Mars Small Spacecraft – the Opportunity of the Roaring 20ties

Keynote talk for the ISSC by V. Stamenković[1]

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Mars has still many mysteries that wait to be explored. Fast changing whiffs of methane observed over the last fifteen years, and recently measured seasonal fluctuations of oxygen have puzzled scientist—especially as methane on the Earth is manly produced by life and should, on Mars, not decay within days, as observed, but rather slowly with a half-life of three hundred Earth years. Recent data from the MARSIS orbiting radar have suggested the possible existence of liquid groundwater beneath the South Polar Layered Deposits one mile deep. However, the depth at which the data have been taken is at the verge of MARSIS' sounding capabilities and could have alternative interpretations. In the same time, we have finally discovered small quantities of organic material in Martian rocks with the Curiosity rover, ingredients essential for life, but it is not clear whether, or how, that material was created on Mars or whether it might have been delivered exogenically by meteorites.

These discoveries all leave open questions, especially as to whether we might be seeing traces of possibly habitable environments in the Martian subsurface, which to this date has almost not been explored. Could life still be hiding in the Martian deep where groundwater could exist? We do not have the data to judge this.

On the other hand, many processes that occur on Mars—across seismology, climate, atmospheric erosion and many more can only be better understood if we enable 4D monitoring, globally in 3D and across time. This would not just allow us to understand what causes dust storms, quakes or drives water from subsurface to ionosphere, but would also allow us to set monitoring stations for human exploration—emphasizing how big Mars science questions of the future tightly link to human exploration.

Small spacecraft, well below half of the Discovery Class budget, either in orbit or on ground, provide the opportunity to address all those questions by (1) performing fundamental & new measurements, (2) executing targeted science objectives with a focused instrument suite, (3) accessing landing regions which are normally too risky, (4) enabling 3D (global) and 4D (global and temporally continuous) measurements, and (5) exploring large-scale areas with sensor-driven mini-scouts.

Objectives of interest include characterizing the atmosphere and ionosphere, including local and regional dust, energetic particles, wind, temperature, pressure and electromagnetic fields on a global scale and across variable heights above the surface; determining with high spatiotemporal resolution current climate and its variability as a function of season, latitude, time of the day and terrain; polar science would be also significantly enabled due to the higher permitted risk to land in polar regions; performing assessment of resource inventories, including ice water and ores; assessing modern-day habitability by localizing the sinks and sources or trace gases, such as methane, by estimating the delivery of organics by meteorites, by constraining shallow subsurface redox profiles, and by especially characterizing deep subsurface liquid groundwater, a possible last modern habitat on Mars.

In the following talk, I want to provide insight on the big science opportunities that can be addressed with small spacecraft around Mars, first from a wide perspective, and second by focusing on how small spacecraft below a cost target of $250 M might help us answer one of the biggest questions of planetary exploration "*if there is still life on Mars*".

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