

RAMS

RUMINANT-ASSISTED MARTIAN SYSTEMS

Integrated food, life-support, and biome operations

15-person crew | 500-sol commissioned interval | five-year evolution

Operational states, technology choices, resource model, safety case, and validation roadmap

The habitat itself is the food-production machine

RAMS operates one pressurized Earth-life volume as a coupled metabolism. Architecture creates useful gradients; biology turns them into food, water recovery, atmosphere exchange, materials, medicine, and crew comfort.

BERRY OAT BAR

BATCH NO.
1101

80 GRAMS / CREW SERVING

BATCH YIELD
15 SERVINGS

235KCAL
PER SERVING

MACROS / G
P 10 • C 31 • F 9
FIBER 6 G

SUPPLEMENT
AMBIENT

INGREDIENTS / SOURCE

OATS 32 G [EP] • BERRY PASTE 25 G [MP]
SUNFLOWER BUTTER 15 G [MA] • FLAX 8 G [MA]

PREP + HOLD
BAKE, COOL + SEAL
AMBIENT HOLD FOR 3 SOLS

NEXT USE / CLOSED LOOP
CRUMBS TOP CULTURED SOY

SOURCE KEY

EP EARTH-PROVISIONED • MA MARS ANNUAL CROP • MP MARS PERENNIAL
0.386 PYRAMID FOOD SYSTEM / SOL 11 / SUPPLEMENT 01

BERRY SORBET

BATCH NO.
0702

180 GRAMS / CREW SERVING

BATCH YIELD
15 SERVINGS

235KCAL
PER SERVING

MACROS / G
P 9 • C 34 • F 7
FIBER 6 G

SUPPLEMENT
FROZEN

INGREDIENTS / SOURCE

STRAWBERRIES 100 G [MP] • CULTURED SOY 55 G [MF/MA]
BERRY SYRUP 20 G [MP] • WATER 5 G [RM]

PREP + HOLD
FREEZE-CHURN + PORTION
MAINTAIN FROZEN STORAGE

NEXT USE / CLOSED LOOP
SOFTENING SURPLUS BECOMES
SOL 08 SHAKE BASE

SOURCE KEY

MA MARS ANNUAL CROP • MP MARS PERENNIAL • MF MARS FUNGUS / FERMENT • RM RECOVERED MINERAL
0.386 PYRAMID FOOD SYSTEM / SOL 07 / SUPPLEMENT 02

The habitat itself is the food-production machine

RAMS operates one pressurized Earth-life volume as a coupled metabolism. Architecture creates useful gradients; biology turns them into food, water recovery, atmosphere exchange, materials, medicine, and crew comfort.

— PHYSICS FIRST

Daylight, gravity, capillarity, thermal stratification, and phase change carry routine loads before motors and compressors.

— ECOLOGICAL INFRASTRUCTURE

Guilds exchange shade, nitrogen, root volume, litter, pest pressure, moisture, feed, fiber, and fungal substrate.

— FOOD AS CENTRAL

A modular 14-sol menu converts system output into individualized nutrition, hydration, pharmacology, pleasure, and ritual.

— MODULAR ARCHITECTURE

Useful exchange moving while pressure districts, valves, batch identity, and reserves isolate the failed branch.



Terraces turn one atmosphere into a ladder of useful climates

— APEX UTILITY

Condense humidity; recover latent heat; dry seed and herbs; redistribute conditioned air.

— UPPER DRY / COOL

Passive hydroponics, herbs, spices, fiber, seed crops, aromatic pest-management guilds.

