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Electromagnetic Rail Launcher & Radio-Controlled Aircraft

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Abstract: This paper explores the design and implementation of an electromagnetic rail launcher and a radio-controlled (RC) aircraft, emphasizing the use of handmade components and permanent magnets. The rail launcher employs magnetic propulsion principles, offering a clean and sustainable alternative to conventional propulsion systems. The RC aircraft integrates lightweight materials, an efficient motor, and advanced control systems to achieve stable and efficient flight. This work highlights potential applications in UAV deployment, nanosatellite launches, and education, while addressing the challenges and possibilities of clean energy propulsion in aerospace technologies.

1.Introduction

Electromagnetic launchers offer a sustainable alternative to traditional propulsion systems by utilizing magnetic forces for acceleration. Innovations like the convex rail design by Polat et al., achieving velocities of 2355 m/s[1], and Mongeau and Williams' helical rail launcher for high-speed RC glider launches[2], highlight their scalability and efficiency.

Integrating electromagnetic propulsion with RC aircraft provides a platform for modular and aerodynamic designs. RC aircraft have been applied in atmospheric research[9] and educational competitions[10], demonstrating their versatility.

This study introduces an electromagnetic rail launcher integrated with a lightweight RC plane, using permanent magnets and handmade components to enhance propulsion efficiency and cost-effectiveness[3][6]. Applications include UAV launches, nanosatellite deployment, and educational models, supported by research on low-voltage railguns[4] and telemetry systems[8], contributing to sustainable aerospace advancements.

2. Literature Survey

Electromagnetic launchers have emerged as a clean propulsion solution with wide applications in aerospace and defence. Polat et al. demonstrated the advantages of convex rail designs, achieving velocities of up to 2355 m/s with optimized magnet configurations [1]. Similarly, Mongeau and Williams' helical rail glider launcher highlighted scalability for high-speed RPVs[2].

Recent developments also address reliability and thermal challenges. Bandini et al. proposed methods to detect rail-armature contact instabilities[3], while Zhang et al. introduced innovative cooling systems for rapid-fire electromagnetic rails[5].

RC aircraft have advanced in research and educational applications. Kukharets and Tsvang showcased their use in atmospheric monitoring with sensor-equipped aircraft[9], and Dinç et al. emphasized their educational value through design optimization[10]. Additionally, Shoufan et al. explored telemetry for enhanced security and control[8].

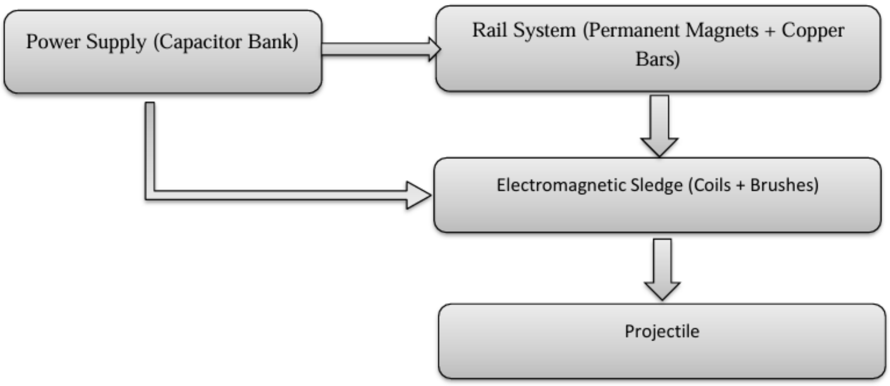
Integrating electromagnetic propulsion with RC aircraft leverages these advancements. Andraud et al. highlighted the relevance of electromagnetic launchers in UAVs and nanosatellites[4], while modularity and telemetry systems enhance RC aircraft adaptability [8][9]. This survey underscores innovations in propulsion, aerodynamics, and modular design, aligning with the research goals of creating sustainable aerospace systems.

3. Methodology and Mechanism

Electromagnetic Rail Launcher: The rail launcher design employs alternating north-south poles of neodymium magnets along the rail to create propulsion zones through attraction and repulsion. The sledge, equipped with electromagnetic coils, amplifies this propulsion. The system relies on a capacitor bank to supply high-current pulses, synchronized through optical sensors for precise coil activation.

