ARCJET: Plasma-Assisted Reentry Braking System

Concept Owner: Randall Simmons

Date: June 29, 2025

Short Description

ARCJET is a dual-phase, plasma-assisted reentry and aquatic propulsion system that uses electrically powered ion jets for safe, eco-friendly descent and post-splashdown mobility.

Objective

Design a feasible reentry braking system for space vehicles using electrically-powered reverse plasma jets, supplemented by solar, ionospheric, and onboard battery energy sources. The system doubles as a water propulsion mechanism post-splashdown.

System Overview

Deployment Phases:

Pre-Entry (20050 km): Slow orbital velocity - Use solar-powered plasma jets and onboard batteries for deorbiting

Upper Reentry (15080 km): Begin controlled deceleration - Engage plasma jets using compressed gas, powered by solar and battery systems

Mid Reentry (8060 km): Increase braking force - Maximize jet use, control descent vector

Lower Descent (6020 km): Orient capsule - Retract or deactivate jets, stabilize with lift or fins

Splashdown (0 km): Post-landing mobility - Reactivate jets as water propulsion systems

Power Sources

- Solar Panels: Provide electrical power to the plasma arc system during orbital and upper reentry phases (not used for drag)

- Onboard Batteries: High-output lithium or graphene-capacitor banks

- Ionospheric Charge Harvesting (Theoretical): Potential passive or assisted energy draw from the Earthionosphere voltage differential. While speculative, this could provide supplementary power during orbital braking and upper reentry particularly effective in high-voltage regions of the upper atmosphere where natural electrical gradients are strongest (e.g., ionospheric layers or near thunderstorms).

Propulsion & Braking Mechanism

ARCJET employs a plasma propulsion system rather than a traditional ionic (ion-only) thruster. Unlike deep-space ion engines that produce minimal thrust with high efficiency, ARCJET uses electrically ionized gas (plasma) composed of both electrons and ions. This hot, accelerated plasma is expelled through electromagnetic nozzles, generating usable thrust for reentry braking and aquatic propulsion in near-real-time conditions.

- Electrically ionized compressed air or inert gas (nitrogen/argon)
- Electromagnetic acceleration via Lorentz-force nozzles
- Vector control for attitude and drag orientation

Compressed Gas System

- Lightweight composite high-pressure tanks
- Heat-shielded release valves and regulators

Materials & Structure

- External Shell: Ablative ceramic or carbon-carbon composites
- Plasma Nozzles: Tungsten alloy or high-temp ceramics
- Jet Shielding: Retractable fairings or heatproof covers

Marine Operations Mode

- Post-splashdown propulsion uses the same plasma jet system in water.
- Operates with inert or atmospheric compressed gas (e.g., air, nitrogen, argon).
- No combustion or toxic propellant involved system is entirely electrically powered.
- Plasma chamber and exhaust are internalized and water-sealed, preventing any direct arcing or chemical release.
- Materials chosen for marine safety: non-corrosive, non-leaching, and environmentally neutral.
- Optional hybrid with electric impeller or water-jet mode for silent, clean navigation.
- Complies with modern eco-friendly engineering standards for oceanic recovery or mobility.

Failsafe & Safety Systems

- Life Support Emergency Mode: In the event of cabin atmosphere degradation or CO buildup (as occurred during Apollo 13), ARCJET can be equipped with an onboard CO scrubbing module. This system may include swappable lithium hydroxide or amine-based cartridges for immediate use, or advanced plasma-assisted CO dissociation units for longer missions. The scrubbing system draws on ARCJET's internal power systems and airflow regulation and can be manually or automatically activated. Designed as a last-resort life support redundancy for occupied capsules in power-limited scenarios.
- Emergency Ionospheric Jumpstart (Theoretical): In the event of primary power failure, ARCJET could attempt to draw emergency voltage from the ambient ionospheric electric field using a paired positive/negative collector array. These collectors would remain shielded under manually or electronically ejectable ceramic panels until needed. When deployed, they form a localized high-voltage circuit to recharge onboard capacitors or temporarily power plasma jets, providing critical propulsion or stabilization. Includes automatic discharge regulation and isolation circuitry to prevent overload or unsafe current spikes.
- Plasma chamber isolation: Each port is electrically separated with dedicated grounding paths and insulated housings.
- Dielectric barriers: Prevent back-arcing into compressed gas system using ceramic mesh or non-conductive barriers.
- Arc spike sensors: Real-time monitoring of plasma behavior. Automatic shutoff and reroute on irregular voltage detection.
- Electromagnetic blowback: Magnetic pulse systems to neutralize errant arcs.
- Self-cleaning ports: Microburst purge or vibration-enabled grates to dislodge debris from nozzle openings.
- Seawater shielding: Auto-sealing magnetic shutters post-landing protect nozzles from water intrusion.
- Modular override: Faulty nozzles can be isolated, ejected, or swapped from an internal reserve

bank.

Benefits

- Active reentry speed control without explosive retropropulsion
- Multi-phase use: orbital braking, descent slowing, water navigation
- Safer splashdown targeting and retrieval
- Lower G-loads on occupants or cargo
- Environmentally safe operation across all mission phases
- Built-in safety layers to prevent back-arcing, contamination, and plasma failure

Next Steps

- Mass and thrust profile calculations
- CAD mockup of plasma jet layout
- Simulation of gas flow and thermal dissipation
- Concept validation with aerospace materials expert

Notes

This concept blends field-proven technologies (plasma cutters, compressed gas systems, solar panels) into a novel aerospace application. Its feasibility is grounded in existing tech with room for enhancement.