University at Buffalo
The State University of New York

AIAA
SHAPING THE FUTURE OF AEROSPACE

AMSAR: Autonomous Maritime Search and Rescue

Challenge 1: Surface Autonomous Vehicle for Emergency Response (SAVER)

State University of New York at Buffalo

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UB AIAA Micro-g NExT Research Team

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Table of Contents

I. Technical Section

A. Abstract

NASA's Artemis Program was developed to secure the next Moon landing by 2024. Ensuring the well-being of NASA operatives is at the forefront of our mission objectives and is also in accordance with "Duty to Rescue". In the unlikely event of an egress, NASA will require a timely procedural response. AMSAR (Autonomous Maritime Search and Rescue) is a proposed solution that improves response times via an integrated, fully autonomous system. Designed to search for and deliver aid to astronauts in distress, AMSAR is optimized for maritime environments. The hull structure ensures the integrity of all equipment and allows for rapid deployment by a Group 1 close-range UAV. Immediately upon impact, the accelerometer's limit will be breached, activating the direction-finding using the ANGEL Beacon's 121.5MHz homing signal. A software-defined radio (SDR) will then listen for the beacon and return that information as a unit vector to the guidance computer, prompting autonomous manipulation of the power and steering systems in a direct route to the beacon signal. To increase precision and the chance of a successful mission outcome, sensor sub-systems consisting of both object and proximity detection are implemented via a TensorFlow-enabled camera and an ultrasonic sensor. TensorFlow allows AMSAR to recognize NASA operatives and return a directional vector with increased accuracy to the SDR. To compensate for the lack of depth perception in single-view cameras, an ultrasonic sensor will determine close-range distance. Safety considerations necessitate that AMSAR throttles down the motor when the object and proximity sensors are triggered simultaneously, inferring close proximity to the ANGEL Beacon. Upon arrival, the astronaut can access all required survival aid equipment through the use of AMSAR's mechanical latch.

B. Design Description

AMSAR is a fully autonomous system that must undergo multiple mission procedures in order to attain its goal state. **Figure 1** [pp. 3] shows the System Block Diagram which defines the exact actions and states within the AMSAR system. The sensors required for mission success include the accelerometer, software-defined radio, motor software, TensorFlow object detection, and ultrasonic proximity detection.

Accelerometer ADXL337

To detect significant acceleration changes that indicate that AMSAR has been released by the drone and made an impact with the water, AMSAR will be equipped with the ADXL337 triple-axis accelerometer. The force of impact from a drop will initialize KerberosSDR, allowing it to receive a transmission from the ANGEL beacon. A significant value for accelerometer force measurements will be determined through drop testing. As an example of the drop test for the AMSAR refer to Drop Test Procedure [pp. 15].

KerberosSDR

In order to receive transmissions from the ANGEL beacon, the KerberosSDR and its corresponding open-source software will be utilized. This encompasses a frequency range from 24 MHz to 1.7 GHz, allowing for testing in 121.5 MHz and 406MHz. Four omnidirectional antennas with a spacing factor of $0.33(\lambda)$ will be arranged in a uniform circular array and let AMSAR detect a relative unit vector toward the ANGEL beacon (Gerigk and Wojtowicz 594). As noise generated through multipath propagation may increase error in the beacon's determined location, AMSAR incorporates homing to visual contact for increased positional accuracy (Cochran and Pater 595-597).

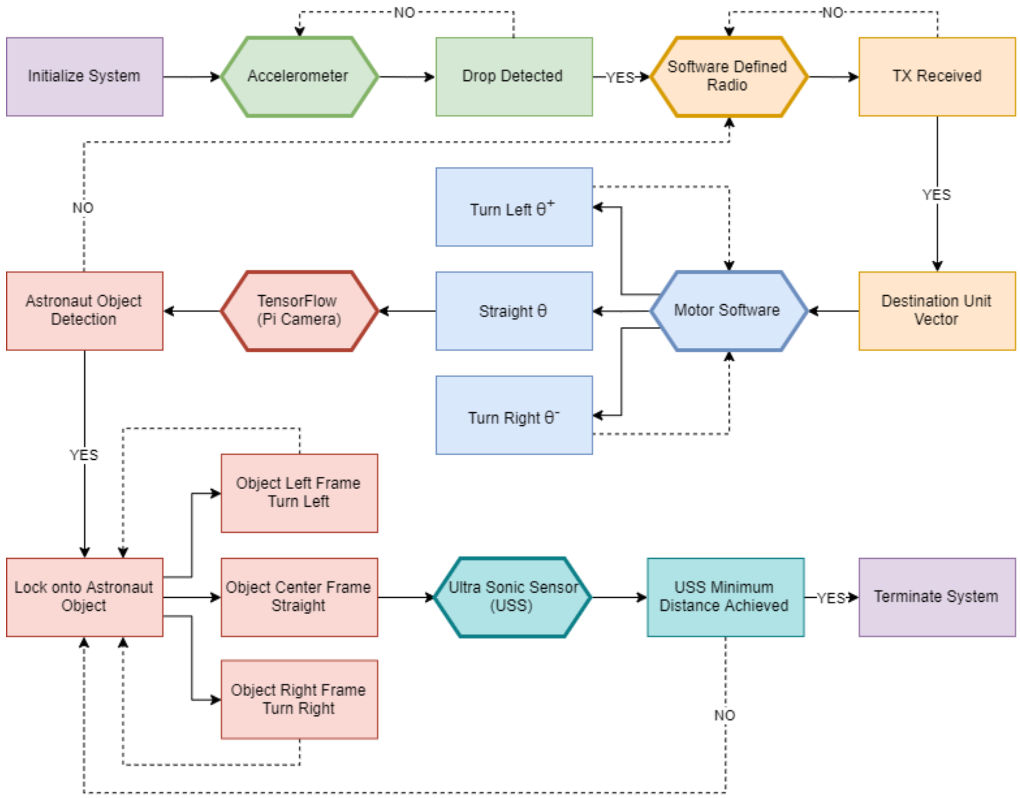

Figure 1. System Block Diagram defining specific actions and states of the AMSAR system.

Motor Software

There are two divisions of motor control: throttling (dependent upon a drive motor) and steering (contingent with the servo motor). A script allowing inputs of the radio frequency for direction finding, object detection, and proximity detection will run both motors. Throttle will initially be at its maximum defined power setting for the journey to the stranded astronaut, minimizing the time to intercept. The defined maximum throttle is active when the KerberosSDR is the *only* sensor returning an output. Upon visual detection, the throttle will be reduced and the triggering of the ultrasonic sensor will halt the throttle completely. The initial destination vector shall be determined from the SDR's output, which then allows AMSAR to steer until its forward-facing unit vector is aligned with that of the destination relative unit vector. Turning shall only be dependent on the SDR and the object detection outputs. Fine steering control during the final approach will be informed by the output of the TensorFlow computer vision software. The servo motor steering can be seen in the frontal section of **Figure 2** [pp. 4]. Nozzle horizontal movement shall be controlled via servo motor connected at the top of the nozzle. Pivoting and stability will be enabled through the use of a ball bearing at the bottom connection. All computations and scripts will be processed through the Raspberry Pi 4. The power distribution of the motors and connections can be referred to in **Figure 4** [pp. 5].

