15 YEARS HIGH RESOLUTION STEREO CAMERA OBSERVATIONS WITH ESA'S MARS EXPRESS MISSION.

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Introduction: 15 years ago, on January 10, 2004, the first of thousands of images of the Martian surface was captured by the High Resolution Stereo Camera (HRSC), which is a German research instrument onboard the European Space Agency's Mars Express spacecraft, in orbit around Mars since December 2003. January 19, 2004, was the date of the first HRSC image release featuring Hydraotes Chaos at the Martian equator (Fig. 1), an image that has been recorded on January 14 in orbit #0018. During the last 15 years HRSC has collected image data in more than 5000 orbits, resulting in a steadily increasing set of image, mosaic, and movie releases [1].

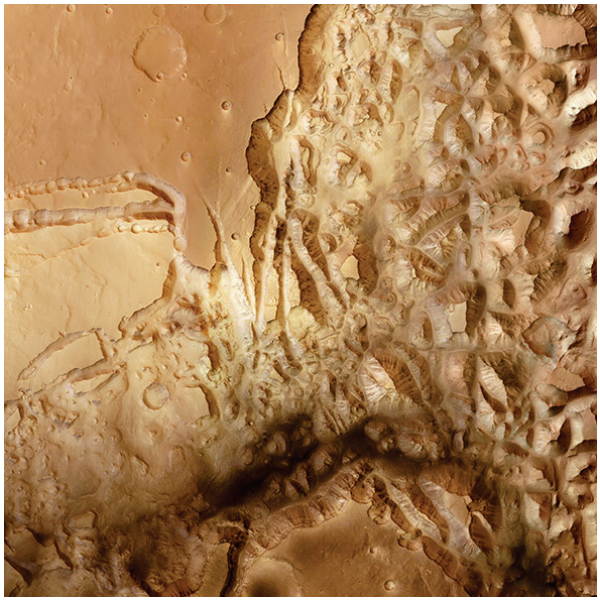

Figure 1: Mosaic of Hydraotes Chaos created in 2014, including in the central part the first released image of HRSC recorded in 2004.

Data Processing: Decompression, calibration and projection of the raw image data is performed at the Institute of Planetary Research of the German Aerospace Center in Berlin-Adlershof. This level 2-4 data is then processed to higher-level products by the Planetary Sciences and Remote Sensing Team at Freie Universität Berlin (FU Berlin). Here, the camera data from the various channels (stereo, color, nadir) is combined to produce color images, anaglyphs, digital terrain models, 3D perspectives and movies of the Martian surface and Martian moons. ESA, DLR and FU Berlin are publishing these HRSC products online on a regular basis since 2004 [1,2,3].

Achievements after five Years: After five years in orbit HRSC has captured nearly half of the surface of Mars in high resolution (<20 m/px), color, and stereo.

For the first time, a comprehensive set of digital terrain models was released through ESA's Planetary Science Archive [4] and NASA's Planetary Data System [5]. Digital terrain model mosaics of Olympus Mons and Valles Marineris [6,7] were prepared by FU Berlin as a special release to demonstrate the outstanding benefit of the camera to record data in three dimensions. Also in 2008, the first simulated flights were produced at FU Berlin, featuring the Hebes Chasma canyon, the Mawrth Vallis outflow channel, and the impact crater Nicholson.

Within the first five years of observations, HRSC imaged the Martian moon Phobos several times. In observing Phobos, Mars Express benefits from its highly elliptical orbit which takes it from a closest Mars approach of 270 km above the surface up to a maximum of 10 000 km distance, crossing the 9 000 km orbit of the moon Phobos.

Achievements after ten Years: After ten years in orbit, HRSC has mapped about two-thirds of the surface of Mars with a resolution <20 m/px.

In addition to numerous color and digital terrain model mosaics already released (e.g., Dao and Niger Valles region, Valles Marineris, Elysium), the up-to-date largest color mosaic consisting of 67 single image strips was produced and color-adjusted at FU Berlin in 2013. It shows an impressive outflow channel system on Mars, the 3000 km Kasei Valles, which was flooded several times and also shaped by tectonic and volcanic activity.

Another highlight of color mosaic processing was the north polar ice cap of Mars, produced from 32 orbit strips in 2017. This is the first image mosaic of this region in high resolution showing details of the dark troughs and trenches (Fig. 2).

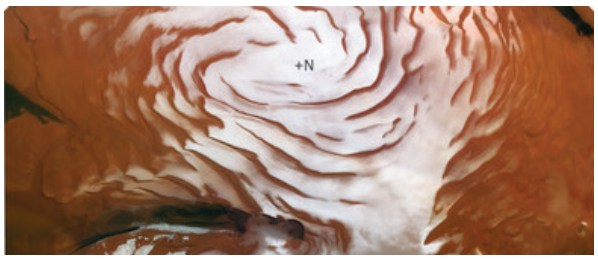

Figure 2: Detail of the north polar ice cap mosaic.

Fifteen Years and beyond: After fifteen years in orbit, HRSC has mapped about 80% of the surface of Mars at <20 m/px.

In January 2018, an image mosaic of Neukum Crater was released (Fig. 3), showing a 102 kilometer-wide impact crater in the southern highlands of Mars that was named after the German physicist and planetary scientist Prof. Gerhard Neukum by the International Astronomical Union (IAU) in 2017. Gerhard Neukum, who passed away in 2014, developed the HRSC during his time as a researcher at the DLR sites in Oberpfaffenhofen and Berlin-Adlershof between 1988 and 1996, and was the Principal Investigator (PI) for this camera experiment between 2003 and 2013.

Figure 3: HRSC mosaic of Neukum Crater on Mars.

In the future, the plan is to fill in successively the quadrangle scheme of 30 Mars charts (MC) with high resolution HRSC color mosaics and digital terrain models. The ambitious goal is a global dataset that can be used for Mars science research and also for public relations. The first part of the MC11 quadrangle was presented in 2015 at the European Geosciences Union General Assembly in Vienna. Currently, the MC11 Eastern and Western quadrangles are being reprocessed. In addition, MC13 Eastern quadrangle is being processed, since it covers the announced landing site for NASA's Mars 2020 Rover mission. High resolution color and topography mapping, which is the special strength of HRSC, is essential to assist in the selection of the appropriate landing sites for future missions.

References: [1] www.fu-berlin.de/planets – see Images&Animations. [2] https://www.dlr.de/marsexpress. [3] http://www.esa.int/Our_Activities/Space_Science/Mars_Express. [4] https://archives.esac.esa.int/psa. [5] http://pds-geosciences.wustl.edu. [6] Dumke, A. et al. (2008) 39th LPSC Abstract #1910. [7] Dumke, A. et al. (2009) 40th LPSC, Abstract #1985.

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