Ion Propulsion Drone Hybrid Aerial Surveillance Platform

Estel Galo (MAE), Axel Marquez Lujan (MAE), John Noel, Katie Rink (MAE)

New Mexico State University (NMSU)

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36th WERC
ENVIRONMENTAL DESIGN CONTEST
NEW MEXICO STATE UNIVERSITY

Mission & Constraints

The Ion Propulsion Drone Team at NMSU is developing an aerial system capable of delivering controlled high-voltage ionization. The system must integrate propulsion, power distribution, and control electronics while maintaining stable flight. The drone must meet the following requirements:

- Provide stable power distribution from the main battery to all the subsystems.
- Safely power and control high-voltage generators and servos during the flight.
- Minimize weigh and volume while maintaining structural integrity and accessibility for maintenance.

The Ion Propulsion Drone Team will design, integrate, and test the power and control to ensure reliable operational performance.

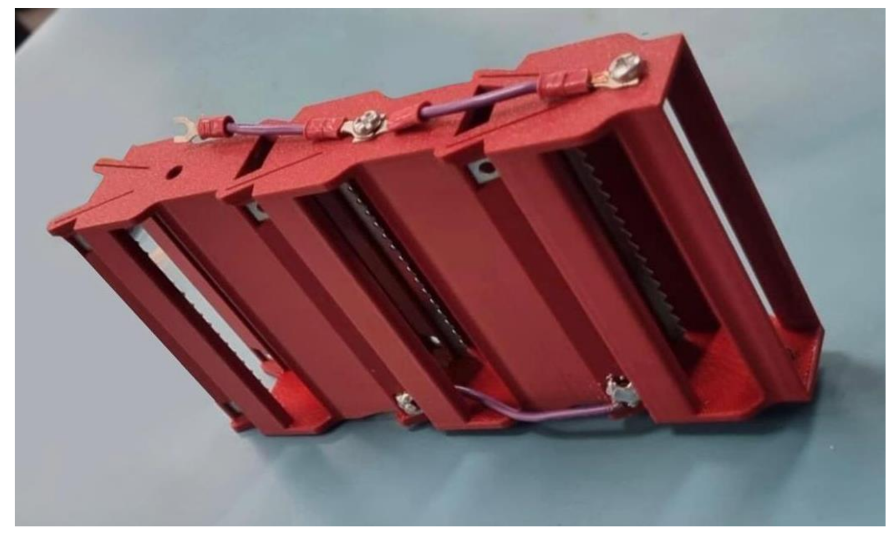
Research

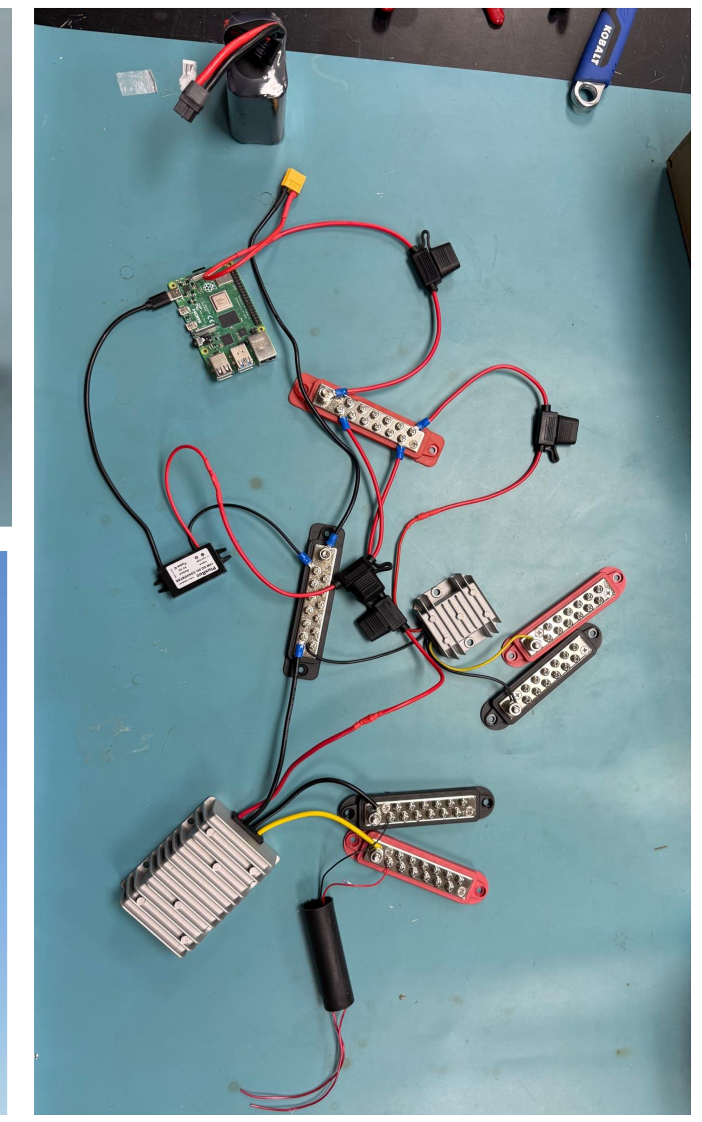
Research focused on identifying feasible technologies for a long-duration, low-noise hybrid aerial surveillance system.

