University at Buffalo
The State University of New York

AIAA
SHAPING THE FUTURE OF AEROSPACE

MinOS: Mini-Arm Ocean World Scavenger

Mini-Arm End-Effector

State University of New York at Buffalo

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UB AIAA Micro-g NExT Research Team

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I. Technical Section

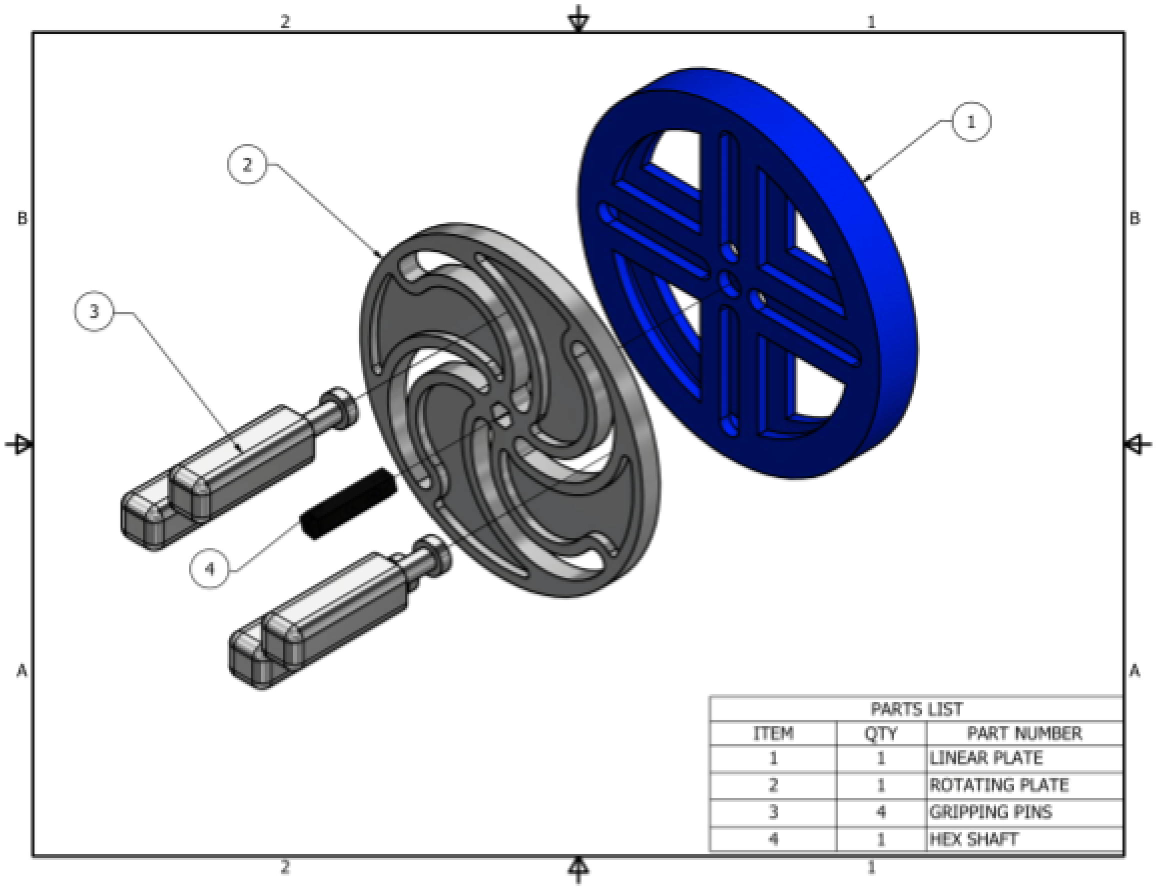
A. Abstract

NASA continues to be the forefront of space discovery, and the exploration of "Ocean Worlds" is important because it provides the potential for discovering microbial life. Worlds like Europa and Enceladus are deemed the most likely candidates for containing life, but they have extreme cryogenic environments (Greeley R. (2001)). Further research on these worlds will be performed by remotely operated vehicles (ROVs). Vital data can be retrieved from water samples and ice cores. To ensure that the cores can be properly collected, our team has designed MinOS (Mini-Arm Ocean World Scavenger). The name MinOS was inspired by the son of Zeus and Europa, with the same name, in Greek mythology. MinOS is an end effector for NASA's recently designed robotic "Mini-Arm". It is designed to be easily 3D printable, allowing simple assembly, similar to the mini-arm it will be attached to. It is also capable of a traditional assembly for when more robust capabilities are needed. Its method of action is its adaptive diameter in combination with the mini-arm's maneuverability. During manufacturing, we plan to run a finite element analysis (FEA) to make final material decisions. Once FEA has been completed, the components of the project will be 3D printed in the material which has the best simulated performance. The components will then be tested to ensure performance and safety. MinOS finished device testing will only be done once individual component testing is complete. NBL simulated environment testing on MinOS will be applied to ensure the operators, divers, and the Neutral Buoyancy Lab pool will remain hazard free, and that the device will perform. After testing and manufacturing, MinOS will be an easily manufacturable, precise design that will provide NASA the capability to perform Ocean World missions successfully.

B. Design Description

Initial prototypes will be 3D printed as a full assembly, in place, on a Makerbot Replicator. One semi-working prototype has already been printed, with parts printed separately and then assembled. This was done in order to provide a proof of concept. Future prototype iterations will be printed already assembled, with support material maintaining a 0.01 inch clearance between all moving parts. This support material will then be removed in post processing to allow the components to move freely. After testing of the prototype and iteration to improve the design, the final version can be either machined from aluminium or 3D printed in high strength resin on The University at Buffalo campus.

The design has 4 separate parts that can be seen in the exploded view in **Figure 1**. The rendering is labeled **Figure 2** and **Figure 3** with two different phases, open and closed respectively.



PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	LINEAR PLATE
2	1	ROTATING PLATE
3	4	GRIPPING PINS
4	1	HEX SHAFT

Figure 1. Exploded View

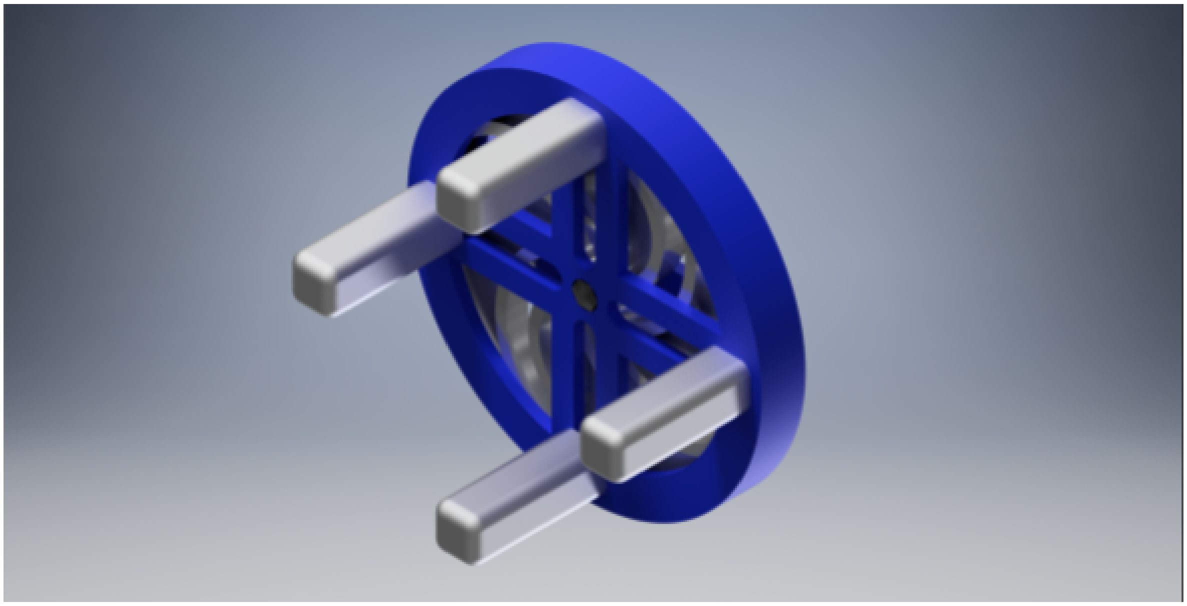


Figure 2. Open

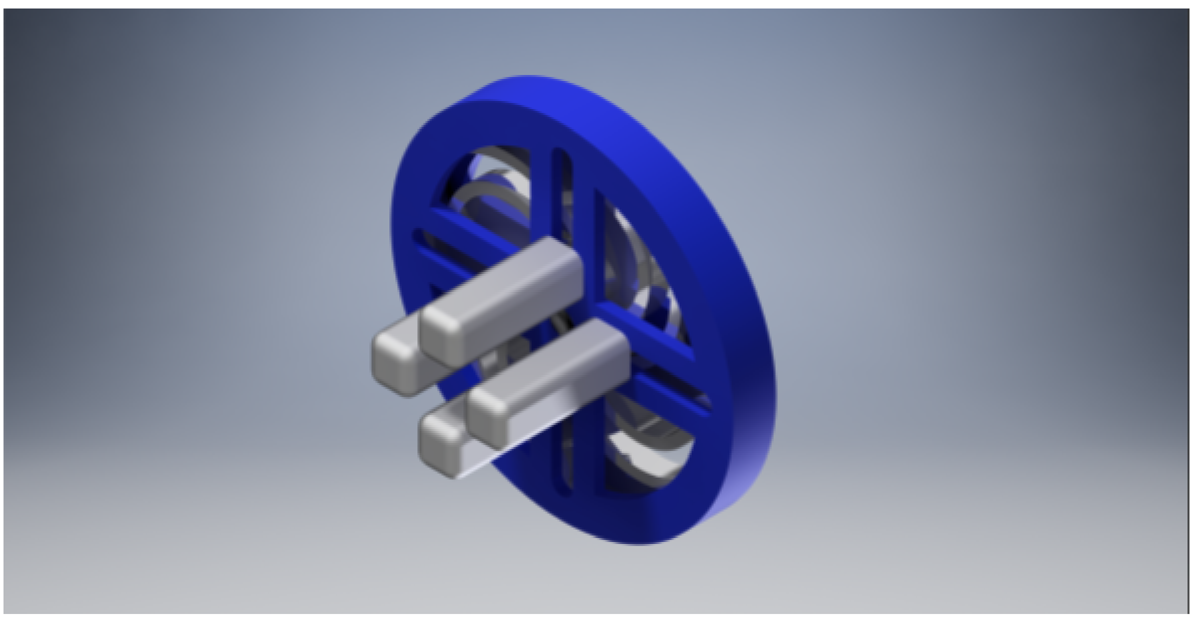


Figure 3. Closed

Part 1, the linear plate , Part 2, the rotating plate, and Part 3, the arms, work in conjunction. As the rotating plate rotates, the pins follow along where the two plates' slots align and the rod arms move apart from each other (**Figure 2**) . When the rotating plate rotates the other direction, the rod arms get closer together (**Figure 3**). We created dimensions that allowed the arms to open to 2.729 inches between each other and close to about 0.381 inches. The amount of arms is subject to change. Currently, we have 4 arms in our design but this can possibly expand up to 8 arms in other iterations. This will be finalized with some more testing and prototyping.

Part 4 is a hex shaft. This hex shaft goes through the center hole and will connect to waterproof motor. When the motor spins, it results in the rotation of the hex shaft and the rotating plate.

In order to get a better understanding and visual of this idea, we decided to 3D print a simple prototype. They can be seen in the pictures labeled **Figure 4** to **Figure 7**. This is a rough draft of our final product. Figure 4, which shows the top of the rotating plate in open position. Figure 5 shows the bottom in closed position. Figure 6 and 7 shows the closed version of the top and bottom of MinOS.

