THE AI SUPPLY CHAIN FIELD MANUAL · MARS DOCTRINE EDITION

THE PLAYBOOK FOR SUPPLY CHAINS TO MARS

Solve the supply chain for Mars, and you've solved it for anywhere on Earth.

A measurable, physics-grounded operating doctrine for moving packages, products, and people from Earth to Mars — and keeping them alive, supplied, and on schedule once they arrive.

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[DOC-01]

Why Mars Is the Forcing Function

Every weakness in how supply chains run today gets exposed — brutally — by Mars. On Earth, a missed shipment is an expedite call. On Mars, a missed launch window is a **26-month delay**. There is no air freight option. There is no spot buy. There is no RMA.

Here is the part most people miss: **you cannot manage a Mars supply chain by phone.** At closest approach, a message takes 3 minutes each way. At maximum distance, 22 minutes. During solar conjunction, the link goes dark for roughly two weeks. A buyer on Earth cannot approve a transaction on Mars in real time. Physics forbids it.

That means the Mars supply chain **must** run on autonomous agents executing inside human-set guardrails: agents that source locally, verify deliveries, manage inventory, reroute around failures, and escalate only what crosses a decision threshold. Humans set doctrine and own judgment. Agents execute. On Mars that isn't a productivity strategy — it's the only architecture that works.

Which is exactly why it's the right way to think about Earth. The latency on Earth isn't light-speed — it's inbox-speed, meeting-speed, time-zone-speed. The fix is the same: humans lead, agents execute. Mars just makes it non-negotiable.

KEY FIGURE	VALUE	WHAT IT MEANS
Max one-way comms delay	`22 min`	Real-time human approval is physically impossible. Autonomy is orbital mechanics, not preference.
Launch window cadence	`~26 months`	Miss the window, miss the cycle. Planning discipline at a level no Earth chain has needed.
Returns to Mars	`0 RMAs`	Quality must be verified before the part leaves Earth — or made and certified on-site.

[DOC-02]

The Physics That Run the Schedule

A Mars supply chain isn't planned around customer demand first — it's planned around orbital mechanics. None of these constraints are negotiable, and every one has an Earth-side lesson buried inside it.

CONSTRAINT	FIGURE	SUPPLY CHAIN CONSEQUENCE
Synodic launch window	~780 days (26 mo)	Demand planning runs on a 26-month heartbeat. BOMs, kits, spares locked and QC'd before the window — or wait a full cycle.
Transit duration	180–270 days	In-transit inventory frozen up to 9 months. Cycle counts, condition monitoring, cryo boil-off managed autonomously.
Earth–Mars distance	54.6M–401M km	A 7x swing drives comms, navigation, abort logic. Design for worst case, not average.
One-way light delay	3–22 min	No real-time control. Every decision under ~44 min of round-trip value is delegated to on-site agents and crew.
Conjunction blackout	~2 wks / 26 mo	Run fully disconnected 14+ days: pre-authorized playbooks, local authority, buffered consumables.
Trans-Mars injection (Δv)	~3.6 km/s	Propellant dominates the manifest. Orbital refueling (~10+ tanker flights per ship) is scheduled logistics, not a stunt.
Transit radiation dose	~1.8 mSv/day	Measured by Curiosity's RAD in cruise. Shielding mass and electronics/pharma shelf life are radiation line items.
Mars atmosphere	95% CO2 · 0.6% press.	Too thin for cargo aircraft, thick enough to burn careless entries. EDL tonnes/window is the bottleneck metric.
Gravity / day length	0.38 g · 24h 39m sol	Material handling, racking, and workload models all change. Warehousing at 0.38 g is an open field.
Launch cost trajectory	$54.5K → $2.7K → <$200/kg	Shuttle to Falcon 9 to Starship-class targets: two orders of magnitude in 30 years. Volume planning replaces ounce-counting.

Figures: NASA mission data, Curiosity MSL-RAD cruise measurements, published launch-cost analyses, standard Hohmann-class transfer values. Representative planning numbers.

[DOC-03]

People Are the Hardest Cargo

Hardware tolerates vacuum, delay, and storage. People don't. The moment a human boards, the supply chain inherits a daily, non-negotiable demand signal that never stops and can never stock out.

