Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Engineering Comparison and Multi-Criteria Selection of Micropropulsion Systems for Small Spacecraft

Nazmul Hasan Anik Chawdhury

anikchyaf@gmail.com

Aviation and Aerospace University Bangladesh

Mahbub Sultan

Northwestern Polytechnical University

Systematic Review

Keywords: Micropropulsion, CubeSat, small spacecraft, electric propulsion, water resistojet, Hall thruster, electrospray, specific impulse, multi-criteria decision-making, AHP-Entropy-TOPSIS

Posted Date: June 30th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10190671/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: The authors declare no competing interests.

Abstract

Micropropulsion has become a mission-enabling subsystem for CubeSats and other small spacecraft because it supports orbit maintenance, attitude control, collision avoidance, drag compensation, formation flying, and controlled disposal. The modern design problem is no longer whether propulsion should be used, but which micropropulsion architecture is most suitable under severe constraints in mass, volume, power, total impulse, safety, and mission duration. This paper reviews the recent 2020-2026 micropropulsion literature and reorganizes it into an engineering comparison framework covering cold-gas, chemical, and electric propulsion systems, with electric propulsion further divided into electrothermal, electrostatic, and electromagnetic types. A key argument of the paper is that propulsion selection should not be based on a single metric such as specific impulse. Instead, preliminary selection should be approached as a multi-criteria engineering decision problem. To address that problem, the paper introduces a universal weighting method based on a hybrid Analytic Hierarchy Process (AHP), entropy weighting, and TOPSIS ranking framework. The review shows that electric systems generally dominate missions requiring high propellant efficiency or high-precision control, while cold-gas, electrothermal, water-resistojet, and monopropellant systems remain attractive when simplicity, faster response, safer handling, or stronger thrust are more important. The paper concludes with a comparative engineering analysis and proposes a structured decision framework for mission-specific micropropulsion selection.

1. Introduction

Small spacecraft have moved rapidly from educational demonstrations to operational platforms in Earth observation, communications, scientific payloads, cislunar technology demonstrations, and deep-space precursor missions [1]-[5]. As mission ambition has increased, propulsion has changed from an optional enhancement to a core subsystem for many classes of small spacecraft. Without onboard propulsion, small satellites face strict limitations in orbit transfer, station-keeping, drag make-up, phasing, collision avoidance, end-of-life disposal, and precision relative motion control [1]-[4].

The challenge is that micropropulsion does not admit one universally best solution. Cold-gas systems are simple and mature but usually suffer from low specific impulse. Electrothermal systems improve efficiency but consume additional electrical power. Chemical systems can provide higher thrust but raise concerns about thermal control, feed-system complexity, and handling safety. Electrostatic and electromagnetic devices often provide high specific impulse or high controllability, but their absolute thrust can be low and their power-processing requirements can be severe for small buses [1]-[6], [8]-[18].

Accordingly, this review is written around a practical engineering question: how should micropropulsion technologies be compared when thrust, specific impulse, power demand, system mass, package volume, maturity, and operational simplicity all matter simultaneously? The novelty of this paper lies in combining a recent literature review with a universal weighting method for preliminary selection. The aim is not to claim that a single technology dominates all missions, but to provide a more traceable and defensible comparison structure for early design.

2. Research Background

Recent reviews confirm that the current micropropulsion landscape is broader and more mature than earlier taxonomies suggested. Electric propulsion reviews have emphasized ion, Hall, electrospray, FEEP, pulsed plasma, and cusped-field devices for their propellant economy and precise controllability [1], [3], [13]-[19]. At the same time, CubeSat-oriented surveys have highlighted the persistent practical value of cold-gas, butane, water, resistojet, and green monopropellant solutions because they can ease integration and improve operational robustness [2], [7], [10], [20], [25].

Another recurring theme in the recent literature is that system-level constraints dominate propulsion choice. A thruster with excellent specific impulse may still be unattractive if it requires a heavy power-processing unit, complex thermal management, unusual tankage, or long maneuver times. Conversely, a less efficient system may be optimal when rapid response, simplicity, safer handling, or low integration burden is the main driver [2], [6], [10], [14], [20]. This means that a

review paper that only classifies technologies without offering a decision structure leaves a major gap between literature synthesis and preliminary design practice.

