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Mars Express sees the Red Planet in three dimensions

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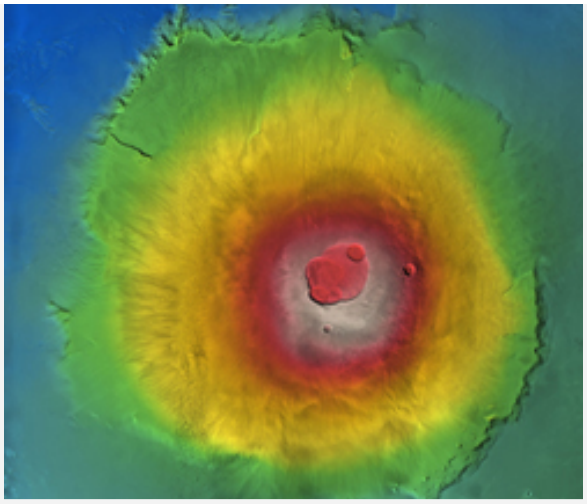
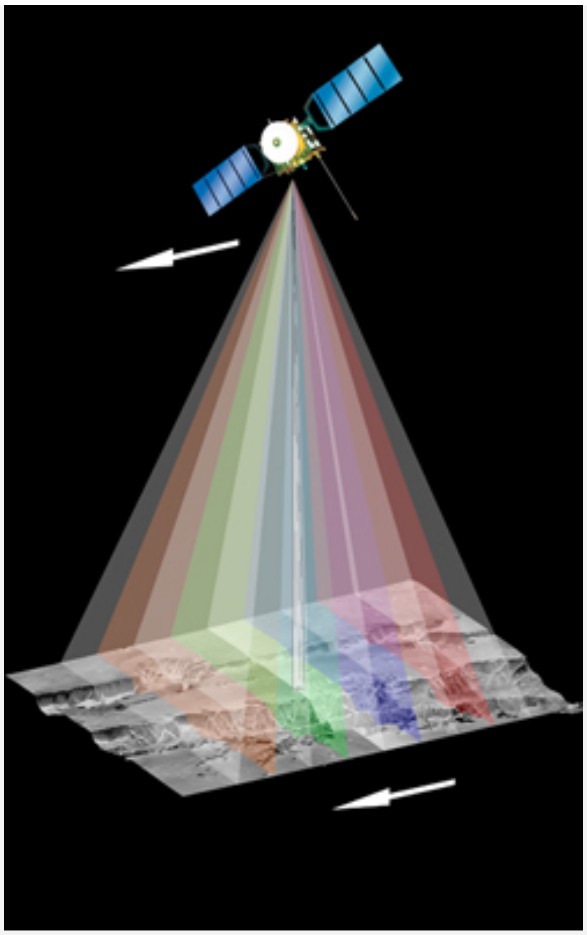


Image mosaic of the Olympus Mons volcano showing relief

One of the most important aspects of the ESA Mars Express mission is the high resolution topographic mapping it is able to produce of our nearest planetary neighbour. For more than four years, the DLR-operated High Resolution Stereo Camera (HRSC) on board the probe has been producing these 3D maps.

A new high-resolution "Digital Terrain Model" dataset that is about to be released onto the internet, will allow researchers to obtain new and better 3D information about the Red Planet. Digital Terrain Models (DTMs) allow scientists to ‘stand’ on planetary surfaces, seeing the mountains, valleys, craters and volcanoes. Although ordinary images can give spectacular bird’s-eye views and in very sharp detail, they can only convey part of the picture. They miss out on the topography of the surroundings. How high are the mountains and how deep are the valleys? The new DTM will take Mars research onto a new level and comes thanks to the cooperative work of the German Aerospace Center (DLR) and the Freie Universität (FU) in Berlin.

The High Resolution Stereo Camera was specially designed to provide Digital Terrain Model information and, after years of specialised data processing, the first comprehensive release of 3D data of a large part of the martian surface is now ready. Understanding the topography of Mars is essential to understanding its geology.



The HRSC camera system on Mars Express

3D, high resolution, colour... – the HRSC does it all

The stereo (3D) production of the Digital Terrain Model by the HRSC uses some of the same techniques we do - the observation of the martian landscape with slightly different points of view uses the same principle with which two-eyed humans see their surroundings. With earlier probes this was usually managed by twice flying over and photographing the same region on close orbits. This had disadvantages as the surfaces were always seen at different times. The HRSC is the first camera system to produce stereo photographs from the same orbit.

