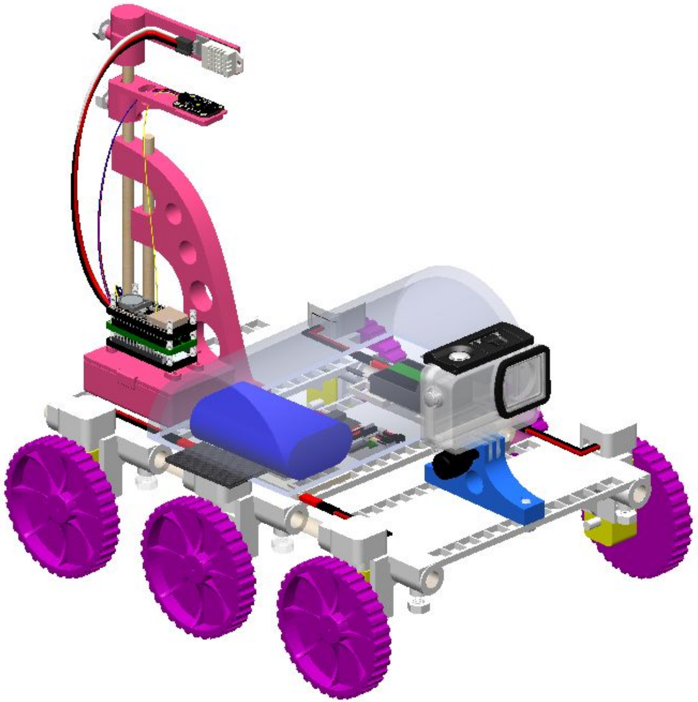


The TerraROVER

Boston University College of Engineering

Senior Capstone Presentation 2023

Team 9: Darin Sumetanon, Erin Dougherty, Justin Le and Kiran Gomatam

Advisor: Professor Anthony Linn

Clients: Professor Caleb Farny, Geoffrey Bland, Andy Henry

Meet the Team

Darin Sumetanon
Mechanical Engineering

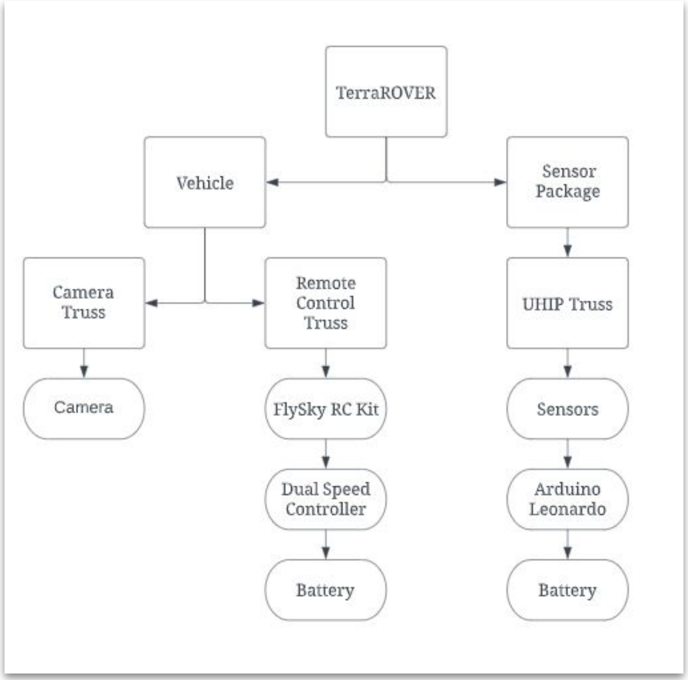
Erin Dougherty
Mechanical Engineering

Justin Le
Mechanical Engineering

Kiran Gomatam
Mechanical Engineering

Introduction to the TerraROVER

- Developed by the AREN Project in collaboration with GLOBE and funded by NASA Science Activation
- Created to be a remotely operated vehicle to act as an educational and data acquisition tool
- Sensor packages aid in the collection of data surrounding climate phenomena, and more specifically, Urban Heat Islands.