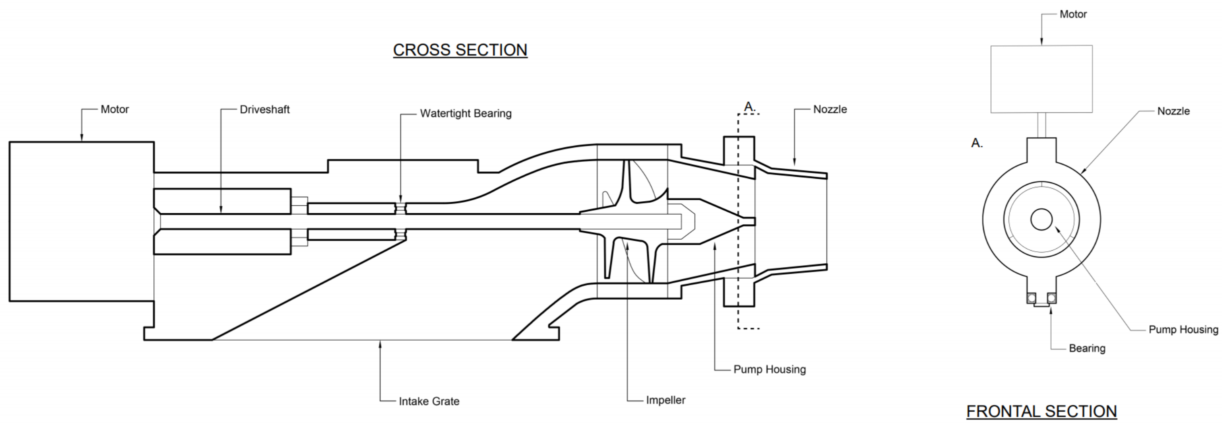

Figure 2. Propulsion System Diagram

Object Detection

Once the vehicle has started advancing towards the astronaut in distress, the AuviPal Raspberry Pi Camera shall begin the detection process. Utilizing TensorFlow's open API, the device will be trained with approximately 2,000 unique maritime environment images to detect and lock onto the astronaut (Ranjan 2017). Upon target recognition, the position of the astronaut within the camera's frame will determine subsequent turning and throttling as follows: if the target is located at the center of the frame, AMSAR shall throttle forward; when the target is situated to the left of the frame, AMSAR shall turn left, then proceed to throttle; if the target is to the right of the frame, AMSAR shall turn right, then proceed to throttle. Each of these scenarios is shown in **Figure 3** from the Pi Camera's point of view. The degree of turn shall be directly correlated to the offset between the detected astronaut centroid and the frame center.

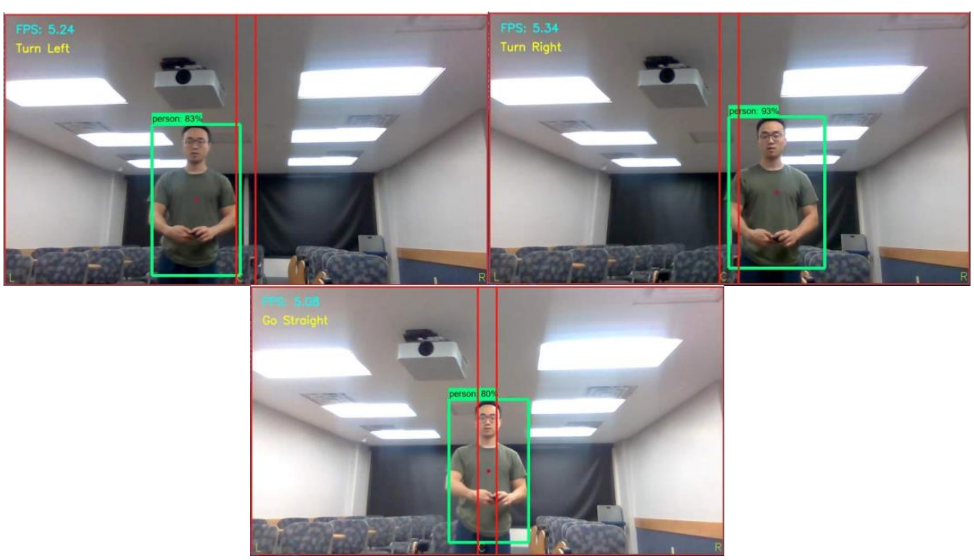

Figure 3. Object detection using TensorFlow software. A target is shown (from top-left in a clockwise direction): left, right, and aligned with the frame's center.

Proximity Detection

The utilization of a single-view AuviPal Raspberry Pi Camera makes the system incapable of depth perception. To compensate for this, AMSAR shall utilize a Waterproof Ultrasonic Module JSN-SR04T. This sensor shall be running after the initial drop and can detect objects in a straight path up to four meters. Acquisition of a target within this range will begin AMSAR's deceleration until the ultrasonic sensor is also triggered, meaning the system has successfully reached the astronaut. As a safety precaution, AMSAR will cut power to the motor if there is no visual feed but an object is detected by the ultrasonic sensor. The software governing AMSAR has been integrated with a median filter to prevent false readings (AMSAR 2019). Power and connection will be provided through the Raspberry Pi 4 (**Figure 4**).

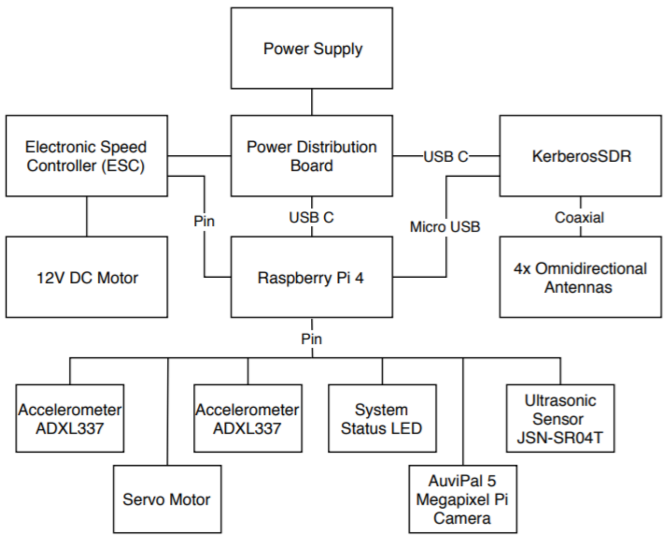

Figure 4. Electrical connections interfacing umbilical power supply with sub-systems.

Manufacturing Plan

Part No.	Manufacture Method	Rationale
1 (Hull)	Mold	The hull will be cast from two fiberglass molds—one for the top and the bottom. This allows the vehicle to achieve a solid uniform material while still giving ease of access for assembly of the various internals. The hull itself will be waterproofed together with a thorough amount of NBL approved Hi-Solids Catalyzed epoxy. Structural rigidity is maintained through an internal skeleton of hydrofoil support structures. The hull maximum thickness shall be maintained at 0.25 inches to comply with weight requirements. The top part of the hull will accommodate the presence of a latch so operatives can access emergency supplies.
2 (Inlet Pump)	CNC Milling, 3D Printing	The inlet pump of the propulsion system shall be manufactured in-house utilizing a combination of the university's machine shop and 3D manufacturing lab. This hardware shall be custom-made as opposed to purchased, due to the tight integration with the thermal management system for the electronics. The waterproof motor driving the pump will be purchased online.
3 (Hydrofoils)	CNC Milling	The hydrofoils shall be manufactured from a 0.25 inch plate of aluminum 6061 on a CNC milling machine. These hydrofoil plates shall then be assembled into an

		internal skeleton to provide structural support and internal mounting points to the hull.
4 (Electronics)	Online Purchase	Raspberry Pi 4 Waterproof Ultrasonic Module JSN-SR04T AuviPal 5 Megapixel Raspberry Pi Camera KerberosSDR Accelerometer ADXL337 4 Omnidirectional Whip Antennas DXF 4S 6500mah 14.8V Battery LED Bulb Power Distribution Board Circuit Switch

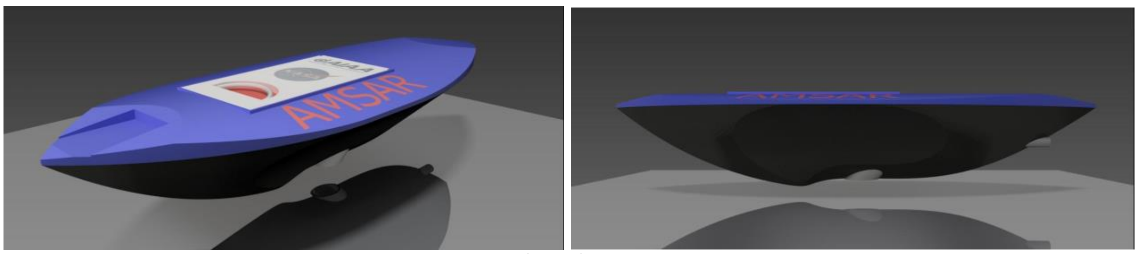

Figure 5. AMSAR Concept Renders.

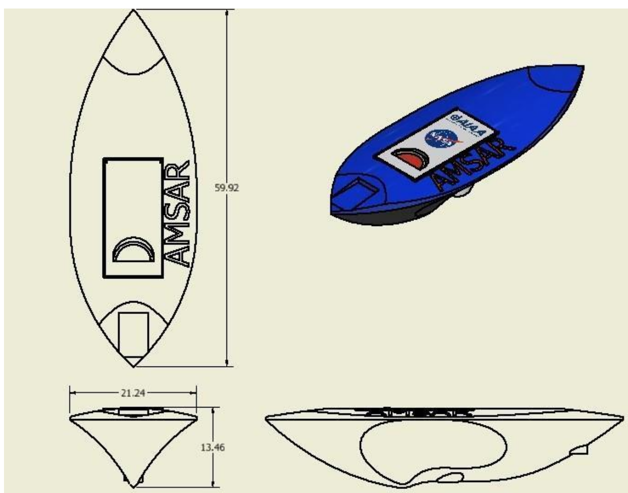

Figure 6. AMSAR overall dimensions.

