Low Density Atmospheric Turbulence Measurement using Pitot Tubes

**Adrien Bouskelaa, Chris Masona, Sergey Shkarayeva**

*a Department of Aerospace and Mechanical Engineering, University of Arizona, Tucson, AZ 85721, USA*

Unsteadiness in atmospheric flows is of great importance to modeling accuracy and studies of airborne vehicle dynamics. These can include local variations in holographic winds, shear layers between high-speed regions, and perturbations due to thermal variations. In addition to weather modeling, all of these features are of interest for atmospheric energy extraction using fixed wing aircraft, meaning such data is of high engineering and scientific value. Yet, there is a gap in regular measurements on Earth and an absence of significant measurements on Mars. Although there are regular weather balloon launches on earth for high altitude measurements, wind is determined by the relative position of the balloon via a GPS sensor. On Mars, limit data is measured during spacecraft Entry Descent and Landing phases and at the landing site. For more detailed and global results simple distributed sensors are required.

The growing field of autonomous Unmanned Aerial Vehicles (UAVs) in the form of aircraft, rotorcrafts and controllable balloons offer an elegant solution to this problem. Any steady wind or turbulence present in the atmosphere is represented by their difference in ground relative and air relative velocities. With the ground velocity measurement being trivial, a sensor capable of high frequency measurements of the velocity relative to the atmosphere would complete the solution.

In the present work such a sensor is developed based on the proven pitot-static tube design. Multiple probes placed at known angles relative to the vehicle body provide the components required to determine both relative velocity magnitude and body relative angles. Analysis of flow components on the measuring ports of commercially available pitot probes is conducted. Experiments in a low-speed wind tunnel are performed, validating the system performance, analyzing its limitations, and conducting sensor calibration. Then, results from ongoing flight experiments using weather balloons will be presented. These Sensors have the capability of mounting on the previously presented Mars sailplane, completing its autonomous navigation system with accurate wind measurements of the environment while flying within it. Furthermore, dedicated missions are imagined, replicating daily NOAA launched on mars using the pitot-probe system and small spacecrafts. Proposing a method for comprehensive atmospheric measurements for remote planetary bodies.