

Title: Nanotechnology-Enabled Sensors for Characterizing Martian Dust Properties

Summary of Project

Exploration of planets, dwarf planets, moons, asteroids, and comets is dependent on well-designed and robustly engineered sensors to characterize the environmental conditions found in these extreme environments. The proposed work creates a path to a sensing technology for exploration offering improved long-term sustainability of detection performance in terms of durability, sensitivity, response time, and repeatability across a broad spectrum of environmental variables.

Our project will develop new, innovative, nanotechnology-enabled flexible sensors for characterizing and quantifying particulate matter suspended in the Martian atmosphere that would be carried by an unmanned aircraft system (UAS). The objectives are: 1) develop sensors that measure the size and compositional properties of dust particles suspended in the atmosphere; 2) develop sensor housings that effectively deliver particles to the sensor for measurement; and 3) demonstrate that design and control of the UAS can enhance measurement capabilities. The focus on Martian dust is due to its importance in multiple NASA initiatives that recognize dust plays a major role in the Martian climate system and aeolian processes are the dominant geomorphic agents on Mars.

We propose to construct two prototype nanosensors one with a piezoelectric 2D material field-effect transistor (FET) configuration and LED emission with photodetectors to size dust particles and the second with optical excitation from multiple LEDs and spectral filters (excitation wavelengths ultraviolet to infrared) to identify particle composition. In parallel with sensor development, design of an intake for the nanosensors will be investigated. Due to the highly turbulent flow around a UAS mounted sensor it is critical to design the intake nozzle for the sensing volume of the dust sensor, seeking isokinetic or uniform flow conditions of dust in that space. Computer simulation and experimental validation will be carried out for the design of the intake nozzle. Synthetic sensor data will be fed into sensor-in-the-loop flight control software to evaluate the expected flight response of a UAS to maximize sample collection effectiveness.

Our proposal addresses NASA Planetary Science goals under Strategic Objectives 1.1 and 2.2 of the 2018 Strategic Plan and NASA's decadal survey for Planetary Science that prioritizes understanding Mars dust cycle effects on its atmosphere. This proposal is relevant to Strategic Goal 1 of NASA JPL to exploit data from science-driven robotic space missions, Goal 3.1 to develop and transfer revolutionary technologies to enable exploration, and NASA Ames Research Center strategic goals for instrument development and Mars climate modeling. Our project would support the 2015 NSHE Science and Technology Plan as nanosensor development aligns with objectives to innovate "Advanced Materials" and "Materials Science". Additionally, the project aligns with Nevada development goals to provide a workforce for the UAS industry (NV Transportation Goal 7) and the development of sensors for UAS (Moving Nevada Forward: A Plan for Excellence in Economic Development).

Student involvement will be three projected-supported Ph.D. students and part-time undergraduate research assistants receiving hands-on research experience in sensor development and UAS design and optimization. The students will be drawn from UNLV, the nation's most diverse campus with more than half from minority groups, and UNR will use the resources of its Office of Diversity and Inclusion to aid in recruiting students to this project. DRI will lead K-12 outreach including development of curricula for science themes such UAS and space exploration.