Compliance Matrix

Req No.	AMSAR Requirement Design Justification
1	The vehicle has a fiberglass hull supported by a rigid aluminum skeleton to maintain structural integrity under the loads of impact with the water's surface. The hull shall be comprised of two segments, joined with NBL approved Hi-Solids Catalyzed epoxy and screws. This two-segment design minimizes the possibilities for leakage into the vehicle to occur.

2	The external shape and hull shall be made of fiberglass supported by a skeleton of aluminum trusses. These materials will help AMSAR achieve a mostly hollow and therefore lightweight design, keeping it within the carrying capacity of the Group 1 UAV.
3	The vehicle shall include a simple mechanical hatch that opens to an internal storage space with a tentative size of fifteen liters. This space shall contain all essential items for the astronaut. The mechanical latch compartment will be sealed and watertight, keeping the emergency items contained within the vehicle until the latch is physically opened.
4	The KerberosSDR will be utilized to receive the ANGEL beacon's 121.5 MHz transmission. A circular configuration of four omnidirectional antennas with a spacing factor of 0.33λ will allow AMSAR to maintain a directional unit vector toward the beacon. The equipment is compatible with 24 MHz to 1.7 GHz frequencies, allowing for a received signal range calibrated to the mission needs through KerberosSDR's open-source software.
5	Upon impact, AMSAR shall wait for the transmission from the ANGEL beacon, which will provide the initial directional unit vector. Taking the relative direction as an input, AMSAR's integrated software shall steer AMSAR toward the person in distress. The system will also utilize TensorFlow's Object Detection through the Pi Camera to lock onto the astronaut once within range. This allows the motor script to switch to TensorFlow outputs rather than the KerberosSDR outputs, providing a more accurate motor maneuver (AMSAR 2019). AMSAR's maneuverability and object/proximity detection sub-systems already account for a number of situations. For example, a false reading by the ultrasonic sensor will not halt the motors, but a prolonged signal will stop the system, to avoid damage (AMSAR 2019).
6	Various aspects of the vehicle's design account for the well-being of NASA operatives including: deceleration upon target acquisition with TensorFlow software, termination of motor power if ultrasonic sensor is simultaneously triggered, implementation of a watchdog within software in the case of a time-out, and custom heat sinks integrated with the inlet pump system to provide cooling to the Raspberry Pi. An inlet grate will prevent unwanted items or limbs from entering the intake. Waterproof connections will be used with all electronic components, which will be stored in a separate watertight area to keep both the equipment and astronauts safe.

Power Budgeting

The maximum power provided by the umbilical cord, according to Section II of the NBL Safety Requirements, is 300 Watts. This caps the system's power allowances, and in anticipation of spikes in power consumption, the budget has been constructed to use much less than the maximum wattage. Refer to **Table 1** below for information regarding the power requirements of AMSAR's electrical components:

Component	Raspberry Pi 4	Brushless Motor	LED	Servo Motor	Pi Cam	Ultrasonic Sensor	SDR
Power (Watts)	15	70	1.65	0.5	0.0175	0.044	~20
						Total	107.21
						Max	300.00
						Remaining	192.79

Table 1. AMSAR's estimated power consumption, broken down by component.

Electronic Speed Controller (ESC) and Brushless Motor: This electronic circuit regulates the speed of the motor. It takes pulse width modulation input from the Raspberry Pi and converts the input to currents for the brushless direct current motor.

Power Distribution Board (PDB): Will connect directly to the umbilical power supply at the NBL. The Pi, SDR, and ESC shall be connected to the PDB. If integration and testing is completed early, a custom power distribution solution will be implemented rather than using an off-the-shelf component for mass conservation.

Battery Power Supply: At the NBL, the vehicle will be powered by a 12 Volt and 25 Amp umbilical cord. To power the AMSAR for the Artemis mission itself and for prior testing, the vessel will require an internal power source. One DXF 4S 6500mah 14.8V battery will be connected to the Power Distribution Board, which in turn will deliver managed power to the Pi, SDR, and ESC.

KerberosSDR: Software-defined radio that shall measure the phase change between each antenna of the circular array for the 121.5 MHz transmission. It sends this information to the Pi, which will calibrate and use an algorithm to interpret the data. This will allow us to get a direction towards the beacon every time it pings or if it is a continuous signal.

Pi Cam: This high-definition video camera will be able to recognize human elements in the maritime environment. This sensor will be connected to the Raspberry Pi.

Servo Motor: This motor shall use the directional input provided by the KerberosSDR and the TensorFlow Object Detection to change the direction of the AMSAR. It will be powered through the Raspberry Pi, through which it will also receive its instruction.

Ultrasonic Sensor: This sensor shall emit ultrasonic waves to determine the distance to the astronaut and avoid other objects. It will be connected in conjunction with the Raspberry Pi.

Antennas: Four Omnidirectional Whip Antennas in a circular array. They shall be used to receive the 121.5 MHz transmission. The phase difference between the antennas and the magnitude of the signal will be sent to the KerberosSDR. They will be connected to the KerberosSDR with four coax cables.

LED: An LED light powered by the pins of the Pi Four, located on the nose of the AMSAR. It will signal system status to the deployment and recovery team, as well as the stranded astronaut.

Circuit Switch: Used to initialize the AMSAR.

C. Operations Plan

The following test procedure is designed to test the autonomous capabilities of the AMSAR. AMSAR is operating under the assumption that the stranded astronaut (represented by a diver) will have the ANGEL beacon in the NBL pool.

1. Plug the umbilical cord into the exterior plug on the AMSAR, and thread the cap tightly to ensure that it is watertight.
2. Use the switch located on the exterior of the AMSAR to turn on the device. Wait at least 1 minutes for the system components to initialize . The LED on the nose of the AMSAR will produce a solid green light once the system is initialized
3. If Step 2 does not produce a solid green light but rather a pulsing green light, system has error.
4. The diver should enter the pool with the beacon. They shall be located a reasonable distance from the AMSAR's initial point to ensure their safety during Step 5 and 7.
5. Hoist the AMSAR to height of 15 feet using the crane.
6. Have the diver turn on their ANGEL beacon transmission at 121.5 MHz.
7. Release the AMSAR from the crane.
8. The AMSAR will begin moving autonomously towards the diver with the beacon.
9. Once within a predetermined safe distance from the diver, the AMSAR will stop moving and the LED on its nose will start blinking

10. To test the capabilities of the cargo hatch, the diver navigates to the AMSAR and opens the hatch. The diver removes the contents of the cargo hold.
11. Have the diver switch the AMSAR off.
12. Return the AMSAR to its starting location.
13. Repeat steps 1 through 12 a total of three times.

The test shall be completed and rerun a total of three times to yield an average response time for an area the size of the NBL pool. Each test iteration shall be limited to a time of twenty minutes, based on the DXF 4S 6500mah 14.8V battery life and the worst-case power consumption scenario of the AMSAR. Successful completion of this testing will demonstrate the capabilities of AMSAR. The switch is for testing in the NBL and is not designed to be a part of the final product.

D. Safety

To ensure the well-being of all operatives involved, the research team identified possible safety concerns generated by the device in **Table 2** and specifically outlined how to address these.

Concern	Systems Affected	Method of Addressing Concern
Interface between Drone and Device	Upper Hull	Possible complications may arise when mounting to the close range UAV. Since details of the interfacing method have not yet been released, concerns will be tended to in the next project phase. One such remedy might be stashing the antennas in a horizontal alignment to be vertically erected upon water entry. Once details are released regarding mounting, we will design a custom mount to interface the UAV with the AMSAR.
Premature Motor Activation	Motor	The accelerometer is implemented for impact detection, which will subsequently initialize both motors and the software-defined radio.
Overheating of System	Raspberry Pi	A custom heat sink shall be implemented to transfer thermal energy from the Raspberry Pi to the external maritime environment through the use of intake water as a liquid coolant.
	Motor	A heat sink shall be implemented to transfer thermal energy from the motor to the external maritime environment through the use of intake water as a liquid coolant.
Inaccurate Human Detection in Maritime Environment (refer to *TensorFlow Object Detection Implementation and Testing Procedures*)	Raspberry Pi Camera	Human detection in a maritime environment shall be implemented using TensorFlow software, which has been trained to identify and lock onto a generic human form. Calibration of the software will be required so that TensorFlow can readjust the initial input of a generic form to that of a human in a maritime environment (Abadi 265-283).
Software Timeout	Software	A watchdog timer will be implemented in the case of software timeout. If the system fails to reset the timer, the system will reinitialize, excluding the accelerometer.
Waterproofing (refer to *Waterproof Testing Procedures)*	Hull	The hull of the system will be two halves bolted together and sealed with a waterproofed NBL-approved Hi-Solids Catalyzed Epoxy connection. Testing shall be conducted to ensure that the system is buoyant and sealed properly.
	Propulsion Motor	The motor shall be connected to the impeller via a drive shaft and waterproofed through the use of a watertight ball bearing as seen in **Figure 2** [pp. 4].

