LIDAR INSTRUMENT FOR GLOBAL MEASUREMENT OF MARS ATMOSPHERE

Farzin Amzajerdian[(1)], George Busch[(2)], Norman Barnes[(1)], Robert Tolson[(3)], and Diego Pierrottet[(2)]

[(1)]NASA Langley Research Center, MS 468, Hampton, VA 23681, USA, Email: f.amzajerdian@nasa.gov
[(2)] Coherent Applications, Inc., 20 Research Drive, Hampton, VA 23666, USA, Email:George.e.busch@nasa.gov
(3)National Institute of Aerospace, 100 Exploration Way, Hampton, VA 23666, Email: Robert.h.tolson@nasa.gov

Future NASA missions to Mars must focus on either obtaining high value scientific data or serve as precursor in preparation for human exploration. Laser-based instruments (lidars) can play a key role in achieving both of these objectives. Lasers offer clear advantages over passive and active radio-wave measurements. These advantages include excellent spatial resolution, nonreliance on natural light sources, and the ability to aim and scan. This paper proposes a multi-functional lidar instrument providing all critical atmospheric data while meeting the stringent mass and power constraints of a Mars mission. We refer to this lidar as "coherent Doppler/DIAL lidar" since it combines the attributes of a “coherent Doppler lidar” with those of a “Differential Absorption Lidar”. As an orbiting instrument, this lidar will provide global measurements of atmospheric winds, density, and aerosol with a high degree of precision and spatial resolution. The wind velocity is measured using the Doppler frequency shift of laser light scattered from suspended aerosols transported by the winds. The atmospheric density is determined from measurements of the concentration of CO_2, which constitutes about 97% of Mars atmosphere. The concentration is determined by measuring the ratio of transmitted intensities of two different wavelengths emitted by the lidar, corresponding to high and low CO_2 transmission. The CO_2 concentration is profiled along the entire path of the laser beam. The aerosol concentration is simply derived from the intensity of the returned signals.

Presently, individual lidar systems measuring Earth atmospheric winds and CO_2 exists in the form of ground and airborne-based scientific instruments. Lidar aerosol measurement is more mature as several instruments have been successfully deployed to Earth orbit since 1994. The multifunctional lidar being proposed combines the functions of each individual sensor into a single device resulting in a more robust instrument with fewer components, and thus greater reliability, as well as reduced mass, volume, and power compared with multiple systems to handle each function. This lidar takes advantage of the fact that the aerosol concentration in Mars atmosphere is almost 2 orders of magnitude greater than that of the Earth thus permitting smaller lasers and smaller transmitter/receiver telescope apertures. The lower laser pulse energy required for Mars allows for use of a novel highly-efficient near-infrared laser currently under development at NASA LaRC. This laser has much improved performance characteristics compared with current laser technologies available. That simplifies the instrument thermal management design and significantly reduces the overall payload mass and power consumption.

This paper will describe the lidar instrument concept and its potential for providing global measurements of Mars atmospheric parameters. The instruments trades and limitations will also be discussed. Finally, the current state of the technology will be presented, along with a plan for advancing its readiness towards deployment in Mars orbit.