German Aerospace Center

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Two years of high-quality images of Mars courtesy of a German camera

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One third of the Red Planet already mapped by DLR scientists at Berlin-Adlershof

Image gallery - the best of HRSC - open

For over two years in orbit around Mars, it has had to withstand extreme temperatures ranging from around -100ºC to +100ºC, high-energy cosmic radiation and the solar wind - yet it is still working flawlessly. The German High Resolution Stereo Camera (HRSC) onboard the European space probe Mars Express is a reliable source of outstanding images for science.

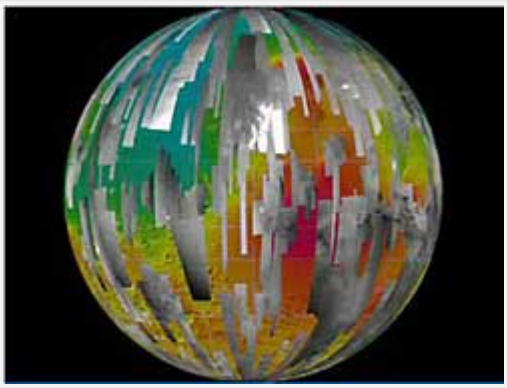
The HRSC was developed by the German Aerospace Center (DLR) at Berlin-Adlershof and is the first camera system onboard a planetary probe to be capable of mapping a high resolution surface in three dimensions and in colour – all at once. The 3-D images taken by the camera, which is operated by DLR's Institute for Planetary Research in Berlin, are creating a whole new paradigm in Mars exploration.

This marvel of science has been intensively surveying the surface of Mars from orbit since 10 January 2004. The stereo camera has seamlessly recorded image data and then transmitted it back to Earth via the probe during almost 1000 orbits of Mars.

The result of this mission is that, after just over two years, 30% of the Red Planet has been mapped with a high level of precision. That's 41 million square kilometres or the equivalent of around one third of the land mass on Earth.

Scientists from ten different countries analyse the images from Berlin to try and follow up important geological questions: "We're especially interested in the question of whether there was once water on Mars," explained Professor Sigmar Wittig, the Chairman of DLR's Executive Board, as the European Mars Express mission celebrated its second anniversary. "The high-precision data gathered by DLR's scientists at Berlin-Adlershof is essential to help us answer this question."

German HRSC operating successfully for two years – mission extended for another two years



Video: The mapping of Mars with the HRSC - open

It was thanks in no small part to the exceptional success of the HRSC that the European Space Agency (ESA) decided to extend the Mars Express mission, which has been orbiting our neighbouring planet since Christmas 2003. The mission was initially scheduled to last two years but has now been extended for another two years until the end of 2007.

"During what will soon be a total of 3000 orbits of Mars, we switched on the camera roughly once in every three times that the probe neared the planet's surface. Using this procedure, we have so far been able to map almost 30% of Mars in a high resolution of 20 metres or more per pixel," says Dr Ralf Jaumann, who is in charge of the HRSC Experiment Team at DLR's Institute of Planetary Research in Berlin.

"Never before have we had access to such a coherent set of image data. And what's more, these images are available for the first time in three dimensions and in colour. Mars researchers around the globe will need many more years to analyse the huge amount of data collected. But we already have the first scientific findings - findings that stem directly from our images," says Jaumann, who is also a member of the HRSC science team.

Five angles + four colours = Nine simultaneous sets of data - 3-D images, thousands of kilometres long

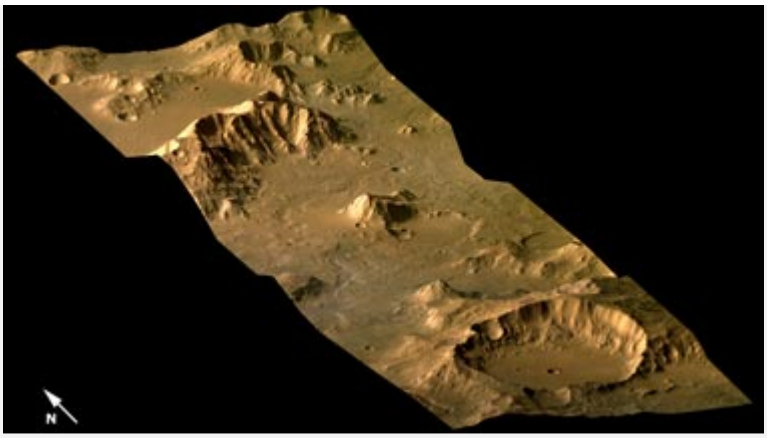
The Berlin-built stereo camera – one of seven experiments onboard Mars Express – has helped to generate the largest collection of data that has ever been gathered by a German instrument in the exploration of our Solar System. Because of the unusual way the camera works, every time the probe comes near the planet in its elliptical orbit, at a height of 250 to 300 kilometres above the surface, the camera maps the surface in long strips, 50 to 100 kilometres wide and many hundreds or even thousands of kilometres long.

Every time DLR's stereo camera takes an image of Mars, it records the data from five different angles and in four colours. Because nine light-sensitive scanner sensors are used during the surface scanning process, the camera maps nine strips of terrain simultaneously which can then be combined by the computer to generate different views and even to simulate overflights.

Large amounts of data densely compressed for its journey from Mars to Earth

This also means that huge data volumes from Mars somehow have to be transmitted back to Earth with maximum precision, despite the limited range of bandwidth available. Because Mars takes about 687 Earth days to orbit the Sun – almost twice as long as Earth – the distance between the two planets varies between 55 and 400 million kilometres. The strength of the radio signal between the probe and Earth decreases by the square of the distance between the two.