Urban Heat Islands

- The TerraRover currently carries the UHIP (Urban Heat Island) Sensor Package
  - This sensor package can be interchangeable with others
- Urban Heat Islands occur when urban areas become significantly warmer than surrounding rural areas
  - Due to urban surfaces absorbing and re-emitting heat
  - Causes increased air pollution, more energy usage (ex. Air conditioning)
  - Students can take data on local heat islands

Identifying the Problem

Alongside acting as a data acquisition tool, the TerraROVER developers intended for it to be an educational tool used in classroom lessons. However, initial versions of the TerraROVER proved confusing to build and required resources that may not be available to secondary schools in the United States, limiting the extent of the educational aspect.

Customer Requirements

- Adjust TerraROVER design to optimize safety and ease of use for students.
- Organize ROVER components into simple assembly kit.
- Design assembly and user manuals for both the ROVER and UHIP sensor package that can be easily understood by middle and high school students.

ROVER Mechanical and Electrical Design Improvements

Design Improvements: The Initial Build

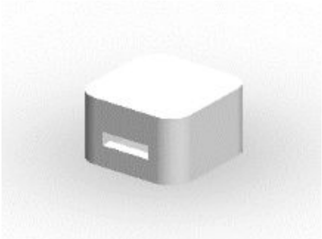
To identify areas of improvement with the ROVER design, the team worked together through an initial build and noted struggles that arose along the way.

- Heavily reliant on soldering.
- Disorganized wires (safety i.e., wiring polarity)
- Confusion concerning diagrams.
- Lack of conceptual descriptions.
- Noted lack of weather protection.

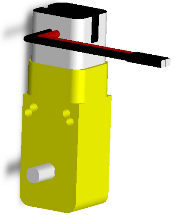
Design Improvements: Motors

- Motors initially required soldering to connect to power.
- Electrical connections not weather resistant.

- Used crimp connectors to eliminate need for soldering.
- Developed motor caps to protect from heat/rain.



- Purchased pre-soldered motors.
- Adjusted motor cap design to accommodate.



Design Improvements: Thermoform Cover

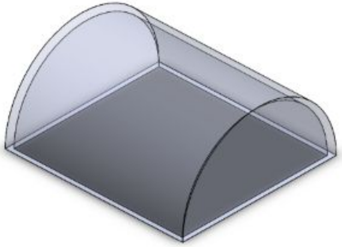
- Initially, all electrical components of the ROVER were exposed to weather-based impacts.

- Planned to use an acrylic board bolted onto the truss.

<u>Drawbacks</u>

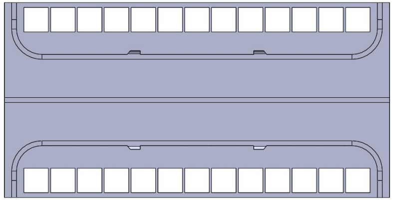
- The wheels of the rover kick up water so a flat cover on top would not keep out dirt/water.
- Hard to remove.

- Designed an acrylic thermoformed cover that can be attached and removed with velcro for easy access to ROVER components.



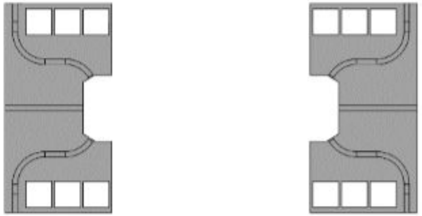
Design Improvements: Wiring Plates

- Each motor requires 2 wires (+/-) and there are 6 motors total.
- Tracking each wire to the required motor was messy.



