Possible Martian Landing Sites to be Considered for Future European Exploration Missions P. Martin and M. Castillo, ESA - European Space and Astronomy Centre, PO Box 78, E-28691 Villanueva de la Cañada (Madrid), Spain; patrick.martin@sciops.esa.int.

Introduction: The selection of landing sites for Mars missions typically follows a roadmap such as represented in Figure 1, implying a required number of iterations that must reconciliate landing site engineering constraints with the scientifically-driven selection process and lead to the identification of prime and backup landing sites. Pinpointing with precision, revising or updating a number of landing sites for future Mars missions is now possible thanks to the wealth of scientific data and high-resolution mapping products resulting from recent and ongoing successful Mars orbiter missions. The main goal of this work is to consolidate available mapping products (e.g., geological, hyperspectral and compositional) in order to support the selection process of candidate landing sites for future European Mars missions.

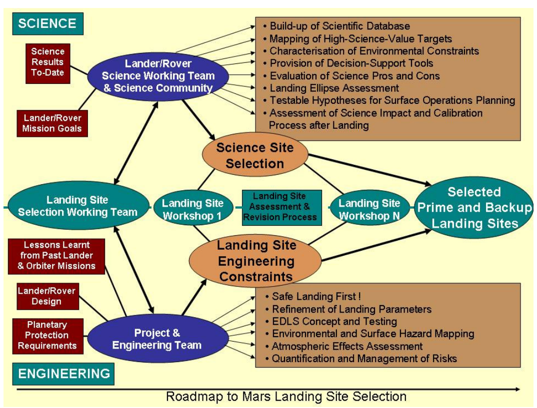

Figure 1. Mars landing site selection roadmap.

Landing viability assessment: A modelling method oriented toward the risk evaluation of a defined EDL system configuration was elaborated to support the selection process of candidate landing sites on Mars [1]. Different effects potentially influencing landing are considered, as well as lessons learned from past landing experiences, in order to characterize the risk of landing in various locations on the planet. Parameters such as altimetry, critical slopes, thermal inertia, dust index and terrain roughness are used for estimating the risks to safe parachute and airbag operations and to lander/rover deployment and mobility once on the surface. The full iterative process as described in [1] leads to the landing risk map displayed in Figure 2.

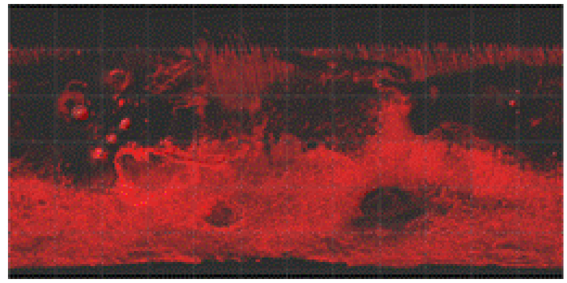

Figure 2: Landing risk map. Red indicates the areas exhibiting higher landing risk.

The landing viability is then estimated adding environmental constraints to the landing risk (e.g., for safe solar power supply). See Figure 3 below.

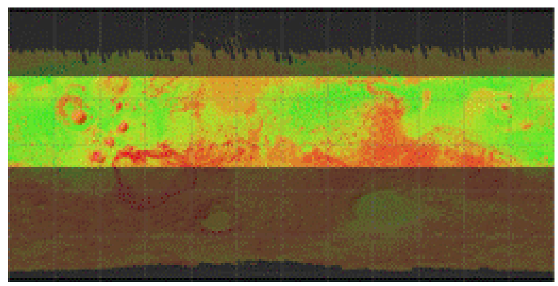

Figure 3: Landing viability map. Green: high; Yellow: moderate; Red: low.

Science interest assessment: To support the identification of suitable sites, various mapping products were consolidated, and areas of Mars identified in the recent scientific literature [e.g., 2] as primary targets for landing were taken into account. The results of the consolidation process led to the map of Figure 4, which can be used as information contributing to the scientific part of the site selection process (science constraint).

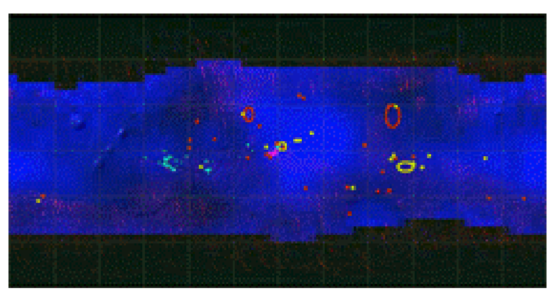

Figure 4: Science interest map, which in this example indicates the presence of hydrated minerals, hematite, and H_2O concentration.

