



Capillary Action Device for Investigation (CADI)

Jesus Pacheco, Rebecca Garcia, Jaylene Pompa, Raul Ornelas, Mia Rodriguez, Ayleen Rodriguez, Mariela Guerra and Dr. Contreras

NASA Techrise Project 2022-2023



Abstract

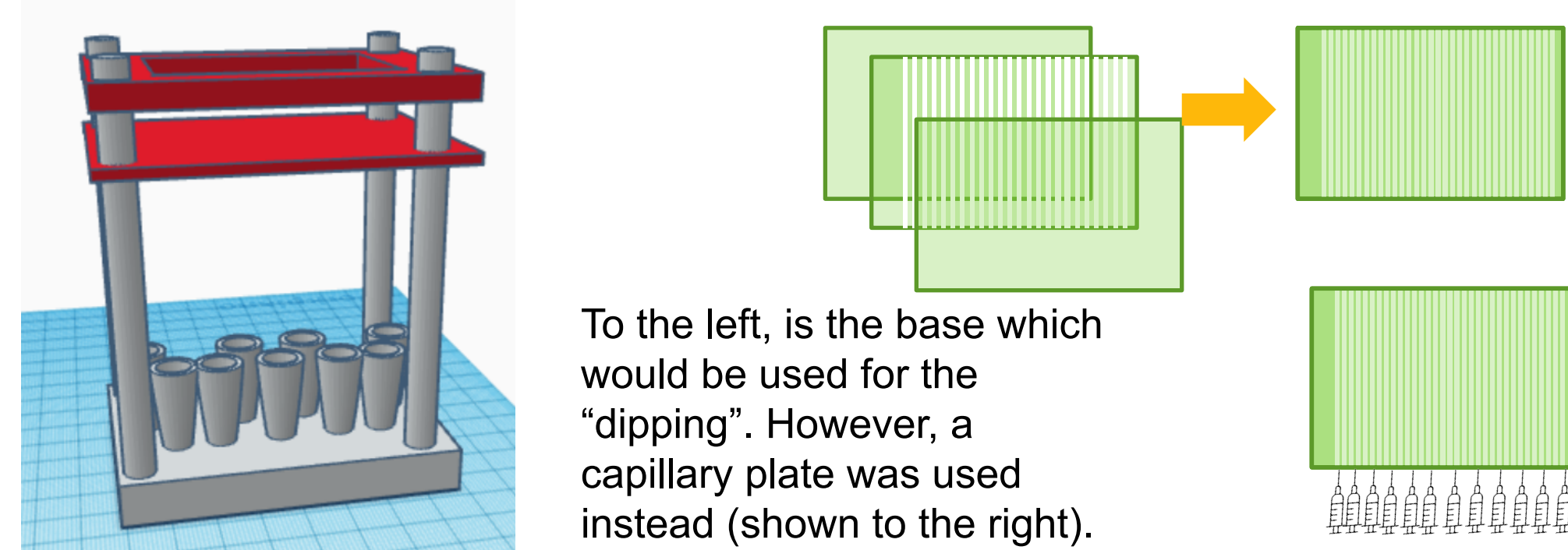
This project was selected to improve the methods of growing food in microgravity conditions. Based on NASA publications, efforts are being made to improve the yield and conditions for growing produce in micro-gravity conditions for use by astronauts on extended missions. In this experiment two main variables will be explored for optimizing water delivery systems for plants: capillary flow across different materials and the flow of fluids of different viscosity.

This experiment will allow for a large proportion of the experiment to be tested on Earth. Materials will be designed to optimize root anchoring on Earth. In addition to root anchoring, capillary flow will need to be optimized to support water in an aeroponics/hydroponics system. These experiments will allow for design of hydroponics/aeroponics fluids and the vehicle materials that carry them across root systems in an aeroponics or hydroponics system. Different viscosities may occur in fluids designed to carry nutrients to soilless systems such as those aboard the ISS or any vehicle traveling in space. In addition, different methods of moving water across a membrane can be explored. Students may take advantage of water's polarity and use magnets to direct the motion of water. Furthermore, zero gravity conditions will prevent suspended particles from settling, adding magnetic particles to a fluid can enable increased adhesion and direction of a fluid.

