ExoMars

5th Landing Site Selection Workshop

Final Report

EXM-RM-REP-ESA-00010

		Date
Prepared	**LSSWG, J. L. Vago, D. Rodionov**	10 December 2018
Agreed		
Approved		

Leicester, 8–9 November 2018

FINAL REPORT

EXECUTIVE SUMMARY

On 8–9 November 2018, more than seventy international scientists, project, and industry engineers gathered at the National Space Centre, Leicester (UK), for the fifth ExoMars 2020 Landing Site Selection Workshop (LSSW#5).

The workshop was co-organised by ESA and IKI/Roscosmos with the support of the ExoMars 2020 Landing Site Selection Working Group (LSSWG). The goal of the meeting was to review and discuss the merits and challenges of the two remaining candidate landing locations—Mawrth Vallis and Oxia Planum—to formulate the final recommendation for the mission's landing site. The ExoMars project team requires this input to initiate final targeting and Entry, Descent, and Landing (EDL) optimisation work in time for a launch in July–August 2020.

Description of Activities

The morning of Day 1 started with a short introduction about the National Space Centre and its goals.

Thereafter, ESA/IKI described the workshop organisation (please see attached agenda in Annex 1). ESA/IKI explained that, following detailed science and engineering presentations, participants would be invited to express their preference by voting in writing. The voting results would constitute an important input to the LSSWG deliberations; however, ESA/IKI clarified that it was the LSSWG's responsibility to produce the final recommendation and that its science and engineering experts could have good reasons to deviate from the vote outcome.

This first introduction presentation also included information on potential ancient Mars biosignatures and on what organic molecules the mission could expect to encounter based on (1) the latest Curiosity rover findings and (2) signs of life glimpsed from early Earth formations. The ensuing discussion emphasised the importance of hydrothermal settings for supplying nutrients and boosting biomass production.

A second talk presented the project's state of advancement, addressing the various challenges that the team must successfully negotiate to deliver a well-tested spacecraft composite to Baikonur for launch in July–August 2020.

Next, a block of site-specific science presentations began with an overview about sedimentary clay deposits in the Circum-Chryse region—where both candidate landing sites are located. This was followed by site-dedicated talks, initially for Mawrth Vallis, and after lunch for Oxia Planum. The scientific presentations were organised in the following manner:

- Introduction to the landing site: Location and ellipses for the 2020 launch opportunity.
- Science diversity: Geological context, depositional history and age of the major units; mineral and morphological evidence for sustained, low-energy aqueous activity; biosignature preservation potential (unit deposition, water, burial and exhumation history); and types of high-priority scientific targets.
- Science accessibility: Distribution and accessibility of high-priority targets within the landing ellipse(s).
- Mission examples: Presentation of one or two examples of possible, ~3-km rover exploration missions to showcase the site's science variety and interest.

A discussion period allowed participants to ask questions to both of the site teams.

Thereafter, the Project (TAS-I, LAV, and ESA) presented the conclusions of the landing site certification work. The two sites were analysed in terms of (1) probability to accomplish a safe entry, descent, and landing (EDL) and robustness against possible problems during EDL, (2) compliance with engineering constraints, and (3) risks for rover egress and terrain mobility. This was followed by a landing safety summary presentation and a general discussion.

The afternoon of Day 1 came to a close with presentations encompassing both locations. The following topics were addressed: (1) Clay stratigraphy and erosion at the two sites: what can be accessed and where?; (2) Morphological analysis of both locations aiming to identify the extent of past liquid water catchment areas; and (3) Expected lithologies at Oxia and Mawrth based on Curiosity findings at Gale Crater. After more discussions, the evening concluded with a presentation by TAS-I about their plans for activities after ExoMars.

Day 2 began with a short presentation describing the voting process and summarising the main findings of the previous day. Next, followed a two-hour discussion period, which culminated with two short summary presentations, one dedicated to Oxia Planum and the other to Mawrth Vallis.

Based on the material presented at the workshop and on the results of the various discussions, the LSSWG requested participants to express their preference by stating in writing which site they considered more appropriate for the mission. Participants provided their inputs in folded, anonymous forms supplied by the LSSWG. As shown below, the ballots also requested additional information to help assess the participants' experience.

VOTE:

Please assign a priority (1=first, 2=second) to the two candidate landing sites:

☐ Oxia Planum ☐ Mawrth Vallis

Additional Information:

Please indicate with a cross as applicable:

☐ I am an ESWT member (PI or Co-PI of an instrument)
☐ I am a Rover instrument team member.
☐ I am a Surface Platform instrument team member.
☐ I am a Project team member (ESA/ROS/Industry).
☐ I have attended at least one other LSS workshop (MSL, Mars 2020, ExoMars, etc.).
☐ I have attended two or more other ExoMars LSS workshops.
☐ I understand the safety issues involved.
☐ I understand the science issues involved.

