TASTE - Terrain Analyzer and Sample Tester Explorer: A CubeSat mission with a Miniaturized Lander to Martian Moon Deimos

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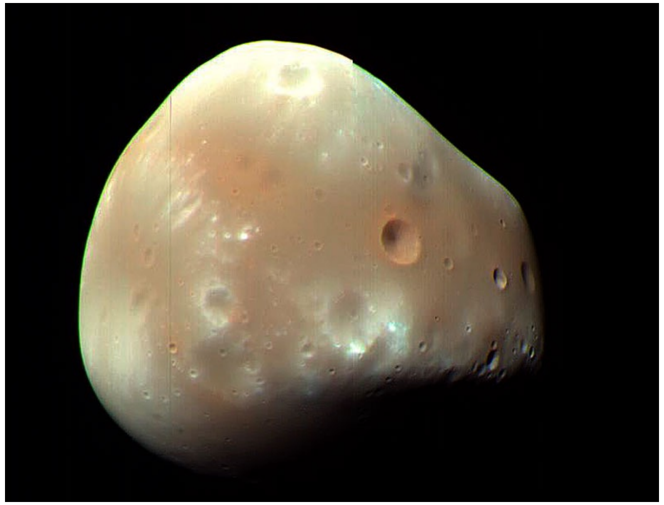
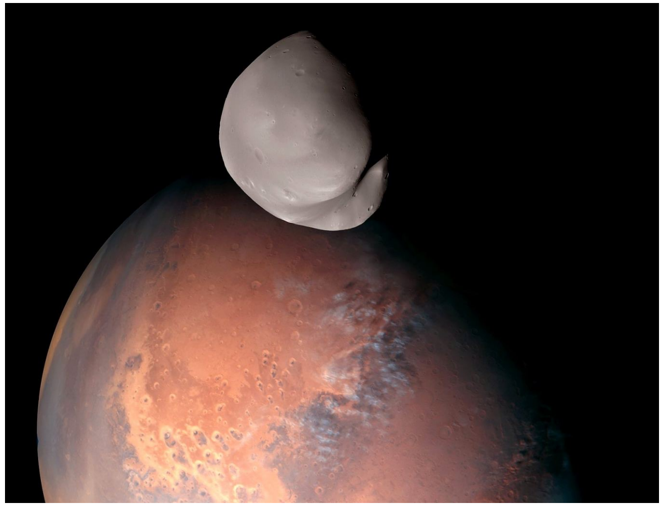
TASTE Mission Overview

- The Terrain Analyzer and Sample Tester Explorer (TASTE) is a CubeSat mission consisting of an orbiter capable of deploying a lander to explore Deimos.
- TASTE is funded by the Italian Space Agency (ASI) under the Alcor programme.
- The consortium, consisting of Prime INAF-Arcetri, INAF-Trieste and Politecnico di Milano, has successfully completed Phase A and is about to start Phase B.

Discovering and Observations of Deimos

- Deimos was discovered by Asaph Hall in 1877.
- Since then, it was observed from Earth and during space mission (Mariner 9, Viking 2, Fobos 2, MGS, Mars Express, MRO). Observation of Deimos were also performed from Martian rovers.
- The MMX (Martian Moons eXploration), set for launch in 2026, should perform close flyby of Deimos.
- UAE’s Emirates Mars Mission (EMM), currently on-going, provides images and spectral data.





Facts about Deimos

- Deimos is the farthest moon of Mars, it’s tidally locked, its orbit is almost circular (e=0.0003), and it lies almost exactly on the equatorial plane of Mars.
- Its dimensions are 16x12x10 km with an estimated mass of 1.4762×10^{15} kg and a density of 1.46 g/cm^3.
- There is still some debate about the origin of Deimos (and Phobos): captured asteroids or in situ formation:
    1. Some spectral measurements, the shapes and the cratered surfaces suggest that they were captured by the gravitational pull of Mars, but computer simulations showed that they're likely to have more irregular orbits.
    2. They could have formed from a disk of rock and dust orbiting Mars, but studies suggest a large disk and a single moon like the Earth's moon. If the origin was a cosmic impact on Mars (such as the one that created the Borealis Basin), it is thought to have happened early in the life of the Solar System: if Phobos was that old, it should have already crashed into Mars.

