German Aerospace Center

News Archive 2009

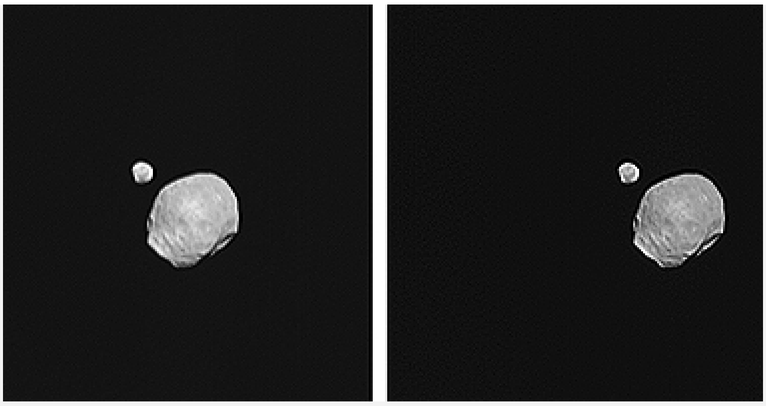
Martian moons Phobos and Deimos together in one image for the first time

11 December 2009

HRSC on Mars Express photographs Phobos and Deimos together and in high resolution

Animation: The Mars moons Phobos and Deimos

Ultimate precision is one of the most important prerequisites for successful space missions. The German Aerospace Center (DLR), in collaboration with the European Space Agency (ESA) in Darmstadt, has now provided an impressive example of the planning to perfection of the perfect shot of an unusual object in the Solar System. For the first time, the two tiny Martian moons Phobos and Deimos have been photographed together in a high-resolution image sequence. This was made possible using the Super Resolution Channel (SRC) of the High Resolution Stereo Camera (HRSC) operated by DLR and carried by ESA's Mars Express spacecraft.



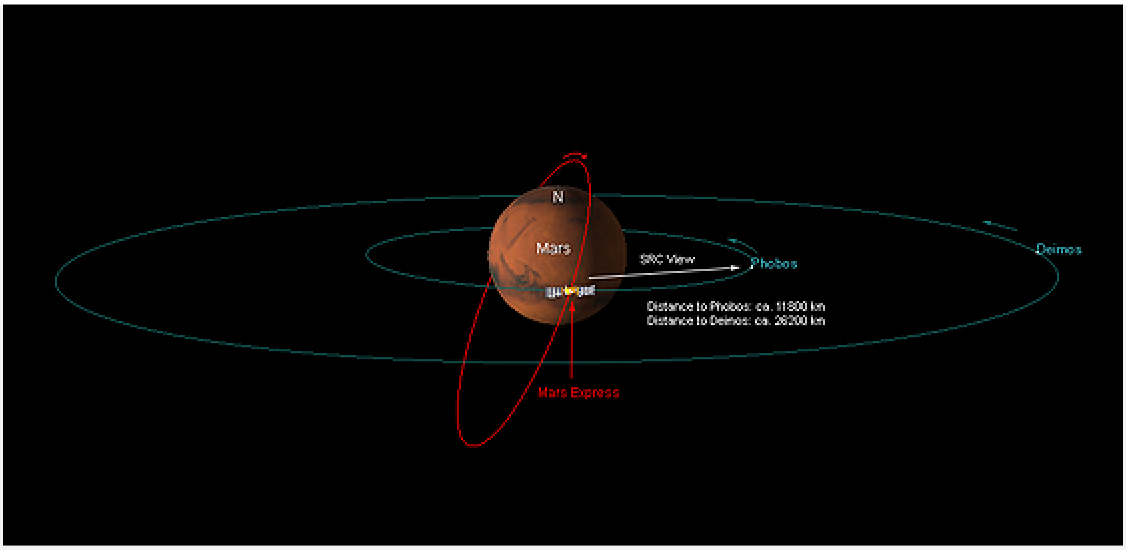
Phobos and Deimos together for the first time and in high resolution

"It doesn't happen very often that both Martian moons are right in front of the camera, directly one behind the other," says the DLR institute's Harald Hoffmann. "During the now more than six-year long project, we have had several opportunities to photograph the two moons together," explains Klaus-Dieter Matz, who planned the acquisition of the extraordinary images together with Harald Hoffmann and in coordination with the working group of the scientific leader of the HRSC experiment at the Free University of Berlin (FUB), Professor Gerhard Neukum. "The geometry of the constellation during Orbit 7492 on 5 November 2009 was especially favourable, so this time we wanted to try taking a sequence of photographs – and this first attempt has delivered the expected result!"