Voting Results

Seventy-one votes were cast. Their results were:

Site	All Votes
Oxia Planum	51 (72%)
Mawrth Vallis	20 (28%)

Based on the additional information requested, fourteen ExoMars Science Working Team (ESWT) members cast their vote—the ESWT groups the ExoMars instrument Principal Investigators (PIs) and (Co-PIs):

Site	ESWT Votes
Oxia Planum	9 (64%)
Mawrth Vallis	5 (36%)

The indications from Rover instrument team members were:

Site	Rover Votes
Oxia Planum	20 (67%)
Mawrth Vallis	10 (33%)

For Surface Platform investigators we obtained:

Site	Surface Platform Votes
Oxia Planum	3 (43%)
Mawrth Vallis	4 (57%)

The Project Team input was:

Site	Project Votes
Oxia Planum	12 (100%)
Mawrth Vallis	0 (0%)

A large proportion of the participants had experience from previous Mars landing site selection efforts. From the 71 voters, 53 had taken part on at least one other LSS workshop, and 42 on two or more ExoMars-specific workshops. When considering only their inputs, the respective outcomes were:

Site	At least one other LSSW
Oxia Planum	36 (68%)
Mawrth Vallis	17 (32%)

Site	Two or more Ex-oMars LSSW
Oxia Planum	27 (64%)
Mawrth Vallis	15 (36%)

Five people, presumably from the Project Team, did not tick the box “I understand the science issues involved.” One person failed to tick “I understand the safety issues involved.” When those votes are excluded from the count, the results are:

Site	Only if last two boxes ticked
Oxia Planum	45 (69%)
Mawrth Vallis	20 (34%)

In conclusion, taking into account the mission’s search-for-life science goals in conjunction with the EDL and rover trafficability possibilities, the majority of the participants opted for Oxia Planum.

LSSWG Recommendation

LSSW#5 Outcome

The participants to the 5th Landing Site Selection Workshop, present at the National Space Centre, Leicester (UK) on 8–9 November 2018, have reviewed the latest information regarding the two candidate landing sites, Mawrth Vallis and Oxia Planum.

The ExoMars 2020 Landing Site Selection Working Group (LSSWG) has been tasked with recommending the mission's landing site from among Mawrth Vallis and Oxia Planum. This input is required by the Project to perform final targeting and Entry, Descent, and Landing (EDL) optimisation work for a launch in July–August 2020.

1. The LSSWG thanks the two teams for the excellent sites proposed and for the impressive work performed to characterise and present them.

2. In the course of the workshop, the participants discussed and considered the two candidate sites. Both locations are regarded suitable to address the mission's search-for-life scientific objectives, and each has specific advantages and disadvantages. Oxia provides an additional margin of safety for EDL and for rover trafficability.

   Mawrth is assessed to be a scientifically unique site, but is considered less well-matched to the ExoMars mission's landing and roving capabilities.

3. Based on the participants' presentations, discussions, and voting the LSSWG recommends the following:

   Oxia Planum as the landing site for the 2020 launch opportunity.

4. The LSSWG strongly encourages the proposing teams to combine in the further analysis of the recommended landing site and bring to bear their considerable expertise for the benefit of ExoMars and its scientific return. This includes producing publications on the geology of Oxia Planum and its characteristics as a landing site.

5. The discoveries generated during this landing site selection process are essential to guide preparations for upcoming ExoMars rover science operations.

Next Steps

The ExoMars 2020 project team will proceed to initiate final targeting and Entry, Descent, and Landing (EDL) optimisation work. This work may involve additional analysis of the landing site. The LSSWG is willing to support this process as required, working in collaboration with site proposers, the agencies, and Industry.