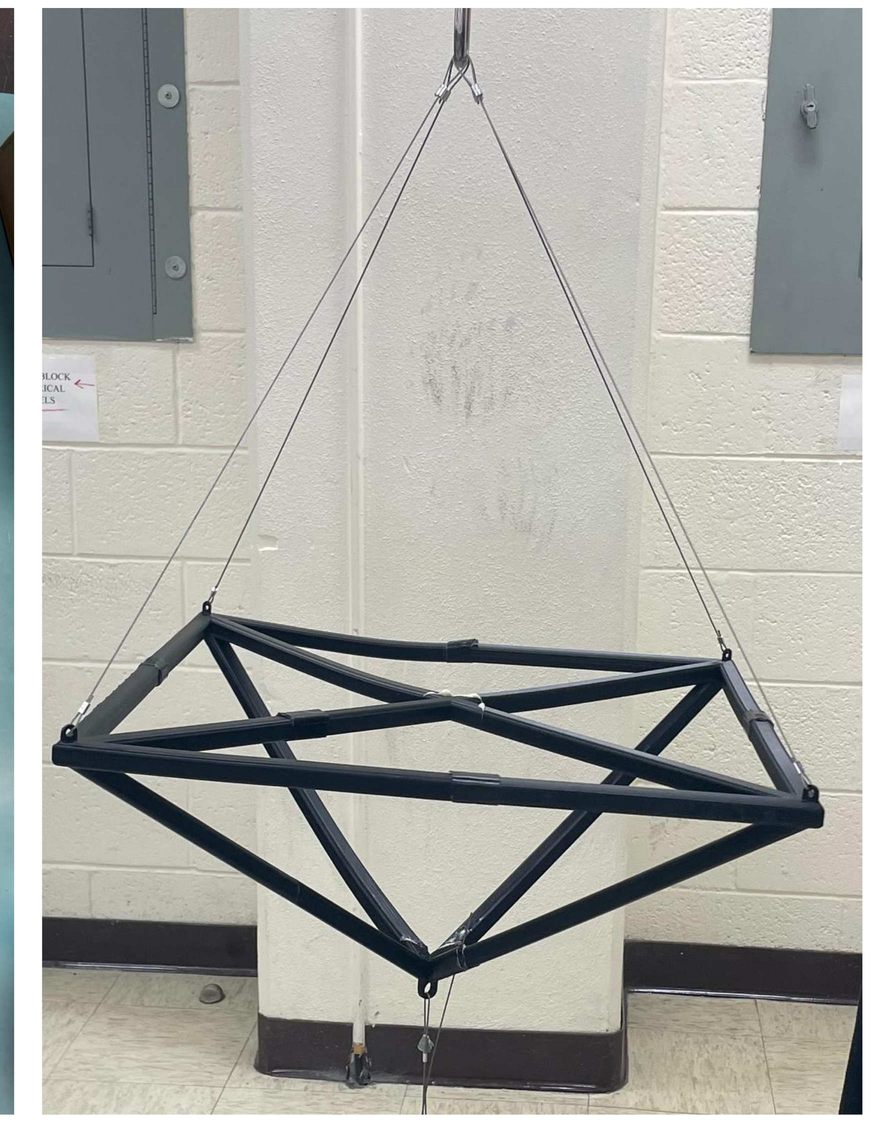
- Evaluated high-altitude balloon systems; selected lift approach to meet ~12 lbs payload and endurance requirements.
- Compared ABS vs. ASA polymers; chose ASA for UV resistance, thermal stability, and environmental durability.
- Analyzed electrohydrodynamic (EHD) ion propulsion; confirmed suitability for low-thrust drift correction, not primary propulsion.
- Investigated ion thruster electrode configurations to improve ionic wind efficiency.
- Performed power system analysis to size battery capacity for extended operation.
- Selected Raspberry Pi + HQ camera system for onboard processing and reliable video transmission.
- Reviewed FAA regulations (14 CFR Parts 101 & 107) and safety requirements for tethered aerial systems.

