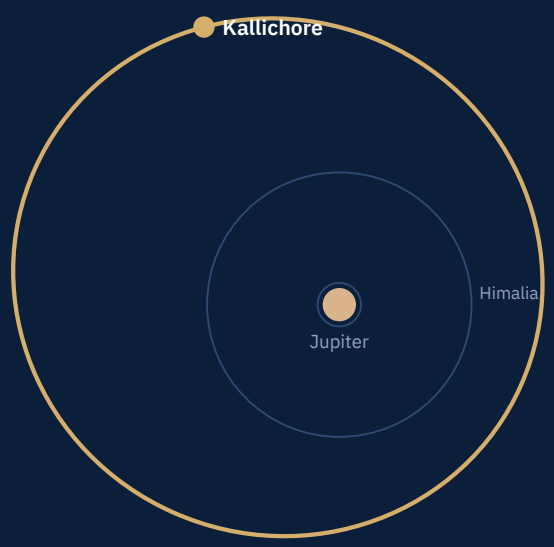
SINGLE-BODY REPORT

# Kallichore

Water, ice and volatiles: what is known, what is not, and what it would take to use them




DIAMETER · IDEAL Δv FROM LOW EARTH ORBIT (SRI CALC)

## 4.8 km · 10.5 km/s from LEO

For space-focused venture investors, mining & aerospace corporate strategy, sovereign space agencies and family offices.

Kallichore around Jupiter: a = 23,017,100 km, e = 0.25. Neighbour orbits for scale; orientation schematic.

REPORT + VALUATION MODEL (XLSX)

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*Research product, not investment, legal or engineering advice. Model outputs are illustrative scenarios driven by stated assumptions. Every factual figure is sourced (Appendix A) and graded MEASURED / INFERRED / ASSUMED.*

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## How to read this report

- MEASURED = a published measurement in the sources cited on kallichore.space. INFERRED = derived by SRI arithmetic from measured inputs, or estimated by the source (for example, size from brightness). ASSUMED = an SRI assumption, stated with its basis.
- All delta-v, transfer-time, gravity and temperature figures are SRI model estimates from published orbital and physical data; real trajectories and conditions differ.
- Scores, contained-resource tiers and valuation scenarios are rule-based SRI models (Appendix B). They are illustrative, not forecasts and not facts.
- The companion workbook (SRI_Kallichore_Valuation_Model_SAMPLE.xlsx) contains every valuation formula; the scenario figures in Section 12 are computed from the same inputs.

PART I

# The body and the evidence

## 4.8 km

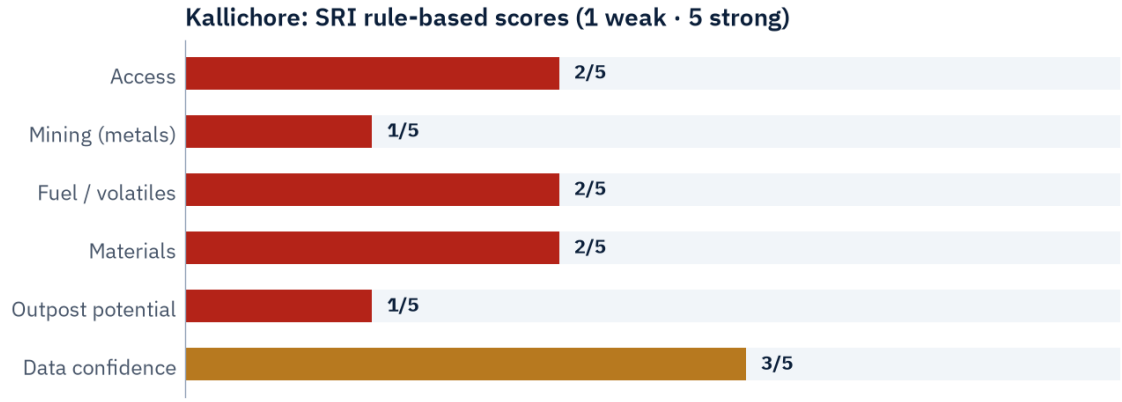
mean diameter (inferred). Sections 1–4: summary, key figures, physical profile, exploration record.

Every figure is graded MEASURED, INFERRED or ASSUMED and traced to a numbered source.

SECTION 1

# Executive summary

**Kallichore** is an irregular moon of Jupiter (retrograde). In SRI's framing it belongs to the **captured irregular moon** class, so the most relevant product is **water / volatiles for propellant and life support**. Access is **poor**: about 10.5 km/s of ideal delta-v from low Earth orbit and an ideal transfer of about 2.7 years (SRI calc). Data quality is **moderate**.




Source: SRI rule-based scoring (Appendix B). Teal = strong (4–5), gold = moderate (3), red = weak (1–2).

## What the sources show

- Diameter about 4.80 km INFERRED [4]; midpoint of 3.5–6.1 km from a 2025 stellar occultation (albedo ≈3.7%).
- Bulk density 1.50 g/cm³ ASSUMED (SRI assumption) (assumed (range 1.0–2.0); no irregular moon of this size has a measured density).
- Observations of a stellar occultation in 2025 show Kallichore is between 3.5 and 6.1 km across, with a dark surface of albedo around 3.7%. [1]
- It is suspected to be a rubble pile, like asteroids Ryugu and Bennu. [1]

## SRI view: the thesis, and what would make us wrong

### THESIS

Kallichore is today mainly an information asset. Its data help calibrate how we read more accessible bodies of the same class; any commercial use of its water is a 20-year-plus question.

