Technical Review

Das Marsprojekt × Mars DRA 5.0 × Starship = v0.2.4

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Overview

This is a technically ambitious, Starship-leveraged architecture that deliberately avoids cryogenic long-duration storage and ISRU in favor of space-storable propellants (preferred ethane/MON-25; MMH/MON-25 more probable) and heavy robotic surface operations. It is framed honestly as draft "Starship fan fiction" contingent on prerequisites that do not currently exist at the required maturity. Incremental inconsistencies exist (as the author notes), but the more important issues for a manned-spaceflight-literate reader are structural design choices, high-risk dependencies, and areas that remain too under-specified for credible technical assessment.

1. Extreme Dependence on Unproven Autonomous Robotics

The architecture hinges on Optimus-class robots (or equivalent) performing metalworking (cutting/welding/drilling), tile stripping of 10,000+ tiles up to ~30 m height, nozzle-extension installation, base setup, and ~160 t of propellant transfer across 1–2+ km lines of landed vehicles. Robots are sealed into the cargo hold pre-launch and must cut themselves out of 1.75 mm skin after landing.

For a crewed mission this is a single-point-of-failure class risk. Current humanoid robot capability (even optimistic 2033 projections) does not support unsupervised, high-reliability work in abrasive, dusty, low-temperature, low-pressure environments with limited power and no easy recovery. Tile removal "regularly performed by SpaceX" on Earth does not translate directly; access, tool reaction forces, electrostatic dust, and thermal cycling on Mars are different. Failure of the robot team after the 2033 landers arrive strands the 2035 crew with an unfueled or incompletely prepared ascent vehicle. The document correctly lists this as a prerequisite (Appendix H) but does not quantify reliability, power, thermal, or contingency requirements.

2. Surface Propellant Logistics and Thermal Management

~160–180 t of ascent propellant must be transferred from multiple MDVs into MDAV-1 (the heated surface depot) using insulated tank trailers (~5 t loads, ~32 trips). MON-25 freezes at −55 °C; Mars nights are substantially colder. The solution is a 10 kWe Kilopower-class reactor on MDAV-1 plus sequential tanker landings during northern summer (Ls 90–180), with trailers charged by the reactor.

This is workable in principle but under-specified:

- Interface design, leak rates, contamination control, and pump reliability over dozens of transfers are not addressed.
- Thermal balance (insulation mass, residual tile coverage, heater power, stratification, and day/night cycling) is only sketched. Leaving some tiles on for insulation is noted but not quantified against the ascent mass penalty (~3.7 t propellant per tonne of dry mass that flies).
- Power margin is tight; solar arrays average only ~3.1 kW over a sol. Reactor failure or under-performance after years of unattended operation ends the mission.
- The document notes this is "probably less difficult than managing a Sabatier plant plus cryogenic storage," which is fair, but the absolute difficulty remains high and the operational sequence is brittle.

3. New High-Thrust Pressure-Fed Storable Engine ("UltraDraco")

Sixteen engines per lander, ~125 kN with ascent nozzle extensions (~315 s), throttled 30–92 %, used for both long landing burns (134–183 s) and a ~266 s ascent after months on the surface. Propellant is electric-pumped into COPV reservoirs then pressure-fed. Engines are canted ~20° and scarfed, imposing large cosine losses (axial Isp drops significantly for landing).

This is an entirely new engine development. SuperDraco is a useful ancestor (MMH/NTO, ~71 kN, short burns) but the UltraDraco needs higher thrust, different oxidizer (MON-25), longer burn times, different cooling/throttling behavior, and (if ethane) an igniter. Qualification for long-duration storage, thermal cycling, dust exposure, and restart reliability after months on the surface is a major program in itself and is listed as a prerequisite. The pressure-fed COPV architecture also implies significant tank and feed-system mass and packaging constraints that are only partially captured in the mass budgets.

4. Habitation, Crew Systems, and Radiation Largely Undesigned

MTVs are sized only as mass and propellant envelopes; "habitat, consumables and structure are not designed." Systems allowance for power/avionics/ECLSS is a placeholder. Radiation shielding discussion is limited to a 30 cm ethane sheath (helpful for SPE/Van Allen but not GCR) plus optional water around sleeping quarters. The author correctly notes that even with this, the total dose (transit + 500+ day surface stay) exceeds current NASA standards, so those standards would have to be relaxed.