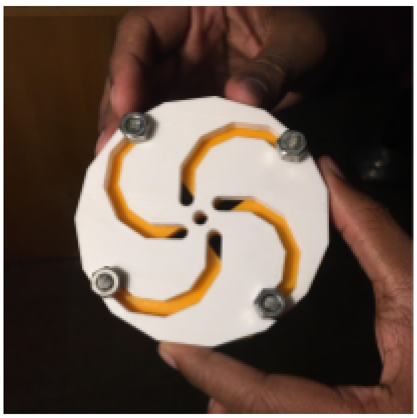


Figure 4. Open Top

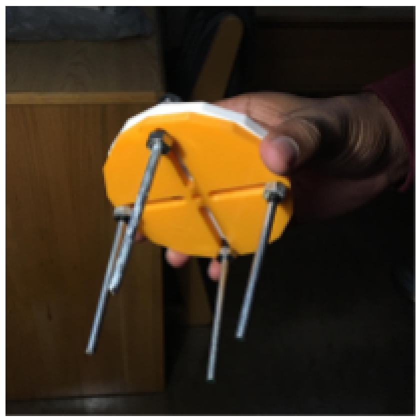


Figure 5. Open Bottom

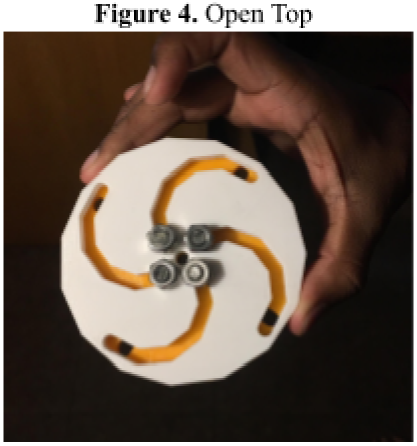


Figure 6. Closed Top

Figure 7. Closed Bottom

Hardware to software interfaces:

The operation of the motor will be accomplished by using a “Teensy” microcontroller, which uses Arduino IDE. There are three hardware serial ports on the Teensy, and therefore the device will use UART to control the very simple inputs to the motor. The initial input will cause the motor to spin in one direction, closing the arms in towards each other. The arms will be equipped with 2 pressure sensors and once there is sufficient pressure on the core sample, the sensor will relay back to the microcontroller to stop the motor. There will be enough pressure on the ice core to help left the samples in MinOS’s grip. When the Mini-Arm is in place to release the sample, a second input code will read the input and cause the motor to change direction, opening up the rod arms. Since there are only three inputs, and there are three hardware serial ports, it is possible to use UART to command. If during the testing phase we find that UART is not feasible, then the backup plan is to use GPIO, but still using all the same commands.

Compliance Matrix:

No.	Description of Requirement	How the MinOS Design Meets the Requirement.
1	The device shall be able to grasp and transfer cylindrical nylon samples, 0.5” in diameter and 3” deep, into a 6” wide by 6” long by 2” tall sample collection bin.	-The device has rod arms which can contract around nylon sample in order to grasp it. -The rod arms can contract to below size of diameter of nylon sample and can expand to be larger than 3’’ length of the sample. -The device is less than 6’’ wide and 6’’ tall when fully deployed and can fit inside of the collection bin to deposit samples. -The rod arms are coated with a rubbery grippy material to make sample collection easier.
2	The device shall be able to grasp 1” x 1” 8020 aluminum extrusion.	-The device has rod arms which can contract to less than 1’’ wide and can grasp onto the extrusion. The final claw will have between 4-8 rods which can pick up an object in any orientation.
3	The device shall mechanically interface with the ROV mini-arm using the provided M3x0.5, 6 mm deep tapped holes on the output plate (see Figure 2).	-The waterproof housing of the MinOS device will have screws which align with the holes of the ROV Mini Arm.
4	The device shall be electrically operated by no more than 12V and 3A. Power will be supplied by the NBL and teams must be able to connect to a standard banana plug connector commonly found on power supplies.	-We have found many options for motors that operate with enough power that are also waterproof. 12V is more than enough to sufficiently power all of the motors we have found in our research. -We have found a few different options for connecting to a standard banana plug while under water. It is our hope that we may decide between these many choices once we have clarification on a few questions regarding the connector. However, no matter what, we have found waterproof connector options for both male and female headed banana plug connectors. -Currently the best option for the motor is a 4.5V(6.0V input) brushless motor which has the capability of manual or pulse width modulation (PWM) inputs.
5	The device can have multiple parts that can attach and detach.	-The device includes multiple parts which can attach and detach by the hand of the operator, but won’t detach itself. These parts are only for modularity purposes, though the

		primary configuration will be able to perform all of the functions required without any part changes.
6	The device (in stowed configuration) shall fit within a 4” diameter x 5” long cylinder.	-The device is less than 5’’ long and has a diameter less than 4’’ and can not expand outside of this area while being stored or while in use, therefore it fits inside the required area.
7	The device (all parts) shall operate underwater with provided electrical power.	-The device will have a waterproof motor. -Waterproof motor and necessary components like drivers and microcontroller are housed inside a waterproof compartment to provide 2 fault tolerance. -The power connector is plugged inside waterproof housing allowing it to function underwater.
8	The device (all parts) shall have a dry weight less than 2 lbs.	-The complete device weighs less than 2 lbs. (exact weight needed) From our figures of merit calculations, our material weight estimations put the device below 2 pounds. -We have eliminated all unnecessary material in the design of this effector.
9	The device (all parts) shall be close to neutrally buoyant, with a buoyancy no more than +1 lb and no less than -1 lb.	-Weight can be added or subtracted inside the waterproof compartment on the motor end of the device in order to adjust the buoyancy.
10	The device shall be commanded via general purpose input/output lines (3.3V or 5V compatible), or via a Universal Asynchronous Receiver / Transmitter (UART – 3.3V / 5V).	-The microcontroller that we will be using will be UART circuit. -A backup plan to use GPIO as our interface, just in case. -The microcontroller we will be using will be a “Teensy” which uses Arduino IDE
11	The device shall be compatible with a chlorine water environment and a salt-water environment.	-All materials are operable in chlorine water environments and saltwater environments. -The exposed parts of our design would be using aluminum which is relatively resistant to corrosion. Perhaps we can get anodized aluminum.
12	The device shall operate within an environment from -5 deg C to 30 deg C.	-During the design process, we have tried to be mindful that the temperature on Europa is well outside the temperature range for this project, we have tried to select materials and configurations based on excessively cold temperatures.