The literature also shows a strong movement toward water-based and green-propellant concepts. Water resistojets have now demonstrated useful on-orbit capability in deep space, while green monopropellant concepts continue to attract interest for higher-thrust CubeSat applications [20], [25]. In parallel, electrospray and Hall-thruster studies continue to push precision control, plume shaping, lifetime extension, low-power operation, and alternative propellants [15]-[19], [21]-[24]. These developments justify a fresh review built around engineering comparison rather than descriptive taxonomy alone. Several recent studies have also emphasized the importance of system-level integration constraints such as power processing units, thermal management, and propellant storage architecture when evaluating micropropulsion technologies.

3. Methodology

This study follows a structured review-and-selection methodology. First, the reference base was limited to journal literature published between 2020 and 2026 and checked against publisher records and scholarly-search discoverability. Second, the collected literature was grouped by propulsion family and by engineering performance criteria. Third, a universal preliminary selection method was formulated using a hybrid AHP-Entropy-TOPSIS framework [26]-[30]. The method is universal in procedure rather than in fixed numerical weights. That distinction is important because propulsion priorities change with mission type, but the logic for deriving and using weights can still remain consistent.

AHP is used to capture engineering judgment through pairwise comparison of criteria. Entropy weighting is then used to capture the objective information carried by each criterion across the competing alternatives. The final criterion vector is obtained by combining the subjective and objective weights, after which TOPSIS is used to rank alternatives according to their proximity to an ideal solution and remoteness from a non-ideal solution [27]-[30]. This hybrid approach is better justified than assigning fixed weights by intuition because it makes the weighting step traceable, repeatable, and mission-adaptable. This hybrid weighting framework is particularly suitable for micropropulsion technology assessment because it integrates expert judgment with objective data variability, thereby improving the robustness of early-stage propulsion selection.

The overall suitability score of an alternative can be written as:

$$S = \sum_{j=1}^{n} w_j \, r_j, \quad \text{with} \quad \Sigma \, w_j = 1$$

where S is the overall suitability, w_j is the final combined weight of criterion j, and r_j is the normalized rating of the propulsion option under that criterion. The combined weight used in this paper follows the standard hybrid form:

$$w_j^{(c)} = \alpha \; w_j^{(AHP)} + (1 - \alpha) \, w_j^{(E)}$$

where w_j^{AHP} is the subjective weight from AHP, w_j^{E} is the objective entropy-derived weight, and α is the balance factor between expert judgment and data-driven variation. The approach is especially suitable for micropropulsion because it allows different missions to reuse the same decision structure while changing only the pairwise judgments or the alternative data matrix [27]-[30].

4. Existing Micropropulsion Methods

The recent literature supports organizing micropropulsion into three primary engineering groups: cold-gas propulsion, chemical propulsion, and electric propulsion [1]-[5]. For clearer comparison, electric propulsion is further divided into electrothermal, electrostatic, and electromagnetic systems, while chemical propulsion is separated into monopropellant, bipropellant, and solid-propellant microthruster concepts. This revised classification preserves the engineering distinction required for thruster-level comparison rather than relying only on broad propulsion-family labels.

Cold-gas systems remain attractive where simplicity, high reliability, low contamination risk, and rapid integration are more important than propellant efficiency. Electrothermal systems such as resistojets and vaporizing-liquid devices improve performance relative to pure cold-gas thrusters, but they introduce heater power and thermal-management penalties. Chemical systems provide the strongest maneuver authority in micro-scale packages, especially where impulsive or rapid translational control is needed, but they often increase system complexity and operations risk [2], [7], [10], [20], [25].

Electrostatic systems, including ion thrusters, electrosprays, and FEEP-type devices, are strongly favored for high specific impulse and precise low-thrust control. Electromagnetic systems, especially Hall thrusters and pulsed plasma thrusters, provide a different compromise between power demand, thrust density, and propulsion architecture. Hybrid and water-based systems are especially important in current small-satellite programs because they promise safer storage, operational simplicity, and practical integration, even when they do not maximize specific impulse [3], [11]-[24].

