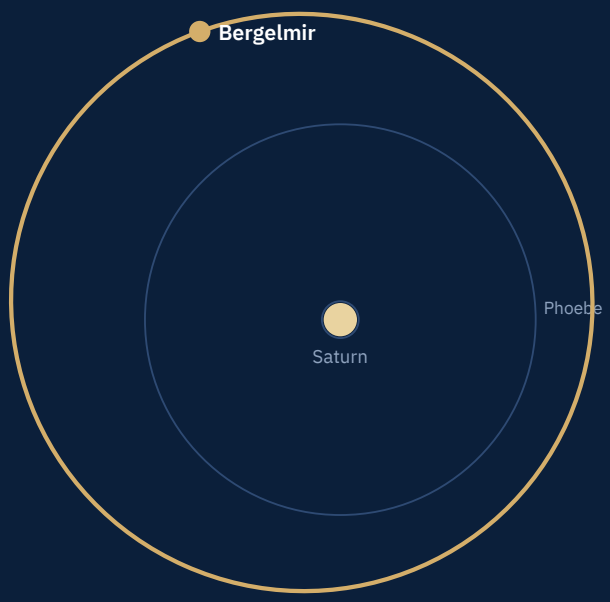
SINGLE-BODY REPORT

Bergelmir

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)

6.0 km · 11.7 km/s from LEO

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

Bergelmir around Saturn: a = 19,268,100 km, e = 0.14.
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.

CONTENTS

Contents

#	SECTION	PAGE
1.	Executive summary	4
2.	Key figures at a glance	5
3.	Physical and compositional profile	6
4.	Exploration record	7
5.	Access: orbit, delta-v and transfer time	9
6.	Resource assessment	10
7.	Peer comparison	11
8.	Company landscape	13
9.	Legal and regulatory	14
10.	Risks, unknowns and data gaps	15
11.	Ranked opportunity matrix	16
12.	Valuation model	18
	Appendix A: Sources	20
	Appendix B: Methodology and assumptions	21

How to read this report

- MEASURED = a published measurement in the sources cited on bergelm.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_Bergelmir_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

6.0 km

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

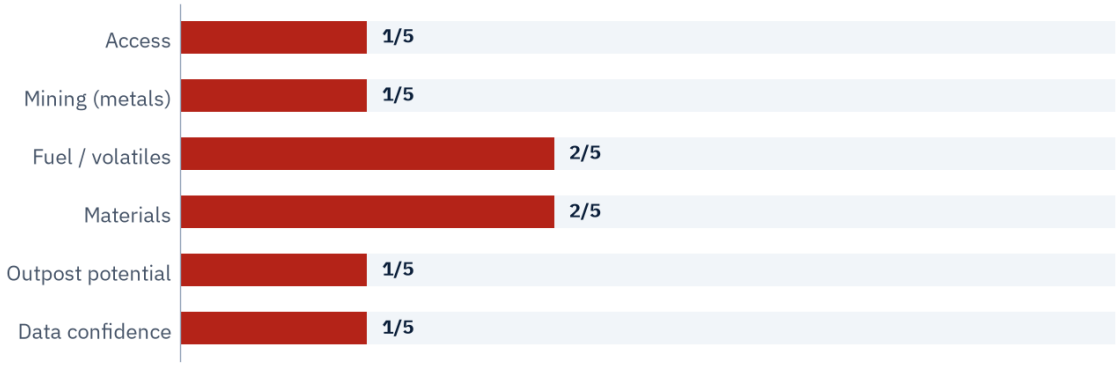
Every figure is graded MEASURED, INFERRED or ASSUMED and traced to a numbered source.

SECTION 1

Executive summary

Bergelmir is an irregular moon of Saturn (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 **very poor**: about 11.7 km/s of ideal delta-v from low Earth orbit and an ideal transfer of about 6.1 years (SRI calc). Data quality is **thin (size from brightness; density assumed)**.

