THE HIGH RESOLUTION STEREO CAMERA (HRSC) FOR MARS 96: RESULTS OF OUTDOOR TESTS;
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Introduction. The High Resolution Stereo Camera (HRSC) is one of the principal orbiter payload instruments for the Russian Mars 96 Mission to be launched in November this year. The pushbroom scanner is equipped with a single 175 mm lens and 9 linear CCD arrays (5 panchromatic and 4 narrow-band color filters) mounted in parallel providing nadir, forward, and backward looking viewing conditions for each line, respectively. In orbit, images will be acquired line by line as the spacecraft moves. The goal is to obtain large-scale high-resolution (10- 15m/pixel) multispectral stereo images at different phase angles. In spring 1995, the flight hard-ware was tested at the prime manufacturer's facility near Lake Constance (Germany) in order to verify the geometric and radiometric performance of the camera as well as the software developed for HRSC ground data processing. It was demonstrated that instrument and processing software met or exceeded their design goals.

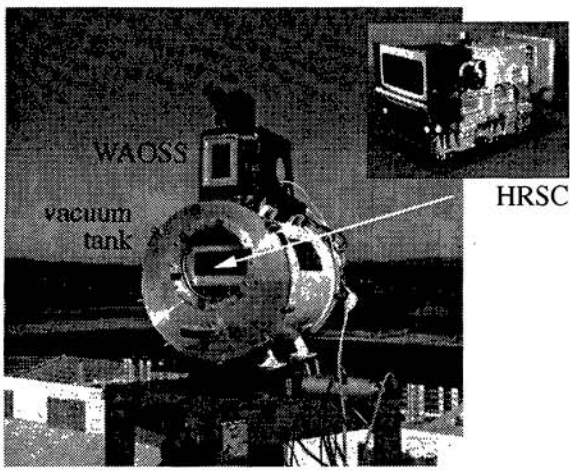

Figure 1: Configuration of the HRSC during outdoor tests. HRSC is mounted in a thermal vacuum tank. The Wide Angle Optoelectronic Stereo Scanner (WAOSS; also developed by DLR) is mounted on top of the tank.

Experiment Set-up. In order to mimic flight conditions, the camera was mounted on a slowly rotating table in a way that the line sensors were aligned perpendicular to the horizon (see Fig. 1). The camera was rotated around azimuth angles from 45° to ≥ 90°with a scan rate of the camera and the rotation rate of the table selected to be similar to the viewing conditions expected in Mars orbit. The experiment produced about 50 panoramic views with maximum sizes of up to 70,000 lines, each line containing up to 5,000 pixels. High rate DCT data compression was applied during imaging with compression ratios of up to 40 depending on the images, the selected quality factor, and the selected code tables. Typically, compression ratios are higher for the stereo channels and lower for the color channels to retain optimum radiometric accuracy. Images have been obtained from two camera locations about 20km apart to gather stereo data. Figure 2 shows a typical example of an image taken during these tests, covering a large part of Lake Constance and the Swiss Alps. The images obtained by the single channels are all arranged so that identical objects observed by different channels appear vertically aligned.

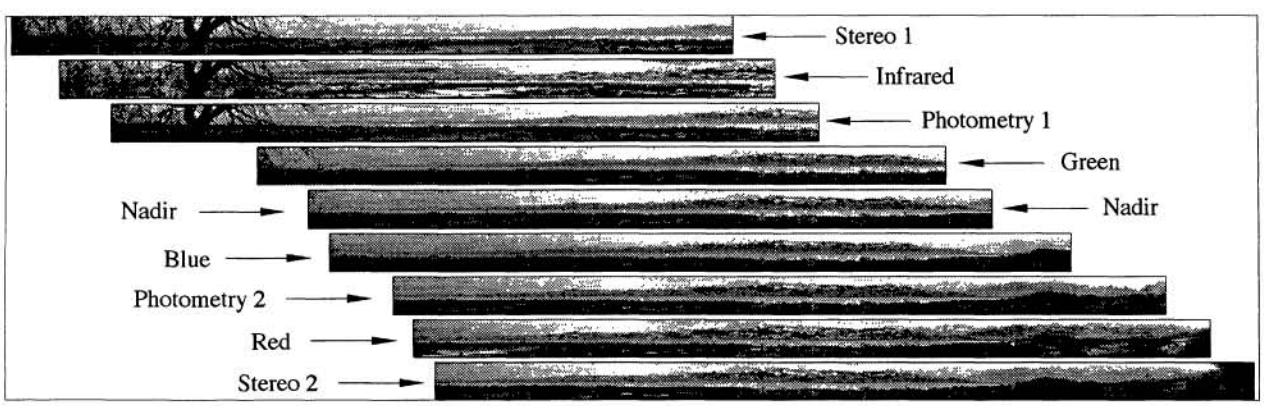

Figure 2: Example of HRSC image sequence involving all 9 channels -
- rotated clockwise by 90°(1st line = right edge of image)
- all channels resampled to a common macropixel format (nadir: 44,712 lines x 2,448 samples)
- compression ratios between 8.05 (nadir) and 15.4 (red)

