NASA SPACE APPS CHALLENGE 2026 · FINAL COMPETITION RELEASE

MITOCHONDRIA

Astronaut Health Intelligence Platform

Master Operations & Technical Manual

Final Competition Edition · 14 November 2026

Live application: https://mitochondria.edocinfo.com

Open source: https://github.com/computech-gr/astro-vitality-core · Apache License 2.0

A functional, integrated, open-source astronaut health intelligence research platform

Research prototype with human oversight. Synthetic data only. Not endorsed, certified or operated by NASA. Not clinically validated and not a medical device. Not flight-qualified. Not connected to NASA astronaut telemetry.

01. Document Control and Audience

Document	MITOCHONDRIA — Master Operations & Technical Manual
Edition	Final Competition Edition · public presentation 14 November 2026
Repository baseline	github.com/computech-gr/astro-vitality-core, branch `main`, release commit `4e448ea7873b0e9a1120f43bd0fd76fb928c1c54` (“Applied P53 evidence patch”). The supplied source archive is identical to this commit in every file it contains (compared file by file).
Release scope	All implemented work up to and including the P53 milestone: four integrated health domains, Unified Data Intake and universal medical-document parsing, the Astronaut Health History Report, the Daily Health Companion, Crew Self revalidation, the canonical evidence projection, the Ground Medical Workspace with fail-closed revalidation and stale-response protection, the CI repairs of P52/P52.1 and the P53 evidence-readiness register. Milestone identifiers appear only in Appendix E.
CI evidence on the release commit	GitHub Actions on `4e448ea`: Quality #338 — success (1 min 30 s); Security Scan #326 — success; Medical v3 Release Gate #75 — failure by design, because the owner-evidence gates P3663 (restore evidence), P3664 (owner risk acceptance) and P20 (official 2026 rules) remain blocked. The manual P47 Competition Submission Validation workflow has not been re-run on this commit. See Section 32.1.
Purpose	Complete operational and technical reference for NASA Space Apps Challenge 2026 evaluators and for technical, scientific and security reviewers
Companion documents	NASA Evaluator Quick Start Guide (FINAL) · NASA Space Apps 2026 Presentation (FINAL) · NASA Demo Video (final MP4) and its production documentation · Scientific Evidence and Limitations summary · narrated presentation (PPTX)
Live application	https://mitochondria.edocinfo.com
Source code	https://github.com/computech-gr/astro-vitality-core · Apache License 2.0
Authoritative sources	The application repository at the commit above, including its source-controlled validation, scientific-governance and submission ledgers; the Astronaut Biomarker Matrix v1.1; the Bone Health Handbook v7; the Cardiovascular Handbook (expanded biology); and Nikolas' immune and behavioural developer handbooks
Supersedes	All earlier editions. The filename is unchanged so that the existing “Master Technical Manual (PDF)” menu link continues to work.

1.1 Audience

Table 1. Intended readers

Reader	Use this manual for	Start at
NASA Space Apps evaluators and judges	Understanding the platform, its evidence and its boundaries; running the demonstration	Sections 02–04, 29, 35 and the Evaluator Guide
Mission Operators (synthetic missions)	Mission set-up, crew, invitations, settings, audit, demonstration launchpad	Sections 09–13, 17, 34
Crew Self participants (synthetic)	Sign-in, Daily Health Companion, Unified Data Intake, Health History Report, live capture, readiness, documents, guidance	Sections 09, 14, 18–23

Reader	Use this manual for	Start at
Ground Medical reviewers (synthetic)	Ground Medical Workspace: mission snapshot, eight-value synthetic batch review, research-only decisions, session safety	Sections 15, 24, 31.4
Researchers	Research Privacy Workspace (aggregate-only export), scientific sources, NASA OSDR metadata	Sections 15.4, 24–25, 37
Software engineers and self-hosters	Architecture, stack, installation, data model, CI, contribution	Sections 05–08, 30, 32, 36
Scientific and security reviewers	Evidence levels, pending verification, traceability	Sections 04, 25, 31–32, 37, 39

1.2 Capability status labels

Every capability in this manual carries one of six status labels. The same labels are used in the Evaluator Guide and the presentation.

Table 2. Status labels

Label	Meaning
OPERATIONAL	Implemented, reachable in the live application and covered by the automated test suite.
FIELD-VERIFIED	Operational and additionally observed in production use or on a physical device, as recorded in the repository.
SYNTHETIC DEMONSTRATION	Works only on generated, fictional data, by design.
RESEARCH-ONLY	Scientific reference or descriptive analysis with no operational, clinical or alerting effect.
VALIDATION BOUNDARY	Engineering work is complete; an independent acceptance, scientific review or security sign-off remains outside the evidence of this release.
OUT OF SCOPE	Specified (for example as an adapter contract) but not implemented in this release.

Independently of the status label, every claim in this edition is assigned one of four **evidence classes**. The same classes are used in the Evaluator Guide, the presentation and the demo-video production package.

Table 3. Evidence classes used across all four competition deliverables

Class	Meaning	Typical evidence
E1 — Implemented and verified	Implemented in the release source and verified with real authenticated sessions, a real database or the live public site	Live-site observation; disposable PostgreSQL integration suites; development-environment runs against real crew accounts; physical-device records
E2 — Synthetic or simulated only	Implemented, but exercised only with synthetic fixtures, stubbed responses or simulated browser events	Browser scripts with stubbed membership/evidence; simulated tab visibility; hard-coded illustrative series
E3 — Not independently verified	Implemented and reported working by the developer or owner, without independent or reproducible acceptance evidence in the repository	Owner-reported signed-in checks; development-environment reports without exact-commit CI
E4 — Planned or experimental	Specified, staged, disabled by default or explicitly not authorized for production	Pending migrations; server flags left unset; adapter contracts; roadmap items

Figures marked as screen images are unedited captures of the public view of the live application, taken before sign-in. Views that require a role-holding account are described in text and shown during the live demonstration; no screen image in this manual is simulated.

Some pages display a short module label above the page title (for example “P17 · Simulation & synthetic mission dataset”). These labels identify the software module; this manual refers to every page by its title.

SAFETY BOUNDARY — MITOCHONDRIA is an independent open-source research prototype built for the 2026 NASA International Space Apps Challenge. It is **not** NASA-approved, endorsed, sponsored or operated; **not** clinically certified or validated; **not** operationally flight-qualified; and **not** connected to NASA astronaut telemetry. NASA OSDR metadata shown by the platform is published research metadata, not crew data. Clinical activation is disabled throughout the platform.

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02. Executive Overview and Platform Objectives

MITOCHONDRIA is a functional, integrated, open-source astronaut health intelligence research platform. It demonstrates how multimodal physiological signals, personal baselines, scientific interpretation, offline mission operations and human-supervised workflows can support future space health research.

The platform runs in the browser and works offline first. It brings physiological signals, synthetic laboratory evidence, cognitive and behavioural self-reports and spacecraft environment context into one vendor-neutral, provenance-preserving data model, organised by mission and by mission-scoped role. Its governing rule is that missing, poor-quality, synthetic or research-only evidence stays visibly labelled and is never silently converted into a health conclusion.

2.1 Platform objectives and how they are met

Table 4. Objectives and status

Objective	How the platform delivers it	Status
Keep the health loop working without Earth	Encrypted local store, store-and-forward synchronization and cached protocols (Sections 26–27)	OPERATIONAL; airplane-mode device validation pending
Personal rather than population interpretation	Versioned, phase-aware personal-baseline engine; descriptive history in the product (Section 22)	Engine OPERATIONAL; persisted profiles OUT OF SCOPE
Explain, never diagnose	Reviewed pattern catalogue, evidence coverage and attention states (Section 24)	RESEARCH-ONLY
Device-agnostic integration	Adapter SDK; Camera PPG, phone motion and Web Bluetooth in the browser; native host-bridge contracts (Sections 18–19)	FIELD-VERIFIED (camera, motion); OUT OF SCOPE (native hosts)
Mission-scoped governance	Four roles enforced in PostgreSQL with row-level security, governed functions, audit and separation of duties (Sections 09–11, 31)	FIELD-VERIFIED
Human-reviewed evidence intake	Mission Documents → synthetic Cloud batch → independent Ground Medical research decision (Sections 14–15)	OPERATIONAL; live acceptance VALIDATION BOUNDARY
Reproducible open source	Apache-2.0, self-hosting, CI quality and security workflows (Sections 07, 36)	FIELD-VERIFIED (independent reproduction recorded)
Support the astronaut day to day	Daily Health Companion: five mission environments, routine checklist, optional foreground reminders, read-only personal trends with source and quality (Section 14.5)	OPERATIONAL; real-account trend projection reported by the development environment; physical-phone notification test VALIDATION BOUNDARY
Protect private data during long sessions	Fail-closed revalidation on tab return, sign-in change and mission switch; stale-response rejection; private-data clearing (Section 31.4)	OPERATIONAL; signed-in revocation acceptance VALIDATION BOUNDARY

2.2 Platform highlights

- **Mission Console** with five grouped menus (Mission Console, Health & Intelligence, Science, Technology, About & Open Source) and global search (Ctrl/⌘+K).
- **Live monitoring** that separates identity, device transport, physical samples and encrypted storage, and never fabricates a reading.
- **Offline-first operation:** every capture is encrypted on the device before anything else, then synchronized only through an authorized, idempotent server function.
- **Evidence intake:** a Crew Self Mission Documents workbench extracts exact catalogue matches from synthetic laboratory reports in the browser and can submit reviewed values as a pending-review batch.
- **Independent review:** Ground Medical members review pending synthetic batches read-only and record a final, research-only decision with a database receipt.
- **Health Intelligence Research Explorer:** a searchable, filterable, read-only view of 54 provisional scientific semantic proposals derived from Nikolas' immune and behavioural handbooks — with zero independent approvals and zero operational activations by design.
- **Science surfaces:** English display of the Bone (63 variables) and Cardiovascular (96 measurements) handbooks with the original Greek preserved; immune and behavioural draft catalogues (35 + 36 proposals); NASA OSDR study metadata import.
- **Daily Health Companion:** five selectable mission environments, a four-item routine checklist, optional user-chosen foreground reminders, a clearly labelled synthetic trend demonstration and — for an authorized Crew Self member — read-only personal trends with source, unit, time-window filters and data-quality colours.
- **Unified Data Intake and Astronaut Health History Report:** one review workflow for manual entry, CSV, PDF and scanned documents (up to 20 files per batch, processed on the device), and a locally generated, research-only history report with A4 PDF and text export.
- **Ground Medical Workspace:** read-only review of pending synthetic batches (for example the eight-value batch of the synthetic crew FV01-TEST-B) with a research-only decision and receipt; private rows are hidden while authorization is re-checked, and stale responses are discarded.
- **Research Privacy Workspace:** researcher and Ground Medical access to an aggregate-only export with server-side suppression (at least three contributing crew and ten events; counts rounded down to tens).
- **Demonstration support:** an operator Synthetic Mission Demo Launchpad with a ten-step journey, runbook, fictional dataset, offline report and verifiable bundle.