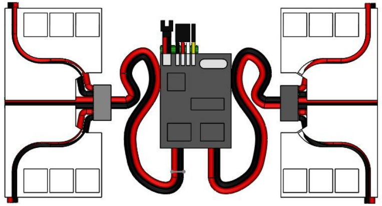
V1

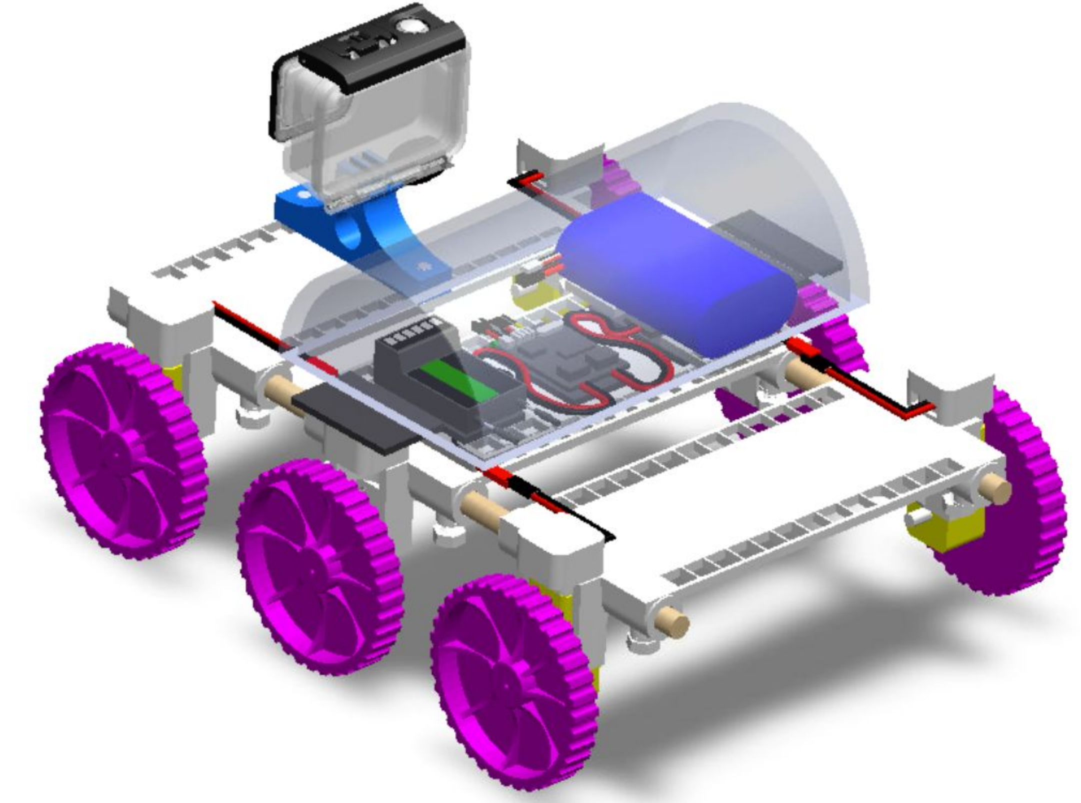
- Iterated from full plate to two plates to make space for RC components and wiring.



V4

- Final design allows for visualization / organization of the motor connections.

