University at Buffalo
The State University of New York

PNEU-Core

Design Challenge: Subsurface Sampling Device

UB AIAA Microgravity Research Team

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Paul T. Schifferle

Paul Schifferle, Adjunct Instructor, AIAA Faculty Advisor

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I. Technical Section

A. Abstract

NASA has been actively creating systems to allow for travel and exploration beyond Low Earth Orbit. Destinations of interest include celestial bodies in milligravity and microgravity. In order to study these types of bodies, we need to collect samples from underneath their surfaces. Subsurface samples are important in understanding the history of the body and also in describing its internal structure. The tool which we have designed to collect subsurface samples is the *PNEU-Core*. This tool is a drill with the ability to extract subsurface samples in microgravity conditions while minimizing cross contamination between the samples. It will be able to drill into sedimentary regolith as well as solid rock via the use of two different coring attachments. One is an auger coring attachment for use in loosely compacted regolith, and the other is a polycrystalline diamond compact (PDC) attachment for use in solid rock. These attachments will be stored on the device when not in use, and the device will have a safe design to protect the user at all times.

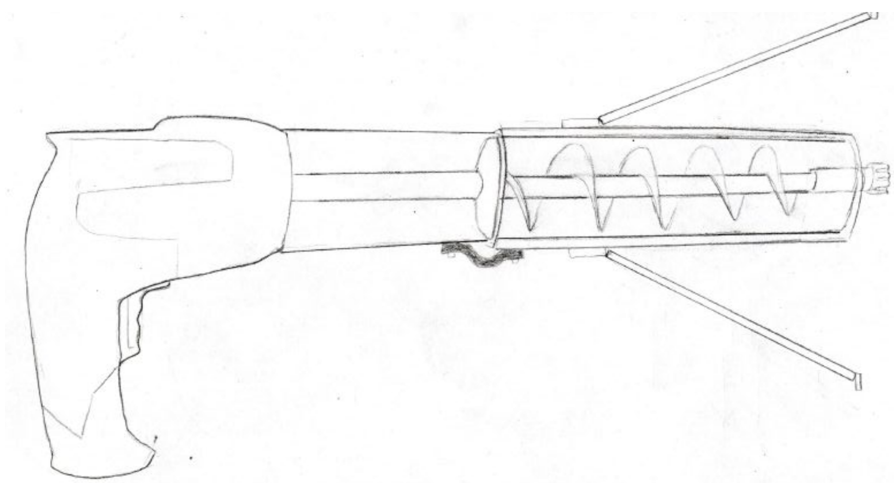

Figure 1. PNEU-Core Preliminary Design

B. Test Objectives

1. Manufacturing Methods:

The sampling device will be manufactured as follows:

- Commercially available pneumatic drill as our base component.

- Non PVA filament (as it is water soluble) used with an additive manufacturing method, such as 3D printing, to develop prototypes of attachments and components to improve ergonomics.
- Metal alloys such as carbon steel used with a subtractive manufacturing method, such as turning, to develop components such as the outer and inner shells.
- Permanent joining methods, such as welding, to combine the parts into a complete assembly.

Upon completion, the prototype will be analyzed and tested for effectiveness and error. Redesigns will be made to improve the design to ensure a polished, successful final product.

2. Device Description:

Our design will utilize a premade pneumatic drill as the power device used to spin the coring devices. It will be operated at 90 psi (according to the safety specifications found in section II). This device will have a tether that is one inch in diameter, attached to the diver's tether line at all times.

For the regolith coring device, there will be three main parts. One component is the hollow, rigid, and transparent inner tube that will be used as the collection chamber for the regolith sample. Lining this transparent tube will be a clear and flexible plastic sleeve that acts like a drawstring bag or pouch. When the drawstring is pulled at the top of the collection device, the bottom of the sleeve will close around the regolith. This sleeve will not leave the rigid tube, even after coring is complete, and is only used as a capture device to keep the regolith from falling out of the bottom of the collection tube. The top of the collection tube will have a very fine titanium mesh which prevents any regolith from escaping while allowing the water to leave during the coring process. A similar device can be seen in the figure below (Quan, Tang and Jiang).