C. Operations Plan

The purpose of MinOS is to grab ice cores in varying sizes and place them into a sample collection bin. For testing at the NBL, we plan to orient the "ice core" (nylon) samples in a few different ways, such as standing straight up, laying flat down, and in a pile.

Testing Instructions

1. Unload MinOS from its carrying case.
2. Connect MinOS to the Mini-Arm using the holes on the Mini Arm, and screw connectors on the end effector.
3. Connect the banana plug to the side of the waterproof housing.
4. Align the Mini-Arm so that MinOS can pick up the samples.
    a. When ice core samples are standing up-right, align the rod arms vertically above them using the motions of the Mini Arm move down over the sample.
    b. When ice core samples are laying horizontally down, rotate the Mini-Arm joint so that the sample can fit between the arms.
    c. If there is difficulty, try other orientations of the mini arm and end effector.
5. Once MinOS is properly in place over top of the core samples or aluminum extrusion, close the arms.
6. Once the ice core sample is gripped, place MinOS into the sample collection bin using the motions of the Mini Arm. Make sure the bottom of the rod arms, or the sample, is touching the bottom of the collection bin.
7. Open the arms for a gentle release of the sample.
8. Repeat these steps for each of the samples.

D. Safety

Being that this is an end effector for a Remotely Operated Vehicle, its primary function is operated while the device is not around people, therefore, our primary safety concerns are with the environment of the NBL pool, and for the testers who are operating the device during testing week. Below is a list of some of the potential hazards and how we plan to deal with them.

Hazards:

Waterproofing
- Motor
- Tether Connection
- Microcontroller

Pinch Points
- Gripping Pin Slots
- Tether Connection

Sharp Edges

Mitigation:

Waterproof (2 fault tolerant)

- Waterproof motor housing IP68 rated liquid sealants (IEC 60529)
- Purchase of waterproof motor
- Tether connection will seal completely to ensure it is waterproof.
- Waterproofing of microcontroller using IP68 rated liquid sealants (NBL approved)
- Insulating housing for the microcontroller (plastic/rubber)

Pinch Points

- Warning signs on gripping pin slots and tether connection
- Small slots and the specific motor will be used to prevent significant pinching (warning label will still be applied)

Sharp Edges

- Exterior edges rounded to prevent sharp corners and burrs

Materials

- Materials are selected specifically to avoid contaminating the NBL pool. Any material with a potential for oxidizing will not be used.
- Any and all adhesives and lubricants will come directly from the NBL approved materials list.

Testing:

- Individual housings will be tested in slightly chlorinated water (this applies to both the microcontroller and motor) to simulate NBL conditions. They will be tested again in saltwater.
- Waterproof coating of the microcontroller will be tested in a similar manner.
- Gripping pins and their slots will undergo a finite element analysis simulation to determine stress loads and ensure the device does not break and leave matter in the NBL pool.
- The physical device prototype will be tested in an NBL simulated environment to ensure it is both usable and safe.

Safety Acceptance Criteria:

- These characteristics indicate a condition that, while not necessarily perfect, the manufactured device will maintain the integrity, safety, and reliability of the device in its testing and service environment.
- As a bare minimum of acceptance criteria, the device at all points of operation must have the ability to stay waterproof to a degree of two fault tolerance in order to hold paramount the health safety of the divers and astronauts, as well as any engineers or other people that may operate the device.
- There must be no risk of contamination to the NBL pool. Materials chosen will be on the accepted materials list of the NBL or accepted by our mentor's approval.

E. Technical References

IEC 60529, “Degrees of Protection Provided by Enclosures (IP Codes),” Ed. 2.1 (Geneva: International Electrotechnical Commision, 2011)

Greeley R. (2001) The Icy Crust of the Jupiter Moon, Europa. In: Dempsey J.P., Shen H.H. (eds) IUTAM Symposium on Scaling Laws in Ice Mechanics and Ice Dynamics. Solid Mechanics and Its Applications, vol 94. Springer, Dordrecht

II. Outreach Section

A. Introduction

Science and technology is a foundational component of modern society. Dedication to understanding the world's dynamic processes, and finding practical solutions to the challenges that humanity faces are necessary for the upcoming generation. The University at Buffalo AIAA Micro-G NExt research team feels that the most effective means to scientific inquiry and application is a comprehensive, multifaceted approach. We believe critical thinking, and creativity are vital factors of education. Traditionally, the structure of a classroom environment lacks outlets for interactive design and experimentation. It is our intent to bring aspects of both NASA's mission and New York State curriculum requirements to our outreach activities. Our team will implement two main foci within the plan for outreach, (1) educational and (2) informational programming, whose objectives and relevant activities are respectively outlined below:

B. Educational Programs

In university engineering programs, upper-level classes provide the tools to apply theoretical knowledge and concepts to our work. However, UB AIAA Micro-G NExt regards any person as capable of learning these materials; it is not age, but rather mindset that makes a successful engineer. Many of the students we will reach haven't taken any STEM-specialized courses for reasons of feasibility (e.g., low-income schools and institutions that do not offer STEM-related clubs or higher-level sciences/mathematics). The unfortunate reality is that often engineering is seen as unreachable goal to children, mostly due to lack of exposure. Therefore, many students do not consider engineering as career path. As it stands, students are able to learn from the environment around them and solve complex problems as well as construct ideal solutions. Our educational programming includes demonstrative events, and interactive projects, designed for a range of ages. Our target audiences range from grade school through college.

