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GETEMME – A Mission to Explore the Martian Satellites and the Limits of Solar System Physics

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Abstract

We propose a mission to Mars and its satellites Phobos and Deimos, within the ESA COSMIC VISION program. A spacecraft (S/C) shall deploy retroreflectors on each satellite. These reflectors will act as targets for laser ranging from a Martian orbit for a wide range of science applications in Solar System Dynamics and Fundamental Physics.

1. Introduction

GETEMME (**G**ravity, **E**instein's **T**heory, and **E**xploration of the **M**artian **M**oons' **E**nvironment), targeted for Mars and its two satellites Phobos and Deimos, consists of one spacecraft with four embedded landers. Using an electric propulsion system, GETEMME will rendezvous with Deimos after 700 days of flight, stay in orbit for three months and then continue to rendezvous with Phobos. During these rendezvous phases two passive landers will be deployed on each moon. The spacecraft will finally move to a circular Mars orbit for a one-year scientific operations mission.

2. Mission objectives

The S/C shall deploy passive Laser retro-reflectors on Phobos and Deimos and carry out a comprehensive mapping of the two satellites.

In the second stage of the mission, the spacecraft will be transferred into a lower 1500-km Mars orbit, to carry out routine Laser range measurements to the reflector targets (see Figure 1). In addition, two-way (asynchronous) range measurements to terrestrial ground stations will be carried out.

An onboard accelerometer will ensure highly accurate spacecraft orbit determination. The inversion of all range and accelerometer data will allow us to determine or improve dramatically on a host of dynamic parameters of the Martian satellite system.

From the complex motion and rotation of Phobos and Deimos we will obtain clues on internal structures and the origins of the satellites. Also, novel data on the time-varying gravity field of Mars due to climate variations will be obtained.

Measurements by GETEMME will firmly embed Mars and its satellites into the Solar System reference frame. Finally, ranging measurements will be essential to improve on several parameters in fundamental physics, such as the Post-Newtonian parameter β as well as time-rate changes of the gravitational constant and the Lense-Thirring effect.

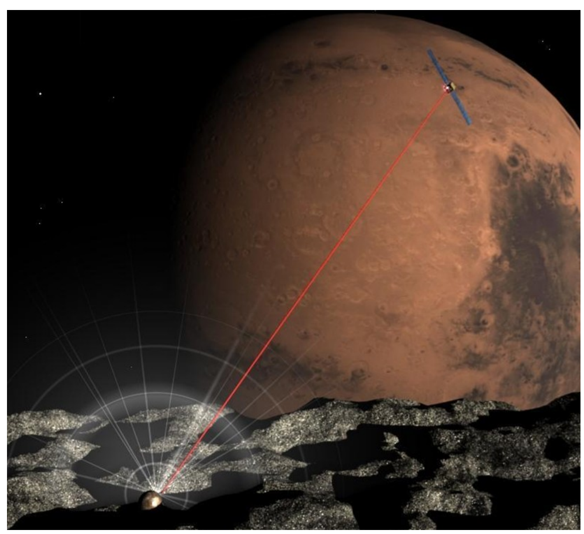
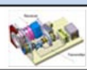
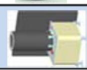


Figure 1: Artist's picture showing S/C performing laser ranging to Phobos

3. Payload

A Laser transmitter and a Laser receiver are central payload elements to the science objectives of GETEMME. The landed modules will carry one retro-reflector each, which will act as target for laser ranging from the S/C.
The orbiter will also carry a multispectral camera, which will be used for the full characterization of the satellites at high resolution, multiple phase angles, and color. In addition, the orbiter will carry an accelerometer, which is intended to measure non-gravitational forces acting upon the spacecraft and help in the orbit determination of the spacecraft (see Table 1).

Table 1: Main payload overview

Retroreflectors		4 passive landers with retroreflectors Heritage: CHAMP, GRACE, GOCE; 150 x 150 x 100 mm³; Mass: 20 kg
Laser Ranging		Range measurements to Phobos, Deimos, Earth Heritage: Bepi Colombo Laser Altimeter; 1,000 x 550 x 450 mm³; Mass: 15.5 kg
Accelerometer		Ultrasensitive accelerometers Heritage: CHAMP, GRACE, GOCE; 340 x 340 x 200 mm³; Mass: 3.5 kg
Camera		Imaging Science Heritage: ROKVISS, SRC@MEX, DAWN camera; 700 x 420 x 450 mm³; Mass: 5.6 kg
Spectrometer		Spectro-photometry: 400–2900 nm Heritage: CRISM Imaging Spectrometer; 310 x 430 x 510 mm³; Mass: 14 kg

4. Spacecraft key issues

A Soyuz-Fregat will bring the S/C into initial Mars transfer; for further navigation, an electrical propulsion system will be used.
The baseline S/C configuration adopts a cubical spacecraft bus of 1 m x 1 m x 1 m with a total launch mass of 1600 kg.
A solar generator of 32 m^2 is generating about 2600 W of electric power. A high-gain RF antenna is foreseen for X-band communication with Earth during transfer as well as during operation in Mars orbit.

<u>Spacecraft specifications:</u>

- Dimension: 1 m x 1 m x 1 m
- Total launch mass: 1600 kg
- Dry mass: 1190 kg
- Payload mass: 120 kg
- Solar array: 32 m^2
- Propulsion: Solar-electric
- Propellant mass: 410 kg

References

[1] J. Oberst, V. Lainey, C. Le Poncin-Lafitte and the GETEMME proposal team; *GETEMME - A Mission to Explore the Martian Satellites and the Fundamentals of Solar System Physics*; submitted Apr. 2011