The second part of the regolith device is an auger that fits around the rigid collection tube. The rigid collection tube will be attached to this auger via planetary gears. In the planetary gear assembly, there will be a mounting plate on which the gears are placed. This mounting plate is what the inner collection tube will be mounted to. This mounting plate will be locked to the drill head to prevent rotation relative to the drill. This will prevent rotation of the collection tube as well. We do not want the collection tube to rotate in order to preserve the stratigraphy of the regolith sample. The planetary gears will step down the gear ratio in order to create a very slow angular velocity of the auger. This will allow the diver to control how slow the auger will dig into the sample bed. The auger will be wide enough to not disturb the soil around the collection tube.

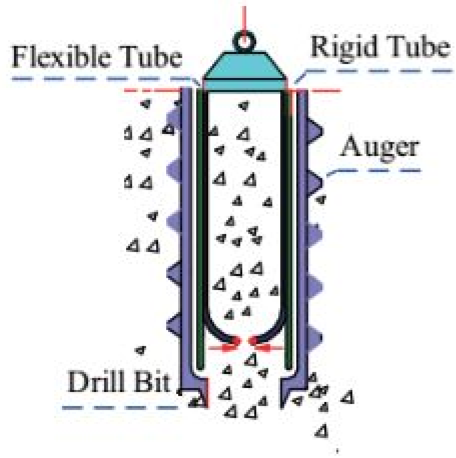

Figure 2. Regolith Core Sampler

The third component will be a safety casing that surrounds the auger and compresses when the auger digs into the regolith. This is in place to cover the sharp edges of the auger and to prevent accidental damage or puncture of any astronaut equipment. There will be appropriate warning labels on the outside casing, advising users to be careful of the sharp objects contained within.

The sandstone coring device will be slightly different. It will still feature the first and third parts listed previously (the inner tubes and outer cover). The difference is in the drill bit. Instead of an auger, the end of the drill attachment will consist of a PDC coring bit. This bit is made to bore holes in hard, solid materials.

3. Challenge Requirements:

1. Your device shall be able to extract sample from the provided sampling platform. Please refer to Micro-G NExT Sampling Platform Presentation for descriptions of the sampling platform.

We will have two types of coring attachments, one for the regolith platform and one for the sandstone platform. Our regolith drill will consist of a threaded auger, drill bit, flexible tube, rigid tube, and seal. The drill will penetrate the surface, while the auger rotates and the inner tubes (the flexible tube being the innermost) will remain stationary. Once the desired depth is reached, the flexible tube is closed using drawstrings.

Our sandstone drill will consist of an outer tube, polycrystalline diamond compact (PDC) coring bit, flexible tube, and seal. It will operate similarly to the regolith drill, but the PDC coring bit is better suited for medium-hard rock.

2. The device shall be able to collect cylindrical samples 1” in diameter and 8” deep.

Our device will drill at least 8-inches deep into the ground with a 1-inch diameter collection tube, secure the sample inside the tube by closing off at the bottom and then allow it to be removed. For convenience, the sample tube will be easily removable from the tool.

3. The device shall obtain a subsurface sample from solid rock and bins of regolith. The bins will contain mixtures of unconsolidated sand and rock fragments <0.25” in diameter. The solid rock will be sandstone or a comparable rock.

Our device is based on previously successful subsurface drills, such as the Luna 16 robotic sample return spacecraft used in 1970 (Zacny, Paulsen and M.); this drill had a 26-mm diameter hollow auger (with outer threads) and rotated at 508 revolutions per minute (rpm). We have chosen a 500-rpm Chicago Pneumatic reversible air drill (Model CPT789HR).