Kids' Day

UB AIAA Micro-G NExt has designed this day activity to encourage and guide elementary school students through the process of scientific experimentation. This includes data collection, and analysis, using the scientific method. Recognizing that past Micro-G participants have included a similar program in their outreach plan, we hope to build upon their legacy, as their program (buoyancy experimentation) is interactive and teachable for younger children. We will follow a rough outline of the lesson plan titled "Oh Buoy!", which can be found in its entirety within the references. "Oh Buoy!" ties the esteemed children's book *James and the Giant Peach* to principles of positive, neutral, and negative buoyancy through demonstrations and observation. In addition to these experiments, we will have a marshmallow launcher project where students create a catapult, allowing for the introduction of the engineering and design process, and basic Newtonian physics. Here the students will think conceptually about the outcomes before experimenting with various items and collect their data to share with others, just as researchers reflect the knowledge gathered within the scientific community.

<u>"Oh Buoy!" Activity Overview</u>

Required Items:

- Peach
- Nectarine
- Lemon
- Lime
- Modeling Clay
- Aluminum Foil
- Plastic Film canisters
- Transparent Cups

Our Oh Buoy! Activity will start with showing the students the peach and asking them if we put this in water what will happen, will it sink or float. We continue this process with the Peach, Nectarine, Lemon and Lime. Some items will float, some will not. We would facilitate a conversation beginning with asking "why?". "Why do some items float or not float?". Then we'll introduce the concepts of density and buoyancy. After the demo there will be an interactive activity: each student will be given modeling clay, aluminum, plastic film canisters, and transparent cups; with these items they will perform their own buoyancy experiments with the goal of creating a positively buoyant system , neutrally buoyant system, and along the way unintentionally having negatively buoyant systems. The goal, in simple terms is to understand and see why things flow, and why things sink, through observation and trials.

<u>Marshmallow Launcher Activity Overview</u>

Items Required:

- Marshmallows
- Large Popsicle Sticks
- Rubber Bands
- Plastic Spoons
- Safety Scissors (To be used by us, not accessible to the children)

Using these materials, kids make a catapult, either of their own design or one provided to them which they will be allowed to modify. Helpers will make sure the kids are safe and able to customize their design if they so choose. Components of the project are adjustable for different age groups. For higher-level elementary grades (e.g., fourth and fifth) more options for personalizing and modifying the design can be presented (with the inclusion of other materials). Both age groups would experiment to see which design works the best within the requirements given by the UB AIAA Micro-G NExT team. The criteria to be tested would include farthest toss, highest toss, most durable, most creative design, etc.. Through this, the students are exposed to the design process and basic physics. The Marshmallow Launch is one of the two activities to take place for Kids' Day but can also be applied in a more competitive form for the Buffalo Science Museum's Engineers' Week activity.

[Sample Design Options]

Marshmallow catapult[2] Marshmallow catapult 2[3] Advanced Marshmallow catapult[4]

Mini Micro-G

With Mini Micro-G our objective is to host an interactive seminar, oriented toward middle and high school children, with separate activities for these respective age ranges. STEM-interested students from participating schools will be first introduced to theoretical concepts via demonstrations. Then, just as NASA gives the UB AIAA Micro-G NExt. team design challenges, we will ask the students to engineer a solution to a problem we present. They will be asked to apply their new knowledge of the theory as well as draw from personal experience. Our team members will help guide each student through the process of creative design. At the end of the activities, we'll provide UB Micro-g NExt contact information should they wish to stay in connection with students in STEM.

Mini Micro-G Activity Overview

For each seminar, we will follow an informal lesson plan of the team's creation in which popular engineering concepts are presented to students in raw form. Hands-on demonstrations will aid their understanding of real-world applications. Please refer to the appendix for a sample lesson plan of our creation for students between the ninth to twelfth grades. A similar lesson plan will be applied to younger students with modifications to the topic's implementation and depth. We will then introduce our process in regards to engineering creative solutions and transition to a mini-project where this can be practiced.

Engineering Process:

- Problem Identification—What is the issue to be solved and why?
- Generation of Alternatives—Includes drawings, specifications
- Alternative Comparison—What is similar in the designs and why is the selected option better?
- Preliminary Design Analysis—Test if possible. How would it be tested? How does this meet specific needs and relate to social constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability?

- Problem Improvements—What would be changed if you were to go back and redo/edit? Go back and improve if these are feasible modifications. What are some factors not taken into consideration? Repeat this process as many times as needed.
- Engineering Recommendation—What do you recommend, or propose?

Engineering Challenge:

As NASA provides our Micro-G teams with challenges, we will likewise provide the students with a challenge based on what was presented to them, highlighting the translation from concepts to engineering solutions. For a fully planned activity please refer to the appendix where an example activity for high school students is listed.

Pop-Up Workshops

As the name suggests, these would be interactive and experiential-based learning workshops that provide an introduction to software available through The University at Buffalo. These beginner-level activities will be open to interested students of University at Buffalo on a “first-come, first-serve” basis. We have learned from prior reservations, we must do this due to limited space and funds. Our Micro-G NExt team boasts an excess of talents and consists of not just engineering students engineering, but of multiple fields (e.g., computational physics, computer science, and mathematics, economics). Each member has a unique skill set to bring to the table and most importantly, is willing to share their knowledge among those who are willing to learn.

Activity: As we previously mentioned we will hold several introductory workshops some of which we have discussed to be 3D CAD modeling, and the basics of coding and algorithms. These workshops will be held within the University at our lab. Advertising for these events will be done by posting on our Parent organization UB AIAA’s facebook page, as well as posting the event throughout parent organization on UBlinked, which is our Universities event page. The anticipated take away from these workshops is to introduce interested students to the basics of technical development tools.

