



PSIONIC AVIATION

Altimetry without RF Vulnerability



The FAA has documented more than 100 incidents of potential 5G interference since 2022. The majority of these were found to have a direct Radio-Altimeter (RA) impact resulting in safety alerts by other airborne safety-critical systems. In a Notice of Proposed Rulemaking (NPRM) dated Jan 11 2023, the FAA would require modifying certain airplanes to allow safe operations in the United States 5G C-band Radio Frequency (RF) environment by requiring that C-Band *tolerant* RAs be installed on those airplanes. In the same NRPM, “the FAA’s initial determination that radio altimeters cannot be relied upon to perform their intended function if they experience interference from wireless broadband operations in the 5G-Band remains unchanged.”

The aviation industry is taking on the burden of designing and implementing costly retrofit solutions to ensure that RAs are not compromised during landing.

AT&T and Verizon voluntarily implemented various mitigations, such as lowering the power levels of their 5G systems near airports and tilting antennas downward. They have agreed to continue these measures through July 2023.

This investment by the aviation and telecom industries will be wasted if a long-term mitigation plan is not put in place and codified in regulation since AT&T and Verizon operate their antennas in nominal conditions, additional wireless providers are expected to begin providing 5G services, and the FCC continues to auction frequencies that transmit close to the range used by RAs [4,200-4,400MHz].

Psionic FlightPath can be integrated into existing aircraft architectures to provide altimetry without RF vulnerability, offering a long-term mitigation solution for aviation.

Psionic FlightPath is based on the Navigation Doppler Lidar (NDL) technology developed by NASA for a fully autonomous, human-rated, rocket-powered lunar lander. The NDL is part of a navigation sensor suite designed to land on the lunar surface under any lighting condition and without GNSS aids.

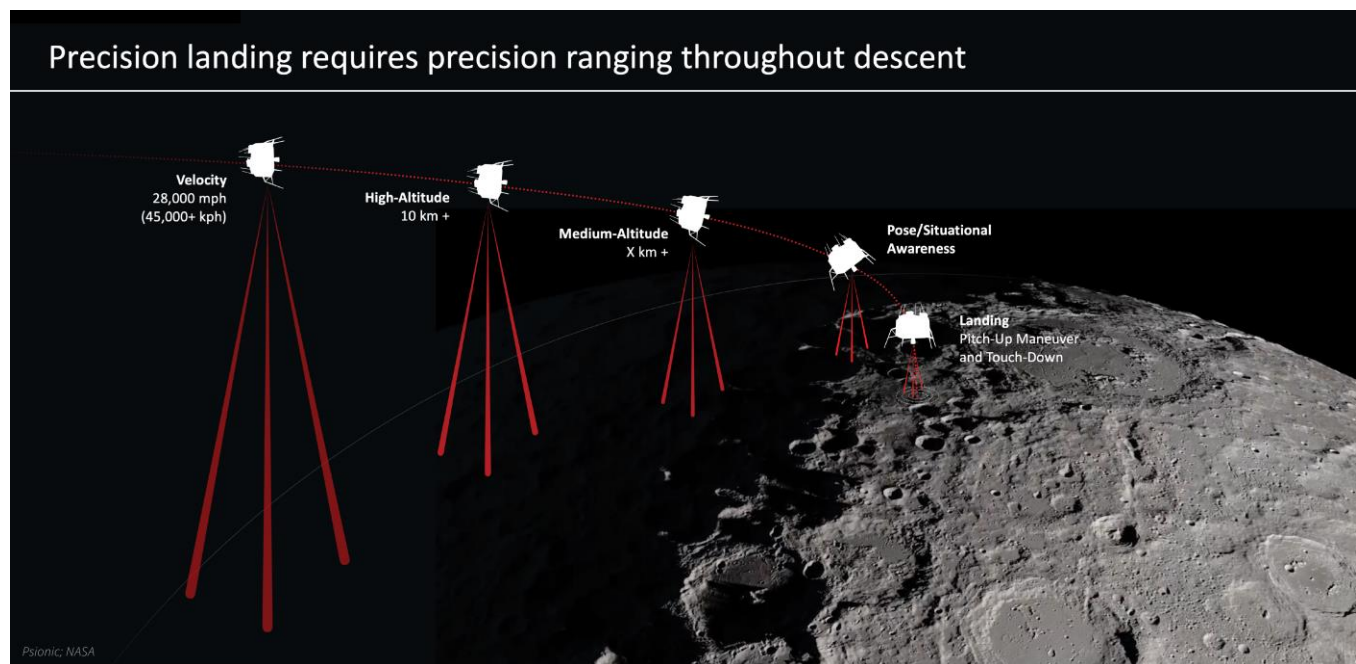
In each of its three (or more) beams, this coherent lidar measures the line-of-sight velocity and range of the sensor relative to the target.

For geometries similar to that shown in the illustration below, the line-of-sight velocity measurements are used to derive the three vector components (V_x , V_y , V_z) of the vehicle's velocity relative to the ground.