Each tube will have enough room to collect and contain the sample while maintaining the geological stratification of the surrounding area to prevent further environmental impact. Our sampling device will function by utilizing a hollowed diamond PDC drill bit to collect and distribute stratigraphy samples to the sample collection tube.

4. The device shall maintain the stratigraphy of the regolith and rock during collection, containment, and transportation.

Our device will use a flexible-tube sampling method which has been used to effectively maintain stratigraphy in the past. During the Luna 24 mission in 1976, a flexible liner was fit inside a hollow auger, which could be extracted and closed using strings (Zacny, Paulsen and M.). Since there is no relative motion between the flexible tube and the soil within, the original stratification will remain (Shi, Tang and Quan).

The tubes will have only enough room to contain the sample, leaving no room for the layers to shuffle and mix during transport. Also, the tube’s movement during drilling will be minimized via the implementation of planetary gears. These gears will allow the outer drill to spin while the inner collection tube stays in place. The drilling device will wrap around the head of the drill in a way to prevent rotation of the entire enclosure relative to the drill. This attachment will connect to a mounting rack where the planetary gear will be mounted. The planetary gears will then attach to the power drive of the drill, which will provide rotation of an objects attached to the gears will keeping the mounting rack stationary.

The collection device for the regolith will also be attached to the mounting rack. This is to prevent the spinning of the sample collector in order to preserve the stratigraphy of the regolith. An auger will be attached to the outside ring of the spinning planetary gear. This will allow the auger to slowly pull the collection device down into the soil while maintaining a designated clearance from the collection device as to prevent disturbing the sample. There will also be a sliding cover that goes over the auger blades that attaches to the same mounting plate to prevent spinning.

5. The device shall minimize cross contamination between samples.

Upon filling the cylindrical sample tubes, they will be removed to accommodate additional sample specimens. There will be multiple collection tubes on the device, one for each sample, that will completely enclose the sample, sealing it off from possible contamination through contact.

6. The device shall allow for removal of samples for verification that the stratigraphy is maintained.

Once the core sample is contained, the tubes can be removed from the drilling attachment for analysis. The flexible and acrylic tubes that collect the samples are transparent. This will allow the operator to verify that the stratigraphy has been maintained.

7. The device can be operated manually or under power. Powered operations shall be driven pneumatically.

Our device will use pneumatic power (via a commercially available pneumatic drill) for obtaining both the regolith and monolith samples.

8. The device can have multiple parts that can attach and detach.

The multiple collection tubes will be made to easily attach and detach.

9. The device (all parts, in stowed configuration) shall fit within an 8” x 8” x 18” volume.

The device coring bit and collection tube attachments will be able to fold and be stored on the pneumatic drill, to allow the device to fit within the specified volume.

10. The device (all parts) shall have a dry weight less than 15 lbs.

Our drill and attachments will weigh less than 15 pounds with all parts combined.

11. The device shall be ambidextrous.

Our device will require both hands to assemble, but can be operated to collect samples with one hand. The geometry of the device will be symmetric, allowing for it to be operated ambidextrously.

12. The device and any removable components shall have a tether attachment point 1" in diameter.

Our device will have a main tether attachment located on the base of the drill head to be used to tether the device to the operator of the device. Tether rings will also be on the top of each collection tube, these tether points will be used to tether the collection tubes to the drill. We will use self-retracting tether devices with synthetic cording, suitable in chlorinated water. All other removable coring attachments will be tethered to the base of the drill or will be permanently attached the device.

13. The device shall be compatible with a chlorine water environment.

Our device will be made of materials which are safe to use underwater and are non-reactive with chlorine water solution. The device will use a combination of standard and custom components for the assembly process and will be manufactured with the use of a commercially available pneumatic drill that will be modified to improve ergonomics and allow for machined components and 3D printed components to be fitted with a permanent joining method to accommodate the required design specifications and maintain a well built and structurally sound assembly.

