Flow rate and filter efficacy analysis for measurement and collection of stratospheric aerosols.

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Project Synopsis:

H.A.R.B.O.R. (High Altitude Reconnaissance Balloon for Outreach and Research) is a student run program at Weber State University in which high altitude balloon systems are designed, constructed, and flown by students to carry out their individual research projects. These systems are constructed using commercially available weather balloons from which several research payload capsules are suspended. Payloads include atmospheric monitoring equipment along with both still and video cameras. The payloads have to fit within tight restrictions such as weight and density to comply with the F.A.A. regulations to fly. As well these capsules have to withstand the harsh conditions, such as cold temperature and high G forces, that exist during these flights to the upper atmosphere.

The HARBOR program has successfully flown for five seasons now and has gathered extensive data that has become a foundation for further research topics. One area of interest is particulate measuring, sampling, and testing from the upper atmosphere. Particulate capturing and study of them under the SEM (Scanning Electron Microscope) can help answer many questions such as the origin of the particulates, their effect on climate change or directly measure the pollution of air traffic. The SEM has the ability to analyze these particulates captured on a filter and determine their elemental composition by way of EDS (Energy Dispersive x-ray Spectroscopy)

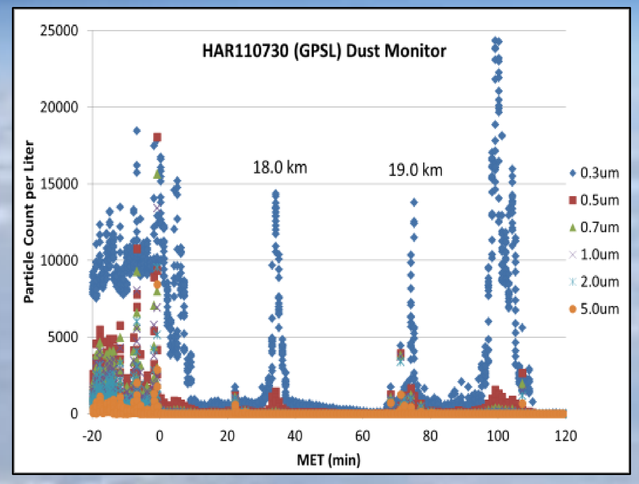

Figure 1: Typical dust monitor data that shows very distinct spikes of counts at about 18 km.

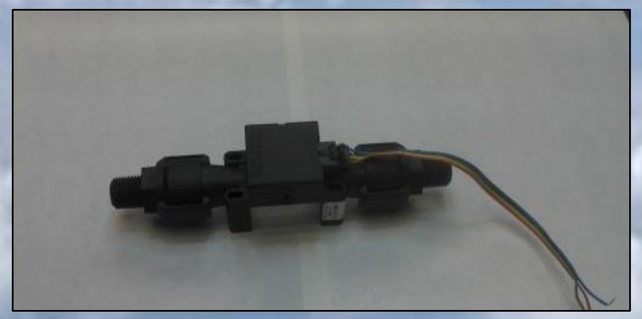

Figure 2: AWM5101 Flow sensor was pushed to its limits In the environmental chamber.

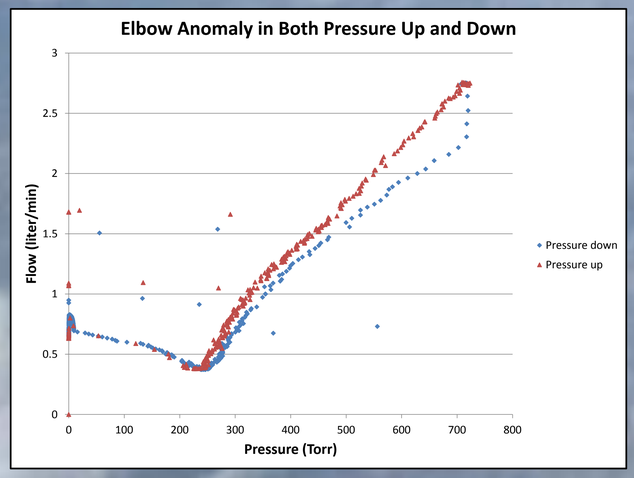

Figure 3: Strange behavior in the flow at about 250 Torr. Anomaly is still being investigated. There are two regions with a linear relation between pressure and flow. We assume the pumping changes at a critical mean free path.

