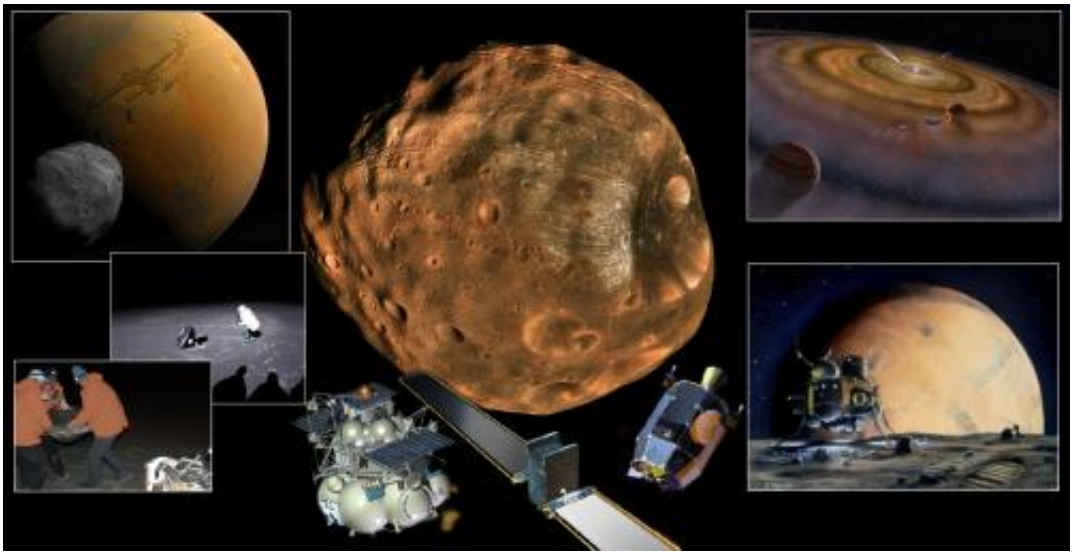
The case for a mission to Mars' moon Phobos

October 2 2014, by Tim Reyes



From where did Phobos arise or arrive? The Inner or Outer Solar System? Is it dry or wet? Should we flyby or sample & return? Or should it be Boots or Bots? In the illustration, space probes (L-R) Phobos-Grunt 2, JPL/SAR, ARC PADME. Also, Stardust's return capsule, Phobos above Mars, the Solar Nebula and the MRO HiRISE photo of Phobos. Credit: NASA, Illustration:T.Reyes

Ask any space enthusiast, and almost anyone will say humankind's ultimate destination is Mars. But NASA is currently gearing up to go to an asteroid. While the space agency says its Asteroid Initiative will help in the eventual goal of putting people on Mars, what if instead of going to an asteroid, we went to Mars' moon Phobos?

Three prominent planetary scientists have joined forces in a new paper

in the Journal *Planetary and Space Science* to explain the case for a mission to the moons of Mars, particularly Phobos.

"Phobos occupies a unique position physically, scientifically, and programmatically on the road to exploration of the solar system," say the scientists. In addition, the moons may possibly be a source of in situ resources that could support future human exploration in circum-Mars space or on the Martian surface. But a sample return mission first could provide details on the moons' origins and makeup.

The Martian moons are riddles, wrapped in a mystery, inside an enigma. Phobos and its sibling Deimos seem like just two asteroids which were captured by the planet Mars, and they remain the last objects of the inner solar system not yet studied with a dedicated mission. But should the moons be explored with flybys or sample-return? Should we consider "boots or bots"?

The publications and mission concepts for Phobos and Deimos are numerous and go back decades. The authors of "The Value of a Phobos Sample Return," Murchie, Britt and Pieters, explore the full breadth of questions of why and how to explore Phobos and Deimos.

Dr. Murchie is the principal investigator of the Mars Reconnaissance Orbiter's CRISM instrument, a visible/infrared imaging spectrometer. He is a planetary scientist from John Hopkins' Applied Physics Lab (APL) which has been at the forefront of efforts to develop a Phobos mission. Likewise, authors Dr. Britt, from the University of Central Florida and Dr. Pieters from Brown University have partnered with APL and JPL in Phobos/Deimos mission proposals.

APL scientists are not the only ones interested in Phobos or Deimos. The Jet Propulsion Laboratory, Ames Research Center and the SETI Institute have also proposed several missions to the small moons. Every NASA

center has been involved at some level.

But the only mission to actually get off the ground is the Russian Space Agency's Phobos-GRUNT[ref]. The Russian mission was launched November 9, 2011 and two months later took a bath in the Pacific Ocean. The propulsion system failed to execute the burns necessary to escape the Earth's gravity and instead, its orbit decayed despite weeks of attempts to activate the spacecraft. But that's a whole other story.