<table>
<tr><td rowspan="5"></td><td>Nozzle Interface</td><td>A watertight ball bearing shall be used to waterproof the servo motor to the nozzle connection in the same manner in which the drive shaft is waterproofed as seen in Figure 2 [pp. 4].</td></tr>
<tr><td>Camera</td><td>The hydrophobic surface of a suitable protective case will act as a waterproof protectant for the visual equipment.</td></tr>
<tr><td>Ultrasonic Sensor</td><td>A waterproof sensor shall be purchased and the connection interfaces will be sealed with NBL-approved Hi-Solids Catalyzed epoxy.</td></tr>
<tr><td>Electrical Connection</td><td>Umbilical cord shall be connected to an exterior plug on the AMSAR using a commercial watertight banana plug connector with a screw cap design.</td></tr>
<tr><td>Internal Circuitry & Systems</td><td>AMSAR has been designed to be constructed in two separate halves. By means of bolt connections and NBL approved Hi-Solids Catalyzed epoxy, it shall prevent water from reaching internal electrical components.</td></tr>
<tr><td rowspan="4">Impact-Resistant Structural Integrity
(refer to Drop Test Procedure)</td><td>Lower Hull</td><td>The hull shall be cast in fiberglass and will contain a frame-like structure. The latter shall be constructed with aluminum and 3D-printed materials to maintain rigidity.</td></tr>
<tr><td>Internal Circuitry & Systems</td><td>Inner components shall be secured through shelving, with strategically-built holes and systems bolted down. To address safety and organizational concerns, zip ties can be utilized to arrange wires.</td></tr>
<tr><td>Camera</td><td>The visual equipment shall be in a sealed and bolted case mounted to the front of the vehicle.</td></tr>
<tr><td>Ultrasonic Sensor</td><td>A bolted camera case located on the front exterior of the vehicle shall aid in maintaining the sensor’s structural integrity.</td></tr>
<tr><td rowspan="5">Operational Hazards</td><td>Impeller</td><td>The impeller shall be placed within internal piping running through the hull’s bottom to prevent contact with the external environment. Mesh will be placed within the pump’s inlet to filter debris, and the generated flow of water will prevent the entry of materials into the pump outlet.</td></tr>
<tr><td>Shape</td><td>The vehicle shape shall be manufactured to have rounded edges, as to mitigate sharp corners.</td></tr>
<tr><td>Battery</td><td>A DXF 4S 6500mah 14.8V Battery was chosen to meet energy requirements for personal off-site testing. For testing purposes while at the NBL, this component will be replaced with a block of equal mass. No other energy source will be present at NBL.</td></tr>
<tr><td>Operational Labeling</td><td>Warning tags for hazardous areas shall be used. Operational directions shall be labeled on the capsule prior to testing. Color-coded wiring for each system shall be implemented.</td></tr>
<tr><td>Motor
(refer to Deceleration Test Procedure)</td><td>Full stop time and distance required from cutoff to power (upon target detection) and target collision shall be found via deceleration testing. This testing will determine ideal reduced throttle, and ultrasonic sensor trigger distance.</td></tr>
</table>

	Capsule	Premature capsule opening shall be prevented by a mechanically operated latch requiring physical turning.
Transportation to Testing Site	Entire Device	A transportation case shall be created to prevent damage to the system.

Testing Results and Procedure Overviews
Complete testing procedures can be found in the Technical Appendix.

Accelerometer Testing Results
Accelerometer testing was performed by drop testing an accelerometer sensor at free fall into the water at the specified heights of one, two, and three meters. Accelerometer absolute value readings can be seen in **Figures 8, 9,** and **10**. All three figures display an absolute acceleration of nearing or surpassing 150 m/s^2. Taking both factors into consideration additionally with the or increasing testing height leading an increased acceleration. The absolute acceleration difference which indicates impact into water will thus be 100 m/s^2. Actual values for AMSAR will vary from previous examples, due to differences in the system being tested.

TensorFlow Object Detection Implementation and Testing Procedure
To implement TensorFlow Object Detection, approximately 2,000 images will be taken with the device's Pi Camera of the desired object in a maritime environment. The images are then processed with TensorFlow, resulting in a device that is trained to identify individuals in a maritime environment. To ensure the device was trained with a sufficient data set, the device will be placed in a maritime environment, emulating the movement of AMSAR, confirming that the device will be able to accurately track and detect individuals. In the event that erroneous readings are present and frequent, additional images would be taken, added to the data set, and the device will be retrained.

Hull/Internal Circuitry & Systems
Once the hull has been completed, waterproof and buoyancy testing shall be conducted by placing the hull in water, dunking it, and examining for interior water or moisture.

Brushless Motor and Servo Motor
Testing for both components shall be identical. To simulate the electronic components being within the hull, the rod and drive shaft shall be placed in plastic boxes with holes cut out. The watertight bearing will be placed into these holes, with the rod and driveshaft going through them, respectively. The actual motors will not be present in their respective boxes to ensure their safety. Then motion performed by motor will be simulated, examining for penetrating fluid.

Umbilical Connection
The umbilical connection shall be tested for waterproof capability in a similar manner to the watertight bearing and seal. A watertight box will have a hole cut in to insert the umbilical connection. Multiple types of cables with various girths shall be placed in the connection to ensure universal water sealing.

Drop Testing
The fully constructed exterior core shall be dropped into a body of water from 15 meters. This test will be two phases first the outer shell alone then the shell with the circuits and systems inside. For the first we will be observing if any damage was inflicted on the structure and any fluid penetration, for the second if the fall has relocated or disconnected any interior components.

Deceleration Testing Overview
Deceleration testing will be performed to achieve an understanding of the time and distance required for the vehicle to come to a complete halt once the ultrasonic sensor detects the object.

This testing will be performed by placing the completed device in water and simulated NBL testing procedure, by altering the reduced throttle velocity we will document time, and distance required for halt.

