

AIRBUS PERLAN MISSION II



Teachers in Space



ISEP Interdisciplinary Science and Engineering Partnership



Atmospheric Net

Through Teachers in Space, Inc., our CubeSat experiment has been chosen, as one of eight, to fly aboard the Airbus Perlan II. The mission is to set a new altitude record for a fixed-wing aircraft by flying a pressurized high-altitude glider (the Perlan II) higher than any other manned wing borne aircraft has ever flown (90,000 feet – into the stratosphere). The Perlan II will ride stratospheric mountain waves and the polar vortex to obtain its record altitude, and in so doing, harvest invaluable data about earth's atmosphere and its ozone layer. Our experiment addresses the question: can the deployment of an atmospheric net allow us to see some aspects of what normally cannot be seen? We are casting a net into the atmosphere to capture a variety of tiny particulates drifting above the Earth's surface ([a nod to Mary Poppin's "Let's Go Fly a Kite"](#)), to identify a few of them using electron microscopy, and to show how they differ with altitude. Using rubber bands as a form of proxy data (rubber band degrade with exposure to ozone) we will demonstrate the high concentrations of ozone in the stratosphere. This project involves two groups of students: six college students from SUNY Buffalo State (BSC) registered for an Atmospheric Science course, and five 8th Grade students from the Dr. Charles R. Drew Science Magnet School (Drew Science Magnet), an inner-city school partnered with the Buffalo Museum of Science (BMS). We are supported, in part, by a joint University of Buffalo/Buffalo State/Buffalo Public School Interdisciplinary Science and Engineering Partnership (ISEP), funded by NSF DUE 1102998.

<http://teachers-in-space.com/>

<http://www.perlanproject.org/>



Dr. Stephen Vermette is a professor of Geography within the Department of Geography & Planning at SUNY Buffalo State. He received his doctorate from McMaster University (Hamilton, Canada). Stephen teaches meteorology and climatology courses at SUNY Buffalo State, and he has published a number of research articles, as well as popular magazine articles, on meteorology- and climatology-related subjects. Stephen was awarded the National Council for Geographic Education (NCGE) 2006 Distinguished Teaching Achievement Award, SUNY Buffalo State's President's Award for Excellence in Teaching 2010, and the Virginia Figura Award (2011) for distinguished service to geographic education in New York State.



Mrs. Stephanie Finn is the Science Instructional Coach at the Dr. Charles R. Drew Science Magnet School P.S. 59 in the Buffalo Public School District working with teachers and students from PK – 8. Prior to becoming an instructional coach Mrs. Finn taught middle school science (grades 5-8) in the Buffalo Public School System. Mrs. Finn is an ISEP (Interdisciplinary Science Engineering Partnership) Coordinating Teacher, member of STANYS (Science Teacher Association of New York State) and the National Science Teachers Association (NSTA).

Experiment:

Atmospheric Net

Faculty:

Stephen Vermette (BSC)
Stephanie Finn (Drew)

BSC Students:

Seth Atkinson
Zachary Greymont
Zachary Klisiewicz
Rachel Lucas
Amanda Skowron
Kayla Szykowny

Drew Students:

Walter Anderson
Austen Fiannaca
Kyneshi Holloway
Destiny Goldsmith
Cintera Quigley

ISEP Support:

Dan MacIsaac (BSC)
Joe Gardella (UB)

Additional Support:

Peter Bush, Lab for Forensic Odontology Research (UB)

Dept. Geography & Planning (BSC)

Arthur W. Gielow
Meteorology Fund

Week 1 – Program Kick-off

Stephanie Finn hosted our kick-off event at the Dr. Charles R. Drew Science Magnet School. Here the two groups of students (Drew and Buffalo State) met for the first time, learned about their project, and as a symbol of commitment signed the project poster.



The Student Team

Top (L to R): Zachary Klisiewicz, Amanda Skowron, Rachel Lucas, Zachary Greymont, Seth Atkinson, and Austen Fiannaca
 Bottom (L to R): Kayla Szykowny, Cintera Quigley, Destiny Goldsmith, Kyneshi Holloway, and Walter Anderson.
 (not shown: Ryan Mutterer)



Stephen Vermette describing the Perlan II mission



Signing the project poster



Learning about their project

Continues...

