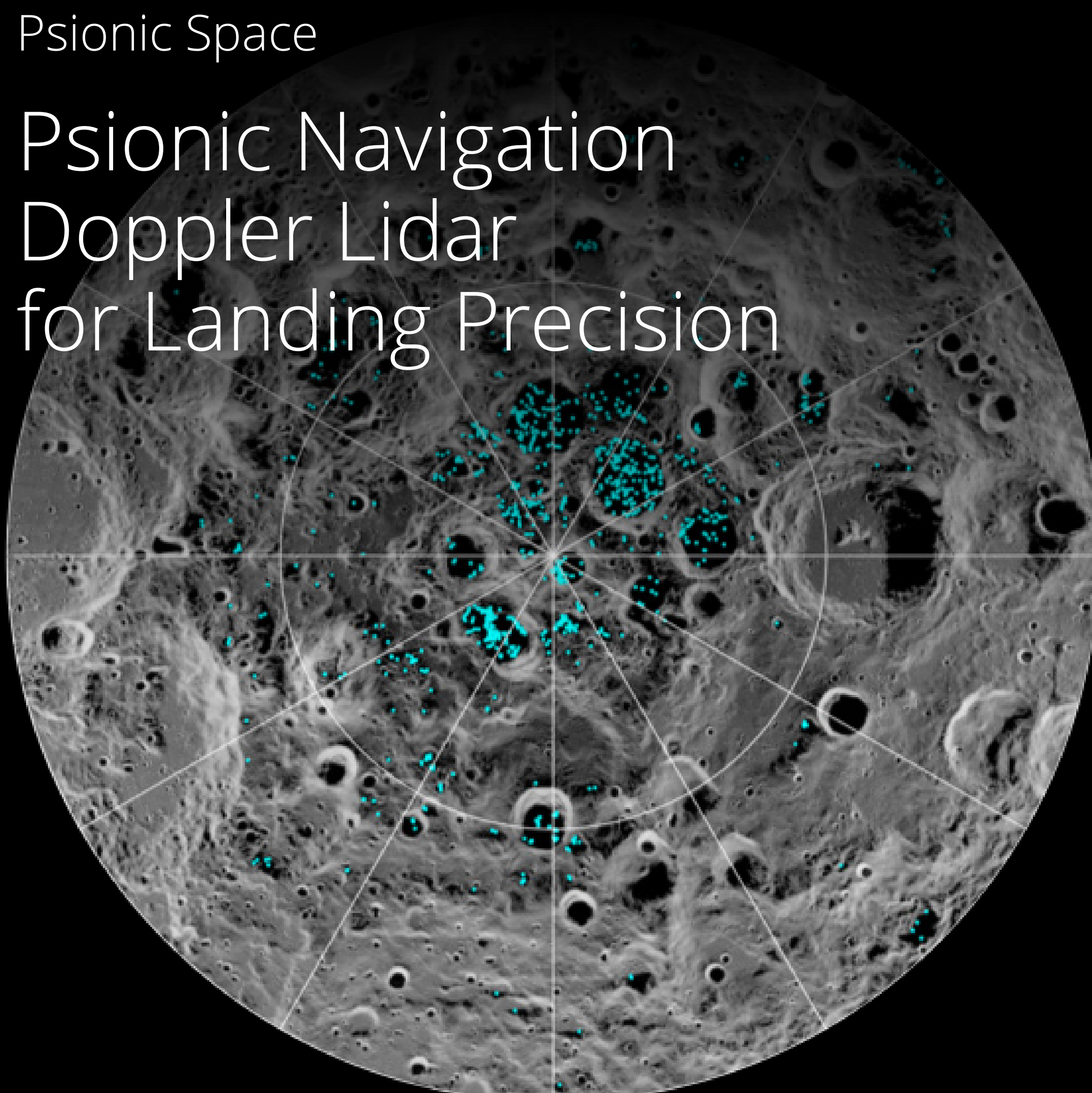
Technical Note

Psionic Space

Psionic Navigation Doppler Lidar for Landing Precision



Psionic Navigation Doppler Lidar for Landing Precision

Background

For a sustainable lunar base, both astronauts and cargo will have to land safely close to the supplies and inhabitants. Currently, human-rated landers are working toward the requirements for Class A payloads according to NASA NPR 8705.4.