2.3 What the platform deliberately does not do

- No diagnosis, treatment prescription, fitness-for-duty verdict, readiness score, flight-rule change or automatic medical escalation.
- No clinical thresholds: personal baselines, clinical reference intervals and mission limits stay separate, and none triggers alerts by itself.
- No administrator super-role: Mission Operator membership administers missions but is not a platform administrator grant.
- No promotion of reviewed synthetic batches into health records, timelines or reports.
- No live NASA astronaut data and no real astronaut or patient data in the repository or demonstrations.

03. NASA Space Apps Challenge Context and Problem Statement

Challenge addressed	NASA International Space Apps Challenge 2026 — “Create Health Monitoring Software for Astronauts on Space Missions” (as referenced in the application)
Challenge page	https://www.spaceappschallenge.org/2026/challenges/health-monitoring-software/ (the link used by the application)
Team	The Mitochondria — Nicosia, Cyprus local event. Nikolaos Silvestros (team owner), Andriani Christoforou, Freideriki Polyxeni Sopikioti, Eleftheria Stavraki, Theodore Silvestros. Team page: /competition/team; official team profile on the Space Apps site.
Interpretation	Long-duration missions expose crews to radiation, isolation and confinement, altered gravity and a hostile, closed environment that affect immune, bone, cardiovascular and behavioural health. Software should gather health indicators and let astronauts evaluate and act on their health.
Product thesis	An open-source, offline-first platform that combines physiological, biological, cognitive, behavioural and environment data, learns each astronaut’s personal baseline, detects meaningful multi-signal deviations and provides explainable, protocol-linked actions — even when disconnected from Earth.

3.1 Problem statement

As distance from Earth grows, real-time ground medical support becomes delayed or unavailable; NASA lists distance from Earth among the five hazards of human spaceflight. Crew health data are fragmented across devices, laboratory reports, questionnaires and habitat telemetry; their quality, provenance and comparability are uneven; and population thresholds do not describe how an individual adapts in flight. A crew-facing tool must therefore work offline, keep evidence traceable and avoid overstating what any signal means.

3.2 Mission constraints that shaped the design

Table 5. Mission constraints and design responses

Constraint	Design response
Distance / delayed support	Local capture, review and protocol access never depend on the cloud
Intermittent connectivity	Store-and-forward queue with idempotency and explicit conflict states
Multiple devices and vendors	Adapter contract and canonical metric model
Artifacts and missing data	Quality levels, freshness states, no silent imputation
Physiological adaptation	Personal, phase-aware baselines
Closed spacecraft environment	Environment and radiation context on the same timeline, never causal
High-consequence decisions	Explainability, audit, explicit uncertainty and human authority
Open-source delivery	Synthetic data only, no secrets, reproducible deployment

04. Scope, Research Status and Safety Boundaries

4.1 Scope

Table 6. Scope boundaries

In scope	Out of scope
Browser capture, encrypted local storage, review and governed synchronization	Native mobile apps (Health Connect and HealthKit are host-bridge contracts)
Mission and crew identity with four mission-scoped roles enforced in PostgreSQL	Platform administrator super-role, role switching, impersonation
Synthetic laboratory-report review and synthetic Cloud batches	Real medical documents, document storage in the cloud, clinical health-record import
Research-only Ground Medical decisions on synthetic batches	Clinical approval, diagnosis, escalation, flight-rule decisions
Reference display of scientific handbooks and draft catalogues	Activating any pending scientific metric, unit, threshold or rule
Public NASA OSDR study metadata (research-only)	Live NASA crew feeds; binding research samples to crew

4.2 Maturity at a glance

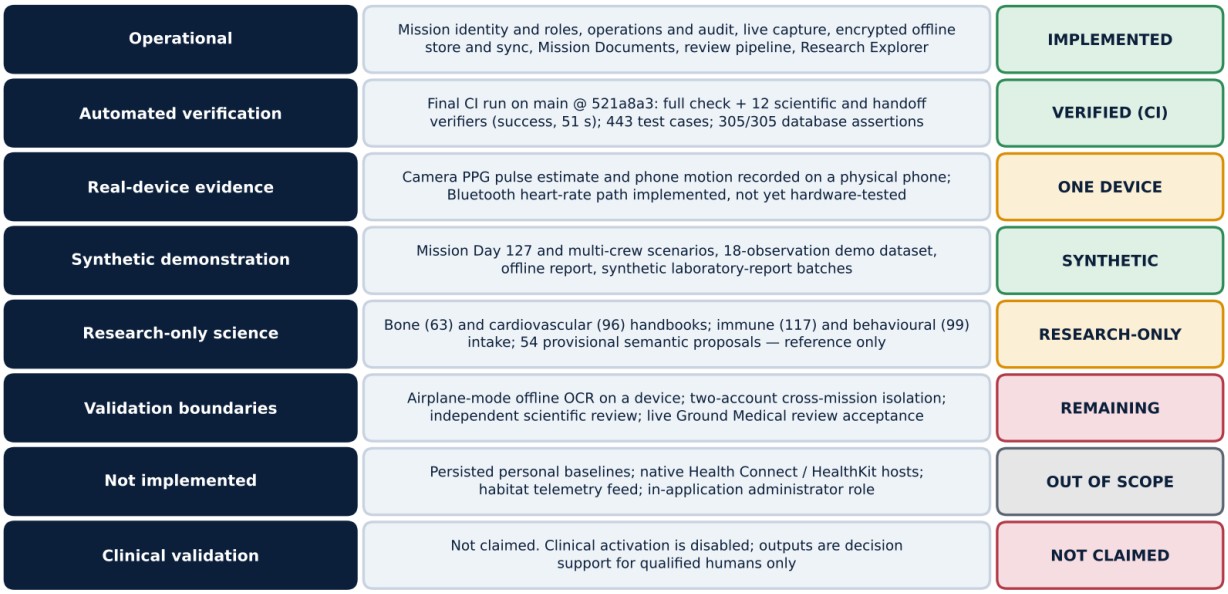


Figure 1. Capability maturity: what is operational, demonstrated, research-only, pending and planned

4.3 Research status of scientific sources

Table 7. Scientific source status

Scientific source	Status	Platform use
Astronaut Biomarker Matrix v1.1 (70 reviewed metrics encoded)	Implementation review by the team biologist; not clinical validation	Canonical catalogue (Section 25)
Bone Health Handbook v7 (63 variables, Greek original)	Pending independent review; English layer machine-assisted, pending review	Reference labels, bone entry and import, advisory document hints

Scientific source	Status	Platform use
Cardiovascular Handbook (96 measurements, 8 relationship examples, Greek original)	Pending independent review; reference-only; clinical activation off	Reference catalogue; 96 metric/unit pairs for synthetic review
Immune & microbiome (35) and behavioural, sleep & cognitive (36) draft catalogues	Pending independent scientific review	Read-only searchable proposal lists on the domain pages
Nikolas' immune (117 entries) and behavioural (99 entries) developer handbooks, plus 3 cross-domain contexts	Intake and reconciliation complete; owner reports a verbal scientific review by Nikolas; a signed per-entry review record is not yet recorded; independent review pending	Research-only intake data; reconciled against the draft catalogues (Section 25.3)
54 provisional semantic proposals (11 potential equivalences, 42 distinct components, 1 related assay)	0 independent approvals · 0 operational activations	Health Intelligence Research Explorer (Section 24.1)
Independent scientific review	VALIDATION BOUNDARY	No scientific approval is claimed

4.4 Safety boundaries

SAFETY BOUNDARY — Human oversight is mandatory. Outputs are decision support for qualified humans and never a diagnosis, prescription, readiness verdict or escalation.

Associations are never presented as causes. Personal-baseline deviations are never diagnoses. Self-assessment questionnaires are not validated clinical instruments in this implementation.

Synthetic datasets are never astronaut health evidence. A Ground Medical “accepted_for_research” decision means usable for research demonstration only — it is not medical validation.

For any real health concern, follow established mission medical and emergency procedures.

4.5 Validation boundaries (details in Sections 32.3 and 32.6)

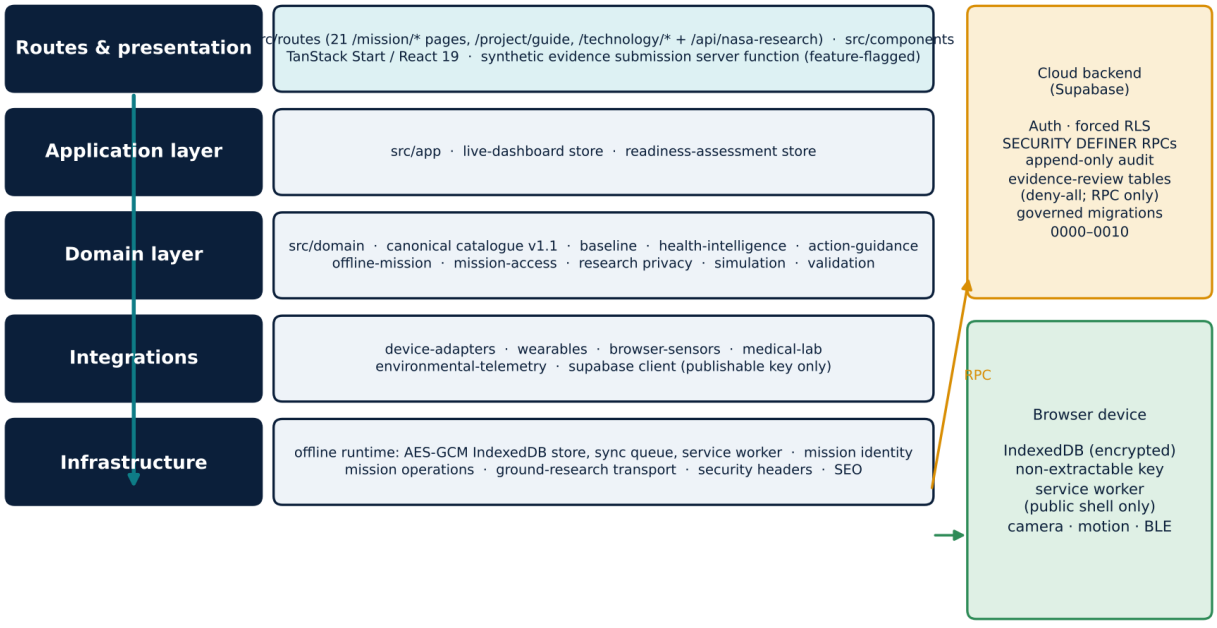
The software implementation is complete for this edition. The following boundaries describe evidence that lies outside it; they are stated so that no claim exceeds what has been demonstrated.

