FLOCK OF LOW COST MICROLANDERS TO SURVEY LIQUID WATER POTENTIAL ON MARS ALONG THE RECEDING POLAR CAP.

A. Kereszturi[1], H. Miyamoto[2], B. Pal[1,3] B. [1]Research Centre for Astronomy and Earth Sciences, Konkoly Thege Miklos Astronomical Institute, Hungary. [2]Dept. Systems Innovation, University of Tokyo, Tokyo, Bunkyo, Japan. [3]Eötvös Lorand University, Budapest, Hungary (kereszturi.akos@csfk.org)

Introduction: The aim of this work is to overview a possible near future mission, composed of several small, identical landers/ electromagnetic property measurement devices, which would survey the specific humidity values at the surface and shallow subsurface on Mars. The already available in-situ humidity detectors on Mars provided some information like TECP [1], REMS [2] as well as useful constrains. However these data do not give results on the area of seasonal water ice surface cover and on the ice content change in the shallow subsurface regolith layer by in-situ methods at high temporal resolution from multiple sites simultaneously. The proposed mission could survey several locations on Mars around the receding edge of the northern or southern seasonal cap, which are otherwise difficult to explore for larger rovers. It would able to analyze both the water ice coverage, defrosted surface with shallow ice [3], hydrated and later dehydrated shallow regolith. The pioneering aspects of this mission are the first in-situ measurements of humidity and temperature daily cycles (at the most relevant springtime period) at different depths in the shallow subsurface, definitely with and without water ice and hydrated OH content at a fast changing location regarding volatile occurrence.

Methods: The small landers would be constructed by using already existing and tested technology. We call these probes microlanders, because although they are designed as strong and robust like a penetrator and could penetrate a few cms below the surface, their main aim is to realize electromagnetic property measurements. The almost purely heritage based payload would help to assure mission success and shorten the amount of time needed for design planning. Main focus of the lander construction should be on ensuring their sturdiness while keeping costs low. After landing, the probes could use the orbiters to relay data back to the Earth. This could be done by non-oriented radio broadcasting, thus their orientation after landing would be no issue.

Results: Below we outline the elements of the concept, grouped according to the main topics.

Getting to Mars: As the mass scale of the probes is in the order of 1-3 kg, similar to the mas of Deep Space-2 penetrators [4], a piggyback mission is proposed to arrive to Mars. The atmospheric entry could happen directly from interplanetary orbit. The best case scenario should be such an atmospheric entry point, that the microlanders could land during spring at the edge of the seasonal ice cap. The number of such penetrators can be tailored to the available funding, thus the full cost of the mission is flexible.

Timing of landing: The focus should be the local springs, when the seasonal polar caps recede. Although seasonal parameters influence the mission much as the landing should ideally happen during the given L_S interval (approximately between LS 0^o–90^o in the northern, and LS 180^o–270^o in the southern hemisphere), the landing and the surface survival is almost independent on meteorological conditions, like temperature and atmospheric humidity.

Landing process: Landing accuracy is expected to be in the order of some 100 kms, thus in general only the atmospheric entry sites matter. Several probes could enter behind the same heat shield as one unit, and then they could separate during the atmospheric descend. Timing of the separation and parachute deployment could help to adjust the distance of the final surface landing points. These could be even further apart by using parachutes in different sizes.

Surface activity: The main mission of the probes is to gain accurate in-situ measurements from various parts of the Martian surface simultaneously. Acquired data would provide a better understanding of the climate and smaller scale variations. Useful data to measure would be for example surface temperature, relative humidity, pressure, wind speed and direction. By dropping the probes in a chain-like formation, the acquired data could be used to extrapolate to other areas, where nothing has landed yet, and also might witness the sublimation of water ice cap, shallow subsurface ice sublimation and final dehydration subsequently at different locations, under somewhat different conditions.

