Autonomous Environmental Monitoring Drones

HOWARD UNIVERSITY 1867 x NOVAORBIT CORP PRECISION IN MOTION

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OUTLINE

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BACKGROUND

As space missions grow in frequency and complexity, there's an increasing need for autonomous systems that minimize human intervention and ensure reliability in extreme conditions. Lunar exploration requires technology that can consistently monitor the environment, sustain long operations, and enable secure communication between drones, lunar bases, and Earth. AEMDs address these needs by providing a transformative solution that reduces risks, improves decision-making, and supports extended missions. Aligning with NASA's goals and those of commercial space entities, AEMDs have the potential to revolutionize lunar exploration and advance humanity's reach into space.

The Autonomous Environmental Monitoring Drones (AEMDs) are built to handle the harsh lunar environment, addressing gaps in current technologies. By using advanced features like LiDAR for terrain mapping, high-frequency radio, and optical communication for data transfer, and durable power solutions for long operations, AEMDs enable autonomous monitoring, terrain navigation, and real-time data analysis. This enhances astronaut safety and mission efficiency, supporting ongoing exploration efforts.

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PROBLEM STATEMENT BREAKDOWN

Lunar surface technologies face significant challenges due to harsh, ever-changing conditions, necessitating reliable environmental monitoring, communication, and long-lasting power for autonomous drones assisting astronauts. Our approach leverages space-enabled technologies such as LiDAR, high-frequency radio, and optical communication to ensure essential functions like environmental monitoring and continuous data transfer between drones, bases, and Earth. By providing autonomous monitoring and real-time data analysis, our project enhances astronaut safety and improves mission efficiency, enabling more informed and secure lunar exploration.

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SPECIFICATIONS

With dimensions of 1.5m length, 1.2m width, and 0.8m height, these compact drones offer impressive payload capacity of 10kg.

This allows for a variety of scientific instruments and sensors to be equipped, enhancing their versatility for different mission profiles.

The power system of our AEMDs is designed for maximum efficiency and endurance. Featuring 1.5m2 of high-efficiency solar panels, the drones can collect up to 3.375 kWh of energy during 6 hours of lunar daylight. This energy is stored in advanced batteries, ensuring continuous operation during the long lunar night periods.

Dimension	Specification
Length	1.5 meters
Width	1.2 meters
Height	0.8 meters
Payload Capacity	10 kilograms
Solar Panel Area	1.5 square meters
Energy Collection (6h)	3.375 kWh

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DESIGN REQUIREMENTS

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Multi-Spectral Sensor Suite

- This array includes sensors to detect and measure radiation levels, atmospheric conditions (like temperature and pressure), and lunar dust density. It enables the AEMDs to gather comprehensive environmental data and supports real-time monitoring of lunar conditions.

Radiation-Hardened Processing Unit

- The processing unit is built with radiation-shielded materials to withstand cosmic and solar radiation, ensuring reliable operations and data processing in the harsh lunar environment without degradation of sensitive electronics.

Autonomous Navigation and Obstacle Avoidance System:

- Using AI and sensor data, this system enables the AEMDs to navigate and avoid obstacles independently on the lunar surface, even in GPS-limited conditions. It includes LIDAR and cameras to create a map of the environment, supporting safe and efficient movement.

Thermal Regulation System

- This system protects the drone's electronics from the extreme temperature variations on the Moon. It includes insulation and heat dissipation mechanisms to maintain stable operating conditions across day and night cycles on the lunar surface.

High-Frequency Communication Module

- The communication system is optimized for long-distance data transmission, allowing the AEMDs to send environmental data back to Earth in real-time or near-real-time. This module is essential for maintaining contact with Earth-based control systems without significant lag.

Lunar-Optimized Propulsion System:

- The propulsion unit is specifically designed for low-gravity environments and is dust-resistant to prevent abrasive lunar dust from clogging the components. This system allows the AEMDs to maneuver efficiently over rugged terrain on the Moon.