C. Informational Programs

A major component of any outreach program is not only to educate, but also inform the local community of our purpose and current ventures. This will encourage the public to value our purpose, and guide understanding of the organization and its parent institutions. It will also showcase UB students’ work. Future developments can be informed by the feedback received from these endeavors. This will also relate to the larger scientific community why the engineering field is relevant and necessary to solve the complex challenges that humanity faces. Here the goal is to advertise both the Micro-g NExt mission, and team-specific undertakings, giving an inside perspective on our process (including outreach activities and, if accepted, subsequent testing at NASA). Doing so may attract potential future club members and/or donors. We feel information sessions to be impersonal and we would rather invite the local community to follow our journey as active participants. To accomplish this, we will be utilizing the following outlets:

Pamphlets

This aspect of our outreach plan will be relatively passive, meaning there is no bodily complement. We would again like to highlight the importance of a creative and analytical mindset, however are a finite group of people with a limited budget and so cannot host as many workshops and seminars as is preferred. To cost-effectively reach a more extensive audience, brochures that the UB AIAA Micro-G NExt team intends to construct will be distributed to The Teacher's Desk (a local organization where teachers are offered free classroom supplies and at which UB AIAA Micro-G NExt regularly volunteers. The pamphlets will outline decision matrices, as this tool is taught in introductory courses for UB engineering students and identifies with state curricula requirements of analytical problem-solving skills. Members of our team will distribute these during the volunteer opportunities regularly held at The Teacher's Desk throughout the school year to teachers who wish to incorporate decision matrices into their future lesson plans.

Snapchat

In anticipation for the events formerly outlined, our team has created a snapchat (*ubmicro-gnext*) to begin building a follower base. Advertisement of our username/Snapcode will include 4" x 5" handouts distributed throughout the campus lecture halls and 8" x 11" flyers posted to community bulletin boards, both typical manners of disseminating information to UB students and visitors. UB Engineering Week, an annual spring event dedicated to highlighting engineering and its subdisciplines wholly throughout our school, includes seminars and friendly club competitions as well as tabling. UB AIAA Micro-G NExt will take this opportunity to continue gathering a base of supporters by incentivizing potential Snapchat followers with a prize to be determined at a later date.

[UBMicro-GNext Snapcode]

Content to be posted by our team's Snapchat will follow the 2018 Micro-G NExt journey. Our team has outreach events , weekly meetings as well as breakout sessions where small groups of people work on specific tasks [specific details of our design and the proposal will at no point be displayed]. The snapchat account will be available to every member of UB AIAA Micro-G NExt team, so updates will be posted at each of these gatherings. This enables viewers to see our process from design to manufacturing, as novel update will be recorded and posted. By the end of our journey, we expect our viewers to have an understanding of who the team consists of, the role we possess at our university and in relation to NASA, the incentive that drives us as aspiring engineers, and the process in which we handled our project.

UB Snapchat Takeover

As part of the University at Buffalo community we have at our disposal the University's Snapchat account with previously acquired followers. This program, UB Snapchat Takeover, allows registered clubs or organizations to submit a takeover request; if our proposal is selected to be tested in NASA's Neutral Buoyancy Lab we intend to submit a UB Snapchat Takeover request. We do not foresee a reason for the school to reject this, as the account is specifically used to highlight important activities of registered UB clubs. Our takeover will reach Snapchat users within the UB student population and display the final steps of our 2018 Micro-G NExt journey.

[University at Buffalo Snapcode]

Instagram

Our team's instagram account is UBMicroGNExt this is the our schools first Micro-G instagram account and we aim to target followers the same method as our snapchat account. We will build a follower base by advertising out Instagram on the back side of our small 4 x 5 in. snapchat print out flyers and leave them around lecture halls. This instagram account is to hold permanent content in comparison to snapchat, we aim to post all content as occurring in present time on snapchat and then transfer the highlights on to out UBMicroGNExt instagram account. Our team journey will all be permanently stored in our instagram account and this account will serve as an archiving resource for future teams to utilize.

UB Spectrum

Our university has our own independent student publication that is distributed twice weekly throughout campus. The spectrum publication's shine an uncensored focus on topics throughout our university, but additionally cover milestones within the university as well as feature organizations. Our team has taken the liberty of contacting the Spectrums Senior Features Editor informing them who we are what we do and discuss the possibility of featuring UBMicro-G NExt. The Spectrums Senior Features Editor is contacting the person he believes will be the best fit for our story. We do not foresee a reason for not having a feature in the spectrum. With this feature we aim to have a debrief of our overall experience through NASA's Micro - G NExt program and overview of our project and process.

D. References

[1] Expedition Northwest. "Oh Buoy!" https://omsi.edu/sites/all/FTP/files/expeditionnw/4.P.1.Buoy.pdf

[2]"29 Of The BEST Crafts For Kids To Make (projects for Boys & Girls!)." Listotic. May 10, 2018. Accessed October 30, 2018. http://www.listotic.com/29-fun-crafts-kids-adults-will-actually-enjoy/8/.

[3]Stoegbauer, Kim. "How to Make a Toy Marshmallow Catapult." DIY. October 06, 2018. Accessed October 30, 2018. https://www.diynetwork.com/how-to/make-and-decorate/crafts/how-to-make-a-toy-marshmallow-catapult.

[4]"Marshmallow Catapults." Bowen After School Care Program. September 22, 2014. Accessed October 30, 2018. http://bascp.org/marshmallow-catapults/.