"The Value of a Phobos Sample Return" first discusses the origins of the moons of Mars. There is no certainty. There is a strong consensus that Earth's Moon was born from the collision of a Mars-sized object and Earth not long after Earth's formation. This is just one possibility for the Martian moons. Murchie explains that the impacts that created the large basins and craters on Mars could have spawned Phobos and Deimos: ejecta that achieved orbit, formed a ring and then coalesced into the small bodies. Alternative theories claim that the moons were captured by Mars from either the inner or outer solar system. Or they could have co-accreted with Mars from the Solar Nebula. Murchie and the co-authors describe the difficulties and implications of each scenario. For example, if captured by Mars, then it is difficult to explain how their orbits came to be "near-circular and near-equatorial with synchronous rotational periods."

A MRO HiRise image of the Martian moon Phobos. Taken on March 23, 2008. Phobos has dimensions of 27 × 22 × 18 km, while Deimos is 15 × 12.2 × 11 km. Both were discovered in 1877 at the US Naval Observatory in Washington, D.C. Credit: NASA/MRO/HiRISE

To answer the question of origins, the paper turns to the questions of their nature. Murchie explains that the limited compositional knowledge leaves several possibilities for their origins. They seem like D-type asteroids of the outer asteroid belt. However, the moons of Mars are very dry, void of water, at least on their surfaces as the paper discusses in detail. The flybys of Phobos and Deimos by NASA and

ESA spacecraft is simply insufficient for drawing any clear picture of their composition or structure, let alone their origins, Murchie and co-authors explain.

If the moons were captured then they have compositions different from Mars; however if they accreted with or from Mars, then they share similar compositions, with the early Mars when forming or from Martian crustal material, respectively.

The paper describes in some detail the problem that billions of years of Martian dust accumulation presents. Every time Mars has been hit by a large asteroid, a cloud of debris is launched into space. Some falls back to the planet but much ends up in orbit. each time, some of the debris collided with Phobos and Deimos; Murchie uses the term "Witness plate" to describe what the two moons are to Mars. There is an accumulation of Martian material and also material from the impactors covering the surfaces of the moons. Flyby images of Phobos show a reddish surface similar to Mars and numerous tracks along the surface as if passing objects struck, plowed or rolled along. However, the reddish hue could be weathering from Solar flux over billions of years.

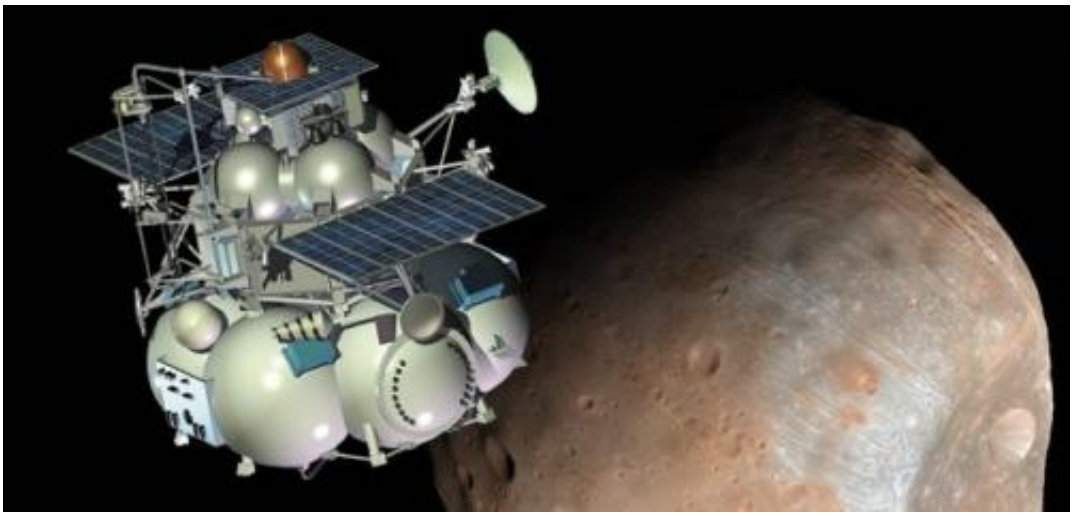
The paper continues with questions of the composition and how rendezvous missions could go further to understanding the moons makeup and origins, however, it is sample return that would deliver, the pay dirt. Despite how well NASA and ESA engineers have worked to shrink and lighten the instruments that fly, orbit and land on Mars, returning a sample of Phobos to labs on Earth would permit far more detailed analysis.