Key components include:

- **Neodymium Magnets:** Provide strong magnetic fields for propulsion.
- **Coils:** Wound with 24-gauge copper wire, optimized for weight and force balance.
- **Capacitor Bank:** Stores and delivers high-current energy bursts.
- **Sliding Brushes:** Ensure consistent electrical contact with copper bars on the rail.

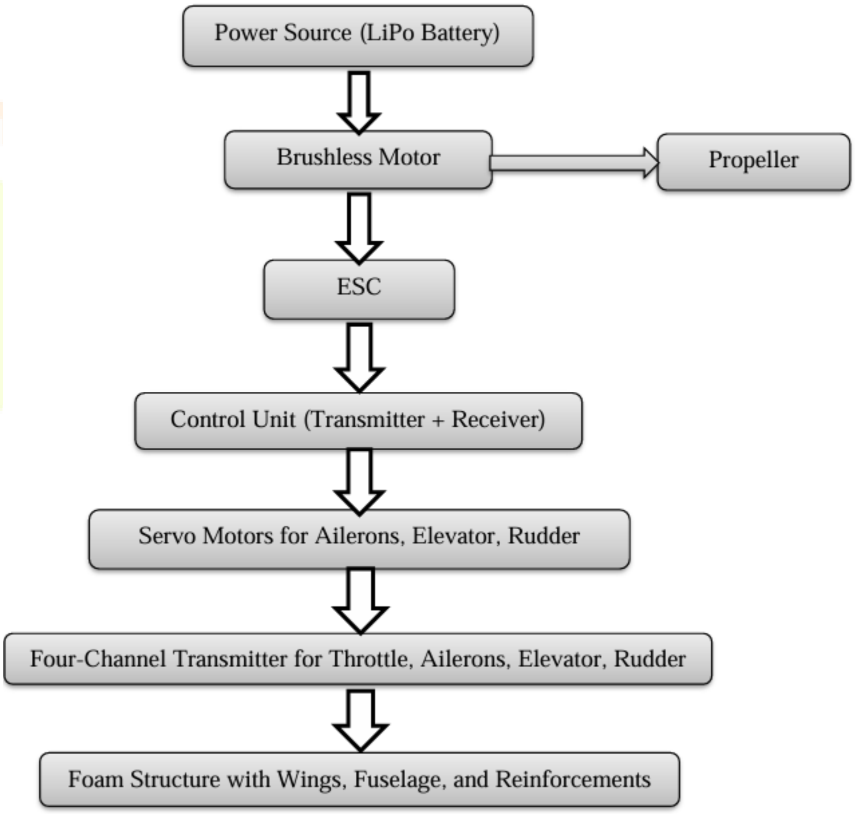


Conceptual Design Electromagnetic Rail Launcher

Radio-Controlled Aircraft: The RC aircraft utilizes a lightweight foam structure reinforced with carbon fiber for durability and aerodynamic efficiency. The propulsion system is powered by a brushless motor connected to a LiPo battery and controlled via an electronic speed controller (ESC). Key components include:

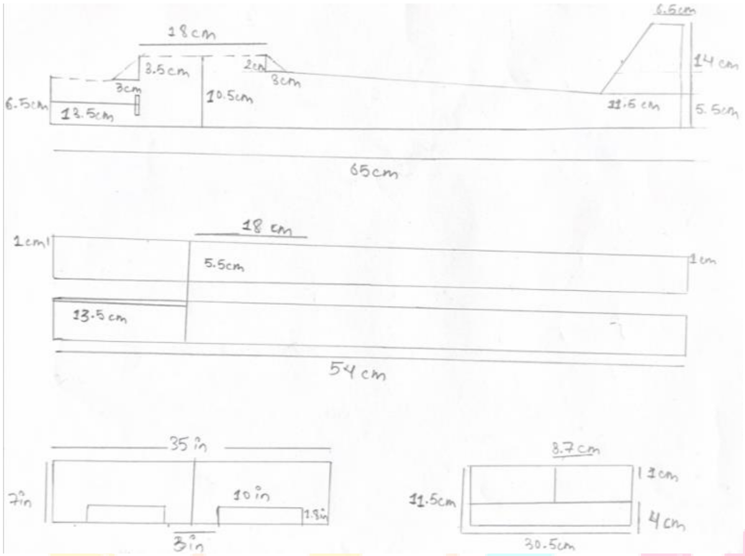
- **Brushless Motor:** Drives the propeller with high efficiency.
- **LiPo Battery:** Supplies power with a high energy-to-weight ratio.
- **Servo Motors:** Control ailerons, elevator, and rudder for precise flight manoeuvres.
- **Four-Channel Transmitter and Receiver:** Enable real-time control of the aircraft.