ANNEX 1

5th LSS Workshop—AGENDA: 8–9 November 2018
Who: Mars Science Community, Project Team National Space Centre, Leicester (UK)

Thu 8 Nov 2018 Sol 1:

08.30 Arrival, name badges, refreshments in Boosters area

Introduction:

09:00	Welcome (10 min)	J. Vago/D. Rodionov/F. Spoto
09:10	National Space Centre and Leicester Space Park (10 min)	A. Ohja, G. Bourhilll
09:20	Workshop objective and organisation (20 min) Intro on biosignatures and ExoMars	J. Vago
09:40	Overall mission status (20 min)	ESA/ROS (F. Spoto)

Science Presentations

10:00 Introduction, Circum-Chryse presentation (15 min) J. Carter

10:15 Mawrth Vallis (90 min) Mawrth Team

Please organise your site presentations as follows:

- Site refresher: Where is the site (Context, HRSC/MOLA, CTX scale images); please show the site with superimposed landing probability model for your ellipse (GIS products available on LSSWG web page – see 'Resources' section).
- Science diversity: Provide your best interpretation of the regional geological history and describe deposition and alteration environment(s) at the site.
  - Site's search for life potential.
  - Identify high-priority scientific targets to search for traces of past life with an emphasis on possible basins and low-T hydrothermal settings: Describe their geological context, age, mineralogy, water setting, and potential for chemical biosignature preservation. Identify relevant soft sedimentary deposits that the rover could drill into. What can be learned from MSL observations that could be analogue to this site?
  - Discuss target distribution and variety within the ellipse.
- Accessibility: 1) Colour-code the landing 1-sigma ellipse based on the regions that are never more than 1000 m from a prime target (corresponding to 20 sols of 50 m/sol driving) 2) Do the same for those parts never more than 60 sols driving (2000 m) and 90 sols (~5000 m) away.
- Mission example: Assume you land at the ellipse centre ort close to it. Please present an example for a 3-km traverse mission that you could conduct. What are the chances of finding physical and chemical biosignatures? Where? How easy is it to move around?

11:45 Discussion (30 min) All

12:15 Lunch (75 min)

13:30 **Oxia Planum** (90 min) Oxia Team

Please see previous description to prepare presentation.

15:00 Discussion (30 min) All

Engineering Presentations

15:30 **Landing Site Certification Results** (60 min) Industry

- *Entry, Descent, and Landing (EDL) analysis results (TAS/LAV);*
- *Compliance with landing site engineering constraints (TAS);*
- *Rover egress and terrain trafficability analysis results (TAS).*

16:30 Landing sites safety assessment summary (30 min) ESA/ROS

17:00 Discussion (30 min) All

Science Presentations

17:30 **Comparisons between Lading Sites** (60 min) C. Quantin, P. Fawdon, J. Bridges

Please organise your site presentations as follows:

- Clay stratigraphy: Transition from Mawrth to Oxia (C. Quantin).
- Morphology: Possible basins and other water contributions (P. Fawdon).
- Expected lithologies and geomorphology: Lessons from Curiosity (J. Bridges).

18:30 TAS-inI intro (10 min) S. Portigliotti

18:40 Conference finishes in the Shuttle Suite

18:40 Planetarium Show

19:15 Drink reception in Boosters

19:45 Call through to dinner

20:00 Dinner served

Transport to 3 hotels.

Fri 9 Nov 2018 Sol 2:

Transport from 3 hotels, refreshments in Boosters area.

09:00 Introduction and recapitulation (15 min) J. Vago/(D. Rodionov)

09:15 **Discussion of the sites** (120 min) All

11:00 Two-minute summary talk for each site.

11:15 **General voting** (30 min)
Please note: To vote you need to have been there for all presentations!!!
Participants will be asked to rank in writing Oxia Planum and Mawrth Vallis in order of priority taking into account the available scientific and engineering information. This input will be used to identify the relative preference of the two locations.

ESWT
We would specifically like to know the opinion of the ExoMars Science Working Team (the PIs and Co-PIs of the nine rover instruments), as they have invested many years of hard work to prepare their instruments and will need to run them at the location we will land on. It is fair that we listen to what they have to say.
So please mark on the ballot if you are a member of the ESWT, state which instrument.

The voting results will be used by the LSSWG as an important input to help identify which site gathers the highest preference. However, the responsibility for the final recommendation is the LSSWG's, who may decide to deviate (for good reasons) from the voting results.

11:45 Lunch (75 min)

13:00 **Landing Site Selection Working Group Meeting in Room XXX** (2.0 hrs)
LSSWG counts votes, analyses outcome, discusses results, formulates recommendation and prepares to inform participants.

Vote counting (60 min)	Becky, Lyle, Jorge
Creation of Pros and Cons table	All
Evaluation and discussion based on pros and cons	All
Formulation of a written recommendation	All
Concluding remarks	All

15:30 **LSSWG Recommendation:** LSSWG announces voting results and explains the reasons for their recommendation —which may or may not be in agreement with the general voting.

Discussion (30 min)

16:00 End of Workshop

Transport to railway station or 3 hotels.