Science Fiction writers and mission designers have imagined Phobos, in particular, as a starting point for the human exploration and colonization of Mars. A notable contemporary work is "Red Mars" by Kim Stanley Robinson; however, the story line is dated due to the retirement of Space

Shuttle and the external tanks Robinson clustered to form the colonization vessel. While this paper by Murchie et al. is purely scientific, fiction writers have used the understanding that Phobos is far easier to reach from Earth than is the surface of Mars (see Delta-V chart below).

Phobos, orbiting at 9,400 kilometers (5,840 miles) and Deimos at 23,500 km (14,600 miles) above Mars avoids the need for the 7-odd minutes of EDL terror – Entry, Descent and Landing—and pulling oneself out of the Martian gravity well to return to Earth. Furthermore, there is the interest in using Phobos as a material resource – water, material for rocket fuel or building materials. "The Value of a Phobos Sample Return" discusses the potential of Phobos as a resource for space travelers – "In Situ Resource Utilization" (ISRU), in the context of its composition, how the solar flux may have purged the moons of water or how Martian impact debris covers materials of greater interest and value to explorers.

With so many questions and interests, what missions have been proposed and explored? The Murchie paper describes a half dozen missions but there are several others that have been conceived and proposed to some level over several decades.



The Russian-led mission Phobos-Grunt did not end well; under Pacific swells to be exact. Undaunted Russian scientists are pressing for Phobos-Grunt 2 (illus.), an improved lander with sample-return. Proposed for 202os Credit: CNES

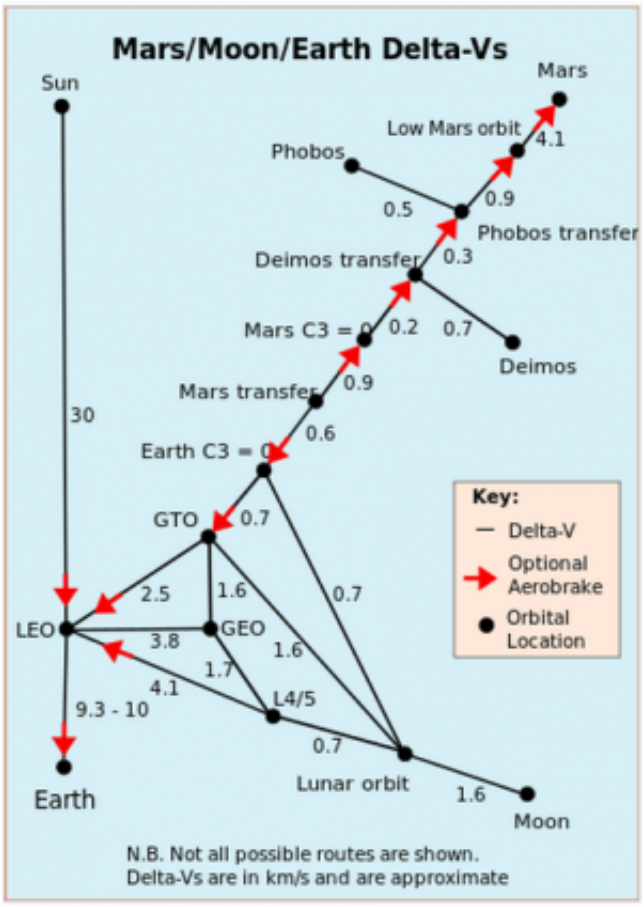
At present, there is at least one mission actively pursuing funds. The SETI and Ames proposed "Phobos and Deimos & Mars Environment" (PADME) mission led by Dr. Pascal Lee is competing for Discovery program funding. Such projects must limit cost to $425 million or less and be capable of launching in less than 3 years. They are proposing a launch date of 2018 on a SpaceX Falcon 9. The PADME mission design would reuse Ames LADEE hardware and expertise, however, it does not go so far as what Murchie and co-authors argue – returning a sample from Phobos. PADME would maintain a synchronized orbit with Phobos and then Deimos fore repeated flybys. The mission is likely to cost in the range of $300 million. Stardust, a relevant mission due to its sample return capsule, launched in 1999 and had costs which likely reached a similar level by end of mission in 2012.

The Russian Space Agency is attempting to gain funding for Phobos-Grunt 2 but possible launch dates continue to be moved back – 2020,

2022 and now possibly 2024.

Additionally, each of this papers' authors have mission proposals described. Dr. Pieters, JPL and Lockheed-Martin proposed the Aladdin mission and Dr. Britt at APL also with Lockheed-Martin proposed the mission Gulliver; both would re-use the Stardust sample-return capsule (photo, above). Dr. Murchie also describes his APL/JPL mission concept called MERLIN (Mars–Moon Exploration,Reconnaissance and Landed Investigation).

Phobos and Deimos are the last two of what one would call major objects of the inner Solar System that have not had dedicated missions of exploration. Several bodies of the Asteroid Belt have been targeted with flybys and Dawn is nearing its second target, the largest of the Asteroids, Ceres.