E. Technical References

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F. Technical Appendix

Enlarged Structure Model

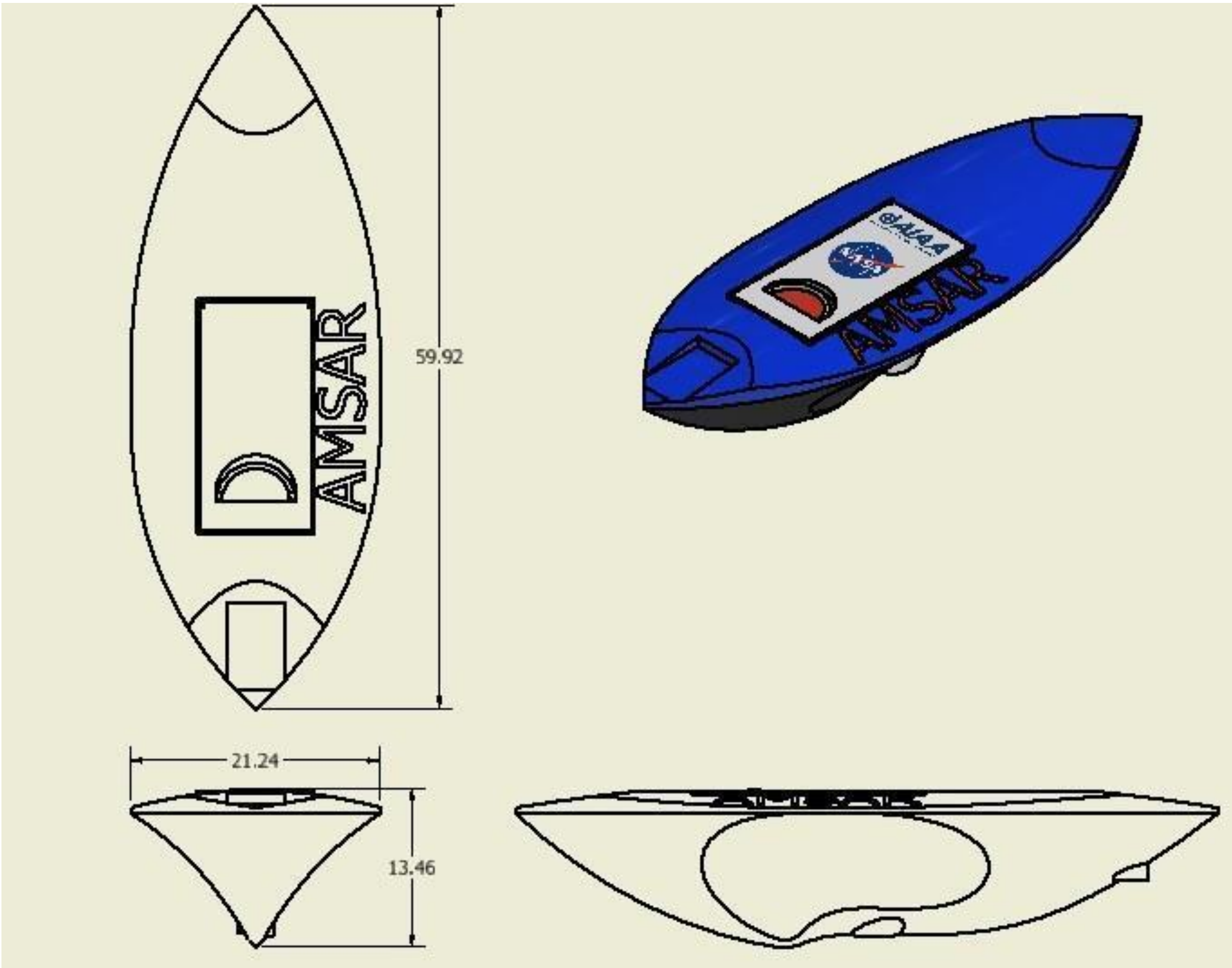

Figure 7. AMSAR overall dimensions, Enlarged.

Testing Results & Procedures

Accelerometer Results

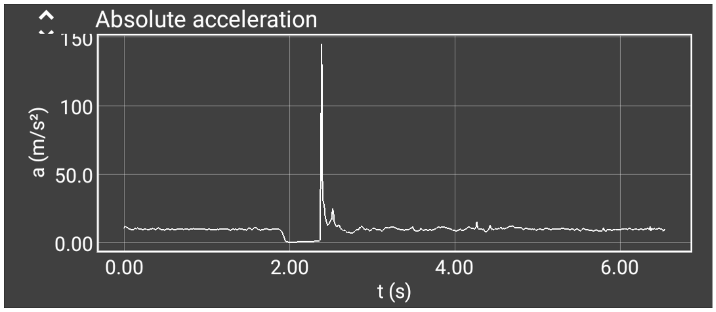

Figure 8. Accelerometer results for free fall drop of one meter.

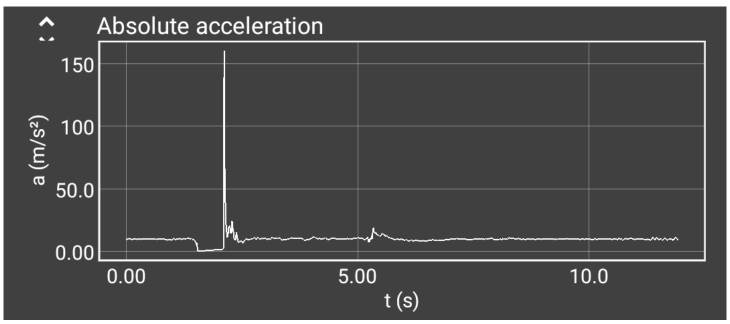

Figure 9. Accelerometer results for free fall drop of two meters.

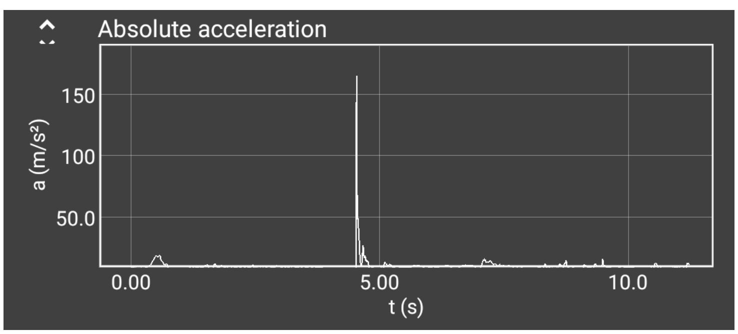

Figure 10. Accelerometer results for free fall drop of three meters.

Hull/Internal Circuitry & Systems

Place the hull in water, with accurately replicated weight and placement of inner components.

1. Let it rest in this environment for 3 hours. If water or moisture is detected inside the vessel, abort further testing.
2. If no water and/or moisture buildup is detected, dunk the craft underwater.
3. Repeat Step 2 a total of 5 times.

If any steps fail, waterproofing shall be reexamined. This testing procedure shall be followed until the waterproofing is satisfactory.

Brushless Motor and Servo Motor Testing Procedure

1. Place the boxes in water. Leave them for at least an hour.

2. If no water and/or moisture is seen, continue.
3. While underwater, rotate the driveshaft or servo link, depending on which component is being tested.

This test procedure tests the waterproof capability as well as the impact of motion on the water tightness of the bearing and seal.

Umbilical Connection

1. Place the cable in the connection, threading the cap down until it is tight.
2. Place the box with the cable connected into water.
3. Move the umbilical connection with box into and out of the water.
4. Remove the box from the test environment. Thoroughly wipe down the umbilical connection.
5. Unthread the cap. Check for water or moisture below the top of the threaded cap.
6. Check for water or moisture inside the box.

Impact Drop Testing

The impact testing will be based primarily on the hull as well as the internal shelving for the electronics. The completed hull, with the appropriate sensor and motor component exterior interfaces installed, shall be used during this testing.

1. Elevate the AMSAR without circuitry to 15 feet using diving boards at the UB pool. Ensure its weight is at most 20 pounds, simulating the completed vessel.
2. Clear the drop area below the diving board.
3. Drop the AMSAR from the diving board.
4. Let the AMSAR remain in the water.
5. After 20 minutes, check if any water or moisture has developed on the interior of the AMSAR.
6. Check the shelving for signs of damage or fatigue.
7. Repeat Steps 1 through 6 for a total of 5 drop tests.
8. Elevate the AMSAR with circuitry to 15 feet using diving boards at the UB pool. Ensure its weight is at most 20 pounds, simulating the completed vessel.
9. Repeat steps 2 through 6 for a total of 5 drop tests for the AMSAR with circuitry.

Deceleration Testing

1. Place AMSAR in pool of water
2. Run AMSAR for motor system at reduced throttle for 2 minutes then shut off
3. Document time and distance required for AMSAR to come to complete halt
4. Repeat steps 1-3 for varying velocities.

From these results we will select a reduce throttle velocity in which AMSAR will come to a full halt within the proximity range of our ultrasonic sensor.

TensorFlow Object Detection Training and Testing

To ensure that the Pi Camera can accurately detect and track the astronaut in a maritime environment, the AMSAR’s RaspberryPi was loaded with TensorFlow’s object detection library and a trained model. The model will be trained with approximately 2000 images of people at different angles, positions, and lighting in the water.

Training

1. For each image taken, bound and outline the object of interest.
2. Separate the images into two different subdivisions: testing and training. Approximately 10% will be placed into testing and the other 90% will be placed into training.
3. Run TensorFlow Training SSDlite-MobileNet-V2 Model
4. Train model until it has achieved loss of less than 0.05, at which point the Pi Camera shall be able to accurately detect Artemis astronauts in the maritime environment (Loss is the likelihood that the prediction will deviate from the actual result)
5. If deemed necessary AMSAR will utilize Google Coral as a TPU to boost the Pi's performance, as well as running a TPU based model, hence increasing frame rate.

Artificial Testing

1. Find online photos of people in water.
2. Run script object detection script on image. Image should be at most 1080p.
3. Script should return image with border around human object with probability over 80%.

Real World Testing

1. Place waterproofed camera in maritime environment
2. Place person into maritime environment
3. Run Tensorflow Object Detection script, live feed should show accurate outline of person and the probability of it should be at least 80%
4. Navigate around people from different angles while tracking live feed to make sure no errors arise.
5. If model is having error, more images need to be added to training.