LIFE SUPPORT LINE ITEM	FIGURE	PLANNING CONSEQUENCE
Open-loop consumables	~5.4 kg/person/day	Food, water, oxygen with no recycling. A crew of 4 on a ~1,000-day mission is roughly 21+ tonnes before a single spare part.
Water recovery (state of art)	~98%	ISS-class closed-loop recovery collapses the water manifest — but makes the recycler itself the most critical machine in the chain.
Oxygen via ISRU	Proven (MOXIE)	122 g produced on Mars, ~12 g/hr peak. Scale-up turns air into a local supplier with a qualification file.
Medical & pharma shelf life	Radiation-limited	Transit dose degrades pharmaceuticals. Cold chain plus rad-aware expiry becomes a standing inventory discipline.
Abort options	None for months	Once past TMI there is no turnaround. Safety stock policy is written in survival days, not service levels.

The doctrine: crew consumables are managed like flight-critical hardware — serialized, condition-monitored, agent-counted daily, with human review only on threshold breach.

[DOC-04]

The Six Rules of Martian Logistics

RULE 01 · PRE-POSITION

Cargo Flies Before Crew

No human launches until their consumables, spares, power, and return-propellant capability are already on the surface and verified. Reference architectures send cargo a full window — 26 months — ahead.

RULE 02 · AUTONOMY AT THE EDGE

Humans Lead, Agents Execute

Every decision worth less than the round-trip light delay is delegated to agents inside human-set guardrails: inventory, condition monitoring, local sourcing, delivery verification, rerouting.

RULE 03 · LOCAL SOURCING

ISRU Is a Supplier, Not Science

Making propellant, oxygen, and water from Martian CO2 and ice is supplier development with better chemistry. Qualify it like any new source: capacity, quality, lead time, yield.

RULE 04 · MASS IS MONEY

Every Kilogram Has a P&L

Each kg landed on Mars carries launch, refueling, transit, and EDL cost. Make-vs-buy becomes ship-vs-print-vs-extract — the future of inventory strategy.

RULE 05 · ZERO-RETURN QUALITY

There Is No RMA to Mars

Returns are physically impossible for years at a time. Quality moves entirely upstream: source verification, serialized provenance, test-before-pack, digital-twin acceptance.

RULE 06 · DESIGNED REDUNDANCY

Two Is One, One Is None

Dual sources, dual routes, dual depots, dual comm paths. The network absorbs a failed lander or a two-week blackout without a human in the loop.

[DOC-05]

Five Heresies (Read Before You Disagree)

Doctrine is only useful if it costs something to hold. These five positions will annoy someone in every supply chain organization. Mars proves each one.

HERESY 01

Your ERP will not survive contact with Mars.

Monolithic systems that assume always-on connectivity and centralized approval fail the first conjunction blackout. The future is edge autonomy with synchronized ledgers — the ERP becomes the system of record, not the system of action.

HERESY 02

Just-In-Time is dead doctrine for anything mission-critical.

JIT optimizes for a world with infinite expedites and cheap recovery. Mars has neither — and neither does a carrier deck, a disaster zone, or a contested strait. Mission-critical chains run buffered, pre-positioned, and window-locked.

HERESY 03

Most 'digital transformation' is dashboard theater.

Visibility without execution authority is a very expensive way to watch problems happen. If your transformation produced screens but no agent can act on what the screens show, you bought scoreboards, not capability.

HERESY 04

The control tower is a single point of failure.

Centralized control rooms fail the blackout test. Mars-grade design pushes decision authority to the edge and keeps the center for doctrine, thresholds, and exceptions — command intent, not command queue.

HERESY 05

If a human must approve everything, you don't have a supply chain — you have a queue.

Approval latency is the silent killer of every operations team. Count the decisions in your chain worth less than the time it takes to approve them. On Mars that math is enforced by light speed. On Earth it's enforced by your competitors.

[DOC-06]

The Network, Node by Node

NODE	FUNCTION	OPERATING REALITY
01 · Earth	Factory, QC & kitting	Source, test, serialize, kit by mission manifest. Every part gets a digital twin and a radiation-rated shelf-life record. The last point where fixing a mistake is cheap.
02 · LEO	Orbital propellant depot	The Mars ship parks while ~10+ tanker flights fill it with cryogenic methalox. A fuel farm with launch cadence, boil-off losses, and a schedule. Treat it like terminal operations.
03 · Departure	Trans-Mars injection	A ~3.6 km/s burn commits the manifest. After TMI: no change orders, no expedites, no add-ons. The hardest ship-confirm discipline anywhere.
04 · Transit	The nine-month warehouse	Inventory in motion 180–270 days. Onboard agents run cycle counts, monitor temperature, radiation, and cryo margins, and re-plan the landing manifest — reporting up on delay, never waiting on a reply.
05 · Mars orbit	Staging & descent scheduling	Aerobraking arrival, then EDL slot management. Tonnes-landed-per-window is the network's true bottleneck — schedule descents like port berths.
06 · Surface	Depot, ISRU & last 100 km	Receiving and putaway at 0.38 g, ISRU feeding the propellant ledger, additive manufacturing working the spares long tail, autonomous rovers running last-100-km delivery. The first off-world DC.

