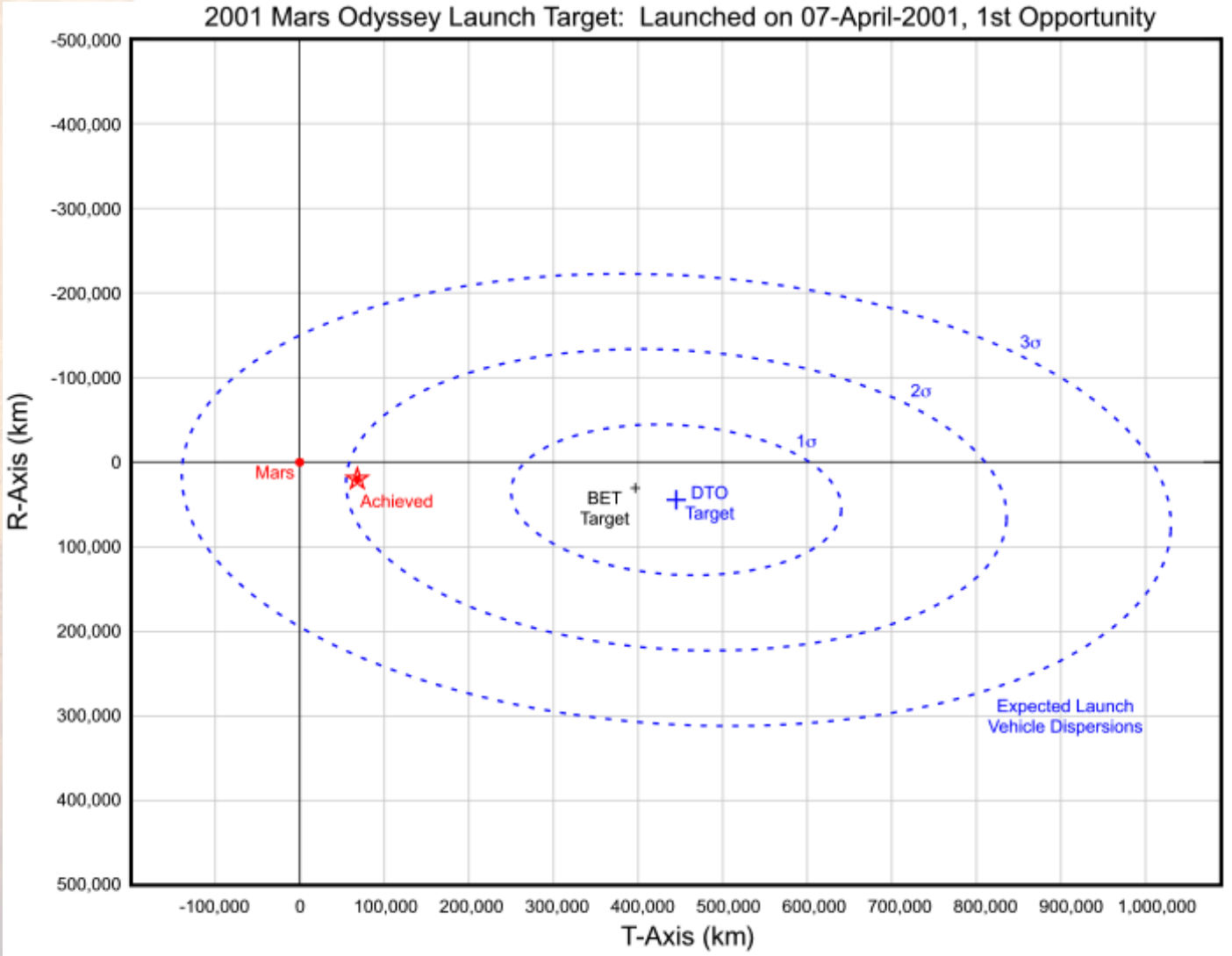
Note: All bioburden constraints are defined with respect to the number of aerobic microorganisms that survive a heat shock of 80°C for 15 minutes (hereinafter "spores") and are cultured on TSA at 32°C for 72 hours.

Category III. Mars orbiters will not be required to meet orbital lifetime requirements* if they achieve total (surface, mated, and encapsulated) bioburden levels of $\leq 5 \times 10^5$ spores. (*Defined as 20 years after launch at greater than or equal to 99% probability, and 50 years after launch at greater than or equal to 95% probability.) (DeVincenzi et al. 1994)

