Applications of LAMS in Addition to Wind Measurement

1. Calibration of Pressure Systems
2. Determining Temperature from LAMS and a Pitot-Static System
3. De-Iced Airspeed Indicator and Temperature Sensor

Calibration of Pressure Systems

All aircraft have systems for measuring the pressure at the altitude of flight. Usually these are connected to openings called static ports, which are placed to minimize distortions caused by airflow around the airframe. Calibration of these systems is very important for operation of the aircraft because the altitude at which an airplane flies is determined from this pressure measurement. Incorrect pressure measurement therefore can lead to an incorrect altitude and possible flight hazards.

For this reason, aircraft manufacturers calibrate pressure-sensing systems accurately, often using a device called a trailing-cone system that trails a pressure sensing port behind the aircraft. Such systems are expensive to install, and their deployment in flight also involves special precautions. For these reasons, an alternate system capable of calibrating pressure-measuring systems on aircraft might have commercial value.

The LAMS can provide such an alternative if used in combination with a pitot tube that measures the "total" pressure, which is the combination of the pressure at the flight altitude and the excess pressure, called dynamic pressure, that results from the motion of air impacting the forward opening of the tube. The airspeed that LAMS measures can be used to predict the dynamic pressure, and subtracting that from the total pressure yields the desired pressure and flight altitude. The equations for this calculation are given in the attached draft manuscript, which also shows how this can be applied to the NCAR/NSF GV to improve the pressure measurements on that aircraft.

Determining Temperature from LAMS and a Pitot-Static System

The measurement of temperature from an aircraft is made more difficult by the dynamic heating experienced by a sensor exposed to the air stream. The LAMS, when combined with a standard pitot-static system, can provide an alternate measurement of temperature that does not rely on and exposed sensing element. This is possible because LAMS measures the airspeed directly, while the pitot-static system permits measurement of the Mach number. The attached draft manuscript shows that the speed of sound is given by the actual airspeed divided by the Mach number, so the speed of sound can be determined by the combination of LAMS and a pitot-static system. The speed of sound in error is a function only of the temperature, so this makes it possible to measure temperature independent of any standard temperature sensor.

One problem with normal temperature sensors is that they can become wet in cloud, and if wetted they will sense an incorrect temperature. The LAMS provides valid measurements in cloud because the laser light is backscattered from cloud droplets or ice crystals just as it is from aerosol particles. Therefore the measurement of temperature provided by the LAMS should remain valid in cloud. This argument is also developed and evaluated in the attached draft manuscript.

Anti-Iced Airspeed Indicator and Temperature Sensor

Commercial airliners and other high-altitude aircraft have occasionally encountered flight conditions that cause their airspeed indicators to become inoperative. While this can occur as a result of normal icing, the more serious events have arisen in regions where there is a high concentration of small ice crystals. It is thought that these ice crystals accumulate so as to block airflow to the airspeed sensor. The same phenomenon can also affect temperature sensors. Because most commercial and high-altitude aircraft are flown under the control of flight management systems, the incorrect information fed to those systems can cause them to malfunction. Loss of airspeed information can be particularly troublesome to pilots, who rely on this information to keep the aircraft in a safe flight envelope.

Because of the importance of these systems to flight safety, alternate reliable measurements could have commercial value. For LAMS to provide such an alternative, a means of protecting the optical window from coverage by ice is needed. In the current version of LAMS, this is provided by heaters in thermal contact with the windows. To handle the highest rates of ice accumulation, these heaters would need to be more powerful, or else airflow control would need to shield the windows at least partially from the impact of ice particles.

The importance of an alternate measurement like this is highlighted by the accident involving Air France Flight 447, which is thought to have occurred after an effect like this on the airspeed measurements of the aircraft. See http://www.skybrary.aero/bookshelf/books/1834.pdf#page=42.