Week 2



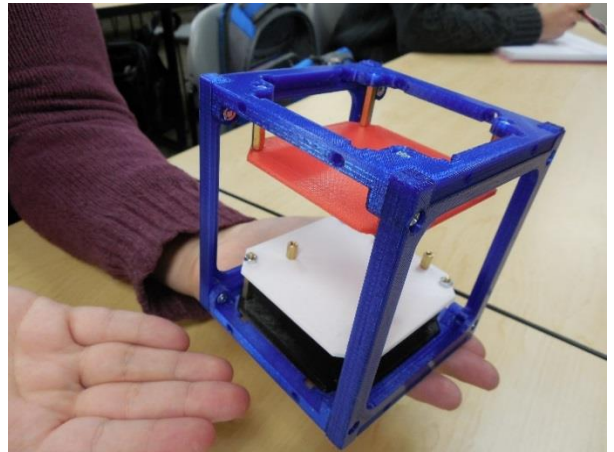
A segment of WeatherBUFF talk radio (WBNY-FM 91.3), hosted by Kayla Szykowny and Seth Atkinson, discussing our 'Atmospheric Net' experiment.

For the Perlan II mission, one thing we would like to do is to determine the amount of ozone in the stratosphere without directly measuring its concentration. The reaction of a rubber band to high levels of ozone provides a proxy method to measure the presence of ozone, much in the same way a climatologist would observe tree rings in order to determine how wet or dry the climate was at a particular time in the past. Rubber bands consist of molecules that are very long chains called polymers. Ozone has a high oxidation capacity, and after short exposure, weakens the molecular bonds that constitute the rubber bands causing the rubber to actually break down – a process called “ozonolysis”. In breaking down, the rubber releases carbon atoms, ultimately changing the weight, structure, functionality, tensile strength and appearance of the rubber band. Physical evidence of ozonolysis can be seen in the “cracks” or “pits” perpendicular to the direction of stress.

Based on literature research, provided by the college students the rubber band is best stretched while exposed to stratospheric ozone, but as cold temperatures relax rubber, the experimental rubber band may ‘relax’ when exposed to cooler temperatures at high altitudes. To keep the rubber band at a continuous tension, tweezers, springs or even weights need to be considered as part of the experimental design. The response of the rubber band could be determined by noting any cracks or pits in the rubber band pre- and post-flight, measuring differences in the stress relaxation pre-and post-flight, and weighing the rubber band (measuring carbon loss) pre-and post-flight. By determining the amount of carbon lost, compared to the amount of ozone exposure, we can possibly obtain a ratio that tells us the expected loss of carbon from the rubber band at stratospheric ozone levels.

The amount that the rubber band is stretched may affect its response to ozone. Taking information provided by the college students, as well as from their own search of the literature, the 8th grade students are currently testing the response of rubber bands to the effects of heightened ozone concentrations to come up with an ideal tension for the experiment.

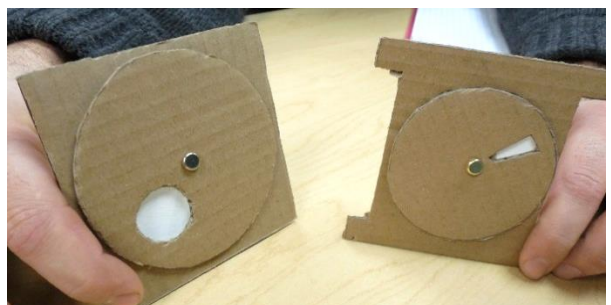
This week the college students assembled our CubeSat, and came up with filter cartridge concepts for consideration in the experiment.



Our assembled CubeSat frame. The blue frame was created on a 3D printer.



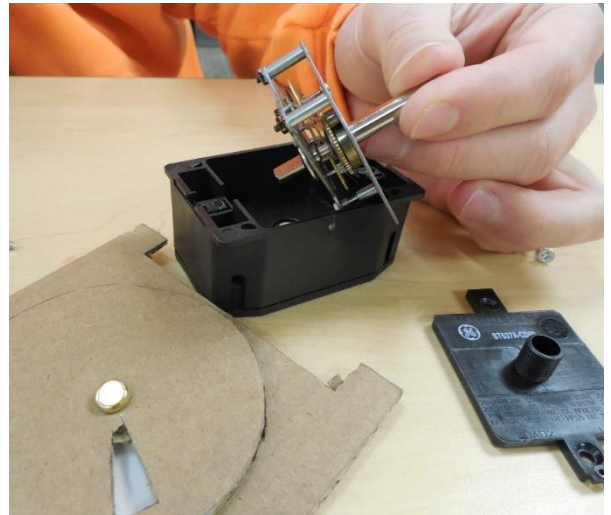
Filter Concept #1: using barometric readings a stepper servo rotates the opening to expose filters at specified altitudes.



Filter Concept #2: The opening rotates on a clock mechanism creating a streak of collected particles on one filter. Time and altitude are correlated from data provided by the Perlan II mission.

