Proposed Checklist for ExoMars 2020 Site Proposers

ExoMars Landing Site Selection Working Group

LSSWG#4

Draft V12, 17 February 2017

The proposers' answers to these questions should be in the form of text and diagrams. PowerPoint slides are acceptable.

Proposers' responses should be limited to no more than a total of 20 pages (including figures).

Please note that sharing of data between site proposal teams is strongly encouraged, as well as discussion and evaluation of the various sites' properties with the goal to assemble the most complete body of information possible.

We recognise the limited time available and we appreciate the efforts of the proposing teams in addressing this request as effectively and concisely as possible. To support proposing teams we are setting up ExoMars Landing Site Study pages, which will be populated with information and data that may aid in assessment of candidate sites. To access these pages self-registration is required.

To register please visit:

https://www.cosmos.esa.int/web/exomars/2020-ls-study-registration

Once registered you may access the pages at:

https://www.cosmos.esa.int/web/exomars/2020-ls-study-resources

The LSSWG would appreciate the chance to provide their feedback to the proposing teams prior to the workshop. The proposing teams are requested to please send their reports by 20 March 2017.

1. INTERESTING SCIENCE TARGETS

Position of ellipses

The landing ellipse dimensions to be used should be:

- For Aram 100 km major axis x 19 km minor axis
- For Oxia and Mawrth 120 km major axis x 19 km minor axis

Do you use different centres for the various ellipse azimuths?

- If not, please confirm the centres' aerocentric latitude and longitude.
- If yes, can you provide the centres' aerocentric latitude and longitude coordinates for at least the ellipses having the smaller and larger azimuths?

Landing Ellipse Azimuth Range (note the update for Aram Dorsum since LSSW#3):

Aram Dorsum	93˚–116˚
Oxia Planum	100˚–125˚
Mawrth Vallis	102˚–129˚

Arc Files attached?

Yes/No?

Figure of probability within ellipses

Please superimpose the supplied shapes with figures of probability (currently based on a bidirectional Gaussian distribution, but with intention to be computed on the basis of EDL Montecarlo simulation shots). Please make sure that the ellipse centre, and corresponding landing probability distribution model, is positioned to simultaneously maximise rover access to scientifically interesting targets and minimise potential terrain hazards.

Identification of high priority targets, regions, and formations

Proposers should summarise the palaeoenvironments and rationale for habitability and presence of ancient life at each of the candidate sites. Proposers should make reference to CRISM, OMEGA and geomorphology in this section.

Please include in your answer evidence or likelihood of bodies of standing water, hydrothermal, diagenetic, palaeosol or other processes of significance to the assessment of the site's habitability, and its catchment region (where appropriate).

Until now we have tried to identify minerals associated with low-energy circulating water and ponded water, typically clays and salt evaporites, as possible "traps" or "preservation windows" for organic matter/microbes. It may be that other criteria may also be of interest for our rover's objectives. For example, in samples of ancient Earth, well-preserved and relatively abundant biosignatures are encountered in association with low-temperature (≤ 120°C) hydrothermal systems, either subaqueous or with contributions of silica-rich waters coming from a nearby system.

Besides addressing other potentially interesting ancient water-rock settings, we invite proposing teams to present any interpretations that shed light on the presence and nature of ancient hydrothermal environments, in the landing ellipse or any catchment area (where appropriate) particularly those that indicate low to moderate temperatures as associated with preserved terrestrial biosignatures.

Probability of reaching high priority targets

Please use the figures of probability (from LLSWG web page) in combination with your landing ellipse, geological maps, mineralogical and morphological information, to display the probability of being able to reach a high priority target after landing. Please assume a drive of 1 km, 3 km, and 5 km. Please consider the quality of the terrain you will need to negotiate and identify any potential "no-go" areas, and any safe areas that are interpreted to be inaccessible due to the distribution of hazards around them.

2. TERRAIN AND HAZARDS

Elevation

What percentage of the ellipse satisfies the present –2km MOLA maximum elevation constraint? Describe the variation of elevation over the ellipse

How were these data obtained (from MOLA or HRSC and interpolated or not)?

Slopes

For your ellipse(s), please report the percentage compliance at the scales 2–10 km, 330 m, 7 m, and 2 m. The table below provides a reminder of the requested limits at each scale.

Base-length	Slope Requirement	Rationale
2000 m	≤ 3°	To ensure slant and incidence compatible with radar.
330 m	≤ 8.6°	To ensure proper fuel consumption during powered descent.
7 m	≤ 12.5°	To ensure an adequate altitude error at touchdown.
2 m	≤ 15° (TBC)	To ensure stability at landing.

Though not required, results are also welcome regarding slope distribution at other baselines that may be more relevant to the scales of local geomorphologic features and rover traverses (e.g. high slopes at scales of several decameters, that are not captured by either 7 or 330 m maps, could still be relevant to rover performance).

