Sail Mobile Mini Landers for Opportunistic Mars Sample Return Mission. Ashitey Trebi-Ollennu and Harish Manohara. Jet Propulsion Laboratory, California Institute of Technology, ashitey@jpl.nasa.gov.

Introduction: We propose a Sail Mobile Mini Lander (SMML) based system for opportunistic Mars sample return mission. The opportunistic Mars Sample Return (MSR) concept proposed is a single mission campaign that would be a NASA-built SMML primarily based on the highly successful capabilities that were demonstrated on the Mars Phoenix Lander mission [2]. The proposed flight system comprises two separate vehicles launched together on an Atlas V: Mars Surface Module (MSM) and the Sample Return Vehicle (SRV). Post launch the MSM and SRV fly independently to Mars. The MSM consist of three identical Sail Mobile Mini Landers with passive wheels on each of the three Lander legs. The MSM would be landed using Phoenix descent and Landing design approach. Post landing the MSM would separate into three Sail Mobile Mini Landers. To avoid collecting samples from surface area contaminated by the MSM landing event the SMML is equipped with a deployable sail module that would enable repositioning of the SMML up to about 200m from the landing site. The proposed concept is in line with the Palnetary Decadal survey report [1] that states "*During the decade of 2013-2022, NASA should establish an aggressive, focused technology development and validation initiative to provide the capabilities required to complete the challenging MSR campaign.*" The proposed SMML concept would enable acquisition and return to Earth of Martian materials that has been a high science priority since the 1970s and is responsive to the scientific goals articulated by the National Research Council Planetary Decadal Survey [1] and to the President's challenge of sending humans to orbit Mars in the decade of the 2030s. The proposed SMML system for opportunistic MSR would provide NASA with a unique near-term (2018-2020) mission concept with a high science pay-off . In addition, the proposed mission architecture is compatible with foreign collaboration, as required by Planetary Decadal survey report [1] for MSR.

Sail Mobile Mini Lander Mission Concept: The proposed SMML MSR mission concept uses the heritage and experience from over a decade of surface operations on Mars, from Mars Pathfinder, MER rovers to the Mars Phoenix Lander [2,3]. The Sail Mobile Landers when assembled would be the same size as the Phoenix Lander [2] but would comprise of three separate Landers that can be deployed independently to different locations on Mars from a single spacecraft.

Figure 1: Phoenix Mars Lander at Lockheed Martin in Denver.

Mars Surface Module (MSM): The MSM consist of three identical Sail Mobile Mini Landers with passive wheels on each of the three Lander legs. The MSM would be landed using Phoenix descent and Landing design approach. Post landing the MSM would separate into three Sail Mobile Mini Landers. Each SMML consists of a Mars Ascent Module with an Orbiting Sample (OS) container, a Sample Canister (with sample capacity of 0.3kg), a Sail Module, a Sampling Tool, a Stereo Camera, a Communication Module and Power Module.

Sail Mobile Mini Lander (SMML): To avoid collecting samples from surface area contaminated by the MSM landing event the SMML is equipped with a deployable sail module that would enable repositioning of the SMML up to about 200m from the landing site. Since the SMML mobility is dependent on Martian winds its final position cannot be predetermine making the sampling event opportunistic. The sail module would consist of 2m x 2m nano sail material. The Sail module can also be used to collect atmospheric particle samples from 1micron to 1 mm in size. The sail can be deployed and folder into a 20cm x 20cm x 20cm volume.Each SMML would be equipped with a sampling tool capable of collecting surface and subsurface samples using Phoenix sampling techniques [2]. A sim-

ple scoop may be adequate to collection samples 2cm to 5cm below the surface. The capability of the sampling tool would be similar to contingency sampling tools proposed in previous MSR missions [4 – 6]. The sampling tool and sample canister would be mounted on a 50cm long 2 DOF robotic arm that would also be used to transfer the sample canister to the OS.

Mars Ascent Module: In contrast to previously proposed MAVs [4-6] the SMML MAV would have a single solid-propellant stage without thrusters for 3-axis control. Depending on the mission scenario the SMML OS would be mounted on a spin-eject mechanism inside a nosecone [4]. The MAV could also carry UHF beacon to enable rapid detection of the OS by the SRV. The result is that a lower mass MAV system landed on Mars that could be used to launch the sample into Mars orbit. The MAV would launch the OS into a circular orbit of 500 km+/- 200 km and within 3 degrees of inclination. The proposed SMML MAV can be considered a dummy MAV compared to previously proposed MAVs [4-6]. There is a design trade between the MAV and SRV, the SRV would be a more capable spacecraft for rendezvous and capture of the OS thus requiring lower landed mass for the MSM because of a less capble MAV. The MAV on each Sail Mobile Mini Lander can depart the Martian surface at any time after landing from the earliest moment that sample is acquired through an extended surface mission that lasts for 60 sols.

Sample Return Vehicle (SRV): The Sample Return Vehicle (SRV) carries the Earth Re-Entry Vehicle (ERV), the sensors and mechanisms for detetion, rendezvous, and capture and transfer of the OS. After transit to Mars the SRV would transit to an elliptical orbit followed by another transition into circular orbit 500 km for rendezvous with the free-flying OS and transfer of the OS to the ERV. The SRV would act as a communication relay for the MSM units that would be deployed to the surface of Mars. The SRV would detect the OS using optical sensors and UHF beacon signal. SRV would have a total of three MAV docking maneuvers and OS capture opportunities. Depending on the mission scenario the SRC might be commanded to dock and capture the OS in the most favourable or opportunistic orbit. After a successfully rendezvous and capture of the OS the Earth re-entry vehicle would return to Earth on a ballistic trajectory. It would then be recovered and isolated in a 'curation' facility.

Summary: SMML builds on technologies developed over the last decade of Mars exploration in an incremental fashion reducing MSR mission technical, science and cost risks. SMML advances cross-cutting technology development efforts for capture and docking and can be used to demonstrate key technologies needed for human exploration of Mars. Although there remain some technology development challenges such as the sail and mini Lander these are solvable because they are in fact engineering developments. The SMML MAV maybe the biggest technology development challenge however, we believe it is feasible in the near-term (2018-2020). The proposed SMML mission architecture is compatible with foreign collaboration as required by Planetary Decadal survey report [1] for MSR. International contributors can potentially provide the Sample Return Vehicle including the Earth Re-Entry Vehicle.

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