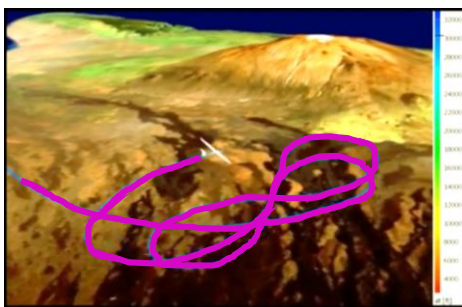
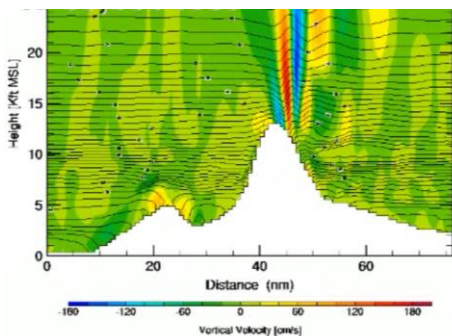
Spring-wound?

We continue to engineer our CubeSat experiment. After receiving and assembling the Cube with parts provided, we realized that the addition of an Arduino computer, servo, battery pack, and circuit board left little space for our experiment. The Arduino board and servo were to be used to rotate our filter carousel. The first filter concept required the Arduino and a barometer (detects altitude) to control the rotation of the filter carousel, exposing filter at set altitudes. The second filter concept only requires the filter carousel to rotate. Why not use a simple spring-wound timer? We are experimenting with a 60-min timer, and if found suitable, we will purchase an 8-hour timer. This will allow room on the CubeSat for our filter carousel as well as other proposed experiments.

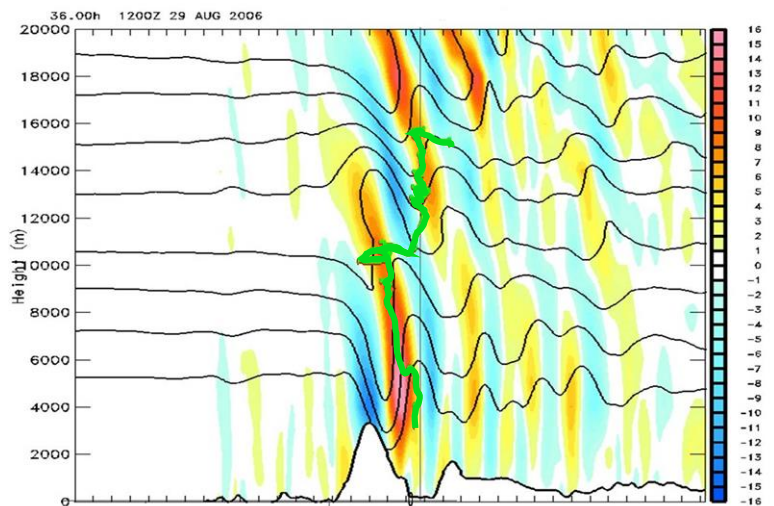


Mountain Waves

This week our discussion focused on Mountain Waves, as it is these waves that will provide the lift for the Perlan II. Mountain waves, the periodic changes of atmospheric pressure, temperature and height in a current of air - occur wherever winds are perpendicular to the mountains and are forced up and over the mountain range. The energy gained by the wind, as it rises over the mountain, is expressed as wave like motion on the leeward (downwind) side of the mountain. Ideal conditions require winds blowing across a sea or plain, encountering a mountain with a gradual slope on the windward side and a steep slope on the leeward side. The strongest waves develop in a stable layer of air. The first leeward wave usually has the greatest amplitude – propagating upward due, in part, to decreasing air density. The resulting decrease in resistance focuses the waves energy on amplitude growth.



We viewed a Hawaii mountain wave flight (April 4, 2008 – David Bigelow) Note the orange area (above diagram) shows rising air. The lower diagram shows the figure eight flight path, as the glider stays in the rising air.