For a technical reader this is a large gap. Six crew, ~6-month outbound, 500+ days on the surface, and longer return require a complete ECLSS architecture, consumables closure, medical/psychological support, dust mitigation, power, and thermal control. Microgravity (or partial gravity) effects, radiation biology, and abort-to-surface or abort-to-orbit medical contingencies are not addressed. The dual-MTV redundancy is a positive feature, but without habitat design it is difficult to assess living volume, contingency consumables, or docking/transfer operations.

5. EDL and Ascent Performance Margins

Atmosphere does most of the deceleration ("98 %"), engines are used late after a belly-first entry and flip. Multiple internal models disagree on landed propellant (landing calculator 44 t, webapp 33 t, mission model higher and currently unachievable). Tankers require ~8–10 t dense trim cargo low in the basket. Flaps on the MDV manage CG shift; jettison option is open. Ascent benefits significantly from discarding the cargo basket (~10 t) and removing tiles.

Gaps include:

- Incomplete hypersonic heating and CO_2 plasma radiation modeling (leeward white tiles are motivated by stronger IR radiation, but thickness and performance are TBD).
- Structural load limits (entry force, hull force) that bind and reduce performance.
- Engine-out, plume-surface interaction, dust lofting, and precision landing into a 1 km-spaced line (requiring a navigation constellation that does not yet exist).
- Ascent T/W and engine-out margins are calculated but depend on successful tile/basket jettison and nozzle-extension installation by robots.

6. Absence of ISRU Drives Large Propellant Transport Burden

No ISRU is required; all ascent propellant is delivered from Earth. This is a conscious departure from DRA 5.0 (which produces oxygen on Mars). It avoids the development and operational risk of ISRU but multiplies the number of tanker landers and the surface logistics problem. The fleet for one six-person

round trip is eight vehicles and ~65 Starship-boosted launches (methalox + storable). That is a substantial campaign even with high Starship flight rates.

7. Abort, Contingency, and Reliability Depth

Backstops exist: MTV-2 as an LMO depot with rescue reserve; MDAV-2 as a surface backup that can be stripped and fueled from MDAV-1. These are sensible. However, the document does not develop detailed failure trees for entry/landing (engine-out, guidance, dust), surface power or propellant transfer failure, or ascent underperformance. Long-duration unattended operation of reactors, robots, and propellant systems before crew arrival is assumed to succeed with high probability. Planetary protection (forward and backward) is mentioned mainly in the sample-return appendix; crewed surface operations with large vehicles and robots raise additional issues that are not treated.

8. Manufacturing, Materials, and Other Under-Specified Areas

PH 13-8 Mo isogrid steel is chosen because Starship TPS is presumed better suited to steel than aluminum. Manufacturing (rolling, TIG welding into 9 m hoops, isogrid machining, furnace aging of large segments) is described at a high level. Other areas that remain thin for a technical reader include:

- Detailed propellant management (electric pump sizing, COPV pressures and residual management, thermal stratification, transfer interfaces, leak rates over years).
- Full power budgets and distribution beyond the 10 kWe reactor.
- Vehicle dynamics, aeroelasticity, and control during entry with shifting CG and flaps.
- Docking and crew transfer operations between MTV and MDAV.
- Qualification timeline for the new engine, reactor, robots, and vehicles themselves (the document notes that man-rating the landers by 2033 is unrealistic).

Prerequisites and Timeline Realism

The 2033 cargo flights require: proven economical Starship-to-Starship refueling; a Mars communications/navigation constellation (minimal GPS-like + large Earth relay); Optimus robots capable of the tasks above; autonomous trucks that fit the 3 × 2.8 m door and move multi-ton loads; a qualified UltraDraco-class engine; and a 10 kWe-class fission surface power unit that can land and run unattended for years. As of the document's date (late 2026), none of these are demonstrated at the required level. The architecture is therefore correctly presented as contingent.

Overall Assessment

The concept is coherent in its major choices (expendable Starship-derived stages, storables to avoid ZBO cryogenics, pre-positioned landers + robots, dual MTV redundancy, basket/tile jettison for ascent). It correctly identifies many of its own hard problems and lists them as prerequisites or TBDs. For a knowledgeable reader the central difficulties are the combination of (a) an entirely new pressure-fed storable engine family that must work after long surface exposure, (b) multi-year unattended robotic surface logistics and propellant handling at the scale of ~160 t, and (c) the fact that crew habitation systems and radiation closure are still at the envelope level. These are not incremental inconsistencies; they are the primary risks that would have to be closed before the architecture could be considered more than a technically interesting outline.