Table 1. Engineering comparison of representative micropropulsion thruster types for small spacecraft.

Propulsion class	Thruster type	Typical thrust	Typical I_{sp}	Typical power demand	Main engineering strength	Main engineering limitation	Ref.
Cold-gas	Nitrogen / butane cold-gas thruster	μN–tens of mN	~ 40–100 s	< 5 W	Simple, reliable, clean	Low propellant efficiency	[2], [6]
Electrothermal	Resistojet / water resistojet	sub-mN–tens of mN	~ 70–200 s	~ 1–50 W	Better efficiency than cold gas; safer propellants	Heater and thermal losses	[7], [20]
Electrothermal	Vaporizing-liquid microthruster	μN–mN	low–moderate	~ 1–20 W	Compact liquid-fed design	Phase-change and thermal-control complexity	[9]
Chemical	Monopropellant thruster	mN–N	~ 150–250 s	< 10 W	High thrust and fast response	Catalyst, thermal, and handling complexity	[2], [6], [26]
Chemical	Bipropellant thruster	mN–N	~ 250–350 s	< 10 W	Higher performance than monopropellant	Feed-system and ignition complexity	[2], [6]
Chemical	Solid microthruster	mN–N	~ 150–250 s	< 5 W	Simple stored-energy system	Limited restart and throttling	[2], [6]
Electrostatic	Ion thruster	μN–mN	~ 1000–4000 s	~ 10–300 W	Very high efficiency and precision	Low thrust, high voltage, PPU requirement	[3], [27]
Electrostatic	Electrospray / FEEP	nN–mN	~ 800–5000 s	~ 1–50 W	Ultra-precise thrust control	Emitter lifetime and contamination	[17], [18], [21]–[23], [25]
Electromagnetic	Hall thruster	mN–tens of mN	~ 1000–2000 s	~ 50–1000 W	Good thrust–efficiency balance	Cathode, erosion, and power limits	[14], [15], [19], [24]
Electromagnetic	Pulsed plasma thruster	μN–mN	~ 500–1500 s	~ 1–50 W pulsed	Compact solid-propellant system	Low efficiency and electrode erosion	[11], [16]

***The values are representative ranges compiled from the row-wise references listed in the Ref. column. Actual performance may vary with propellant, design scale, input power, feed-system configuration, and operating conditions.**

5. Weighting System

The earlier version of this paper assigned fixed weights to thrust, specific impulse, power, mass, volume, maturity, and safety. That approach is not methodologically strong because such numbers appear arbitrary unless they are explicitly derived. A stronger approach is to keep the criteria fixed but derive their importance through a universal weighting procedure. In that sense, there is no universal fixed set of weights for micropropulsion, but there is a universal way to generate them for a specific mission [26]-[30].

The criteria adopted in this paper are thrust capability (F), specific impulse (I_{sp}), electrical power demand (P), propulsion-system mass (m_{sys}), propulsion-system volume (V), technical maturity or flight heritage (TRL), and safety or operational simplicity (S_f). Benefit criteria such as thrust, specific impulse, maturity, and simplicity should increase the score; cost criteria such as power demand, mass, and volume should reduce it. These criteria appear repeatedly in recent micropropulsion surveys and device-level studies, which confirms their engineering relevance [1]-[6], [10]-[25].

Table 2
Proposed weighting system for preliminary micropropulsion selection based on a hybrid AHP-Entropy framework.

Criterion	Symbol	Type	Weight source	Engineering relevance
Thrust capability	F	Benefit	AHP + Entropy	Response authority
Specific impulse	I_{sp}	Benefit	AHP + Entropy	Propellant efficiency
Electrical power demand	P	Cost	AHP + Entropy	Power budget fit
Propulsion-system mass	m_{sys}	Cost	AHP + Entropy	Bus mass burden
Propulsion-system volume	V	Cost	AHP + Entropy	Packaging fit
Technical maturity / flight heritage	TRL	Benefit	AHP + Entropy	Risk reduction
Safety / simplicity	S_f	Benefit	AHP + Entropy	Ops simplicity

*Criterion weights are derived using a hybrid AHP-Entropy approach combining expert judgment and objective data variability.

