EEMA

Design Challenge: Zip Tie Cutters

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University at Buffalo
Buffalo, NY 14260

Paul Schifferle, Adjunct Instructor, AIAA Faculty Advisor

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I. Technical Section

A. Abstract

For decades, NASA has been actively involved in innovating, and aiding in advancing space exploration. NASA uses many devices that contribute to everyday convenience. Zip ties, for example, have an endless array of operations in just as many categories. Keeping wiring together with a zip tie is common practice, but when the tie need to be removed, it needs to be cut without damaging the wires. The tool that we designed, The EEMA (Extractor for EVA Maintenance Activities), has the ability to accomplish this task. The EEMA is able to cut zip ties of a variety of widths and compositions while minimizing damage to the wires, and simultaneously retaining the zip tie. Retaining the zip tie is important for preventing space debris, and for protecting the NBL pool from debris. The EEMA can be used like a normal pair of pliers, so it is simple tool for anyone to understand. The user simply slides the end of the plier-like head between the zip tie and the wire and clamps down to cut the zip tie. The lever attached to the handle is then squeezed, which rotates the head of the device in a semi-circular motion to a container for the tie. The zip tie will be kept contained by a series of bristles at the entrance of the compartment. The compartment will be attached at the top of the device to one of the handles. The user then simply releases the handle which allows the head of the pliers to return to its initial position. Private testing will be done before the device is brought to the Neutral buoyancy lab to ensure that the device works properly, and poses no risk to the operator, the divers assisting, or the NBL pool itself.

B. Design Description

The design that we have provided is for a zip tie cutter, that will be manually operated, by a single hand. The grip strength required to operate this device will not exceed what is considered a 'very poor' grip strength, which is forty nine pounds (Nicola M Massy-Westropp et. al.). The device will be easily operated with EVA gloved hands. The device will be capable of use with either the right or left hand.

The design of this device consists of three main parts: the handle, the drive shaft, and the cutting mechanism. The handle will be squeezed to hold the zip tie in place. From there, the cutting mechanism will engage as the handle is being pressed. The driveshaft will turn the gearing, bringing the blade to the tie. A second handle, or lever off of the handle, will be used to trigger the head of the device to spin so that the zip tie can safely be dropped off into the storage compartment attached to the handle of the tool. After releasing the handle, the jaw will rotate back around the joint, in the reverse manner, back into its initial position. Lastly, there will be a one inch hole to properly attach a tether to ensure the device does not float away in the NBL pool or in space.