Most relevant product: **water / volatiles for propellant and life support**. Access 2/5, data confidence 3/5 (SRI rule-based scores, Appendix B).

### WHAT WOULD MAKE US WRONG

**Bulk density is not measured**; we assume 1.50 g/cm³ (assumed (range 1.0–2.0); no irregular moon of this size has a measured density). Mass, gravity and every tonnage figure scale directly with it.

**Size is estimated** (midpoint of 3.5–6.1 km from a 2025 stellar occultation (albedo ≈3.7%)). Volume, and so mass, scale with the cube of diameter: a 20% size error is roughly a 70% mass error.

**Rotation period** is not given in our sources. It matters for anchoring, thermal cycling and solar-power planning.

**Surface composition** (spectrum or colour class) is not published in our sources.

SECTION 2

# Key figures at a glance

Every figure carries a confidence grade. Source numbers refer to Appendix A. Spheres are assumed for gravity and volume, which overstates precision for elongated or contact-binary shapes.

| QUANTITY | VALUE | GRADE | SOURCE / BASIS |
|---|---|---|---|
| Object type | Irregular moon of Jupiter (retrograde) · Carme group | MEASURED | [1] |
| Orbit around Jupiter (a / e / i) | 23.017 million km / 0.253 / 164.7° | MEASURED | [2] |
| Orbital period | 713.6 days | MEASURED | [2] |
| Mean diameter | 4.80 km (midpoint of 3.5–6.1 km from a 2025 stellar occultation (albedo ≈3.7%)) | INFERRED | [4] |
| Mass | $8.69 \times 10^{13}$ kg (model estimate: assumed density × sphere-equivalent volume) | ASSUMED | (SRI calc) |
| Bulk density | 1.50 g/cm³ (assumed (range 1.0–2.0); no irregular moon of this size has a measured density) | ASSUMED | (SRI assumption) |
| Geometric albedo | 0.037 | MEASURED | [4] |
| Spectral class / colour | Colour not published in our sources | — | [1] |
| Equilibrium temperature (mean distance) | ≈122 K | INFERRED | SRI calc (albedo 0.037) |
| Surface gravity (sphere-equivalent) | 0.0010 m/s² (≈1/9,700 of Earth's) | ASSUMED | SRI calc from mass and diameter |
| Escape speed | 2.2 m/s | ASSUMED | SRI calc |
| Sunlight vs Earth (mean) | 3.69% | INFERRED | SRI calc ($1/r^2$) |
| One-way light-time from Earth | 32.7–53.8 min | INFERRED | SRI calc |
| Ideal Δv LEO → rendezvous | 10.5 km/s (departure 6.3 + arrival 4.2) | INFERRED | SRI calc (Appendix B) |
| Ideal transfer time | 2.73 yr | INFERRED | SRI calc (Hohmann) |
| Launch-window spacing (synodic period) | 1.09 yr | INFERRED | SRI calc |

SECTION 3

# Physical and compositional profile

What the sources cited on kallichore.space say about structure and composition:

- Observations of a stellar occultation in 2025 show Kallichore is between 3.5 and 6.1 km across, with a dark surface of albedo around 3.7%. [1]
- It is suspected to be a rubble pile, like asteroids Ryugu and Bennu. [1]

## Analyst interpretation

**SRI interpretation (density).** A assumed bulk density of 1.50 g/cm³ is consistent with a porous mix of rock and ice or a rubble pile of carbonaceous material. Because the value is assumed, this is a statement about our model, not about the body.

**SRI interpretation (albedo).** A geometric albedo of 0.037 is very dark, typical of carbon-rich or organic-coated surfaces. Albedo describes only the top surface layer.

**Measured vs inferred.** In this report, figures graded MEASURED come straight from the cited sources. Composition statements above are the sources' own. The class label *captured irregular moon* is an SRI grouping used to pick a product and an assumption set; it is not a new measurement.

SECTION 4

# Exploration record

| ITEM | DETAIL | SRC |
|---|---|---|
| Object type | Irregular, retrograde moon of Jupiter | [1] |
| Group | Carme group | [1] |
| Discovered | 6 Feb. 2003 by Scott S. Sheppard (Canada–France–Hawaii Telescope) | [1] |
| Named | 30 March 2005, after Callichore | [1] |
| Diameter | ≈ 3.5–6.1 km (2025 stellar occultation) | [1] |
| Albedo | ≈ 3.7% | [1] |
| Shape | Elongated, axis ratio a/b ≥ 1.53 (Hubble) | [1] |
| Brightness | Apparent magnitude ≈ 23 | [1] |
| Mean distance | ≈ 23.0 million km from Jupiter | [2] |
| Orbital period | ≈ 714 days | [2] |
| Inclination | ≈ 165° (retrograde) | [2] |
| Possible flyby | Juice, < 1 million km on 7 Oct. 2031 | [1] |

## How it has been observed

- Kallichore is a potential flyby target for ESA's Juice mission, predicted to pass within 1 million km of the moon on 7 October 2031. [1]
- Juice launched on 14 April 2023 and is expected to reach Jupiter in July 2031. [3]
- An occultation happens when one object hides another passing behind it. [4]

**Implication:** without close-up data, every resource statement about this body rests on remote observation and assumption. Characterisation is the first investable step.