— MIDDLE TERRACES

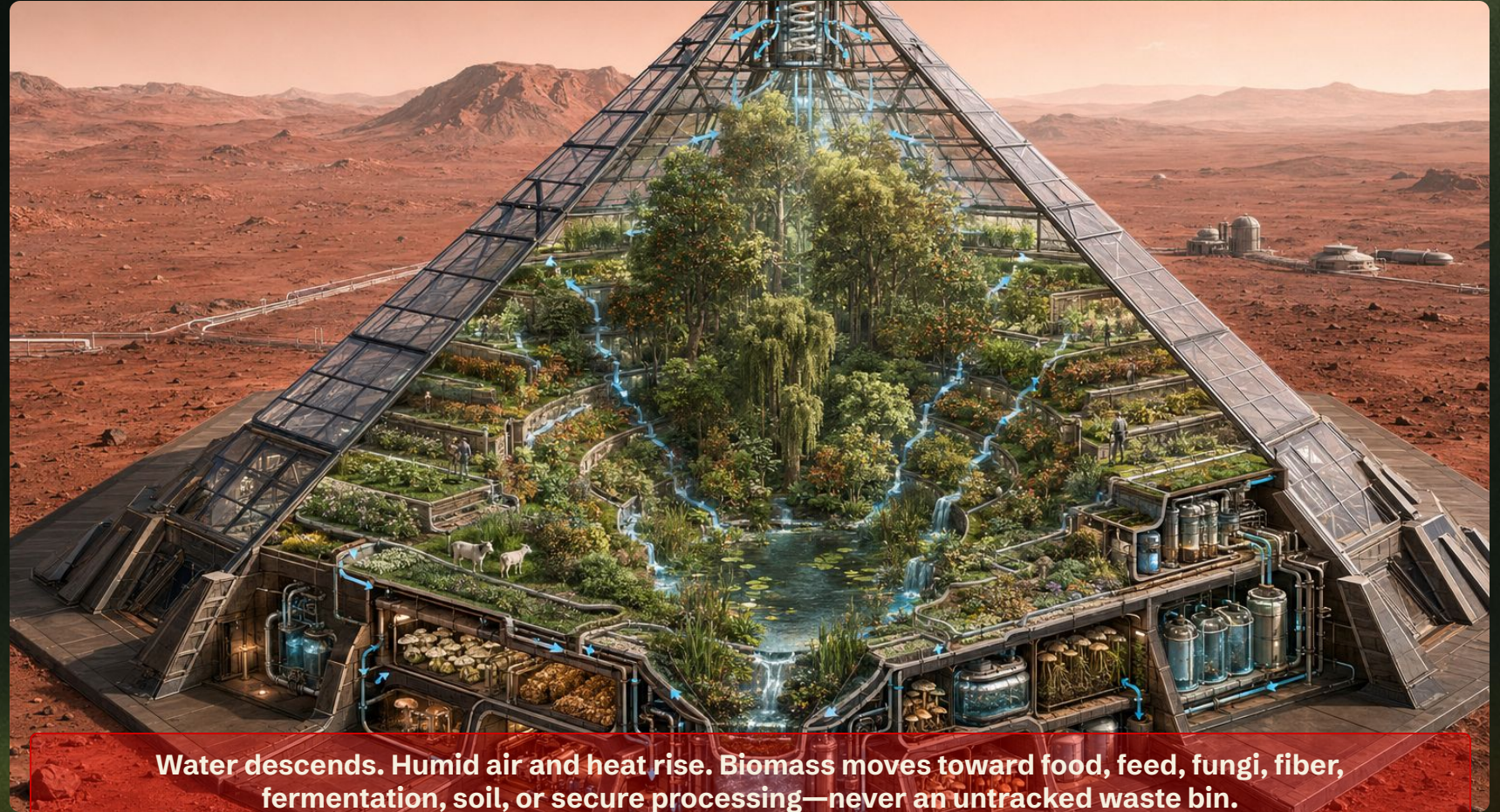
Annuals, roots, pulses, berries, medicinal shrubs, fodder, nitrogen fixers and trellised vines.

— SUNKEN GROVE + WETLAND

Canopy fruit and medicinal trees, shade guilds, aquatic foods, root polishing and the collection basin.

— RAISED FOUNDATION

Fungi, fermentation, composting, water treatment, cold stores and brownfield regolith refining.



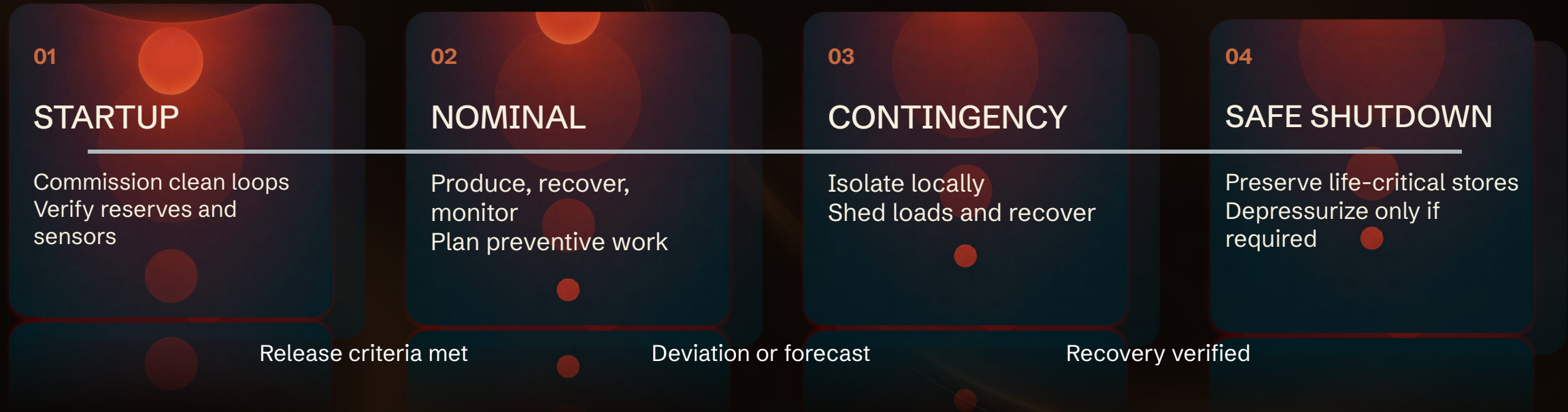
Pipes, ducts, drains and handoffs make the ecology operable