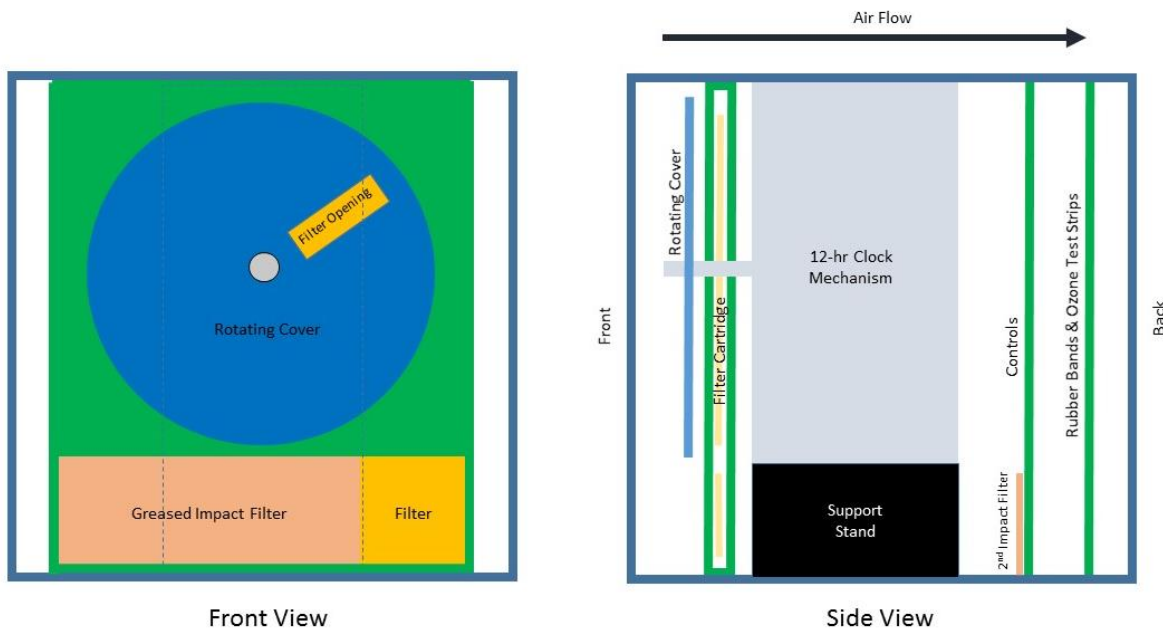


Flight path (green) of the Perlan I (2006). Air is rising in orange-shaded areas. Note that the first wave has the greatest amplitude, and was used by Perlan I to gain altitude.



We studied the geography of the launch site - El Calafate, Argentina (orange dot) – and determined that the westerly winds associated with the 'Furious 50's', the ocean fetch, and the morphology of the Andes Mountains at this location (steeper on the leeward side) are ideal for the production of mountain waves.

Week 4



Draft Schematic of our CubeSat

After much discussion and experimentation we have come up with a draft schematic of our CubeSat (see above). We have decided to go with a spring-wound clock mechanism to rotate our filter carousel. We tested the clock down to -23°C , and it worked fine. We have learned from Teachers-in-Space that we are to provide four duplicate experimental sets for each flight. To minimize set up time and chances of contamination, etc. we decided to assemble are experiments on three cartridges which are easily added and removed on rails from our CubeSat. The schematic shows three cartridges – the filter cartridge, the control cartridge, and the rubberband/ozone test strip cartridge – of which four sets of each will be provided to the Perlan II mission.

Filter Types

The original proposal called for two filter setups. One to collect material at different altitudes, and another to be continually exposed for the duration of the flight. Both filters would be analyzed by electron microscopy. We are currently exploring filter types for electron microscopy (see next weeks report). We also explored the possibility of an additional type of filter – a greased impact filter - to be employed as part of our experiment. A thin layer of petroleum jelly would be applied to a glass plate. It is sticky, not harmful, and has no freezing point, thus it will remain sticky throughout the Perlan II mission. After exposure, material collected on the greased impact filter would be heated (liquefied) in our lab and passed through a filter designed to collect material caught on the original grease impact filter.



We tested the petroleum jelly down to -23°C and it did not freeze.

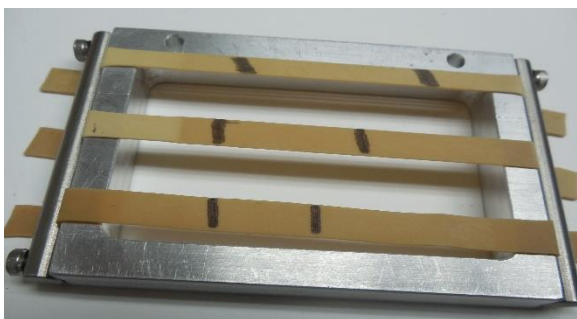
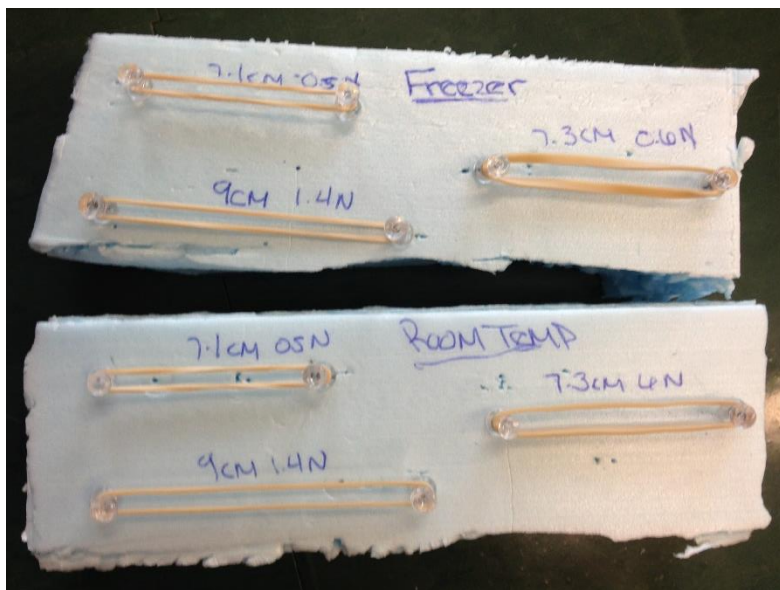
What Might be Found by Casting Our Net?