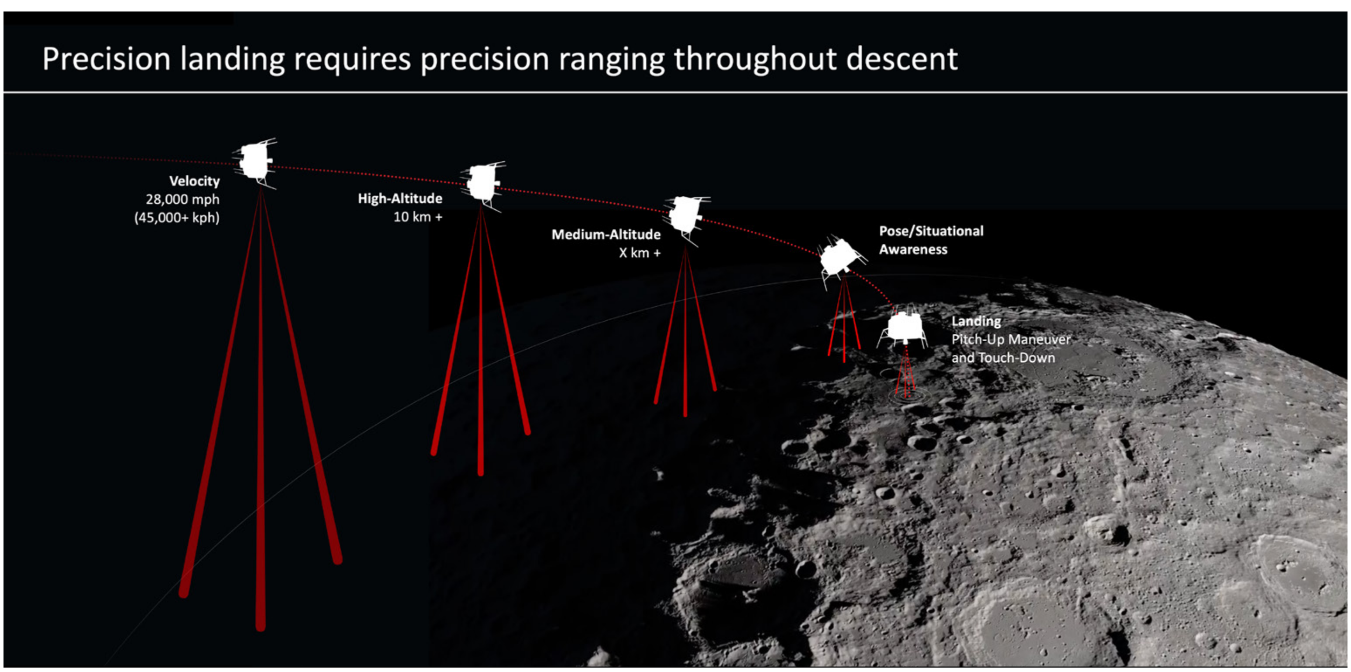
Given that cargo lander failures will endanger crew already on the surface, once the base is operational, un-crewed vehicles will also need to demonstrate exceptional reliability to protect human life.

For these reasons, it is critical that there are independent vehicle velocity sensors on board all landers to the Artemis base of operations.

Velocity

Navigation Doppler Lidar (NDL) is a three (or more) beam coherent lidar that directly measures the line-of-sight velocity of the sensor relative to the target in all beams. When the target is the surface of Mars or the Moon, these three line-of-sight velocity measurements are combined to calculate the three components (v_x, v_y, v_z) of the vehicle's velocity vector across the surface of the planetary body independently of any other sensor.