RAMS is not a pond with rooms around it. Five physically distinct networks exchange measured products at release gates; an industrial contaminant stream never becomes farm water merely because both contain H₂O.



Grow crates are removable root cassettes. Dry-break quick couplings connect each cassette to a valved supply manifold and drain pan; RFID/batch identity follows every physical handoff.

Four operating states make every transition explicit



Contingency is a normal operating state – not a surprise exception. Local zones can fall back while life-critical functions continue.

Startup validates each loop before expansion

- 1

Land precision seed

Power interfaces, seals, sensors, robotics, assay tools, reserves

2

Establish barriers

Raised foundation, dust control, pressure districts, clean receiving

3

Start shared water + air

Ice assay, purification, fire-safe common atmosphere, branch conditioning, leak and quality checks

MARS

RADIUS 3389.5 KM

MASS 6.4191E+22 KG

GRAVITY 3.71 M/S²

—

4

Start simple biology

Controlled soil cassettes, roots, grains, greens, fungi, ferments

02

25

5

Release by evidence

Nutrient closure, pathogen, power-loss, crop-failure, branch-bypass, and autonomy tests

NO ANIMALS BEFORE FEED, WATER, VETERINARY, AND WASTE SYSTEMS ARE MATURE

Nominal operations keep the metabolism connected and routine production autonomous

CONTINUOUS

Atmosphere, leaks, flow, temperature, water quality, crop imaging, animal welfare

DAILY

Autonomous irrigation, dosing, pollination, harvest staging, sanitation, inventory and residue routing

PERIODIC

Robotic maintenance, seed/culture bank audit, nutrient balance and equipment self-test

Observe

Measured state and forecast

Plan

Digital twin schedules crops, food and recovery

Execute

Robotic handling, dosing, cleaning and transport

Verify

Batch release, traceability, next-use destination

No scheduled crew labor is required for routine production; people participate by choice and retain authority over exceptions.

Contain the failed branch; keep every other exchange running

TRIGGER	IMMEDIATE CONTAINMENT	RECOVERY / SHUTDOWN PATH
Pressure loss	Isolate district; close shutters; move crew and animals	Robotic cover or tile repair; proof test; staged repressurization
Power reduction	Preserve O2, water freeze protection, lighting, cold stores	Load shedding; restart by biological criticality
Water contamination	Close the suspect branch; keep clean-water and unaffected crop circulation online	Trace batch; polish, recover nutrients, or divert to industrial treatment
Crop / ferment failure	Bypass the affected bed or vessel; keep shared air, water and heat serving healthy modules	Sanitize, reseed, rebalance menu, verify reconnection
Sensor / AI failure	Deterministic set points and local manual procedures	Cross-check redundant instruments; replace module; restore from logs
1 Confirm fault	2 Isolate minimum branch	3 Keep shared headers online
		4 Repair and verify
		5 Reconnect gradually