For the entropy-weight stage, the normalized decision matrix is first computed and then converted to criterion entropies. A typical sequence is $r_{ij} = x_{ij} / \left(\Sigma\ x_{ij}^2 \right)^2$, followed by $p_{ij} = r_{ij} / \Sigma\ r_{ij}$, $e_j = -k \Sigma\ p_{ij}\ \ln\left(p_{ij}\right)$, $d_j = 1 - e_j$, and $w_j^E = d_j / \Sigma\ d_j$ [28]-[30]. After that, TOPSIS is used to calculate each alternative's distance from the positive and negative ideal solutions. This step is particularly useful for micropropulsion because it makes tradeoffs visible rather than hidden inside narrative judgments.

6. Comparative Study

A fully numerical comparison requires a mission-specific database of alternatives, including thrust, I_{sp}, power, wet mass, dry mass, total impulse, package volume, thermal constraints, plume characteristics, and lifetime. Because the recent literature often reports different subsets of these parameters, this paper uses an illustrative class-level comparison rather than a false sense of precision. That choice is deliberate. A review article should not pretend that every propulsion family can be ranked by one universal fixed number when the input data are heterogeneous [2], [6], [10], [14], [20].

Even at the class level, however, useful patterns are clear. Cold-gas systems score strongly in simplicity and maturity but weakly in specific impulse. Water and resistojet systems usually improve the overall balance for missions with tight safety or storability constraints. Chemical systems offer strong impulsive capability but often lose points in integration complexity and risk. Ion, electrospray, and Hall-type electric systems usually score strongly in efficiency, precision, or long-duration controllability, but they can be limited by power and by absolute thrust [1]-[6], [10]-[25].

Figure 2 presents a representative thrust–specific impulse map for selected micropropulsion systems using model-level examples instead of only broad propulsion classes. The numbered markers correspond to: (1) cold-gas/butane CubeSat propulsion, (2) EQUULEUS water resistojet, (3) resistojet/vaporizing-liquid microthruster, (4) MIMPS-G green monopropellant system, (5) micro pulsed plasma thruster, (6) low-power Hall thruster, (7) miniaturized/iodine ion thruster, and (8) ionic-liquid

electrospray/FEEP thruster. The comparison shows that chemical micropropulsion provides the highest representative thrust, while ion and electrospray/FEEP systems provide much higher specific impulse but lower thrust. The plotted values are representative comparison points and should not be interpreted as universal performance limits, because actual performance depends on thruster model, propellant, input power, scale, and operating conditions [2], [3], [6], [7], [9], [11], [14]–[27].

Table 3. Comparative assessment of representative micropropulsion thruster types with numerical indicators, maturity level, and safety/complexity explanation.

Thruster type	Isp range	Power demand	Indicative maturity	Safety / complexity note	Application role	Ref.
Cold-gas	~ 40–100 s	< 5 W	Flight-proven, TRL 8–9	Pressure vessel and leakage risk	ACS and safe missions	[2], [6]
Water resistojet	~ 70–200 s	~ 1–50 W	Demonstrated / flight-relevant, TRL 6–8	Non-toxic; heater, vaporization, and freezing control required	Safe CubeSat propulsion	[20]
Resistojet / vaporizing-liquid	~ 70–200 s	~ 1–50 W	Demonstrated, TRL 5–7	Heater and thermal-management requirement	Cold-gas alternative	[7], [9]
Monopropellant	~ 150–250 s	< 10 W	Demonstrated / flight-relevant, TRL 6–8	Catalyst bed, decomposition, thermal and handling risk	Fast maneuvering	[2], [6], [26]
Bipropellant	~ 250–350 s	< 10 W	Demonstrated; limited micro-scale use, TRL 5–7	Two propellants, valves, ignition, and mixture control	High-performance missions	[2], [6]
Solid microthruster	~ 150–250 s	< 5 W	Demonstrated / mission-specific, TRL 5–7	Simple storage; limited throttle/restart after ignition	Impulse generation	[2], [6]
Ion thruster	~ 1000–4000 s	~ 10–300 W	Flight-proven in EP; miniaturized versions vary, TRL 6–9	High voltage and PPU; very low thrust	Long-duration efficiency	[3], [27]
Electrospray / FEEP	~ 800–5000 s	~ 1–50 W	Emerging to demonstrated, TRL 4–7	Emitter lifetime, contamination, and beam-control issues	Precision control	[17], [18], [21]–[23], [25]
Hall thruster	~ 1000–2000 s	~ 50–1000 W	Flight-proven; low-power versions developing, TRL 6–9	Cathode, PPU, thermal-control, and erosion issues	Orbit raising / station keeping	[14], [15], [19], [24]
Pulsed plasma thruster	~ 500–1500 s	~ 1–50 W pulsed	Demonstrated, TRL 5–8	Solid propellant; electrode/insulator erosion	Impulse-bit control	[11], [16]