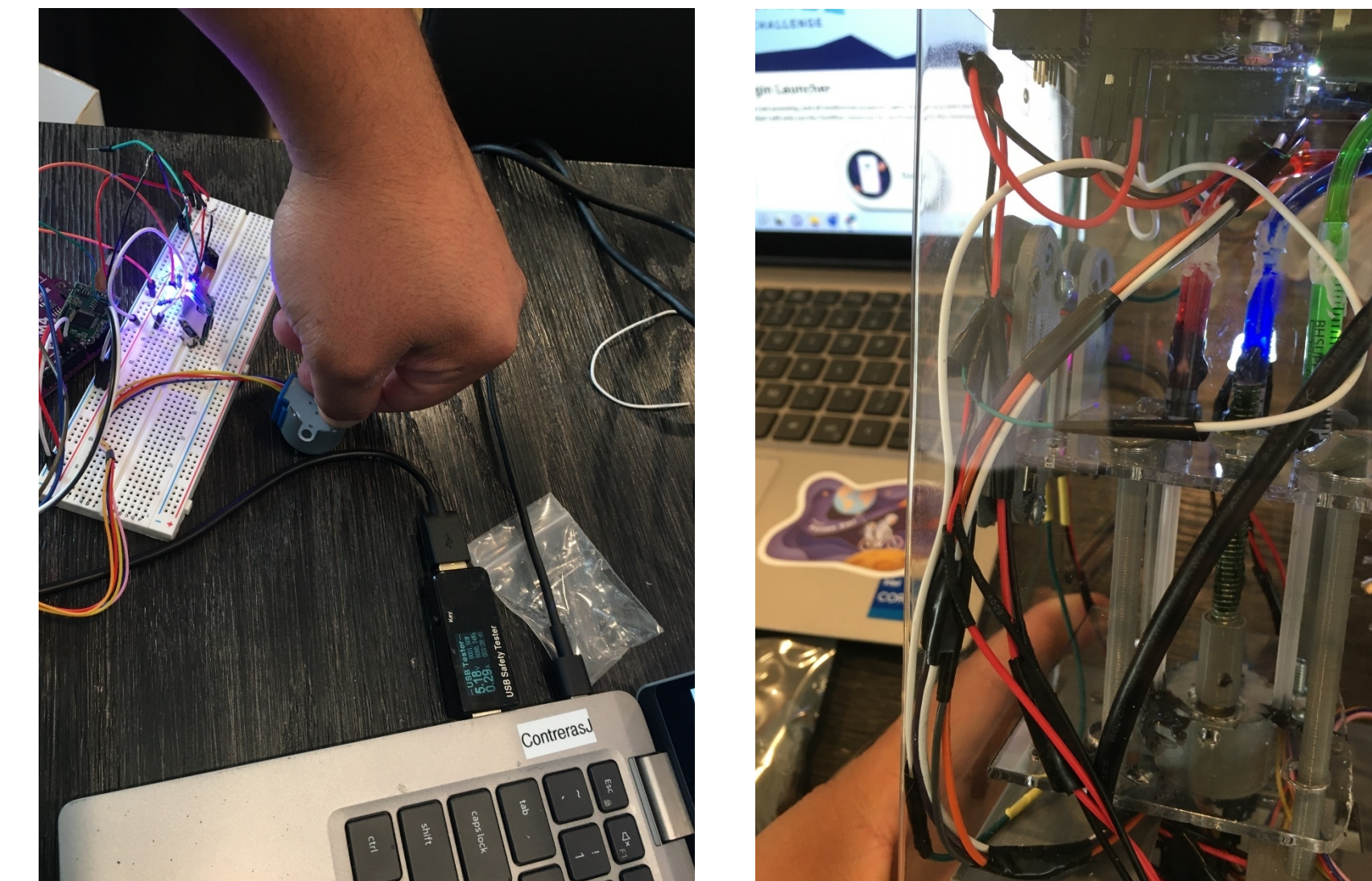
In this experiment we will be testing two variables to gain insight on capillary flow of fluids in microgravity: viscosity of fluid and capillary action of different materials. The miniature device will capture capillary flow of different fluids across different media designed to optimize capillary flow. Data will be recorded aboard the rocket by communicating with the rocket's data to begin experiment at zero gravity and release the fluids in micro-containers. Fluid flow will be calculated as volume/time rate of flow and by total volume removed from source to feed.