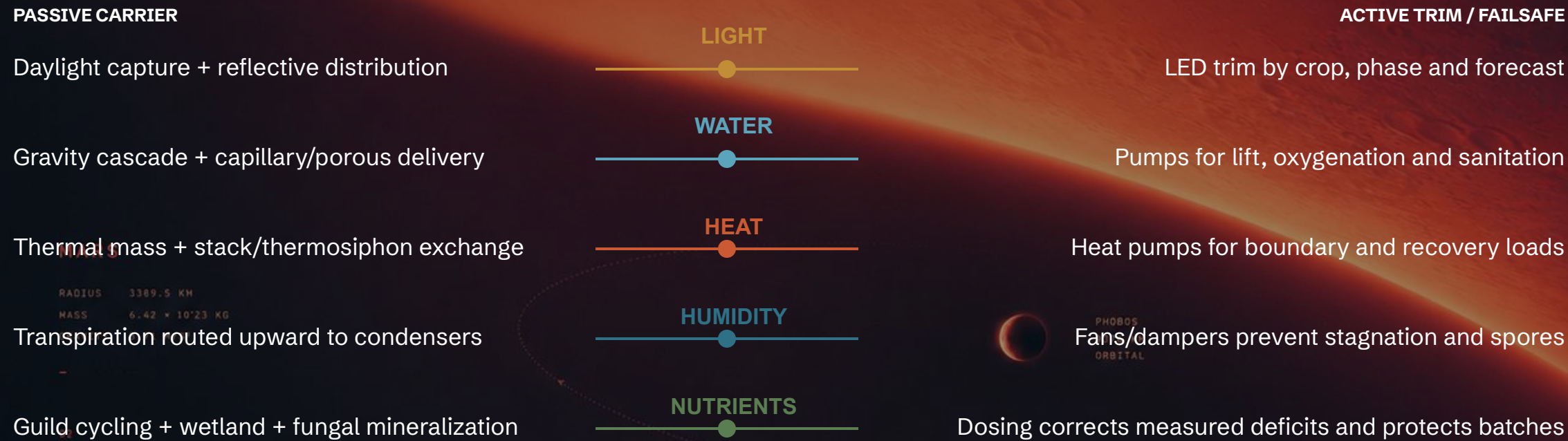
Production diversity prevents any one growing method from becoming life-critical

TECHNOLOGY	ROLE	SELECTION RATIONALE	RELEASE POSITION
Recirculating hydroponic / soilless systems	Greens, herbs, strawberries, vines, propagation	Fast control, high planting density, precise water and nutrient recovery	Operational foundation
Living-soil terraces + perennial cartridges	Grains, pulses, tubers, roots, berries, shrubs	Crop rotation, soil carbon, nitrogen fixation, familiar field and garden foods	Commission in stages
Fungi + fermentation	Protein diversity, preservation, flavor	Transforms residues and stabilizes food without one crop dependency	Core; strain controls required
Aquaponics + constructed wetlands	Aquatic plants, optional protein, water polishing	Captures nutrients, adds trophic diversity, and returns cleaner water to shared treatment	Integrated pilot, then scale
Poultry + small ruminants	Eggs, milk, fiber, manure, culture	Valuable but feed-, welfare-, methane-, gravity-, and labor-intensive	Later, after ecological gates

Selection rule: no single crop, flock, or experimental reactor may become life-critical.

Passive-first farming reserves power for precision

The control system does not replace physics. It trims, buffers, and verifies physical processes already created by the habitat section.



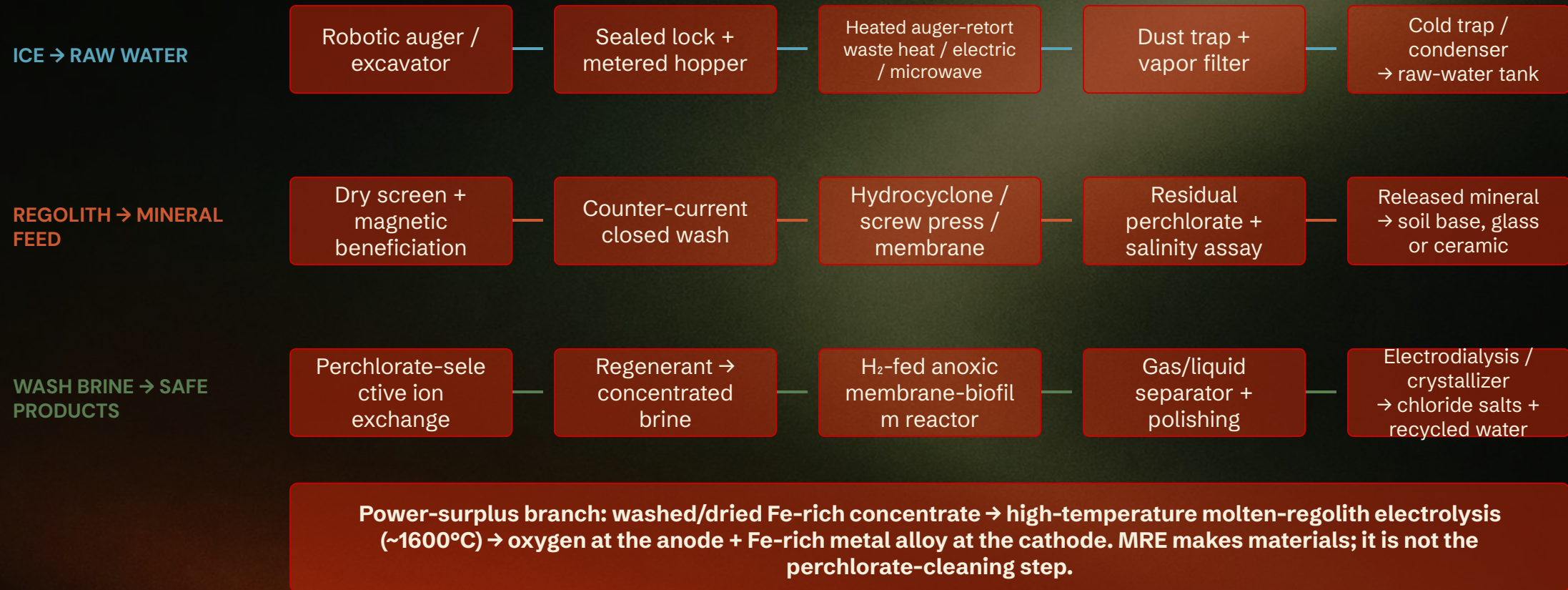
Nominal objective: reduce continuous pumping, fan, cooling, and lighting loads—without making crop survival depend on an unmeasured passive effect.

