National Center for Atmospheric Research
Earth Observing Laboratory

Development Project

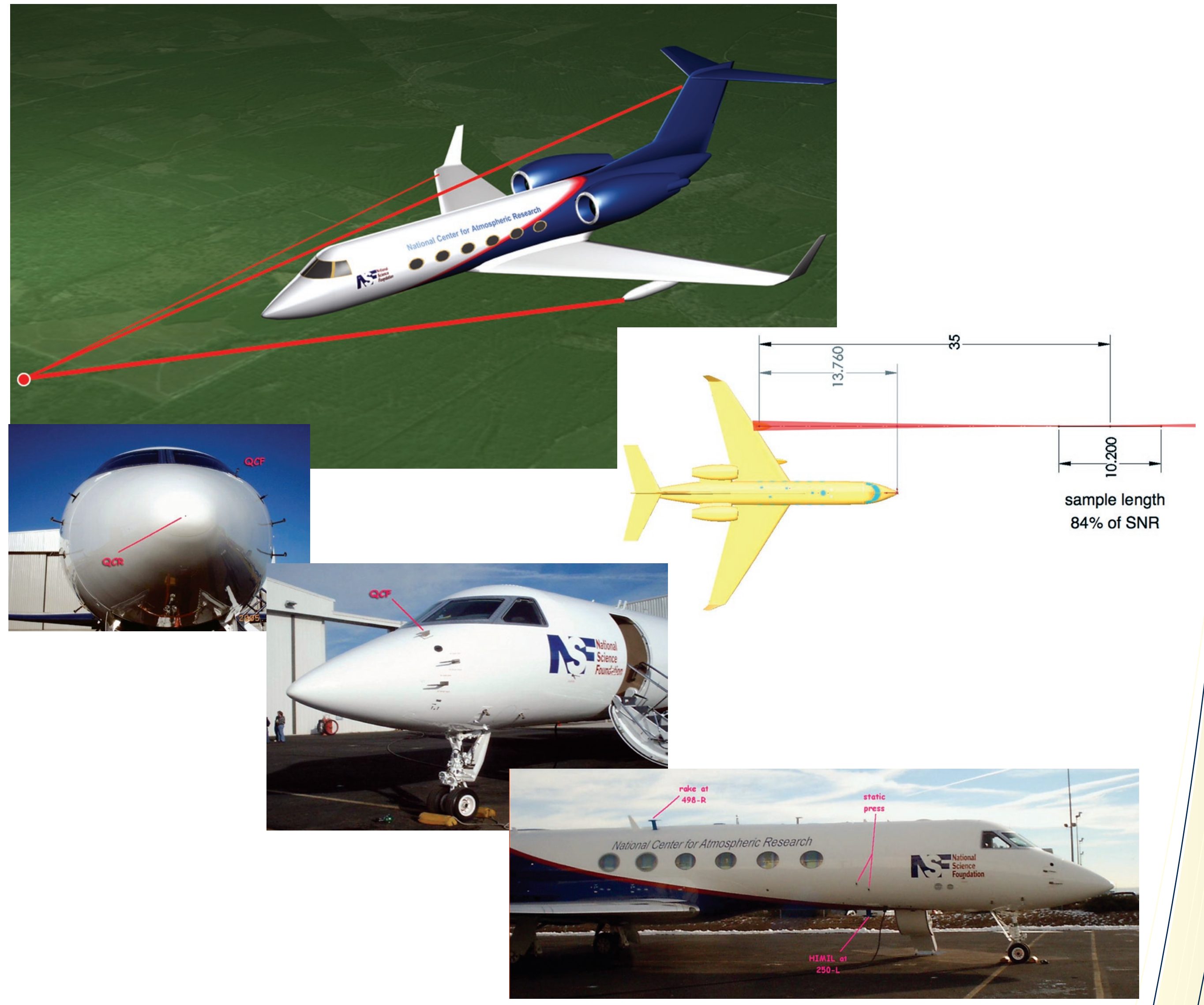
Laser Air Motion Sensor (LAMS)