Bergelmir: SRI rule-based scores (1 weak · 5 strong)



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

What the sources show

- Diameter about 6.00 km INFERRED [1]; from brightness (albedo assumed).
- 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).

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

THESIS

Bergelmir is very hard to reach (ideal transfer about 6 years, SRI calc). Its value is scientific and as long-horizon option value; we see no commercial case within any investable horizon.

Most relevant product: **water / volatiles for propellant and life support**. Access 1/5, data confidence 1/5 (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 (from brightness (albedo assumed)). Volume, and so mass, scale with the cube of diameter: a 20% size error is roughly a 70% mass error.

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

Resource content of water has not been measured in place for this body; the tiers in Section 6 are assumptions.

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 Saturn (retrograde) · Norse group	MEASURED	[1]
Orbit around Saturn (a / e / i)	19.268 million km / 0.145 / 158.8°	MEASURED	[3]
Orbital period	998.6 days	MEASURED	[3]
Mean diameter	6.00 km (from brightness (albedo assumed))	INFERRED	[1]
Mass	1.70×10^{14} 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)
Rotation period	8.13 h	MEASURED	[1]
Spectral class / colour	Colour not published in our sources	—	[1]
Equilibrium temperature (mean distance)	≈90 K	INFERRED	SRI calc (albedo 0.04, assumed)
Surface gravity (sphere-equivalent)	0.0013 m/s² (≈1/7,800 of Earth's)	ASSUMED	SRI calc from mass and diameter
Escape speed	2.7 m/s	ASSUMED	SRI calc
Sunlight vs Earth (mean)	1.09%	INFERRED	SRI calc (1/r²)
One-way light-time from Earth	67–92.2 min	INFERRED	SRI calc
Ideal Δv LEO → rendezvous	11.7 km/s (departure 7.3 + arrival 4.4)	INFERRED	SRI calc (Appendix B)
Ideal transfer time	6.08 yr	INFERRED	SRI calc (Hohmann)
Launch-window spacing (synodic period)	1.04 yr	INFERRED	SRI calc

SECTION 3

Physical and compositional profile

The sources cited on bergelm.space contain no direct statements about this body's composition beyond the size, orbit and brightness data in Section 2. This is itself the main finding: composition is unmeasured.

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.

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 Saturn	[1]
Group	Norse group	[2]
Discovered	Dec. 12, 2004 — one of 12 Saturn moons found that day	[2]
Named	April 2007, after a giant of Norse myth	[1]
Diameter	≈ 6 km	[1]
Rotation period	≈ 8.13 hours	[1]
Mean distance	≈ 19.3 million km from Saturn	[3]
Orbital period	≈ 999 days	[3]
Inclination	≈ 159° (retrograde)	[3]
Eccentricity	≈ 0.15	[3]

Our sources describe no dedicated spacecraft observations of Bergelmir. What is known comes from the observations behind the figures in Section 2.