II. Outreach Section

A. Introduction

Science Technology Engineering and Math (STEM) are vital components to an advancing society, as innovation and creativity in these sectors has historically induced global advancements (e.g., boosted economies, prolonged health, sustainable initiatives, discovery and understanding of some of the universe's mysteries, and overall improvement to the average standard of living). The National Aeronautics and Space Administration is at the forefront of advancement in aeronautics, space science, and exploration, yet the scope of NASA's mission further encompasses the betterment of knowledge for future generations. Driven by a passion for STEM fields, members of the University at Buffalo AIAA Micro-G NExT team hope to make purposeful contributions to the surrounding community through various outreach endeavors and partnerships with local organizations. The team will implement two methodologies of outreach programming: proactive and passive, whose objectives and procedures are outlined in the following sections.

B. Proactive Programming

Educational settings are often limited by uncontrollable systematic factors. Many institutions lack STEM-related clubs or courses due to funding gaps, and in most cases, the higher level math and science courses that do exist focus purely on 'textbook knowledge'. This can be seen from elementary-level schooling through institutions of higher education--many educational programs venerate theory while neglecting hands-on implementation. UB AIAA Micro-g NExt believes true inquiry originates from scientific encounters and application to real-world situations. Exposure to labor of this type activates critical thinking and may cultivate lifelong interests. One of the main objectives of this mission is to provide educational activities where people of any age can learn key concepts and gain hands-on experience. While project funding is dependent upon the proposal's acceptance, the team has concrete dates set with our current partners, including both University at Buffalo Sustainability and the UB School of Engineering and Applied Sciences. The team aims to volunteer our time, experience, and passion to three primary campaigns:

<u>Say Yes to Education</u>

Say Yes to Education is a local Buffalo organization that advocates for every student's ability to graduate from high school and college given the proper support. Our team's role in Say Yes events will be to engage middle school youth and retain their interest in higher education, specifically in the STEM-related fields. Hands-on activities, such as the wind turbine/wind energy plan and solar panel vehicle plan (outlined in Appendix 2.1 and 2.2, respectively), will provide an engaging, interactive experience for the students while also communicating vital knowledge.

<u>Buffalo Promise Neighborhood</u>

Buffalo Promise Neighborhood is a proponent of the belief that education is directly related to opportunity. UB AIAA Micro-g NExt team intends to host a variety of engineering and sustainability activities geared toward elementary school children as well as their parents. This is in the hopes of sparking the children's lifelong interest in STEM and showing the importance of engineering and sustainability to their parents. Some of the activities utilized are the wind turbine and wind energy plan, as well as a solar panel vehicle plan outlined in the appendix. These will be adjusted accordingly given a younger target audience.

Engineering Week

Engineering Week at the University at Buffalo is hosted from February 16th through the 22nd and spotlights the need for engineers to the public. This is achieved through informational sessions, interactive activities, and shows. Common events held include guest lectures, Engineering Club showcases, egg drop contests, etc. with the week culminating at the renowned Battlebots competition. Our Micro-g NExt team plans to participate in Engineering Week by hosting events for fellow college students. Activities shall be centered around the SAVER Micro-g project, such as buoyancy and drop testing of a down-scaled model.

Buoyancy Testing will be an adaptive activity called "Oh Buoy!", where miniature boat-building stations will be set up. Since natural materials are rather dense more often than not, students will be challenged to create a floating prototype. They shall have the liberty of choosing from the provided materials, and through trial-and-error, students will ultimately achieve a buoyant boat. The lesson highlights what may cause a boat to sink or float and outlines the principles needed to displace fluid.

Drop Testing will be an adaptive version of the egg drop activity featuring the need to create a protective structure surrounding an egg to keep it intact following a drop from a specified height. AMSAR is not only required to take the impact of a drop but also remain afloat, and the contest will mirror this requirement. The protective structure containing a raw egg must fall into water and stay afloat. The aim is for students' to incorporate buoyancy into their structure design.

C. Passive Programming

Volunteering, while good at raising awareness and helping society, does not always reach entire communities. The team aims not only to influence our community and the current and younger generation in STEM, but also highlight the purpose behind NASA's mission and work, give an inside perspective of the AMSAR design process live, and highlight NASA as an institution. For that reason passive programming has been incorporated with the outreach portion of this challenge, maximizing reach to the local community and recruiting potential team members or donors for the coming years.

UB Spectrum

The University at Buffalo has our own independent student publication called *The Spectrum*, which distributes roughly seven-thousand newspapers twice per week--the second largest student newspaper within New York State. The paper can act as a professional outlet for the 2020 Micro-g challenge and showcase the club to the UB community. The authors foresee no complications with obtaining a feature in *The Spectrum* for our Micro-g NExt team under the

‘Special Features’ section, which is designed to highlight community achievement. Last year, *The Spectrum’s* Senior Features Editors responded positively to the feasibility of obtaining a paper highlight. Following acceptance, the team will again reach out to these same editors for two features: one announcing the team’s acceptance, project description, and next steps; and the second debriefing the final project result and testing at the NBL. This will generate publicity for NASA and for the team as well, which in turn may garner community support and increase interest toward STEM as a whole within the university community.

Paint the Bull

Located outside of the UB Student Union is a life-sized statue of an American Buffalo, which various student groups are allowed to use to raise awareness, display school spirit, and exercise their First Amendment rights. “Paint the Bull” offers students the ability to paint a life-sized buffalo between the hours of sunset to sunrise, as long as it shows respect to the statue and members of our community. The Student Union’s central location results in extensive foot traffic, as it is the main cafeteria and sits adjacent to two bus/shuttle transportation hubs. Upon completion of the proposal, the team painted a space scene (to the best of each person’s ability) with “Micro-g NExT” in the center with the NASA and the American Institute of Aeronautics and Astronautics (AIAA) logos appearing with the team’s social media outlets. The team is fortunate enough to have a large, eager group, and persisted through Buffalo’s cold, damp seasonal weather to raise awareness for and make UB AIAA Micro-g NExt’s presence known to the entire campus of almost thirty-thousand students. Refer to **Figure 11** for the completed UB Bull fashioned in an astronaut helmet for Halloween. Obtaining a strong social media presence with substantive content brings the opportunity to influence and educate a large population.

Figure 11. The UB AIAA Micro-g NExt team (top) posing with the painted UB Bull (bottom)..

Snapchat

Social media can be a great tool for promoting our club and message, as social media platforms enable individualized content to reach a global audience. From brainstorming sessions to biweekly meetings, and from volunteer dates to testing plans, the team has a considerable amount of material for the community to witness. The primary use of these social media accounts will be to attract a base of followers who engage with the content for increased exposure to Mirco-g and NASA. This exposure is aimed to generate interest in and understanding of STEM's societal roles while bringing the community together. Achieving a regular following base will be addressed by the previously outlined "Paint a Bull", as well as the distribution of account information on quarter-sheet handouts throughout campus lecture halls, and self-promotion at all intended outreach events.

Figure 12. UBMicro-GNext (the team Snapchat account) Snapcode.

Instagram

An Instagram account was created late last year and have since gained a number of followers. During the challenge process, meeting shares have been posted as well as daily Instagram stories of the team's endeavors and through this content maintenance, have been able to attract followers outside of the crew's immediate social circles. Motives for using the Instagram platform are identical to that of the team's Snapchat: showcase the project process from recruiting members, creating the design, brainstorming sessions, late-night proposal editing, and continuous volunteering to, hopefully, testing at NBL. It is strongly believed that highlighting the team's continual work (not simply the finalized project) will induce greater respect for the scientific community.

Figure 13. Current following of UB_AIAA_Micro_G_Next (the team Instagram account).

UBLinked Public Testing

UBLinked is an on-campus event management platform for club activities, special guest speakers, residence hall events, etc. Local tests planned for the AMSAR prototype will be open for public viewing and be posted on the Snapchat/Instagram accounts. Members of the community will be made aware of events through the UBLinked platform in hopes of educating newcomers on the design process and mission importance.

D. References

[1] https://www.nasa.gov/careers/our-mission-and-values
[2] https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-nasa-k4.html
[3] http://engineering.buffalo.edu/home/outreach/camps/sustainability.html
[4] http://www.buffalo.edu/sustainability/OurStrategy/our-future.html

E. Outreach Appendix

Outreach Confirmed Event Dates	
Date	**Event**
11/16/2019	Say Yes Academy
11/23/2019	Buffalo Promise Neighborhood
12/14/2019	Say Yes Academy
02/08/2020	Say Yes Academy
02/08/2020	Buffalo Promise Neighborhood

02/16-22/2020	University at Buffalo - Engineering Week
03/14/2020	Say Yes Academy
04/04/2020	Buffalo Promise Neighborhood
04/25/2020	Say Yes Academy
05/23/2020	Say Yes Academy

Table 2. Current list of the team's confirmed outreach events.