*TRL values are indicative device-level maturity ranges compiled from the row-wise references listed in the Ref. column. Actual maturity and performance may vary with thruster model, propellant, input power, scale, flight heritage, and operating conditions.

The main lesson from Table 3 is that the preferred propulsion solution changes with mission requirements. The comparison therefore uses representative numerical ranges for specific impulse and power demand, together with indicative

TRL/maturity status and explicit safety or complexity explanations. These values are intended for preliminary engineering comparison rather than exact device-level ranking, because actual performance depends strongly on propellant, thruster scale, power-processing architecture, feed system, and mission environment [1]-[6], [10]-[25]. In practice, propulsion choice is inseparable from spacecraft power architecture, available volume, acceptable risk, maneuver timescale, and whether the mission values precision, efficiency, or stronger immediate thrust [1]-[6], [10]-[25].

The recent 2020–2026 literature shows that micropropulsion has moved beyond proof-of-concept taxonomy and into system-level mission application. Low-power Hall thrusters, water resistojets, green monopropellant modules, precision electrosprays, pulsed plasma thrusters, and novel cusp-field systems now offer distinct and increasingly validated capability envelopes [10]-[25]. At the same time, the literature still suffers from inconsistent reporting: some studies report thrust and specific impulse, others emphasize lifetime, mass, or plume shape, and many do not publish a full system budget. This reporting inconsistency is one reason why a structured weighting and ranking method is useful. The revised comparison replaces qualitative H/M/L indicators with literature-supported performance ranges and explicit engineering explanations to improve transparency and traceability.

7. Conclusion

Micropropulsion selection for small spacecraft is fundamentally a trade-study problem rather than a single-parameter optimization problem. The most defensible conclusion from the recent literature is not that one technology dominates all missions, but that different technologies dominate under different mission priorities. Electric systems usually lead when propellant economy or precision are central. Cold-gas, electrothermal, water-based, and green monopropellant concepts remain highly relevant when safer handling, lower complexity, packaging practicality, or stronger thrust are more important [1]-[6], [10]-[25].

The main contribution of this paper is therefore methodological as well as descriptive. It reframes the review from a simple catalog of propulsion classes into an engineering comparison supported by a universal AHP-Entropy-TOPSIS weighting logic. That structure is stronger for journal publication because it makes the reasoning traceable and opens a direct path from literature synthesis to preliminary design practice [26]-[30]. The present review is limited to class-level engineering comparison and does not attempt device-specific numerical ranking, because performance data are often reported inconsistently across studies. This framework may assist spacecraft system engineers in conducting early-stage propulsion trade studies and selecting appropriate micropropulsion technologies for future small-satellite missions. Future work should progress along four lines. First, authors should publish complete system-level data, including wet mass, dry mass, feed-system overhead, PPU mass, and package volume, rather than reporting thrust and Isp in isolation. Second, more on-orbit results are needed, especially for water-based, green monopropellant, electrospray, and low-power Hall systems [14], [15], [17], [20], [23]-[25]. Third, future comparative studies should include uncertainty and sensitivity analysis so that weight changes and data uncertainty can be propagated through the ranking process. Fourth, public datasets linking propulsion class to mission type, flight heritage, and failure mode would significantly improve the quality of early design decisions [26]-[30].