[DOC-07]

The Mars Scoreboard: KPIs That Translate

MARS KPI	DEFINITION	EARTH EQUIVALENT
On-Window Delivery (OWD)	% of manifest launched in its planned synodic window	OTD with a 26-month penalty for failure — the ultimate schedule-adherence metric
EDL throughput	Tonnes safely landed per window	Port / airlift chokepoint capacity
Autonomy rate	% of operational decisions executed by agents without human touch	Touchless transaction rate; approval-latency reduction
Blackout readiness	Days of fully disconnected operation supported	Disaster / cyber-outage continuity rating
ISRU yield attainment	Local production vs. plan (propellant, O2, water)	New-supplier ramp performance
Landed cost per kg	Fully loaded $/kg on the surface	Total landed cost discipline, line item by line item

MARS KPI	DEFINITION	EARTH EQUIVALENT
Survival-day coverage	`Crew consumable buffer in days at current burn rate`	Safety stock measured in consequence, not units

[DOC-08]

The 2026–2031 Technology Horizon

NOW → 2027

Orbital cryogenic refueling at scale

Ship-to-ship propellant transfer converts 'one launch, one payload' into a hub-and-spoke architecture in space. Unlocks: heavy Mars manifests; depot network planning as a profession.

NOW → 2028

Deep-space optical communications

NASA's DSOC already pushed 267 Mbps by laser across 31 million km. Latency stays — bandwidth explodes. Unlocks: full digital twins, video QC, rich telemetry sync on a delayed link.

2026 → 2029

Agentic operations stacks

Agent patterns deployed in terrestrial chains today — open-order follow-up, expedites, sourcing, delivery verification, contingency routing — harden into certified autonomy with audit trails. Unlocks: 14+ day disconnected operations.

2027 → 2030

ISRU pilot plants

From MOXIE's grams-per-hour proof to pilot scale: Sabatier reactors making methane from Martian CO2, electrolysis cracking mapped water ice. Unlocks: propellant made at destination; return trips without shipping the gas.

2027 → 2031

Regolith additive manufacturing

Printing structures, shielding, and spares from local material plus shipped feedstock. Unlocks: stocking printers, feedstock, and certified design files instead of ten thousand SKUs.

2028 → 2031

Autonomous last-100-km networks

Rover and drone-class vehicles on scheduled delivery between landing zones, depots, and outposts — no driver, no dispatcher, no cell tower. Unlocks: off-grid autonomous distribution; doctrine for every disaster zone on Earth.

[DOC-09]

The Translation Layer

This is the point of the whole manual. Mars is the hardest possible test case — so every solution it forces is a best practice everywhere else: a carrier deck, a disaster zone, a forward operating base, a factory in a hurricane path.

MARS CONSTRAINT	MARS SOLUTION	EARTH APPLICATION
22-min light delay	Agents execute inside human-set guardrails	Open-PO follow-up, expedites, and sourcing run by agents; leaders own thresholds and exceptions
2-week conjunction blackout	Pre-authorized playbooks; disconnected ops	Disaster, conflict, and cyber-outage continuity
26-month launch windows	Window-locked demand planning and kitting	Program-driven procurement with hard PoP and long-lead discipline
No returns possible	Test-before-pack; serialized digital provenance	Counterfeit-part defense and upstream quality in aviation, defense, and space hardware
EDL landing capacity limit	Schedule descents like port berths	Constraint-based network design around ports, airlift, chokepoints
Every kg has landed cost	Ship vs. print vs. extract on each item	Make/buy/print decisions; additive for long-tail spares
No local supplier base	Qualify ISRU like a new source	Supplier development in austere, contested, or single-source markets
One failed lander kills the plan	Dual routes, depots, pre-authorized rerouting	Contingency logistics and resilience as standing doctrine

DASHBOARDS SHOW THE WORK. AGENTS MOVE THE WORK. EVEN AT 225 MILLION KILOMETERS.

The teams who learn to run supply chains for Mars will be the teams everyone on Earth wants running theirs.

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