ENGINEERING FEASIBILITY REVIEW

Marsprojekt2035

Starship-derived Mars round-trip architecture

An architecture-level assessment of PH 13-8 Mo isogrid structures, lander cargo capacity, Mars ascent propellant closure, surface freight, electrical distribution, reactor and solar power, thermal control, and base construction.

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Draft reviewed Marsprojekt2035 v0.2.4 (PDF dated 11 November 2026)
Scope Large engineering and mission-architecture uncertainties; not copyediting

This report reformats the detailed assessment already provided in the conversation. Quantitative estimates are preliminary, and illustrative engineering assumptions are identified where applicable.

Executive assessment

The architecture is worth developing further, but the current version does not yet establish that the eight-vehicle mission closes. The largest uncertainties are landed propellant capacity, structural mass margins, descent guidance, reliable surface power, and the equipment required to establish a DRA 5.0-class surface base.

The distinction is between a **physically plausible mechanism** and a **closed engineering design**. The draft contains many promising examples of the former, but several key budgets for the latter remain unresolved.

Subsystem	Assessment
PH 13-8 Mo isogrid structure	Plausible concept; structural validation incomplete
Landing 35–44 t of useful cargo	Plausible target; 44 t is not yet robust
Landing 50+ t	Requires substantial guidance and/or mass improvement
Refueling MDAV-1 for ascent	Marginal in the present fleet
Stripping MDAV-1 for ascent	Large mass benefit; operational challenges
Electric propellant trucking	Energetically quite feasible
MON-25 temperature management	Feasible in principle; redundancy and thermal design missing
10 kWe reactor	Useful for depot; inadequate for complete base
200 kV power distribution	Unnecessary and undesirable
Protective regolith berms	Mechanically feasible with dedicated equipment
Full human DRA 5.0 mission	Surface infrastructure and crew-supporting mass not yet shown

> **Highest priority: integrate launch, entry, landing, ascent, and surface-system mass and energy budgets in one consistent scenario.**

Sections: 1 Mass closure; 2 PH-steel structure; 3 UltraDraco propulsion; 4 Electric trucking; 5 Power transmission; 6 Propellant heating; 7 Solar/base power; 8 Regolith berms; 9 Surface manifest; 10 Landing guidance; 11 Redundancy; 12 Radiation; 13 Recommended revisions.

1. The mass budgets do not yet describe the same mission

Appendix D.1 describes eight spacecraft, 2,161 t dispatched toward Mars, 7,676 t initially in LEO, and approximately 65 launches. Appendix D.2 contains later landing-optimizer results that do not fully reconcile with those masses and deliveries.

For the 125 kN engine case, the D.2 tanker nominally delivers 36.9 t of propellant plus 9.5 t of trim cargo. MDAV-1 lands with approximately 28 t of its ascent propellant. Against an approximately 180 t ascent requirement, this leaves around 152 t to deliver. Four tankers × 36.9 t deliver 147.6 t: a shortfall of **4.4 t before transfer losses**.

The paper proposes converting ballast into transferable propellant. That might close the shortfall, but requires its own container, mounting, plumbing and entry-trim demonstration. The 253 t after-TMI masses in D.1 and 147–183 t entry masses in D.2 also need consistent treatment of expendables, orbit changes, and propellant consumption.

Dry-mass growth amplifies ascent demand

Appendix A gives a flying MDAV mass of 49.9 t without growth and 55.8 t with growth. Appendix C uses approximately 49.6 t in its ascent case. At the paper's estimate of 3.7 t ascent propellant per additional tonne lifted, 5.9 t of mass growth implies approximately **21.8 t of additional propellant**.

Possible added ascent burden	Extra propellant
2 t crew, equipment and samples	~7–8 t
5.9 t flying-mass growth allowance	~22 t
1.7 t retained TPS and attachments	~6 t
Combined indicative sensitivity	~35–36 t

These are sensitivities, not automatically independent increments: the calculator's crew and TPS cases must be reconciled before they can be added to a final manifest. Nevertheless, the baseline 173–180 t ascent requirement could rise toward **200–210 t** in an unfavorable growth case—roughly another dedicated tanker at a ~37 t delivery rate.