Declarations

Acknowledgments

The author would like to acknowledge the academic environment and research support provided by Aviation and Aerospace University, Bangladesh, which facilitated the completion of this study. No external funding was received for this research.

References

1. O'Reilly D, Herdrich G, Kavanagh DF (2021) Electric Propulsion Methods for Small Satellites: A Review, Aerospace, 8, 1, Art no 22
2. Alnaqbi S, Darfilal D, Swei SSM (2024) Propulsion Technologies for CubeSats: Review, Aerospace, 11, 7, Art no 502
3. Yeo SH et al (2021) Miniaturization perspectives of electrostatic propulsion for small spacecraft platforms. Acta Astronaut
4. Wei Y et al (2022) The View of Micropropulsion Technology for China's Deep Space Exploration, Research. Art no 9769713
5. Liu H, Niu X, Zeng M, Wang S, Cui K, Yu D (2022) Review of micro propulsion technology for space gravitational waves detection. Acta Astronaut 193:496–510
6. Pei J, Kamhawi H, Wirz RR (2020) Survey and Performance Evaluation of Small-Satellite Propulsion Technologies. J Spacecr Rockets
7. Romei F et al (2020) Validation of an additively manufactured resistojet through experimental and computational analysis. Acta Astronaut
8. Craft KJ, Hecht GR, Darling JE, Pernicka HJ (2022) Development, Verification, and Analysis of a Small Satellite Thrust Determination Filter. J Spacecr Rockets 59(2):360–374
9. Pugia SM et al (2022) Characterization of film-evaporating microcapillaries for micropropulsion. Acta Astronaut
10. Wang Z et al (2021) Design and demonstration of a micro air-fed magnetoplasmadynamic thruster for small satellites. Acta Astronaut
11. Li H et al (2020) A model for macro-performances applied to low power pulsed plasma thrusters. Acta Astronaut
12. Yeo SH et al (2024) Multi-objective design optimization and physics-based analysis of low-power electric thrusters for small spacecraft. Vacuum
13. Blättermann H et al (2024) Endurance testing and characterization of a novel candidate for CubeSat propulsion. The Advanced Cusp Field Thruster (ACFT), Acta Astronautica
14. Zhang G et al (2024) Development of a low-power Hall thruster with permanent magnets and a dual trigger electrode hollow cathode for the Qilu satellite constellation. Propulsion and Power Research
15. Tsuchikawa S et al (2024) Performance evaluation of a low power Hall thruster with carbon dioxide propellant. Acta Astronaut
16. Ou Y et al (2024) Design and performance of a micro-pulsed plasma thruster used in miniaturized satellites. Adv Space Res
17. Sun W et al (2024) Lifetime experiment and analysis of an electrowetting ionic liquid electrospray thruster. Acta Astronaut
18. Yang C et al (2024) Study on the modes transformation and emission characteristics of ionic liquid electrospray thrusters. Acta Astronaut
19. Liu X et al (2024) Optimizing a Hall thruster with aft-loaded magnetic field by flow-field regulation, Vacuum
20. Moriai I et al (2025) A water resistojet propulsion system on a 6U CubeSat EQUULEUS: Demonstration of reaction control in deep space. Acta Astronaut, 227
21. Li J et al (2025) Experimental study on beam focusing of ionic liquid electrospray thrusters. Acta Astronaut
22. Cheng Y et al (2025) Axial emission characteristics of an ionic liquid electrospray thruster for micro-nano satellite applications. Chin J Aeronaut
23. Sun W et al (2025) Measurement of long-time performance changes of porous ionic liquid electrospray thrusters after electrowetting replenishment. Chin J Aeronaut
24. Fan H et al (2025) Plume focusing characteristics and optimal design of Hall thruster magnetic field using an artificial-intelligence-assisted approach. Chin J Aeronaut
25. Kim H et al (2025) High-Impulse, Modular, 3D-Printed CubeSat Electrospray Propulsion System. Adv Sci