In class students researched the types of materials that may be captured with our atmospheric net. Materials included various anthropogenic (man-made) pollutants, resuspended materials, particulates associated with forest fires and volcanic eruptions, insects (check out the Billion-Bug Highway at: <https://vimeo.com/21493827>), smaller bioaerosols (including pollen and spores), and even the possibility of nanobacteria. It was clear in our discussions that the winter flight of Perlan II at El Calafate, Argentina, while perfect to catch a mountain wave, is not best suited for capturing particles in the atmosphere. The latitude of El Calafate in the southern hemisphere does not include many anthropogenic pollution sources, insects and bioaerosols might be scarce due to winter conditions, and much of everything else is limited by the limited land masses found at the latitude of El Calafate, Argentina. On the other hand, aerosols from the previous summer and secondary pollutants (sulfate particles) may still be found at high altitudes and the amplitude of the mountain wave may bring materials up into the atmosphere.

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Rubber Bands

As rubber bands are to be used as a proxy method for ozone concentration within our CubeSat, we spent time this week working up some experiments.

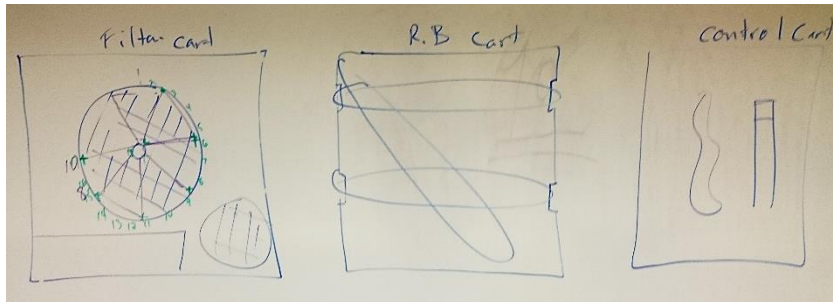
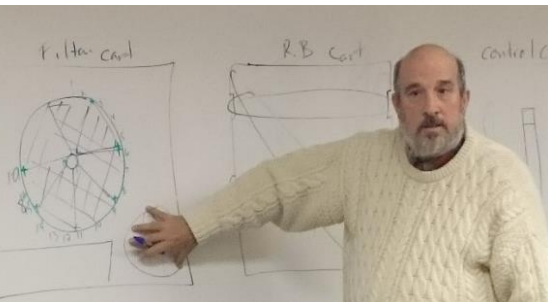


During a visit to an electron microscopy lab at the University at Buffalo, we learned that they will be able to use electron microscopy to measure pitting and tears in rubber bands to identify the impact of ozone exposure. Above, students are preparing a slide for electron microscopy.



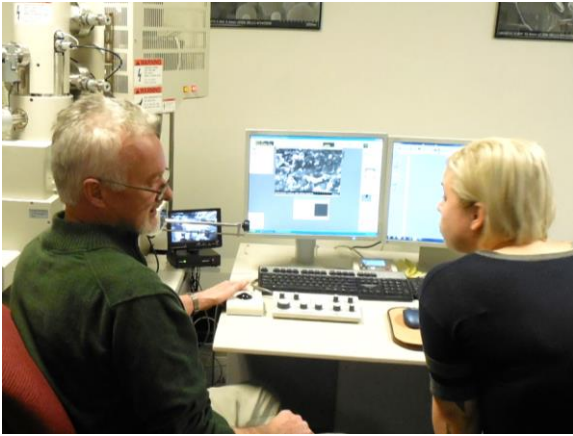
The 8th grade students were testing the impact of extreme cold on rubber bands placed in a freezer at -18°C , and compared them with rubber bands at room temperature. Rubber bands were stretched to different lengths for the tests. They noticed that the ones in the freezer were harder to stretch and appeared "stronger". They did not break as easy. They also noticed that they warmed up pretty quickly (within 3-4 minutes).

The 8th grade students are also preparing for a visit to the electron microscopy lab, where they will look at material caught on a filter, as well as their ozone exposed rubber bands.