> **The 65-launch headline is a scenario, not yet an auditable, fully closed fleet count.**

2. PH 13-8 Mo steel isogrid: buckling and manufacturing

PH 13-8 Mo in H1100 condition is a defensible candidate: high strength, useful toughness, and a weld/age manufacturing path. Its roughly 930 MPa minimum room-temperature yield strength does not guarantee a lightweight shell, however, because local buckling can govern long before yield.

Appendix A specifies 1.75 mm minimum skin, approximately 2 mm-wide ribs 16–22 mm deep, and a 28.2 t hull (16.7 t isogrid shells plus 11.5 t frames and other parts). The governing structural questions are rib pitch, load paths, panel imperfections, weld joints, cutouts, pressurization, and local hot spots.

Illustrative local buckling check

For a simply supported square skin panel under in-plane compression, using E = 195 GPa, Poisson’s ratio 0.30, and t = 1.75 mm:

$$\sigma_{cr} \approx [4\pi^2 E / 12(1 - \nu^2)] \times (t / b)^2$$

Unsupported skin width b	Elastic buckling stress
100 mm	216 MPa
150 mm	96 MPa
200 mm	54 MPa
250 mm	35 MPa

This is not a finite-element prediction for a real isogrid: curvature, rib restraint, directional loading and postbuckling behavior matter. But it demonstrates the sensitivity to effective skin-panel width. A 5.97 MN entry load transmitted uniformly axially through a 9 m-diameter shell with 2.7 mm equivalent wall thickness would produce a mean membrane stress near 78 MPa—comparable to some of the illustrative local buckling values, though far below alloy yield.

Fabrication, heat treatment and TPS-loss cases

The proposed sequence—roll and weld Condition A plate, machine the inside, join large sections, age at 593°C for four hours, and bolt the segments together—requires validation of distortion, thin-skin damage, joint efficiency, strength at weld intersections, and furnace dimensional control. Supplier guidance supports the alloy’s general processing route, not necessarily the behavior of this immense welded assembly.

Appendix A.4 predicts approximately 781–792°C local bare-skin temperatures after a lost black tile. These temperatures greatly exceed H1100 aging temperature. A transient excursion does not necessarily cause immediate loss of integrity, but time-dependent temper changes and hot-shell buckling must be modeled instead of relying on room-temperature yield strength.

Compare the total vehicle-level mass of PH 13-8 Mo isogrid, 304L isogrid, and a high-strength aluminum structure after accounting for TPS, frames, joints, attachment hardware and manufacturing allowances.

The strongest alloy need not yield the lightest buckling-limited structure.

3. UltraDraco electric-pump and accumulator closure

The electric-pumped, pressure-fed accumulator scheme eliminates the need to keep the entire liquid inventory at full engine inlet pressure, but creates a multi-megawatt power system. With 646.8 kg/s propellant flow, 50 bar pump pressure rise, effective liquid density 1,100 kg/m³, and 65% motor/pump efficiency, electrical pump power is approximately **4.5 MW**.

$$P_{pump} \approx \dot{m}\,\Delta p / (\rho\,\eta) \approx 4.5\ \text{MW}$$

Operation	Propellant pumped	Indicative electrical energy
MDV landing	69.4 t	135 kWh
MDAV ascent	163.4 t	317 kWh
Pumping 180 t	180 t	350 kWh

Actual demand depends on pressure differentials, density, efficiency and the prepressurized fraction. The 410 kWh usable propulsion battery mentioned in Appendix G is in the general ascent-energy range, but does not alone establish adequate power, thermal margin or engine-out contingency. The 13.3 t tank/feed allowance should be decomposed into tanks, accumulators, pumps, motors, batteries, power electronics, pressurization and thermal hardware.