TASTE Scientific Objectives

- The scientific objective of the TASTE is to help to understand the origin of Deimos by combining global morphology and composition data obtained by an orbiter with local elemental, organic and mineralogical composition obtained by a lander.
- In particular, the main objectives are to study:
    - Global morphology
    - Global elemental abundance
    - Landing site morphology and texture
    - Landing site organic content
    - Landing site properties vs global surface properties
    - Gravity field determination and internal structure

TASTE Science Traceability Matrix

Science Goals	Science Objectives	Measurement	Methods
1. Origin of Deimos	(A) Classification of Deimos (B) Same/different origin of Phobos and Deimos (C) Formation timescale	Map the surface of Deimos, acquire data about the texture, the composition, and the organic abundances of its surface, measure its gravitational field	Orbiter imaging Spectrometry In-situ sample analysis Radio science
2. Characteristics of the surface	(D) Cartography (E) Surface global properties (F) Shape model improvement (G) Comparison of the global properties of the surface with the local texture (H) Reason of the different morphology of Phobos and Deimos	Map the surface composition of Deimos and compare the global results with the local properties	Orbiter imaging Spectrometry In-situ sample analysis In-situ Imaging
3. Elemental and organic composition	(I) Elemental abundances on the surface (J) Organic contents on the surface	Map the elemental global abundance on Deimos surface and its organic content	In-situ sample analysis
4. Inertial properties	(K) Gravity field (L) Mass estimate (M) Reason of different densities of Deimos and Phobos	Map the gravity field of Deimos and correlate it with the shape properties	Radio science Orbiter imaging

TASTE Payload

- TASTE will carry a suite of instruments on the orbiter and lander submodules:
  - The orbiter will carry a camera and an X-ray and γ-ray spectrometer.
  - The lander will carry a camera and the Surface Sample Analyser (SSA).
- In addition, the orbiter's radio will be used to collect gravity field data.

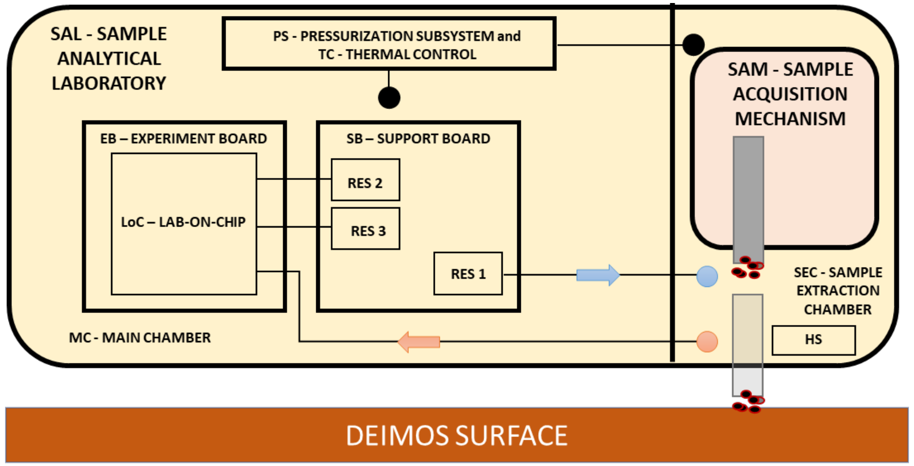
		Payload				
		Orbiter			Lander	
		Camera	Spectrometer	Radio Science	SSA	Camera
Objectives	Global morphology and settings	✓				
	Global elemental abundance		✓			
	Landing site morphology and texture	✓				✓
	Landing site organic contents				✓	
	Landing site properties compare to global surface properties	✓	✓		✓	✓
	Gravity field determination and internal structure			✓		