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

11.7 km/s

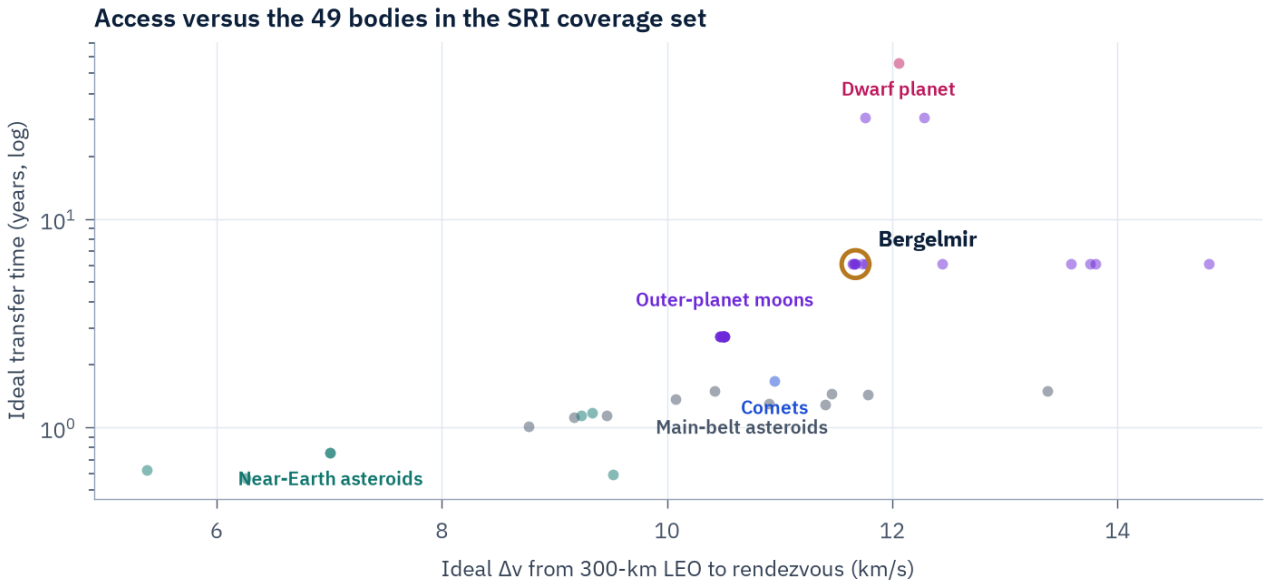
ideal delta-v from low Earth orbit to rendezvous, with an ideal transfer of about 6.1 years (SRI calc). Sections 5–7: access, resources, peers.

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	7.29	INFERRED	Hohmann transfer to Saturn
Arrival / rendezvous	4.39	INFERRED	Capture and transfer to the moon's orbit
Total	**11.67**	INFERRED	SRI calc
Transfer time	6.08 yr	INFERRED	Half-ellipse transfer time
Synodic period (window spacing)	1.04 yr	INFERRED	Earth vs Saturn
Distance from Earth	1.21e+09–1.66e+09 km	INFERRED	SRI calc
One-way light-time	67–92.2 min	INFERRED	SRI calc



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

Reading. With an access score of 1/5 (very poor), Bergelmir is among the hardest bodies in the set to reach. One-way radio delay of up to 92 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

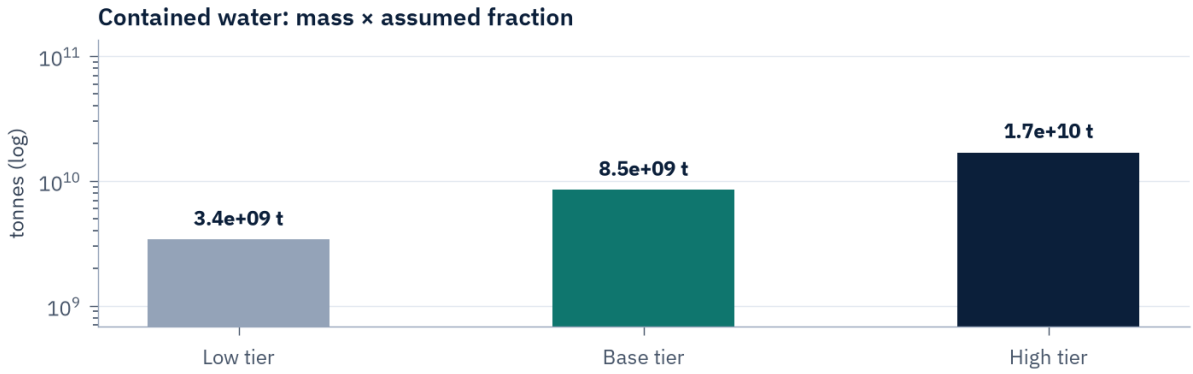
Resource assessment

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 0.0013 m/s² (escape speed 2.7 m/s); sunlight is about 1.09% of earth's, too weak for practical solar power; nuclear power would be needed; radio delay up to 92 min one way.
Data confidence	1	Thin (size from brightness; density assumed).