ANNEX 2

LIST OF PARTICIPANTS

(ordered alphabetically by last name)

1.	Emily Baldwin	ESA/ESTEC	emily.baldwin@esa.int
2.	Matt Balme (LSSWG)	Open University (UK)	matt.balme@open.ac.uk
3.	Robert Barnes	Imperial College London (UK)	robert.barnes@imperial.ac.uk
4.	Thomas Barrett	Open University (UK)	thomas.barrett@open.ac.uk
5.	Olivier Bayle (LSSWG)	ESA/ESTEC	olivier.bayle@esa.int
6.	Candice Bedford	Open University (UK)	candice.bedford@open.ac.uk
7.	Helen Bevins	University of Leicester (UK)	hjb31@leicester.ac.uk
8.	Jean-Pierre Bibring (LSSWG)	IAS (FR)	bibring@ias.u-psud.fr
9.	Tomaso Bontognali	Space Exploration Institute (CH)	tomaso.bontognali@space-x.ch
10.	Sylvain Breton	Université de Lyon (FR)	sylvain.breton@ens-lyon.fr
11.	John Bridges (LSSWG)	University of Leicester (UK)	j.bridges@le.ac.uk
12.	Robert Bruner	Denver Museum of Nat. History (USA)	bobbruner40@hotmail.com
13.	Benjamin Bultel	University of Oslo (NO)	benjamin.bultel@geo.uio.no
14.	Fabio Calantropio (LSSWG)	Thales Alenia Space (IT)	fabio.calantropio@thalesaleniaspace.com
15.	John Carter	IAS (FR)	john.carter@ias.u-psud.fr
16.	Valérie Ciarletti	LATMOS (FR)	valerie.ciarletti@latmos.ipsl.fr
17.	Andrew Coates	University College London-MSSL (UK)	a.coates@ucl.ac.uk
18.	Claire Cousins	University of St. Andrews (UK)	crc9@st-andrews.ac.uk
19.	Fabiana da Pieve	Royal Belgian Inst. Space Aeronomy (BE)	fabiana.dapieve@aeronomie.be
20.	Joel Davies	Natural History Museum (UK)	joel.davis@nhm.ac.uk
21.	Maria Cristina De Sanctis	IAPS INAF (IT)	mariacristina.desanctis@inaf.it
22.	Véronique Dehant	Royal Observatory of Belgium (BE)	veronique.dehant@oma.be
23.	Michel Denis	ESA/ESOC	michel.denis@esa.int
24.	Howell Edwards (LSSWG)	University of Bradford (UK)	h.g.m.edwards@bradford.ac.uk
25.	Mohamed Ramy Elmaarry	Birkbeck; University of London (UK)	m.elmaary@bbk.ac.uk
26.	Alberto Fairén (LSSWG)	Centro de Astrobiología (ES)	agfairen@cab.inta-csic.es
27.	Peter Fawdon	Open University (UK)	peter.fawdon@open.ac.uk
28.	Jessica Flahaut (LSSWG)	CNRS/CRPG (FR)	flahaut@crpg.cnrs-nancy.fr
29.	Alessandro Frigeri	IAPS INAF (IT)	alessandro.frigeri@inaf.it
30.	Walter Goetz	MPS (DE)	goetz@mps.mpg.de
31.	Brigit Gondet	IAS (FR)	brigitte.gondet@ias.u-psud.fr
32.	Peter Grindrod	Natural History Museum (UK)	p.grindrod@nhm.ac.uk
33.	Cristoph Gross	Freie Universität Berlin (DE)	christoph.gross@fu-berlin.de
34.	Ivan Grudev	Lavochkin (RUS)	grudev@laspace.ru
35.	Sanjeev Gupta	Imperial College London (UK)	s.gupta@imperial.ac.uk
36.	Svein-Erik Hamran	FFI (NO)	svein-erik.hamran@ffi.no
37.	Ian Hutchinson	University of Leicester (UK)	ibh1@leicester.ac.uk
38.	Marie Josset	Space Exploration Institute (CH)	marie.josset@space-x.ch
39.	Jean-Luc Josset	Space Exploration Institute (CH)	jean-luc.josset@space-x.ch
40.	Luc Joudrier (LSSWG)	ESA/ESTEC	luc.joudrier@esa.int
41.	Nikolaus Josef Kuhn	University of Basel (CH)	nikolaus.kuhn@unibas.ch
42.	Stephen Lewis	Open University (UK)	stephen.lewis@open.ac.uk
43.	Damien Loizeau (LSSWG)	Université Paris Sud XI (FR)	damien.loizeau@ias.u-psud.fr
44.	Leila Lorenzoni (LSSWG)	ESA/ESTEC	leila.lorenzoni@esa.int
45.	Lucia Mandon	Université de Lyon (FR)	lucia.mandon@univ-lyon1.fr
46.	Javier Martín-Torres	Luleå University of Technology (SE)	javmar@ltu.se
47.	Yardena Meister	University of Basel (CH)	y.meister@stud.unibas.ch
48.	Andrea Merlo (LSSWG)	Thales Alenia Space (IT)	andrea.merlo@thalesaleniaspace.com
49.	Melissa Mirino	Open University (UK)	melissa.mirino@open.ac.uk
50.	Pia Mitschdoerfer	ESA/ESTEC	pia.mitschdoerfer@esa.int
51.	Andoni G. Moral	INTA (ES)	moralia@inta.es
52.	Raffaele Mugnuolo	Italian Space Agency (IT)	raffaele.mugnuolo@asi.it
53.	Anu Ojha	ESA/HESAC	anuo@spacecentre.co.uk
54.	Andrea Pacifici (LSSWG)	IRSPS (IT)	pacifici@irsps.eu
55.	Lu Pan	Université de Lyon (FR)	lu.pan@univ-lyon1.fr
56.	Adam Parkes Bowen	University of Leicester (UK)	acdpb1@le.ac.uk
57.	Manish Patel	Open University (UK)	manish.patel@open.ac.uk
58.	David Pecover	Airbus (UK)	david.pecover@airbus.com
59.	Cédric Pilorget	IAS (FR)	cedric.pilorget@ias.u-psud.fr
60.	Simone Pirrotta	Italian Space Agency (IT)	simone.pirrotta@asi.it