The methodologies for both systems were iteratively refined through prototyping and testing to ensure reliability and performance.



Block Diagram for the RC Plane System

Schematic of RC Plane:



4. Materials Used

Electromagnetic Rail Launcher:

- **Neodymium Magnets:** Known for their high magnetic strength, used to generate propulsion.
- **Copper Bars and Coils:** Provide electrical conductivity and magnetic field generation.
- **Acrylic or Non-Magnetic Rail Base:** Ensures structural integrity while minimizing interference with the magnetic field.
- **Sliding Brushes:** Made of braided copper for reliable electrical contact.

Radio-Controlled Aircraft:

- **Foam Board:** Lightweight and easy to shape, forming the main structure of the aircraft.
- **Carbon Fiber Rods:** Reinforce structural components like the wings and fuselage.
- **Brushless Motor and Propeller:** Provide efficient propulsion.
- **Lithium Polymer (LiPo) Battery:** Lightweight power source with high energy density.
- **Adhesives:** Foam-safe glues for bonding components securely.

5. Design, Development, Fabrication, and Assembly

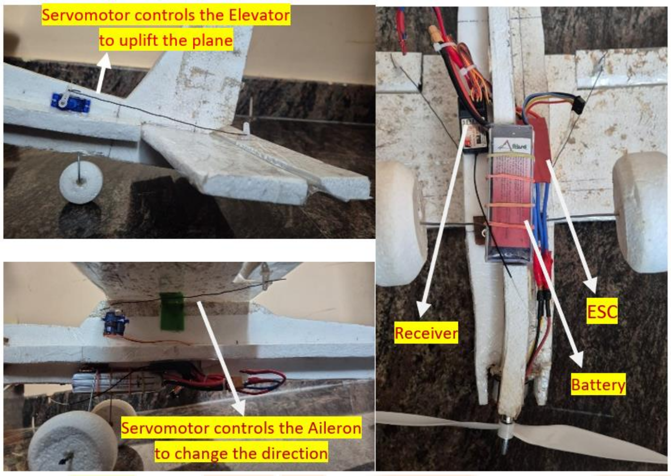
Electromagnetic Rail Launcher:

- **Design:** The rail was designed with alternating magnetic poles for consistent propulsion, with calculations ensuring optimal spacing and alignment of magnets. The sledge incorporated a coil system designed for maximum interaction with the magnetic field.
- **Development:** Iterative prototyping involved testing coil configurations (100-400 turns) and refining the capacitor bank to optimize power delivery.
- **Fabrication:** The rail base was constructed using acrylic material for lightweight durability. Magnets were mounted securely using UV-curable resin, and copper bars were polished for smooth power delivery.
- **Assembly:** The sledge was aligned on the rail with sliding brushes ensuring consistent electrical contact. A spring-loaded switch was added for precise triggering of the coil activation.

Rail and Magnet Setup **Sledge Placement on Rail**

Radio-Controlled Aircraft:

- **Design:** The airframe was modelled with a streamlined fuselage and dihedral wings for aerodynamic stability. Control surfaces were sized for optimal responsiveness.
- **Development:** Prototypes were tested for lift-to-drag ratio, centre of gravity, and control surface effectiveness. Adjustments were made to improve balance and flight performance.
- **Fabrication:** Foam board was cut into wing and fuselage templates, with carbon fibre rods embedded for reinforcement. Components like the motor mount and landing gear were secured with lightweight materials.
- **Assembly:** The propulsion system (motor, ESC, and battery) was integrated into the fuselage. Control linkages were tested and adjusted to ensure smooth operation of the ailerons, rudder, and elevator.