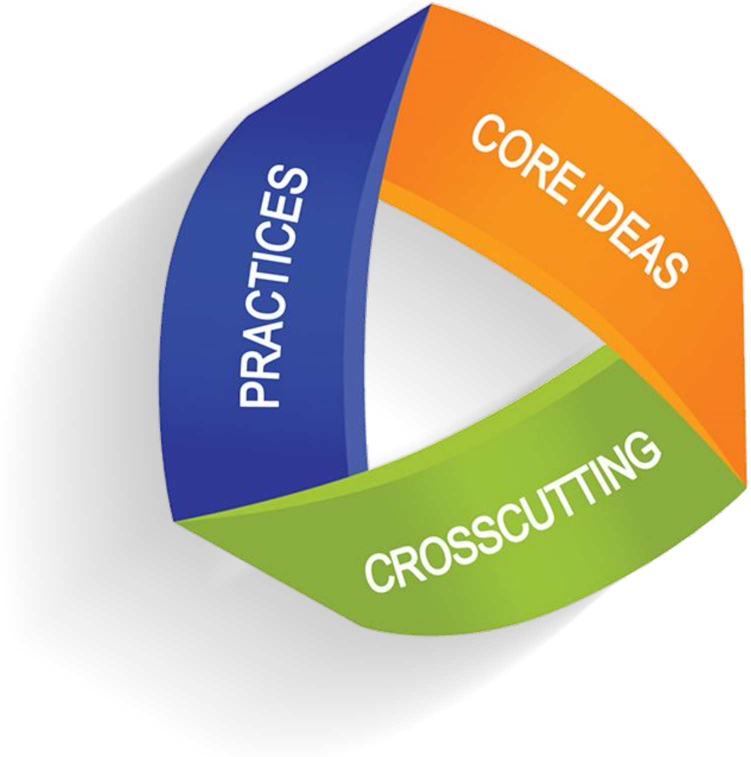




Instructional Components for Assembly and Operation

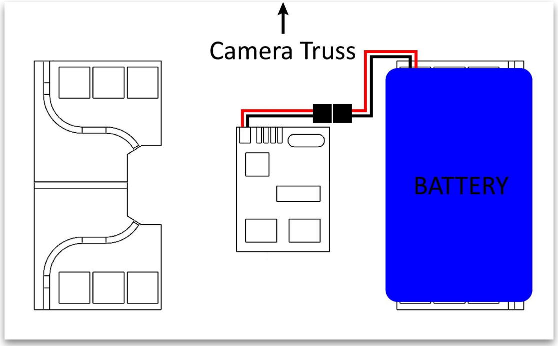
Instructional Components: Next Generation Science Standards (NGSS)

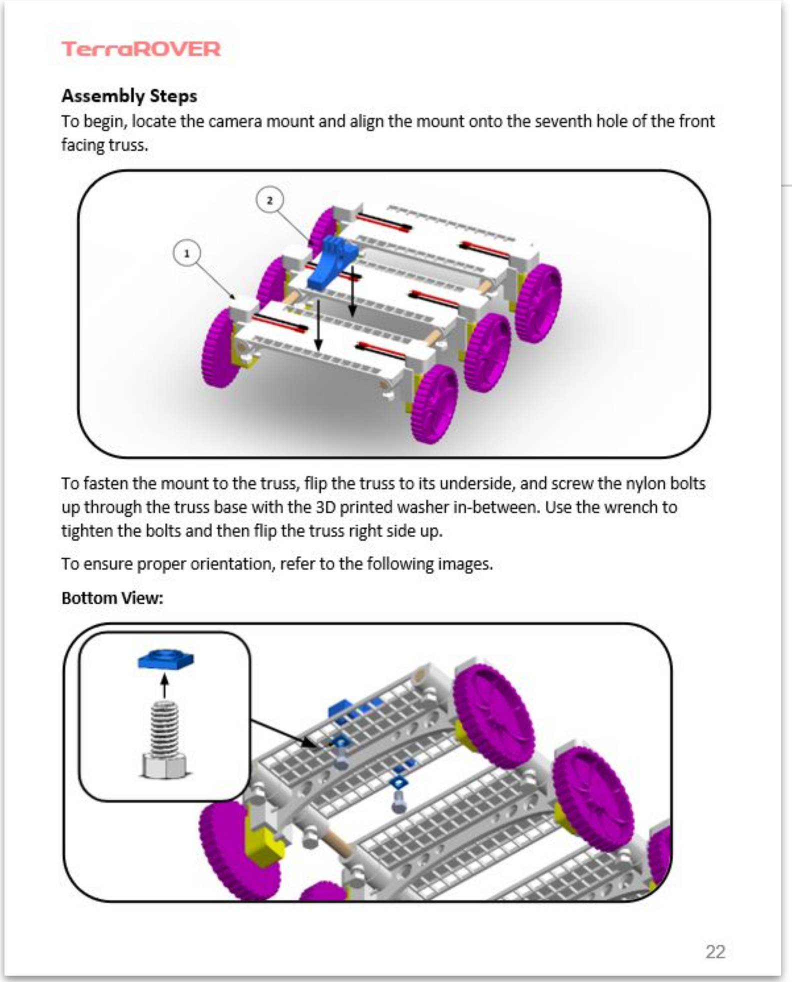
- **"3D Learning Approach"**
  - Practices
  - Core Ideas
  - Crosscutting
- Seeks to provide an investigative aspect to STEM learning.
  - Students are left with open-ended questions that inspire design decisions or different ways of thinking



Instructional Components: TerraROVER Manual

- Utilized Solidworks to create step-by-step instructions with exploded views.
- Incorporated simple and clear wiring diagrams.
- Incorporated **Checkpoints** as well as **Conceptual Tidbits** throughout.




