# THE BIOLOGICAL OXIDANT AND LIFE DETECTION (BOLD) MISSION: A PROPOSAL FOR A MISSION TO MARS.

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**Introduction:** The next step in the exploration of Mars should include a strong and comprehensive life detection component. We propose a mission called *BOLD: Biological Oxidant and Life Detection* mission [1,2]. The primary objectives of the BOLD mission are to characterize the habitability of the Martian near-surface and to search for evidence of extinct or extant life.

In contrast to the Viking mission, which was designed to detect heterotrophic life on Mars, the BOLD mission incorporates a more comprehensive search for autotrophic microorganisms, as well as detecting a variety of biomarkers and understanding their environment. The Viking landers were launched with the objective to conduct life detection experiments on Mars. The consensus view is that Viking did not detect life, with many convinced that the reactivity seen in the Viking response was due to reactive soil chemistry rather than biology. However, recent findings raise questions about the certainty of these interpretations [3,4].

Recent missions that studied/study the martian near-surface include the NASA Pathfinder, the Phoenix lander, the on-going Mars Exploration Rover (MER), and the upcoming Mars Science Laboratory (MSL) mission, which is currently enroute to Mars. Mission results so far are confirming that favorable habitable conditions existed on early Mars and imply that possibly large standing bodies of water existed. The MSL will further test the habitability of Mars, both in regard to possible future human colonization and endemic martian life. However, beyond MSL the future of Mars exploration appears uncertain. No currently scheduled or planned future mission contains a life detection component.

The possibility of extant life and biological activity remains an open question despite past and current missions. Many recent mission results, such as the finding of large deposits of water ice on Mars as well as evidence of contemporary liquid water [5], methane [6], and possibly even hydrothermal activity [7], hint at the possible presence of life. The proposed *Biological Oxidant and Life Detection Mission (BOLD*) will search for evidence of biological activity in these martian environments and examine the martian near-surface habitability.

**BOLD Mission Design:** In particular, the BOLD mission will search for oxidants, especially hydrogen peroxide and perchlorates, and probing for biosignatures near the martian surface. In contrast to the Viking mission, which focused on possible heterotrophic life on Mars, the BOLD mission will conduct a more comprehensive search targeting autotrophic microbes, as well as generic biomarkers indicative of the possible presence of life [1]. The mission will consist of six lander probes to provide redundancy in case some of them do not make it to the surface safely or fail. Robust propulsion is coupled with a terrain navigation system to permit landing precision on the order of 10 meters. However, the probes will require an orbiter for communicating data to Earth, which could be an existing spacecraft such as NASA Mars Reconnaissance Orbiter, ESA Mars Express, or another spacecraft orbiting Mars at that time.

The BOLD mission lander probes will employ an optical guidance system and live telemetry during the descent. They will be powered by batteries and are light-weight, with a science payload of about 6 kg, or about 10% of the landed mass. The lander system is designed to use a crushable shell behind the heat shield instead of landing gear. The mission duration for each lander probe is envisioned to be no more than 10 Sols. Currently we still consider various designs of the landing probe. One possibility under discussion is to have the probe in the shape of an inverted cone descending on a parachute, so that the impact velocity can be controlled. The impact is expected to push the probe a few tens of centimeters into the martian regolith. After impact, a spring-action sampler will be engaged, which collects and delivers near-surface materials to instruments located in the center of the probe. The sampler will also be equipped with moisture and temperature sensors, as well as with the capability to collect and return material to the interior of the lander probe for further analysis. We plan to use a pressurized device, such as a volatile cartridge with regulated pressure, to assist the hollow-stem penetrator. The design of the sampler and of the lander probe will be further optimized for the environmental and near-surface conditions likely to be encountered on Mars. The design will be based on tests on Earth where conical shape, mass, and impact velocity will be varied to determine on how deep the lander probe might penetrate depending on various soil conditions. The sampling mechanism can only be activated once for each probe [1]. The conical design eliminates the need for a drill, but its use is therefore confined to soft sediments rather than rocky materials. Remote imaging of the prospective landing sites (e.g., via HiRISE) combined with high precision landing capability will reduce the chances of landing on hard surfaces. The mission risk associated with landing on undesirable surfaces is reduced by probe redundancy, i.e., the use of six lander probes.

**BOLD Lander Instrumentation:** As with all space missions there is a need for miniaturization with payload mass, size, and power consumption remaining the primary concerns and constraints. Miniaturization is especially a concern for the BOLD instrumentation, because of weight constraints for each lander probe. Our strategy for miniaturization is potentially includes the use of Micro Electro Mechanical Systems (MEMS) [8]. MEMS devices, due to their inherently low mass, size, and power, are ideal for both space and sensor network applications and have been developed specifically for the purpose of robotic planetary exploration [1,8].

The instrumentation package aboard each lander probe will include six major experiments related to life and oxidant detection, in addition to a battery package, a sampler, and a transmitter for surface to orbit communication. Each BOLD lander probe will incorporate a Mars Soil Analyzer, a Multispectral Microscopic Imager, a Nanopore-ARROW (capable of detecting biopolymers with single molecule resolution), an Atmospheric Structure and Surface Environment Instrument, a Fluorescent Stain experiment, and a Chirality experiment.

In depth information of the planned experiments, the lander probe design and instrumentation, and the overall BOLD mission design are provided in [1].

**References:** [1] Schulze-Makuch D. et al. (2012) *Planet. Space Science*; doi:10.1016/j.pss.2012.03.008; [2] Schulze-Makuch D. et al. (2007) *Proc. SPIE*, Vol. 6694, 66940O (2007); DOI:10.1117/12.732155; [3] Houtkooper, J.M., Schulze-Makuch, D. (2007) *Int. J. of Astrobiology* 6, 147-152; [4] Navarro-Gonzalez, R., et al. (2006) *Proc Natl Acad Sci USA* 103, 16089-16094; [5] Malin, M.C. et al. (2006) *Science* 314, 1573-1577; [6] Mumma, M.J. et al. (2004) *Bull. Amer. Astronom. Soc.* 36, 1127; [7] Schulze-Makuch, D. et al. (2007) *Icarus* 189, 308-324; [8] Fink, W. et al. (2007) *Proc. SPIE Defense & Security Symposium*, 6556, 655611.