Outreach Lesson Plans

2.1 Wind Turbine/ Wind Energy Lesson Plan **UB Sustainability (Micro-g NExT)**

1. Lesson Plan Information
Subject/Course: DIY Renewable Energy
Grade Level: can be adapted for any grade level
Topic: Wind Turbine Activity

2. Expectation(s)
Expectation(s)*:* Students will learn how wind energy can be harnessed and utilized to power everyday objects. **(Depending on the age group there can be more leeway for letting the students fully designing/constructing their turbines from the bottom up. This will also largely depend on the materials we have to provide the students so that they can come up with designs.)** **Learning Skills *(Where applicable):***

3. Content
What do I want the learners to know and/or be able to do? The students will be able to make a wind turbine and how that energy works. Students will know that: 1) Wind energy is a renewable energy source, and its utilization has numerous benefits for our environment 2) The number of spokes on the turbine, strength of wind, pitch of blades, and number of blades will have an effect on the energy output 3) In order to construct a wind powered system that will work at a maximum efficiency, numerous factors pertaining to the design, such as gear ratio and power output, must be considered. **Today learners will:** ● Identify the advantages of location for maximum wind power collection ● Explain advantages and disadvantages of different angles of their blades on the wind turbines ● Explain how engineers design and redesign wind turbine technology ● Use multimeters to gauge the power output from their constructed wind turbine

4. Assessment (collect data) / Evaluation (interpret data) (Recording Devices (where applicable): anecdotal record, checklist, rating scale, rubric)
Based on the application, how will I know students have learned what I intended? Students will be able to demonstrate their level of understanding by applying the concepts to wind turbine that they can test out the lessons on. From the lesson the students should be able to predict which turbine construction would be able to allow for max wind flow while keeping into consideration the environmental impacts. Further their participation throughout the design process of the turbine and presentation in their wind turbine powered lego house design will be good indicators as to how well the students learned the material.

5. Learning Context
A. The Learners **(i) *What prior experiences, knowledge and skills do the learners bring with them to this learning experience?*** No prior experiences, knowledge, or skills are needed for the students to understand the concepts, only an open mind and readiness to learn. **(ii) *How will I differentiate the instruction (content, process and/or product) to ensure the inclusion of all learners?* (Must include where applicable accommodations and/or modifications for learners identified as exceptional.)** The lesson will be able to reach all students by giving students the chance to learn both from oral presentations and hands-on work that will allow them to fully gauge the concepts and grasp the material. Further, this lesson will include a video representation, hands-on help, and teamwork with other students to help everyone understand what the objective of the lesson is.
B. Learning Environment The learning environment can be done either indoors or outdoors. For indoors activities, it'll require lots of space for students to construct their turbines and test them with large floor fans. The students will work in teams to design their turbine and power an LED. Each team can grab a different amount of materials for their turbine or can also explore the effects of blade pitch.
C. Resources/Materials Materials include: ● Scissors ● Duct tape ● Wooden dowel ● Multimeter ● Fin material (basal wood or foam) ● LED ● Alligator clips ● Floor fans ● PVC pipe for construction ● Cutting mats ● Hub materials for turbine housing

6. Teaching/Learning Strategies
INTRODUCTION ***How will I engage the learners?* (e.g., motivational strategy, hook, activation of learners' prior knowledge, activities, procedures, compelling problem)** Ask students if they can explain what a wind turbine is and why it is good. Students can typically answer these questions and this helps to open up the discussion about this renewable energy. From there start talking about what makes a good turbine and how we use these guys to capture wind (which in all things considering is like another form of solar energy).

MIDDLE:
Teaching: ***How does the lesson develop?***
How we teach new concepts, processes (e.g., gradual release of responsibility - modeled, shared, and guided instruction).

The lesson will start with an engaging conversation and depending on the age group a short presentation with lots of visuals on wind turbines or items that the students can pass around to each other. Next the students will be given supplies and an instruction packet that will walk them through how to assemble everything. Volunteers from the UB Sustainability office will go around to all of the tables and assist the students with constructing their wind turbines. At the end the students will be engaged again with more questions on what they learned, what was the objective, and why is this source of energy important. There will also be a discussion of what worked for them and what did not. This is a good reflection period to get young kids to understand it's alright if something didn't work, but to think critically about why that happened.

Consolidation and/or Recapitulation Process***: How will I bring all the important ideas from the learning experiences together for/with the students? How will I check for understanding?***

To ensure that all the students have fully understand what was occurring, you could ask the students in their separate groups to tell you how they think the turbine operates with wind and how that transitions to moving the motor and powering the LEDs. Ensure that the students have a good understanding by encouraging participation and helping students answers, no answer is wrong but ensuring that their thoughts are validated and encouraged will help create a great learning experience with the activity.

Application: **What *will learners do to demonstrate their learning?***

Learners will be able to demonstrate their understanding of the topic by answering questions at the end and applying their knowledge to building a wind turbine and showing how its design and construction can light up a small lego building or LED. Further, through a think-tank scenario kids will be able to tell whether or not they have a full understanding of the lesson.

CONCLUSION: ***How will I conclude the lesson?***

Conclude the lesson by asking students what did they learn from the lesson, specifically asking them direct questions about how does the design of the turbine affect the power output and what were major obstacles they needed to overcome to increase their power output. Further, asking the kids about examples they've seen about wind energy around them besides near the great lake will prompt them to understand the diversity of wind energy. Lastly information can be shown to kids that demonstrates that the activity that they did is something that students can do at all levels in education, like competitions in high schools to competitive groups in college. The lesson is just an introduction for students to become more aware of opportunities to learn and explore renewable energy at an educational level that they can potentially use in their future endeavors.

7. My Reflections on the Lesson
What do I need to do to become more effective as a teacher in supporting student learning?   **Having some knowledge on solar panels and their effectiveness in direct vs. indirect sunlight as well as what time of year are they more efficient are ways that one can prepare for a lesson prior.**

1. Lesson Plan Information

Subject/Course: Solar Panel Vehicle

Grade Level: can be adapted for any grade level

Topic: Solar energy

2. Expectation(s)

Expectation(s)*:*
Students will understand how solar panels work and how the power load of the panels can be altered by changing the amount of the cell that is exposed to direct sunlight.
(Depending on the age group there can be more leeway for letting the students fully design their cars from the bottom up. This will also largely depend on the materials we have to provide the students so that they can come up with designs.)

Learning Skills *(Where applicable):*

3. Content

What do I want the learners to know and/or be able to do?
The students should learn how altering the amount of direct sunlight will affect the power output produce by the solar panel.
Students will know that:

1) Solar energy is a renewable energy source, and its utilization has numerous benefits for our environment
2) The angle at which a solar cell is positioned in relation to the sun affects its power output
3) The amount of current produced by a photovoltaic cell is proportional to the amount of light hitting the cell; therefore, increasing light intensity or increasing the size of the cell will increase the power output of the cell.
4) In order to construct a solar powered system that will work at a maximum efficiency, numerous factors pertaining to the design, such as gear ratio and power output, must be considered.

Today learners will:
Learn how changing the amount of exposed solar cell will affect its performance when running down a race track. They will also utilize the design process to construct a solar-powered car.

4. Assessment (collect data) / Evaluation (interpret data)
(Recording Devices (where applicable): anecdotal record, checklist, rating scale, rubric)

Based on the application, how will I know students have learned what I intended?
Students will be able to demonstrate their level of understanding by applying the concepts to toy solar vehicles that they can test out the lessons on. From the lesson the students should be able to predict which cars would be able to knock over the plastic cups. Further their participation throughout the design process of the car and presentation in their solar-powered car design will be good indicators as to how well the students learned the material.

5. Learning Context

A. The Learners
(i) *What prior experiences, knowledge and skills do the learners bring with them to this learning experience?*
No prior experiences, knowledge, or skills are needed for the students to understand the concepts, only an open mind and readiness to learn.

(ii) ***How will I differentiate the instruction (content, process and/or product) to ensure the inclusion of all learners?*** **(Must include where applicable accommodations and/or modifications for learners identified as exceptional.)**
The lesson will be able to reach all students by giving students the chance to learn both from oral presentations and hands-on work that will allow them to fully gauge the concepts and grasp the material. Further, this lesson will include a video representation, hands-on help, and teamwork with other students to help everyone understand what the objective of the lesson is.