Mission targeting assessment: The selection of a landing target is a compromise between the landing engineering feasibility and the science interest. Finding the locations where both types of constraints are in agreement constitutes an optimization problem to be solved. In Figure 5 below the landing viability map and the science interest map are combined to represent suitable landing sites.

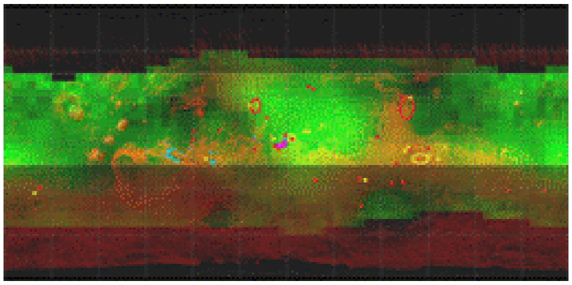

Figure 5: Mission targeting map. Green: good targeting suitability; Yellow: possible targeting; Red: landing zones to be avoided for targeting.

Possible landing sites: Possible landing regions on Mars resulting from this investigation were categorised into two classes, depending on the level of risk assessed for the landing, as summarized below:

- Low-risk regions: Amazonis Planitia, Utopia Planitia, and Elysium Planitia. One of their potential drawbacks is that most areas of these regions exhibit a relatively high dust index [3] which could be detrimental to the scientific interest of the in-situ mission.
- Moderate-risk regions:
    - Syrtis Major / Nili Fossae, where phyllosilicates and hydrated minerals can be found based on evidence from orbit (Mars Express/OMEGA [2]).
    - Isidis Planitia, in particular because this region presents a low vertical roughness [4].
    - Chryse/Acidalia Planitia, where phyllosilicates, hydrated minerals and sulfates can be found [2].
    - The region that spans the terrains from Sinus Meridiani to Syrtis Major, between 15ºS and 45ºN. This region exhibits a high dust index, and is represented by rougher, heavily cratered terrains in many areas.

Within these regions, a more detailed identification of landing sites has been started by refining the study (top-down approach) using higher-resolution geological and compositional maps coupled with other parameters and constraints. Preliminary results lead to the following, non-exhaustive list of suitable candidate landing sites.

- Nilo Syrtis Mensae (moderate risk & H_2O)
- Nili Fossae region (moderate risk, high H_2O concentration, hydrated minerals)
- Western Syrtis Major (moderate risk, moderate H_2O concentration, phyllosilicates)
- Ochus and Mawrth Vallis (moderate risk, moderate H_2O concentration, phyllosilicates)
- Gale crater (moderate risk, high H_2O concentration, hydrated minerals)
- Schiaparelli and Gusev Craters (low risk, high H_2O)
- Memnonia Sulci (low risk, high H_2O concentration)
- North Meridiani Planum (low risk, high H_20 concentration, hydrated minerals)
- Gangis Chasma (moderate risk, high H_2O, sulfates)
- Melas Chasma (moderate risk, high H_2O, sulfates)
- North Terra Arabia (low risk, high H_2O concentration, hydrated minerals)
- Trouvelot crater (low risk, high H_2O concentration, phyllosilicates)

Conclusions: The identified areas may be considered as a first set of study zones as part of the science-driven and success-oriented selection process for future Mars missions such as Exomars. The targeting assessment process shall be improved as follows in order to be fully operational:

- Automatic parts of the process shall be improved by adding optimization algorithms
- The processed spatial resolution shall be increased from medium to high
- Once a candidate site is selected, the process shall be applicable to very high resolution data sets
- Other parameters shall be considered, such as atmospheric and aeolian activity, power/comms systems requirements, illumination and temperature requirements
- Other studies shall be taken into account [5]

References:

[1] Castillo, M. and Martin, P. (2008) 39th LPSC, Abstract #1605, this issue.
[2] Bibring, J. –P. et al. (2006) Science 312.
[3] Ruff and Christensen (2002), JGR 107.
[4] Kreslavsky and Head (2002), GRL 29.
[5] Koenders, R. (2007) EMSEC Conf., ESTEC