- Real-device offline OCR in airplane mode has not been demonstrated with timestamped evidence.
- Cross-mission isolation has been verified by database tests and single-account browser sessions; a negative test with two independent Crew Self accounts in different missions has not been performed.
- The 54 provisional biomarker proposals and the domain handbooks await independent scientific review; none is approved or activated.
- Live acceptance of the Ground Medical review workflow with independent reviewer accounts, and the human real-device acceptance cases, have not been executed.
- Ground Medical tab-return retention, fail-closed revalidation and stale-response protection are implemented in the release source and the fail-closed status texts are visible on the live site; a signed-in revocation test with two independent accounts is not recorded in the repository.
- Crew Self revalidation has been exercised with stubbed responses and simulated tab visibility; revocation while a tab stays continuously visible is detected only at the next tab return, sign-in change, mission switch or request — row-level security remains the enforcement point.
- The Medical v3 Release Gate stays red by design until the owner-evidence gates P3663, P3664 and P20 are closed with genuine evidence (Section 32.1).

- Not clinically validated, not a medical device, not flight-qualified, not deployed with astronauts; synthetic data only.

05. System Architecture and Component Interactions

MITOCHONDRIA is a TanStack Start (React 19) web application with server-side rendering and a Supabase backend hosted on Lovable Cloud. The browser holds the critical health loop — adapters, canonical normalization, an encrypted IndexedDB store and the synchronization queue. The cloud boundary — authentication, row-level security and SECURITY DEFINER functions — sits outside the sensor-to-astronaut path, so the crew-facing loop keeps working when the link to Earth does not.



Source: repository architecture documentation and src/ tree

Figure 2. Layered architecture

Table 8. Component responsibilities

Layer	Responsibility	Key locations
Routes & presentation	25 `/mission/*` pages, `/competition/team`, `/competition/demo-video`, `/project/guide`, `/technology/*`, home; three API routes: `/api/nasa-research`, `/api/medical-document-extraction` and `/api/medical-ai-draft` (both medical routes default-deny and disabled unless their server flags are set)	src/routes, src/components
Server functions	Synthetic evidence submission and saved-review history; Crew Self synthetic intake (default off); synthetic research administration and guarded synthetic Q&A (policy paused, production not authorized). All execute as the signed-in user (never the service role) behind server-side feature flags	src/lib
Application	Live dashboard store, readiness store	src/app
Domain	Catalogue, baseline, health intelligence, action guidance, offline contracts, mission access and demonstration, biomarker registry, NASA research, localization, navigation search	src/domain
Integrations	Device adapter SDK, wearables, browser sensors, medical-lab, environment/radiation, Supabase client (publishable key)	src/integrations
Infrastructure	Encrypted offline runtime and sync, identity, operations, ground research, ground medical review, security headers, SEO	src/infrastructure, src/security

Layer	Responsibility	Key locations
Database	Forced-RLS tables, governed RPCs, append-only audit, evidence-review tables (deny-all, RPC-only)	supabase/migrations, drizzle/migrations

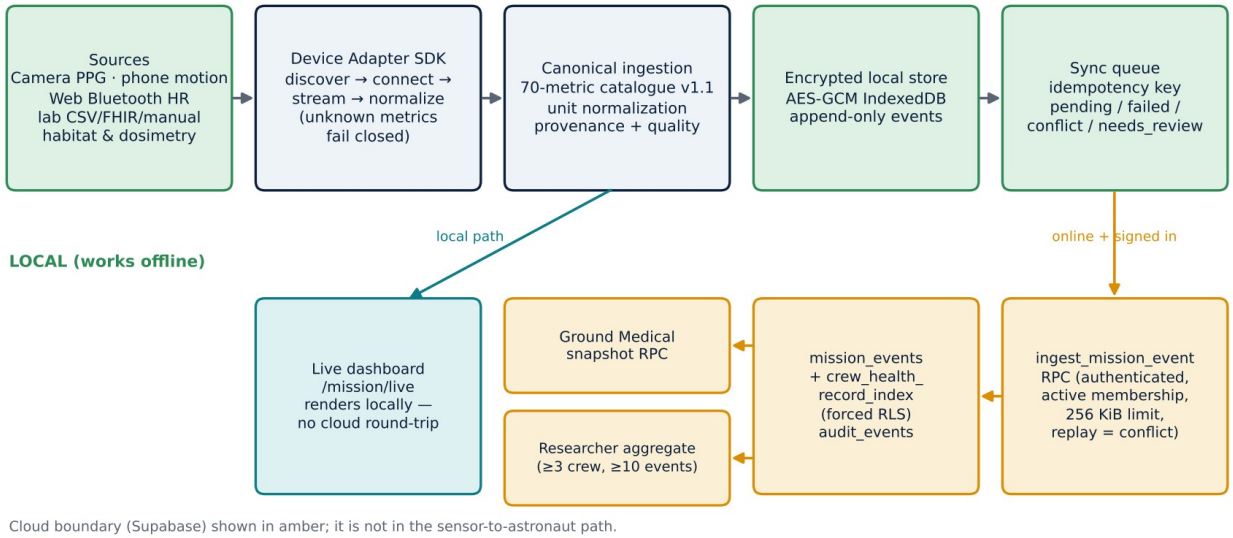


Figure 3. Health-data flow: local first, governed cloud boundary second

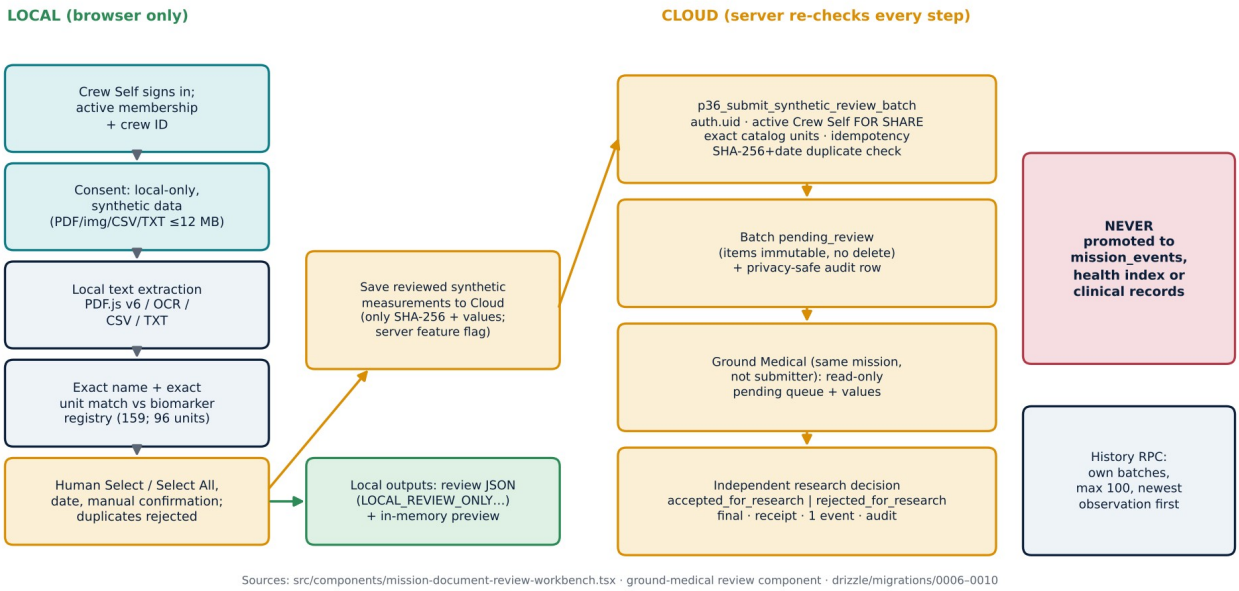


Figure 4. Synthetic document-to-review pipeline: local extraction → Cloud batch → independent research decision

5.1 Key component interactions

Table 9. Interactions

Interaction	Path	Authorization point
Live capture	Adapter → canonical ingestion → encrypted append → live store	Local; mission-bound only with an active Crew Self membership and crew ID

Interaction	Path	Authorization point
Synchronization	Queue → `ingest_mission_event` → `mission_events` + `crew_health_record_index` + `audit_events`	Function checks auth.uid(), active membership, crew assignment and mission lifecycle
Synthetic document batch	Workbench → server function → synthetic review-batch submission function	Server flag; the database re-checks Crew Self membership, catalogue units and idempotency
Ground Medical review	Review panel → pending-queue, batch-detail and decision functions	Active Ground Medical in the same mission, different user from the submitter
Mission administration	Operations console → workspace, create, update and invitation functions	Active Mission Operator
Audit viewer	`get_mission_audit_log`	Active Mission Operator; allow-list redaction
NASA OSDR metadata	Browser → `/api/nasa-research` → fixed NASA origin	No credentials; bounded, validated, nothing persisted

06. Technology Stack, Repository Organization and Dependencies

Table 10. Technology stack (package.json)

Component	Version	Notes
React	^19.2.0	User interface
@tanstack/react-start / react-router	1.168.60 / 1.170.41	SSR framework and file-based routes
Vite	8.1.5	Build
TypeScript	^5.8.3	`bun run typecheck`
Tailwind CSS	^4.2.1	Styling
@supabase/supabase-js	^2.116.0	Authentication and RPC (publishable key only in the browser)
pdfjs-dist	^6.4.299	Local PDF text extraction (patched release)
tesseract.js	^6.0.1	On-device OCR fallback (English)
zod	^3.25.76	Validation
Dependency overrides	@modelcontextprotocol/sdk 1.32.1; js-yaml 4.3.2; source-map-js 1.2.2; rolldown 1.2.1	Pinned patched releases
Runtime / package manager	Bun 1.x (`bun.lock`)	Node.js used transitively

6.1 Repository organization

Table 11. Repository layout

Path	Content
src/routes	File-based routes (`mission.*.tsx`, `project.guide.tsx`, `technology.*.tsx`, `api.nasa-research.ts`)
src/components	Page and panel components (mission document workbench, ground medical review, demo launchpad and others)
src/domain	Pure domain logic and contracts (no I/O)
src/infrastructure, src/integrations, src/lib, src/security	I/O, adapters, server functions, security headers
supabase/migrations	Baseline SQL migrations from bootstrap onward
drizzle/migrations	Governed migration history 0000–0010
supabase/pending	Staged copies and manual rollback scripts; never applied automatically
data/scientific, data/validation, data/submission, data/synthetic	Source-controlled catalogues, ledgers and fixtures
docs	Architecture, security model, operational and design records
tests (101 test files)	Unit, domain, navigation, security, identity, mission, documents and PostgreSQL integration suites
scripts	Verification gates, bootstrap, PostgreSQL integration harness, release verifiers

Path	Content
.github/workflows	quality.yml, security.yml (Trivy), release-candidate.yml

07. Installation, Prerequisites, Configuration and Deployment

7.1 End-user prerequisites

Table 12. Browser requirements

Requirement	Detail
Browser	Current evergreen browser with JavaScript, IndexedDB and Web Crypto. English user interface.
Secure context	HTTPS (or localhost) for camera, motion, Web Crypto and Web Bluetooth
Camera PPG	Rear camera, permission and fingertip contact; Permissions-Policy allows the camera for the same origin
Motion	DeviceMotion support; some platforms prompt; a clear startup error appears if no usable events arrive
Web Bluetooth	Chromium-class browser, operating-system Bluetooth and a standard Heart Rate Service sensor; not available on iPhone/WebKit
Network	Not needed for local capture and review once loaded; needed for sign-in, password change, Cloud saving, NASA OSDR and synchronization

7.2 Local development and self-hosting

1. Install Bun 1.x, Git and (optionally) Docker with Docker Compose and the Supabase CLI.
2. Clone the repository and run `bun install --frozen-lockfile`.
3. Run `bun run setup:local` to bootstrap a local Supabase stack and environment file.
4. Run `bun run dev` for the development server, or `bun run docker:up` for the self-hosted build (`bun run docker:down` to stop).
5. Run the full gate `bun run check` (verifiers, security audit, tests, typecheck, lint, format check, build) before proposing any change.
6. Optional: `bun run sample:release` for a deterministic Mission Day 127 sample.