To adhere to the nature of the testing facility, our assembly must allow for fluid to exit the device while simultaneously maintaining the extracted stratigraphy layers for geological testing. Our sample tube will have an open top that contains a wire mesh to filter fluid from the extracted sample once the sampling device resurfaces

Conclusively, the materials used for our sampling device will not be reactive to a chlorine water environment and can be used safely without caution.

C. Test Description

We are collecting two different samples to analyze. The regolith sample will be examined to see how undisturbed the layers are after the collection process. The sandstone (or soft stone) will also be examined to observe how effective the *PNEU-Core* is at collecting even samples of stone. The stone will be inspected for cracks or breaks, as we desire one solid sample. We will measure the size of the sample to see if it is 1” by 8” in dimension. We expect to learn about the purpose of sample extraction to accelerate our understandings and motivation towards deep space environments. By extracting and analyzing a stratigraphic sample, information regarding the nature of the surrounding area can be obtained thus improving our grasp on space exploration.

Testing Instructions:

1. Remove the drill and components from the storage bin.
2. Attach drill tether cord to astronaut’s (diver) tether.
3. Remove a regolith sampling device from its storage bin (do not remove the tether yet).
4. Attach the regolith core sampler to the drill head.
5. After attaching it to the drill head, remove the tether from the collection tube (only for the duration of the coring process).
6. Connect the pneumatic air hose to the drill.
7. Open the tripod legs on the drill blade cover to stabilize the drill during the coring process.

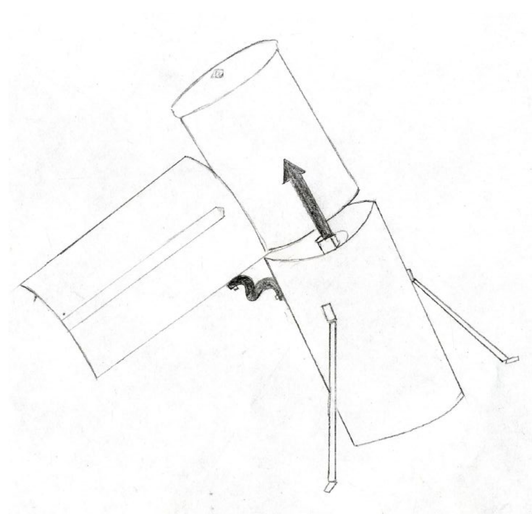

Figure 3. Removal of Sample Tube

8. Place the drill and the tripod legs on the surface of the testbed so that the tripod legs keep the drill at a 90-degree angle to the surface.
9. Begin the coring process by slowly pressing the button on the handle of the drill and applying pressure towards the sample bin.
10. Allow the auger to slowly pull the collection tube straight down into the soil until it has reached its maximum depth of 8 inches.
11. Once drilling is completed, switch the drill into reverse by flipping the large paddle over to the reverse position.
12. Pull the drawstring, using a mechanical lever by located by the fingers, to close the flexible tubing which will contain the sample. Do not remove the flexible tubing from the rigid collection tube. The sample will stay in this tube until operations are finished.
13. Slowly reverse the drill and auger out of the regolith bin until the drilling device is completely removed from the test bed.
14. Re-tether the sample collection device to the drill.
15. Remove the sample collection device from the drill head and return it to the storage tube.
16. Now, using the PDC coring bit attachment, repeat steps 3 through 14 for the sandstone (or soft rock) bin. This time, apply pressure on the drill.
17. Return the sample to its storage container.

D. Technical References

Chicago Pneumatic. "CP789R Series Air Drill." Instruction Manual. Rock Hill: Chicago Pneumatic, 2004.

Quan, Qiquan, et al. "Control System for a Drilling & Coring Device in Lunar Exploration." International Conference on Information and Automation. Yinchuan: Proceeding of the IEEE, 2013.