A conversation with Peter Bush (Lab for Forensic Odontology Research at UB) helped us choose the correct filter and pore size. We chose a Nucleopore filter with a pore size of 0.2 microns, as this size allow us to capture bacteria. In addition we worked out a design that included a mesh support and the cutting of filters into pie shapes. Dr. Vermette is shown discussing the design with students. Above, an illustration of our three cartridges during a class presentation.

Week 6



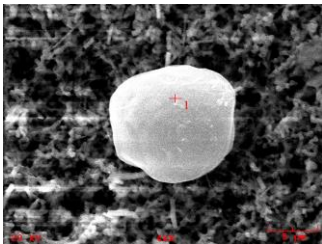
Dr. Peter Bush (UB) explaining the workings of the electron microscope to Kayla (BSC).



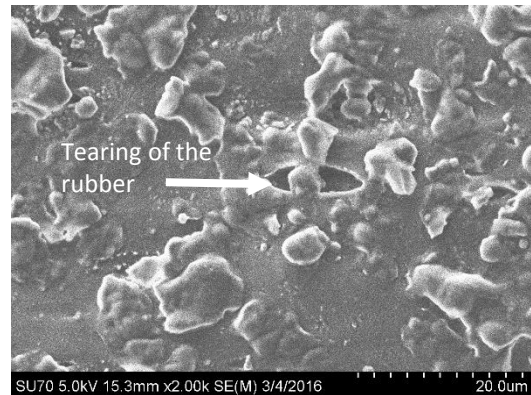
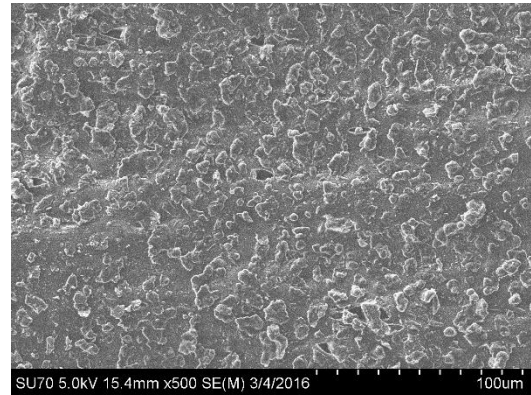
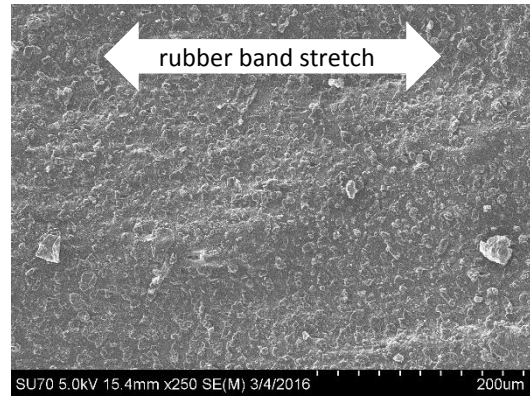
Kayla having an opportunity to work the controls.



A visit with Dr. Peter Bush at the electron microscopy lab at UB allowed us the opportunity to test procedures to view rubber bands under different magnifications on the electron microscope. The tests were successful (see images to right). This test also allowed us to view the rubber bands before exposure to ozone (fresh out of the bag). These images will be compared to images taken after our test exposure to ozone. The rubber bands appear to have two coatings, one is made up of CaCO_3 , which is likely used to lighten the color. Besides noting a coating on the rubber bands we also noticed tearing in the stretched bands (lower right image). In addition, the use of Energy-dispersive X-ray spectroscopy allows us to study the chemical composition of the rubber band (sulfur is an indicator of rubber) and eventually will be used in identifying material caught by our filters on the Perlan II mission. As a test, we identified a 10 micron particle caught on a filter. It turned out to be composed of NaCl – likely sweat that fell on the filter.



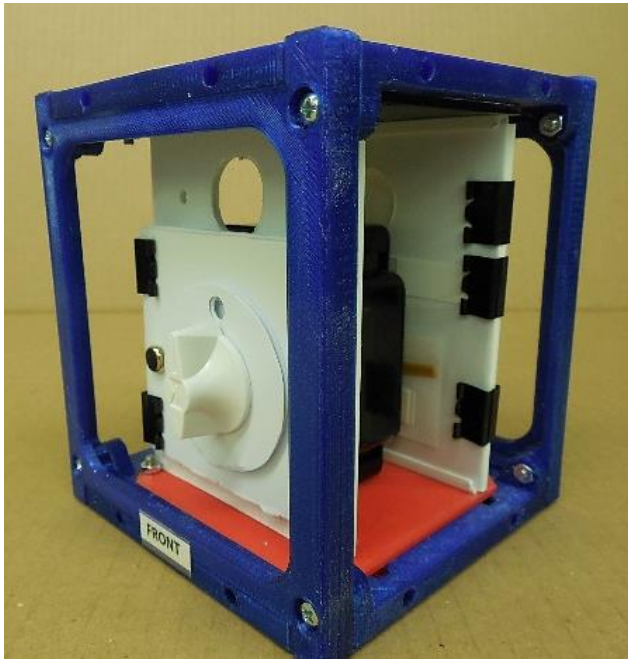
NaCl particle on filter



Atmospheric Science class watching a Google Hangout with the Perlan team <https://vimeo.com/156959084>