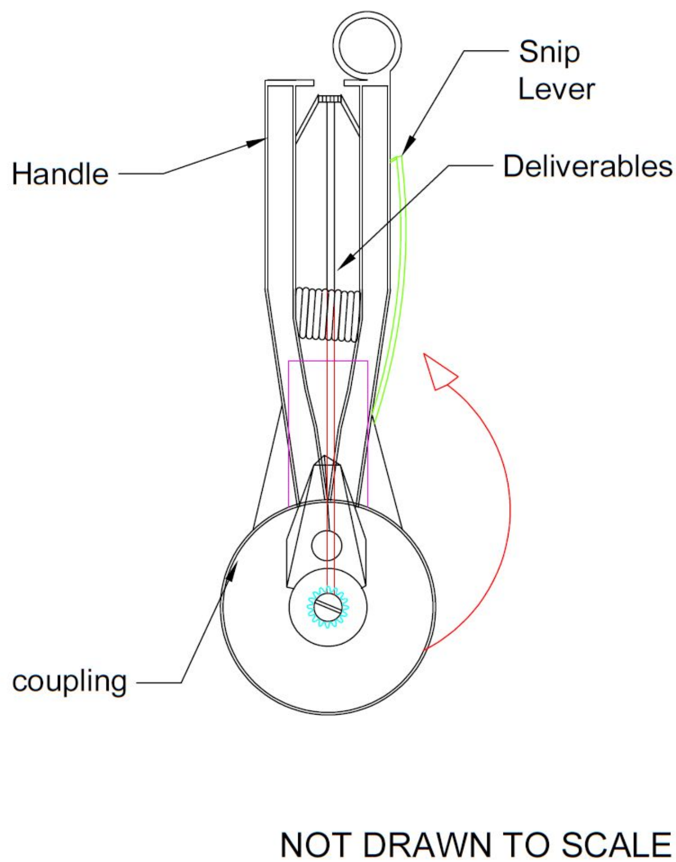


Figure 1. Preliminary Design

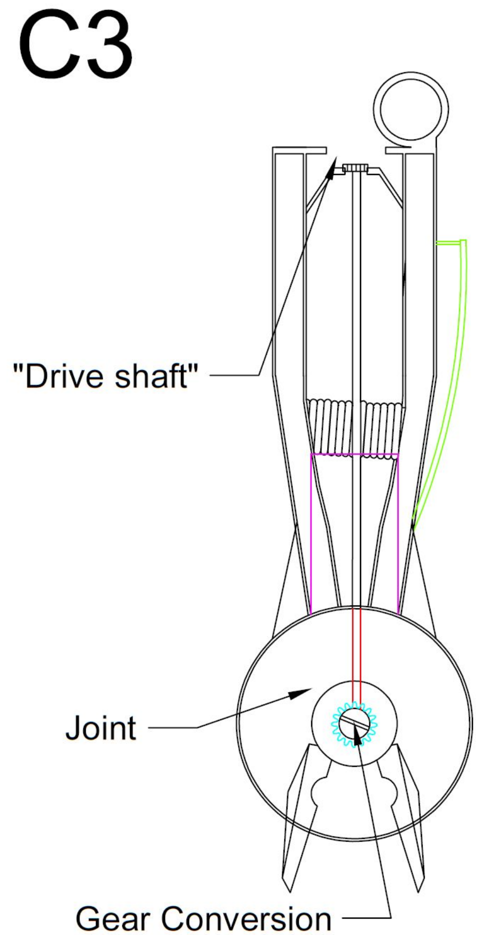


Figure 2. Design Mechanics

Manufacturing Plan:

The coupling system will be produced first, followed by the drive shaft and the jaws. The handle and cover will be the final components created. At least one prototype will be produced for early testing. The handles and blades will be machined in UB's machine shop, with the assistance of UB's professional machinists if necessary. Some parts such as the handles may be 3D printed using UB's 3D printer if proven beneficial. UB AIAA has a 3D printer which can be used if any of the parts are to be made of plastics (possibly the handle and cover if material strength requirements are met). Commercial off-the-shelf hardware (springs and gears) will be used when possible to minimize manufacturing time and costs. We intend on manufacturing the joint, gear conversion, drive shaft, and plier head out of aluminum or steel that is accepted based on the NBL terms. The rest of the tool we intend on making out of plastic through the us of our own 3D printer, again these materials will abide by the restrictions set forth by the NBL.

Challenge Requirements:

1. **The device shall be able to cut and retain a tightly installed zip tie.**

The device will cut the zip tie as the handles are squeezed. A rotating mechanism will then deposit the zip tie into a storage device for retainment. As you release the handle the zip-tie is deposited and kept in storage through the use of bristles.

2. **Damage to anything other than the zip tie should be minimized.**

A small tug will be applied to the zip tie and items contained by the zip tie, but only the zip tie will be cut by the device. All sharp parts will be safely contained in a manner that eliminates damage to anything other than the zip tie.

3. **The device shall use only manual power.**

The zip tie cutter works by manually squeezing the handles. This is the only motion required to use the device, therefore the device will use only manual power.

4. **The device shall be able to pack within a 4” x 4” x 12” volume.**

The device will be stored in a compartment that meets the specified volume requirement.

5. **The total weight of all parts you provide should be less than 8 lbs.**

The maximum weight requirement will be accounted for in the device manufacture.

6. **The device shall be capable of one-handed operation.**

The device will have the capacity to be operated with a single hand. The device will be designed to be compatible with either hand, and easily used in EVA gloved hands.

7. **The device shall be ambidextrous.**

    The device handles can be easily squeezed by either hands, i.e. ambidextrous.

8. **The device and any removable components shall have a tether attachment point 1” in diameter.**

A 1” metal loop will be incorporated into the handle, allowing the attachment of a tether.

9. **All tools must be operable with EVA gloved hands (like heavy ski gloves).**

Since squeezing is the main motion of the device, it should not take long to become accustomed to it with EVA gloved hands. We have made ease of use a large priority in the design of the zip tie cutting device.