4. Electric trucks: transporting 5 t over Martian terrain

The energy required to move the propellant is much smaller than the energy required to keep it temperature-controlled and transfer it safely. A reasonable illustrative vehicle is a 3,000 kg truck/trailer carrying 5,000 kg of propellant. Assume 3.71 m/s² Martian gravity, 5 km loaded outbound and 5 km empty return, 8 km/h average speed, 70% traction efficiency, and 2 kW auxiliary heating.

$$E_{wheels} = C_{rr}\, g_{Mars}\, (m_{loaded} d_{out} + m_{empty} d_{back})$$

Effective rolling resistance	Estimated 10 km battery use
0.05: firm terrain	6.6 kWh
0.10: moderate terrain	10.6 kWh
0.15: soft terrain	14.7 kWh
0.20: difficult terrain	18.7 kWh

These level-route values include about 2.5 kWh for auxiliary heat. Hills, slip, steering losses and adverse ground could push a trip toward 25–40 kWh. An **80 kWh installed battery** is therefore a sensible preliminary allowance, offering cold-weather and routing margin. At 200–300 Wh/kg at pack level, this implies approximately **270–400 kg** battery mass. The pack needs active temperature control and protection from deep nighttime cold.

A 5 t ethane shipment may require roughly 9–11 m³ of liquid-tank capacity, whereas MON-25 requires much less volume. Trailers should therefore be sized and configured for their distinct fluids.

Entire transfer campaign

For 160 t moved in 32 loads, with eight trips each from 2, 3, 4 and 5 km: total round-trip distance = 8 × 2 × (2+3+4+5) = **224 km**. Moderate-terrain traction and auxiliaries consume approximately **240 kWh** overall, perhaps 400–500 kWh with worse ground and allowances. A 10 kWe reactor could generate 240 kWh in about one Earth day, if dedicated to this service; in practice it also supports heating and other critical loads.

The operational risks are truck reliability, connectors, positive displacement pumps, contamination control, unloading sequencing, and temperature maintenance. A backup vehicle and spare transfer hardware are more important than an oversized battery.

5. Electrical distribution: why 200 kV is unnecessary

At 10 kW transmitted and 200 kV, current is only 0.05 A, so resistive loss is tiny—but the insulation, converters and Martian breakdown environment become disproportionately difficult. For a 5 km one-way line consisting of two copper conductors (10 km total), copper resistivity 1.724×10^{-8} Ω·m:

Distribution	Copper cross-section / wire	Copper mass	Resistive loss
2.8 kV	5 mm²	448 kg	~440 W
5 kV	2 mm²	179 kg	~345 W
10 kV	1 mm²	90 kg	~172 W
10 kV	2 mm²	179 kg	~86 W
200 kV	0.5 mm²	45 kg	~1 W

The 10 kV/1 mm² line loses only approximately 1.7% of the power. Raising voltage to 200 kV saves around 45 kg of copper in this specific comparison, far less than the mass of more elaborate insulation and power-conditioning gear. The table excludes insulation, sheathing, armoring, supports, joints, conversion hardware and redundancy.

Low-pressure CO_2 complicates external high-voltage insulation; a Martian atmosphere cannot be handled like ordinary sea-level terrestrial air. NASA surface-power studies have explored ±2.8 kV DC for approximately 1 km distribution. A **several-kilovolt DC microgrid, with 5–10 kV differential as a**

study range, is preferable here. Allow several hundred kg for a protected multi-kilometer installation, subject to final mechanical and redundancy requirements.

6. Thermal management of the propellant depot

MON-25 freezes near −55°C and MMH near −52°C. Ethane reduces the freezing concern on the fuel side but introduces different vapor-pressure and containment issues. MDAV-1 is expected to retain its fuel for approximately four Earth years while the vehicles await ascent, making reliable thermal control a mission-critical function.