Design and Methodology:

During previous flights particulates were counted as the flight ascended into the stratosphere. Multiple flights detected two very distinctive spikes of particulate counts at approximately the same altitude. This resulted in a new HARBOR research effort dubbed the “Sample Return Mission”

A preliminary sample return mission was attempted by Allen Liddell in the 2011 flight season. That system was simple and self sufficient, but did not include the element of air flow measurement. The 2013 flight season will have an improved sample return system including measurement of air sample flow.

To measure flow we ordered a AWM5101VN flow meter which uses thermal resistivity to a heated grate that the air flows though. The change in temperature is directly related to the volume and density of the air flowing.

Once calibration was set, the same test was run in a vacuum chamber, to simulate the conditions in the stratosphere. It was linked up directly with the same type of pump found in the dust monitor. Gathered all the data of pressure and air flow through a LabVIEW program. An unexpected anomaly occurred at about 250 Torr (the pressure at an altitude of 8.5km or 28kft ASL), where the flow rate increased and almost leveled out at around .75 liter/min. This is most likely caused by a change in pumping dynamics related to the longer mean-free-path between gas molecules. Although, we cannot yet rule out that the gauge has a critical point for measuring mass flow.

This data will be used to calibrate our own dust monitor and various gas sensors that will be a part of our Multi-Sensor Array which is flown on every HARBOR flight.

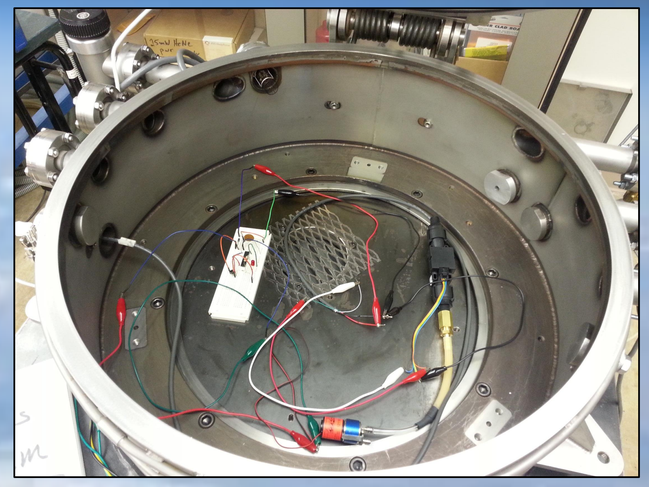

Figure 4: Flow test in the environmental chamber. Pump, (blue) is pulling air through the Flow sensor and is being controlled by a PIC microcontroller (white board)

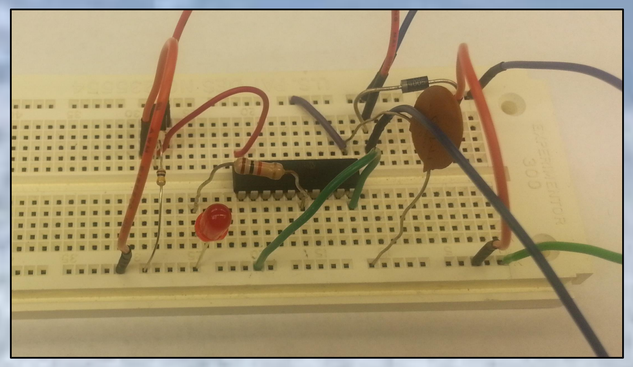

Figure 5: Microcontroller that controls the air pump, switching it on and off at pre-determined altitudes for sample collection.

The future of this project is to measure air flow through different sample collection filters to understand both the flow rate and filtration capabilities at low pressure. We will then implement this into the new design of a Sample Return device that will be flown during the 2013 flight season.

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