Is there a strong variation in slopes over the ellipse? How were these values calculated (e.g. steepest neighbour, adirectional slope), using which data and which areas in the ellipses? Describe whether or not you think the slopes are representative over the entire ellipse.

Crater density and distribution

Describe crater densities over the landing ellipse. Are there strong variations in crater density in the ellipse? Is it due to the presence of secondary craters? Or to different geological units (with different age or different erosional properties)?

Albedo, Thermal inertia, Dust

With the new 2020 launch date ellipses, are there new values for the compliance with the original requirements? Requirements were to have a surface thermal inertia ≥ 150 J m^{-2} $s^{-0.5}$ K^{-1}, and albedo between 0.1 and 0.26.

Rock Abundance

Are you aware of any new results on rock abundance at your site and how do they compare to the manual counts done by the LSSWG (Fig. 1)?

				F_k (D) fit (%)		
Site	Total area (km²)	Number of features	Number of rocks (1.5≤D<2.25 m)	D ≥ 0 m	D ≥ 0.18 m	D ≥ 0.35 m
Aram	7.00	12951	1923	17.6	10.9	6.9
Oxia	5.00	2122	590	13.8	8.2	5.0
Mawrth	2.50	2713	242	12.2	7.1	4.2

Figure 1: [from Bridges et al. 2017] Cumulative areal percentage occupied by shadow-casting features manually counted in selected areas inside 3-sigma ellipses at ExoMars Rover candidate landing sites. Diameter is constrained 1.5 ≤ D ≤ 2.25 m, where the signal from float rocks is highest (Golombek et al., 2012).

Given that thermally-derived rock abundance can include float rocks, but also includes flat and sloping terrain, what is your interpretation of thermally-derived rock abundance at your site?

Other?

The LSSWG has led studies on loose deposits (TARs and flatbeds) and on rock abundance at the three candidate landing sites. The major results of the studies are summarised in Bridges et al. 2017 LPSC #2378, *Selection and Characterisation of the ExoMars 2020 Rover Landing Sites*. A summary table can be found hereafter, as well as a further note about loose soils based on a parallel study at U. Lyon. Please tell us if you agree or disagree with any point in these results, in particular with the distribution and density of TARs, sub-TAR scale bedforms, dust coverage, loose soil, or other aeolian features, highlighting any areas likely to pose problems for rover mobility.

Table 1. ExoMars Landing Site Characteristics

	Oxia Planum	Aram Dorsum	Mawrth Vallis
Lat, Long	**18.159°N, 335.666°E**	**7.869°N, 348.800°E**	**22.160°N, 342.050°E**
Azimuth Range	100-125°	93-116°	102-129°
Semi-Major Axis	60 km	50 km	60 km
Elevation	100% <-2 km -3.6 km to -2.66 km	≥ 93% <-2 km -2.57 km to -1.88 km	≥ 89% <-2 km -3.02 km to -1.46 km
Slopes	**% Compliant**	**% Compliant**	**% Compliant**
2-10 km	> 99	>99	>98
330 m	98	99	98
7 m	94	95	88
2 m	95	95	92
Thermal Inertia	100% ≥150 J m^{-2} $s^{-0.5}$ K^{-1}	99% ≥150 J m^{-2} $s^{-0.5}$ K^{-1}	99.5% ≥150 J m^{-2} $s^{-0.5}$ K^{-1}
Albedo	100% 0.1 - 0.26	100% 0.1 - 0.26	100% 0.1 - 0.26
TAR Coverage	4.1 %	1.4 %	20.3 %
Rock Abundance (d≥18, 35 cm)	8.2, 5%	10.9, 6.9%	7.1, 4.2%

Loose soil estimates for discussion (see D. Loizeau presentation on LSSWG website, and LPSC abstract Loizeau et al. 2017 LPSC #1927):

These are based on preliminary HiRISE mapping at ~0.1% coverage of the ellipses, so the percentage coverage are possibly biased. Thickness estimates are very difficult and only made via the observation of filled or partially filled structures. We have differentiated thin dust/sand deposits, perhaps as thin as millimetres, and up to several cm, from thick dust/sand deposits (TARs, dunes and flatbeds) that are likely to be at least a few tens of cm in thickness.

According to this study:

1. *It has been estimated that the surface of Oxia Planum is covered roughly equally by bedrock, thin deposits and thick dust or sand deposits. The thick sand deposits are concentrated on the delta/fan area and on the valleys that cross the site in its eastern part.*

2. *The surface of Aram Dorsum has extensive thin dust deposits of varying thickness covering the major part of the surface of the site, with local thicker sand or dust deposits. The abundance of entirely dust-free bedrock abundance is uncertain and mainly concentrated on steep slopes.*

3. *The surface of Mawrth Vallis is largely covered with thin and thick dust or sand deposits. A significant part is also occupied by bedrock. The remnants of the dark capping unit seem to produce the sand that feeds the sand bedforms.*