Autonomous Methane Monitoring Rover

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Background

- Microbial decomposition of waste in landfills produces methane and carbon dioxide, contributing significantly to greenhouse gas emissions.
- Landfills are designed to collect methane to convert it to CO_2.
- Current methane monitoring is time-consuming and infrequent.
- Methane's potential to trap atmospheric heat is 34 times greater than CO2 over a 100-year period, making leak prevention crucial[1].
- Hannigan Lab has tasked us with creating a fully autonomous rover, coupled with a charging station, to increase the frequency and precision of methane detection.

Source: WM-North Weld Landfill

Key Requirements

- Traverse over obstacles that are at least 8 inches in height or depth.
- Traverse an incline of up to 30 degrees and traverse horizontally across a 30-degree incline.
- Autonomously follow a user-defined waypoint path.
- Traverse a 6-mile path every 3 days.
- Recharges itself autonomously with renewable energy.

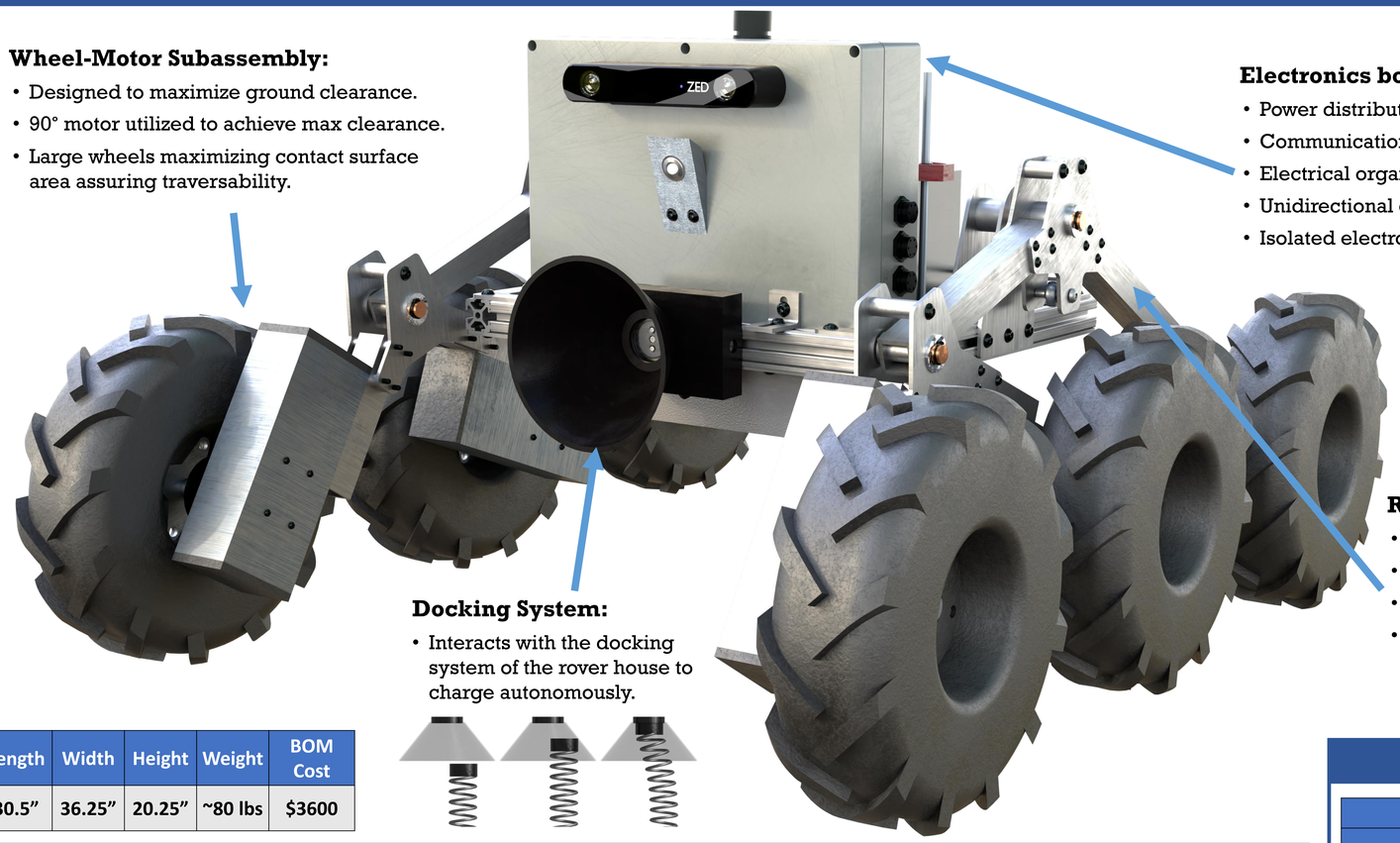
Rover House (Charging Station)

The Rover house serves as a charging station for the rover. Atop the housing are solar panels which charge the station's 12V 100Ah battery during the day. The rover can dock with a charging interface inside of the housing to charge and be protected from the elements while not in use.

Rover

Wheel-Motor Subassembly:

- Designed to maximize ground clearance.
- 90° motor utilized to achieve max clearance.
- Large wheels maximizing contact surface area assuring traversability.



