SCIENCE OPERATIONS READINESS OF THE EXOMARS 2022 ROVER MISSION. E. Sefton-Nash[1], J. L. Vago[1], I. Torres[1], R. Fonteyne[1], C. Orgel[1], R. Bahia[1], L. Joudrier[1], F. Haessig[1], A. Williams[2], T. Lim[3], A. J. Ball[1], P. Mitschdoerfer[1], the ExoMars Rover Science Operations Working Group (RSOWG) and Industrial Teams. [1]European Space Research and Technology Centre (ESTEC) European Space Agency, Noordwijk, The Netherlands (elliot.sefton-nash@esa.int), [2]European Space Operations Centre (ESOC), Darmstadt, Germany. [3]European Space Astronomy Centre (ESAC), Villanueva de la Cañada, Madrid, Spain.

Introduction: The ESA-Roscosmos ExoMars 2022 mission is scheduled to launch in September this year. The *Kazachok* Surface Platform, carrying the *Rosalind Franklin* Rover will touch down at Oxia Planum on 10 June 2023. The Rover mission science objectives are to search for signs of past and present life, and to investigate the subsurface water/geochemical environment as a function of depth [1]. We report on activities underway by the Science, Industry and Project Teams to advance the science operations readiness.

Rover Science Operations Working Group (RSOWG): The ExoMars 2022 RSOWG was chartered in 2019 to advance the state of preparation for Rover science operations within the science team. During 2022 the group will focus maturing the mission's *'Strategic Plan'*, which provides traceability from the Rover mission science objectives to individual rover and instrument activities, taking into account the realities of the landing site. The RSOWG is tasked to form the Strategic Plan by 1) identifying questions that stem from the Rover mission science objectives and organizing them into scientific priorities, 2) defining hypotheses that should be tested using rover instruments, and 3) identifying targets and 'skeleton' plans of activities that could be performed by the rover and its instruments that would address specific groups of hypotheses.

Further, the RSOWG forms and tasks sub-groups on specific topics as necessary. Three sub-groups have been formed to address specific needs:

RSOWG-Micro address topics pertaining to the spatial scale of the samples that will be extracted from down to 2m by the rover's drill, their analogues, and plans for their analyses. Notable recent work by the *Micro* sub-group has included (i) Producing recommendations for a sequence of rover activities executed following egress from the Surface Platform and commissioning, named '*Science.0*'. The goal of the Science.0 activities is to prime the rover's analytical laboratory and characterise its initial state prior to commencing the analysis the search for biosignatures on Mars samples. (ii) Running a process to propose, select and analyse a set of 'Mission Reference Samples' – a suite of analogue samples most relevant to the landing site and mission objectives. The suite of reference samples will be characterized by ground models of the MicrOmega [2], RLS [3] and MOMA [4] instruments to build a knowledge base that will aid interpretation of Mars sample data during the mission.

RSOWG-Macro address topics using the wealth of remote sensing data amassed by orbiter missions, and at rover to regional spatial scales. In 2020-2021 the Macro group performed a group mapping exercise of the Oxia Planum landing site [5] with the principal aim to

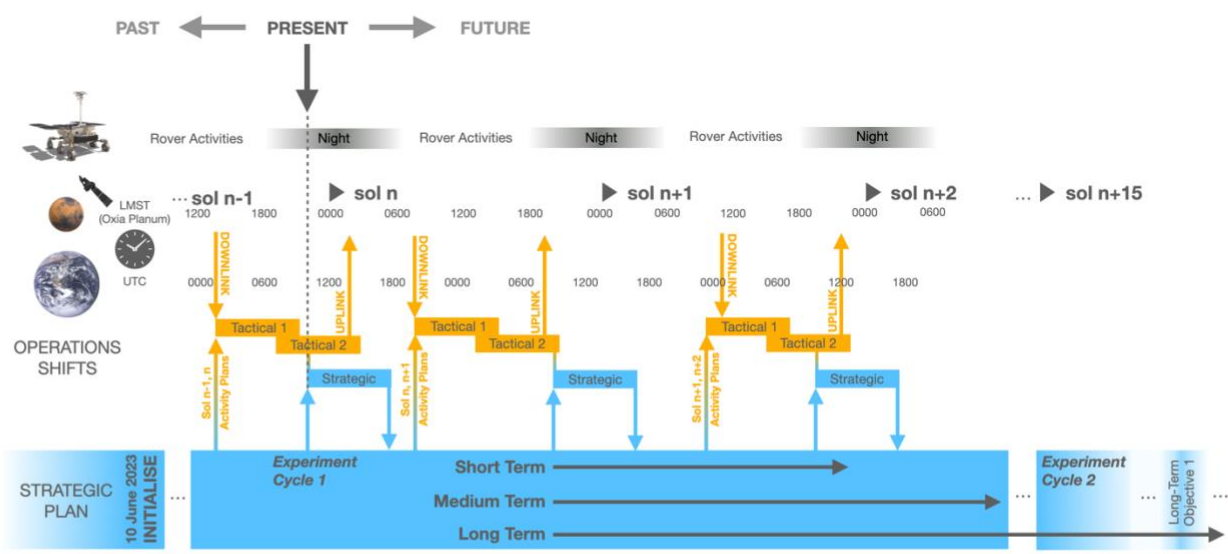

Figure 1: Illustration of Tactical planning (synchronized with orbiter overflights) and Strategic Planning (office hours) shifts as they relate to UTC and Local Mean Solar Time at Oxia Planum. The 'Strategic Plan' is that which guides and governs the decisions made during planning cycles.