	UV Resistance	Weather Resistance	Heat Resistance (ºC)	Cost ($/kg)
ABS	Poor	Limited	80 - 90	15 - 25
ASA	Excellent	Superior	95 - 100	25 - 35

Final Design







Results

The final design consists of an ionic thruster-based propulsion system integrated into an inverted pyramid frame constructed from 3D-printed ABS using Fused Deposition Modeling (FDM). While ASA material was initially considered for its superior environmental resistance, ABS was selected due to time constraints. The structure includes a central payload container housing the onboard electronics.

The system integrates a camera capable of motion detection, real-time notifications, and live video streaming, enabling remote monitoring functionality.

Early design concepts included the use of solar panels to enable extended or continuous operation. However, this approach was not implemented due to power and weight limitations. The solar panels were unable to generate sufficient energy to sustain system requirements, and battery storage capacity was constrained by weight considerations. As a result, the final system operates using a pre-charged battery, prioritizing reliability, and reduced system mass.

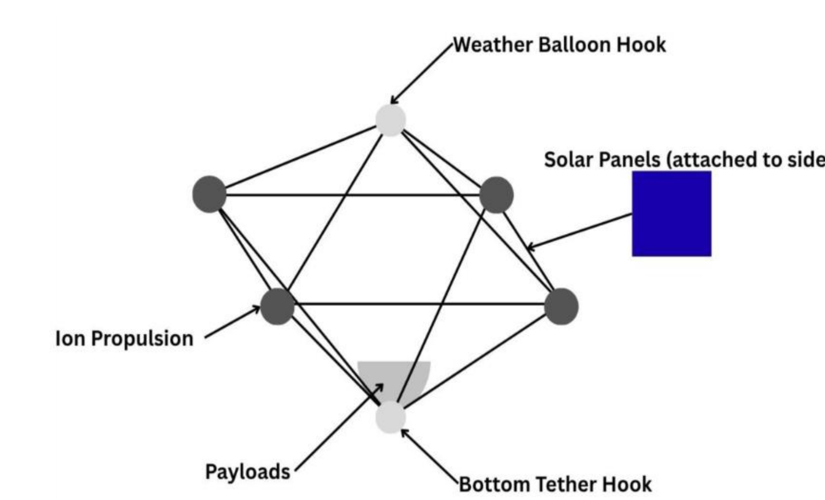
Validation testing confirmed successful operation of the motion detection system, notification features, and live streaming capabilities, along with adequate structural performance. The structure withstood a proof load of 1.25 times the expected load of 12 lbs for 15 minutes with no permanent deformation, bending, or cracking. The ion propulsion system successfully proved the ionic wind phenomenon using a configuration of two sharp positive electrodes and one rounded negative electrode. Multiple thruster modules were connected in series to enhance the observable effect. Flow visualization using lightweight threads confirmed the generation of directional airflow, confirming the electrohydrodynamic (EHD) thrust principle. Due to safety considerations, the ionic thrusters were tested by limiting the input to the high-voltage generator to a maximum of 12 V, resulting in a power consumption of approximately 20 W. This constraint ensured safe operation while still allowing observable thrust generation and system validation.

These results are consistent with prior research on ionic wind propulsion, which shows that ionized air particles can transfer momentum and produce measurable thrust without moving parts. Overall, the final design meets the primary objectives while balancing performance, feasibility, and system constraints.