On one hand, the images underline that it is easily possible, with the existing orbit data for the space probe and the two Martian moons, to aim at the target objects with the highest precision. On the other hand, the image data serve one of the long-term tasks of the HRSC science team – the validation and refinement of existing orbit models for the two moons.

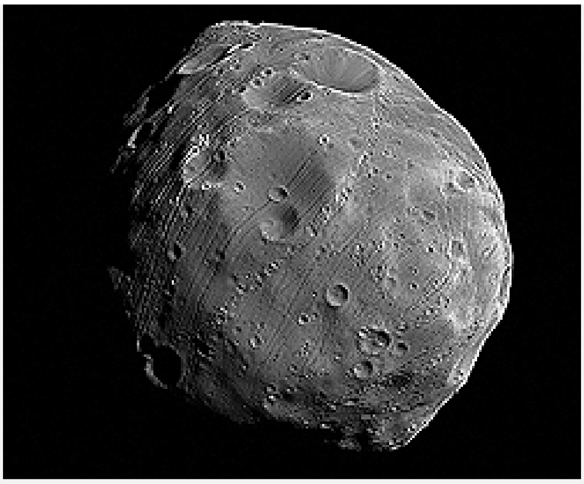
Image sharpening in post-production

At the time of the exposures, Phobos, the larger of the two moons and the one whose orbit is closest to planet, was 11,800 kilometres away from Mars Express. Phobos orbits the planet in just 7 hours and 39 minutes, and is thus travelling much faster relative to Mars than the Moon travels relative to Earth, which means that the exact timing of the exposure was absolutely critical. At the time of the exposures, Deimos was 26,200 kilometres away from the probe. Due to its distance from the camera, the Super Resolution Channel of HRSC was used, a channel which uses an additional lens which, with its angle of view of just 0.5°, provides four times the magnification of the HRSC itself.



The geometrical relationships between Mars, its moons and the Mars Express probe at the time of the sequence

Due to the telescope mirror's triple-focus distortion error in the Super Resolution Channel, the images had to be processed. This was done by the working group at FUB. "It is now possible to almost completely eliminate the unsharpness of the SRC images," says Dr Gregory Michael, also from FUB. "The distance between the space probe, Phobos and Deimos was relatively large, so that the resolution of the SRC images was around 110 metres per pixel for Phobos and 240 metres per pixel for Deimos, which was twice as far from the camera."



Close-up of Mars' moon Phobos, acquired on 28 July 2008

The orbital trajectory of Mars Express, in contrast to that of the two NASA orbiters, Mars Odyssey and Mars Reconnaissance Orbiter, means that only the ESA probe ever sees both moons at the same time. Mars Express' elliptical orbit puts it at around 10,000 kilometres away from the planet's surface, which gets it as close as 9,000 kilometres away from Deimos in ideal conditions. The best image so far taken of Deimos by Mars Express was made at a distance of 10,000 kilometres, and the best images so far of Phobos were made in 2008 at a distance of just 93 kilometres. Both moons orbit Mars in almost circular and close to perfectly equatorial orbits.

High precision ephemerides are the basis for the camera's accurate targeting

In a critical period of one and a half minutes, the SRC took 130 images at intervals of one second, speeding up to half-second intervals towards the end. "As soon as the pictures were sent from the ESA Control Centre in Darmstadt to our team in Berlin, we recognised that our camera targeting and ESA's orbital calculations were in perfect agreement," says HRSC planner Hoffmann. "We were pretty sure that the shoot would be successful, because our colleagues at ESA had seen no reason to make corrections to our calculations on the basis of Mars Express' trajectory." ESA's European Space Operations Centre (ESOC) in Darmstadt has controlled the Mars Express probe since its launch on 2 June 2003; the mission has just recently been extended to the end of 2012.