Contained water: model estimate

Contained water = total mass (1.70×10^{14} kg, ASSUMED) × an assumed fraction of 2% / 5% / 10% (low / base / high, ASSUMED). This gives about 3.4×10^{9} / 8.5×10^{9} / 1.7×10^{10} 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
Bergelmir	captured irregular moon	6.00 INFERRED	1.50 ASSUMED	11.7	6.1	thin
Narvi	captured irregular moon	7.00 INFERRED	1.50 ASSUMED	11.7	6.1	thin
Hyrrokkin	captured irregular moon	8.00 INFERRED	1.50 ASSUMED	11.7	6.1	thin
Tarqeq	captured irregular moon	6.00 INFERRED	1.50 ASSUMED	11.6	6.1	thin
Surtur	captured irregular moon	4.00 INFERRED	1.50 ASSUMED	11.7	6.1	thin
Halimede	captured irregular moon	52.0 INFERRED	1.50 ASSUMED	11.8	30.8	thin
Fornjot	captured irregular moon	6.00 INFERRED	1.50 ASSUMED	11.8	6.1	thin

Pattern. Bergelmir ranks 3 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 Bergelmir 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 [9]; TechCrunch (Sep 2026) reports $56M in venture funding [10] MEASURED	Odin launched 26 Feb 2025 on the IM-2 rideshare; contact lost, flyby of 2022 OB5 not achieved [11][12]. Next vehicle named DeepSpace-2 [12]
Karman+ (Colorado, US)	NEA regolith excavation; water for in-orbit refuelling; later metals	$20M seed (Feb 2025) co-led by Plural and Hummingbird [13] MEASURED	High Frontier demonstration targeting a 2027 launch; aims to mine ~1 kg; budget goal under $10M [13]
TransAstra (California, US)	Optical mining, Capture Bag, space logistics, asteroid detection	$2.5M NASA CCRPP contract matched by $2.5M private investment (Sep 2025) [14] MEASURED	1-m Capture Bag delivered to the ISS for testing (Sep 2025); scaling to 10 m [14]
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 [15]
Planetary Resources (US), historical	Asteroid prospecting	Acquired by ConsenSys in 2018 [16]	Assets later dispersed; a cautionary precedent
Deep Space Industries (US), historical	Asteroid mining; small-satellite propulsion	Acquired by Bradford Space in 2019 [16]	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 [17].
- **Lunar landers and rideshare hosts.** Small asteroid probes have flown as secondary payloads on lunar missions (e.g., Odin on IM-2 [11]). 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 [16]. Today's cohort runs on much smaller budgets, and its first deep-space attempt, Odin, did not achieve its objective [11]. 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 [18]
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 [19]
Luxembourg: Law of 20 July 2017	Space resources are capable of being appropriated; activities require national authorisation	In force	Legilux [20]
UAE: Federal Law No. 12 of 2019	Regulates authorised space-resource activities, including extraction, use and trade	In force	UAE Ministry of Justice [21]
Japan: Act No. 83 of 2021	Permit holders acquire ownership of resources extracted under an approved plan	In force	Cabinet Office [22]; Library of Congress [23]
Artemis Accords (2020–)	Resource extraction to comply with the OST; deconfliction via notified, temporary "safety zones"	77 signatories as of 19 Oct 2026 [24] MEASURED	NASA [24] [25]
UN COPUOS Working Group on Legal Aspects of Space Resource Activities	Drafting non-binding recommended principles	Draft principles updated during 2026; not binding	UNOOSA [26]

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 Bergelmir 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
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) [13]; 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 [27][28]
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 [16]; the Odin anomaly [11]	A successful rendezvous and landing by a private spacecraft
Legal acceptance	Market access, insurance, sovereign participation	Final COPUOS principles [26]; 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; this body is thinly measured.
Technology demonstrations at more accessible analogues	5–10 yr	Medium	High	Lessons transfer to Bergelmir 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.
Commercial extraction	Beyond any investable horizon	—	—	Transfer times dominate.