Concept Development

The design phase focused on developing a compact and efficient drone system capable of stable flight lifted by a balloon. Initial requirements included lightweight construction, reliable propulsion, and integration of onboard electronics such as a camera and control system. Multiple iterations were used to refine the frame structure, optimize component placement, and ensure proper balance and stability during operation. Computer-aided design (CAD) tools were used to model and evaluate the system before assembly.

Several design configurations were evaluated to determine the most effective solution. These included variations in frame geometry (quadcopter vs. alternative layouts), propulsion systems (motor and propeller combinations), and materials for weight reduction and durability. Trade-offs between flight time, payload capacity, and stability were considered. The final design was selected based on its ability to provide consistent performance while meeting project constraints such as cost, simplicity, and ease of implementation.



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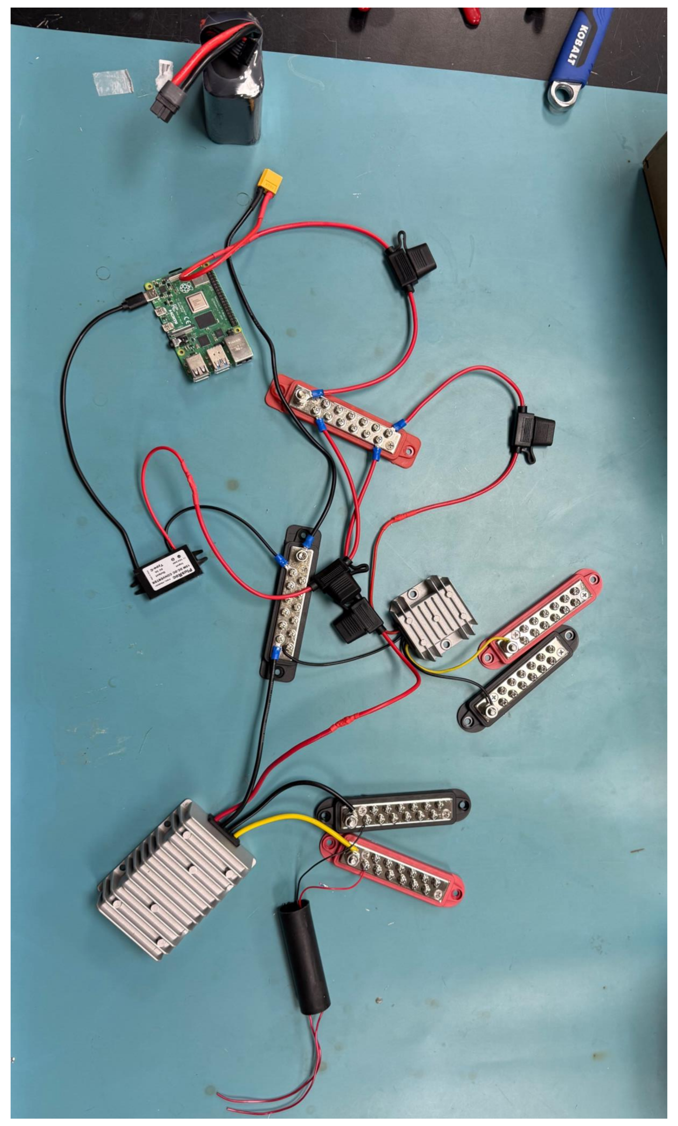