Results. The data evaluation focused on three main tasks. Large numbers of tiepoints were collected in the images of the different sensors. With these data, a adjustment was carried out to determine alignment offsets between the rotational axis of the table to the vertical axis and between the camera coordinate system and the rotational axis. As an additional result of this adjustment, we obtained the ground coordinates of the tiepoints in the terrain.

Automatic digital image matching between single channels was used to measure the relative pixel positions of the CCD lines as derived previously during the geometric calibration of the camera in the laboratory. Matched pixel positions were compared with the nominal scan rate of the camera, the turn rate of the table, the angular separation of control points in the terrain, and the nominal angular separation of pixels in different channels in order to verify the internal consistency between the different camera commanding parameters and the obtained images. This end-to-end test verified correct pixel positions to great accuracy. Typically, the difference between the pixel positions as expected from the geometric calibration and the observed pixel positions in the images are less than 2-3 pixels.

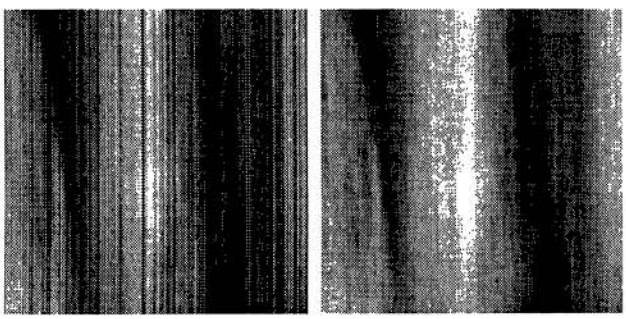

Figure 3: Detail of HRSC test image showing cloudy skies (200 x 200 pixel). The effects of the flat-field correction are clearly visible comparing both images (*left:* before correction, *right:* after correction; both images strongly contrast enhanced: Note that brightness differences between single vertical stripes is only 1-2 DN's).

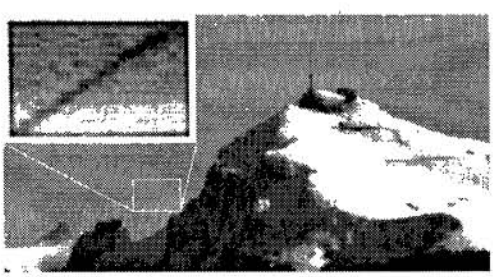

Figure 5: The visibility of the cables of a cable car at a distance of about 40km demonstrates the excellent radiometric and geometric properties of HRSC (size of large image: 416 x 208 pixel). The 8x8 pixel blocks in the small detail to the upper left are effects of the DCT data compression employed by the HRSC experiment.

Radiometric accuracy is a significant requirement for a spectrophotometric analysis of the Martian surface. To verify the radiometric performance of HRSC, the images were flat-field corrected (Fig. 3) and DN values of identical objects obtained by the panchromatic channels were compared. This indicated that brightnesses in different channels could be reproduced with very high accuracy (see Fig. 4 and 5).

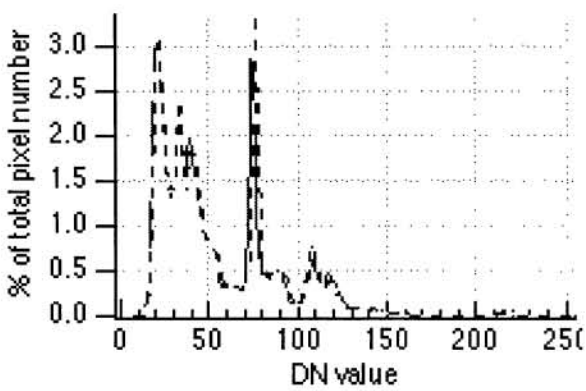

Figure 4: Comparison of histograms of identical image scenes obtained by the two photometric channels (see Figure 2). No significant variation between the histograms can be observed in either the dark or the bright region of the histogram range.