Planetary Protection

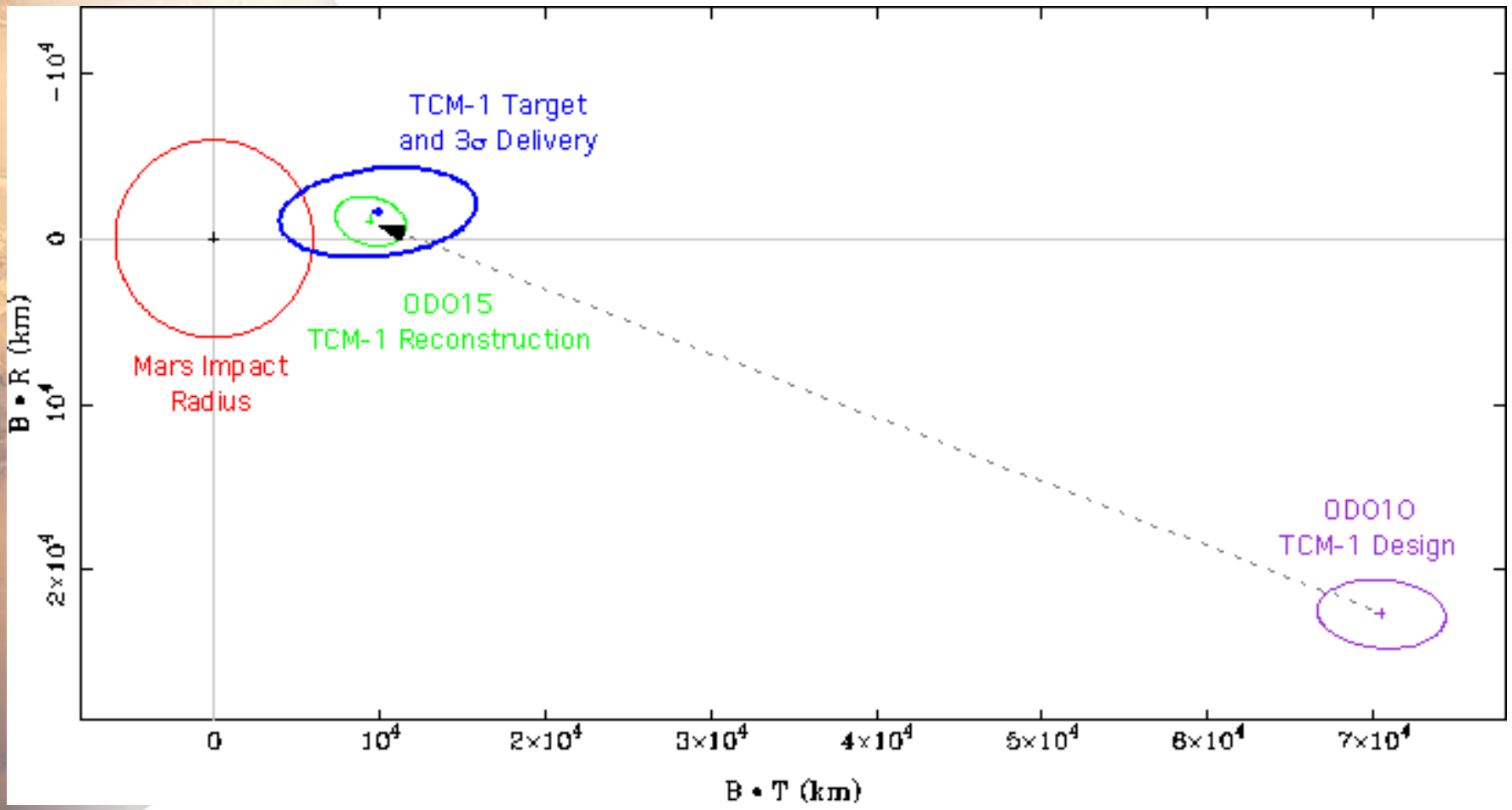
- The spacecraft system will satisfy a Category III mission.
- Interplanetary
  - The launch will be biased away from Mars.
  - TCM-1 will bring Hope back onto target to Mars. By executing TCM-1 we have confidence that Hope is a capable vehicle.
  - TCM-2 may also have a small amount of deterministic ΔV, depending on the nav simulations and resulting probabilities of impact.
  - The TCM strategy will follow the Cat III requirements.
- Mars Orbit
  - The Capture Orbit periapse is high enough to prevent Hope from entering the atmosphere for decades (centuries?). Analysis forthcoming
  - The Science Orbit will satisfy Planetary Protection until the end of the Solar System.

Mars Odyssey Navigation



Mars Odyssey Navigation

TCM-1 Execution Date: 23-May-01



Planetary Protection Approvals

- In Direct Contact with Dr. Gerhard Kminek (Chair, COSPAR Panel on Planetary Protection)
- Dr. Kminek commented ”Activities Described in EMM Planetary Protection Plan are in line with the requirements for Planetary Protection Category III mission to Mars described in COSPAR Planetary Protection Policy”
- EMM will continue engaging Dr. Kminek and COSPAR for feedback.

Commitment

The Mohammed Bin Rashid Space Centre (MBRSC) is committed to the Planetary Protection Policies and will apply them in all phases of Emirates Mars Mission.