TerraROVER

Assembly Steps

To begin, locate the camera mount and align the mount onto the seventh hole of the front facing truss.

To fasten the mount to the truss, flip the truss to its underside, and screw the nylon bolts up through the truss base with the 3D printed washer in-between. Use the wrench to tighten the bolts and then flip the truss right side up.

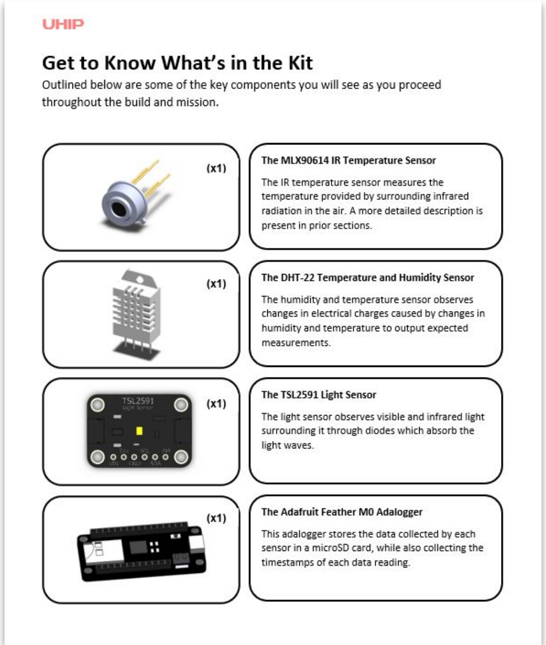
To ensure proper orientation, refer to the following images.

Bottom View:

22

Instructional Components:

UHIP Manual

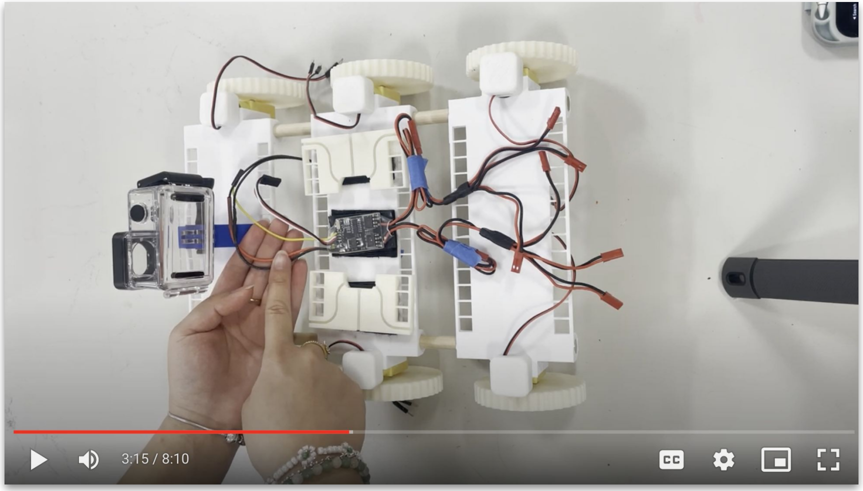

UHIP

Get to Know What's in the Kit

Outlined below are some of the key components you will see as you proceed throughout the build and mission.

(x1)	**The MLX90614 IR Temperature Sensor** The IR temperature sensor measures the temperature provided by surrounding infrared radiation in the air. A more detailed description is present in prior sections.
(x1)	**The DHT-22 Temperature and Humidity Sensor** The humidity and temperature sensor observes changes in electrical charges caused by changes in humidity and temperature to output expected measurements.
(x1)	**The TSL2591 Light Sensor** The light sensor observes visible and infrared light surrounding it through diodes which absorb the light waves.
(x1)	**The Adafruit Feather M0 Adalogger** This adalogger stores the data collected by each sensor in a microSD card, while also collecting the timestamps of each data reading.