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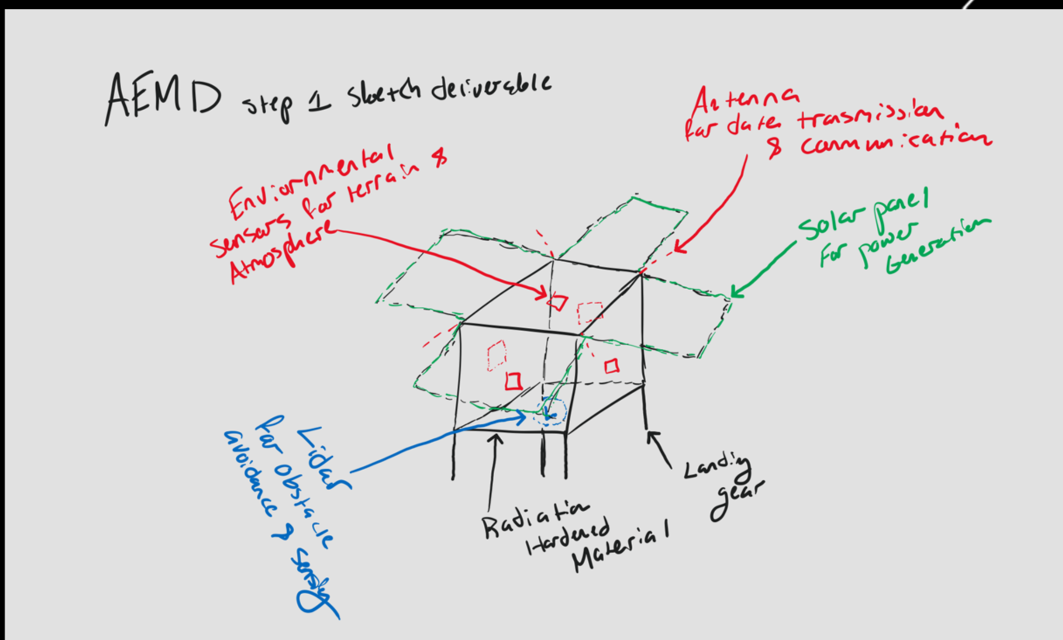
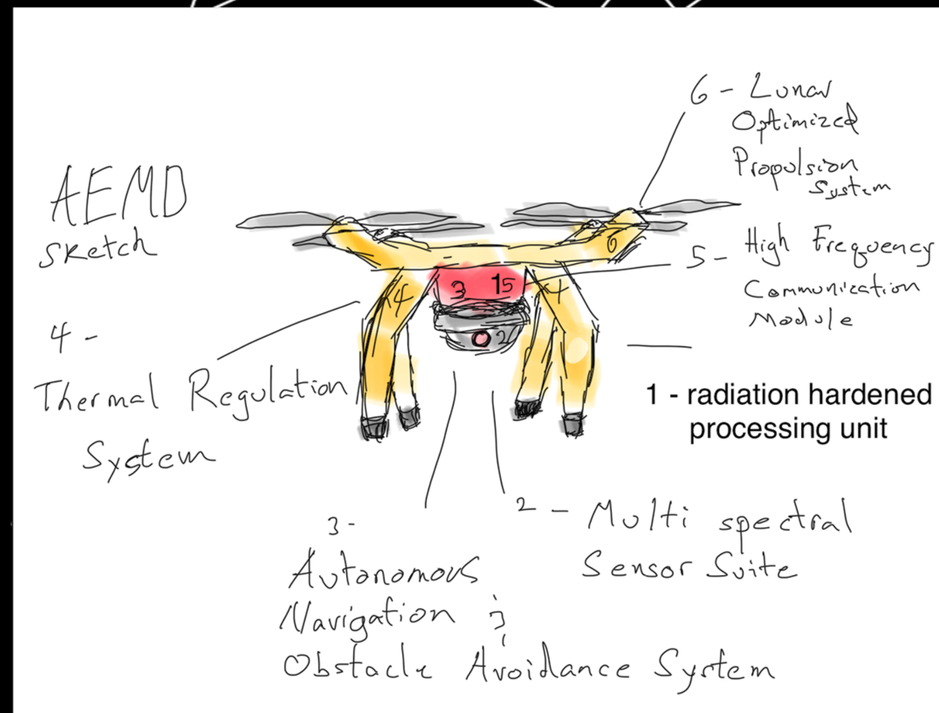
SOLUTION GENERATION

DESIGN 1



DESIGN 2



DESIGN DECISION MATRIX

Column1	Wt	Design 1	Score	Agg. Score	Design 2	Score2	Agg. Score3
Functionality	5	Well-equipped drone for aerial operations.	4	20	Multi-purpose drone for various tasks	4	20
Connectivity	2	Antenna for communication, data sensing, RFID..etc.	3	6	High-frequency communication module included	3	6
Weight	3	Potential trade-off between weight and durability.	3	9	5-15 kg	2	6
Power	4	Solar panel for sustainable power generation.	4	16	Lunar optimized propulsion system for power	4	16
Convenience	1	Remote operation included for debugging/Data observ	3	3	Autonomous navigation and obstacle avoidance included	3	3
Total				54			51