10. **Tools must not have holes or openings which would allow/cause entrapment of fingers.**

    The device will not have holes or openings that can cause entrapment of fingers.

11. **Tools must be made from the NBL Approved Materials List or a waiver must be granted.**

The device will be comprised of materials exclusively from the NBL Approved Materials List, including typical engineering metal alloys and plastics.

12. **Lubricants must be selected from the NBL Approved Lubricant List or a waiver must be granted.**

The tool is not expected to require lubricant, but an approved lubricant will be selected if necessary.

13. **There shall be no sharp edges on the tool. Functional sharp edges are acceptable but should be exposed only during operations.**

There will be no exposed sharp edges at any point during the operation of the tool. There will be a safety guard to prevent entrapment of EVA gloved hands.

14. **Pinch points should be minimized and labeled.**

Pinch points will be clearly labeled, minimized, and covered. Any remaining pinch points will be labeled with bright colored, reflective labels.

15. **Tools shall be designed with drain holes or geometry to allow the free flow of air and water as required to support submersion and removal to and from the NBL pool.**

The natural geometry of the tool will allow for the flow of water. Any containment parts for the retained zip ties will have holes to support submersion.

C. Operations Plan

During Extravehicular Activity, the removal of zipties is sometimes a required maintenance task. To prevent damage to ISS hardware; retaining the zip tie after it is cut is key. The test has three main objectives: Cutting the zip tie, retaining the zip tie, and minimizing damage to the hardware beneath. Plastic zip ties and zip ties with metal tangs, both of widths ranging from .1” to .375” and wrapped around differing geometries, will be tested upon.

Testing Instructions:

1. Remove the EEMA from the storage bin.
2. Attach the diver’s tether to the 1” ring located on the device.
3. Confirm that the spring is not in compression, meaning the jaws of the tool are wide open.
4. Look for visual cue to confirm that the tool will not spin into the wire and is being held facing the proper way. (Side with loop is the direction of elliptical motion)
5. Assess local environment geometries, and determine first zip tie to cut.
6. Apply pressure to the handle grip, and compress completely once the zip tie is locked within the jaws.
7. Squeeze secondary lever to cut the zip tie.
8. Lightly tug back to free the zip tie from the geometry that it surrounds.
9. Release the secondary lever.
10. Gently release grip, as zip tie falls into the collection container outlined in violet (figure 3), as the spring puts the device back into the resting tension position.
11. Repeat as necessary for additional zip ties in area

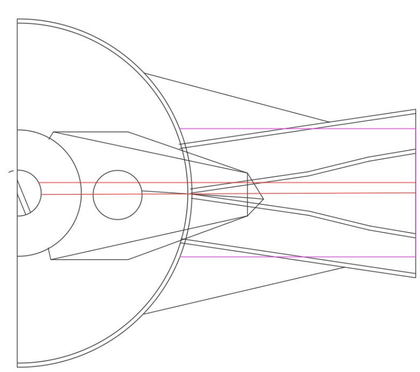
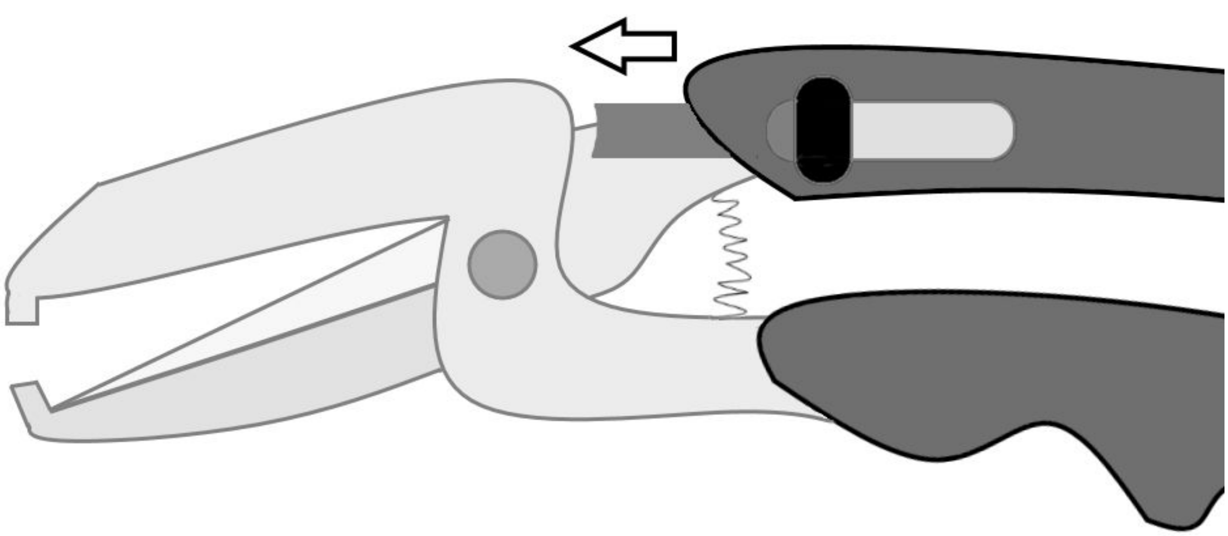