PART II

# Getting there, and what it holds

## 10.5 km/s

ideal delta-v from low Earth orbit to rendezvous, with an ideal transfer of about 2.7 years (SRI calc). Sections 5–7: access, resources, peers.

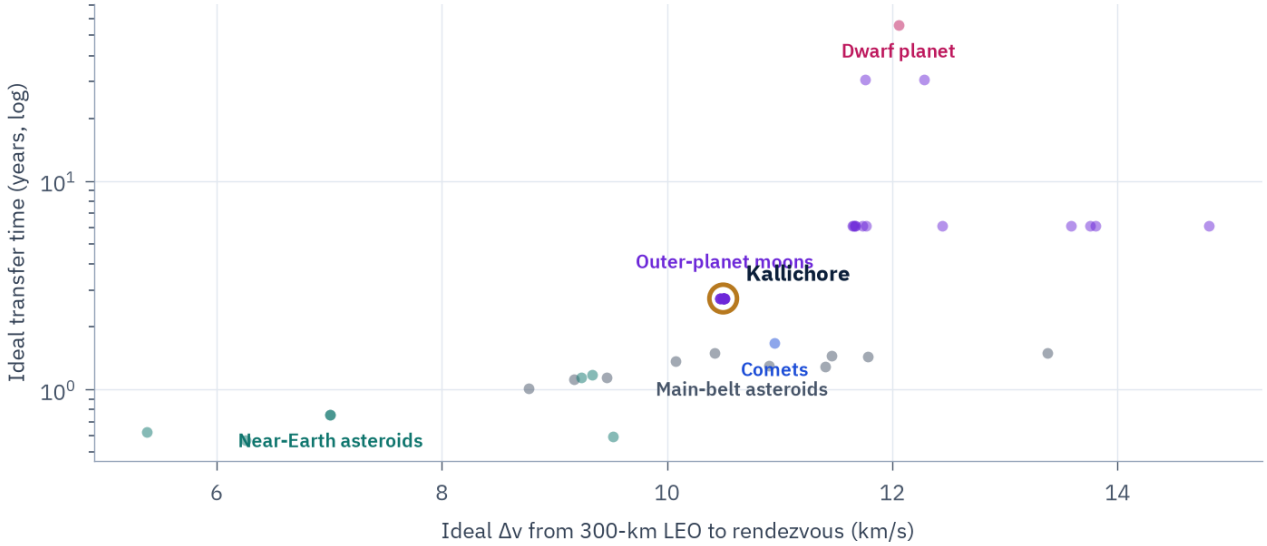
Real trajectories differ; the comparison across bodies is what matters.

SECTION 5

# Access: orbit, delta-v and transfer time

| LEG (IDEAL, IMPULSIVE) | ΔV (KM/S) | GRADE | BASIS |
|---|---|---|---|
| Departure from 300-km LEO | 6.30 | INFERRED | Hohmann transfer to Jupiter |
| Arrival / rendezvous | 4.20 | INFERRED | Capture and transfer to the moon's orbit |
| **Total** | **10.50** | INFERRED | SRI calc |
| Transfer time | 2.73 yr | INFERRED | Half-ellipse transfer time |
| Synodic period (window spacing) | 1.09 yr | INFERRED | Earth vs Jupiter |
| Distance from Earth | 5.88e+08–9.68e+08 km | INFERRED | SRI calc |
| One-way light-time | 32.7–53.8 min | INFERRED | SRI calc |

**Access versus the 49 bodies in the SRI coverage set**




Source: SRI calc from JPL orbital elements (Hohmann transfers, Appendix B). Model estimates, not mission designs.

**Reading.** With an access score of 2/5 (poor), Kallichore needs more delta-v or time than the near-Earth bodies in the set. One-way radio delay of up to 54 minutes rules out real-time teleoperation; operations must be autonomous. Ideal impulsive figures understate real missions, which use low-thrust spirals and gravity assists that trade time for propellant.

SECTION 6

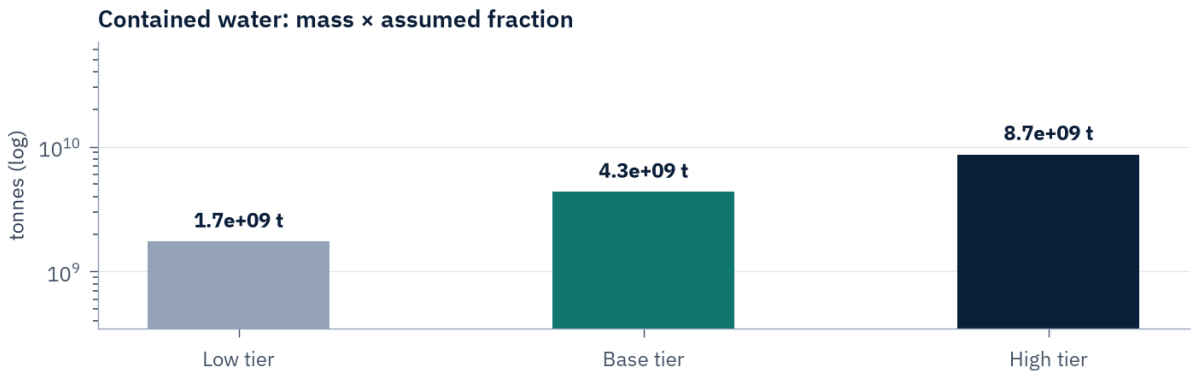
# Resource assessment

Four lenses, each scored 1–5 by the SRI rules in Appendix B. Scores compare bodies within our coverage set; they are not probabilities.