So even at maximum transmission output of 182 bits per second, less and less data can be transmitted as the probe moves further away from Earth. To try to compensate for this, the data volume is reduced in size by compressing the digital image signals in the camera as soon as they are taken, and sending them to the Mars orbiter's main memory in this reduced form. This allows the images from the HRSC to be condensed into smaller packages of data with almost no loss of quality.

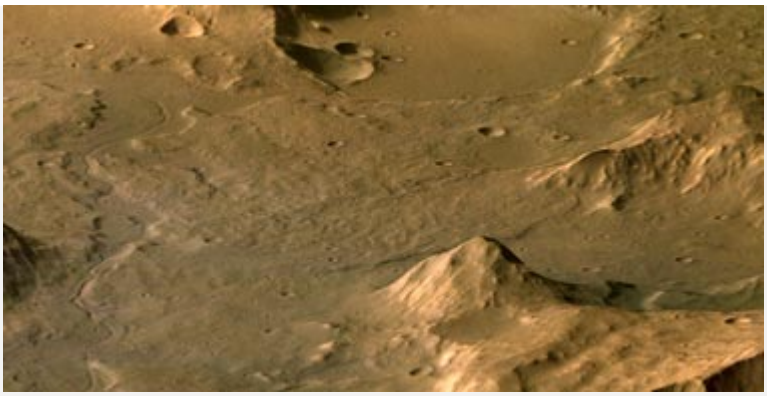


Dry riverbed in the Libya Montes highlands of Mars

To date, the HRSC has gathered almost 100 gigabytes of this compressed raw data. After the data has been received by ESA and NASA space antennae in Australia, Spain and California, it is transmitted to the European Space Operations Centre (ESOC) in Darmstadt (Germany) and from there straight to the HRSC team at Berlin-Adlershof.

Data processing at DLR in Berlin takes just a few hours

"Any small errors caused by the different sensitivities of the sensors are automatically corrected before we turn the images into accurate maps, which takes just a few hours," explains Dr Ralf Jaumann. "Once we've done that, every single pixel on the map will be in its exact geographical location."



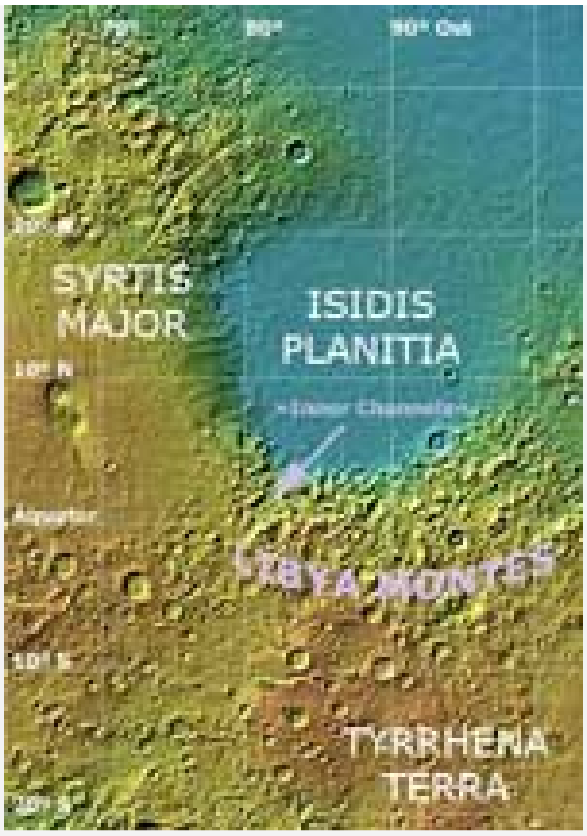
Dry river bed in the Libya Montes highlands of Mars

However, the DLR team's speciality is the creation of what are called 'digital terrain models', which accurately portray the surface of Mars in three dimensions. "As part of the mission we're creating the first global topographical map of Mars," says Dr Jaumann.

The volume of data generated during the various stages of processing grows much larger when the data packages are decompressed and the map-projected images are created. To date, DLR's archives in Berlin have accumulated 1450 gigabytes of systematically-processed images of Mars. After a waiting period of one year, the data on the ESA and NASA server systems are made accessible to researchers throughout the world who are not directly involved in the Mars Express mission, through one of the ESA's science teams.

Data quickly sent out to scientists around the world for analysis and interpretation

The experiment team is usually able to send the processed images straight to the Mars researchers involved in the project on the very day the data is received. The HRSC science team is led by Principal Investigator Professor Gerhard Neukum from the Freie Universität Berlin, who was also responsible for developing the concept of the HRSC.



Topographical map - Libya Montes

The HRSC science team consists of 42 scientists from ten countries (Europe, the USA, Japan and Taiwan) together with their research groups, who work directly with the image data. The team also includes seven scientists from DLR. “From a scientific point of view, these images are gradually providing us with a new picture of Mars,” says Neukum. “This 3D data is filling in a large gap in Mars research. In just the first two years we’ve already achieved some very important results.”

By the time the first extension of the mission comes to a close at the end of 2007, the HRSC will have covered all 145 million square kilometres of Mars in colour 3-D images with a resolution of at least 40 metres per pixel. “But to carry out the wide range of research activities we have in mind, we aim to achieve an even better global resolution of 20 metres per pixel. To do this the mission would need to be extended again,” says Neukum.

Contact details for image and video enquiries as well as information regarding DLR's terms of use can be found on the DLR portal imprint.