NOTE — An independent reproduction on Ubuntu/WSL is recorded in the repository: frozen install, full check, local Supabase from scratch, Docker self-hosting and smoke tests all passed.

7.3 Production deployment model

- Hosting and database: Lovable with Lovable Cloud (Supabase). Publication is controlled by the project owner.
- Database changes are applied only through the governed migration mechanism, once each, with a recorded SHA-256 fingerprint (Section 30.2). Staged SQL in `supabase/pending/` is never applied automatically.
- Synthetic Cloud saving of reviewed document values is controlled by a server-only feature flag; when it is off, the workbench shows a clear pending-activation state and local review continues to work.

08. Environment Separation, Credentials and Secret Management

Table 13. Environments

Environment	Purpose	Rule
Production (Lovable Cloud)	Live application with synthetic missions	Governed migrations only; owner approval per migration
Disposable PostgreSQL 17.9	Integration tests for RLS, triggers and concurrency (`tests/integration-pg/*.sql`)	Throwaway database; staged SQL is exercised before approval
Local Supabase	Development and self-hosting	Synthetic data only

8.1 Credentials and secrets

- Only the Supabase publishable key reaches the browser; service-role keys, database passwords and tokens are blocked from bundles and tracked source by `bun run security:audit`.
- The synthetic submission server function uses the signed-in user's bearer token, **never** the service role.
- Feature flags and owner approval records are server-side or held privately; they never appear in browser bundles or in the repository.
- Invite codes, bootstrap secrets, passwords and decision idempotency keys are never pasted into tickets, logs, screenshots or documentation.
- The CI security workflow pins its third-party actions to immutable commit SHAs with read-only permissions and no persisted credentials.

SECURITY — This manual publishes **no** credentials, passwords, invite codes or private approval records. Evaluators receive synthetic role accounts from the project owner through an approved channel.

09. Authentication, Authorization and Mission-Scoped RBAC

Authentication (who you are) is provided by Supabase Auth. Authorization (what you may do) is always evaluated inside PostgreSQL from `mission_memberships`, through forced row-level security and SECURITY DEFINER functions that check `auth.uid()` and an **active** membership in the requested mission. The browser only mirrors these rules to decide what to show; navigation is never authorization.

9.1 Screen — Mission Identity & Sign-in

Screen name (as rendered)	Mission identity & governed cloud access
Verified route	/mission/identity
Navigation path	Mission Console → Mission & crew → Mission Identity & Sign-in
Authorized role(s)	Public page. Sign-in, account creation and magic link: anyone. Join a mission and Change password: signed-in users. Operator invite issuance: active Mission Operator. First mission activation: deployment bootstrap only.
Purpose	Sign in, create an account, change your password, redeem one-time invites and choose the active mission membership used by crew-facing pages.
Prerequisites	HTTPS; browser-safe Supabase configuration present (otherwise “Cloud identity configuration is unavailable.”).
Capability status	FIELD-VERIFIED for sign-in and membership selection (recorded production use); OPERATIONAL for password change, inline sign-in feedback and invitation feedback.

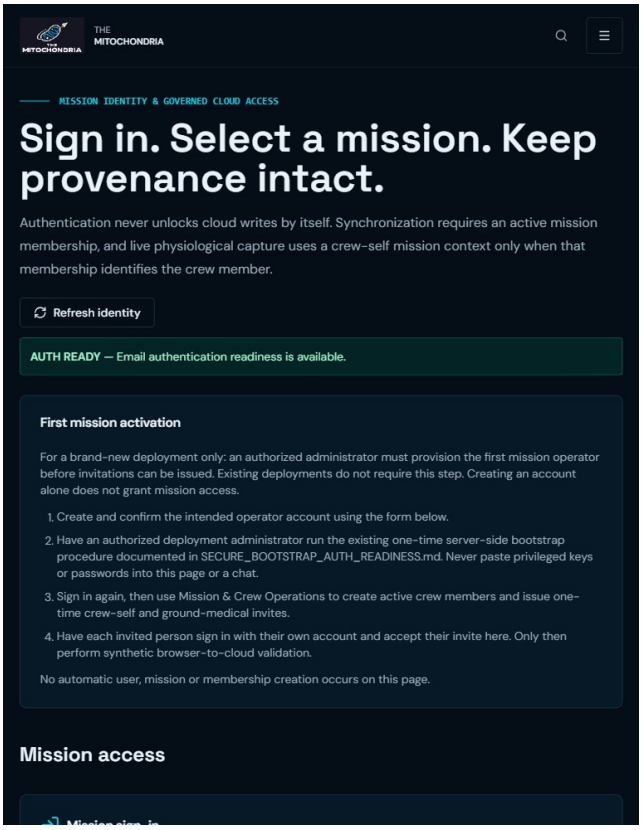


Figure 5. Mission identity & governed cloud access — public view of mitochondria.edocinfo.com/mission/identity (before sign-in: authentication readiness and first-mission activation panel). Unedited capture, 765 × 990 px.

> **FURTHER VIEW —** Scrolling or interacting with the page shows the signed-in summary (Identity AUTHENTICATED, active memberships and live sensor context) with membership cards, one marked ACTIVE.

Table 14. Mission identity & governed cloud access — controls and inputs

Visible control / input	Expected input format and behaviour
Auth readiness banner	AUTH READY · AUTH READINESS UNKNOWN · CONFIGURATION REQUIRED (probe of `/auth/v1/settings`)
Email	Required; must match `name@domain.tld`; inline: “Please enter your email address.” / “Please enter a valid email address.”
Password	Required for sign-in (“Please enter your password.”); ≥ 12 characters for account creation
Sign in / Create account / Email magic link	Buttons; magic link needs email only
Inline sign-in alert (under Password)	Generic “Incorrect email or password. Please try again.” for unknown accounts and wrong passwords; other mapped messages: “Too many attempts…”, “Please verify your email address before signing in.”, “Unable to connect…”. Email kept, password cleared, alert cleared on edit.
Membership cards	Mission code/name, role badge, mission and crew IDs; click to make ACTIVE
Join a mission → One-time invite code + Accept invite	Paste code; button shows “Accepting…” and is disabled while pending; inline success/failure message; memberships refresh on success
Change password → Current password, New password, Confirm new password, Update password	Online only; new ≥ 12 characters, must match confirmation and differ from current; current password verified first; “Updating password…” while running
Operator invite issuance	Role, crew member (for Crew Self), Create one-time invite — see Section 11
First mission activation (no memberships only)	First mission code, First mission name, One-time bootstrap secret (≥ 32 chars), Redeem first-operator activation
Refresh identity / Sign out	Reload memberships; sign out clears the active selection

User action sequence

1. Open `/mission/identity` and read the auth readiness banner.
2. Enter Email and Password and select **Sign in** (or **Email magic link**).
3. Confirm the summary shows **Identity: AUTHENTICATED** and the count of **Active memberships**.
4. Select the membership card for the mission and role you will act under; it becomes **ACTIVE**.
5. For Crew Self, confirm **Live sensor context: MISSION-BOUND**.
6. Optional: redeem an invite under **Join a mission**, or change your password under **Change password** (then sign out and sign in again to verify).

Expected observable results: Authenticated summary; selected card marked ACTIVE; Crew Self context MISSION-BOUND. Successful password change shows “Password updated. Sign out and sign in again to verify your new credentials.” Successful invite shows “Mission invite accepted. Your mission membership is being refreshed.”

Table 15. Mission identity & governed cloud access — status values

Status value	Meaning
AUTHENTICATED	Valid session
ACTIVE (card badge)	Membership selected in this browser (stored as `userId|membershipKey`; discarded if another user signs in)

Status value	Meaning
MISSION-BOUND	Active membership is Crew Self with a crew ID; live capture is attributed to that crew identity
LOCAL FALLBACK	No eligible Crew Self membership; captures stay in a local fallback context and never upload anonymously

Data persistence and synchronization: Session handled by Supabase Auth. The active-membership choice is stored in browser storage bound to the user ID. No password is stored in application tables; password changes go only through Supabase Auth (`updateUser` after verifying the current password).

Table 16. Mission identity & governed cloud access — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Incorrect email or password. Please try again.”	Wrong credentials or unknown account (deliberately indistinguishable). Retry or use the magic link.
“Please verify your email address before signing in.”	Confirm the account e-mail first.
“Too many attempts. Please wait and try again.”	Rate limit; wait.
“Current password is incorrect.” / “Passwords do not match.” / “The new password must differ from the current password.”	Correct the change-password inputs.
“Password changes require an online connection.”	Reconnect.
“Invitation acceptance could not be confirmed…” or server refusal text	Code invalid/expired/used, bound to another account, self-issued, awaiting approval, or role incompatible (Section 11).
Membership list empty	New account; accept an invite.

Security and scientific limitations: Identity assurance equals e-mail confirmation (no MFA). Selecting a card changes what is offered, never what the server allows. Self-sign-up does not grant any mission access.

Verification procedure

1. Sign in with a synthetic account; confirm AUTHENTICATED and membership count.
2. Enter a wrong password; confirm the generic inline message under the password field and that the password field is empty.
3. Select a Crew Self card; open `/mission/live` and confirm Mission identity reads AUTHENTICATED MEMBERSHIP before any sensor starts.
4. Never test invite acceptance with codes you are not authorized to use; never record codes.

Implementation evidence: src/components/mission-identity.tsx; src/infrastructure/mission-identity.ts (validateMissionSignInInput, missionSignInErrorMessage, MISSION_PASSWORD_MIN_LENGTH = 12, changeMissionPassword, acceptMissionInvite); tests/identity/ (password change, sign-in validation, inline feedback and invitation feedback suites)

9.2 First-operator bootstrap (new deployments only)

A clean deployment never promotes the first browser user to administrator. The first Mission Operator is provisioned by a one-shot, audited bootstrap: an intended operator account is created and confirmed; a trusted terminal runs `bun run bootstrap:first-operator`, which arms only a SHA-256 hash and consumes the 256-bit secret through `bootstrap_first_mission`. The production deployment has completed this step once; it is never repeated.