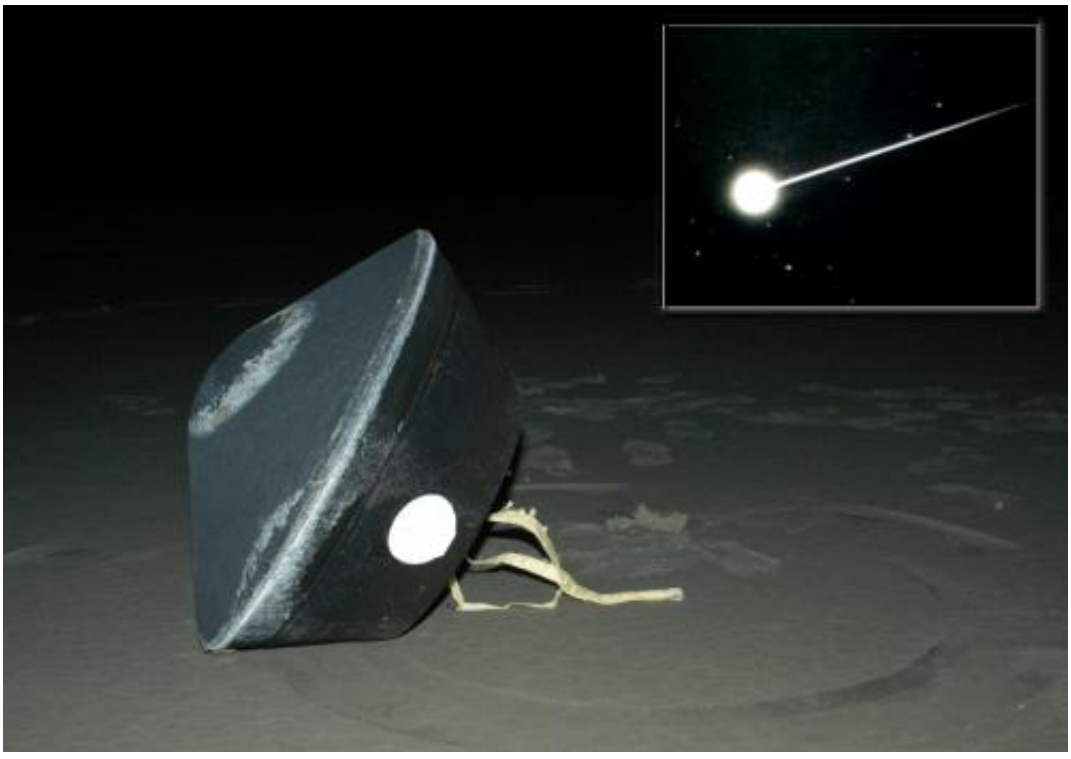


A diagram showing the stair-step energy needed to travel to places beyond the Earth. Delta-V is the speed in km/sec required to reach a destination. As shown, the Delta-Vs are accumulative. Note that it takes an extra 5 km/sec beyond Phobos to reach the Martian surface; a prime reason for making the journey to the moons of Mars. Credit: Wikipedia, Delta-V

So sooner rather than later, a spacecraft from some nation (not necessarily the United States) will target the moons of Mars. Targeted Phobos/Deimos missions are also likely to include both flyby missions and one or more sample-return missions. A US-led mission with sample-return in the Discovery program will be strained to meet both criteria – $425 million cost cap and 3 year development period.

Those utilizing the Lockheed-Martin (LM) Stardust design have a proven return capsule and spacecraft buses (structure, mechanisms and avionics) for re-use for cost and time savings. This includes five generations of the LM flight software that holds an incredible legacy of mission successes starting with Mars Odyssey/Genesis/Spitzer to now Maven.

All three proposals by this paper's authors could be re-vamped and proposed again and compete against each other. All three could use Lockheed-Martin past designs. Cooperation in writing this paper may be an indicator that they will join forces, combine concepts and share investigator positions on a single NASA-led project. The struggle for federal dollars remains a tough tight battle and with the human spaceflight program struggling to gain a new footing after Space Shuttle, dollars for inter-planetary missions are likely to remain very competitive. However, it appears a Phobos-Deimos mission is likely within the next ten years.



Return of the Stardust sample inside the Lockheed-Martin developed sample-return capsule. Seen here upon successful landing in the Utah desert. Credit: NASA/Stardust

More information: "The Value of a Phobos Sample Return", Scott L. Murchie, Daniel T. Britt, Carle M. Pieters, *Planetary and Space Science*, 1 November 2014. www.sciencedirect.com/science/ … ii/S0032063314001123

Source: Universe Today