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Hannigan Air Quality Lab: Autonomous Methane Monitoring Rover (Ralph-E III)

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HAQ Lab
Hannigan Air Quality Lab

BACKGROUND AND GOAL

- Methane is a greenhouse gas 34x more potent than CO_2
- Landfills account for 18% of U.S. methane emissions
- Landfills use Surface Emission Monitoring (SEM), which is costly, labor-intensive, and infrequent

Goal: Develop a rover to enhance methane detection in landfills to make SEM cost-effective, efficient, and frequent

DESIGN OBJECTIVES

COST-EFFECTIVE
Design using affordable and eco-friendly components to enable scalable, cost-efficient production

ROBUST BODY
Ensure the chassis can withstand California desert conditions and mechanical stress

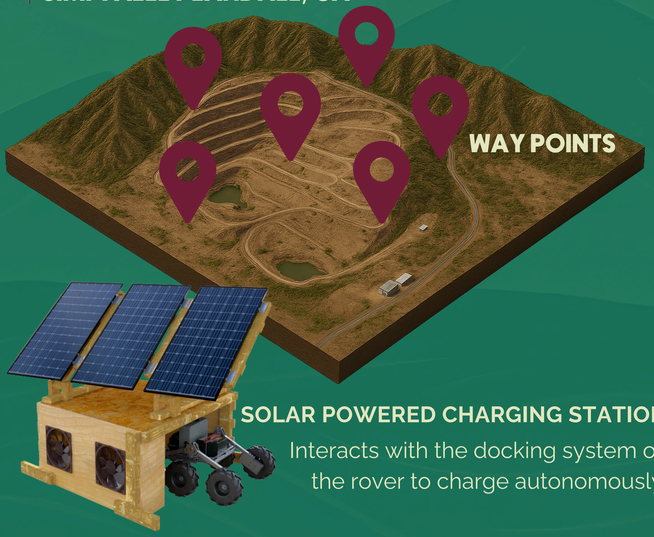
ALL-TERRAIN MOBILITY
Enable the rover to navigate smoothly across varied surfaces, including grass, gravel, off-road rocks, and concrete

AUTONOMOUS OPERATION
Develop autonomous functionality to complete tasks with minimal human oversight or control

FUNCTIONALITY REQUIREMENTS

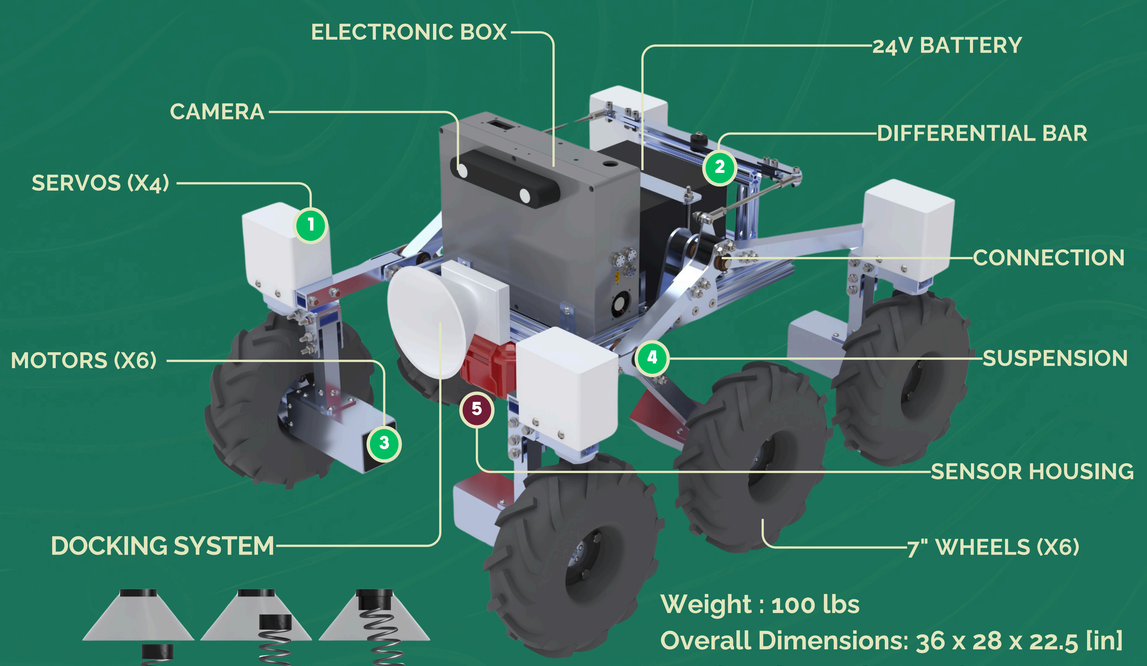
- ☐ **Terrain Adaptability -** Maneuver on grass, dirt, gravel, off-road rocks, and concrete
- ☐ **Hazard Avoidance** - Detect and avoid obstacles >12.5 in, puddles, and impassable ruts
- ☐ **Obstacle Handling** - Traverse 12-inch obstacles with a 90˚ forward-facing edge
- ☐ **Autonomous Navigation** - Navigate set waypoints with ≤3 ft error and patrol 3x per week
- ☐ **Incline Capability** - Climb slopes up to 30.5˚
- ☐ **Dual Control** - Manual on/off switch and arming sequence