NDL measures all three line-of-sight velocities simultaneously, every 50 msec, to provide rapid, accurate, independent vehicle velocity vector measurements for precise navigation. These measurements give excellent horizontal velocity knowledge that is completely independent of any other sensor and are especially useful for optimizing the lander structural mass and ensuring astronaut safety. Demonstration tests prove NDL can provide these measurements from 4–5 km above the lunar surface.



Psionic Navigation Doppler Lidar for Landing Precision (Continued)

Line-of-Sight Range

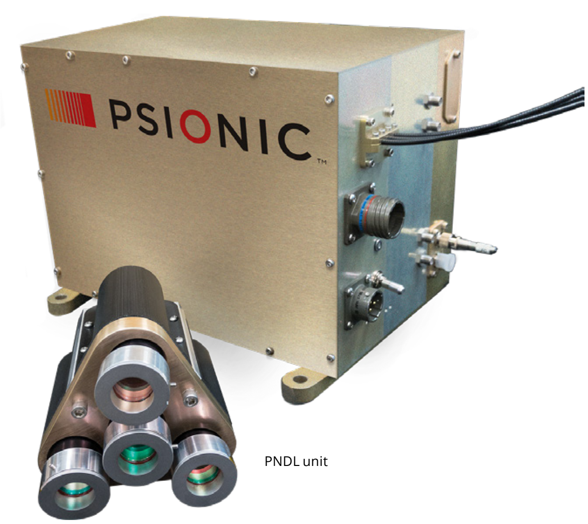
If the lidar beam frequency is linearly chirped, NDL can also measure line-of-sight range. Using three or more range measurements, the vehicle height above the ground and the vehicle pitch and roll can be determined.

Terrain Relative Navigation (TRN)

With its high SNR, NDL can measure up to 20 km without an atmosphere and can therefore serve as a sensor for terrain-relative navigation by measuring the vertical changes in the terrain below the vehicle for correlation with an onboard elevation model.

The impact on vehicle mass

In addition to safety and reliability, highly accurate and independent velocity vector measurements from NDL also reduce vehicle mass by reducing fuel consumption and structural mass through higher altitude measurements and lower horizontal velocity at touchdown.



PNDL unit

Comparing technologies

For Apollo, the IMU and the Doppler radar provided independent, dissimilar sensors for velocity and height measurements. NASA's Langley's Navigation Doppler Lidar, under exclusive license to Psionic, provides a smaller and more accurate method than Doppler radar. Both the Apollo radar and the newer Doppler lidar instrument measure Doppler shifts in at least three different beams to provide vector velocity measurements for the lander vehicle GN&C system to complement the traditional IMU.

There are other lidar sensors that use multiple time-of-flight lidars available as well. However, they can only provide height and vertical velocity measurements independent of the IMU. Adding a single beam Doppler lidar can provide horizontal velocity components, but only with knowledge of heading derived from other sensors, such as the IMU. As a result, this approach does not provide an independent velocity vector measurement.

Only NDL can provide highly accurate independent velocity vector measurements. This is especially important near touchdown when it is critical that the horizontal velocity of the vehicle be minimized.

Psionic NDL
Smaller than other solutions
Independent, simultaneous velocity (v_x, v_y, v_z); 50 msec
More accurate than other solutions
Consumes less power than other solutions
Exclusive NASA license to patents

PSIONIC™

About Psionic

Founded in 2017, Psionic is dedicated to the advancement and commercialization of Doppler Lidar for navigation.

The company has licensed the foundational NASA Langley patents around Navigation Doppler Lidar (NDL) and has further developed this technology to create an improved next -generation Psionic Doppler Navigation Lidar.

In addition to Space, Psionic's technology is applied to applications in Defense, Industrial, and Consumer markets.

psionic.ai

About the Author

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Steve spent 25+ years at NASA, including managing a staff of 600 people at NASA's Langley Research Center.

Sandford holds a BS in physics from Randolph Macon, MSEE from University of Virginia, MS in Optical Science from the University of Arizona. He is an author and lecturer on space, including *The Gravity Well* (thegravitywell.org) and *Shifts Happen* for TEDxNASA@ SiliconValley.

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