2-MICRON MARS-ORBITING LIDAR FOR WIND, DENSITY AND DUST MEASUREMENTS

Upendra N. Singh
Engineering Directorate, NASA Langley Research Center, Hampton, VA, USA (Upendra.N.Singh@nasa.gov)

Abstract:

Planetary winds have implications to understanding planetary weather and conducting planetary exploration. In the case of Mars, the interplay between winds, dust storms and the radiative feedback is critical to the prediction of operational meteorology but remains poorly understood. Two major components of the Martian weather are the episodically strong winds and the dust storms. Both have implications to understanding Martian weather and to the prediction of hazardous conditions for landing and exploration on the surface of Mars. The feedback between winds (driven by thermal gradients), dust storms (sustained suspension of high optical depth dust clouds) and the consequential changes in the thermal gradients, is recognized as fundamental to the Martian weather. In addition to the weather/climate issues, the knowledge of the 3-dimensional wind field would be beneficial and could be critical to both the design and execution of future robotic and human expedition missions. As an example, the wind field (and wind shear throughout the atmosphere) is a crucial factor in the entry, descent, and landing of instrumented craft and subsequent airborne and surface exploration.

Future robotic missions to Mars and, eventually, human missions to Mars will require landing massive spacecraft with "pin point" accuracy, e.g., the planned Mars Sample Return (MSR) mission will require "pin point" landing accuracy to rendezvous with the previously cached Mars samples to be returned to Earth and the first human mission to Mars, with payloads estimated to be in excess of 40 metric tons, must land very close to the cargo spacecraft that precede it on the journey to Mars. Hence, "pin point" entry, descent and landing (EDL) has become a major technological driver in future massive robotic and human mission to Mars [1]. To achieve "pin point" EDL on Mars, we must predict the atmospheric density, atmospheric winds and atmospheric dust level to an accuracy previously unobtainable. To develop an accurate and precise predictive model of the atmosphere of Mars, we propose a Mars-orbiting LIDAR system to measure/monitor the density, winds and dust in the atmosphere of Mars over two Mars years.

Approach:

The lack of measurements of Martian atmospheric density in the 30-80 km range, dust storm formation and movements, and horizontal wind patterns in the 0-20 km range pose significant risks to aerocapture, and EDL of future robotic and human Mars missions. This lack of data leads to a large uncertainty in prediction of the Martian atmospheric density and winds in the altitude regime where deceleration of landers will occur. This uncertainty will have a dramatically large impact on mass, cost and risk. Systematic measurement of the Mars atmospheric density and winds will be required over several Mars years, supplemented with day-of-entry operational measurements.

Research programs were initiated at NASA Langley Research Center to first model the lidar's performance and then build a breadboard lidar system demonstrating a measurement capability for wind, CO_2 concentration, and aerosols suited to meteorological and climatological application for Mars. This 2-μm coherent Differential Absorption Lidar (DIAL) system can simultaneously measure wind by a Doppler technique and CO_2 concentration by a differential absorption technique. Since the source of the backscatter is atmospheric aerosols, aerosol/dust profiling is inherently included. The presentation will outline the proposed development of a 2-micron Doppler/ DIAL lidar system to potentially acquire critically needed density and winds data to reduce the risks of future Mars landing missions.

References:

[1] J.S. Levine and R.E. Schild, (Editors). The Human Mission to Mars: Colonizing the Red Planet. Cosmology Science Publishers, Cambridge, MA, 974 pages, 2010.