NASA SBIR 2017 Phase I Solicitation

S1.01 Lidar Remote Sensing Technologies

Lead Center: GSFC

Participating Center(s): JPL, LaRC

Technology Area: TA8 Science Instruments, Observatories & Sensor Systems

NASA recognizes the potential of lidar technology in meeting many of its science objectives by providing new capabilities or offering enhancements over current measurements of atmospheric and topographic parameters from ground, airborne, and space-based platforms. To meet NASA's requirements for remote sensing from space, advances are needed in state-of-the-art lidar technology with an emphasis on compactness, efficiency, reliability, lifetime, and high performance. Innovative lidar subsystem and component technologies that directly address the measurement of atmospheric constituents and surface topography of the Earth, Mars, the Moon, and other planetary bodies will be considered under this subtopic. Compact, high-efficiency lidar instruments for deployment on unconventional platforms, such as balloon, small sat, and CubeSat are also considered and encouraged.

Proposals must show relevance to the development of lidar instruments that can be used for NASA science-focused measurements or to support current technology programs. Meeting science needs leads to four primary instrument types:

- *Backscatter* - Measures beam reflection from aerosols to retrieve the opacity of a gas.
- *Ranging* - Measures the return beam's time-of-flight to retrieve distance.
- *Doppler* - Measures wavelength changes in the return beam to retrieve relative velocity.
- *Differential Absorption* - Measures attenuation of two different return beams (one centered on a spectral line of interest) to retrieve concentration of a trace gas.

Phase I research should demonstrate technical feasibility and show a path toward a Phase II prototype unit. Phase II prototypes should be capable of laboratory demonstration and preferably suitable for operation in the field from a ground-based station, an aircraft platform, or any science platform amply defended by the proposer. For the 2017 SBIR Program, NASA is soliciting the component and subsystem technologies described below:

- Compact and rugged single-frequency continuous-wave and pulsed lasers operating between 290 nm and 2.05 micrometer wavelengths suitable for Lidar. Specific wavelengths of interest to match absorption lines or atmospheric transmission: 0.29 – 0.32 micrometer (ozone absorption), 0.45 – 0.049 micrometer (ocean sensing), 0.532 micrometer, 0.815 micrometer (water line), 1.0 micrometer, 1.57 micrometer (CO_2 line), 1.65 micrometer (methane line), and 2.05 micrometer (CO_2 line). Architectures involving new developments in diode laser, quantum cascade laser, and fiber laser technology are especially encouraged. For pulsed lasers two different regimes of repetition rate and pulse energies are desired: from 1 kHz to 10 kHz with pulse energy greater than 1 mJ and from 20 Hz to 100 Hz with pulse energy greater than 100 mJ.
- Optical amplifiers for increasing the energy of pulsed lasers in the wavelength range of 0.28 micrometer to

2.05 micrometer. Specific wavelengths of interest are listed in the above bullet. Also, amplifier and modulator combinations for converting continuous-wave lasers to a pulsed format are encouraged. Amplifier designs must preserve the wavelength stability and spectral purity of the input laser.

- Ultra-low noise photoreceiver modules, operating at 1.6 micrometer wavelength, consisting of the detection device, complete Dewar/cooling systems, and associated amplifiers. General requirements are: large single-element active detection diameter (>200 micrometer), high quantum efficiency (>85%), noise equivalent power of the order of 10-14 W/sqrt(Hz), and bandwidth greater than 10 MHz.
- Novel, highly efficient approaches for High Spectral Resolution Lidar (HSRL) receivers. New approaches for high-efficiency measurement of HSRL aerosol properties at 1064, 532 and/or 355 nm. New or improved approaches are sought that substantially increase detection efficiency over current state of the art.   Ideally, complete receiver subsystems will be proposed that can be evaluated and/or implemented in instrument concept designs.
- New space lidar technologies that use small and high-efficiency diode or fiber lasers to measure range and surface reflectance of asteroids and comets from >100 km altitude during mapping to <1 m during landing and sample return with a size, weight, and power substantially less than 28x28x26 cm^3, 7.4 kg, and 17 W respectively. Technologies that can significantly extend the receiver dynamic range of the current space lidar without movable attenuators, providing sufficient link margin for the longest range but not saturating during landing. The output power of the laser transmitters should be continuously adjusted according to the spacecraft altitude. The receiver should have single photon sensitivity to achieve a near-quantum limited performance for long distance measurement. The receiver integration time can be continuously adjusted to allow trade-off between the maximum range and measurement rate. The lidar should have multiple beams so that it can measure not only the range but also surface slope and orientation.
- Fast laser beam steering mechanism to increase the sampling density, coverage, and signal to noise ratio of pulsed space-based Lidar. The mechanism needs to steer a 1064 nm pulsed laser beam through a set of at least 8 discrete and repeatable angles spanning a range of 10 mrad or greater along one dimension. The scan repetition rate needs to be 8 kHz or higher. Desired specifications include a pointing accuracy of 0.1 mrad or better, a settling time of <15 microseconds to switch between two angles apart, and a usable aperture of 10 mm (can be achieved using a beam expander as long as the outgoing beam meets all requirements).