Cooperative Lander-Surface/Aerial Microflyer Missions for Mars Exploration

Bio-inspired principles of key functions are distilled, enabling missions to Mars using multiple microflyers in synergy with the existing surface assets to provide a robust telecommunication architecture for gathering scientific data.

NASA's Jet Propulsion Laboratory, Pasadena, California

Concepts are being investigated for exploratory missions to Mars based on “Bioinspired Engineering of Exploration Systems” (BEES), which is a guiding principle of this effort to develop biomorphic explorers. The novelty lies in the use of a robust telecom architecture for mission data return, utilizing multiple local relays (including the lander itself as a local relay and the explorers in the dual role of a local relay) to enable ranges ~10 to 1,000 km and downlink of color imagery. As illustrated in Figure 1, multiple microflyers that can be both surface or aerially launched are envisioned in shepherding, metamorphic, and imaging roles. These microflyers imbibe key bio-inspired principles in their flight control, navigation, and visual search operations. Honey-bee inspired algorithms utilizing visual cues to perform autonomous navigation operations such as terrain following will be utilized. The instrument suite will consist of a panoramic imager and polarization imager specifically optimized to detect ice and water. For microflyers, particularly at small sizes, bio-inspired solutions appear to offer better alternate solutions than conventional engineered approaches.

This investigation addresses a wide range of interrelated issues, including desired scientific data, sizes, rates, and communication ranges that can be accomplished in alternative mission scenarios.

The mission illustrated in Figure 1 offers the most robust telecom architecture and the longest range for exploration with two landers being available as main local relays in addition to an ephemeral aerial probe local relay. The shepherding or metamorphic plane are in their dual role as local relays and image data collection/storage nodes. Appropriate placement of the landing site for the scout lander with respect to the main mission lander can allow coverage of extremely large ranges and enable exhaustive survey of the area of interest. In particular, this mission could help with the path planning and risk mitigation in the traverse of the long-distance surface explorer/rover. The basic requirements of design and operation of BEES to implement the scenarios are discussed. Terrestrial applications of such concepts include distributed aerial/surface measurements of meteorological events, i.e., storm watch, seismic monitoring, reconnaissance, biological chemical sensing, search and rescue, surveillance, autonomous security/protection agents, and/or delivery and lateral distribution of agents (sensors, surface/subsurface crawlers, clean-up agents). Figure 2 illustrates an Earth demonstration that is in development, and its implementation will illustrate the value of these biomorphic mission concepts.

This work was done by Russell A. Wincheski, Robert G. Bryant, and Min Namkung of NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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Figure 1: A Biomorphic Mars Mission is conceptualized here. (Note: EDL= Entry, Descent, and Landing.)

Figure 2: This is a Conceptual Illustration of a Planned Demonstration, "Bioinspired Engineering of Exploration Systems for MARS," to be performed at a Mars analog site on Earth. Here, microflyers work in synergy with the existing surface/aerial systems to enable new science endeavors. Multiple local comports provide a robust communication route for imagery downlink from the microflyers.