The measurement laser beams project a very small footprint on the ground, on the order of a couple of inches, essentially eliminating clutter error associated with conventional radar.

Impact of terrain

Psionic FlightPath measures relative velocity using the Doppler effect along the beam's line of sight and not from tracking changes in range as a function of time. For this reason, terrain elevation changes do not have any effect on the instrument's ground relative velocity measurements. In turn, terrain topography profiles are faithfully tracked by range measurements as a separate sensor data product.



Line-of-Sight Range

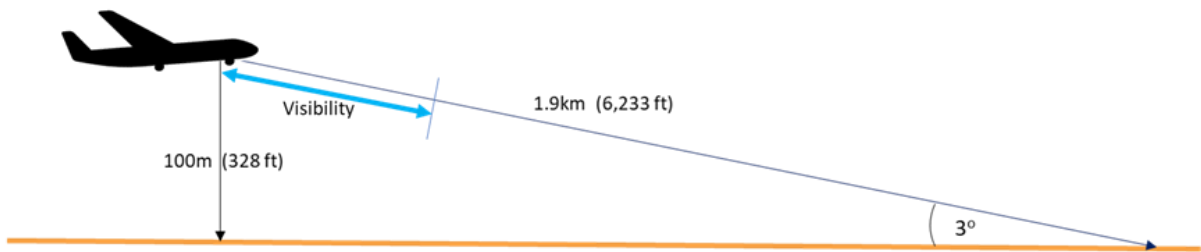
Because the lidar waveform is frequency modulated, Psionic FlightPath also measures line-of-sight range. Simultaneously with the velocity measurements, each beam provides slant-path distance to the ground, and for the special case where line-of-sight distances are available from 3 beams, the geometry reduces in such a way that the measured altitude above ground is derived and independent of the vehicle's attitude. Similarly, the vehicle's roll and pitch relative to the ground below may be derived.

Impact of weather, fog, and smoke

Psionic FlightPath operates in the short-wave infrared (SWIR) wavelength band and can penetrate atmospheric obscurants including fog, smoke, and rain better than a visible camera. see SWIR images below (Courtesy of Sensors Unlimited).



Modeling atmospheric transmission of the laser beams in the presence of various water vapor densities provides estimates of the Psionic FlightPath operational altitude as a function of visibility for a landing geometry similar to the one that is illustrated below.



Weather	Max Psionic Altitude	Visibility
Heavy Fog	100 m / 328 ft	Below 500m / 1,640 ft
Mist / Light Fog	500 m / 1,640 ft	Between 500m / 1,640 ft and 1,000m / 3,280 ft
Haze	1,725 m / 5,670 ft	Between 1,000m / 3,280 ft and 6,000 m / 19,680 ft

Comparing technologies

Compared to other technologies, such as time-of-flight lidars or radar-based instruments, Psionic FlightPath has several attributes:

- **Vulnerability to RF Interference**
None. Coherent lidar does not operate in the RF spectrum and is therefore robust to RF interference.
- **Accuracy and Resolution**
High. Wavelength is 1550 nm, resulting in better precision and accuracy compare to radar, with instrument-limited velocity resolution below 1 mm/s, and altitude within 7.5cm.
- **Clutter in measurements**
Very little to none. Small beam spot size results in little to no clutter in measurement data.
- **Signal-to-Noise Ratio**
High. SNR in the [10–10000] range results in fast, dependable measurements.
- **Impact of high-density urban environments**
None. Collimated beams and coherent-based discrimination allow operation in high-density urban environments.
- **Eye Safety**
 - High. Psionic FlightPath lidar is eye-safe at the telescope aperture.

Psionic FlightPath can be used as a complementary, dissimilar-physics source of height measurement, providing redundancy and increasing aircraft safety.

About Psionic

Founded in 2016, Psionic is dedicated to the advancement and commercialization of Doppler Lidar technology for navigation in the most challenging environments on Earth and in Space.

The company has licensed the foundational NASA Langley patents for Navigation Doppler Lidar and has developed this technology to create improved next-generation navigation, including Psionic SurePath for ground vehicles and Psionic FlightPath for commercial air.

About the Authors

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Founder and Chief Technology Officer

Steve spent more than 25 years at NASA, including managing a staff of 600 people at NASA's Langley Research Center. He holds a BS in physics from Randolph Macon, an MSEE from the University of Virginia, and an MS in Optical Science from the University of Arizona. Steve is an author and lecturer on space. His publications include *The Gravity Well* (thegravitywell.org) and his talks include "Shifts Happen" at TEDxNASA@ Silicon Valley.

Diego Pierrottet

Chief Engineer

Co-inventor on the core patent behind Psionic Doppler Lidar, Diego has 30+ years of experience in the design, development, and evaluation of laser radar systems, including for Air Force Research Laboratory and NASA. He received the NASA Exceptional Engineering Achievement Medal for the development of Navigation Doppler Lidar. He has numerous patents and has authored several articles for technical journals. Diego earned his BSEE from University of New Mexico and his Masters of Science in Electrical Engineering with a core concentration in Opto-Electronics from the University of New Mexico.

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