Electronics box

- Power distribution to sensors, computers, and motors.
- Communication between components and sensors.
- Electrical organization of wiring and sensors.
- Unidirectional connectors to prevent reverse connections.
- Isolated electronics from the environment.

Rocker-Bogie Suspension

- Similar design for Martian rovers.
- Designed for high traversability at low speeds.
- Passive suspension with a differential bar.
- Suspension is mounted above the center of mass for increased stability and handling.

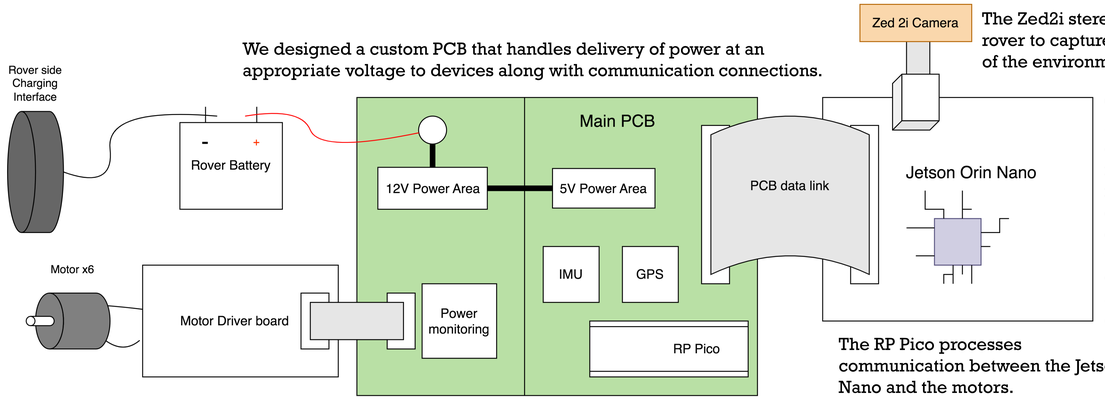
Docking System:

- Interacts with the docking system of the rover house to charge autonomously.

Length	Width	Height	Weight	BOM Cost
30.5”	36.25”	20.25”	~80 lbs	$3600

Rover Electronics Layout (Simplified)

We designed a custom PCB that handles delivery of power at an appropriate voltage to devices along with communication connections.



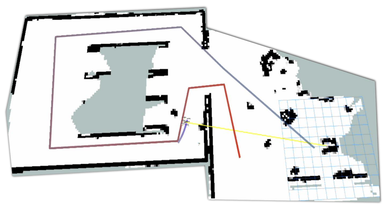
The Zed2i stereo camera allows the rover to capture the 3d geometry of the environment.

The Jetson Nano acts as the main controller for the rover, handling navigation, coordination, and control of motors, as well as communication with all the sensors and other devices.

The RP Pico processes communication between the Jetson Nano and the motors.

Navigation System

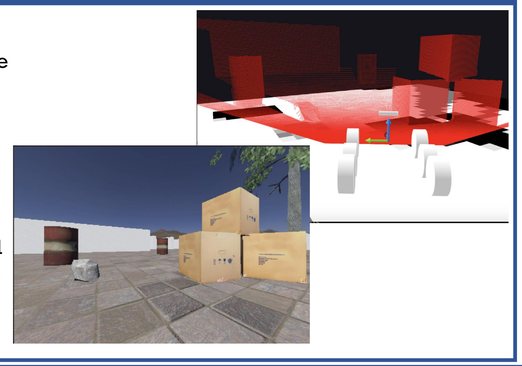
GPS Waypoint following:
We can define a series of coordinates for the rover to drive through.



Each Colored line represents a waypoint.

Sensor data (untraversable areas):
sensor data will be used to generate a live representation of the environment's geometry to determine restricted areas

Autonomous docking for charging:
For a fully autonomous system, the rover needs to be able to recharge its battery without human intervention. We designed a system that allows the rover to locate its charging station and self-dock to begin charging.

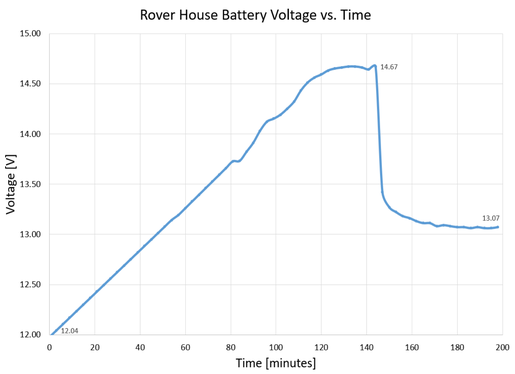


Results & Conclusion

Test Results		
Test Type	**Req.**	**Result**
Traversibility: Even Obstacles*	8”	8.75”
Traversibility: Uneven Obstacles*	8”	8”
Sensor Package Inlet Height	6-8"	6.9”
Terrain Traversibility	Grass	✓
Emergency Stop	Stops Everything	✓

* Only physical tests conducted.

Solar Energy Transfer to Rover House Battery



Impact

- More Frequent Methane monitoring in landfills.
- Fully Autonomous, free from human interference.
- The HAQLab will continue to test and enhance the navigation system throughout the upcoming years.

[1] “Natural Gas | GreenPeace Report.” https://www.greenpeace.org/usa/fighting-climate-chaos

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