| LENS | SCORE | RATIONALE (SRI) |
|---|---|---|
| Mining (metals) | 1 | No metal-rich evidence appears in our sources; metals are not a relevant case. |
| Fuel / volatiles | 2 | Captured irregular moons are often dark and could hold ices, but composition is unmeasured for this body; any water case is an assumption. |
| Materials | 2 | Every body offers loose surface material that could, in principle, be used for radiation shielding or as construction feedstock with little processing. |
| Outpost potential | 1 | Surface gravity of about 0.0010 m/s² (escape speed 2.2 m/s); sunlight is about 3.69% of earth's, marginal for solar power; radio delay up to 54 min one way. |
| Data confidence | 3 | Moderate. |

## Contained water: model estimate

Contained water = total mass ($8.69 \times 10^{13}$ kg, ASSUMED) × an assumed fraction of 2% / 5% / 10% (low / base / high, ASSUMED). This gives about $1.7 \times 10^{9}$ / $4.3 \times 10^{9}$ / $8.7 \times 10^{9}$ tonnes. In-place content is not a reserve: only a tiny share could be extracted with any foreseeable technology, and Section 12 shows why price, not tonnage, decides value.




Source: SRI calc; content fractions are ASSUMED tiers (Appendix B), not measurements.

SECTION 7

# Peer comparison

Peers are drawn from the 49 bodies in the SRI coverage set, matched on class (or, where few share the class, on type) and sorted by closeness in delta-v. Each peer's figures come from its own edition's sources; Δv and transfer time are SRI calc ( INFERRED ).

| BODY | CLASS | DIAMETER (KM) | DENSITY (G/CM³) | ΔV (KM/S) | TRANSFER (YR) | DATA |
|---|---|---|---|---|---|---|
| **Kallichore** | captured irregular moon | 4.80 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | moderate |
| Erinome | captured irregular moon | 3.00 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | thin |
| Isonoe | captured irregular moon | 4.00 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | thin |
| Eukelade | captured irregular moon | 4.00 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | thin |
| Taygete | captured irregular moon | 5.00 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | thin |
| Eurydome | captured irregular moon | 3.00 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | thin |
| Pasithee | captured irregular moon | 2.00 INFERRED | 1.50 ASSUMED | 10.5 | 2.7 | thin |

**Pattern.** Kallichore ranks 4 of 7 on delta-v within this peer group. Better-measured peers can serve as analogues for what remains unknown here.

**Implication:** for a resource venture, the best target in any class is the one that combines low delta-v with measured composition. Bodies with assumed densities should be treated as candidates for characterisation, not as resource cases.

PART III

# Markets, law and risk

4

national laws (US, Luxembourg, UAE, Japan) recognise private ownership of extracted resources, while the body itself cannot be appropriated. Sections 8–11.

Company landscape, legal regime, risks and data gaps, and the ranked opportunity matrix.

SECTION 8

# Company landscape

Stage and funding appear only where a public source supports them. None of the companies below has announced Kallichore as a target in our sources; they target near-Earth objects, in-orbit services or adjacent capabilities. Inclusion is not endorsement.

| COMPANY (HQ) | FOCUS | STAGE / FUNDING (SOURCED) | RECENT MILESTONES (SOURCED) |
|---|---|---|---|
| AstroForge (California, US) | Prospecting and ultimately mining metal-rich NEAs; PGMs | $40M Series A (Aug 2024), total raised $55M at the time [8]; TechCrunch (Sep 2026) reports $56M in venture funding [9] MEASURED | Odin launched 26 Feb 2025 on the IM-2 rideshare; contact lost, flyby of 2022 OB5 not achieved [10][11]. Next vehicle named DeepSpace-2 [11] |
| Karman+ (Colorado, US) | NEA regolith excavation; water for in-orbit refuelling; later metals | $20M seed (Feb 2025) co-led by Plural and Hummingbird [12] MEASURED | High Frontier demonstration targeting a 2027 launch; aims to mine ~1 kg; budget goal under $10M [12] |
| TransAstra (California, US) | Optical mining, Capture Bag, space logistics, asteroid detection | $2.5M NASA CCRPP contract matched by $2.5M private investment (Sep 2025) [13] MEASURED | 1-m Capture Bag delivered to the ISS for testing (Sep 2025); scaling to 10 m [13] |
| Origin Space (China) | Space resources, debris-capture demonstrations, NEO observation | Private funding not sourced here | NEO-01 test spacecraft launched Apr 2021 on a Long March 6 rideshare [14] |
| Planetary Resources (US), historical | Asteroid prospecting | Acquired by ConsenSys in 2018 [15] | Assets later dispersed; a cautionary precedent |
| Deep Space Industries (US), historical | Asteroid mining; small-satellite propulsion | Acquired by Bradford Space in 2019 [15] | Pivoted to propulsion; a cautionary precedent |