Shi, Xiaomeng, et al. "Development of a Drilling and Coring Test-bed for Lunar Subsurface Exploration." *Proceeding of the IEEE*. Shenzhen: International Conference on Robotics and Biomimetics (ROBIO), 2013.

Zacny, K., et al. "LunarVader: Development and Testing of Lunar Drill in Vacuum Chamber and in Lunar Analog Site of Antarctica." Journal of Aerospace Engineering (2012).

II. Safety Evaluation

We will be using a commercially available pneumatic drill that will be modified for use in a microgravity setting during the rock coring process. This premade device has already been safety tested by the manufacturer and rated for a working air pressure of 90 psi. Although the maximum allowable air pressure supplied by the Neutral Buoyancy Lab is 125 psi, we will maintain the air pressure recommended by Chicago Pneumatic which will be maintained at 90 psi or below. The tool will also include drain holes that will allow for water to escape upon completion of the sample extraction process.

The PNEU-Core will be transported to the Neutral Buoyancy Lab facility by a ground vehicle one of the team members will be driving. It will be placed in a protective carrying case that will ensure no harm is caused to the device. Furthermore, it will be firmly secured in the trunk of a vehicle to avoid excessive movement. Upon arriving to the facility in Houston, all we will be bringing into the facility is the PNEU-core sampling device and hose attachments. Pressurized air will be supplied by the Neutral Buoyancy Lab to further supplement its operation.

This particular pneumatic drill avoids the use of sharp corners in its design which reduces the possibilities for stress concentrations to occur in the event a large enough input force is provided to the system. The attachable coring bits for both the sandstone and regolith have sharp corners to allow for sample extraction. To avoid puncturing and causing damages to any astronaut apparatus, such as a space suit, a guard will be developed that encloses the perimeter of the coring bit and compresses once pressure is applied to the guard.

The tool itself will be composed from a high strength metal alloy, and the modified attachments will be constructed from stock carbon steel for maximum strength during the sample extraction process. The overall construction will ensure that the user does not experience fatigue from extended periods of usage, from factors such as weight and unintended vibratory oscillations in the system due to poor connections. This, thereby, allows for the user to control the sampling device freely and provide unconstrained motion for the user to manipulate the orientation of the sampling device when required to retrieve an optimal sample.

A tripod will be one of the modified attachments in the system that will lead to overall safer design. It will be attached coincident to the outer shell that is capable of translating on the same axis. By utilizing a tripod, we can stabilize the sampling device during the sample extraction process, thus making it easier and safer to use due to the decrease in potential user errors and irregularities in stratigraphy layers that can cause instabilities during the drilling process.

To ensure for nominal operating, the pneumatic drill will be lubricated with Neutral Buoyancy Lab approved SAF-T-EZE compound before operation for maximum efficiency and reduction in tool wear during the sample extraction process.

For 3D printed attachments, non PVA filament will be utilized to conform to the nature of the Neutral Buoyancy Lab pool as water soluble materials are non-allowable. Overall, the materials used for the assembly allows for the proper functionality of our subsurface sampling device and will not:

- react to chlorine when submerged.
- impose a risk to the environment of the pool regarding contaminants.
- use sharp edges as they may cause injury and damage, also to avoid effects of larger stress concentrations.

Visually, the user will also be able to distinguish hazards that are present in the system and will be able to take the necessary precautions through the use of safety labels near sharp objects such as our PDC coring drill bit. The caution label will be placed on the outer tube to depict the dangers that exist within.

A. Tool Safety

Tool Restraint

- The PNEU-Core will be fitted with a tether attachment point to ensure that the tool is properly constrained to the user. Other components used in the assembly will be tethered to the body of the tool, thereby allowing for a fully tethered system.

Gloved Operation

- The PNEU-Core will be fitted with a larger throttle button to accommodate for optimal operation when used with gloves designed for extra vehicular activity.