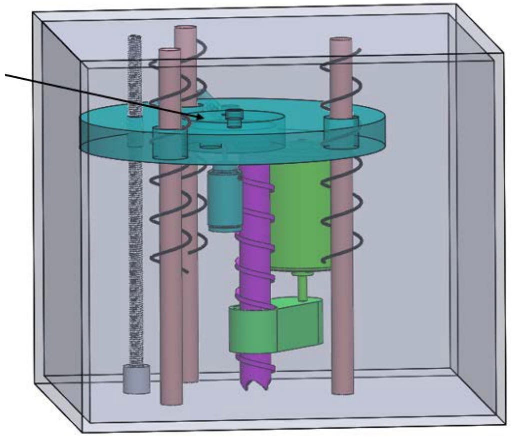
Orbiter Payload

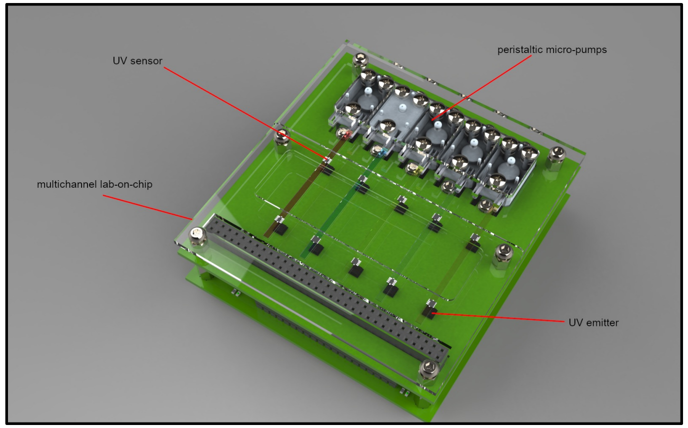
- The orbiter will carry a multispectral camera and miniaturised X-γ-ray spectrometer to characterise the elemental composition of the surface:
  - X-ray spectroscopy will measure the relative abundance of elements with atomic number ≤20 down to a few micrometres of the surface using solar X-rays to excite the atoms of the elements.
  - γ-ray spectroscopy of nuclear lines excited by galactic cosmic rays will also be used to assess the abundance of elements in the surface down to 10-20 cm.
  - This instrument is a revision of the pay-load designed and under development in the HERMES-TP and HERMES-SP EC\MUR\ASI projects.

Lander Payload

- The lander will carry a VIS-IR camera and the SSA.
- The SSA is inherited from the AstroBio CubeSat (ABCS) and will consist of :
  - Sample Acquisition Mechanism (SAM) acquires the samples (a few centimetres of core through a hollow screw)
  - Sample Extraction Chamber (SEC) extracts the liquid sample,
  - Sample Analysis Laboratory (SAL), where the Lab-on-Chip (LoC) is placed, measures the organic content of the samples by fluorescence.



