TARGET SELECTION AND IMAGE PLANNING FOR THE HIGH RESOLUTION STEREO CAMERA (HRSC) ON THE ESA MARS EXPRESS MISSION – AND A TARGET DATABASE FOR MARS EXPLORATION.
E. Hauber[1] , G. Neukum[2], J. Korteniemi[1], Th. Roatsch[1], K.-D. Matz[1], R. Jaumann[1], R. Pischel[1], H. Hoffmann[1], and the HRSC Target Selection Team[‡], [1]DLR-Institute of Space Sensor Technology and Planetary Exploration, Rutherfordstr. 2, D-12489 Berlin, Germany; Ernst.Hauber@dlr.de, [2]Institute of Geosciences, FU Berlin, Malteserstr. 74-100, D-.12249 Berlin, Germany, gneukum@zedat.fu-berlin.de; [‡]*The HRSC Target Selection Team:* Alexander Basilevsky, Ruslan Kuzmin, Vernadsky Institute, Moscow (Russia); Michael Carr, USGS, Menlo Park (USA); Philippe Masson, Francois Costard, Nicolas Mangold, Université Paris-Sud, Orsay (France); Ronald Greeley, David Nelson, Arizona State University, Tempe (USA); James Head, Harald Hiesinger, Brown University, Providence (USA); Boris Ivanov, Institute for Dynamics of Geospheres, Moscow (Russia); Ralf Jaumann, Jürgen Oberst, Harald Hoffmann, Julia Lanz, Stephan van Gasselt, Dennis Reiss, Thomas Roatsch, Klaus-Dieter Matz, Rene Laufer, DLR, Berlin (Germany); Peter Kronberg, Technische Universität Clausthal, Clausthal-Zellerfeld (Germany); Thomas McCord, University of Hawaii, Honolulu (USA); John Murray, Open University, Milton Keynes (UK); Gian-Gabriele Ori, Università d'Annunzio, Pescara (Italy); Martin Pätzold, Universität zu Köln, Köln (Germany); Jouko Raitala, University of Oulu, Oulu (Finland); Tilman Spohn, West-fälische Wilhelms-Universität, Münster (Germany); Steven Squyres, Robert Sullivan, Cornell University, Ithaca (USA).

Introduction: The High Resolution Stereo Camera (HRSC) [1,2] onboard the European ESA Mars Express (MEX) mission [3,4] will map > 50% of the Martian surface in stereo and colour with a resolution of ≤15 m/pixel. In order to optimise the scientific return of the instrument, the preparation of a detailed list of surface targets and their specific scientific interest together with ancillary information is mandatory. We describe the organisation of the list of >1500 individual targets, the parameters specified for each target, and how the list will be used in operations planning. Finally, we outline possible further applications of the list for upcoming Mars missions like the Mars Reconnaissance Orbiter.

Target Selection: In order to facilitate effective operations planning and to maximise the scientific return of the HRSC/SRC instrument by fully exploiting its unique capabilities, we prepared a global list of geologic targets to be imaged during the MEX mission. The target list is organized as a spreadsheet, each line of which represents a single target. Several groups of parameters (i.e., spreadsheet columns) are specified for each target (i.e., line). The parameters and their meanings are defined in Tab. 1 (on page 3). The list, including the separate documents for the scientific rationale,the lessons learned from MGS, and the target image maps, is available to the HRSC Team via a protected website on the internet.

At the time of writing (April 2003, ~1 month before launch), more than 1500 targets have been specified. The original list has been compiled on a quadrangle-by-quadrangle basis. Each of the 30 cartographic quadrangles covering the Martian surface according to the mapping scheme of the U.S. Geologic Survey was assigned to an individual scientist. Since different individuals worked on different quadrangles, there is a bias towards specific processes in some quadrangles, depending on the scientific expertise of the workers. To avoid such inhomogeneities in the final list, we will revise the complete list with a process-based approach. Scientists with a profound background with respect to specific processes, e.g., fluvial processes, will check all targets classified as fluvial, and will approve or reject them, or add new ones.

In separate documents, the scientific rationale for imaging each target is comprehensively specified. Important findings of the MGS mission related to the targets are also described separately. In order to estimate future data rates, we determine the areal size of each target and calculate the number of standard images and the data volume required to obtain an image mosaic of the entire target.

Target maps: In addition to the table, each target is graphically marked on a global, Viking-based image map (i.e., the MDIM-2 imaging model of the U.S.Geol.Survey), allowing for quick visual inspection and further use in planning activities (see below). We prepared separate image base maps for each quadrangle and marked each target in the map. To allow for better visualisation and later processing, the targets were marked in 16 different "layers" of the map, each layer coresponding to one of the 16 HRSC macropixel-formats (MPF) used for standard imaging. Target maps are available in Photoshop and JPEG format.