## Ecosystem players that matter but are not miners

- **Launch providers.** Launch cost sets both the cost base of any venture and the ceiling price of any in-space product (Section 12).
- **Electric-propulsion suppliers.** NASA's Psyche was the first interplanetary use of Hall-effect thrusters; its SPT-140 units show the propulsion class a commercial deep-space bus would use [16].
- **Lunar landers and rideshare hosts.** Small asteroid probes have flown as secondary payloads on lunar missions (e.g., Odin on IM-2 [10]). How often those hosts fly sets the launch opportunities open to start-ups.

**Read-across:** the 2012–2019 cohort, Planetary Resources and Deep Space Industries, ended in acquisitions and pivots [15]. Today's cohort runs on much smaller budgets, and its first deep-space attempt, Odin, did not achieve its objective [10]. Diligence should weight demonstrated flight heritage, cost per attempt and non-mining revenue lines.

SECTION 9

# Legal and regulatory

| INSTRUMENT | KEY PROVISION FOR RESOURCE ACTIVITY | STATUS / RELEVANCE | SOURCE |
|---|---|---|---|
| Outer Space Treaty (1967) | Art. II: celestial bodies are not subject to national appropriation. Art. VI: States bear responsibility for national activities, including non-governmental ones, which need authorisation and continuing supervision | Foundation for every regime below; silent on ownership of extracted resources | UNOOSA [17] |
| US Commercial Space Launch Competitiveness Act (2015), Title IV | 51 U.S.C. §51303: a US citizen engaged in commercial recovery of a space resource "shall be entitled to any asteroid resource or space resource obtained" | In force; covers extracted resources, not the body itself | Public Law 114-90 [18] |
| Luxembourg: Law of 20 July 2017 | Space resources are capable of being appropriated; activities require national authorisation | In force | Legilux [19] |
| UAE: Federal Law No. 12 of 2019 | Regulates authorised space-resource activities, including extraction, use and trade | In force | UAE Ministry of Justice [20] |
| Japan: Act No. 83 of 2021 | Permit holders acquire ownership of resources extracted under an approved plan | In force | Cabinet Office [21]; Library of Congress [22] |
| Artemis Accords (2020–) | Resource extraction to comply with the OST; deconfliction via notified, temporary "safety zones" | 77 signatories as of 19 Oct 2026 [23] MEASURED | NASA [23] [24] |
| UN COPUOS Working Group on Legal Aspects of Space Resource Activities | Drafting non-binding recommended principles | Draft principles updated during 2026; not binding | UNOOSA [25] |

**Analysis.** A growing minority of states recognise private ownership of *extracted* resources while holding that the celestial body itself cannot be appropriated; the US, Luxembourg, UAE and Japanese statutes above are consistent on this. Legal risk specific to Kallichore is low in the near term simply because no near-term activity there is plausible; the general risks (licensing regime, final COPUOS principles, operating-area disputes) still apply.

**Legal verdict:** clear enough to finance prospecting and demonstration missions under US, Luxembourg, UAE or Japanese licensing. International consensus on commercial-scale extraction is not yet in place.

SECTION 10

# Risks, unknowns and data gaps

We state unknowns plainly. Rows marked ASSUMED or INFERRED are the places where this report relies on models rather than measurements.

| UNKNOWN / RISK | WHY IT MATTERS | WHAT DATA WOULD CHANGE THIS |
|---|---|---|
| Bulk density ( ASSUMED ) | Mass, gravity and every tonnage figure scale with it | A mass measurement: spacecraft flyby or rendezvous, a companion moon, or gravitational perturbations |
| Size ( INFERRED ) | Volume scales with diameter cubed | Thermal-infrared measurement, stellar occultation or radar |
| Rotation period (not in our sources) | Anchoring, thermal cycling, solar-power duty cycle | Light-curve photometry |
| Resource content ( ASSUMED ) | Sets the tonnage of water | Close-up spectroscopy; gamma-ray/neutron spectrometry; sample return |
| Surface and interior structure | Rubble pile vs coherent body changes excavation and anchoring | Imaging, gravity-field mapping, radar |
| Extraction technology | No small-body extraction demonstrated at any meaningful scale | Karman+ High Frontier (~1 kg target, 2027) [12]; follow-on demonstrations |
| Launch-cost trajectory | Cuts deployment cost but also the value of in-space product (Section 12) | Published $/kg for reusable heavy lift; rideshare price changes [26][27] |
| In-space demand | No anchor customer for space-sourced water found in our sources | Binding offtake contracts; in-space construction or refuelling programmes |
| Capital and execution | The previous cohort ended in acquisitions [15]; the Odin anomaly [10] | A successful rendezvous and landing by a private spacecraft |
| Legal acceptance | Market access, insurance, sovereign participation | Final COPUOS principles [25]; new national laws |

SECTION 11

# Ranked opportunity matrix

Ranked by SRI judgement using the scores in Section 6. Timing bands are SRI assumptions, not schedules.