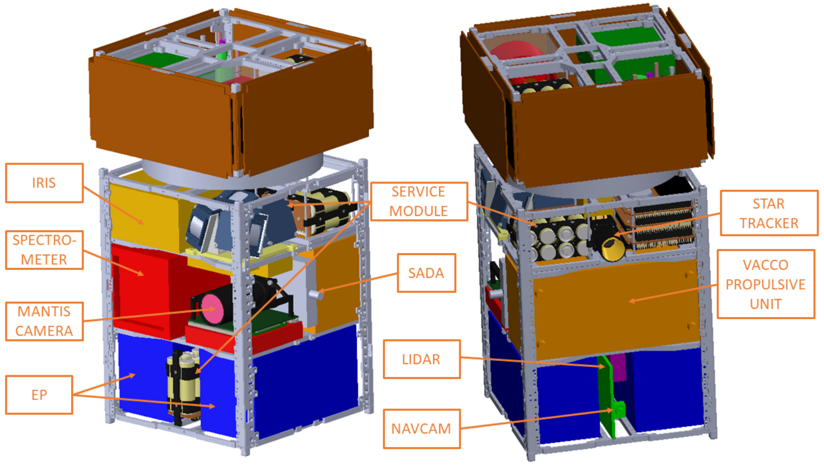


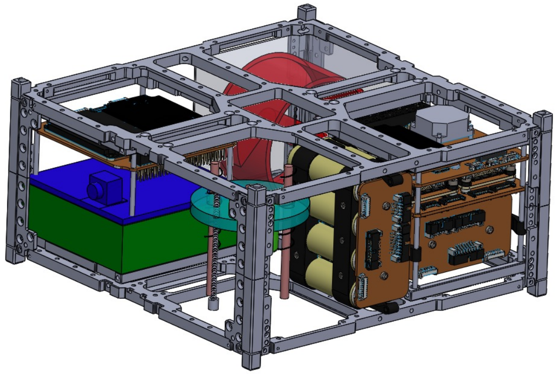


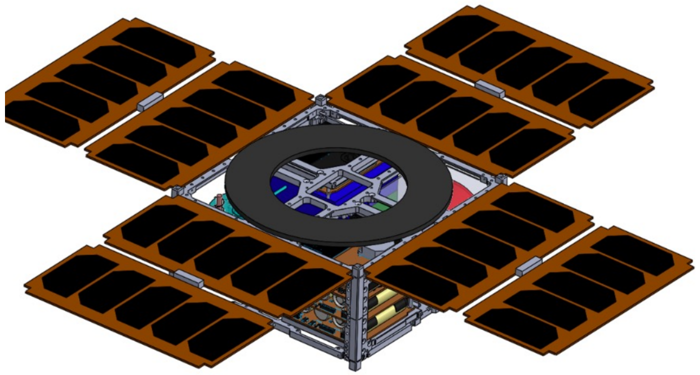
Sample Acquisition Mechanism (SAM) and Sample Analysis Laboratory (SAL)

TASTE System

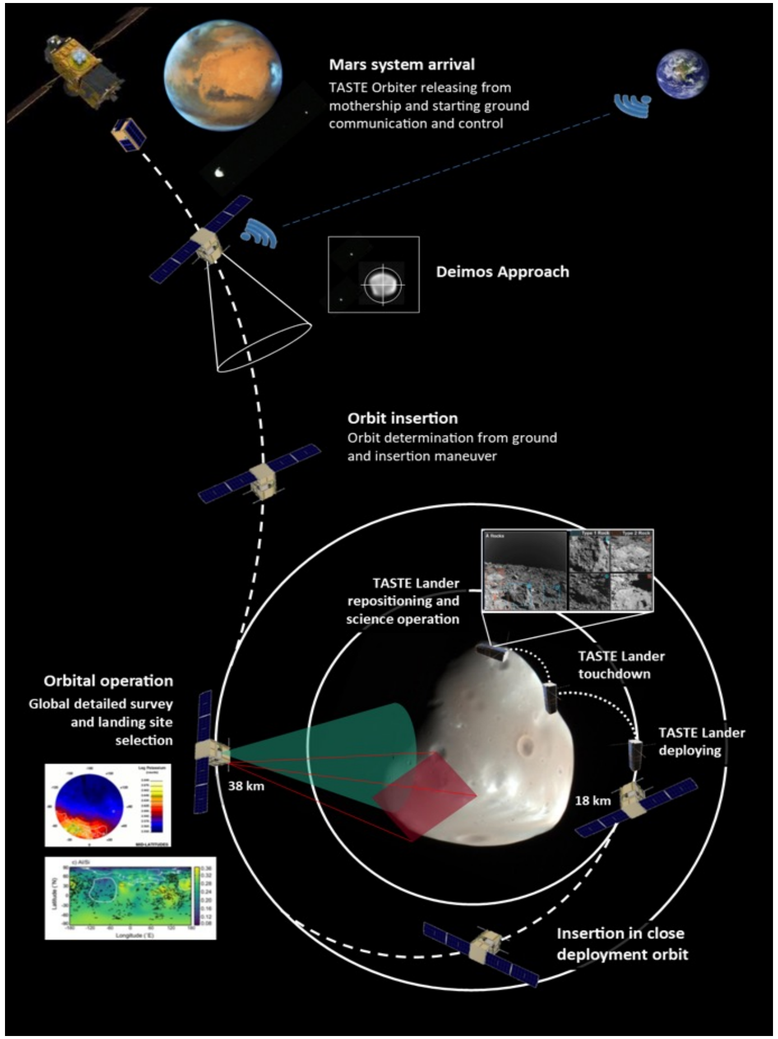
- The TASTE mission will operate a 16U CubeSat consisting of a 12U orbiter and a 4U lander, which will be deployed by a separation ring once in orbit around Deimos.
- The TASTE lander will have a tilt mechanism based on Hayabusa-2/MASCOT experience, to allow position reorientation on the surface.



