Astrovionics Mambatron Plasma Propulsion System

Stage 1 Feasibility White Paper

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1. Abstract

This white paper presents a conceptual investigation of a plasma-based propulsion architecture, referred to as the Mambatron system, designed to explore whether controlled plasma dynamics can produce measurable thrust efficiency beyond conventional electric propulsion systems. The primary objective of this Stage 1 effort is not to claim performance superiority, but to experimentally determine whether the proposed plasma acceleration regime produces reproducible, measurable thrust under controlled laboratory conditions.

A $100,000 feasibility study is proposed to validate core physical assumptions, characterize plasma behavior, and establish whether the concept warrants further development toward higher Technology Readiness Levels (TRL).

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2. Introduction and Background

Electric propulsion systems such as Hall-effect thrusters and ion engines have demonstrated high specific impulse but are fundamentally constrained by known trade-offs between thrust density, power input, and plasma stability.

Recent advances in plasma confinement, magnetic field shaping, and high-frequency power modulation suggest that alternative plasma acceleration regimes may exist that are not fully explored in conventional architectures.

The Mambatron concept investigates whether structured electromagnetic control of plasma may enable:

- Enhanced momentum coupling efficiency
- Improved confinement-to-exhaust transition behavior
- Reduced energy losses through non-linear plasma instabilities

This work does not assume violation of known physics but instead explores under-characterized regimes of plasma behavior under dynamic field conditions.

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3. System Overview

The Mambatron propulsion system consists of the following primary subsystems:

3.1 Plasma Generation Module

A controlled ionization chamber generates a high-density plasma using inert propellant (e.g., xenon, argon, or alternative noble gas). Ionization is achieved through RF or microwave excitation.

3.2 Electromagnetic Acceleration Region

A structured electromagnetic field configuration is applied to shape plasma flow and induce directional acceleration. The architecture explores whether time-varying field geometries can produce non-linear momentum transfer effects.

3.3 Confinement and Control System

Magnetic confinement elements regulate plasma-wall interaction losses and maintain stability within the acceleration channel.

3.4 Exhaust and Thrust Vectoring

Ionized particles are expelled through a controlled exhaust aperture, producing reaction force measured via thrust stand instrumentation.

3.5 Diagnostics and Measurement Suite

- Langmuir probes for plasma density and electron temperature
- Magnetic field sensors (Hall effect sensors / flux probes)
- High-sensitivity thrust stand (torsional balance or micro-Newton scale system)
- High-speed optical emission spectroscopy (optional)

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4. Governing Physical Principles

The system is governed by standard plasma physics and electromagnetic theory, including:

- Lorentz force interaction:

  $$\boldsymbol{F} = q\left(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B}\right)$$

- Conservation of momentum in plasma exhaust systems
- Energy transfer efficiency constraints in ionized media
- Magnetohydrodynamic (MHD) flow behavior

No new physical laws are assumed. The investigation focuses on whether optimized field structuring can improve coupling efficiency between electromagnetic energy input and directed particle momentum output.

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5. Research Hypothesis

The central hypothesis is:

Controlled, time-varying electromagnetic field structures can modify plasma acceleration behavior in a way that produces measurable differences in thrust efficiency compared to conventional steady-field electric propulsion systems.

This hypothesis is strictly experimental and must be validated or falsified through controlled measurement.

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6. Experimental Validation Plan

Phase 1: Plasma Generation Verification

- Confirm stable plasma formation under variable RF/microwave excitation
- Measure density and temperature stability ranges

Phase 2: Field Interaction Testing

- Apply controlled electromagnetic configurations
- Observe plasma confinement and directional behavior

Phase 3: Thrust Measurement

- Mount system on micro-Newton thrust stand
- Conduct differential measurements with and without active field modulation

Phase 4: Data Analysis

- Compare thrust-to-power ratios
- Evaluate repeatability and statistical significance
- Identify noise sources and measurement artifacts

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7. Key Risks and Uncertainties

7.1 Plasma Instability

Non-linear instabilities may dominate plasma behavior under high-energy excitation regimes.

7.2 Measurement Sensitivity

Thrust signals may be near noise floor; environmental isolation is critical.

7.3 Energy Loss Mechanisms

Radiative losses, wall interactions, and recombination effects may dominate energy balance.

7.4 Misinterpretation Risk

Electromagnetic interference may produce false-positive thrust measurements; rigorous control experiments are required.

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8. Budget Overview (Stage 1 – $100,000)

- Laboratory equipment and thrust stand: $10,000
- Plasma generation hardware: $10,000
- Instrumentation and sensors: $10,000
- Fabrication and prototyping: $50,000
- Data acquisition systems: $10,000
- Analysis and engineering support: $10,000

Total: $100,000

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9. Expected Outcomes

This Stage 1 effort will produce:

- Verified plasma generation baseline
- Characterized electromagnetic interaction behavior
- Measured thrust data under controlled conditions
- Determination of feasibility for scaling to higher TRL stages
- Identification of dominant physical constraints

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10. Conclusion

The Mambatron system represents a structured experimental investigation into advanced plasma propulsion regimes. The objective of this Stage 1 effort is to determine whether measurable and reproducible deviations in thrust efficiency can be observed under controlled electromagnetic modulation of plasma flow.

The outcome of this study will either:

1. Validate further development toward a scalable propulsion architecture, or
2. Establish clear physical and engineering constraints that define system limits.

In both cases, the result contributes directly to the understanding of advanced electric propulsion systems.

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11. References (Preliminary)

- Sutton, G.P., Biblarz, O. Rocket Propulsion Elements
- Goebel, D.M., Katz, I. Fundamentals of Electric Propulsion
- NASA Electric Propulsion Research Publications
- IEEE Transactions on Plasma Science