Problem and Motivation

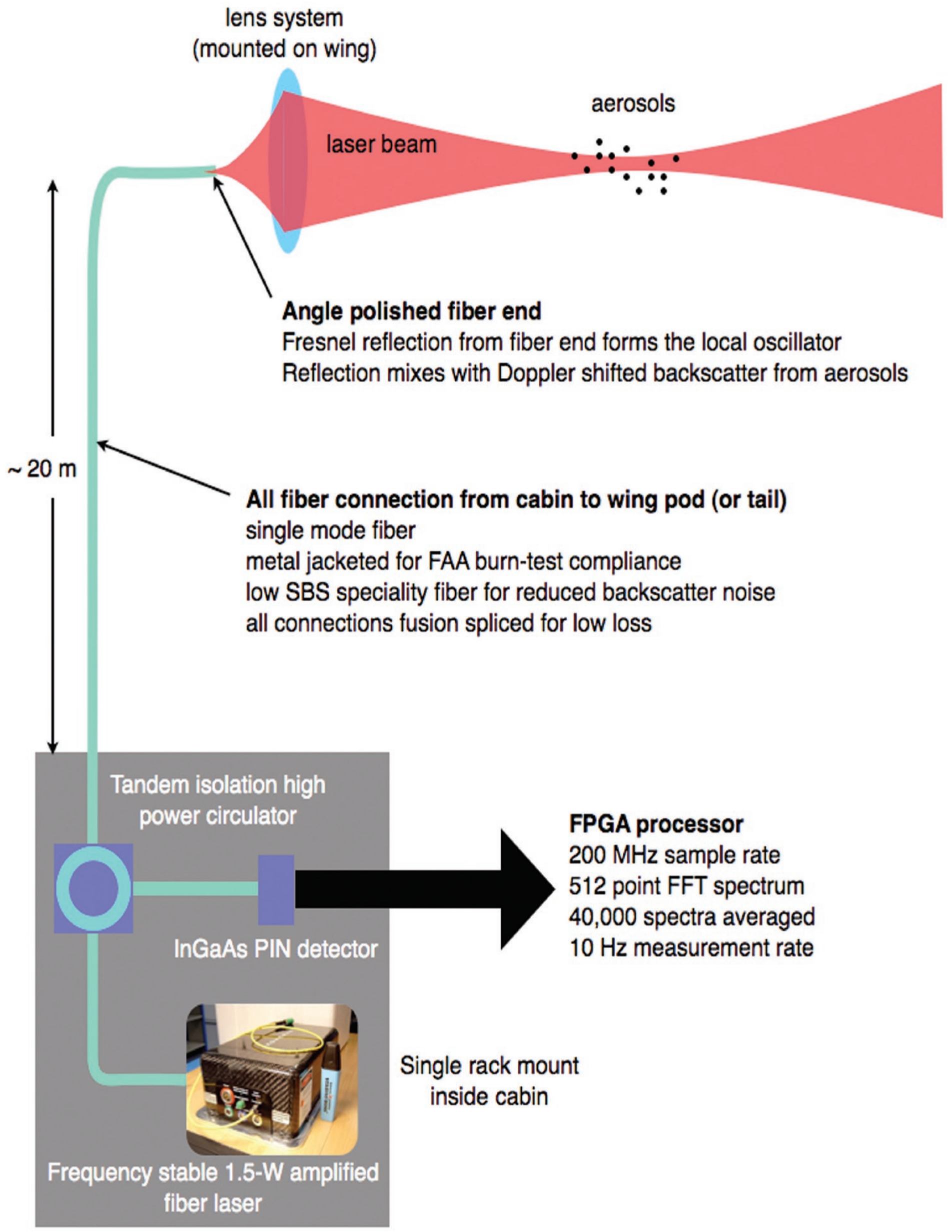
Accurate measurement of wind speed and direction is a fundamentally important measurement for virtually all atmospheric field experiments for the National Center for Atmospheric Research operated NSF Gulfstream V aircraft. Historically this measurement has been accomplished with a 5-hole radome gust probe which measures differential pressure at the surface of the aircraft radome. However air flow around the G-V radome and fuselage, which are not symmetric, are expected to result in significant errors in wind velocity estimates.