Finger Entrapment

- The PNEU-Core does not contain any mechanism or capability to entrap fingers

Hydraulic Power

- The PNEU-Core is not designed for hydraulic power operation

Pneumatic Power

- The PNEU-Core is pneumatically powered and will maintain proper operation with an air pressure of 90 psi or below. Pressure regulators will be supplied by the Neutral Buoyancy Lab to maintain a safe operating pressure for the PNEU-Core device.

B. NBL Design Safety

Environment

- During testing in the Neutral Buoyancy Laboratory pool, the PNEU-Core sampling device will be able to withstand a free chlorine content that ranges from 0.5 to 3.5 parts per million. The tool will properly operate in an ambient temperature of 82 to 85 degrees Fahrenheit and at a maximum depth of 40 feet. These specifications will be adhered to and achieved through prior research and development.

Accepted Materials

- The materials used for the assembly and operation of the PNEU-Core sampling device adhere to the guidelines of allowable materials specified by the Neutral Buoyancy Laboratory.

Edges and Protrusions

- The PNEU-Core sampling device will not have any exposed sharp edges or protrusions in its design. This prevents the potential for damage to occur to the users suit.

Excess Water.

- The PNEU-Core sampling device will contain ports on the body of the tool for water to flow outside once it surfaces.

Labels

- A caution label will be placed on the outer shell of the PNEU-Core, near the PDC drill bit to warn the user regarding the presence of sharp objects.

Loads

- Simulations of various applied loads will be done before formal presentation in the Neutral Buoyancy Lab on Creo Parametric to analyze and improve on the structural integrity of the design. Simulated impact tests will be done in virtual experimentation platforms such as Coppelia V-REP. Physical impact tests will also be done by dropping the device from shoulder height, and forcefully handling the device.

Conclusively our subsurface sampling device will maintain and conform to safe operation and will also adhere to the specifications set by the Neutral Buoyancy Lab.

III. Outreach

The University at Buffalo's Microgravity team has planned out various activities and events to assist us in outreach efforts for our Micro-g NExT project. A few activities include doing a museum presentation, connecting through social media as well as at involving fellow students during our school's Engineering Week. What we seek to achieve through this opportunity is to inform the community about space exploration, broaden their understanding about the engineering field and also inspire young professionals who are seeking to pursue an engineering major and possibly be their mentors.

A. Museum Presentations

The University at Buffalo's Microgravity Team has recently contacted the Museum Education Consortium of Buffalo (MECOB) to discuss outreach programs. This is a large educational organization in Buffalo which connects the many educational facilities in the area together. These facilities include the Buffalo Science Museum, the Buffalo State College Planetarium (separate from our university) and other art and history museums.

We will be arranging a presentation at the planetarium titled "Working in Space", where we will discuss the challenges of space exploration with young students and what it is like to manufacture and use tools that are designed to work in microgravity. With this we hope to inspire the future engineers to join the aerospace industry. This event is currently planned to take place in February. We are also currently trying to schedule a presentation for grade school students at the Buffalo Science Museum which will have the same theme as the previously mentioned presentation, but with a much larger audience. The team hopes to take full advantage of the chance to connect with the community through this NASA Micro-g NEXT opportunity. We also would like to develop a connection to the students who we present to by offering our contact information, should they have any more questions or seek guidance for getting involved in STEM projects or majors in school.

B. Social Media

In order to help connect with the general public, several forms of social media will be used to share updates during our ongoing development on the project. Our project experiences will be documented through updates on our UB AIAA Facebook page. Each week, we will be posting an interesting fact from our research and shall engage the reader by asking them what their thoughts are on the subject. Progress on the project will also be provided along with pictures sharing our experiences of working on a NASA project with our readers.

Another social media outlet that will be utilized is Snapchat. By using Snapchat, members will keep up to date with current updates on the project while simultaneously allowing the audience to view our progresses. Snapchat will make it easy to share updates with a large audience.