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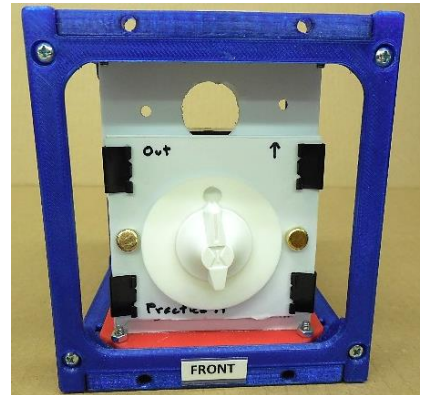
Week 7



Atmospheric Net CubeSat

The 'Atmospheric Net' CubeSat was completed and mailed off to Teachers in Space, Inc. The design is true to the original proposal, although a great deal of work went into implementing our original design. Early on we realized that the Arduino computer, battery, etc. provided by Teachers in Space, Inc. would not allow sufficient space to house our filters mechanisms. We decided to use a spring-wound clock (we used a 10-hour clock) instead of the computer. There were many conceptual and draft models of our filter mechanisms crafted out of cardboard, wood, and plastic. Discussions with Dr. Peter Bush (UB electron microscopy lab) helped finalized our design. Certainly, access to electron microscopy makes our experiment possible.

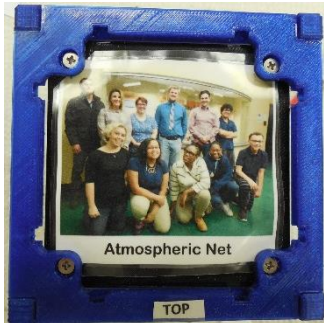
Our experiment will now be sent to Nevada where it will be placed in a vacuum chamber for testing, and later to fly aboard the Perlan II test flights in April. The goal is to test out the glider and our experiment, before the ultimate mission in Argentina.



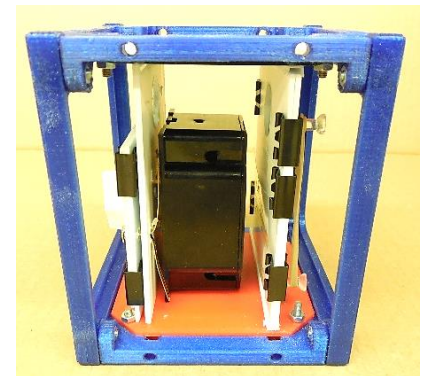
Front



Students assembling experimental cartridges.



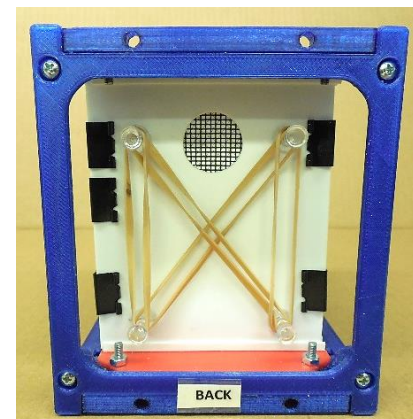
Top view – the team



Side



Cartridges were assembled and sealed in plastic. Four sets of cartridges were prepared (four flight boxes), one for each test flight. A practice cartridge was also prepared.



Back

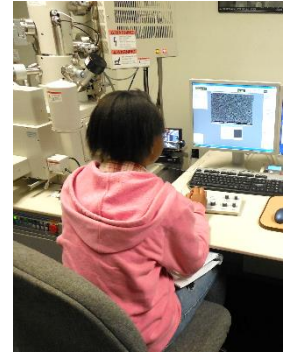
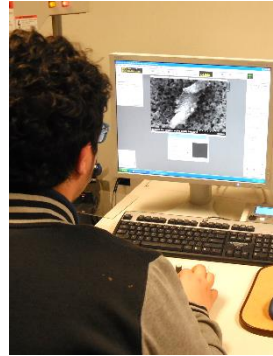
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Week 8