📍 SIMI VALLEY LANDFILL, CA



SOLAR POWERED CHARGING STATION
Interacts with the docking system of the rover to charge autonomously

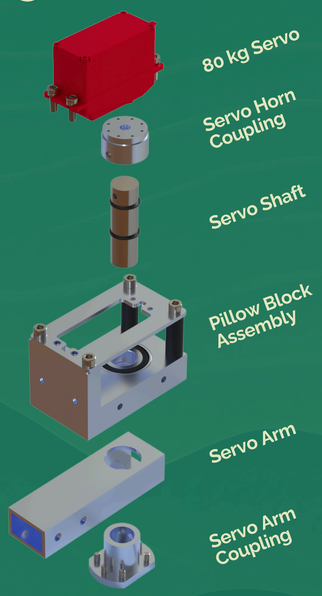
MECHANICAL COMPONENTS



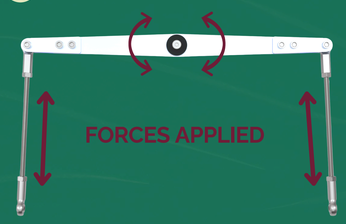
Weight : 100 lbs
Overall Dimensions: 36 x 28 x 22.5 [in]
Total # of Manufactured Parts : 182
Total Hours of Machining : 110 hrs

STEERING & MOBILITY

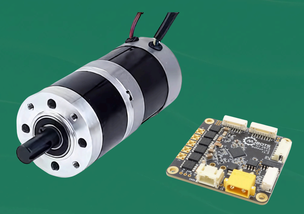
1 SERVO ASSEMBLY



2 DIFFERENTIAL BAR



3 MOTOR SELECTION



24V 101W GEARED BRUSHLESS DC MOTOR

	x1	x6
Torque Output	6.9 Nm	41.4 Nm
Power Output	101 W	606 W
Rated Speed	111 RPM	2.3 MPH

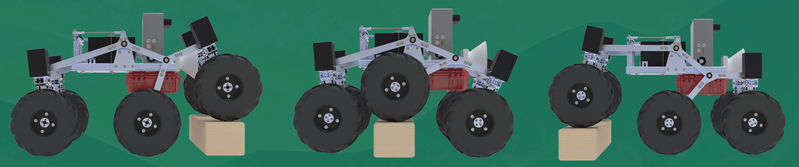
ELECTRONIC SPEED CONTROLLERS (ESCs)
Regulate speed, direction, and braking of each motor