| OPPORTUNITY | TIMING | ATTRACTIVENESS (SRI) | EXECUTION RISK (SRI) | NOTE |
|---|---|---|---|---|
| Information asset: characterisation data and analysis | Now | High | Low | Size, mass and composition data improve every downstream estimate; existing data can be re-used as an analogue. |
| Technology demonstrations at more accessible analogues | 5–10 yr | Medium | High | Lessons transfer to Kallichore later. |
| In-space propellant (water) supply | 20+ yr | Medium | Very high | Value depends on demand beyond LEO. |
| Science-led partnerships (data, instruments) | Now–10 yr | Medium | Medium | Revenue from agencies rather than resources. |

**Bottom line:** Kallichore is today mainly an information asset. Its data help calibrate how we read more accessible bodies of the same class; any commercial use of its water is a 20-year-plus question.

PART IV

# What it could be worth

## 17.4×

base-case break-even delivered value as a multiple of launch cost (SRI model, illustrative, not a forecast). Section 12 and appendices.

Every input is an assumption you can change in the companion workbook.

SECTION 12

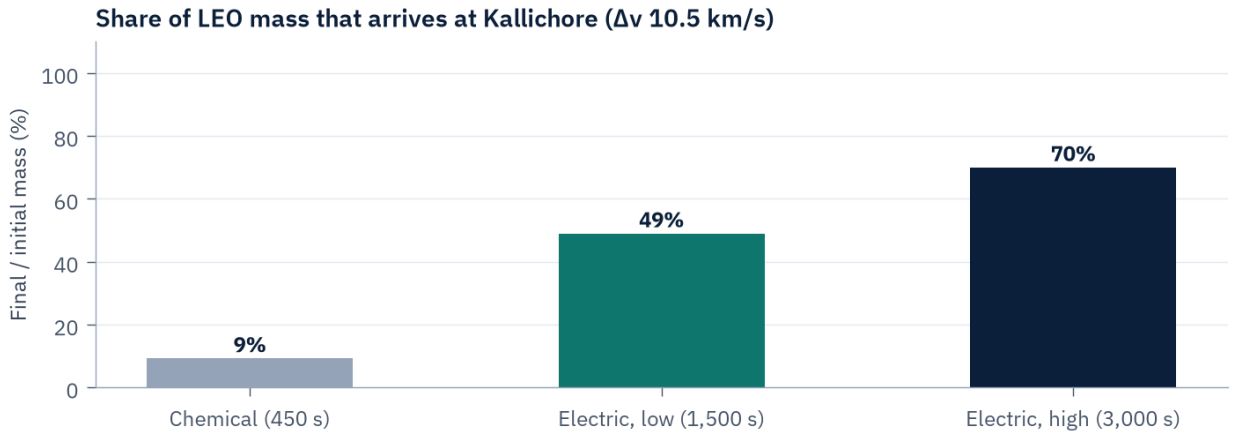
# Valuation model

A transparent cash-flow model for a hypothetical venture supplying **water / volatiles for propellant and life support** from Kallichore. Every default below is an SRI assumption unless a basis is given; the companion workbook contains the formulas and lets users change any input. Outputs are scenarios, not forecasts or a valuation of any company.

| INPUT | UNIT | BEAR | BASE | BULL | BASIS |
|---|---|---|---|---|---|
| Launch cost to LEO | $/kg | 2,720 | 1,410 | 500 | Assumption |
| In-space water value (delivered) | $/kg | 500 | 1,500 | 3,000 | Assumption |
| Plant + spacecraft dry mass at the body | kg | 20,000 | 10,000 | 5,000 | Assumption |
| Propulsion specific impulse | s | 450 | 1,500 | 3,000 | Assumption |
| Delta-v, LEO to rendezvous (ideal impulsive) | km/s | 10.50 | 10.50 | 10.50 | Inferred |
| Programme capex excl. launch | $M | 3,000 | 1,500 | 750 | Assumption |
| Development period | years | 8 | 6 | 5 | Assumption |
| Outbound transit | years | 4 | 3 | 2 | Inferred / Assumption |
| Return transit (laden) | years | 4 | 3 | 2 | Assumption |
| Extraction rate | t/yr | 100 | 1,000 | 5,000 | Assumption |
| Usable water fraction of extracted material | fraction | 0.02 | 0.05 | 0.10 | Assumption |
| Transport efficiency (delivered / shipped) | fraction | 0.50 | 0.70 | 0.85 | Assumption |
| Operating years at body | years | 10 | 10 | 10 | Assumption |
| Annual operating cost | $M/yr | 150 | 100 | 50 | Assumption |
| Discount rate | % | 15% | 12% | 10% | Assumption |
| Probability of technical success | fraction | 0.20 | 0.35 | 0.50 | Assumption |

## Scenario outputs

| OUTPUT (SRI MODEL) | BEAR | BASE | BULL |
|---|---|---|---|
| Launch cost incl. propellant ($M) | 587 | 29 | 4 |
| NPV ($M) | -2,015 | -1,170 | 2,594 |
| Risk-adjusted NPV ($M) | -1,903 | -1,087 | 1,012 |
| Total water delivered (t) | 10 | 350 | 4,250 |
| First delivery year | 17 | 13 | 10 |
| Break-even delivered value ($/kg) | 3,757,901 | 24,551 | 658 |
| Break-even ÷ launch cost (×) | 1381.6 | 17.4 | 1.3 |




Source: SRI calc, rocket equation $m_1/m_0 = \exp(-\Delta v / g_0 Isp)$.