B. Learning Environment
The learning environment will include an outdoor setting (but the lesson plan can start inside and then move outside for the demonstration of the solar vehicles). The students will work in teams to design their car with gear to knock over plastic cups. Each team will have a different car that has a varying degree of the solar panel exposed, while the rest is covered.

C. Resources/Materials
Materials include: 3 toy solar vehicles (can get more for larger groups), 6 plastic cups, legos, double sided sticky tape, cardboard paper, scissors, aluminum foil, paper, stopwatch, various gears with different number of teeth.
Resources: TBD (most likely packets regarding solar energy and their applications to cars as well as WNY.
https://www.youtube.com/watch?v=knbUIlLMmUE
https://www.youtube.com/watch?v=luh6IIHPze8

6. Teaching/Learning Strategies

INTRODUCTION
How will I engage the learners? **(e.g., motivational strategy, hook, activation of learners' prior knowledge, activities, procedures, compelling problem)**
Can engage the students with this: "Who wants to build a car powered with sunlight?"
Strategy is to engage students to understand that they can build, design, create and knowledge for how solar vehicles can work. Further students will be able to be engaged with a hands-on activity that teaches them about solar energy as well as its usage in vehicles and how that can all be applied to a fun activity.

MIDDLE:
Teaching: ***How does the lesson develop?***
How we teach new concepts, processes (e.g., gradual release of responsibility - modeled, shared, and guided instruction).

The lesson would first start out with a discussion about solar cells and vehicles with a video showing what the activity of the day will be centered around. Next the students will be divided into groups and each group will be assigned a solar vehicle. The students will then need to equip their cars with whatever they think is necessary to help it knock over as many plastic cups (pins) in a single run. The students will be able to see the effects of how the different solar cars (each with a varying amount of exposed solar panel) can affect the performance and how its crucial to be able to utilize the fully capacity of the solar panel.

Consolidation and/or Recapitulation Process: ***How will I bring all the important ideas from the learning experiences together for/with the students? How will I check for understanding?***

To ensure that all the students have fully understand what was occurring, you could ask the students in their separate groups to tell you how they think their car will operate. Making sure that each student gives a valid reason and isn't just siding with the other, that way all ideas can be heard. Further the kids can fill out a questionnaire gaining feedback on the event and what they were able to take away from it.

Application: **What *will learners do to demonstrate their learning?***

Learners will be able to demonstrate their understanding of the topic by answering questions at the end and applying their knowledge to building a car and fitting it with different pieces to knock over pins. Further, through a think-tank scenario kids will be able to tell whether or not they have a full understanding of the lesson.

CONCLUSION: ***How will I conclude the lesson?***

Conclude the lesson by asking students what did they learn from the lesson, specifically asking them direct questions about how does the amount of sunlight impact the cars ability to run, what cars were able to knock over the most cups, and what other ways we can make cars light this run on solar energy. Further, asking the kids about examples they've seen about solar energy around them besides solar cells on their houses will prompt them to understand the diversity of solar energy. Lastly information can be shown to kids that demonstrates that the activity that they did is something that students can do at all levels in education, like competitions in high schools to competitive groups in college. The lesson is just an introduction for students to become more aware of opportunities to learn and explore renewable energy at an educational level that they can potentially use in their future endeavors.

7. My Reflections on the Lesson

What do I need to do to become more effective as a teacher in supporting student learning?

Having some knowledge on solar panels and their effectiveness in direct vs. indirect sunlight as well as what time of year are they more efficient are ways that one can prepare for a lesson prior.

III. Administrative Section

A. Test Week Preference

Test Week 2: June 1-6, 2020

B. Mentor Request

The State University of New York at Buffalo Micro-g NExT team would be happy to work with anyone that NASA provided.

C. Institutional Letter of Endorsement

See attachment.

D. Statement of Supervising Faculty

See attachment.

E. Statement of Rights of Use

See Attachment.

F. Funding and Budget Statement

	Expenses	Units Cost	Quantity	Total Cost
Travel	Flight Tickets	$ 399.00	6	$ 2,394.00
	AirBnb	$ 463.00	1	$ 463.00
	Car Rental (Van)	$ 405.30	1	$ 405.30
	Gas	$ 100.00		$ 100.00
	Food	$ 11.00	72 Meals	$ 792.00
	Travel Sub-Total			$ 4,154.30
Outreach	Say Yes Academy	$ -	6	$ -
	Buffalo Promise Neighborrhood	$ -	3	$ -
	Engineering Week	$ 50.00	-	$ 50.00
	Passive Outreach	$ -	-	$ -
	Outreach Sub-Total			$ 50.00
Materials	Raspberry Pi 4	$ 59.99	1	$ 59.99
	Waterproof Ultrasonic Module JSN-SRO4T	$ 13.50	1	$ 13.50
	AuviPal 5 Megapixel Raspberry Pi Camera	$ 9.49	1	$ 9.49
	Kerberos SDR-4 Channel Coherent RTL-SDR	$ 149.95	1	$ 149.95
	Accelerometer ADXL337	$ 5.84	1	$ 5.84
	Omnidirectinal Whip UHF Antennas	$ 34.00	4	$ 136.00
	DXF 4S 65000mah 14.8V	$ 62.89	1	$ 62.89
	GoolRC Waterproof Brushless Motor	$ 49.99	1	$ 49.99
	SunFounder 20KG Servo Motor	$ 14.99	1	$ 14.99
	Power Distrubution Board	$ 20.00	1	$ 20.00
	Structure	$ 100.00	1	$ 100.00
	Device Sub-Total			$ 622.64
+	Miscellaneous	-	-	$ 250.00
	Total Cost			**$ 5,076.94**

Table 3. UB Micro-g NExt's proposed budget statement. Note that club funding ($5,500) should cover the anticipated costs.

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, PhD, MBA
Moog Professor of Innovation, FASME
Chair, Department of Mechanical & Aerospace Engineering
Director, Sustainable Manufacturing & Advanced Robotic Technologies (SMART) Institute
University at Buffalo - SUNY

October 28, 2019

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

Dear Micro-G NexT Staff:

As the Chair of the Department of Mechanical & Aerospace Engineering (MAE), I fully endorse the project entitled "AMSAR" proposed by a team of undergraduate students from the University at Buffalo. I will ensure that the MAE Department will provide the required space and other needs to complete this project, and deliver them in a timely manner to the team. I understand that any default concerning Department requirements and support of this program could adversely affect the selection opportunities for future teams from the University at Buffalo.

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

University at Buffalo
The State University of New York

October 29, 2019

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 "AMSAR" 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.

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

paul.schifferle@calspan.com

Sincerely,

Paul T. Schifferle

Paul Schifferle
Adjunct Instructor,
AIAA Faculty Advisor

E. Statement of Rights of Use

As a team member for a proposal entitled "AMSAR" 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 "AMSAR" 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	Year	Major	Date
Abigail Kerkezis	[illegible]	SO	AERO/MECH	10/23/19
Allison Gardener	[illegible]	JR	AERO/MECH	10/23/19
Christina Colella	[illegible]	SO	AERO/MECH	10/23/19
Henry Leach	Henry Leach	SO	AERO	10/23/19
Herman Bambrah	[illegible]	JR	AERO/MECH	10/23/19
Imon Kallyan Tatar	TATAR	FR	COMP SCI	10/23/19
Jonah Bannon	Jonah Bannon	FR	AERO/MECH	10/23/19
Joshua Duell	[illegible]	SO	AERO/MECH	10/23/19
Kevin Michelsen	[illegible]	SO	AERO/MECH	10/23/19
Kevin Zheng	[illegible]	~~SO~~	AERO/MECH	10/23/19
Liam Field	[illegible]	Sr	AERO	10/23/19
Madeline Frank	Madeline Frank	JR	AERO	10/23/19
Mark Ng	[illegible]	SR	COMP SCI	10/23/19
Mirka Arevalo	[illegible]	SR	AERO/MECH	10/23/19
Ryan Hughes	Ryan Hughes	JR	AERO	10/23/19

Sean Flynn		SR	CIVIL	10/23/19
Tamaghan Maurya		JR	COMP SCI	10/23/19
Teresa Bompczyk		JR	COMP PHY	10/23/19
Viren Parekh		SR	AERO/MECH	10/23/19
Vladimir Tattybayev		SR	COMP SCI	10/23/19

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