61.	Stefano Portigliotti	Thales Alenia Space (IT)	stefano.portigliotti@thalesaleniaspace.com
62.	Pantelis Poulakis (LSSWG)	ESA/ESTEC	pantelis.poulakis@esa.int
63.	François Poulet	IAS (FR)	francois.poulet@ias.u-psud.fr
64.	Cathy Quantin-Nataf	Université de Lyon (FR)	cathy.quantin@univ-lyon1.fr
65.	Ottaviano Ruesch	ESA/ESTEC	ottaviano.ruesch@esa.int
66.	Fernando Rull	Universidad de Valladolid (ES)	rull@fmc.uva.es
67.	Hannah Sargeant	Open University (UK)	hannah.sargeant@open.ac.uk
68.	Elliot Sefton-Nash (LSSWG)	ESA/ESTEC	e.sefton-nash@cosmos.esa.int
69.	Mark Sims	University of Leicester (UK)	mrs@le.ac.uk
70.	François Spoto	ESA/ESTEC	francois.spoto@esa.int
71.	Stuart Turner	Open University (UK)	stuart.turner@open.ac.uk
72.	Jorge L. Vago (LSSWG)	ESA/ESTEC	jorge.vago@esa.int
73.	Matthieu Volat	Observatoire de Lyon	matthieu.volat@univ-lyon1.fr
74.	Stephanie C. Werner (LSSWG)	University of Oslo (NO)	stephanie.werner@geo.uio.no
75.	Frances Westall (LSSWG)	CNRS, Orléans (FR)	frances.westall@cnrs.fr
76.	Lyle Whyte (LSSWG)	McGill University (CAN)	Lyle.Whyte@mcgill.ca
77.	Becky Williams (LSSWG)	Planetary Science Inst. (USA)	williams@psi.edu
78.	María Paz Zorzano	Luleå University of Technology (SE)	marzor@ltu.se

Via WebEx (remote)

1.	Natalia Mozhina	TsNIImash	natali_mozhina@tsniimash.ru
2.	Daniil Rodionov	IKI	rodionov@iki.rssi.ru
3.	Andrew Griffiths	University College London-MSSL (UK)	andrew.griffiths@ucl.ac.uk
4.	Cédric Millot	Université de Lyon (FR)	cedric.millot@univ-lyon.fr
5.	Csilla Orgel	Freie Universität Berlin	orgel.csilla@fu-berlin.de
6.	Divya M. Persaud	University College London-MSSL (UK)	d.persaud@ucl.ac.uk
7.	Håkan Svedhem	ESA/ESTEC	hakan.svedhem@esa.int
8.	Ondřej Santolík	Institute of Atmospheric Physic (CZ)	os@ufa.cas.cz
9.	Roger Stabbins	University College London-MSSL (UK)	roger.stabbins@ucl.ac.uk
10.	Patrick Thollot	Laboratoire de Géologie de Lyon (FR)	patrick.thollot@ens-lyon.fr
11.	Mitch Schulte	NASA HQ	mitchell.d.schulte@nasa.gov