Materials and methods

For the building of this device several tools were used such as a MakerBot 3D printer as well as a Glowforge Laser cutter. The platforms were first constructed of particle board and steel rods to make CADI-1, however this was quickly abandoned due to weight constraints. To travel in the vessel (Blue Origin rocket) our device could not exceed 500g. Initial meetings with our mentors proved very valuable as they raised concerns on how we were going to test the capillary action in tubes. Initially we decided the best way to test capillary action was to use a stepper motor to dip capillary tubes into a reservoir. Our mentors raised the question of how we would keep the reservoirs sealed while the experiment was in storage and how we could pierce the seal when the tubes were to be dipped. We then decided a capillary "plate" would be made using a laser cutter in which the fluids would be injected.



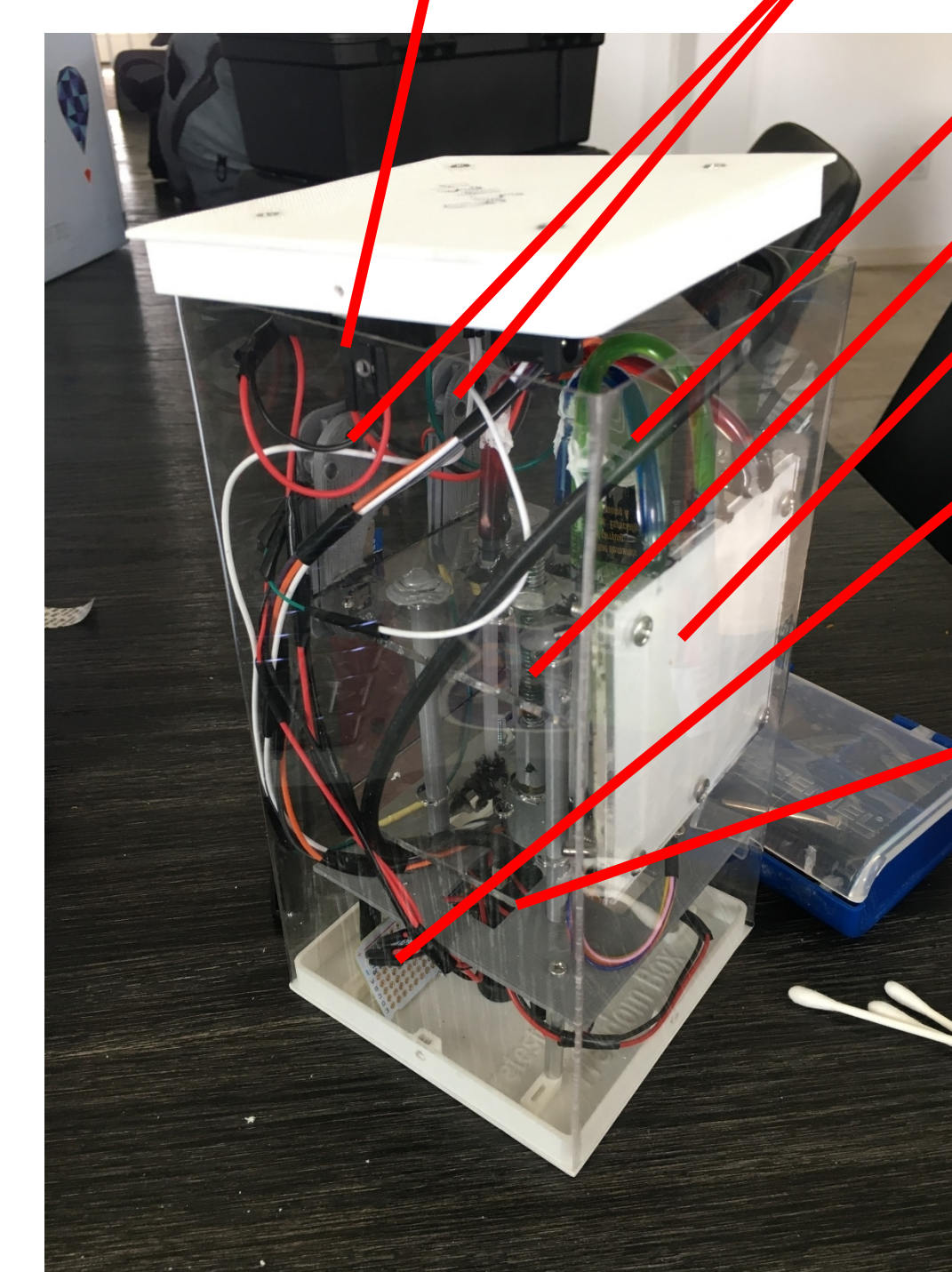
Results



Results- Our final load was below the 500g limit at **432g** and under the voltage and current limits at 5.19V and 5.29amps respectively. We were able to load the syringe tubes with pure water (blue), 0.22g/L of fertilizer (green) and 0.44g/L (red) of fertilizer. Each of the syringe tubes was connected to a capillary plate with a capillary containing: sand, vermiculite, and cotton as substrates for growth medium.