9.3 Roles

Table 17. Mission roles

Role (database value)	Represents	Primary permissions
Crew Self (`crew_self`)	An astronaut / synthetic participant bound to one crew-registry entry	Mission-bound capture and sync of own records; readiness; bone entry for self; own evidence views; Mission Documents; synthetic Cloud submission and own history
Mission Operator (`mission_operator`)	Mission administrator (non-medical)	Create missions; settings; crew registry; invites; memberships; audit log; demo launchpad
Ground Medical (`ground_medical`)	Qualified ground reviewer (synthetic context)	Mission snapshot; bone entry for rostered crew; aggregate export; GM invite approval; pending synthetic review queue and research decisions on others' batches
Researcher (`researcher`)	Scientific analyst	Aggregate-only, suppressed export
Platform administrator	—	Not part of the role model. Operator membership, e-mail matches and navigation never grant administrator rights

9.4 Role compatibility within one mission

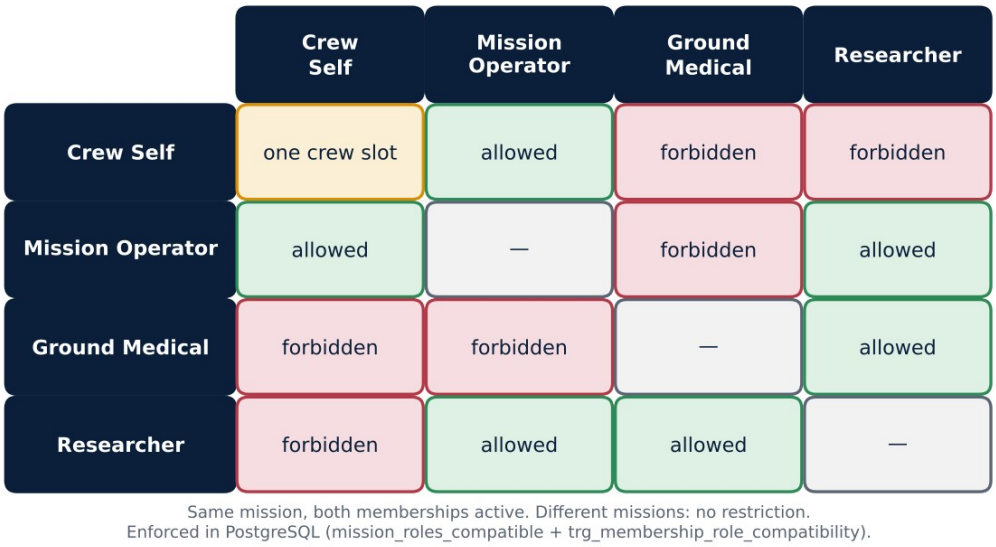


Figure 6. Same-mission role compatibility (enforced by mission_roles_compatible and trg_membership_role_compatibility)

Different missions are independent: one person can be Crew Self in one mission and Ground Medical in another. Denials are returned as `status: rejected` and audited.

9.5 RBAC summary

Table 18. Role-based access (* never for own invite, never as recipient). Enforced by the database and covered by disposable-PostgreSQL tests.

Function	Crew Self	Operator	Ground Med.	Researcher
Create mission / Mission Settings / Audit Log	—	Yes	—	—
Crew registry, invites, memberships	—	Yes	Approve GM invite*	—
Ingest medical events	Own crew	No	Mission	No

Function	Crew Self	Operator	Ground Med.	Researcher
Read identified events / index	Own crew	No	Mission	No
Readiness, self-assessment, evidence views	Yes	—	—	—
Bone-health entry	Self	—	Roster	—
Mission Documents workbench (local)	Yes	—	—	—
Submit synthetic batch / own history (flag on)	Yes	—	—	—
Pending synthetic queue + values (read)	—	—	Yes (not own submissions)	—
Research decision on synthetic batch	—	—	Yes (independent, final)	—
Ground snapshot	—	—	Yes	—
Aggregate export	—	—	Yes	Yes
Demo launchpad, demo-mission activation form	—	Yes	—	—

10. Mission Creation, Configuration and Lifecycle

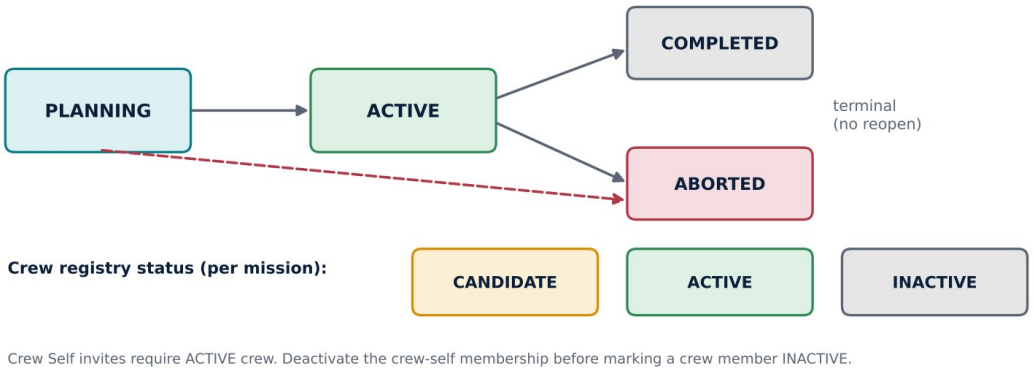


Figure 7. Mission lifecycle and crew registry states

10.1 Create a planning mission

Purpose	Create a new mission; the creator becomes its first operator atomically.
Required role / permission	Established Mission Operator (server `can_create_mission`).
Prerequisites	Signed in with an active operator membership.
Navigation path	Mission Console → Mission & Crew Operations (`/mission/operations`) → Create another mission

Step-by-step

1. Enter **Mission code** (3–32 characters A–Z, 0–9, _ or -; upper-cased automatically; placeholder `LUNAR-01`).
2. Enter **Mission name** (3–120 characters; placeholder “Lunar Surface Mission 01”).
3. Select **Create planning mission** (enabled only when both fields have ≥ 3 characters).

Expected result: “Mission created and your operator membership was provisioned atomically.” The new mission is selected in PLANNING status and an audit event `mission_created` is written.

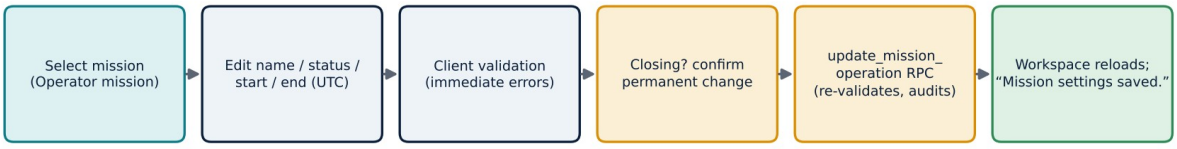
Common errors and recovery

Symptom / message	Cause and recovery
“mission code already exists”	Choose a unique code.
“mission creation denied”	No operator standing.

Security considerations: No “first user becomes admin” shortcut.

Related documentation: src/components/mission-operations.tsx; docs/MISSION_CREW_OPERATIONS.md

10.2 Mission Settings



The saved end date is re-sent on every save (unless you empty the field), so an update never clears it by accident. Start can change but cannot be cleared.

Closed missions (COMPLETED / ABORTED) render read-only; mission code and mission ID are never editable.

Source: src/components/mission-settings-panel.tsx · src/domain/mission-settings/settings.ts

Figure 8. Mission Settings save flow

Table 19. Mission Settings fields (UTC)

Field	Editable?	Rule
Mission code / Mission ID	No	Immutable
Mission name	Yes	3–120 characters
Status	Forward only	PLANNING → ACTIVE or ABORTED; ACTIVE → COMPLETED or ABORTED; COMPLETED/ABORTED terminal
Start (UTC)	Yes	Can change, cannot be cleared
End (UTC)	While open	After Start; set to closing time if empty when closing; immutable after closure; emptying the field on an open mission removes it

Procedure: select the mission in **Operator mission**, open the **Mission Settings** link, edit, select **Save settings** (confirm the permanent-closure prompt for COMPLETED/ABORTED) or **Discard changes**. The function `update_mission_operation` re-validates and audits every save. Status: viewing FIELD-VERIFIED (signed-in production acceptance recorded); saving OPERATIONAL (covered by automated tests).

10.3 Dedicated synthetic demonstration mission (owner-controlled)

Table 20. Owner-controlled demonstration mission (src/components/governed-demo-mission-activation.tsx)

Item	Fact
Where	Mission & Crew Operations → Synthetic mission demo journey → "Dedicated synthetic demo mission — owner-controlled activation"
What it does	Calls the existing `create_mission_operation` RPC to create mission code `MITO_DEMO_2026` in PLANNING; grants only the creator an operator membership; writes an audit event. No health records, crew or other roles are created.
Gate	Typed phrase `CREATE MITO_DEMO_2026` + checkbox "I explicitly authorize creating one new synthetic demo mission in Lovable Cloud." Button Create dedicated demo mission stays disabled otherwise; backend can still deny.
Who uses it	The project owner only. Evaluators use the synthetic mission the owner assigns to their accounts and never press the create button, which performs a real Cloud write.

10.4 Closing a mission

- Synchronize crew devices first (Offline Mission Mode shows an empty queue).
- Closing freezes the research snapshot and fixes the end time; afterwards only events captured before the end time are accepted (“mission closed for new events”).
- Closed missions cannot be reopened and their settings render read-only.

11. Crew Registry, Invitations, Membership and Role Management

11.1 Add and maintain crew

Purpose	Register synthetic crew identities for a mission.
Required role / permission	Active Mission Operator.
Prerequisites	Mission PLANNING or ACTIVE.
Navigation path	Mission & Crew Operations → Add crew member / Mission crew registry

Step-by-step

1. Enter **Display name** (2–100 characters; use synthetic names), optional **External ref** (no personal identifiers) and **Status** (CANDIDATE, ACTIVE, INACTIVE); select **Add to mission registry**.
2. On a crew card, change status with the buttons offered or use **Edit display name** → **Save**.
3. To reuse a crew identity from another mission you operate: **Assign an existing astronaut to this mission** → Source mission → Existing astronaut → **Assign existing astronaut** (starts as CANDIDATE; nothing else is copied).

Expected result: Messages “Crew member added to this mission registry.”, “<name> is now <status>.”, “Display name updated to <name>.”, “Existing astronaut linked as a CANDIDATE…”.

Common errors and recovery

Symptom / message	Cause and recovery
“deactivate crew-self membership before inactivating crew member”	Deactivate the membership first.
“operator access required for both missions”	Reuse needs operator role on both missions.

Security considerations: All changes audited (`crew_member_created`, `crew_member_updated`, `existing_crew_assigned`).

Related documentation: docs/MISSION_CREW_OPERATIONS.md; multi-mission crew reuse design record

11.2 Issue a mission-scoped invite

Purpose	Grant a role in a mission.
Required role / permission	Active Mission Operator of the mission.
Prerequisites	Crew Self: the crew member is ACTIVE in this mission.
Navigation path	Mission & Crew Operations → Issue mission-scoped invite (also on Mission Identity → Operator invite issuance)

Step-by-step

1. Choose **Role**: Crew self, Ground medical, Mission operator or Researcher; for Crew self choose the **Active crew member**.
2. Select **Create one-time invite** and copy the code from the one-time panel; deliver it through an approved channel.
3. For Ground medical, continue with recipient binding and independent approval (11.4).