Each crop uses the growth method that best matches its biology and ecological work

METHOD	CROPS / PRODUCTS	HOW IT IS GROWN	WHAT IT EXCHANGES
Recirculating hydroponic / soilless	Greens, herbs, strawberries, tomato, cucumber, propagation	Pumped nutrient loops; capillary mats or porous media; active root aeration; trellises; robotic vibration or air-pulse pollination	Crew CO2 + recovered water + mineralized nutrients -> food, O2 and condensate
Living-soil terraces	Grains, pulses, tubers, roots, oilseeds, shrubs, medicinal and fiber crops	Replaceable soil cassettes; rotations; cover crops; nitrogen fixers; mycorrhizae; controlled gravity cascade	Compost + conditioned Mars minerals -> food, fodder, soil carbon and fungal substrate
Aquaponic / wetland beds	Duckweed, algae, wetland foods and optional fish or invertebrates	Solids capture; nitrification and mineralization; oxygenated recirculation; plant-root polishing; feed-balanced stocking	Nutrient-rich water -> aquatic food, plant biomass and cleaner return water
Fungi + fermentation	Mushrooms, mycoprotein, tempeh, koji, pickles, cultured soy and flavor bases	Defined substrates or vessels; identity controls; automated temperature, humidity, aeration and harvest timing	Crop residues and food surplus -> protein, flavor, preservation and compost feedstock

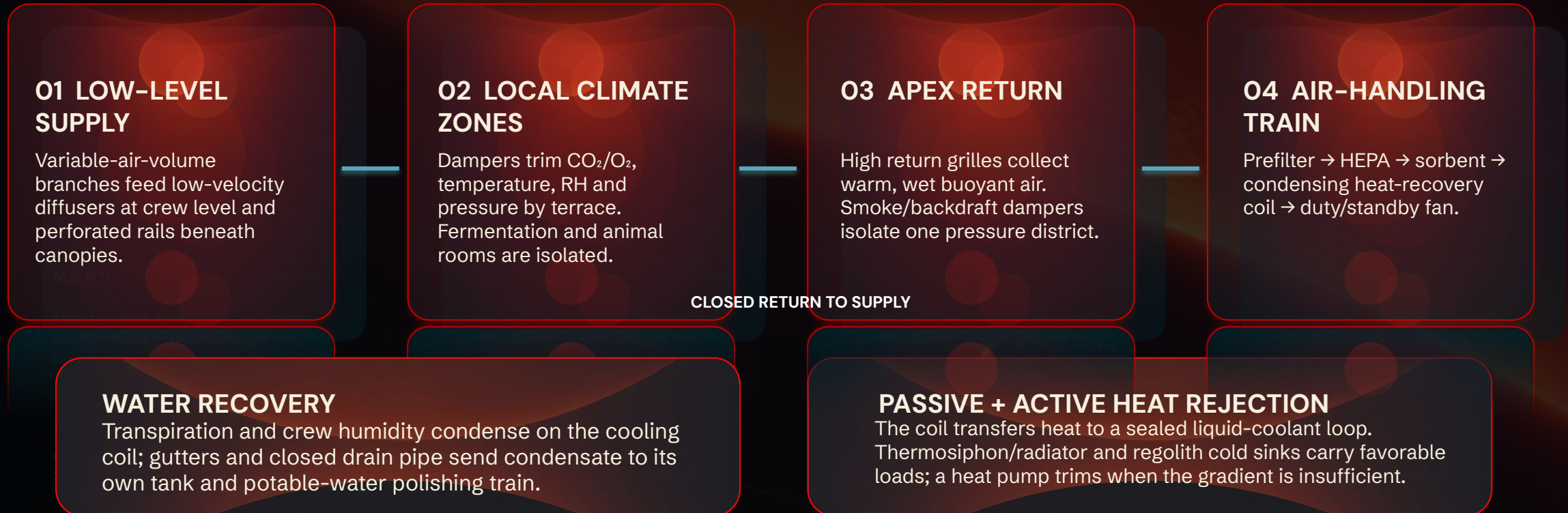
Regolith and Martian ice enter RAMS through a sealed refinery