Consider 180 t of propellant with an illustrative 200 m² effective thermally exposed tank area, stored near −50°C against an effective surroundings temperature between −80 and −100°C. Radiative losses depend strongly on effective emissivity:

Effective emissivity	Illustrative radiative heat loss
0.10	1.2–1.8 kW
0.30	3.7–5.4 kW

These are radiative-only values. Martian convection, structural conduction, sunlight and multilayer insulation modify the true budget. For initial sizing, reserve **2–5 kW continuously** for depot heating, then reduce it by validated thermal design. This equals approximately **49–123 kWh per sol**. At the upper end, half a 10 kWe reactor’s electrical output would go to thermal management.

Recovered waste heat from the reactor may reduce electrical heating, but requires a deliberate heat-transport architecture. Independent heaters, power connections, temperature sensors and safe failure states are crucial. Freezing of a large mixed-oxide inventory is not necessarily harmless or instantly reversible; composition effects, trapped gas and reheating times require specific testing.

> **Propellant thermal survival is a mission-critical system, not a discretionary auxiliary load.**

7. Roll-down arrays and total surface power

Appendix A assigns a pair of 4 × 11 m arrays (88 m²) approximately 31.7 kW at 1 AU, 9.6 kW near a Mars noon, and 3.1 kW averaged over a sol. Their estimated energy production is:

Generating resource	Energy per sol
One array pair	76.4 kWh
Six array pairs	459 kWh
One 10 kWe reactor	247 kWh

The arrays do not themselves store energy. Batteries, which require separate mass and thermal budgets, store some portion of the yield. An 80 kWh truck battery could hold approximately one favorable sol's output from one array pair before losses; a 410 kWh propulsion battery is a larger possible store only if its chemistry, controls and mission rules permit surface use.

Six array pairs produce about 459 kWh per sol under the draft's assumptions—slightly short of a continuous 20 kWe load (about 493 kWh per sol), even before vehicle self-consumption, conversion losses, weather and the night-time storage cycle. Dust storms and dust deposition create further reliability requirements.

DRA 5.0 surface studies used roughly 17–20 kWe continuous for the crewed surface phase, with larger power systems when making ascent oxygen via ISRU. Your plan saves the ISRU load, but still needs life support, habitats, thermal control, rovers, communications, science and maintenance. A four-module **40 kWe fission architecture**, electrically interconnected with independent operation after loss of one module, is a useful candidate for the full human mission. Modules could be distributed across landers.

8. Building protective berms and shielding the base

The paper shows landers approximately 1 km apart. DRA 5.0 Addendum analyses suggested a keep-out radius around 1 km for a roughly 40 t lander. The proposed 100–120 t vehicles have outward-canted high-mounted engines, so the DRA result should not be treated as direct validation of the spacing: plume/ground interaction and ballistic ejecta require their own analysis.

Berm volumes and mass

For a freestanding trapezoidal berm, assume regolith bulk density 1,300 kg/m³, 1.5H:1V side slopes and a flat crest. Cross-sectional area is $h(w_{top} + 1.5h)$, so volume is $V = Lh(w_{top} + 1.5h)$.

Berm	Dimensions: height × length × crest	Volume	Regolith mass
Modest	2 m × 20 m × 1 m	160 m³	208 t
Substantial	3 m × 25 m × 1 m	412.5 m³	536 t
Large	4 m × 30 m × 2 m	960 m³	1,248 t

The middle case involves approximately **536,000 kg of regolith** moved. At 5 t per hauling cycle, that is at least 107 equivalent loads, ignoring grading and extra excavation. The large berm requires about 250 such cycles. A robotic excavator, loader and grading capability are more useful than relying solely on the fuel truck.

Potential energy is almost irrelevant: raising 536 t by 2 m on Mars is only around 1.1 kWh. Excavation, breaking, resistance, wheel slip and processing dominate. An assumed total of 0.5–2 kWh/m³ handled implies approximately **200–825 kWh** for the substantial berm. This is an illustrative productivity range, not a validated Mars construction model.