Required lifetime: It should cover the period from the exposure of seasonal water ice cover till the substantial decrease of regolith H_2O content and even dehydration. This would mean roughly 80 L_S in the northern hemisphere. Due to the limited sunlight available it is challenging to survive using batteries, however it could be achieved with the low energy consumption of the microlanders.

Technical requirements: For the probes: two different options could be considered; the simpler one is powered by batteries and is able to survive only some daily cycles, while a more complex and expensive one could be equipped with a deployable solar panel, ejected to the surface after landing. The latter could support survival for the suggested 80 L_S duration covering the recession of the polar cap and dehydration of the soil.

Proposed scientific payload: Similar temperature and humidity sensor at two or three locations from the lowest possible to the highest possible point on the probe. Very simple light detection sensor is linked to the temperature/humidity detector pair, to identify if the given sensor is covered by regolith (penetrated below the surface or exposed).

Data transfer: By small UHF non-oriented radio broadcast for orbiter missions' passages using around 6-8 kbit/s rate. This requires most of the energy besides possible heating (this later might be minimal by available design of specific humidity and temperature detectors).

Number of probes: Although only one probe could provide good results in itself, in an ideal case multiple probes would result in an even better outcome. Especially since their production would not inflate the cost much (as these are small, inexpensive, low mass probes), and the launch mass increase with raising the number of probes is only moderate as well. In the case of "poor targeting" (with 3 probes for example), even if they enter the atmosphere at the same location and direction, during deceleration and parachute descent phase, the landing distance between them is expected to be around 100 km. If small differences in the parachute size is designed, this distance could be expanded to around 1000 km. The main issue to consider here is more useful results are gained if the distance between these probes increases in meridional direction, they witness the transit of the receding cap edge at different seasonal times and conditions. Although such meridional spatial arrangement between the probes do not emerge by chance, especially as the entry direction used to be in the ecliptic plane – but there is a chance to arrive to the atmosphere at 4-6 degrees [5] relatively to the local horizontal plane at high geographic latitude with proper adjustment of launch time to Martian seasons.

Discussion: The main benefit would be to gain daily and seasonal temporal resolution data on humidity, and better outline the possibility of deliquescence based liquid water potential and related brine formation possibility. While future landers (mainly roves) might carry humidity detectors, no one is planned to gain direct in-situ data from the mm-cm-dm deep shallow subsurface. The receding edges of the seasonal polar caps are also hard to reach by larger rovers. If the small probes prove to be useful, the mission could be expanded in the future to other hard to reach areas as well. According to recent modeling results [6] the receding edges of the polar caps could provide a brief window for possible brine formation through deliquescence. By employing small landers we could get in-situ confirmation of this suggested phenomenon. If brine formation is confirmed, this could be used as a potential resource for future crewed missions as well.

Possible mission scenarios: Because of the simplicity of this mission, there are several possible outcomes and related mission scenarios. Depending on the regolith hardness and design of probes, penetrators could be deeply buried or loosely covered by debris, or even parts of them could stay exposed to the free atmosphere. All of these situations would provide useful information on the volatile cycle, subsurface H_2O migration and exchange processes with the atmosphere. The joint evaluation of the measured daily cycles, including light intensity changes at the detectors allow the rough depth estimation of the given detector at the deepest part of the penetrator needle.

Possibility to accompany other missions: It is proposed and being favorable that this mission could be accompanied with other hard lander style mission or instrument proposals like OPRA [7], or the MetNet isson proposal [8], WetSen detector [9]. New instrumental technology [10] would also provide ideal conditions for such miniaturized sensor sets.

Conclusions: Expected outcome from the mission are the followings: 1. determination of humidity and temperature value of the sublimation of the seasonal ice cap (improving current models where only the temperature is well known), 2. determination of the very near surface humidity, clarifying daily volatile cycle, 3. understanding the vapor migration inside the regolith, 4. understanding the possibility of deliquescence, 5. provide in-situ data to validate regolith desiccation models.

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