CALIBRATION OF TRUE AIRSPEED USING GPS

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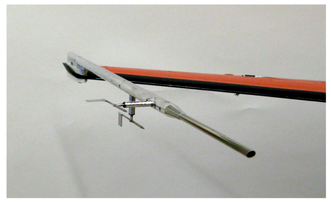
BACKGROUND

- Airspeed is a term used to describe how fast an airplane is flying.
- In flight, airspeed has to be measured very accurately because the safe and efficient operation of an aircraft depends on it.
- The accuracy of airspeed measurements cannot be compromised, because failure of aircraft air data system to report the accurate true airspeed of the aircraft could cause fatal accidents.
- The Air France Flight 447 plane crash into the Atlantic Ocean on June 1st, 2009 was caused by the icing of the aircraft pitot tubes that reported inaccurate airspeed readings, which ultimately resulted in the pilot bringing the aircraft into a stall condition that the plane eventually never recovered.
- The system (sensors and software) used to measure airspeed is called an *air data system*, and it must be calibrated before its first use.

PROBLEM

- Conventionally, airspeed calibrations are done by mounting another calibrated air data system with sensors mounted on long poles jutting out of the leading edge of the airplane wing or the nose.
- This calibration procedure is a complex and time-consuming process, which requires expensive and cumbersome equipment.
- It is not suited for small airplanes such as unmanned aerial vehicles (UAVs).



A conventional precision airdata probe system mounted on the wing tip to calibrate the airspeed sensors on an aircraft [1].

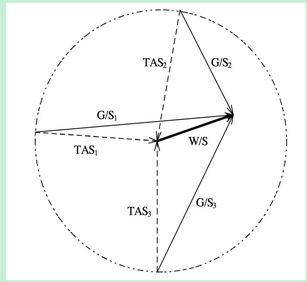
RESEARCH OBJECTIVES

- Explore ways of using GPS to calibrate *air data systems*.
- Produce a MATLAB algorithm that relates the accurate GPS velocities to the airspeed measurements on board the UAV in order to calibrate the airspeed sensors on the UAV.

MATERIALS / METHODS

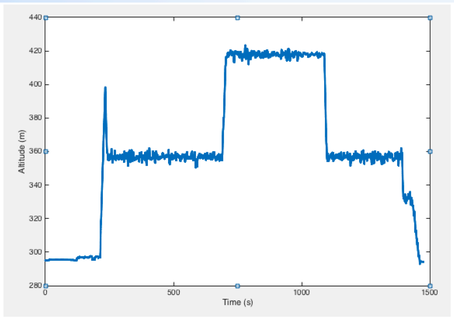
- Flight tests were conducted using a GPS-enabled UAV: The Vireo Unmanned Aircraft System by FourthWing Sensors.
- A MATLAB algorithm was written to relate the UAV airspeed and the UAV ground speed (both quantities obtained from the flight test data matrix).
- The MATLAB algorithm written produced estimates of the wind speeds in terms of its North, East, and Down directions, as well as the errors in airspeed readings.

The Vireo Unmanned Aircraft System used during flight tests [3].



The vector relationship between ground speed, true airspeed, and wind speed [2].

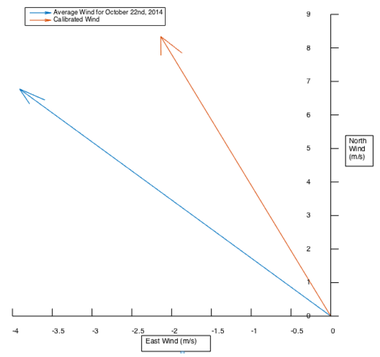
RESULTS



Flight Altitude Profile of Test Flight

	Airspeed Error (m/s)
Overall Flight (Including Ground)	-1.6464
First Altitude (Approximately 360m)	-0.4748
Second Altitude (Approximately 420m)	-0.2249
Third Altitude (Approximately 360m)	-0.5734

Airspeed Errors at Different Altitudes of Test Flight



A Comparison between the Average Wind Vector and the Calibrated Wind Vector

CONCLUSIONS

- The MATLAB algorithm produced could determine the errors of the airspeed sensors of the UAV, and the airspeed errors were verified to be correct.
- The estimates of the wind speeds and directions generated by the MATLAB algorithm generally matched the average wind conditions by the National Weather Service on that day.
- The creation of this airspeed calibration MATLAB algorithm is definitely a step forward in the airspeed calibration field, because it not only simplifies the whole airspeed calibration process, but also is able to determine the wind conditions encountered by the UAV.

REFERENCES

1. Foster, John V., and Kevin Cunningham. "A GPS-Based Pitot-Static Calibration Method Using Global Output-Error Optimization." *48th AIAA Aerospace Sciences Meeting*. 2010.
2. Rogers, David F. "ASI Calibration." *Newsletter of the World Beechcraft Society* 12.4 (2000): 10.
3. FourthWing Sensors [Internet]. "VireoTM Unmanned Aircraft Systems." *FourthWing Sensors;* [cited 2015 Apr 20]; [about 2 pages]. Available from: http://www.fourthwing.com

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2. This research was done under the full guidance of Prof. Demoz Gebre-Egziabher.
3. The UAV flight tests in this research were conducted by Dr. Hamid Mokhtarzadeh with equipments from the University of Minnesota Department of Aerospace Engineering and Mechanics.
4. The verification of research results were conducted by University of Minnesota Department of Aerospace Engineering and Mechanics graduate student Jonathan Mueller.