Why a berm alone does not solve the ejecta hazard

A 100 m/s stone launched at 45° has an ideal vacuum ballistic range $R = v^2/g \approx$ **2.69 km** on Mars. At 1 km downrange it would still be approximately 629 m above its launch level. A 3 m berm cannot intercept that trajectory. The stone may overshoot a particular base, but lower-angle and slower ejecta can still strike it. Berms are useful against low-angle debris; overhead protection or terrain siting is required for more general ballistic protection.

Greater separation—potentially 2 km or more if plume modeling requires it—and use of natural topography should remain options. A deliberately prepared MDAV-2 landing pad could prove less costly than constructing very large emergency earthworks after landing.

Regolith shielding for radiation is a distinct task

A simple hemisphere of 5 m outer radius, protected by regolith on the outside, illustrates the mass required for habitat shielding: approximately **248 t** for a 1 m layer and **594 t** for a 2 m layer, using density 1,300 kg/m³. Those masses exclude foundations, hatch tunnels and structural supports. A trench, supported roof or natural terrain cover could reduce the practical excavation burden.

Shielding thickness depends on regolith chemistry, solar conditions and permitted dose, and must be coupled to the habitat's ability to support external pressure from the soil. A one-direction berm cannot substitute for a comprehensive radiation shelter.

9. A DRA 5.0-class base requires a cargo manifest

The draft assumes Optimus robots can establish the base, but does not yet state what equipment and materials they will assemble. DRA 5.0 considered a centralized habitat, small pressurized rovers, other surface vehicles, logistics equipment and nuclear power. DRA Addendum designs used two approximately 40 t packages for ascent/surface systems and for crew habitat/exploration equipment.

The proposed mission may have comparable aggregate nonpropellant delivery capacity, but it is distributed among different landers, some of whose low-basket volume is already committed to entry-trim ballast. Roughly 70 t of predeployed nonpropellant cargo and ballast capacity plus 10–12 t on the crewed lander are identifiable in the current plan, depending on treatment of ballast. This is not an engineering demonstration that a six-person DRA-class base can be supported.

Subsystem	Critical design decision
Six-person habitat	Monolithic, modular, or assembled in situ?
Environmental control and life support	Degree of recycling and consumable reserve
Pressurized rovers	Full DRA-class rovers or smaller substitutes?
Construction equipment	Excavator, loader, crane, compactor, handling tools
Power and thermal infrastructure	Reactor count, shielding, cables, heat routing

Subsystem	Critical design decision
Propellant transfer	Tanks, hoses, pumps, valves, trailers, cleaning
Crew shielding	Regolith, water storm shelter, or both
Maintenance and spares	Robots, vehicles, power systems, fluid transfer

Robots can reduce labor needs but do not remove the mass of material, handling equipment and heavy machinery. The same is true for removing 10,000+ TPS tiles and fitting 16 nozzle extensions to the ascent vehicle. High-reach access, surface attachment, nondestructive checks, and emergency recovery need hardware.

10. Landing guidance and trim still set fleet size

Appendix B gives approximately 33–44 t landable propellant in its newer models, while older estimates reach 55–65 t. D.2 shows strong sensitivity to engine thrust, entry loads, and trim cargo.

Per-tanker delivery	Planning interpretation
33 t	Conservative working floor until controls and loads are integrated
44 t	Plausible development target, not yet guaranteed
50+ t	Improvement case involving thrust, dry mass, trim and trajectory optimization

Entry-trim propellant may improve manifest accounting but requires vessel structure and potentially changes aerodynamic stability. A baseline that assumes **35 t reliable propellant delivery** is more conservative than the present 44 t target. To deliver roughly 150–180 t after accounting for the fuel landed on MDAV-1, that suggests approximately five or six dedicated tanker deliveries before substantial contingencies.

Two additional couplings matter: (a) the 2033 departure geometry may require high-inclination LEO launches or extra maneuvering, and the draft’s approximately 5–10% delivery penalty could erase tanker margin; (b) the large MTV stacks may approach roughly 192–200 t dry in LEO including the TMI stage, before propellant, which assumes heavy-lift capability or changes in orbital assembly practice.