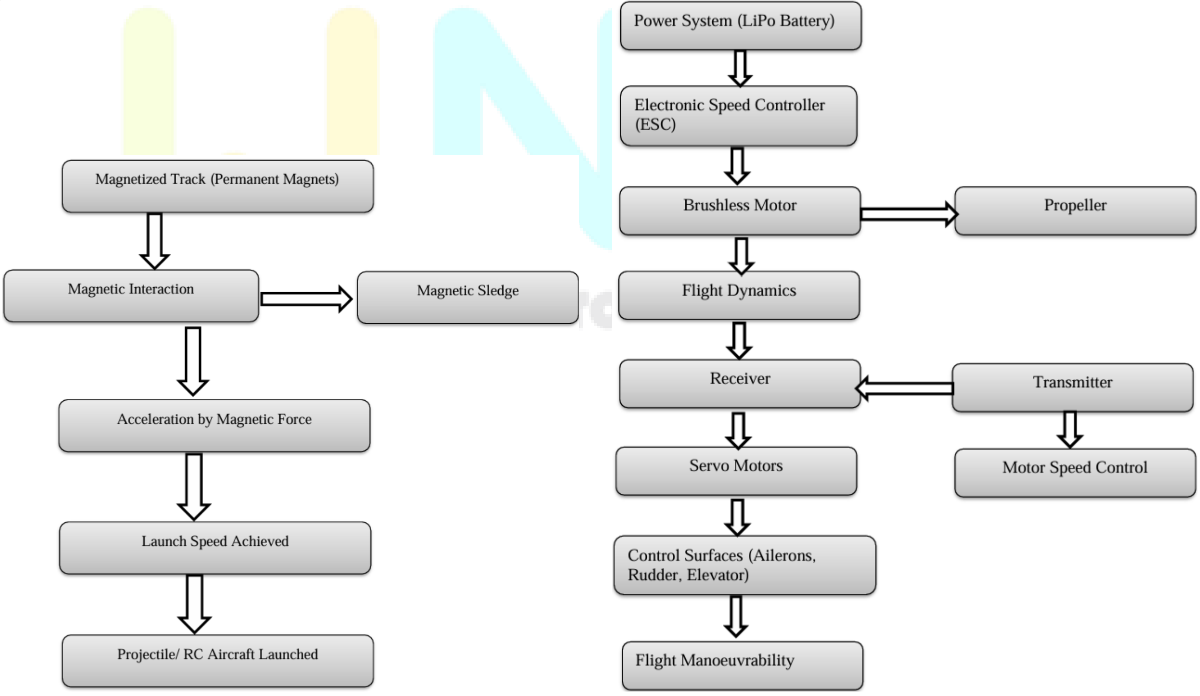
6. Hardware Implementation

The hardware implementation involved meticulous design, fabrication, and integration of components for both systems.