Instagram will also be used to connect and engage with the general public. With most of the young population having an active presence on this app, it will play a key role in helping to share updates on the project for everyone to see. Also, by following various accounts related to the field of engineering and science, we will be exposing our audiences to them, with hopes of sparking their interest. This will help expand their ideas and expose them to the vast impacts one can have in the engineering field.

Throughout the design process we will be utilizing Twitter as well. We will be building and growing our twitter follower count so when the day comes to finally present our tool, we can keep everyone updated on where we are in the testing process and how our tool is performing.

C. Engineering Week

Each year, the Student Association here at the University at Buffalo hosts a week-long event called “Engineering Week” during the spring semester. This is a once-per-year competition where all the engineering clubs throughout the university host a series of events relating to their discipline and a school-wide battle bot competition. There are also several school-organized competitions such as the paper airplane design contest and the RC aircraft competition that seek to engage students in the immersive world of engineering.

We plan to host our own competition during this week where we will demonstrate how the tool works in a tank of water using our early prototype models that will not be taken to JSC. We will hold a challenge that will demonstrate to students how micro-gravity operations work through the use of the *PNEU-Core*. We plan on making our booth and demonstrations very involving and engaging, by asking students how they would redesign the tool. We would also let a few test it themselves (under close supervision) in order to encourage students to get involved in club activities and to expand their knowledge through group projects similar to this one.

D. Educational Institutions

High School: The majority of our high school level outreach consists of presentations to aspiring scientists and engineers at local schools along with the schools of our members' home towns. We currently have plans for outreach at Aviation High School, in New York City, New York and North Bergen High School, in North Bergen, New Jersey.

Our outreach will consist of a Q & A session with the students, as well as individual class presentations. The objective of the programs are to educate the students about the goals of Micro-g NExT, and inform them about the opportunities available for aspiring scientists and engineers in the Aerospace Industry.

Elementary School: Our Elementary School outreach will consist of the team presenting and performing aerospace-related activities. The objective of these events will be to educate the students about Micro-g NExT, NASA and the history of space exploration. We will then use videos and hands on demonstrations to teach the students about basic concepts in interstellar studies. Confirmation have been received allowing us to present again at the Kadima School in Amherst NY.

IV. Administrative Section

A. Test Week Preference:

Our preferred test week is June 5th to June 10th.

B. Mentor Request:

If possible, the team requests Dominic Del Resso as a mentor.

C. Institutional Letter of Endorsement:

See attached.

D. Statement of Supervising Faculty:

See attached.

E. Statement of Rights of Use:

See attached.

F. Funding and Budget Statement:

See Table 1.

G. Parental Consent Forms

All students involved in this project are over the age of 18.

Table 1: Budget Estimation

Part Number	Part Identity/ Purchase Name	Vendor	Unit Cost	Quantity	Total Cost
1	Chicago Pneumatic Drill CP789HR ½ in Super Duty Reversible Air Drill	Chicago Pneumatic	$231.65	1	$231.65
2	3ft long, 1" Diameter Stock Steel	McMaster Carr	$25.23	1	$25.23
3	1.5 " Auger Coring Bit	Mills Machine Company	$60.00	1	$60.00
4	1.5" PDC Coring bit	Mills Machine Company	$80.00	1	$80.00
5	6' Long, 1" Diameter Clear Acrylic Tube	Interstate Plastics	$25.99	1	$25.99
6	8' Long, 1" x 1.25" Flexible Polycarbonate Tube	Interstate Plastics	$28.80	1	$28.80
7	1' Long, 2" Diameter Stock Steel	McMaster Carr	$41.42	1	$41.42
8	1 kg PLA or ABS Filament	Amazon	$30.00	1	$30.00
9	Outreach	N/A	$300.00	N/A	$300.00
10	Hotel (1 Week)	Double Tree	$1044.70	2	$2089.40
11	Flights (Round Trip)	Delta	$500.00	6	$3000.00
12	Miscellaneous	N/A	$250.00	N/A	$250.00
Experimental Components Total Cost:					**$523.09**
Outreach Cost:					**$300.00**
Travel Cost:					**$5089.40**
Total Cost					**$6162.49**

Our UB AIAA budget more than covers the total cost for the year. However, should an issue arise requiring more funding, then we will seek funding from organizations who support us. We will also hold events to fundraise if need be.