Proposed Solution and Concept of Operation

EOL is developing laser doppler velocimeter to measure aircraft wind speed and direction in undisturbed air flow in front of the aircraft.



Technical Approach



The Earth Observing Laboratory (EOL) develops and deploys observing facilities, and provides data services needed by our research community to make observations that are essential to broadening our understanding of the world we live in.

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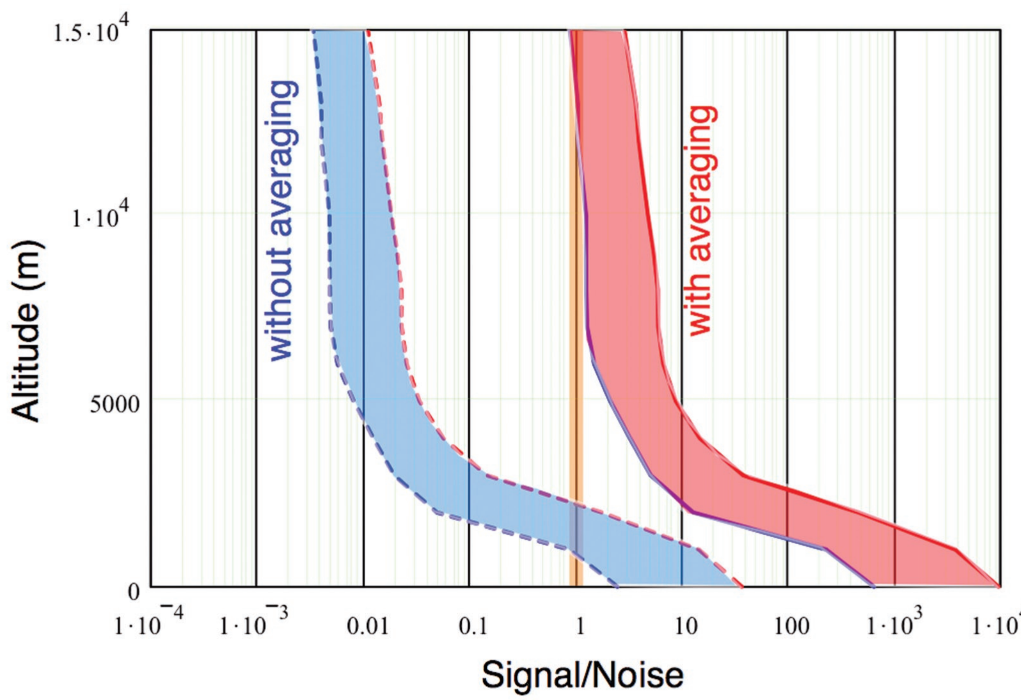
Estimate of Theoretical Performance

- The system performance relies on the presence of aerosols in the atmosphere. Specifically on the aerosol backscatter coefficient at the laser wavelength.
- The theoretical performance model shown below plots the expected signal to noise as a function of aircraft altitude.
- The performance has a range due to the variability of aerosol backscatter coefficients. The range spans from the conservative lower decile (probability of occurring > 90%) to median aerosol loading conditions. The backscatter coefficients used in the model were wavelength scaled from the ATLID reference model of the atmosphere.
- At low altitudes there is a higher loading of aerosols (influenced by planetary boundary layer) and SNR >1 is possible without averaging. The performance without averaging is shown shaded in blue.
- Performance at higher altitudes requires averaging of spectra. The area shaded in red shows expected performance of the instrument when averaging 40,000 spectra (512 point FFT, with 1.0 watt laser output).

