CONTRIBUTION OF HIGH RESOLUTION STEREO CAMERA (HRSC) DATA ANALYSIS FOR LANDING SITE SELECTION ON MARS. K. Gwinner[1], E. Hauber[1], G. Neukum[2], R. Jaumann[1], F. Scholten[1], J. Oberst[1], [1]Institute of Planetary Research, German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany (Klaus.Gwinner@dlr.de); [2]Institute of Geosciences, Free University, Berlin, Germany

Introduction: The High Resolution Stereo Camera (HRSC) [1] onboard ESA`s Mars Express (MEX) mission is a multiple line scanner which acquires 5 stereo channels and 4 colors. HRSC data are unique since a single image sequence covers very large areas (typically in the order of 10^4 km^2) at high image resolution (Tab. 1) while providing also stereo information. HRSC stereophotogrammetric data products include high-resolution digital terrain models (DTM) and map-projected orthoimages [2]. They have proven very useful as base maps for planning and scientific mapping tasks. Accurate georeferencing makes their combination with other spatial datasets straightforward.

In the site selection process for Mars landing missions, quantitative 3D information on the surface topography, and particularly information on local surface slopes, is very important [3,4]. Since the swath width of HRSC is ~60 km, the entire size of, e.g., a Mars Science Laboratory (MSL) landing site ellipse (20 km diameter) can be covered by one HRSC scene. We demonstrate the properties of HRSC DTM and slope data for one of the proposed MSL landing sites, and discuss results obtained from preliminary stereo analysis for most of the presently proposed MSL landing site candidates (http://marsoweb.nas.nasa.gov/landingsites).

Table 1. Comparison between HRSC and other imaging instruments with high spatial resolution.

Instrument	Spatial resolution	Swath width
HRSC (at periapsis)	11 m/pixel	57 km
MOC	~few meters/px (*cPROTO* <1m/px)	typically 3 km
THEMIS-VIS	19 m/px or 38 m/px	20 km
(THEMIS-IR)	~100 m/px	32 km
MRO HiRISE	>0.3 m/px	>6 km (red) >1.2 km (b/g/NIR)
MRO Context Imager	6-8 m/px	40 km
CRISM	~18 m/px	~20 km

Topography and Slope Data: The biggest asset that HRSC provides to landing site selection is the stereo capability [5]. The resolution of the stereo channels is up to 11 m/pixel, while derived DTM have a grid spacing of up to 50 m. The 3D point precison achieved through stereo matching and forward intersection was found to be better than the best ground resolution within a stereo dataset on average, also in the (typical) case where only one stereo channel has been operated at the highest resolution [5]. In comparison, the distance between single Mars Orbiter Laser Altimeter (MOLA) shots, which have very high vertical accuracy, is 330 m along track and up to several kilometres across track. MOLA height information is used to further improve the accuracy of the DTM by adjustment of orbit and pointing data [6]. HRSC DTM provide very good information about slopes over long (>0.5 km) baselengths, and will also be useful to assess slopes over intermediate (~50 m) baselengths.

Candor Chasma MSL Candidate Landing Site: A shaded 50 m/pixel gridded HRSC DTM of this site is shown in Fig. 1, together with the corresponding part of the gridded MOLA 463 m DTM. Image resolution is about 12 m for one of the HRSC stereo channels (nadir looking) and 24 m for the remaining four channels. DTM processing has been performed using the adaptive approach described by [5]. As an example, stereo matching was successful in this case for 73 % of all points on a search grid of about 4 times the best ground resolution (point density: 320 3D points /km^2). Frequently, matching is also possible at higher resolution, which further increases point density. Slope calculation using a First Derivative of Gaussian operator [7] is theoretically feasible up to a baselength close to the DTM grid spacing; in order to improve slope accuracy, it may be preferable to use a baselength of 2-4 times the grid spacing.

HRSC coverage for the MSL Candidate Landing Sites: At the time of writing (January 2007), almost all proposed MSL candidate landing sites have been covered by at least one set of HRSC stereo imagery. Data quality is variable for the different sites (e.g. image ground resolutions between 12 m and 75 m). Since only a small number of the corresponding datasets have been fully processed thus far, we estimated expected DTM resolutions from the precision and density of 3D points determined at different matching resolutions in preliminary stereo matching tests. The expected DTM resolutions for the sites range between 50 m and 175 m, where ~20 % of the image sequences are expected to yield DTM at grid spacings of 50 m and more than 60 % at grid spacings of 75 m or better. DTM accuracy will be assessed in more detail after the image sequences have been fully processed. Note that the preliminary assessment refers to complete image sequences, so the final DTM quality at the exact places of interest may turn out to be better or less good due to local conditions (e.g. atmospheric haze).