Ice-rich material, soluble toxins and mineral feed are handled outside the food pressure volume. Each train reduces bulk, captures a useful fraction, and returns either a tested product or a contained residue.



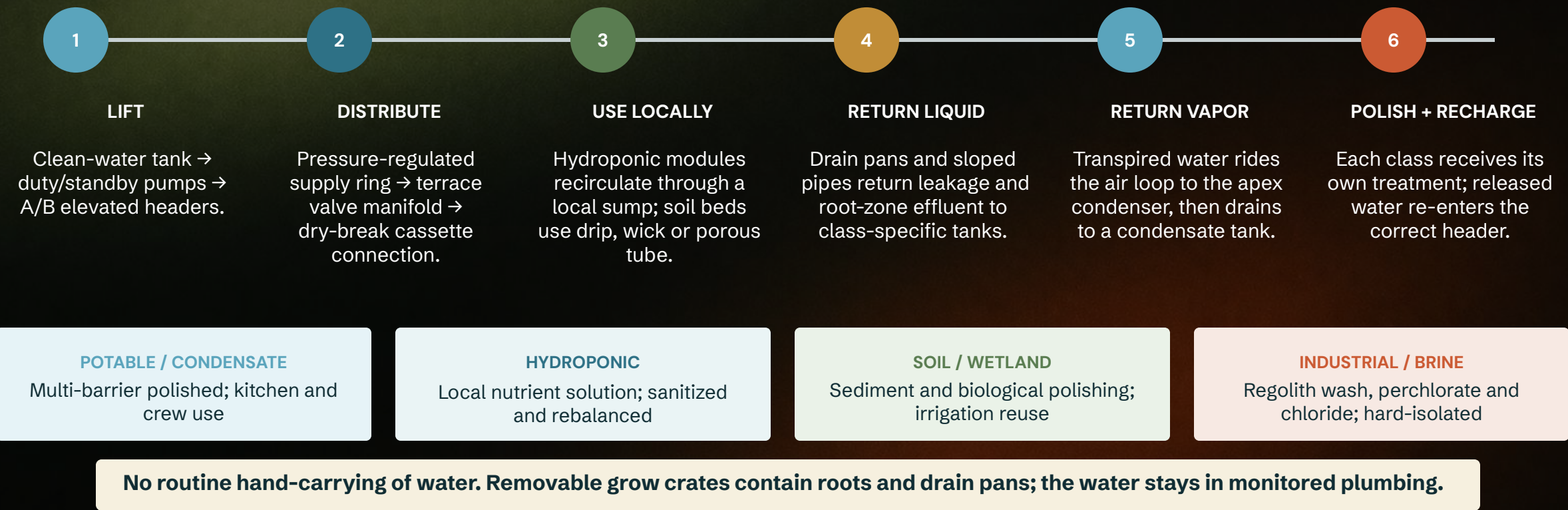
Climate is controlled through a variety of mechanisms.

The habitat air loop controls leaf boundary layers, crew comfort, humidity, spores and pressure while a separate coolant loop rejects heat outdoors.



Water rises once, then returns as liquid and vapor

The vertical habitat becomes a hydraulic circuit: redundant pumps charge elevated clean-water headers; regulated pipes feed each terrace; local loops recirculate; drains and condensate return water by quality class.



Safety preserves metabolic function by isolating the smallest confirmed fault domain

01

PREVENT

Stable shared headers |
clean stocks | bypass
capacity | design
margins | welfare gates

02

DETECT

Redundant sensors |
batch identity |
digital-twin forecasts |
robotic and crew
observation

03

CONTAIN

Close the affected
branch | keep healthy
circulation online | load
shed only where
required

04

RECOVER

Use reserves | repair
locally | verify chemistry
and biology | reconnect
in controlled stages

Crew comfort is a production requirement

The 14-sol menu is the human interaction point to the ecology at large: every harvest can be prepared for nutrition, symptoms, hydration, sensory desire, culture, and emotional regulation. Human needs are considered as central to the success of a meal / eating plan and agricultural endeavor on Mars.