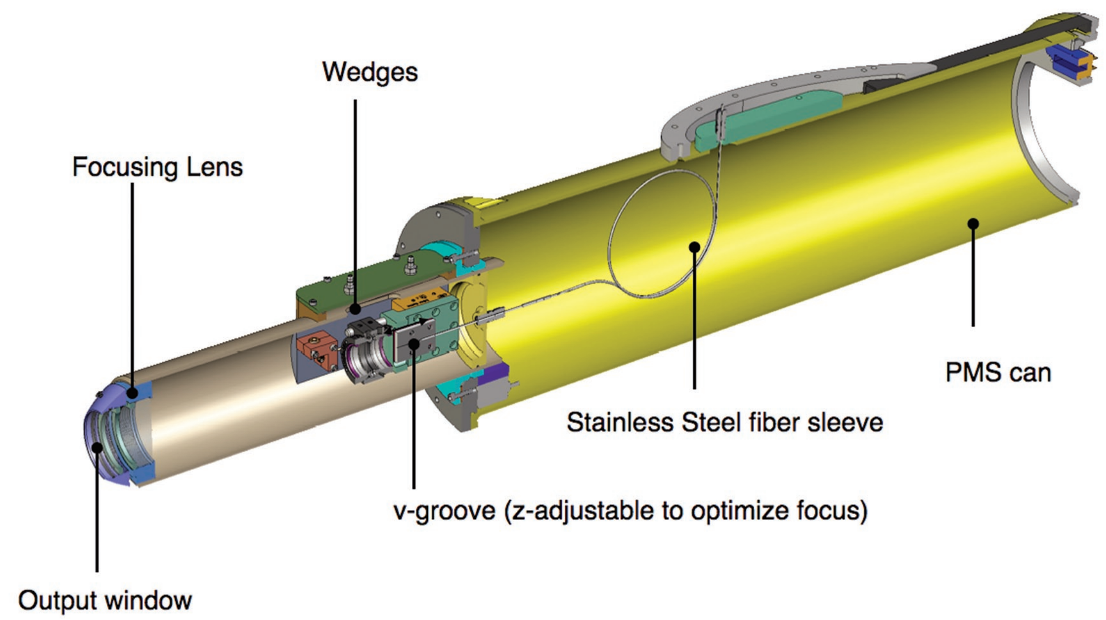


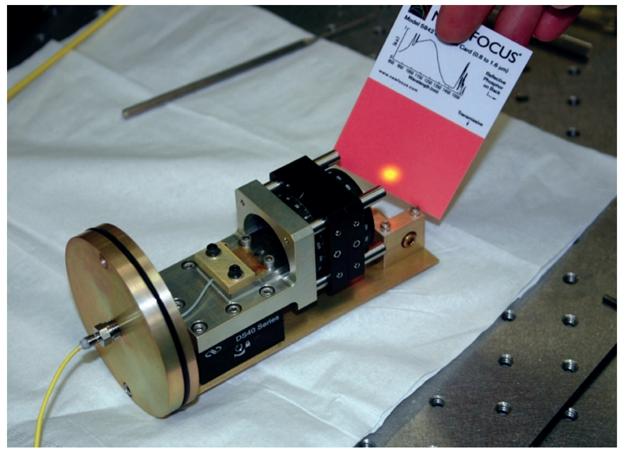
$$\mathrm{S/N} = \frac{\eta P_T \beta_\pi \pi r_t^2}{2Bh\nu} \int_0^\infty \left(L^2\left[1+\left(\frac{\pi r_t}{\lambda L}\right)^2\left(1-\frac{L}{f}\right)^2\right]\right)^{-1} dL$$

$$\mathrm{S/N} = \frac{\eta P_T \beta_\pi \lambda}{2Bh\nu}\left[\frac{\pi}{2} + \operatorname{atan}\left(\frac{\pi r_t^2}{\lambda f}\right)\right]$$

Prototype for initial aircraft tests

Ground validation tests have been performed successfully and development continues to improve instrument performance. Initial flight test demonstrated first principles in high scattering environments.





Fiber Optic Head

LAMS Optical Head installed under GV wing