4 SUSPENSION: ROCKER-BOGIE SYSTEM

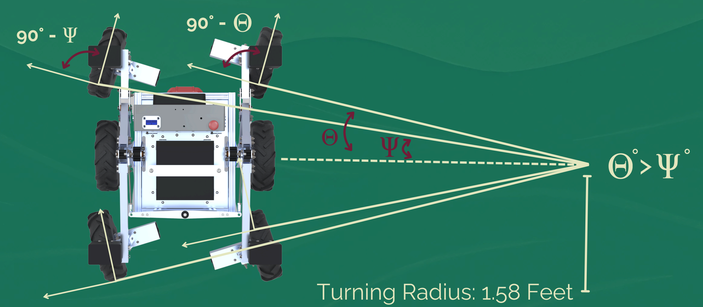
Bogie arm angle increases climbing availability

Differential distributes weight evenly

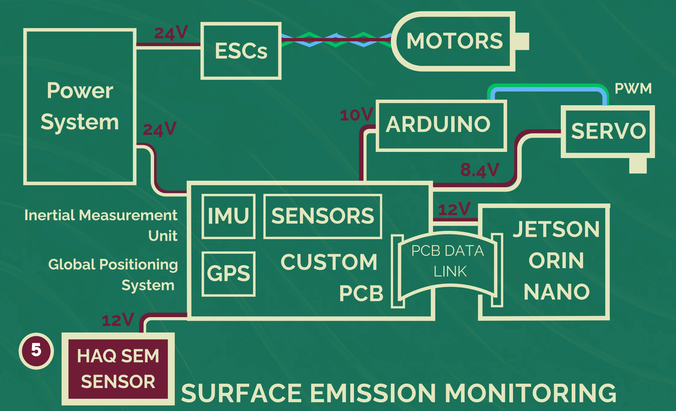
Differential keeps chassis stable to prevent tipping



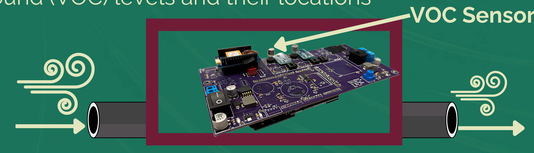
ACKERMAN STEERING



ELECTRONICS (SIMPLIFIED)

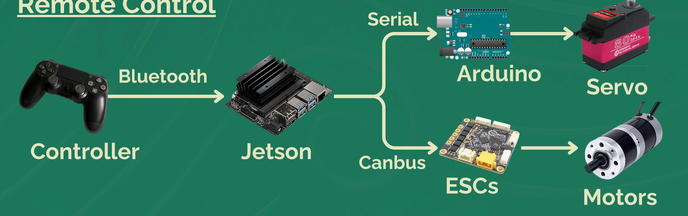


SURFACE EMISSION MONITORING
Sensor measures and records Volatile Organic Compound (VOC) levels and their locations

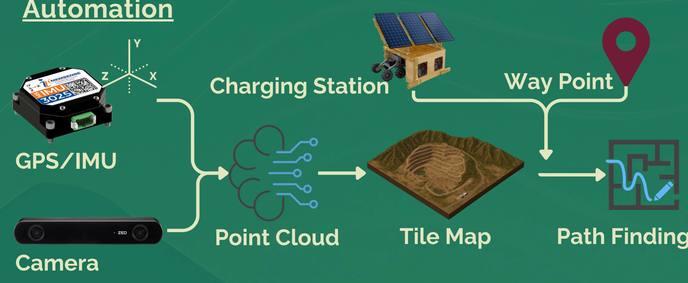


CONTROLS & NAVIGATION

Remote Control



Automation



CONCLUSION & IMPACT

	Terrain Adaptability	Hazard Avoidance	Tallest Obstacle	Way Point Accuracy	Incline Traveled
Req.	Grass, Rocks, Dirt	>12.5 in	12 in	<3 ft	30˚
Result	✓, ✓, ✓	INC	9.5 in	INC	34˚

IMPACT
- Lowers cost for Surface Emission Monitoring (SEM)
- Makes SEM more efficient and less labor intensive
- Increases frequency of SEM data collection on landfills

NEXT STEPS
- Integrate charging station to extend battery life
- Idealize long range communication for remote diagnostic
- Optimize design for lighter weight and modular assembly
- Support scalable deployment for continuous landfill monitoring