Figure (3)

D. Safety Evaluation

When the device is in use, pinch points are created by the squeezing and releasing of the grip. Pinch points could be problematic to the astronaut's safety. In order to prevent any material, apparatus, or tether from being damaged by these pinch points, we will minimize the number of pinch points. Pinch points will be properly marked on the grip area with caution tags in vibrant reflective colors.

To minimize any risk by sharp edges, the cutting blade itself will include a locking mechanism, similar to one found on common shears, that keeps the blades closed when not in use. An example of this mechanism is, when the device is in the closed position, a retractable sliding tab within one grip can be pushed towards the blade. When the tab comes in contact with a perpendicular surface on the blade, it will prevent the blade from rotating, and therefore opening. The blade will be labeled appropriately with hazard symbols and vibrant reflective colors. For example, our following figure shows how this mechanism could function on a regular diagonal pair of pliers:



The retractable tab would be pushed forward until it came in contact with the head of the blade, where it would prevent the device from rotating; hence opening.

The handle itself could potentially serve as a sharp edge, and a hazard to any EVA gloves when squeezed at high grip strengths. In order to prevent any sharp edges on the handle, while still keeping the device from breaking under grip strength (A factor of safety of 4 shall be our goal), the devices grips (handle coating) will be made of a soft rubber or plastic material, with a metal tang running within connecting to the blades. We will not be using any 3D printed parts for the final device, as the 3D printer material has a history of snapping under pressure. The metal for the tang/blades will be made from a high strength metal alloy for maximum safety and quality. This will ensure safety to the astronauts, divers, and the NBL pool.

In order to prevent fatigue of the user and hand muscle cramping, the device will be constructed to be operable and useful, at what is considered a below average grip strength of 49 lbs (Nicola M Massy-Westropp et. al.). The device will feature ergonomic grips for comfortable operation with EVA gloved hands. Prevention of hand slippage and twisting, as well as prevention of fatigue was an important component considered during the design process and materials selection.

Overall, the design and construction of device will:

-Feature no sharp edges other than the blade which is lockable.

-Be clearly labeled according to section III of the safety requirements, to allow the user to easily distinguish hazardous parts of the device.

-**Not** react chemically with the chlorine in the pool.

-**Not** impose any risk to the environment of the pool. No contaminants will be present.

To ensure and analyze the structural integrity, and safety of the device, we will run our own tests prior to final testing at the NBL. Testing of the device will include grip strength tests, to ensure that it is indeed operable at 49 lbs (Nicola M Massy-Westropp et. al.), as well as grip endurance tests, to ensure fatigue is minimized during operation. We will run virtual simulations of applied loads to ensure the structural integrity of the device. Simulations will be done with programs such as Solidworks and Creo Parametrics. We will perform physical testing of the prototype device, such as dropping the device from varying heights, and handling the device with excessive force. These tests will provide a fuller picture of dangers associated with use of the device, allowing us to minimize any potential harm to astronauts, divers, or the NBL pool.

NBL Engineering and Safety Requirements:

Environment:

- While submerged in the Neutral Buoyancy Laboratory pool, our device will be able to withstand a chlorine content range 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 EEMA sampling device adhere to the guidelines of allowable materials specified by the Neutral Buoyancy Laboratory.