**Model logic.** Capex is spread evenly over development; launch cost (dry mass × rocket-equation mass ratio for the body's Δv at the chosen specific impulse × launch $/kg) is booked in the last development year. Operations start after the outbound transit; product delivered each operating year = extraction rate × usable fraction × transport efficiency, paid for after the return transit. Risk-adjusted NPV = −PV(capex + launch) + P(success) × PV(revenue − opex).

**Key tension:** launch cost appears twice, as a cost (launching the plant) and as the ceiling on what in-space product is worth (a buyer will not pay much more than the cost of launching the same mass from Earth). Scenarios that pair very cheap launch with a very high in-space value are internally inconsistent unless the product is used far beyond low Earth orbit.

Launch-cost anchors: Falcon 9 ≈ $2.7k/kg and Falcon Heavy ≈ $1.4k/kg to LEO in 2018 dollars (list price ÷ capacity) [26]; SpaceX's published rideshare rate is $350k for the first 50 kg plus $7k/kg [27]. Capex benchmarks: NASA Psyche life-cycle cost $985M including launch [28]; AstroForge Odin [10].

APPENDIX A

# Appendix A: Sources

Sources 1–7 are those cited on kallichore.space for this body. Later sources are shared industry, legal and cost references reused across Space Resource Intelligence editions. Figures marked SRI calc are our own arithmetic (Appendix B).


[1] Kallichore (moon). Wikipedia. https://en.wikipedia.org/wiki/Kallichore_(moon)

[2] Planetary Satellite Mean Elements. NASA JPL Solar System Dynamics. https://ssd.jpl.nasa.gov/sats/elem/

[3] Jupiter Icy Moons Explorer. Wikipedia. https://en.wikipedia.org/wiki/Jupiter_Icy_Moons_Explorer

[4] Occultation. Wikipedia. https://en.wikipedia.org/wiki/Occultation

[5] Rubble pile. Wikipedia. https://en.wikipedia.org/wiki/Rubble_pile

[6] Jupiter Fact Sheet. NASA NSSDC. https://nssdc.gsfc.nasa.gov/planetary/factsheet/jupiterfact.html

[7] Moon Facts (surface gravity about one-sixth of Earth's). NASA Science. https://science.nasa.gov/moon/facts/

[8] SpaceNews (Aug 2024). AstroForge raises $40 million. https://spacenews.com/astroforge-raises-40-million/

[9] TechCrunch (22 Sep 2026). AstroForge is putting AI in command of its next spacecraft. https://techcrunch.com/2026/09/22/astroforge-is-putting-ai-in-command-of-its-next-spacecraft/

[10] Space.com (Mar 2025). Hope is all but lost for private Odin asteroid probe in deep space. https://www.space.com/space-exploration/private-spaceflight/hope-is-all-but-lost-for-private-asteroid-probe-in-deep-space-the-chance-of-talking-with-odin-is-minimal

[11] AstroForge, Odin page. https://www.astroforge.com/odin-mission

[12] Karman+ press release (19 Feb 2025), "Karman+ raises $20 million to mine asteroids to supply the space economy"; Payload (21 Feb 2025), "Karman+ Raises $20M For Asteroid Mining Demo." https://www.karmanplus.com/karman-raises-20-million-to-mine-asteroids-to-supply-the-space-economy-2/ ; https://payloadspace.com/karman-raises-20m-for-asteroid-mining-demo/

[13] ACCESS Newswire (23 Sep 2025). TransAstra Secures $5M to Scale Asteroid Capture Technology With NASA and Private Investment. https://www.accessnewswire.com/newsroom/en/aerospace-and-defense/transastra-secures-5m-to-scale-asteroid-capture-technology-with-nasa-and-priv-1077114

[14] SpaceNews (2021). China launches space mining test spacecraft on commercial rideshare mission. https://spacenews.com/china-launches-space-mining-test-spacecraft-on-commercial-rideshare-mission/

[15] SpaceNews: "Asteroid mining company Planetary Resources acquired by blockchain firm" (2018); "Deep Space Industries acquired by Bradford Space" (2019). https://spacenews.com/asteroid-mining-company-planetary-resources-acquired-by-blockchain-firm/ ; https://spacenews.com/deep-space-industries-acquired-by-bradford-space/

[16] IEPC-2024-126, "Psyche Launch and Initial Checkout Overview," International Electric Propulsion Conference 2024 (SPT-140 Hall-effect thrusters). https://electricrocket.org/IEPC_2024/126.pdf

[17] UNOOSA. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967). https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html

[18] U.S. Commercial Space Launch Competitiveness Act, Public Law 114-90 (H.R. 2262, 2015), Title IV; 51 U.S.C. §51303. https://www.congress.gov/bill/114th-congress/house-bill/2262 ; https://www.law.cornell.edu/uscode/text/51/51303

[19] Luxembourg. Law of 20 July 2017 on the exploration and use of space resources. https://legilux.public.lu/eli/etat/leg/loi/2017/07/20/a674/jo/en