26. Nosseir AES, Cervone A, Pasini A (2021) Modular Impulsive Green Monopropellant Propulsion System (MIMPS-G): For CubeSats in LEO and to the Moon, Aerospace, vol. 8, no. 6, Art. no. 169
27. Jia-Richards O, Lafleur T (2023) Iodine Electric Propulsion System Thrust Validation: From Numerical Modeling to In-Space Testing. J Propul Power 39(6):896–904
28. Chakraborty S (2023) A comprehensive and systematic review of multi-criteria decision-making methods and applications, Results in Engineering, vol. 20
29. Taherdoost H, Madanchian M (2024) A comprehensive survey and literature review on TOPSIS. Int J Service Sci Manage Eng Technol, 15, 1
30. Chatterjee S, Chakraborty S, Mondal SC (2024) A study on the effects of objective weighting methods on TOPSIS-based optimization, MethodsX, vol. 12
31. Mo W, Liu Z, Zhao X (2025) AHP-Entropy Method for Sustainable Development Assessment, Sustainability, vol. 17, no. 21

Figures

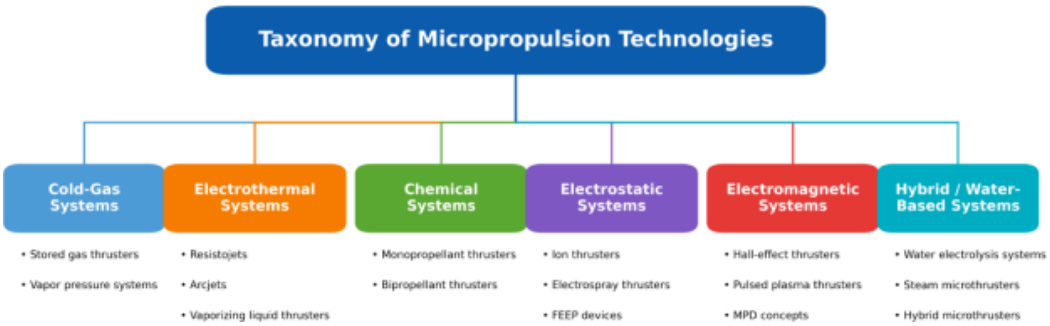


Figure 1

Taxonomic classification of major micropropulsion technologies used in small spacecraft platforms.

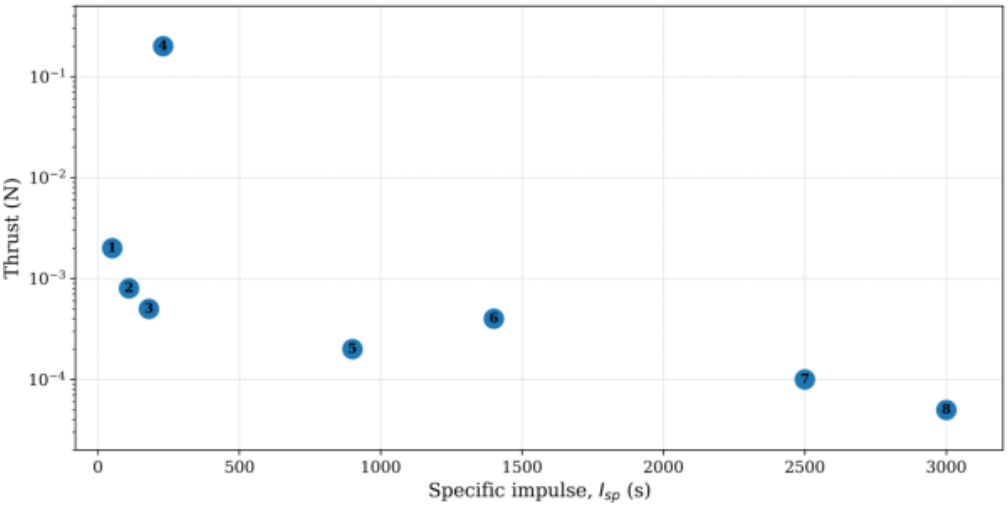


Figure 2

Representative thrust–specific impulse map of selected micropropulsion systems. Numbered markers correspond to the representative thruster models discussed in the text.