Edges and Protrusions:

- Our device will contain minimal sharp edges, protrusions, and pinch points, in order to prevent injury to the user, tether, or other apparatus.

Excess Water:

- Our device will contain ports throughout the tool for water to flow outside once it surfaces. The need for water drainage is minimal for this tool, and the natural design allows for water flow easily around the tool.

Tool restraint:

- The device will include a 1” hole, to be used as a tether attachment point, in order to ensure that it does not float away from the user.

E. Technical References

Hand Grip Strength: age and gender stratified normative data in a population-based study
Nicola M Massy-Westropp, Tiffany K Gill, Anne W Taylor, Richard W Bohannon, Catherine L Hill
BMC Res Notes. 2011; 4: 127. Published online 2011 Apr 14. doi: 10.1186/1756-0500-4-127

**Helen C. Roberts, Hayley J. Denison, Helen J. Martin, Harnish P. Patel, Holly Syddall, Cyrus Cooper and Avan Aihie Sayer, A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach.
Age Ageing (2011) 40 (4): 423-429.

“Zip Ties.” *Zip Tie Guy*, 12 Dec. 2011, ziptieguy.wordpress.com/zip-ties/.

II. Outreach

The Microgravity team of the University at Buffalo has compiled different opportunities for outreach efforts of the Micro-g NExT project within western New York, and possibly further. Such activities include connecting to audiences through the social media application “Snapchat”, to furthering awareness during the battle bots robotic competition during engineering week. Museum presentations will allow us to raise awareness of NASA’s current projects. These outreach opportunities will provide an insight of space exploration to the general community, furthering their own understanding of what NASA does as a whole, and where tax dollars may be spent!

A. Social Media interaction

The University at Buffalo’s Microgravity team will use the Snapchat application to further awareness of the Micro-g NExT project. By distributing the “snap code” to big lecture halls through paper, and writing the snapchat’s username on the board, we will grasp the audience of the school. Due to a high percentage of the UB populace being active on snapchat; this would raise awareness of our project within the school, giving complete transparency to the project, thus making NASA’s objective of these challenges clear to a major portion of the academic community. Updates via short videos or images of group meetings, and workshops will further understanding throughout.

Other social media outlets will be used as well. UB’s AIAA has its own Facebook group, which can be used to post updates, photos, and event information. This page will reach other AIAA members not in the Micro-g NExT project, and AIAA alumni. Facebook is another outlet from where our audience may follow and interact with our updates within the group. Information to connect will be distributed via group members through multiple mediums in order to fully supplement our ideas and and connection.

A YouTube channel will be set up and we will stream certain work sessions in order to highlight specific activities involved in the process of manufacturing the zip tie cutter and allow Q and A with our audience. Individuals interested in our project will be made aware of the channel’s existence and air times from the aforementioned social media outlets. We are hoping to find local schools interested in participating in a Q and A where students can each ask us a question about being an engineer. We can answer their questions, and ask the students questions that will encourage them to explore and be curious about STEM.

B. Museum Activities

The University at Buffalo's Micro-g team will contact the Museum Education Consortium of Buffalo (MECOB) to discuss outreach programs. This organization includes the the Buffalo Science Museum, Buffalo State College Planetarium, as well as other history and art museums. The organization as a whole is educational in nature, connecting all the other educational organizations listed above.

We will be arranging presentations within the planetarium. The first one that we plan on doing is based on space exploration. It will involve a presentation with videos and amicable language for families that touches on current and near future development projects by NASA while focusing on the James Webb Space Telescope. An explanation of the Telescope's mission and how it achieves said mission will be provided in the presentation. If it's a clear night a telescope can be taken out to explore the night sky and view objects that previous large space telescopes have taken higher resolution photos of.

C. Campus Events

Through the Student Association at the University at Buffalo, our team has accessibility to the necessary resources required to host various events related to our engineering disciplines. Through these events, we intend to raise awareness of our programs and enlighten our audiences about the many different and interesting fields of engineering. Many organizations within our school setup information desks in the central atrium of University at Buffalo with mini-games and prizes for those interested in learning about them. The same will be done for Micro-g NExT to inform our peers of the project's and NASA's goals. We will have engaging activities that are fun for college age participants. Public info sessions relaying our progress, and news about NASA, will be held in rooms across campus throughout the project to inform the local STEM community of our involvement and what we have learned. It is important to share knowledge gained to create a better world.