Expected result: Code shown once; only its SHA-256 hash is stored; expires (24 h from the UI; server clamps 1–168 h).

Common errors and recovery

Symptom / message	Cause and recovery
“crew member is not active in this mission”	Activate the crew entry first.
“mission invite creation denied”	Not an active operator here.

Security considerations: The issuer can never accept their own invite. Never paste codes where others can read them.

Related documentation: Multi-role hardening migration (supabase/migrations)

11.3 Accept an invite

The recipient signs in, pastes the code in **Join a mission**, selects **Accept invite** and then selects the new membership card. The client treats only a governed success response (`mission_id` + `role`, or `status=accepted`) as success; null or unknown responses are reported as “Invitation acceptance could not be confirmed. Please try again or contact your Mission Operator.” Refusals include: invalid/expired/used; self-issued (revoked); Ground Medical awaiting approval (remains valid); bound to a different account (revoked); approver cannot accept; role incompatible; different existing crew binding.

11.4 Ground Medical binding and independent approval

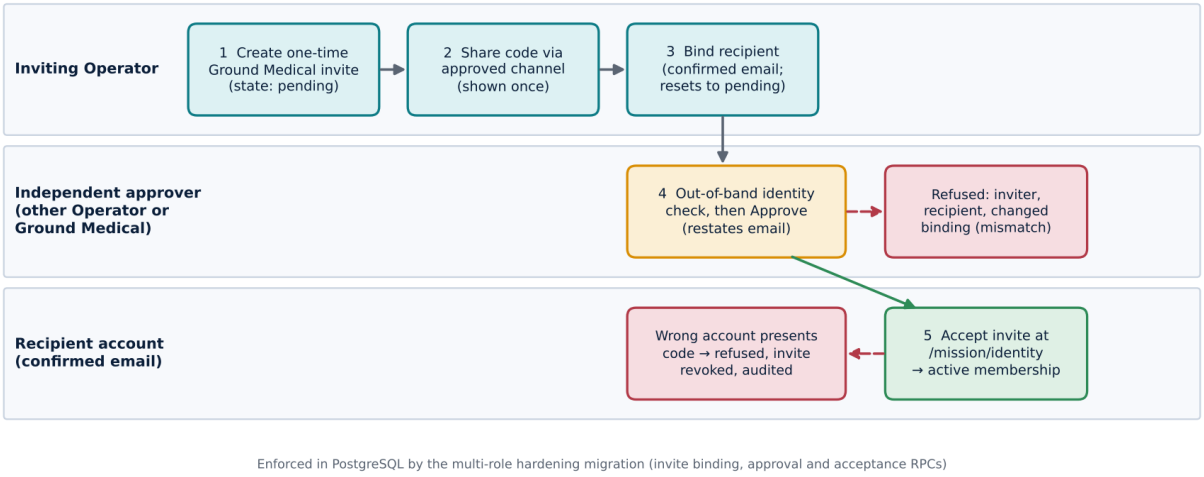


Figure 9. Ground Medical invitation: bind recipient → independent out-of-band approval → acceptance

- The inviter binds the invite to the recipient's **confirmed** account e-mail (**Bind recipient**); binding resets approval.
- A different active Operator or Ground Medical member of the same mission verifies the person out of band and selects **Approve access for <email>**.
- A single-operator mission without an existing Ground Medical member cannot onboard Ground Medical; add a second operator first.
- Residual risk: two colluding members can still onboard an account; detection relies on audit records.

11.5 Membership management

Membership access lists memberships with **Deactivate / Reactivate**. Deactivation is non-destructive and is the immediate revocation mechanism, including for members with historical review records. The last active operator

cannot be deactivated; you cannot reactivate your own sensitive membership; reactivation that would create a forbidden pair is refused and audited.

12. Complete Global Navigation and User Interface Reference

Every page shares one header: **Home** plus five grouped menus and a **Search** button. On narrow screens the menus collapse into an accordion side panel. Search (Ctrl+K / ⌘+K) is derived from the same navigation configuration — there is no second catalogue — and lists public labels only.



Source: src/components/app-shell.tsx (navigation groups, itemHref, searchCatalogue) · src/routes/*.tsx

Figure 10. Global navigation: Home, five grouped menus and search

Table 21. Route reference (src/routes/*.tsx; src/components/app-shell.tsx itemHref)

Route	Rendered page title	Menu location	Access model (verified in code)
/	The Mitochondria | Astronaut Health Intelligence	Home	Public
/mission/identity	Mission Identity & Sign-in	Mission Console → Mission & crew	Public page; actions need auth
/mission/experience	Mission Workspace	Mission Console → Mission & crew	Tasks only with active membership
/mission/operations	Mission & Crew Operations	Mission Console → Mission & crew	Active Mission Operator
/mission/readiness	Cognitive & Behavioral Readiness	Mission Console; Science → Context & safety	Crew Self with crew ID
/mission/live	Astronaut Live Dashboard	Mission Console → Measurements	Public; LOCAL FALLBACK without Crew Self

Route	Rendered page title	Menu location	Access model (verified in code)
/mission/devices	Device Integration Center	Mission Console → Measurements	Public
/mission/records	Recorded Mission Data	Mission Console → Measurements	Local records on device; cloud rows per RLS
/mission/offline	Offline Mission Mode	Mission Console → Measurements	Status public; sync needs membership
/mission/companion	Daily Health Companion	Mission Console → Mission & crew	Public page; private trends only for the signed-in user's own active Crew Self scope
/mission/intake	Unified Intake — Measurements & Review	Mission Console → Measurements (Unified Data Intake)	Public page; recording needs an authorized Crew Self or Ground Medical mission/crew
/mission/health-report	Astronaut Health History & Research Assessment	Mission Console → Measurements (Astronaut Health Report)	Authorized mission/crew membership; reads local encrypted observations only
/mission/ai-administration	AI Administration & Usage	Mission Console → Ground operations	Separately provisioned research-policy owner only (noindex); policy paused
/mission/ground	Ground & Research Console (Research Privacy Workspace + Ground Medical synthetic research review)	Mission Console → Ground operations; Health & Intelligence → Research intelligence (Ground Medical Workspace, Research Workspace)	Ground Medical or Researcher; review panel Ground Medical only
/mission/simulation	Synthetic Mission Simulation	Mission Console → Ground operations (Mission Scenario)	Public; synthetic
/mission/documents	Mission Document Review	Health & Intelligence → Evidence & context	Crew Self with crew ID for file selection
/mission/bone-health	Bone Health	Health & Intelligence → Health domains	Crew Self or Ground Medical for entry; reference public
/mission/cardiovascular-health, /immune-health, /behavioral-health	Cardiovascular Health · Immune Changes · Behavioral Health	Health & Intelligence → Health domains	Reference public; private evidence Crew Self
/mission/intelligence	Health Intelligence	Health & Intelligence → Research intelligence	Catalogue public; evidence Crew Self
/mission/alerts	Explainable Alerts	Health & Intelligence → Research intelligence	Semantics public; crew evidence review Crew Self
/mission/guidance	Action & Protocol Guidance	Health & Intelligence → Research intelligence	Library public; self-assessment Crew Self
/mission/nasa-evidence	NASA Scientific Evidence	Health & Intelligence → Research intelligence	Public; OSDR metadata via /api/nasa-research

Route	Rendered page title	Menu location	Access model (verified in code)
/mission/validation	Validation & Usability	About & Open Source → Governance & references	Public register
/mission/submission	Challenge Demo & Submission	About & Open Source → Governance & references	Public register
/competition/team	Our Team — NASA Space Apps 2026	About & Open Source → Project	Public
/competition/demo-video	MITOCHONDRIA — Demo Video	About & Open Source → Competition Materials (Watch NASA Demo Video)	Public; plays the three-minute demonstration video (a final edition MP4 is prepared for owner-approved replacement)
/project/guide (#anchors)	Project Guide	Science, About & Open Source, Health & Intelligence (overview items)	Public
/technology, /technology/{topic}	Technology topics (8)	Technology	Public

NOTE — About & Open Source → Competition Materials contains four entries: NASA Competition Presentation (PDF), NASA Evaluator Quick Start (PDF) and Master Technical Manual (PDF) — each opening the file of the same name in `docs/competition/` on GitHub — and **Watch NASA Demo Video** (`/competition/demo-video`). The three PDF filenames are unchanged in this edition, so replacing the files updates the menu targets without code changes. The demo-video link stays unchanged; replacing the hosted MP4 is an owner action in the hosting platform and needs no code change to the route or menu.

NOTE — Operational `/mission/*` routes are marked noindex except Validation and Submission, which use indexable heads (SEO policy). The page title for `/mission/submission` is “Challenge Demo & Submission”; the menu label is “Challenge Submission”.

12.1 Screen — Home page and public information pages

Screen name (as rendered)	The Mitochondria (home) · Project Guide · Technology topics
Verified route	/ · /project/guide · /technology · /technology/{topic}
Navigation path	Home; About & Open Source and Science items (Project Guide anchors); Technology menu
Authorized role(s)	Public.
Purpose	Present the mission, health loop, capabilities, offline principle, technology topics, open-source mission and challenge context.
Prerequisites	None.
Capability status	FIELD-VERIFIED (public pages available on the live site).

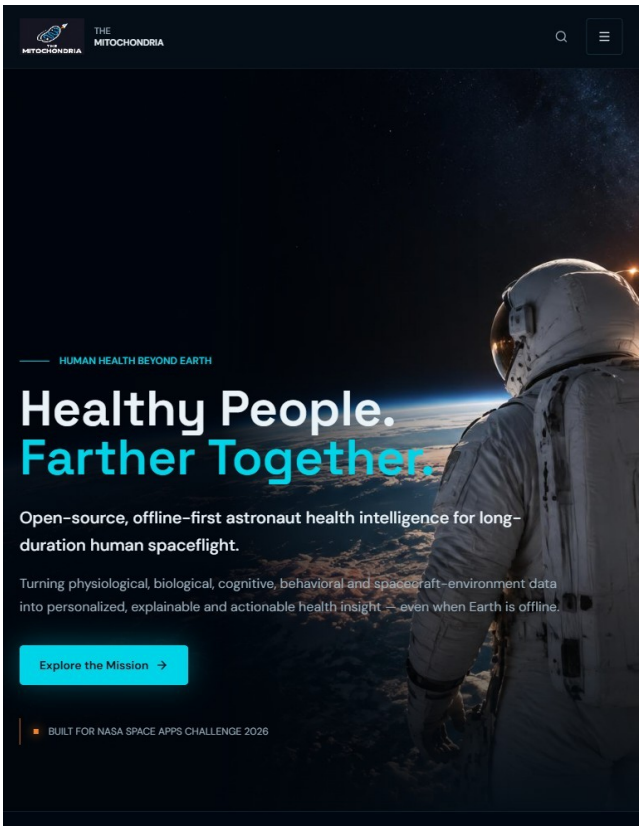


Figure 11. The Mitochondria (home) · Project Guide · Technology topics — public view of mitochondria.edocinfo.com/ (home page). Unedited capture, 765 × 990 px.

