In-space propulsion: manoeuvring after launch

Essential answer

In-space propulsion: manoeuvring after launch. The question to solve is: Why does the spacecraft still need engines after launch vehicle separation? N, N·s, kg, m/s^2, m/s and s for Isp. Propellant flow can be kg/s. The rest of the course turns that idea into an auditable line of reasoning: explicit units, stated assumptions, reproducible calculations, order-of-magnitude checks and interpretation limits. A result is useful only when the reader can explain what it measures, where every input came from and which engineering decision it can support.

Reasoning map

1. 1 — The concrete scene
2. 2 — Essential words, explained before using them
3. 3 — See the architecture before calculating
4. 4 — Formulas, only when they answer a question
5. 5 — What units and margins mean

Trajectory corrections, insertion, station keeping, rendezvous and control use propulsion suited to very different needs.

Specific impulse, indicator related to exhaust velocity.

Before calculating

Quantity:	In-space propulsion: manoeuvring after launch
Check:	units + order of magnitude + assumptions
Decision:	state what the result actually supports

In-space propulsion: manoeuvring after launch

2 — Essential words, explained before using them

Specific impulse, indicator related to exhaust velocity.

Propulsion powered by chemical reaction.

3 — See the architecture before calculating

The jet transfers opposite momentum to the vehicle.

Low thrust over long time can build significant Δv.

Tanks, valves and thermal control belong to the system.

Thrust time and direction come from navigation and control.

4 — Formulas, only when they answer a question

How to read it : impulse equals thrust times duration

How to read it : acceleration equals force divided by mass

For equal thrust, a heavier vehicle accelerates less.

5 — What units and margins mean

N, N·s, kg, m/s², m/s and s for Isp. Propellant flow can be kg/s.

6 — Three concrete demonstrations, calculated step by step

200 N on 20,000 kg.

100 s → Δv≈1 m/s

4 thrusters of 5 N for 20 s.

For 1,000 kg, Δv≈0.4 m/s

2 kW for 10 h.

That energy must be generated and partly rejected as heat.

7 — Deepening: what the simplified diagram hides

Active reading

Sections:	2 — Essential words, explained before using them ; 3 — See the architecture before calculating
Verification:	A value is usable only with its unit and calculation boundary.
Exercise:	change one assumption and predict the direction of change before recalculating

In-space propulsion: manoeuvring after launch

Thrust, efficiency and duration optimise differently.

Higher does not mean better for every mission.

Cryogenic, pressurised and storable options differ.

Jet can heat or contaminate nearby surfaces.

Thrust or alignment error becomes trajectory error.

8 — Application to an Earth-Mars spacecraft

9 — Reference dossier: what a real project must still consider

Launch engines, cruise thrusters, attitude-control jets and rendezvous propulsion solve very different problems. Thrust, specific impulse, mass, power, storage, restart count, precision and lifetime must therefore be evaluated together. There is no universally 'best engine'.

The same force produces different acceleration according to mass: $a = F/m$. This is especially important for electric propulsion, where low thrust applied for weeks or months can accumulate substantial velocity change.

High specific impulse usually reduces propellant needed for a given delta-v, but it says nothing by itself about manoeuvre time, electrical power, tank volume or whether thrust is high enough for a rapid capture.

Cryogenic, storable and pressurised propellants impose different thermal, material and operational constraints. Valves, regulators, sensors and propellant gauging are part of system reliability, especially on long missions.

Plumes can heat or contaminate surfaces and create unwanted torque. Thruster placement must account for plume zones and centre-of-mass motion as consumables change.

Real burns have magnitude, direction and timing errors. Navigation estimates the achieved state after a manoeuvre and may command corrections, coupling propulsion and navigation through models, timing and telemetry.

Mars-produced propellant still requires purification, storage, compatible materials, metrology, spare parts and qualified engines. True autonomy must be measured across the complete resource-to-thrust chain.

10 — Common traps and bad intuitions

Ignoring power and time for electric propulsion.

Active reading

Sections:	8 — Application to an Earth-Mars spacecraft ; 9 — Reference dossier: what a real project must still consider
Verification:	A value is usable only with its unit and calculation boundary.
Exercise:	change one assumption and predict the direction of change before recalculating

In-space propulsion: manoeuvring after launch

Treating tanks and valves as details.

In-space propulsion solves a different problem from liftoff

Once in orbit a spacecraft does not continuously fight weight like a launch vehicle. Propulsion changes orbital energy, plane, transfer trajectory or relative velocity. Low thrust applied for a long time can build large delta-v but follows a different path than a short impulsive burn.

Chemical propulsion provides high thrust for rapid maneuvers; electric propulsion can provide high specific impulse with far lower thrust and continuous electrical demand. Mission time, propellant mass and available power determine the trade.

Stationkeeping and reaction-wheel desaturation may consume tiny impulses individually, yet repetition can dominate annual propellant use. Budgeting therefore includes minimum impulse bit, leakage, calibration and end-of-life reserve.

11 — Guided exercises

Question : What question comes before choosing hardware?

Question : Why is a nominal result insufficient?

12 — What to remember

Explain the topic in simple words before symbols.

Connect at least four interfaces with other subsystems.

Redo the three numerical examples without reasoning gaps.

13 — NASA sources for further study

NASA - 2026 State-of-the-Art: In-Space Propulsion

NASA - 2026 State-of-the-Art: Complete Spacecraft Platforms

Active reading

Sections:	In-space propulsion solves a different problem from liftoff ; 11 — Guided exercises
Verification:	NASA - 2026 State-of-the-Art: In-Space Propulsion | NASA - 2026 State-of-the-Art: Complete Spacecraft Platforms | NASA Systems Engineering Handbook
Exercise:	change one assumption and predict the direction of change before recalculating