D. K-12

Schools for the ages within K-12 will be a large target of our outreach activities. Our outreach plan consists of directly getting students engaged in science and engineering, to ensure a future of passionate innovators. The schools involved include schools from our member’s hometowns, as well as the local schools within the proximity of University at Buffalo. These schools include but are not limited to: Sweet Home High School (Amherst, NY), Sweet Home Middle School (Amherst, NY), The Summit Center (Getzville, NY), Maplemere elementary school (Buffalo, NY), Madison Central School (Madison, NY,), etc. Presentations about the latest innovations in space and our project can be modified to have vocabulary fit for the audience. For younger audiences an interactive environment is best. Such an event may involve simple construction from everyday elements in order to demonstrate the effects of simple scientific or engineering fundamentals such as gravity or electricity.

During the months that our team is less active on campus, we will hold sessions to create lesson plans for engineering activities that are suitable for kids of all ages in hopes to spark inspiration and interest in engineering.

E. National Engineers Week

National Engineers Week is a week of events, sponsored by the Discover non-for-profit, that attempts to inspire young people to become engineers as well as educate adults and educators on the fundamentals of engineering, and how to get their children/students engaged in STEM fields. On their website they post activity plans for anyone to access for free. We can use activities to grab the attention of a young audience and teach them our engineering ways. During National Engineers Week we will post information on Facebook and on paper throughout the school as well as reach out to neighboring community centers and schools to ask them if we can educate their students through these activities.

During this week, our school also holds a battle bot competition between the engineering departments. The increased traffic in the central atrium because of this event will allow us to raise awareness of topics of our choosing at our own booth. Creating a bot for competition would be a great way to spread awareness of our project as well: our ‘EEMA’ has potential to be involved on the bot.

III. Administrative Section

A. Test Week Preference:

Our preferred test week is June 4th to June 9th.

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:

Not applicable.

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*

Category	Part Number	Part Identitiy/ Purchase Name	Vendor	Unit Cost	Units	Total Cost
Travel/ Outreach	1	Round Trip Flights	Spirit	$250	6	$1,500
	2	Hotel (1 Week)	Home2-Hilton	$1,085	2	$2,170
	3	Miscellaneous Costs	N/A	$250	1	$250
	4	Outreach Estimate	N/A	$250	1	$250
Prototyping/ Testing	1	ACT Cable Tie Remover Tool	Amazon-ACT Fastening Sol.	$21.34	1	$21.34
	2	100 .125" Width Zipties	CablesTies-andmore.com	$6	1	$6
	3	100 .35" Width Zipties	CablesTies-andmore.com	$17.50	1	$17.50
	4	100 .34" Width Metal Zip Ties	CablesTies-andmore.com	$20	1	$20
	5	1 kg of ABS fillament	Amazon	$30	1	$30
Manufacturing Estimations	1	2' x2" Machinable Aluminum	MCMaster-Carr	$87.90	1	$87.90
	2	1" Thick, 2'x3" 4140 Alloy Steel	MCMaster-Carr	$96.34	1	$96.34
	3	Miscellaneous Costs	N/A	$200	1	$200
		Travel/Outreach Total Costs				$4,170
		Prototyping/Testing Total Costs				$94.84
		Manufacturing Estimations				$384.24
		Total Cost				**$4,649**

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

Institutional Letter of Endorsement:

University at Buffalo
The State University of New York

November 1, 2017
NASA Johnson Space Center
Mail Code: AE2
2101 NASA Parkway
Houston, TX 77058-3696

Dear Micro-g NExT Staff:

As the Department Chair of the Department of Mechanical & Aerospace Engineering (MAE), we fully endorse the experiment entitled "EEMA" 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 the 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 contact me at (716)645-2682, or via email at kelewis@buffalo.edu

Sincerely,

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

Statement of Supervising Faculty:

University at Buffalo
The State University of New York

November 1, 2017
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 "EEMA" proposed by a team of undergraduate students from the University 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 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:

pschifferle@moog.com
Or
(716)645-4349

Sincerely,

Paul T. Schifferle

Paul Schifferle
Adjunct Instructor,
AIAA Faculty Advisor