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PROS

Solar panels for power generation	Provides renewable energy to sustain during lunar cycles	Autonomous navigation & obstacle avoidance system	Essential for navigating
Low maintainence & reliable for longterm missions	Enviornmentally friendly & aligns with long duration power requirements	Enhances safety by reducing the risk of collisions with obstacles.	
Radiation-Hardened Processing Unit	Protects critical electronics from high levels of lunar radiation.	LiDAR for Obstacle Avoidance	Allows real-time terrain mapping and precise navigation.
- Increases the reliability and lifespan of the drone's systems.	Prevents mission-critical failures caused by exposure to harsh environments.	- Highly accurate for detecting obstacles and avoiding hazards.	
Environmental Sensors for Terrain & Atmosphere	Enables detailed data collection for scientific and exploratory purposes.		
Provides insights into terrain conditions, aiding navigation and mission planning.	Adds multi-functional capability to the drone.		

CONS

Solar Panels for Power Generation	- Limited functionality during lunar nights without sufficient energy storage (batteries).	Autonomous Navigation & Obstacle Avoidance System	- Essential for navigating rough and unpredictable lunar terrain autonomously.
- Efficiency depends on exposure to sunlight (may need optimal positioning).	- Solar panels may be vulnerable to damage from lunar dust or impacts.	- Enhances safety by reducing the risk of collisions with obstacles.	- Supports adaptive exploration in changing environments (like craters or steep slopes).
Radiation-Hardened Processing Unit	Adds weight to the drone, reducing overall efficiency.	LiDAR for Obstacle Avoidance	Consumes significant energy, especially during extended use.
May significantly increase production costs.	Complex to design and integrate with other components.	Requires additional hardware, increasing weight and cost.	- Sensitive to damage from dust or debris on the Moon.
Environmental Sensors for Terrain & Atmosphere	Can be fragile and vulnerable to damage.		
Might require extra shielding, increasing weight.	Some sensors may have limited functionality in lunar conditions (e.g., atmosphere-related).		

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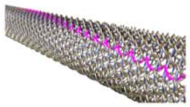
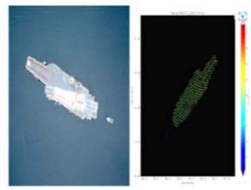
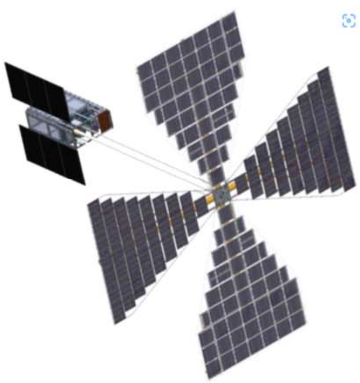


Shape memory alloy tubular structure
-Safe, reliable, and high-strength: the airless SMA structure eliminates the possibility of puncture failure and can withstand excessive deformation (more than 30x that of traditional materials)