LED light, illuminates experiment, under chasis

Camera (2)- will record the capillary tubes being filled with solution and rate of flow among substrates



Tubes with fertilizer solution

Shaft, turned on nut, pushes the plate and syringes

Capillary Plate, contained small tubes filled with sand, cotton, or vermiculite

Miniature Breadboard, connected all the electrical components. (sort of like a chip)

Stepper Motor (under plate), turned shaft to push the plate to press syringes

Conclusion

Conclusion- Our project was sent to California to await launch. Due to some delays, the launch will be taking place late in 2023. We will be anxiously awaiting launch and will update the Tornillo community as soon as we receive word that our project is to fly.



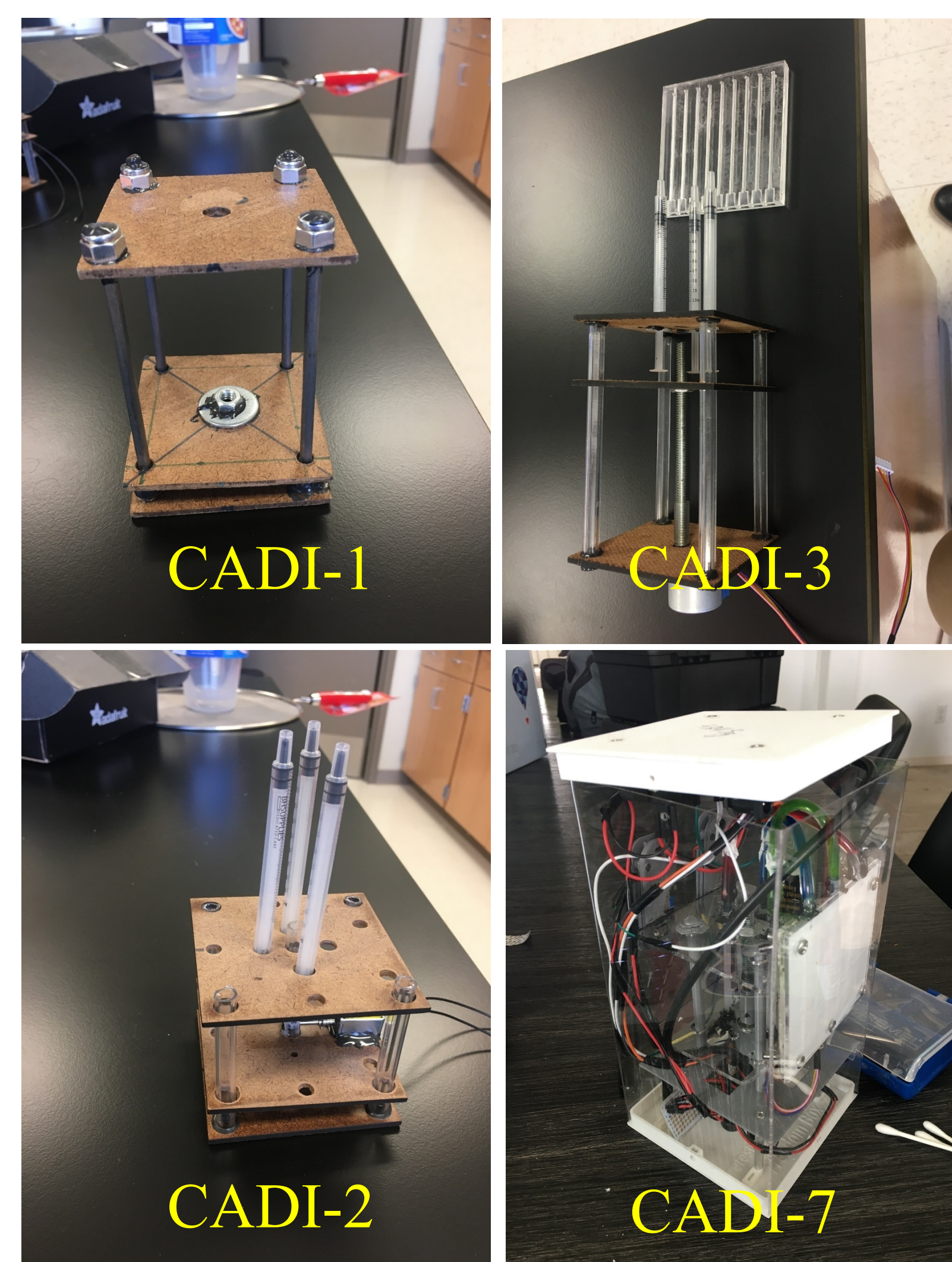
Introduction

- Systems are being developed to grow plants in space for consumption
- Astronauts can grow food by using soil-less growth methods such as hydroponics and aeroponics.
- In these methods, plants are fed using a nutrient mixture which is cycled through the water.
- Our project came about when we were discussing how astronauts can grow food in space if liquids float in space.
- **Problem** -growing plants in zero gravity presents many unique problems. To address these problems, hydroponics and aeroponics can be used to minimize resources and maximize produce production.
- Capillary action is enhanced in zero gravity and can be used as a method to water plants.
- **We will test different concentrations of fertilizer for hydroponics (viscosity changes) with different substrates (soil-less growth substrates for growing plants) to observe capillary action in zero gravity.**