TerraROVER Video



Testing

Testing: Roxbury Tenants of Harvard After School Program

- Introduced the ROVER kit and Manual to high school students in Boston.

- Through a survey and general observations, feedback was gathered to improve upon manual design.
    - Pre-assembly section of the survey revealed that a majority of students had not been exposed to engineering in a classroom setting.

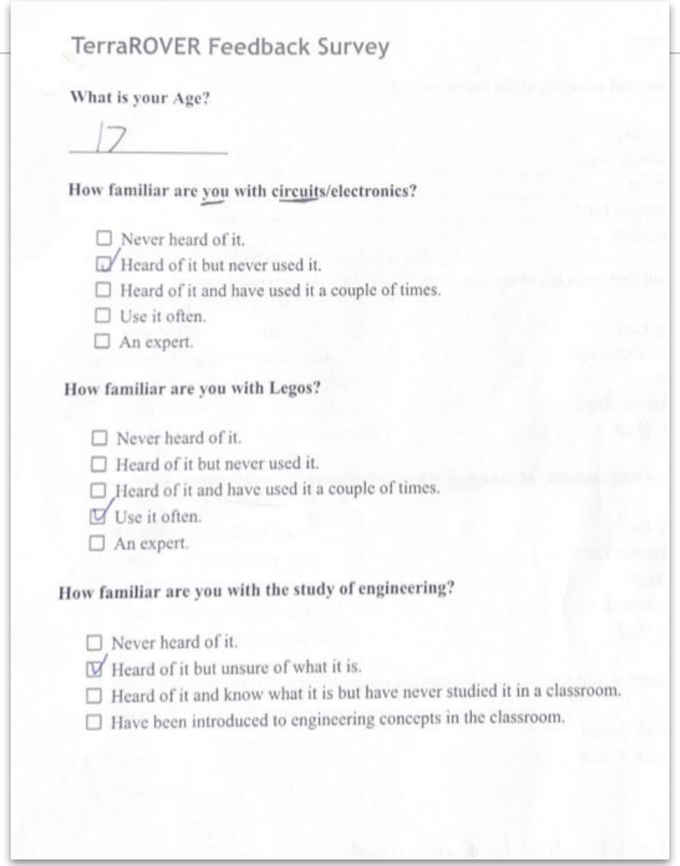
Testing: Observations and Improvements

- Students completed assembly and operation in under 70 minutes.

- General disorganization amongst team delegation.
    - Added a section within the manual that specifies potential **Roles and Responsibilities** of group members.

- Students focused heavily on images within the manual rather than words.
    - Eliminated additional text and made visuals clearer on final version of manual.

- Videos captured students' attention more so than the manual.



TerraROVER Feedback Survey

What is your Age?

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How familiar are you with circuits/electronics?

☐ Never heard of it.
☑ Heard of it but never used it.
☐ Heard of it and have used it a couple of times.
☐ Use it often.
☐ An expert.

How familiar are you with Legos?

☐ Never heard of it.
☐ Heard of it but never used it.
☐ Heard of it and have used it a couple of times.
☑ Use it often.
☐ An expert.

How familiar are you with the study of engineering?

☐ Never heard of it.
☑ Heard of it but unsure of what it is.
☐ Heard of it and know what it is but have never studied it in a classroom.
☐ Have been introduced to engineering concepts in the classroom.

In Conclusion

The Future of the TerraROVER

Our design improvements and manual development have provided a strong foundation for the assembly kit of the TerraROVER. Pending future updates, this kit will be distributed in schools amongst the United States, providing students with exposure to the fields of engineering and climate science at an early age.

Acknowledgements

We are grateful to have received help and knowledge from many different contacts both within and outside of Boston University.

Advisor

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Jennifer Lewis

Thank you!