The camera is aligned by swivelling the spaceship perpendicularly to the Mars surface. The HRSC takes its images with nine photo-sensitive detectors, scanning the martian surface line by line with nine different viewing angles into and against the flight direction of the orbiter. These nine channels include four stereo and four colour channels, as well as the downward-looking nadir channel. .

Various uses for the research

After several years of camera operation and data processing, the HRSC team has gathered data from almost every region of Mars. From the new Digital Terrain Models of Mars, scientists now know slope inclinations which determine depth of valleys, the power and direction of ancient lava stream flows. In particular the data are important concerning questions about the directions water flowed over the early martian surface.

It also allows planetary scientists to better interpret other data sets, for example the results of Mars Express's radar experiment, the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS). Once we know where the surface is, we can correctly interpret the radar echoes we get from below it.

Close-up view of the High Resolution Stereo Camera (HRSC)

Ten metre resolution over millions of square kilometres

The Mars Express DTM is the most detailed topographic dataset of Mars ever released. It has been made possible by processing individual image swaths taken by the HRSC as Mars Express sweeps through its orbit. The individual swaths are then put together into mosaics that cover large regions. The high-resolution images used have a resolution of 10 metres per pixel. The DTM elevation data derived from these images is provided in pixels of up to 50 m, with a height accuracy of 10 m. The goal of the mission is to cover the entire 145 million square kilometres of Mars – an area equivalent to all of Earth's continents put together.

It is Mars Express's elliptical orbit that determines the resolution of its pictures. When it is closest to the surface, it can take the most detailed pictures. As the mission continues, the gaps will gradually filled up by taking high-resolution data whenever possible.

NASA's Mars Global Surveyor carried a laser altimeter instrument (MOLA) that provided spot heights across the surface of Mars but these were often separated by many kilometres. HRSC provides altitude data for every data point the camera sees. It is the first time that high-resolution images have been accompanied by high-resolution topography.

The team plans to add more data to the DTMs, as the HRSC continues its unique scrutiny of the planet, extending the surface coverage as Mars Express continues its mission until at least the provisional end of the mission in May 2009.

Data processing in cooperation between DLR und FU Berlin

The work of deriving new high-resolution archivable DTMs is split between DLR and FU Berlin. The systematic orbit-by-orbit processing of the DTMs is done entirely at DLR's Institute of Planetary Research, Berlin, which also runs the HRSC experiment for Mars Express on behalf of, and in cooperation with, the Principal Investigator, Professor Gerhard Neukum and his team at the Institute of Geological Sciences, FU Berlin.

Mosaics of certain features on Mars, such as the Valles Marineris canyon and the Olympus Mons volcano are processed at FU Berlin using DTM data of individual strips and specialised software developed within the HRSC Co-Investigator Team.

The additional funding required for the special processing of the individual image swaths and for the creation of the mosaics was provided by DLR, to the DLR Institute for Planetary Research and the Institute for Geological Sciences of the FU Berlin. DTMs had been processed in the past for exclusively scientific and outreach purposes, but with additional resources now available, it is possible to release the DTM data in higher quality.

The Mars Express-HRSC DTMs are available to the science community at large through the archives at the ESA Planetary Science Archive (PSA) and the NASA Planetary Data System (PDS). A joint DLR/FU Berlin website allows the general public to visualize the data online.

Remarks on the availability and use of digital elevation models

ESA's Planetary Science Archive (PSA) and NASA's Planetary Data System (PDS) are data sources mainly for scientific use in astronomy and planetary research. Both archives contain calibrated, validated data of measurements and image data from space probes, earth-based observations and laboratory experiments that are formatted for scientific applications. The digital terrain models (DTMs) of the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express mission made accessible now can be downloaded from the PSA and PDS data servers. For their visualisation, though, special software is required for the full-resolution DTMs. For viewing various image products that can be produced with the HRSC data, like bird's-eye views in colour or black and white, DTMs, perspective views, it is most convenient to make use of the "HRSCview" software of Freie Universität Berlin, enabling the user to look interactively on HRSC Mars images – the link to the site is provided in the right-hand column.

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