Bottom line: Bergelmir is very hard to reach (ideal transfer about 6 years, SRI calc). Its value is scientific and as long-horizon option value; we see no commercial case within any investable horizon.

PART IV

What it could be worth

32.8×

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

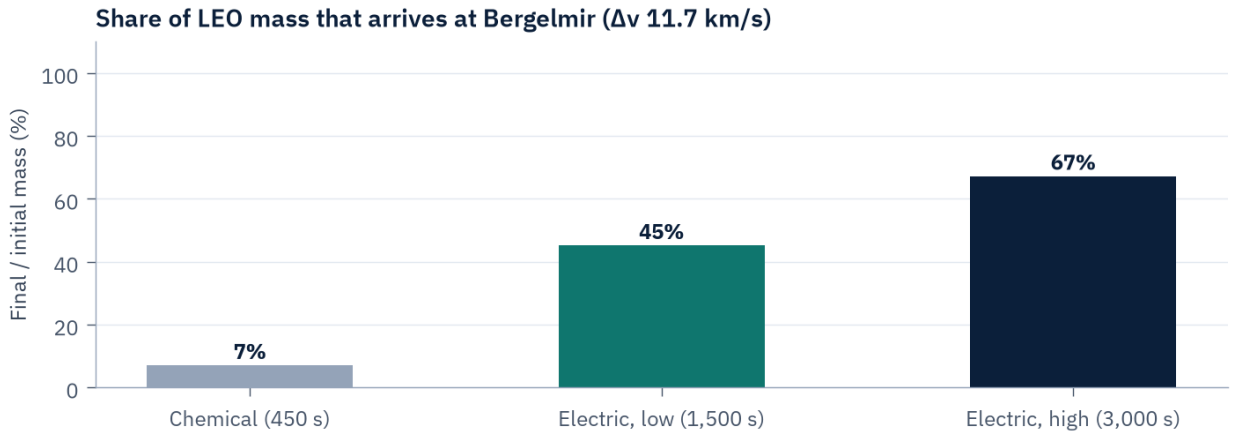
Valuation model

A transparent cash-flow model for a hypothetical venture supplying **water / volatiles for propellant and life support** from Bergelmir. 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	11.67	11.67	11.67	Inferred
Programme capex excl. launch	$M	3,000	1,500	750	Assumption
Development period	years	8	6	5	Assumption
Outbound transit	years	9	6	5	Inferred / Assumption
Return transit (laden)	years	9	6	5	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 ($M)	766	31	4
NPV ($M)	-2,003	-1,150	1,186
Risk-adjusted NPV ($M)	-1,947	-1,081	308
Total water delivered (t)	10	350	4,250
First delivery year	27	19	16
Break-even delivered value ($/kg)	15,108,867	46,222	1,103
Break-even ÷ launch cost (×)	5554.7	32.8	2.2



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) [27]; SpaceX's published rideshare rate is $350k for the first 50 kg plus $7k/kg [28]. Capex benchmarks: NASA Psyche life-cycle cost $985M including launch [29]; AstroForge Odin [11].

APPENDIX A

Appendix A: Sources

Sources 1–8 are those cited on bergelm.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).

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Artwork: all charts and cover graphics are original to Space Resource Intelligence; no third-party images are used. Typefaces: Source Sans Pro and Source Serif Pro (SIL Open Font License).

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 6.00 km: from brightness (albedo assumed).
- Geometric albedo 0.04 assumed for temperature.
- 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.

SCORE	RULE
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.
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.