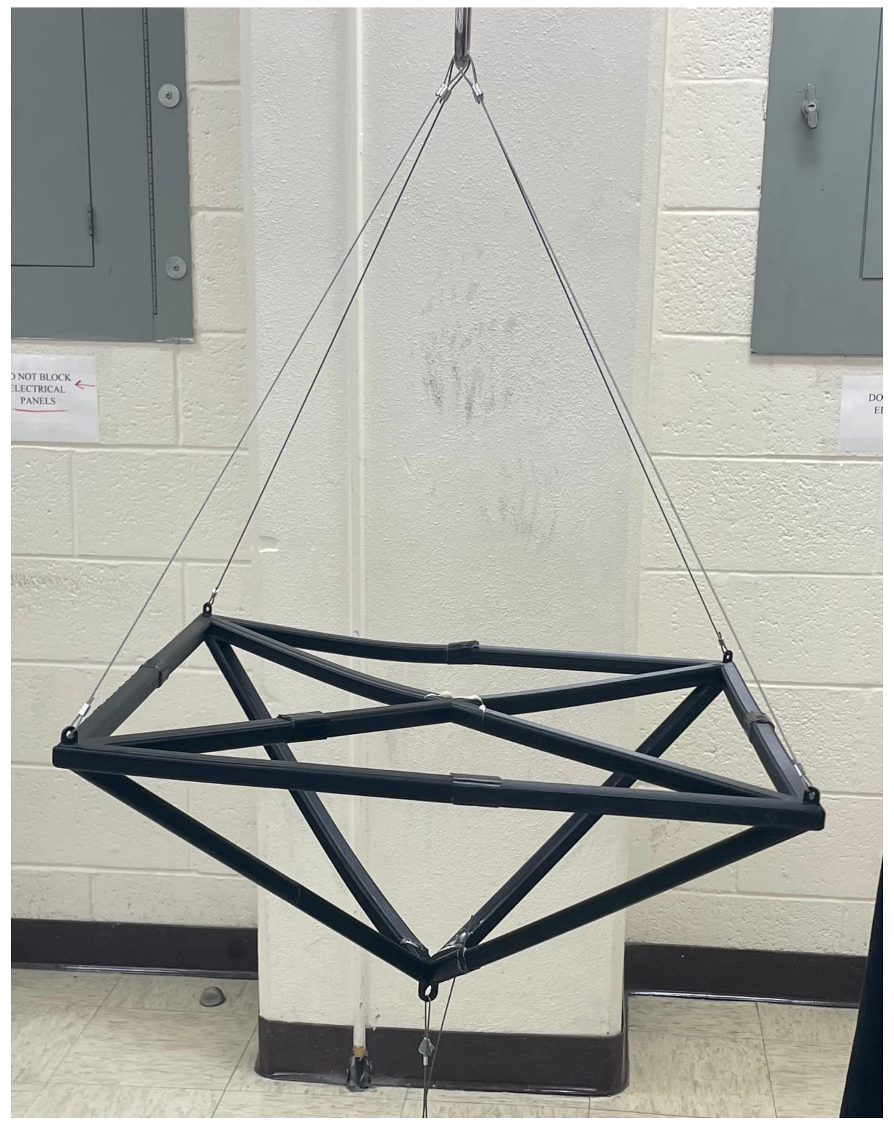

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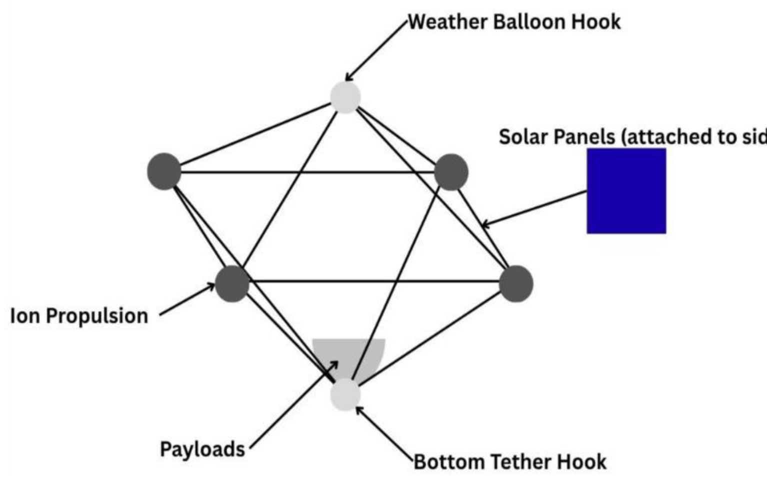

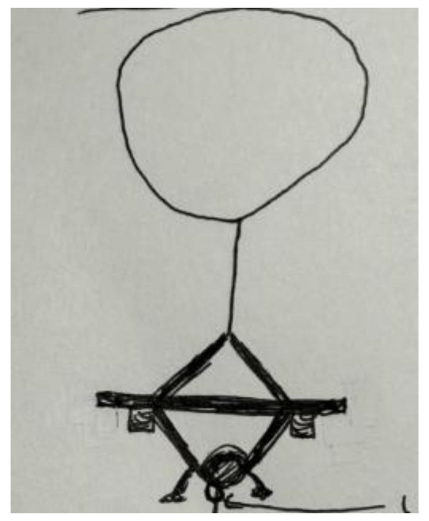

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