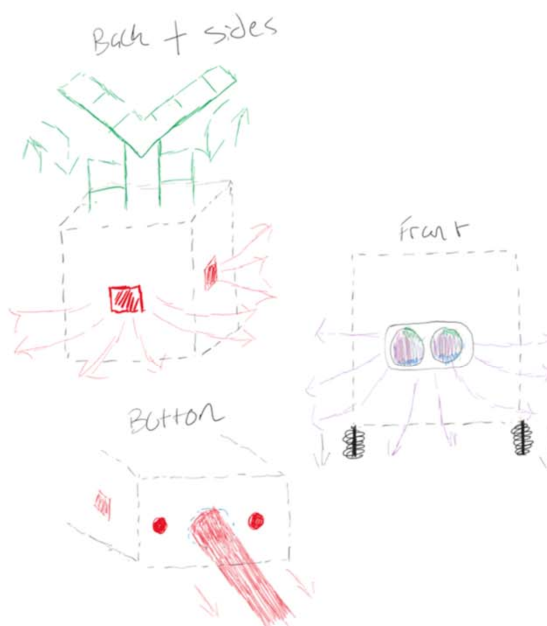


Kodiak 3D Lidar
key feat.
*Lower cost
*Low SWaP
*3d imaging in any lighting

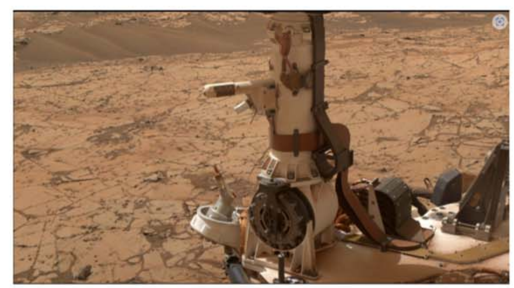
Ocellus 3D Lidar
*Dual mode operation: high altitude (~2 km) altimetry and lower altitude (20 to 200 m) imaging and hazard detection.
*Space qualified components: the MEMS-based mirror assembly is space qualified.
*Meets low SWaP requirements: the 3D lidar system will be 6 kg and require 70W of power.



Self-Deployable Helical Antenna.
Compact Design: NASA's helical antenna stows with significantly less volume than traditional helical or patch antennas, self-deploying to precise specifications while retaining their inherent advantages.
Lightweight: The antenna conserves mass while enabling high-data-rate communications, making it ideal for weight-sensitive applications.
Array Applications: In configurations like a 16x16 array, it offers comparable performance at just one-tenth the size and mass of traditional antenna arrays.

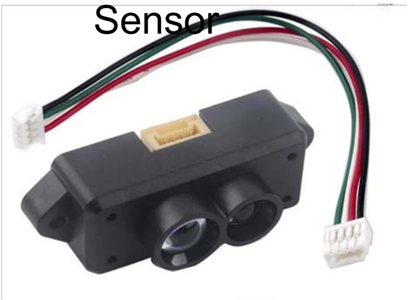


Mars Enviornmental Dynamics Analyzer
*Used aboard the 2020 perseverance rovar
*Collects data on wind, dust, and radiation patterns