[5]South Dakota Public Broadcasting. "Old School Demonstrations: Bernoulli's Principle (Demos)." PBS. http://pbsdll.k12.sd.us/Downloads/7/11415/Bernoulli2018b.pdf

E. Appendix

Mini Micro - G

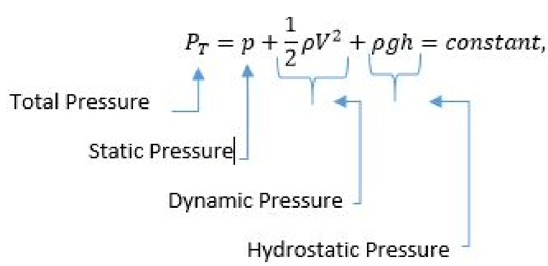
Example of Full Activity Plan:

Target Students in Grades 9-12:
Potential Local Partners:

- Charter School for Applied Technologies (lallan@csat-k12.org)
- St. Joseph's Collegiate Institute
- Canisius High School
- Mount St. Mary Academy

Introduction:

Bernoulli's Significance – Daniel Bernoulli was a Swiss mathematician and physicist who experimented and studied fluid motion. What is fluid, a fluid is either a liquid or gas (so the Air around us is a fluid). We used Bernoulli's equation to apply it to various flows (so we apply it to many cases in which fluid is moving). What is Bernoulli's equation? Bernoulli's equation was derided by Leonhard Euler and it usually is seen as:



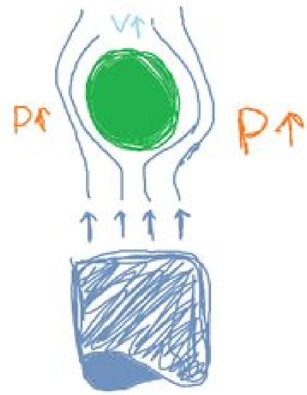
What is this equation saying, Bernoulli's equation says that the total pressure is all of the other pressures added up? Static Pressure is pressure something has How can this be used? Well, Bernoulli's equation equals a constant along a streamline (streamline is just a path). So if we are two random particles going on the same path we can be related through Bernoulli's equation. This relating equation is seen in the form of:

$$p_1 + \frac{1}{2}\rho_1 {V^2}_1 + \rho_1 g h_1 = p_2 + \frac{1}{2}\rho_2 {V^2}_2 + \rho_2 g h_2$$

Demonstrations:

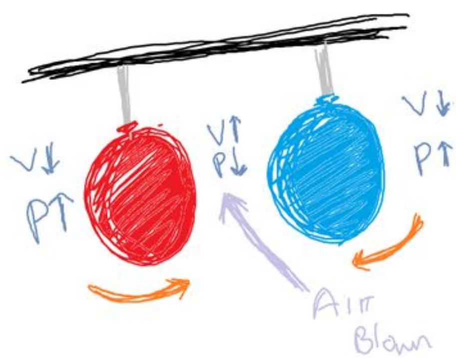
Vacuum Ball:
Place a Ball on top of a hair dryer, or anything blowing out, could be a straw we manually blow out. And place the Ball over the air being blown out. The Ball hovers. This is because of Bernoulli's equation. There is a higher velocity inside and a lower pressure. Resulting in a lower velocity in the outside and higher pressure. Maintaining the ball

within the vortex. This is the same that happens in tornados or free vortex like when a mini vortex forms in a sink. To some extent, the dryer can be moved at an angle until the high pressure is not enough to combat gravitational forces.



Balloons on String:

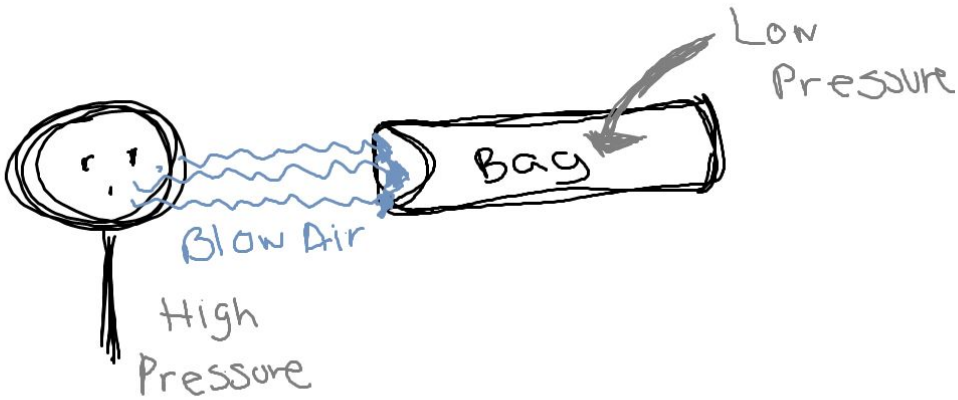
Blow up Two balloons and hang them on a string as shown above, then place them apart. Blow in between the balloons. When blowing the balloons will come together. Blowing in between the balloons creates a greater velocity in between causing a lower pressure. Meanwhile, on the outside of the balloons, it is a low velocity, and higher pressure leading the balloons to move closer together.



Blowing Tube:

The following Demo, was found on PBS, the site is listed below the demo: "Purchase Bernoulli's Bag/WindTube/Bernoulli's Tube. Get students to participate. Tell each they can blow 5 breathes into the bag. Let's see who can blow up the bag the most. Let each student do it at a time. Then with the last bag, blow it up in one breathe. Hold the bag open, removing folds, and place it 6'' - 12'' from your mouth. Blow one large breath into the bag as you step back. The bag can be easily filled with one breath using Bernoulli's Principle. The moving stream of air exhaled is moving faster than the air around it. This creates an area of low pressure (vacuum.) This area of low pressure draws air from the area of high pressure around it, because fluid moves from an area of high pressure to an area of low pressure. The bag is filled with a small amount of air from the lungs and a large amount from the room"

^Demo from PBS [5]



Engineering Process:

Guideline	Possible Student Responses
Problem Identification: What are you trying to solve, why.	Wind Turbine Efficiency, make turbine as efficient as possible.
Generation of Alternatives ○ Drawings, specs.	We are trying to see the impact different components of the wind turbine have on its efficiency. Possible Alternatives: blade count, angle, shape, size.
Alternative Comparison: What is similar, why is your selected option better.	It is customary to see 3 Bladed Turbines, 3 blades is more cost efficient in manufacturing .
Preliminary Design/ Analysis: If possible some testing/ how would it be tested, how does this meet needs, and relate to social constraints such as economic, environmental, social, political, ethical, health & safety, manufacturability, and sustainability.	We will be testing with a fan, and see what the results say of the design.
Problem Improvements: If you can go back and redo or edit, what would you change. If possible, go back and improve. What are some factor not taken into consideration. Repeat as many times as needed	If we could go back, we would try different blades angles, and shape combinations.
Engineering Recommendation	Up to the student based on the results they see as a whole.