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University at Buffalo
The State University of New York

November 1, 2016

NASA Johnson Space Center
Mail Code: AE2
2101 NASA Parkway
Houston, TX 77058-3696

Dear Micro-g NExT Staff:

As the faculty advisor for an experiment entitled "PNEU-Core" proposed by a team of undergraduate students from the State University of New York at Buffalo, I concur with the concepts and methods by which this experiment will be conducted. I will ensure that all reports and deadlines are completed by the student team members in a timely manner. I understand that any default by this team concerning any program requirements (including submission of final report materials) could adversely affect selection opportunities of future teams from the University at Buffalo.

Thank you so much for your consideration. Please feel free to contact me via email or telephone for any other questions at:

paul.schifferle@calspan.com
or
(716)-236-1065

Sincerely,

Paul T. Schifferle

Paul Schifferle

Adjunct Instructor,

AIAA Faculty Advisor

University at Buffalo
The State University of New York

November 1, 2016

NASA Johnson Space Center
Mail Code: AE2
2101 NASA Parkway
Houston, TX 77058-3696

Dear Micro-g NExT Staff:

As the Department Chair and Director of Undergraduate Studies of the Department of Mechanical & Aerospace Engineering (MAE), we fully endorse the experiment entitled "PNEU-Core" proposed by a team of undergraduate students from the State University of New York at Buffalo. We concur with the concepts and methods by which this experiment will be conducted. We will ensure that the MAE Department will provide the required space and other needs to complete the project, and deliver them in a timely manner to the team. We understand that any default concerning Department requirements and support of this program could adversely affect selection opportunities of future teams from the State University of New York at Buffalo.

If you have any concerns or questions, please feel free to call either of us at (716) 645-2682 (Lewis) or (716) 645-1461 (Ringuette) or via email at kelewis@buffalo.edu or ringum@buffalo.edu.

Sincerely,

Kemper Lewis, Ph.D.
Professor and Chair of
MAE Department
Site Director, NSF I/UCRC
Center for e-Design

Matthew J Ringuette, Ph.D.
Professor and Director of
Undergraduate Studies in
Aerospace Engineering

University at Buffalo
The State University of New York

November 1, 2016

NASA Johnson Space Center
Mail Code: AE2
2101 NASA Parkway
Houston, TX 77058-3696

Dear Micro-g NExT Staff:

As team members for a proposal entitled "PNEU-Core" proposed by a team of undergraduate students from the State University of New York at Buffalo, we will and hereby do grant the U.S. Government a royalty-free, nonexclusive and irrevocable license to use, reproduce, distribute (including distribution by transmission) to the public, perform publicly, prepare derivative works, and display publicly, any data contained in this proposal in whole or in part and in any manner for Federal purposes and to have or permit others to do so for Federal purposes only.
We also will and hereby do grant the U.S. Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States an invention described or made part of this proposal throughout the world.

Thank you so much for your consideration. Please feel free to contact me, Asad Esa, via email or telephone for any other questions at:
asadesa@buffalo.edu or (917)-903-7108

Sincerely,

Asad Esa
AIAA President,
ME/AE

Connor Smith
AIAA Micro-g Captain,
ME

Othmane Brika
AIAA Micro-g Captain,
ME

Joseph Jaracz
AIAA Treasurer,
ME/AE

Ema Marter
AIAA Safety Officer,
AE

Deepak Rai
AIAA Secretary,
ME

Paul Schifferle, Adjunct Instructor, AIAA Faculty Advisor