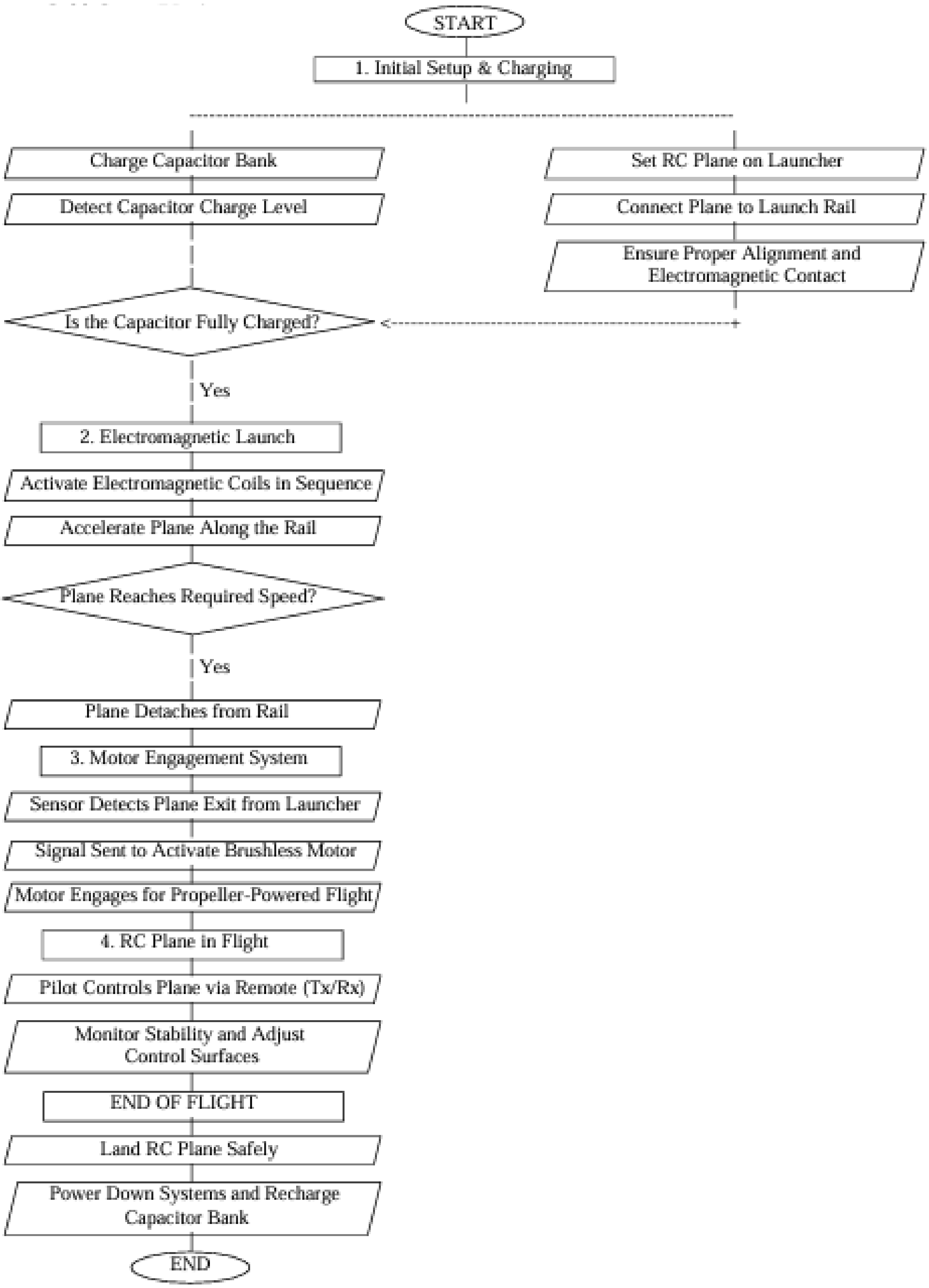
Electromagnetic Rail Launcher: The rail was constructed using lightweight, non-magnetic materials, with neodymium magnets aligned in alternating poles. Copper bars provided stable power connections, and the sledge was equipped with optimized coils and replaceable sliding brushes. A capacitor bank supplied energy, while optical sensors ensured precise synchronization of coil activation.

Radio-Controlled Aircraft: The airframe was fabricated from foam board with carbon fibre reinforcements for strength and durability. The propulsion system featured a brushless motor and a balanced propeller for efficient thrust. Control surfaces, including ailerons, elevator, and rudder, were operated by servo motors connected to a four-channel receiver. These components ensured stable and responsive flight.

Working Mechanism Flowchart



Electromagnetic Rail Launcher Radio-Controlled Aircraft Flowchart



7. Results and Discussion

Electromagnetic Rail Launcher: The launcher achieved a maximum velocity of 10.2 m/s for lightweight payloads. The system demonstrated reliable propulsion and modularity but faced challenges with magnetic alignment and sledge motion, which were addressed through iterative improvements.

Radio-Controlled Aircraft: The aircraft exhibited stable and responsive flight, with precise control achieved through servo-operated surfaces. The propulsion system balanced power and efficiency, while the lightweight design enhanced gliding capabilities. Structural durability was validated during landing and high-speed operations.

Challenges and Improvements:

1. Weight distribution required optimization for better balance and stability.
2. Landing gear enhancements were suggested for improved operability.
3. Adding telemetry systems for real-time data monitoring could improve performance analysis.

8. Conclusion

This paper demonstrates the use of permanent magnets in an electromagnetic launcher, simplifying design and reducing energy requirements compared to electromagnets. Handcrafted parts ensured accuracy and allowed customization for specific needs. By leveraging neodymium magnets, the system efficiently launched lightweight objects like RC planes without requiring high-power electrical supplies.

Challenges such as aligning magnetic fields, ensuring smooth rail movement, and enhancing durability were addressed through thoughtful design and material choices. While the system cannot dynamically adjust magnetic strength or scale for heavier loads, it provides a reliable and energy-efficient propulsion method.

This work offers a simple, sustainable, and affordable solution for hobbyists and educational applications, serving as a foundation for future advancements in magnetic propulsion systems.

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