> **FURTHER VIEW —** Scrolling or interacting with the page shows the same header with the Health & Intelligence menu or global search open.

Table 22. The Mitochondria (home) · Project Guide · Technology topics — controls and inputs

Visible control / input	Expected input format and behaviour
Hero CTAs	Explore the Mission · How It Works
Capability cards	Monitoring, Personal baseline, Trend & pattern detection, Risk assessment, Explainable intelligence, Action guidance, Offline Mission Mode, Device-agnostic integration — each with a link
Technology topic links	8 topics + View all technology topics
Footer	Explore, Project, External links; Apache-2.0 notice

User action sequence

1. Open the official URL.
2. Use hero and card links or the header menus.

Expected observable results: Public pages load without sign-in. The offline section is labelled “Architecture direction” and is not presented as completed flight functionality.

Data persistence and synchronization: None.

Table 23. The Mitochondria (home) · Project Guide · Technology topics — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Blank page offline before first load	Load once online so the public shell is cached.

Security and scientific limitations: Capability cards describe the design direction; for example, no risk scores are computed (Section 24).

Verification procedure

1. Confirm the six header entries and the Apache-2.0 footer notice.

Implementation evidence: src/components/app-shell.tsx; project-guide.tsx; src/content/technology-topics.ts; live site

12.2 Global search

Table 24. Global search (src/components/navigation-search.tsx; tests/navigation/global-search.test.ts)

Element	Behaviour
Open	Search button in the header or Ctrl+K / ⌘+K
Input	Placeholder “Search pages, topics, sections…”; matches titles, groups and keywords (e.g., document, laboratory, biomarker → Mission Documents)
Results	“Suggested” list when empty; external links marked “(opens in a new tab)”; “No matching pages. Try “health”, “offline” or “team”.”
Scope	Public navigation labels and the Project Guide; never private data

13. Mission Operator Workflows

13.1 Screen — Mission & Crew Operations console

Screen name (as rendered)	Mission & Crew Operations
Verified route	/mission/operations
Navigation path	Mission Console → Mission & crew → Mission & Crew Operations
Authorized role(s)	Active Mission Operator (otherwise the page shows “Operator membership required”).
Purpose	Administer missions: create, settings, crew registry, invites, memberships, audit history, and launch the synthetic demo journey.
Prerequisites	Signed in; active `mission_operator` membership.
Capability status	FIELD-VERIFIED (recorded production use); demonstration launchpad OPERATIONAL with SYNTHETIC DEMONSTRATION content.

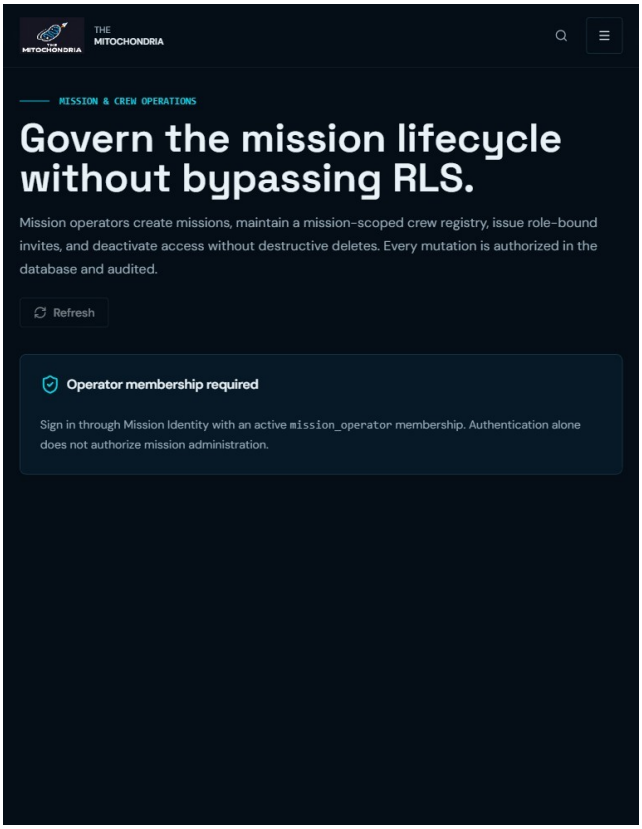


Figure 12. Mission & Crew Operations — public view of mitochondria.edocinfo.com/mission/operations (without an operator membership: access-restriction notice). Unedited capture, 765 × 990 px.

SIGNED-IN VIEW — The image shows the page before sign-in. With an authorized synthetic account the page shows the operator workspace for a synthetic mission — Operator mission selector, section links, Mission Settings and the crew registry.

Table 25. Mission & Crew Operations — controls and inputs

Visible control / input	Expected input format and behaviour
Operator mission → Mission	Selector of missions where you are an active operator; shows code, name, status badge, ID
Create another mission	Mission code + Mission name → Create planning mission (Section 10.1)

Visible control / input	Expected input format and behaviour
Synthetic mission demo journey (launchpad)	Operator-visible demo panel (Section 13.3)
Section links	Mission Settings (#mission-settings) · Mission Audit Log (#mission-audit-log)
Mission Settings	Name, Status, Start (UTC), End (UTC), Save settings, Discard changes (Section 10.2)
Add crew member / Assign an existing astronaut	Section 11.1
Mission crew registry	Status buttons; Edit display name
Issue mission-scoped invite	Role, Active crew member, Create one-time invite; Ground Medical invitations awaiting approval (bind / approve)
Membership access	Deactivate / Reactivate
Mission Audit Log	Filters, list, Load older records (Section 13.2)

User action sequence

1. Sign in as a Mission Operator.
2. Open the console and choose the mission in **Operator mission**.
3. Use the section links to reach Settings or the Audit Log, or scroll to crew and invite panels.
4. Perform the needed workflow (Sections 10–11).

Expected observable results: Workspace for the selected mission; every mutation reports a confirmation message and writes an audit event.

Table 26. Mission & Crew Operations — status values

Status value	Meaning
PLANNING / ACTIVE / COMPLETED / ABORTED	Mission lifecycle badge
CANDIDATE / ACTIVE / INACTIVE	Crew registry status
ACTIVE / INACTIVE	Membership state

Data persistence and synchronization: Cloud only, through SECURITY DEFINER RPCs (`get_mission_operations_workspace`, `create_mission_operation`, `update_mission_operation`, crew and invite RPCs). Nothing is cached offline.

Table 27. Mission & Crew Operations — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Operator membership required”	No active operator membership; sign in with an operator account.
“mission operation denied”	Membership inactive or mission mismatch; refresh.

Security and scientific limitations: Operator role is non-medical: it cannot read identified medical events and is not an Administrator grant.

Verification procedure

1. Open as a non-operator: confirm the restricted card.
2. Open as operator: confirm mission switching reloads all panels.
3. After any change, confirm the matching Audit Log entry.

Implementation evidence: src/components/mission-operations.tsx; mission-settings-panel.tsx; mission-audit-log.tsx; tests/identity/ (mission operations, settings and audit suites)

13.2 Screen — Mission Audit Log

Screen name (as rendered)	Mission Audit Log
Verified route	/mission/operations#mission-audit-log
Navigation path	Mission & Crew Operations → section link “Mission Audit Log”
Authorized role(s)	Active Mission Operator of the selected mission only.
Purpose	Read-only, redacted, mission-scoped history of administrative actions, refusals, event ingestion, snapshot reads, exports and privacy-safe evidence-submission and review-decision rows.
Prerequisites	Audit viewer migration (0005) present.
Capability status	FIELD-VERIFIED (signed-in production acceptance recorded in the repository).

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the audit list with an Outcome filter applied and one row expanded to show the pseudonymous actor and target type. This view is presented during the live demonstration.

Table 28. Mission Audit Log — controls and inputs

Visible control / input	Expected input format and behaviour
From / To (UTC date)	Inclusive days; To sent as next-day start; inverted range rejected
Action	Action identifiers present in this mission
Outcome	All / Success / Refused
Search	≤ 80 characters; action or target type only
Apply filters / Reset	Filters apply only on Apply or Enter
Record row (button)	Expands Actor (You or `member-xxxxxxxx`), Target type, allow-listed details
Load older records	Keyset pagination, 25 per page

User action sequence

1. Select the Mission Audit Log link.
2. Read newest-first records.
3. Apply filters as needed.
4. Expand a row to read details.
5. Load older records until the button disappears.

Expected observable results: Mission-scoped list with UTC timestamps and Success/Refused badges; no IDs, e-mails, codes, names or health payloads.

Data persistence and synchronization: Read-only RPC `get_mission_audit_log` (STABLE, writes nothing). Audit rows are append-only in the database.

Table 29. Mission Audit Log — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Access denied. Only active Mission Operators of this mission can view its audit log.”	Wrong mission or inactive membership.
“invalid cursor”	Reset filters; cursors are bound to mission and filter set.
“…waiting for an approved database update…”	Deployment lacks the reader migration.

Security and scientific limitations: Cursor is authenticated (HMAC), not encrypted. Pseudonyms are mission-scoped. Keyboard check was focus/Tab order only, not an assistive-technology review.

Verification procedure

1. Filter Refused; confirm only refusals appear.
2. Switch missions; confirm record sets change and stale responses are discarded.
3. Scan the page text for UUIDs and e-mails (expect none).