The success of the experiment depended critically on highly precise ephemerides, tables that give the positions of the planets, moons and smaller bodies in the solar system, as well as those of space probes. The ephemerides for Phobos and Deimos have been corrected and refined over the six-year duration of the Mars Express mission, and the orbit of the probe itself can be predicted extremely precisely by ESOC, so that its position during the shoot diverged by only a few seconds or kilometres from the position that had been predicted several months previously during planning. "The orbit diverged by around 10 seconds from the expected values, this is a very small divergence and is well within the tolerance of even as small a field of view as 0.5°," says Klaus-Dieter Matz.

Exploration of Phobos a scientific priority

Along with the high-resolution global mapping of the surface of Mars with the HRSC, in colour and 3D, the exploration of Phobos is another scientific priority of the camera experiment. The potato-shaped, 27 × 22 × 18 kilometre moon has already been photographed 127 times by the HRSC camera system, which has not only significantly improved our topographic knowledge of the satellite, but has also given us important insights into the origins and development of Phobos.

Mars and its Moons Phobos and Deimos

	Mars	**Phobos**	**Deimos**
Mean diameter	6,779 kilometres	26.8 kilometres x 22.4 kilometres x 18.4 kilometres	15.0 kilometres x 12.2 kilometres x 10.4 kilometres
Mean diameter to the centre of Mars	-	9,375 kilometres	23,458 kilometres
Mean distance to the surface of Mars	-	5,985.5 kilometres	20,068.5 kilometres
Orbital period*	686.5 days	0.32 days (7 hours, 39 minutes)	1.26 days (1 day, 6 hours, 17 minutes)
Mean orbital velocity	24.1 kilometres per second	2.14 kilometres per second	1.36 kilometres per second
Inclination	25.2 degrees	1.075 degrees	0.93 degrees
Mean density	3.9 grams per cubic centimetre	1.9 grams per cubic centimetre	1.5 grams per cubic centimetre
Named after	Roman god of war (Ares in Greek mythology)	Greek god of 'fear', son and companion of Ares, the god of war	Greek god of 'dread', son and companion of Ares, the god of war

* *The orbital period for both moons almost precisely equals the length of day since both Phobos and Deimos orbit Mars in what is called a 'coupled rotation', so that one hemisphere of both moons is permanently facing Mars.*

The HRSC camera experiment on ESA's Mars Express mission is directed by the Principal Investigator (PI), Prof. Dr Gerhard Neukum (Free University of Berlin; FUB), who also designed the high-resolution stereo camera. The team is composed of 45 Co-Investigators from 32 institutes in 10 different countries. The camera was developed at DLR under the direction of Prof. Neukum and built in collaboration with industrial partners EADS Astrium, Lewicki Microelectronic GmbH and Jena-Optronik GmbH. It is controlled by DLR's Institute of Planetary Research (IPR), at Berlin-Adlershof. The systematic processing of the data is done by DLR. The images are created by the Institute for Geological Science at FUB in collaboration with IPR.

Contact

Andrea Schaub
Deutsches Zentrum für Luft- und Raumfahrt (DLR) - German Aerospace Center
Corporate Communications
Tel: +49 2203 601-2837

Fax: +49 2203 601-3249
E-Mail: andrea.schaub@dlr.de

Prof.Dr. Ralf Jaumann
German Aerospace Center
Institute of Planetary Research, Planetary Geology
Tel: +49 30 67055-400
Fax: +49 30 67055-402
E-Mail: Ralf.Jaumann@dlr.de

Harald Hoffmann
German Aerospace Center
Institute of Planetary Research, Planetary Geology
Tel: +49 30 67055-327
E-Mail: Harald.Hoffmann@dlr.de