INDIVIDUAL PLATE ENGINE

- 1 Energy follows body mass, activity, EVA, recovery and appetite—not a gender multiplier.
- 2 Iron, folate, B12 and blood-loss planning follow physiology, menstrual status, pregnancy/lactation, labs and actual diet.
- 3 Protein, calcium, vitamin D, sodium, potassium, fluid and texture adjust to training, renal/cardiac status, symptoms and medications.
- 4 Culture, religion, aversion, craving and sensory form remain visible constraints; acceptance is measured, not assumed.

RECIPE-LEVEL CONDITION ADJUSTMENTS

- | | |
|--------------------------|---|
| Dry mucosa / airway | Steamed lily or Ophiopogon; pear; Tremella/Poria soup; warm broth. |
| Nausea / low appetite | Ginger or muña; low-odor warm portions; split servings. |
| Digestive upset | Congee, rice broth, ginger/Poria; measured electrolytes; medical ORS stays exact. |
| Radiation / inflammation | Turmeric-amlā, sea buckthorn, mushrooms, colorful grains and berries. |
| Sleep / stress | Chosen comfort meal; evening Centella, jatamansi or valerian preparation when selected. |

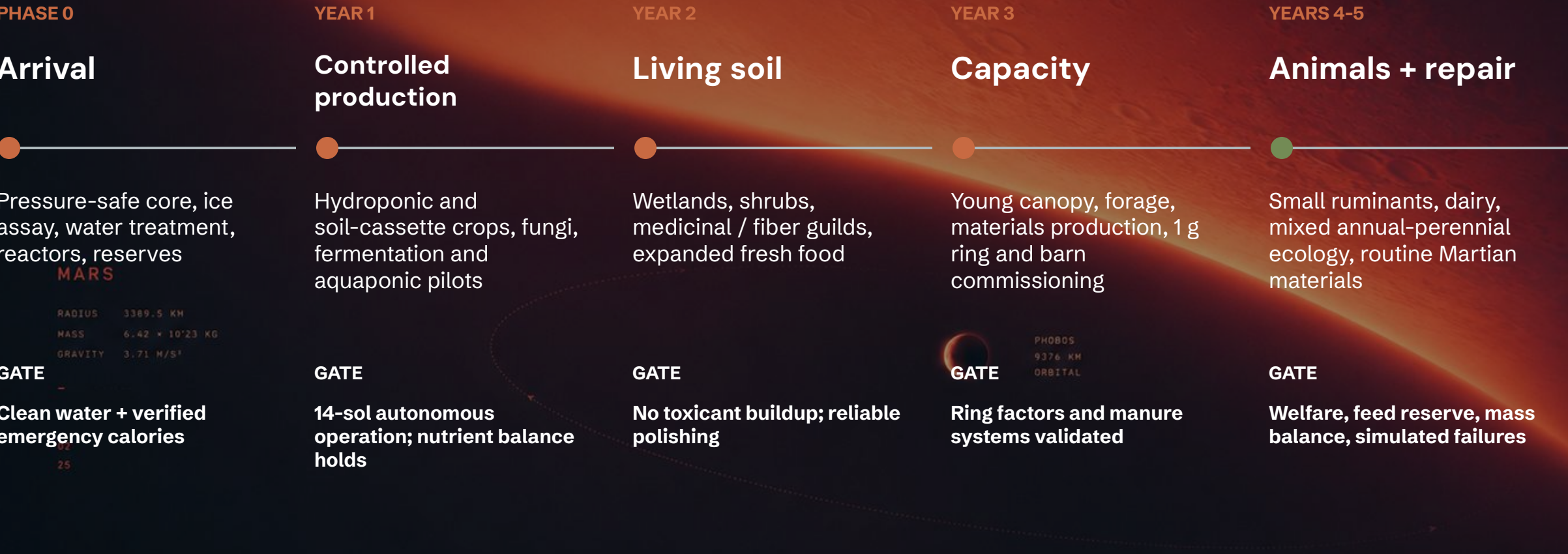
Steamed foods, soups, congee, dumplings, sauces and stewed fruit carry water through food. Early menus deliberately retain Earth-provisioned cheese, SPAM and other processed meats, frozen chicken, powdered egg, dehydrated milk, flours, pasta, pizza components and ferments for familiarity and redundancy.