<u>Engineering Challenge:</u>

When observing a fan on a hot summer day, has it ever occurred to you to question the blade shapes, why are the blades themselves not rectangular, why is the overall shape circular, why are they slightly curved, or straight, or at an angle, why is there four or five or six blades, why that material? These are all variables to consider when designing a fan, each affects its performance. Whether it provides air at a high velocity, or not a great amount of air, or energy consumption. Keeping in mind what we learned about Bernoulli's principle or your general knowledge of life observations lets go bigger a great challenge of our lifetime is renewable energy, solar, wind, hydro; for today let's focus on wind turbines. What would be an optimal wind turbine design, focusing on blade design, what is the ideal blade shape, why, how many blades, what angle? Let’s then test this and see how these variables impact our energy retention.

For this Project:

- We would provide different blade building material for each group.
    - Examples: cardstock, foam.
- We then would test each blade design on our wind turbine model using a fan as a wind source
    - https://www.vernier.com/products/kidwind/wind-energy/kw-awx/

II. Administrative Section

A. Test Week Preference

We would like to make our testing week: May 20th-May 25th.

B. Mentor Request

Just having the opportunity to work with a NASA Mentor is the opportunity of a lifetime. We would be so happy to work with anyone that NASA provided.

C. Institutional Letter of Endorsement

See Attachment

D. Statement of Supervising Faculty

See Attachment. Unfortunately, Professor Schifferle didn't have access to letterheads. We separately created a letter with what was given in the proposal guidelines and asked Professor Schifferle to sign it after reading it.

E. Statement of Rights of Use

See Attachment

F. Funding and Budget Statement

See page 26 for our budget table. Unfortunately, our cost estimate is above our original intended budget. If you look at the table provided, you'll notice that we go over our budget by $120. We have plenty of time to raise funds. Some fundraising ideas include a Chipotle fundraiser which donates up to 33% of the proceeds made or a delivery service of food or coffee during finals week. Occasionally the UB Student Association will award a stipend for a worthy project. All told, we are entirely capable of raising the additional funds that may be needed.

UB Student Association
Attn: Micro-g
350 Student Union
Buffalo, NY 14228
ubsatreasurer@gmail.com

G. Parental Consent Forms

All participating members are over the age of 18.

University at Buffalo
Department of Mechanical and Aerospace Engineering
School of Engineering and Applied Sciences

Kemper Lewis, Ph.D.
Professor and Chair, Department of Mechanical and Aerospace Engineering, FASME
Director, Sustainable Manufacturing and Advanced Robotic Technologies (SMART) Community of Excellence
University at Buffalo - SUNY

October 29, 2018

Dear Micro-g NExT Staff,

As the Department Chair of the Department of Mechanical & Aerospace Engineering (MAE), I fully endorse the project entitled "MinOS" proposed by a team of undergraduate students from the University at Buffalo - SUNY. I approve of the methods of preparations and testing that the Micro-g team requires. 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 the Department requirements and support of this program could adversely affect selection opportunities of future teams from the University at Buffalo - SUNY.

If you have any concerns or questions please feel free to call me at (716) 645-2682 or email me at kelewis@buffalo.edu.

Sincerely,

Kemper Lewis
Professor and Chair

207 Bell Hall, Buffalo, NY 14260-4400
Tel: (716) 645-2682 Fax: (716) 645-2883 www.mae.buffalo.edu

As the faculty advisor for an experiment entitled "MinOS" 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 project 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 State University of New York at Buffalo.

Paul T. Schifferle 11/1/18

Paul Schifferle, Adjunct Instructor, AIAA Faculty Advisor

E. Statement of Rights of Use

As a team member for a proposal entitled "MinOS" proposed by a team of undergraduate students from the State University of New York at Buffalo, I 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.

As a team member for a proposal entitled MinOS proposed by a team of undergraduate students from the State University of New York at Buffalo, I 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.

Print Name	Sign Name	Date Signed
Alvi Hossain	[signature]	10/29/2018
Jack Gallagher	[signature]	10/29/2018
Neil Boe	[signature]	10/29/2018
Vladimir Tattybayev	[signature]	10/29/2018
Teresa Bonipczyk	[signature]	10/29/2018
Joshua Duell	[signature]	10/29/2018
Henry Leach	[signature]	10/29/2018
POMEROY MOHABIR	[signature]	10/29/2018
LIA KNOER	[signature]	10/29/2018
Liam Field	[signature]	10/29/2018
John Meschino	[signature]	10/29/2018
TOAN Le	[signature]	10/29/2018
Paul T. Schifferle	[signature]	10/30/2018
Mirka Arevalo	[signature]	10/31/2018

Table 1:

Expenses	Units	Cost
Travel		
Flight Tickets	6	$2,848
Airbnb	1	$990
Car Rental(Van)	1	$451
Gas		$100
Food		$800
Sub-total		$5,189
Materials		
3D Filament		$50
Aluminum		$90
Pressure Sensors	3	$18
Teensy 3.2	1	$20
Waterproof Servo Motor	1	$20
Plastic Covers	1 Roll	$15
Banana Plug	1	$18
2nd Sub-Total		$231
Outreach Funds		$200
Total		$5,620
Our Budget		$5,500
Need to Raise **(Additional Fundraising will be done to cover all expenses unforeseen)**		$120