Planning Software: The target maps will be the standard input for imaging plannning. As a flexible and user-friendly planning tool we developed the interactive program Mars Express Science Opportunity Analyzer (MEXSOA) within the Interactive Data Language (IDL®) environment. It allows to plot the targets, the spacecraft ground tracks, the orbit periapses, and the HRSC swath onto image maps. Information about the planets, ephemerides, the orbit of the spacecraft, and the instrument are provided to the program in the form of SPICE kernels (**S**pacecraft, **P**lanet, **I**nstrument, **C**-matrix, **E**vent; e.g., [5].

An operator will check which targets are crossed by (or near) the ground track of the spacecraft. It is straightforward, then, to select the desired imaging area. The corresponding start and end times of imaging will be stored together with additional parameters (e.g., imaging mode, illumination conditions) for each orbit. The stored data will then be converted to commanding sequences.

The footprints of acquired images together with ancillary data (e.g., exposure times, image quality) will be stored in a database. In the ongoing mission, the interface between MEXSOA and the database will provide necessary information in order to optimise imaging parameters by learning from previous experience.

Future: The list of targets will be the basis of long-term and short-term science planning for the HRSC instrument. It will be updated continuously, according to new results from the ongoing MGS and 2001 Mars Odyssey missions. Due to the considerable lifetime of Mars Express (nominal plus extended mission: two Martian years or four Earth years) we will also extend or modify the target list in response to incoming MEX data. The list may also be of interest for future orbiter missions like the Mars Reconnaissance Orbiter to be launched in 2005. Besides its original intention to assist in mission planning, it might also be of general interest in ars exploration, e.g., for selecting regions which are particularly interesting with respect to certain processes like volcanism, etc.

References: [1] Neukum G. et al. (1996) The experiments HRSC and WAOSS on the Russian Mars 94/96 missions, *Acta Astronautica*, 38, 713-720. [2] Neukum G. and the HRSC Co-Investigator and Experiment Team (2003) HRSC: The High Resolution Stereo Camera of Mars Express, *ESA SP-1240*, 18 pages, in press. [3] Schmidt R. et al. (1999) ESA´s Mars Express Mission – Europe on Its Way to Mars, *ESA Bulletin*, 98, 56-66, 1999. [4] Chicarro A.F. (1999) Mars Express: Mission Scenario and Objectives, in: *Laboratory Astrophysics and Space Research*, edited by P. Ehrenfreund et al., Astrophysics and Space Science Library, Kluwer Academic Publishers, Dordrecht, 523-527. [5] Roatsch T. et al. (2001) SPICE Usage on the Mars Express Orbiter, *Geophys. Res. Abstracts*, 3, 7202.

Table 1: Parameters specified for each target.

Parameter name	**Example**	**Explanation**
Number	*MC-23_005*	Map quadrangle (e.g., MC-23) and running number (e.g., 005)
Name	*"small valley"*	Short name or description of target
Class (15 columns) V volcanic T tectonic I impact F fluvial G glacial or polar L layering Pf permafrost Eb exobiologic Eo eolian Mw mass wasting La lacustrine Ls landing site Te technical O other Ts terrain sampling	*"x" or " "*	One or several entries possible for each target: What is the geologic process which is of interest for this target? *Notes:* - Although we currently have no evidence for past or present life on Mars, a number of surface features were probably formed by aqueous processes. Several of them (class "exobiologic") might be prime targets in the search for extraterrestrial life. - The class "terrain sampling" was introduced to include those targets which we will image in order to make sure that any type of terrain is covered by HRSC imagery.
Uniqueness	*yes or no*	Is the target unique or not unique within a quadrangle?
Location (4 columns) min latitude max latitude min longitude max longitude	 *5.0* *8.0* *122.0* *124.0*	Geographical coordinates of target boundaries
Mosaic	*6*	Number of HRSC standard images required to cover the target
HRSC macropixel format	*1,2,3,…15,16*	16 possible HRSC imaging modes (see Tab. 2 for details)
Priority (5 columns) nadir stereo photometry colour SRC	*high* *medium* *low*	Priority for good resolution of this/these CCD line(s) and the SRC channel
SRC imaging	*spot, raster, or contiguous*	Mode of SRC imaging (see text for details)
Preferred local time	*morning, noon, evening*	Should the target be imaged during a specific time of the (Martian) day? (e.g., dust devils occur in the afternoon, morning fogs)
Preferred illumination	*low, medium, high*	Elevation of sun above horizon
Preferred local season	*spring, summer, fall, winter*	Season in which the target should be imaged (e.g., imaging of some high latitude targets without coverage by seasonal CO_2 cap)
Multitemporal coverage	*yes or no*	Variable features (e.g., polar caps, dust deposits) might be imaged several times (e.g., summer/winter, before/after dust storms)
Scientific rationale	*separate document*	Why is it important to image this target?
Lessons learned from MGS	*separate document*	What did we learn from the MGS mission about this target?
Geology	*Hr, Npl_1, Ael_1,…*	Target geology
Viking coverage	*(32), 60-100, r,g,b*	(number of Viking Orbiter images), resolution range, color filters
MOC coverage	*good, medium, or sparse*	Availability of very high-resolution images from the Mars Orbiter Camera (MOC)