Swirl torque, wheel momentum and feed-line diagnosis for Psyche

A two-page brief on a simulation study

Prometheus7 Research Institute · November 2026 · prometheus7.com/DeepSpace7/psyche

What this is. An independent simulation study, built only from NASA's public record of the mission, of what an onboard reasoning layer could add to Psyche's propulsion system while it thrusts nearly 90% of the time. The system, DeepSpace7, reads telemetry against itself, keeps several explanations open at once, flies each candidate response ahead in an onboard model built from telemetry, chooses the best worst case, and records why. It runs in about 0.07 ms per one-minute control step. Every result below comes from a pre-registered test run once on fresh scenarios. No Psyche telemetry was used, and nothing here assesses the mission's own design or operations.

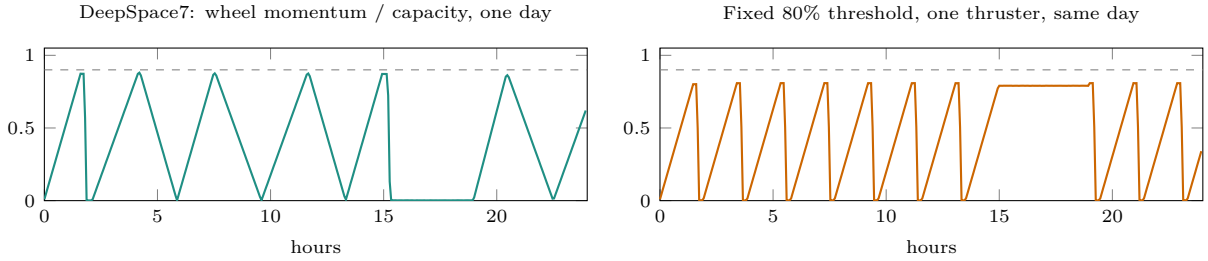
1. Swirl torque and the wheels

From the public record (NASA, 22 October 2026): one Hall thruster fires at a time, nearly continuously, with a weekly pause for Earth contact; the ions' swirl puts a slight torque on the spacecraft that the reaction wheels absorb; every few hours the thruster is turned off, the spacecraft rotates, and another thruster fires at low power for several minutes to unload the wheels. Thrust will throttle toward half power within months.

What the system does. It reads each thruster's torque in flight from the wheels (median error 0.51% in simulation), forecasts wheel momentum in the worst case and keeps it under 90% of capacity, folds unloads into pauses that happen anyway, lets a thruster whose torque opposes the momentum take over instead of an unload, and never restarts thrust above 85% of capacity.

Thrust duty (higher is better)	DeepSpace7	Fixed 80% threshold	Fixed 90% threshold
All cases	92.1%	87.0%	87.9%
Thrusters' torques alike	87.9%	87.0%	88.0%
Torques differ in size	89.9%	87.0%	87.9%
Torques differ in sign	**98.5%**	86.8%	87.9%
Unloads per week, torques differ in sign	**1.4**	46.8	–
Peak wheel momentum / capacity (limit 1.0)	0.90	0.82	0.92

1,920 two-week runs. Swirl torque, thruster differences and wheel capacity have no public numbers, so they were swept: torque 1–5× an estimate, alike / different size / different sign, two wheel sizes, full and half power.



One recorded day, assumed torques of different size and sign. Left: the gradual falls are a thruster with the opposite torque taking over; sharp drops are unloads. Right: every drop is an unload; the flat stretch is the contact pause.

What it means. How much of the unload cost onboard reasoning can take back depends on one property: whether the four thrusters' swirl torques differ. If some swirl the opposite way, thrusters that cancel each other can take turns and the unloads nearly disappear. If they differ only in size, the quietest thruster carries the thrust and about 2% of duty comes back. If all four swirl alike, well-timed unloads are what there is to gain. The measurement that tells these apart is the per-thruster torque, read from the wheels.

2. The feed line

From the public record (NASA, April and May 2025): pressure in the line feeding xenon to the thrusters fell from about 36 to about 26 psi and, as designed, the thrusters were powered off; the team traced it to a part inside a valve obstructing flow, switched to the identical backup line, and is holding that line's valve open.

What the system does. A Hall thruster's discharge current follows its xenon flow, so each pressure reading has a second reading to be checked against. Pressure and flow down together: the line is carrying less than asked. Pressure down, flow holding: the reading is wrong, and both lines stay in reserve. Each response (switch line, throttle to what the line carries, stop) is flown ahead under every explanation still open, including an obstruction that is still growing.

- **10 of 10** replays of the 2025 pressure signature: the primary line named, thrust back on the second line five minutes after the drop began, with a decision record ready for the first downlink.
- **50 of 50** wrong transducer readings that looked like the same event: kept thrusting with both lines in reserve.
- **599 of 600** single-fault runs correct across 12 fault classes, with no harmful action and no damage.
- A partly restricted line still carries flow; as the planned throttle falls, it can feed a thruster again. With the restricted line measured by a flow check, a second fault on the other line left **96.8%** of planned thrust and no damage, and the system forecast the day the restricted line becomes usable, never early in 50 of 50 cases.

3. Faults together, and faults nothing explains

- **100 of 100** runs with two simultaneous faults (a feed fault with a heater, wheel, star-tracker, temperature-sensor or battery fault): both remedied, no harmful action.
- Feed fault with the wheels at 80–86% of capacity: **30 of 30** unloaded first, then switched lines; no restart above 85%. A wrong pressure reading during an unload: marked invalid in **30 of 30**.
- A fault none of its readings explains (an intermittent flameout; a slow drift starving both lines) is not guessed at: thrust stops, attitude is held, and the open question is recorded with the measurement that would settle it (**100 of 100**, no harmful action).

Limits

All results come from a simulator built from public reports; they show what the technology does on that model, not on the spacecraft. Values without a public number are assumed and swept. Every miss is reported in the paper with its measured reason, alongside the code hash and sealed pre-registrations.

More

Interactive simulation and summary: prometheus7.com/DeepSpace7/psyche
Full paper: prometheus7.com/DeepSpace7/psyche/paper
The code is available on request from the page.