Sensors keep shared loops balanced and predict when a local branch needs service

DOMAIN	MEASURE	PREDICT / DETECT	ACTION
Atmosphere	Pressure, O2, CO2, humidity, temperature, VOCs, smoke, leaks	Seal drift, condensation, fire, poor circulation	Rebalance shared air; isolate only the affected branch
Water + minerals	Flow, conductivity, pH, redox, salts, chloride, perchlorate, metals, turbidity	Fouling, contamination, brine accumulation	Reroute, polish, replace media
Crops + microbes	Moisture, O2, nutrients, root-zone salinity, imaging, pests, identity	Yield loss, disease, nutrient drift, contamination	Adjust recipe; bypass affected bed; treat or reseed
Animals + people	Feed / water intake, movement, body condition, health, workload, appetite	Welfare decline, underconsumption, recovery gap	Clinical or husbandry intervention
Structure + machinery	Lidar, strain, crack acoustics, seal pressure, vibration, thermal cycle, motor current	Fatigue, misalignment, bearing and panel failure	Schedule repair before loss of function

OBSERVE -> ESTIMATE -> FORECAST -> AUTHORIZE -> ACT -> VERIFY -> LEARN

Five-year path to self-cycling ecology



Scale by repeating modules while shared metabolic headers keep exchanging resources

01

PRESSURE DISTRICTS

Small replaceable cells, shutters, double seals, service corridors

Contain leaks; commission in verified increments

02

PRODUCTION CARTRIDGES

Hydroponic racks, soil cassettes, berry units, fermenters and wetland cells

Bypass one unit while shared air, water, heat and nutrient headers continue

03

UTILITY SKIDS

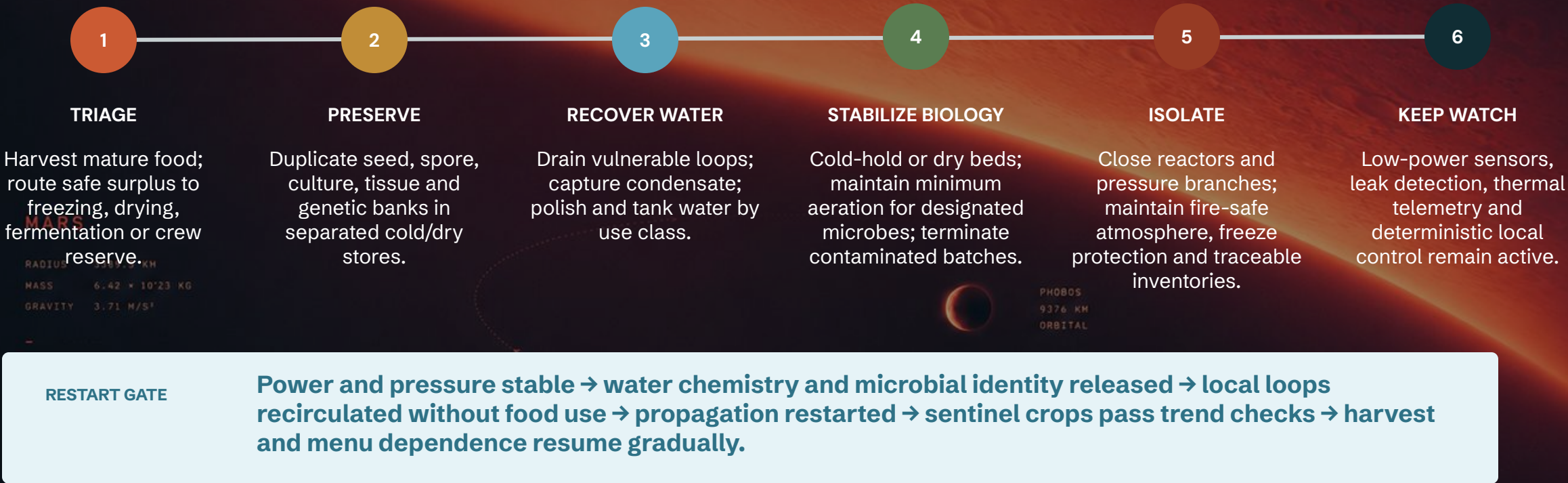
Water polishing, nutrient dosing, heat recovery, sensing and cold storage

N+1 services, robotic replacement and local emergency operation

Future evolution changes the mix of modules while preserving the same interfaces, release criteria, and safety logic.

Safe shutdown preserves the next harvest

Shutdown may be planned, forced by a long power shortfall, or limited to one branch. The objective is a recoverable biological state—not merely an electrically quiet facility.



A living Martian metabolism – designed to circulate, not to segregate.

Share resources by default. Condition every branch. Isolate only the fault. Let people participate because they want to.