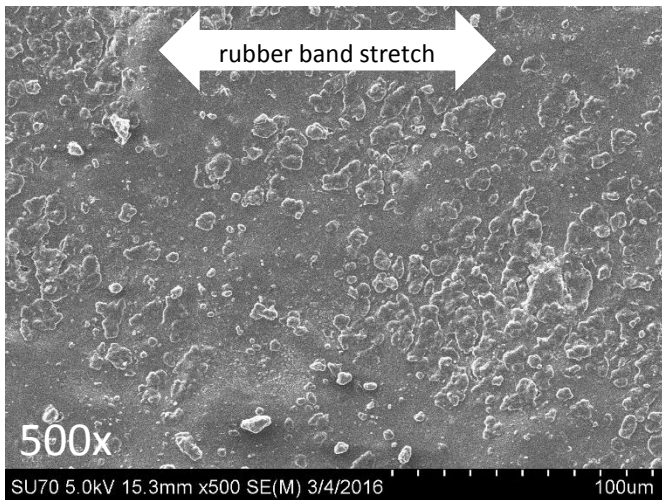


Dr. Peter Bush explaining the workings of the electron microscope to students from the Drew Science Magnet school.

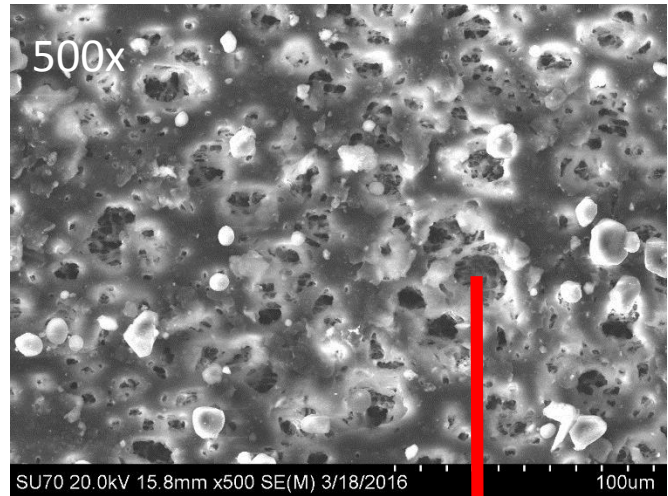
Students from SUNY Buffalo State and from the Drew Science Magnet school visited the electron microscopy lab at UB to identify ozone damage on our test rubber bands. Our rubber bands were placed at two copy centers for 10 to 12 days (copiers produce ozone). Our goal was to identify the signs of ozone-related damage, so that we can later recognize damage associated with exposure to stratospheric ozone.



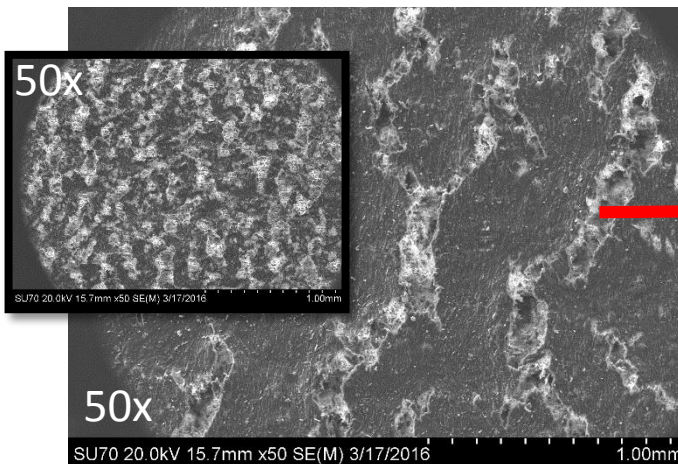
Students working the electron microscope.



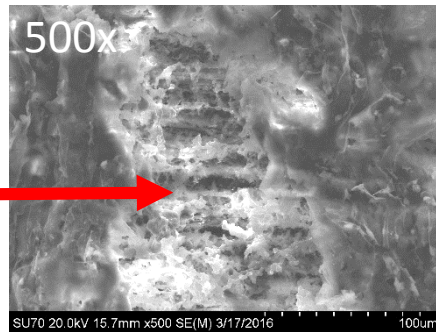
Rubber band not exposed to ozone (fresh out of bag)



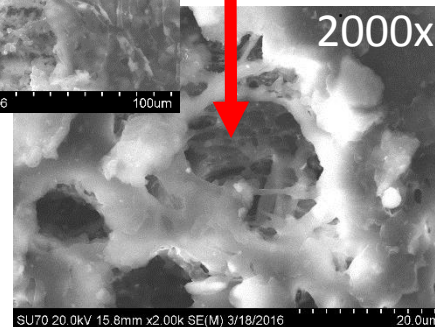
Ozone exposed rubber band (copy center #2). Note pitting of surface.



Ozone exposed rubber band (copy center #1). Note linear degradation of rubber. Insert: greater stretch of rubber band = greater ozone damage. Continues...



Higher magnification. Note tearing parallel to stretch direction.



Pitting shown under greater magnification