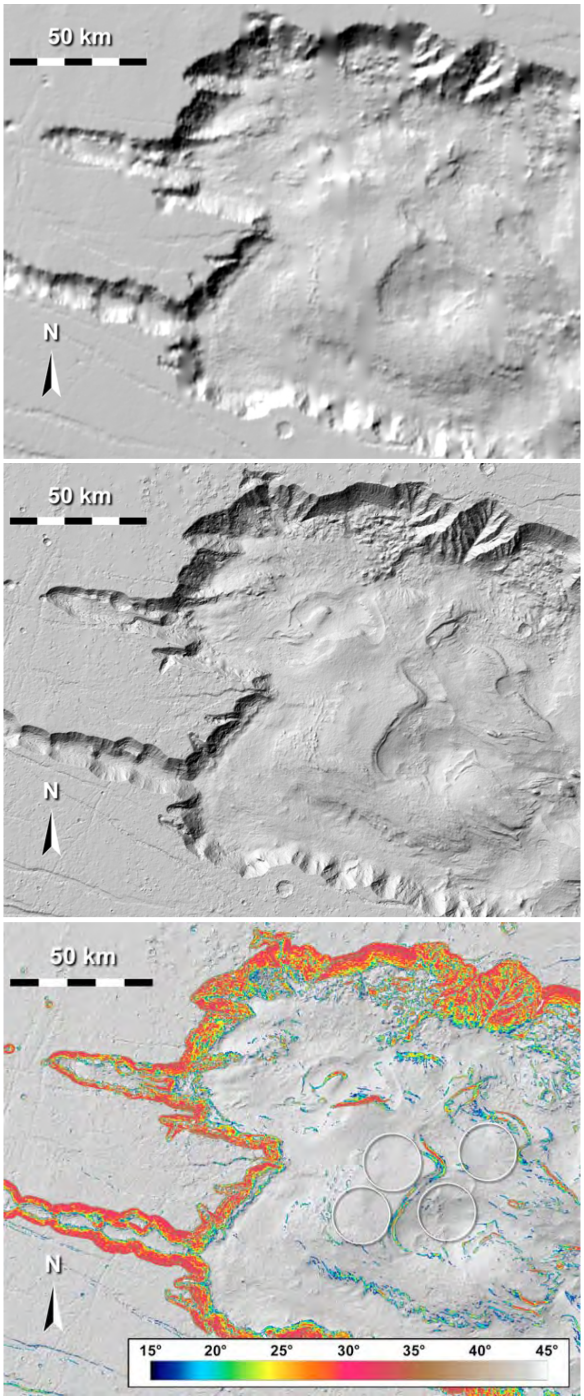

Figure 1. MSL candidate landing site West Candor Chasma, Mars. Top to bottom: shaded views of MOLA DTM, HRSC 50 m DTM, and HRSC DTM with color-coded slope angle. Circles indicate admissible landing sites according to the constraint of <15° slopes on a baselength of 200 m.

Outlook: We conclude that the existing coverage of the proposed MSL landing sites by HRSC stereo imagery can provide useful contributions to the selection process for many of the sites. The ongoing acquisition of HRSC data should help to improve the situation further. Since DLR is currently starting the systematic generation of high-resolution DTM for the complete HRSC data set, preparations for future landing missions on Mars may hopefully benefit from an improved topographic dataset for the entire surface of the planet.

References: [1] Neukum, G., et al., ESA SP-1240, 17-35, 2004. [2] Scholten, F., et al., *PE&RS* **71**(10), 1143-1152, 2005. [3] Vago, J., et al., ESA Bull. **126**, 16-23, 2006. [4] Golombek, M., et al., LPSC XXXVII, #2172, 2006. [5] Gwinner, K., et al., *PFG* **5**, 387-394, 2005. [6] Spiegel, M., et al., LPSC XXXVI, #1761, 2005. [7] Gwinner, K., Albertz, J., 20. EARSeL, ISBN 9058091872, 227-233, 2000.