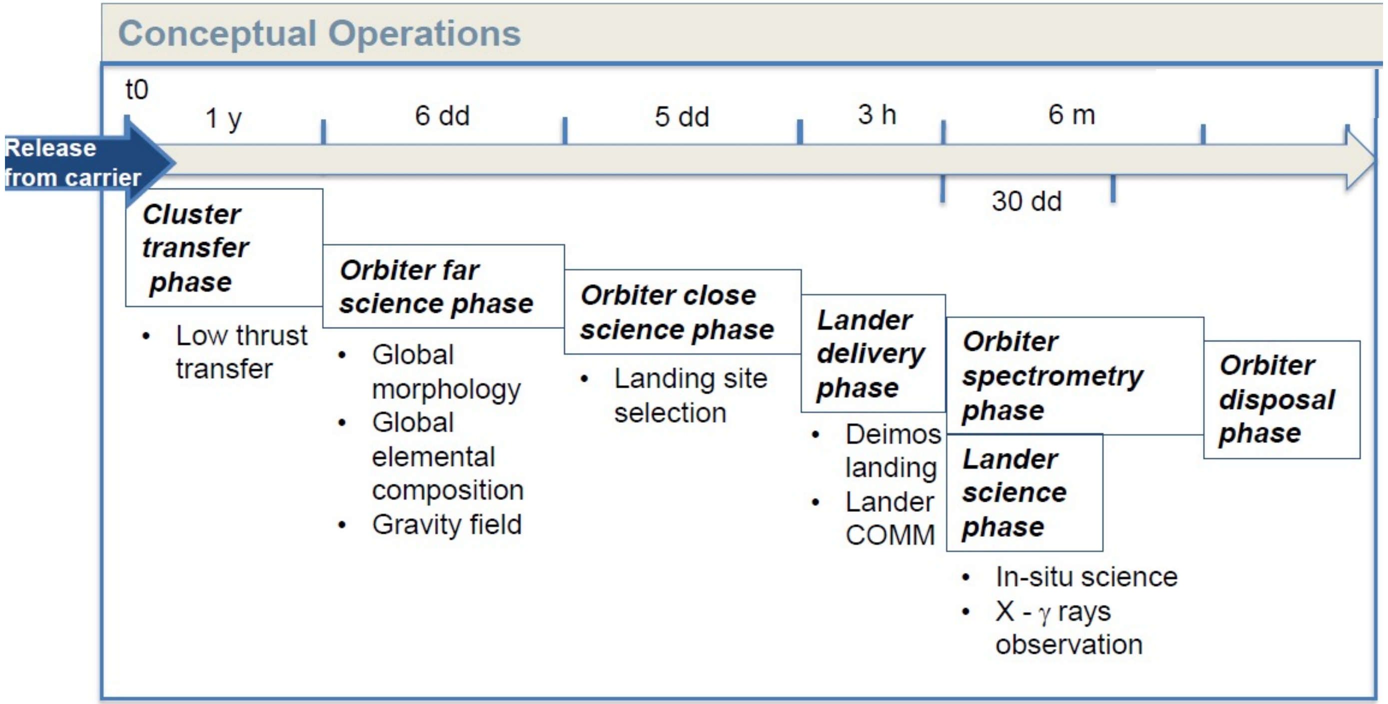




TASTE Operations



Mission Architecture → Orbiter + Lander



Conclusion

- **Launch opportunities:** identification of missions to Mars which are suited to play as carrier.
- **Launcher interfaces:** COTS is adopted as far as possible: the dispenser COTS shall ensure the umbilical for power supply all over the interplanetary transfer, up to the release.
- **Configuration\structure:** both orbiter and lander structures ask for a (slight) customisation. Therefore both of them will be developed in different models (VM/B,EM/C,FM/D) to confirm the design and run functional and qualification tests. The same model philosophy is adopted for the customized lander\orbiter connection ring
- **Lander robotics:** all lander robotics is customized– tilting mechanism, anchoring, sampling-will follow a complete model cycle, VM/B, BB/B-C, EM/C, QM-FM/D
- **Payloads:** visual PLs are COTS with flight heritage. The orbiter-spectrometer and the lander SAL , even if with flight heritage, are here considered at TRL4-5.