- Capillary Action Device for Investigation was what we decided to name our experiment (CADI) in honor of astronaut Cady Coleman (Pictured below)

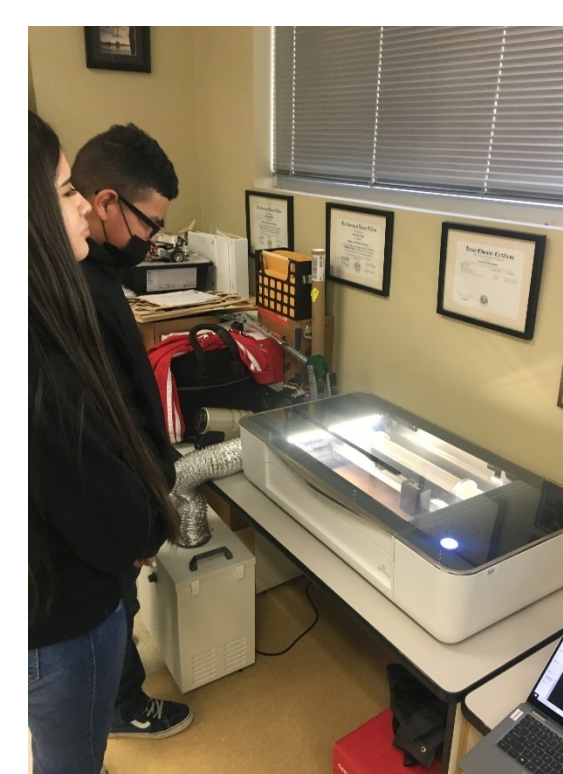


Cady Coleman pictured left onboard the International Space Station (ISS) Investigating capillary action in zero gravity. Our device acronym CADI is in honor of her and women in STEM. Image taken from NASA website:
https://www.nasa.gov/mission_pages/station/research/news/capillary-in-space.html

Iterations



After building the first iteration of our device (CADI-1), we quickly realized we had to abandon the steel rods and the composite boards for something lighter. Using a Glowforge laser cutter, we were able to make more precise cuts, in addition we moved to using a clear acrylic base for our platforms. CADI-7, our final iteration Used only two acrylic platforms secured onto a PLA 3-D printed platform. The final iteration worked and we were able to load it into the capsule.



Our Team



Acknowledgements

We would like to thank the Future Engineers of America for their part in organizing this great opportunity. We would also like to thank the National Aeronautics and Space Administration for their role in providing the personnel and talent needed to guide us. Particularly: **Savannah Jonker** for organizing the events and meetings. **Claire Bengtson** for her role as a key mentor and supporter to our team. **Martin Dalgaard** for his role as a mentor. **Deanne Bell**, **Jarred Sutton**, and **Josephina S. Morales** for their insightful advice and support

Tornillo High School STEM Club