[20] United Arab Emirates. Federal Law No. (12) of 2019 on the Regulation of the Space Sector. https://www.moj.gov.ae/assets/2020/Federal%20Law%20No%2012%20of%202019%20on%20THE%20REGULATION%20OF%20THE%20SPACE%20SECTOR.pdf.aspx

[21] Japan. Act No. 83 of 2021 on the Promotion of Business Activities Related to the Exploration and Development of Space Resources (Cabinet Office English translation). https://www8.cao.go.jp/space/english/resource/documents/act83_2021.pdf

[22] Library of Congress, Global Legal Monitor (15 Sep 2021). Japan: Space Resources Act Enacted. https://www.loc.gov/item/global-legal-monitor/2021-09-15/japan-space-resources-act-enacted/

[23] NASA (20 Oct 2026). NASA Welcomes Uzbekistan as Newest Artemis Accords Signatory. https://www.nasa.gov/organizations/oiir/artemis-accords/nasa-welcomes-uzbekistan-as-newest-artemis-accords-signatory/

[24] NASA. Artemis Accords overview and text (2020). https://www.nasa.gov/artemis-accords/

[25] UNOOSA. Working Group on Legal Aspects of Space Resource Activities; updated initial draft set of recommended principles (2026). https://www.unoosa.org/oosa/en/ourwork/copuos/lsc/space-resources/index.html

[26] Jones, H.W. (2018). The Recent Large Reduction in Space Launch Cost. 48th International Conference on Environmental Systems, ICES-2018-81. NASA NTRS 20200001093. https://ntrs.nasa.gov/citations/20200001093

[27] New Space Economy (27 Feb 2026). SpaceX Rideshare Pricing as of February 2026 (citing spacex.com/rideshare). https://newspaceeconomy.ca/2026/02/27/spacex-rideshare-pricing-as-of-february-2026-what-it-costs-whats-included-and-how-buyers-budget-a-missio

n/
[28] NASA statement on Psyche launch delay and independent review, including the $985M life-cycle cost (2022), via PR Newswire. https://www.prnewswire.com/news-releases/nasa-announces-launch-delay-for-psyche-asteroid-mission-301575060.html

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APPENDIX B

# Appendix B: Methodology and assumptions

## Grades

MEASURED : published measurement in a cited source. INFERRED : derived by SRI arithmetic from measured inputs, or estimated by the source rather than measured directly. ASSUMED : an SRI assumption, with its basis stated. A figure computed from an assumed input is itself graded ASSUMED .

## Formulas (SRI calc)

- Volume = $(\pi/6)\cdot D^3$ (sphere-equivalent); mass = density × volume when no mass is published.
- Surface gravity $g = GM/r^2$; escape speed = $\sqrt{(2GM/r)}$.
- Equilibrium temperature $T = 278.6\ K \times (1 - A)^{1/4} / \sqrt{r(au)}$, with Bond albedo A approximated from the geometric albedo.
- Sunlight fraction = $1/r(au)^2$ at mean distance; light-time = distance / c.
- Δv: two-impulse Hohmann transfer from a 300-km circular LEO (heliocentric bodies include a plane change at the far node); for moons, a Hohmann transfer to the parent planet, capture, then transfer to the moon's orbit.
- Rocket equation: mass ratio = $\exp(\Delta v / (g_0 \cdot Isp))$, $g_0 = 9.80665\ m/s^2$.

## Assumptions specific to this edition

- Bulk density assumed at 1.50 g/cm³: assumed (range 1.0–2.0); no irregular moon of this size has a measured density.
- Diameter 4.80 km: midpoint of 3.5–6.1 km from a 2025 stellar occultation (albedo ≈3.7%).
- Contained-water fractions of 2 / 5 / 10% of total mass are SRI assumptions chosen to bracket plausible values for the captured irregular moon class.
- All valuation defaults (Section 12) are SRI assumptions unless a basis is cited.

## Rule-based scores

| SCORE | RULE |
|---|---|
| Access | Δv from LEO: <6 km/s = 5, 6–8 = 4, 8–10 = 3, 10–12 = 2, ≥12 = 1; minus 1 if ideal transfer >5 yr, minus 2 if >15 yr. |
| Mining (metals) | Metal (M-type) = 4 (3 if measured density <3.5 g/cm³); stony or carbonaceous = 2; other classes = 1. |
| Fuel / volatiles | Comet = 5; carbonaceous = 4; TNO or icy small moon = 3; irregular or dark inner moon (composition unmeasured) = 2; stony or metal = 1. |
| Materials | Metal = 4; stony or carbonaceous = 3; other = 2 (bulk regolith for shielding is assumed available on every body). |
| Outpost potential | Start at 3; −1 if sunlight <4% of Earth's (−2 if <0.2%); −1 if one-way light-time can exceed 30 min; −1 if surface gravity <0.001 m/s²; +1 if diameter >100 km; +1 if near-Earth object. |

| SCORE | RULE |
|---|---|
| Data confidence | Rich data (spacecraft visit or measured mass) = 5; moderate = 3; thin (size from brightness, density assumed) = 1. |

**Limitations.** This is a sample-edition desk study. It relies on published sources and simple physics; it does not replace mission design, geological assessment or legal advice. Nothing here is investment advice.