11. Redundancy: two ascent vehicles share failure modes

The two MTVs and two MDAVs provide useful vehicle redundancy. Nevertheless, both ascent vehicles depend heavily on the same predeployed fuel inventory, heaters and transfer logistics. Moving the fuel from failed MDAV-1 into MDAV-2 does not cure contamination, depot thermal loss, damaged plumbing or a power failure affecting both vehicles.

A genuinely independent return backstop may use distinct electrically heated storage, separate pump routes, redundant connectors and safeguarded reserve propellant. This need not mean a complete second 180 t stockpile, but failure-mode independence should be explicitly demonstrated rather than inferred from the presence of two hulls.

12. Radiation: use a mission-specific calculation

The draft assumes that a human mission would exceed NASA radiation limits and require those standards to be relaxed. That may be true for its particular crew and shielding scenario, but needs to be calculated using the current framework rather than old DRA-era age/sex limits. NASA’s current career limit is 600 mSv effective dose for all ages and sexes.

A mission with roughly 450 days in space and 500+ days on Mars depends on solar-cycle timing, cabin/ethane shielding, surface-habitat regolith shielding and crew occupancy patterns. Model solar particle event survival separately from chronic galactic cosmic-ray dose. The proposed 30 cm ethane sheath can be included as an explicit material in the transport calculation.

13. The five highest-value revisions

1. Reconcile all trajectory and mass models

Produce a single release-controlled mission ledger covering LEO stack mass, TMI consumption, Mars arrival, aerocapture or maneuvering, entry mass, landed propellant, transfer losses, ascent vehicle mass and replenishment. Include mass growth and failure margins in both the eight-vehicle nominal case and a conservative case.

2. Define the minimum viable surface base

Identify habitat, ECLSS, crew radiation shelter, pressurized mobility, nonpressurized freight, excavation, power, propellant handling, science, food/water and spares. Show how these packages fit into lander geometry and mass/trim constraints.

3. Validate the PH-steel isogrid thermostructurally

Use buckling-capable finite-element analysis with actual rib geometry, load paths, joints, cutouts, hot skin, TPS attachments, proof pressure and failure of local tiles. Compare competing material systems at integrated vehicle level.

4. Build a unified surface power and heat balance

Integrate four-year depot survival, 10 kWe reactor output, vehicle arrays, night and dust-storm storage, truck charging, power lines, crew habitat, heaters and contingency operation. Treat power-to-heat recovery as a designed capability rather than a free assumption.

5. Integrate flight dynamics, control and cargo in one lander optimizer

Include the entry-force ceiling, heating, trajectory dispersions, trim ballast, descent thrust limits, canted/scarfed nozzles, structural mass, and terminal control authority in one model. Determine whether reliable delivery is 33, 40, 44 or 50 t rather than selecting a number from several incompatible calculators.

> **Preserve the core architecture: split Starship-derived stages, storable propulsion, aerocapture, predeployed tanker landers, and a stripped MDAV for ascent. Treat three tankers plus a truck as an optimistic scenario until structural and landing margins close; retain a larger conservative fleet in the mission study.**

Final assessment. Electric propellant transportation and multikilovolt distribution are manageable challenges. Plume protection and robotic excavation are also tractable with purpose-built equipment. The decisive unknowns remain the thin-shell structural design, the deliverable propellant per lander, the equipment mass for a genuine six-person base, and the integrated ascent fuel and power budgets. The next major improvement is a single auditable mission mass-and-energy ledger.

Source and interpretation note

This report is a formatted version of the preceding ChatGPT engineering review of *Marsprojekt2035-v121e.pdf* (v0.2.4, 11 November 2026). Values drawn from the draft are identified by appendix where possible; the truck, line, berm, heating and structural sensitivities are first-order calculations with explicit assumptions. References to DRA 5.0, NASA radiation guidance and alloy manufacturer specifications reproduce the scope of the original review rather than constituting a fresh independent verification.