develop a thorough understanding of the site's stratigraphy and geological history [6]. This work has resulted also in the development and publication of a Geographic Framework for the landing site [7], which shall be used during simulations and operations. Other *RSOWG-Macro* activities have included defining the process for initialising the mission's 'Strategic Plan' immediately after landing, running discussions regarding interpretation of orbital datasets, establishing and maintaining a version-controlled repository of orbital data for use during the mission, and establishing conventions for naming features and places at the landing site.

The *RSOWG Simulations Planning Group* comprises a team of 'Simulation Officers', nominated from Pasteur Payload Teams, ESA and industry. In 2021 they were tasked with designing and leading a series of 'RSOWG Simulations', an early series of team simulations that were intended to rehearse and refine strategic science processes. Scenarios for each simulation were designed to cover a range of science operations contexts, required engagement by team members (in science data interpretation, rover activity planning, and decision making) and used data from all 9 Pasteur Payloads. Scenarios were entitled: 'After Landing', 'Site Survey', 'Opportunistic science trade-off' and 'ALD Analyses'. With the RSOWG Simulations in 2021 complete, attention is now focused on transferring lessons learned towards the simulations campaign that will be run by the Rover Operations Control Centre (ROCC – Turin, Italy), participation in which, leads to becoming certified to work on shift during operations.

Plans, People, and Processes: Some aspects of science operations preparations lie outside the responsibility of RSOWG, and are complementary to the industry-led development and testing of systems and rover operations at the ROCC. Selected highlights follow.

The mission has required development of a '*Science Operations Plan',* which describes what is needed to ensure that daily science operations processes in Tactical and Strategic planning cycles (Figure 1) are complete, robust, transparent, efficient, and collegiate. The plan complements ground and flight control procedures, and includes descriptions of the Science Team aspects such as organization, communication, journaling, science-specific tools, and designated roles.

The rover long-term data archive hosted on the ESA Planetary Science Archive (PSA) [8] will contain not only data from science instruments in the Pasteur Payload, but also data regarding the *Rosalind Franklin* rover, its journey through Oxia Planum and the science targets it observes, samples and analyses. To structure records that are archived of the places, features and samples of the mission, the '*Science Target Scheme*' was developed together with RSOWG input. The core of this data 'schema' is a hierarchy of target classes (Figure 2), each with specific attributes and spanning spatial scales from the landing site, to individual spots on crushed samples that are analysed by instruments in the Rover's Analytical Laboratory Drawer (ALD). The scheme is integrated into the daily rover activity planning and science journaling processes.

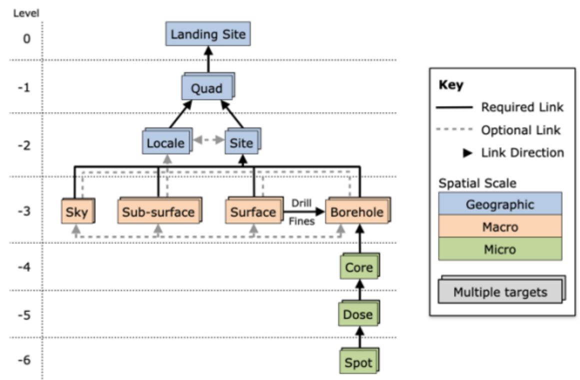

Figure 2: Overview of target classes and the links between them in the ExoMars 2022 Science Target Scheme.

The Sample Analysis Protocol (SAP), in preparation, builds on the ExoMars Biosignature Score (EBS) [1], and will define the investigations and metrics for establishing and reporting whether a location on Mars has hosted microbial life, past or present.

Finally, analyses and specific tools to support operations planning and processes are developed to address specific needs, in areas such as: shift scheduling and staffing, optimisation of sequences of rover activities to minimise resource consumption or maximise science and operational value, 'trade-sheets' to aid decision-making for science targets, and examples of strategic mobility planning.

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References: **[1]** Vago, J. L. et al., (2017) *Astrobiology 17* (6–7), 471–510. **[2]** Bibring, J.-P. et al., (2017) *Astrobiology 17* (6–7), 621–626. **[3]** Rull, F. et al., (2017) *Astrobiology 17* (6–7), 627–654. **[4]** Goesmann, F. et al., (2017) *Astrobiology 17* (6–7), 655–685. **[5]** Sefton-Nash, E. et al., (2021) in *52nd Lunar Planet. Sci. Conf.* **[6]** Fawdon, P. et al. (2022) in *Lunar Planet. Sci. Conf.*, (this conference), **[7]** Fawdon, P. et al., (2021) *J. Maps 17* (2), 762–778. **[8]** Lim, T.-L. et al., (2021) in *5th Planet. Data Work. & Planet. Sci. Informatics & Anal.*, Vol. 2549.