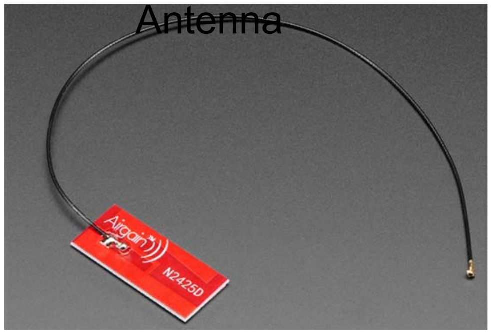


DETAILS OF TOP DESIGN SUBSTITUTES

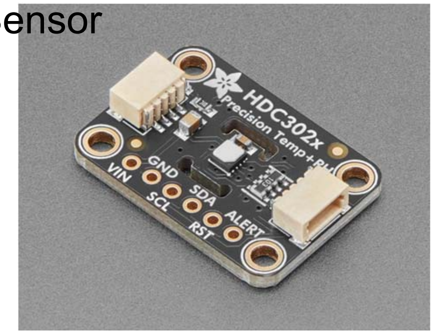
Lidar Sensor



Wifi Antenna



Precision Temp & Humidity Sensor



Arduino Uno R4 Wifi Enabled

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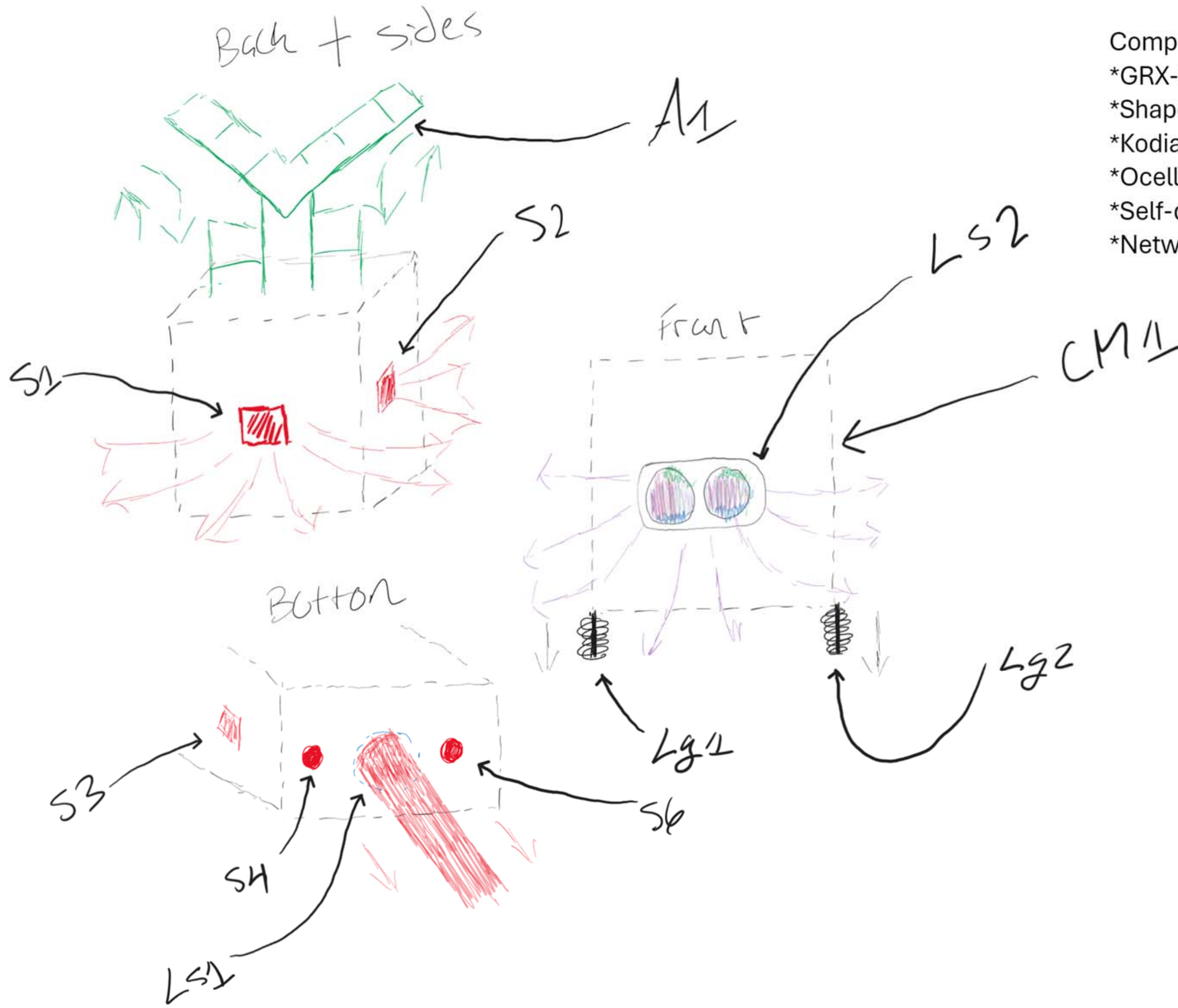
COMPONENT LEVEL BLUEPRINT/SCHEMATICS

Autonomous Exploration and Monitoring Drone (AEMD)

FIGURE 1 represents the schematic diagram of the Advanced Autonomous Exploration System (AAES), which incorporates a structural framework built with GRX-810 Alloy, adaptive mechanisms powered by Shape Memory Alloy, a dual-lidar mapping and navigation system, a self-deployable antenna, and an integrated suite of networked environmental sensors. This system is designed to operate autonomously in extreme environments, such as extraterrestrial surfaces or disaster zones, combining robust structural integrity, advanced navigation, and environmental monitoring capabilities.



Component List
*GRX-810 Alloy
*Shape Memory Alloy
*Kodiak 3D Lidar
*Ocellus 3D Lidar
*Self-deployable antennae
*Networked mini sensors

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CONCLUSION

In conclusion, the Autonomous Environmental Monitoring Drones (AEMDs) offer a cutting-edge solution to the challenges of lunar exploration. By tackling the Moon's harsh conditions, these drones enhance autonomous monitoring, efficient communication, and reliable power systems. Integrating technologies like LiDAR, high-frequency radio, optical communication, and durable energy solutions, AEMDs ensure continuous operation and astronaut safety while boosting mission efficiency. Their detailed design and blueprints illustrate the system's feasibility, paving the way for future lunar missions.

The AEMDs not only meet the immediate needs of lunar exploration but also pave the way for broader applications in other space and extreme environments. This project pushes the boundaries of autonomous systems and advances humanity's capabilities in space exploration. By using cutting-edge technology and robust design strategies, AEMDs offer a reliable and sustainable solution for extended lunar operations, supporting exploration, safety, and innovation. This vision drives more secure, informed, and efficient exploration of the Moon and beyond.

THANK YOU

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