Implementation evidence: Mission audit viewer migration (supabase/migrations); src/domain/mission-audit/audit.ts; tests/integration-pg/ audit viewer suite

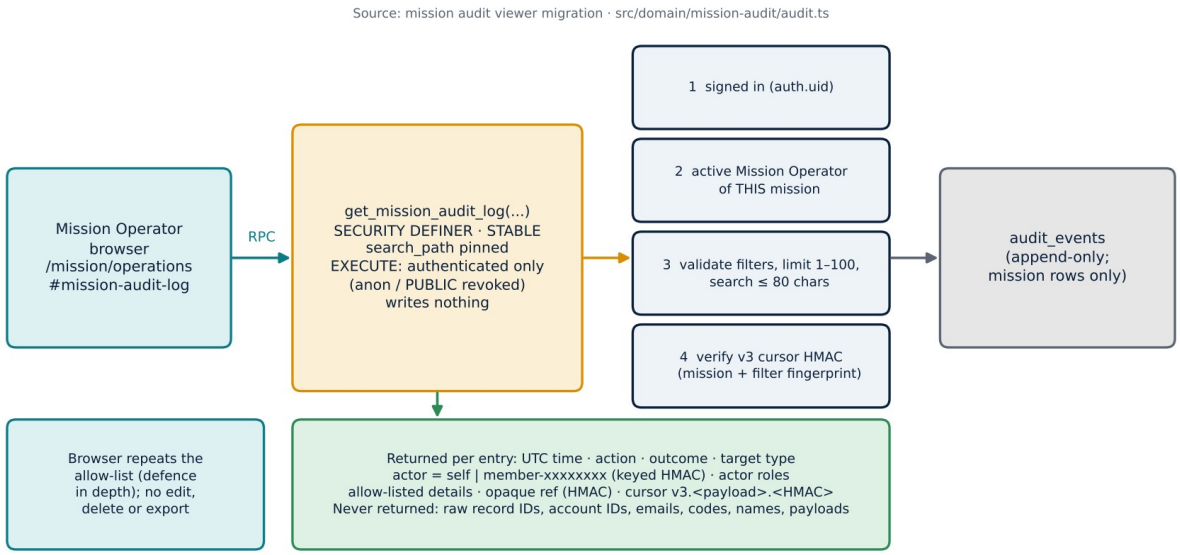


Figure 13. Mission Audit Log authorization and redaction boundary

13.3 Screen — Synthetic Mission Demo Launchpad

Screen name (as rendered)	Synthetic mission demo journey
Verified route	/mission/operations (panel below the mission selector)
Navigation path	Mission & Crew Operations → selected mission → Synthetic mission demo journey
Authorized role(s)	Rendered only inside the operator workspace (active Mission Operator). Destinations enforce their own access.
Purpose	Guide a synthetic demonstration across ten destinations, plan role hand-offs, and rehearse with fictional data — without granting any privileges.
Prerequisites	Operator workspace loaded for a mission.
Capability status	OPERATIONAL (navigation, tracker, runbook, preview) and SYNTHETIC DEMONSTRATION (dataset, report, integrated bundle). Grants no privileges.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the launchpad on a synthetic mission — readiness checks, tracker, role cards and the Day 0/7/14 domain preview. This view is presented during the live demonstration.

Table 30. Synthetic mission demo journey — controls and inputs

Visible control / input	Expected input format and behaviour
Demo authorization readiness	Read-only membership inspection list
Demo execution tracker	Per-step select: Not checked / Observed manually / Blocked / unavailable; Reset checklist; disabled on the reserved acceptance mission; session-only
Operational demo runbook	Actor cards (steps, membership visible / separate authorized account required); Export offline demo runbook (JSON)
Synthetic multi-domain demo dataset	Counts by domain; Export synthetic demo dataset (JSON) — disabled on the reserved acceptance mission
Interactive synthetic health preview	Health domain select; table of illustrative metrics × Day 0 / 7 / 14 (“Missing” where absent)
Astronaut Health Intelligence — synthetic offline report	Domain filter; Export report JSON; Export observations CSV; Print / Save PDF; Provenance and limitations
Integrated synthetic demo — offline execution	Export integrated offline demo bundle (JSON); Inspect synthetic dataset or integrated bundle JSON (local only, ≤ 100 KB); Integrated demo acceptance gates
Dedicated synthetic demo mission — owner-controlled activation	Typed phrase + checkbox + Create dedicated demo mission (owner only; Section 10.3)
Final integrated demo — governed acceptance	Readiness checks; Export acceptance handoff (local JSON)
Ten journey cards	Mission identity, Mission workspace, Mission documents, Device integration, Bone, Cardiovascular, Immune, Behavioral, Health intelligence, Ground & research; each shows advisory “Access:” text

User action sequence

1. Select a non-reserved synthetic mission in Operator mission.
2. Read the readiness list and the per-card **Access:** hints (sign-in required / check destination access / membership visible / separate account required).
3. Open each journey card; after observing the destination, set its status to **Observed manually** or **Blocked / unavailable**.
4. Export the runbook (JSON) for role hand-offs; use separate authorized accounts for Crew Self and Ground Medical steps.
5. Use the preview, offline report and integrated bundle for rehearsal only.

Expected observable results: Tracker counts update (“x/10 observed · y blocked · z not checked”); downloads are generated locally; no network write occurs (except the owner-only create action).

Table 31. Synthetic mission demo journey — status values

Status value	Meaning
Observed manually / Blocked / Not checked	Manual, session-only marks — not authorization or acceptance evidence
Reserved acceptance mission	Tracker and dataset export disabled; runbook export is planning-only

Data persistence and synchronization: Component state only; resets on reload or mission change. Exports are local downloads. No Cloud writes except the separately gated mission-creation RPC.

Table 32. Synthetic mission demo journey — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Buttons disabled on the reserved acceptance mission	By design; use the designated synthetic mission.
Inspector: “Rejected: invalid JSON” / “maximum 100 KB”	Only exact deterministic fixtures for the selected mission are accepted; tampered, cross-mission or extra-field bundles are rejected.

Security and scientific limitations: Values are fictional; bone/immune example units are arbitrary demonstration units; not biomarkers, cutoffs or findings. Exports are never import or authorization evidence.

Verification procedure

1. Confirm the panel is absent when signed out or for non-operators.
2. Export a bundle, re-inspect it (accepted), edit one value (rejected).
3. Confirm Network shows no write requests while using the panel.

Implementation evidence: src/components/mission-demo-launchpad.tsx and sub-panels; src/domain/mission-access/demo-*.ts, synthetic-*.ts, offline-demo-*.ts; tests/mission/

13.4 Operator daily duties (synthetic missions)

- Confirm crew registry and memberships match the plan; deactivate unused memberships.
- Review the Audit Log for Refused entries.
- Keep the reserved acceptance mission free of demonstration records; create a dedicated demonstration mission only with owner approval.
- Do not issue Ground Medical invites without a second, independent approver.

14. Crew Self Workflows

Crew Self members act for their own crew identity only. All workflows below require an active Crew Self membership with an assigned crew ID selected on `/mission/identity` unless stated otherwise.

14.1 Screen — Daily readiness check-in

Screen name (as rendered)	Cognitive & Behavioral Readiness
Verified route	/mission/readiness
Navigation path	Mission Console → Mission & crew → Daily Readiness Check-in (also Science → Context & safety)
Authorized role(s)	Crew Self with crew ID.
Purpose	Record schedule, sleep, fatigue, sleepiness (KSS), stress, a 60-second vigilance demonstration and optional task-linked NASA-TLX.
Prerequisites	Signed in; Crew Self selected; ~3 minutes.
Capability status	OPERATIONAL; demonstration protocol (the under-3-minute completion criterion is recorded as passed in the validation ledger).

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows step 2 (state check-in) with sliders on a phone-sized screen. This view is presented during the live demonstration.

Table 33. Cognitive & Behavioral Readiness — controls and inputs

Visible control / input	Expected input format and behaviour
Current context	Rest, Routine work, Critical task, Exercise, EVA
Recent sleep duration (hours)	Number
Fatigue 0–10 · Sleepiness (KSS) 1–9 · Current stress 0–10	Sliders
Start 60-second task / Respond now	Vigilance demo
Optional post-task workload	Task / shift label + six NASA-TLX dimensions
Complete assessment	Finish

User action sequence

1. Choose context and sleep hours.
2. Set fatigue, KSS, stress → Save & continue.
3. Run the 60-second task, responding only to the target.
4. Review; optionally add NASA-TLX; Complete assessment.

Expected observable results: Records encrypted locally (classification `medical_sensitive`) and queued for sync; no score, diagnosis or alert.

Data persistence and synchronization: Encrypted append-only IndexedDB; governed sync later.

Table 34. Cognitive & Behavioral Readiness — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Sign in and select an authorized crew mission before recording readiness assessments…”	Select Crew Self on /mission/identity.

Failure condition / message	Cause and troubleshooting
“No vigilance result yet”	Complete the task.

Security and scientific limitations: Not a validated PVT; no lapse threshold; KSS/VAS are self-reports, not clinical instruments in this implementation.

Verification procedure

1. Complete a check-in; confirm a new local record and pending queue item on /mission/offline.

Implementation evidence: src/components/readiness-assessment.tsx; docs/COGNITIVE_BEHAVIORAL_MODULE.md; readiness test suite

14.2 Screen — Mission Documents (synthetic laboratory report review)

Screen name (as rendered)	Mission Document Review
Verified route	/mission/documents
Navigation path	Health & Intelligence → Evidence & context → Mission Documents (searchable: document, laboratory, biomarker)
Authorized role(s)	Crew Self with crew ID for file selection and review. Others see the context notice only.
Purpose	Locally extract exact catalogue matches from a synthetic laboratory report, review them, export or preview them, and — when activated — save reviewed synthetic values to Cloud as a pending-review batch.
Prerequisites	Active Crew Self context; consent checkbox; synthetic PDF, image, CSV or TXT ≤ 12 MB. The repository provides a synthetic laboratory-report fixture (TXT is the most reliable format for exact matching).
Capability status	Local workbench OPERATIONAL; synthetic Cloud submission and history OPERATIONAL behind a server feature flag; independent live acceptance of the end-to-end review pipeline VALIDATION BOUNDARY.

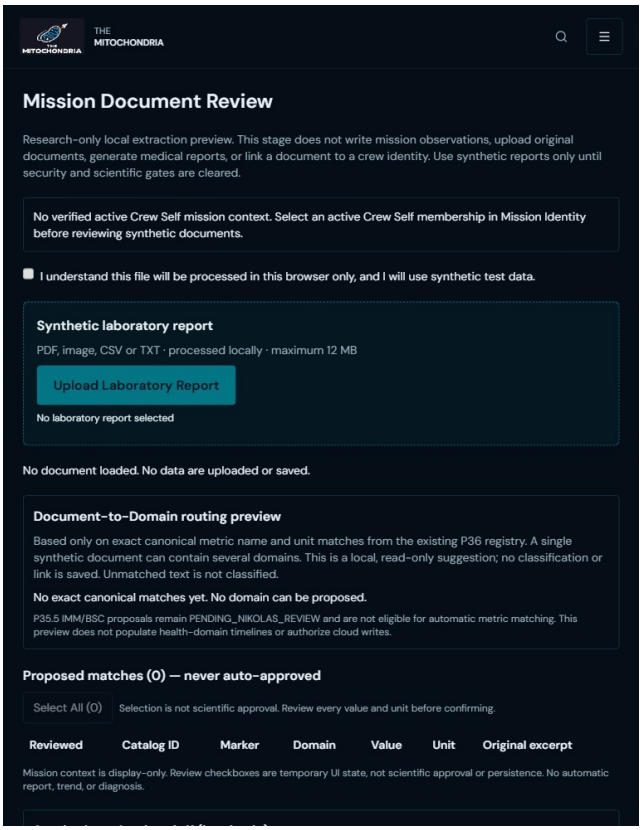


Figure 14. Mission Document Review — public view of mitochondria.edocinfo.com/mission/documents (without a Crew Self context: local-only workbench and consent step). Unedited capture, 765 × 990 px.

SIGNED-IN VIEW — The image shows the page before sign-in. With an authorized synthetic account the page shows the Crew Self context, consent ticked, a synthetic report loaded, the candidate table, observation date and confirmation, and the Save control.

Table 35. Mission Document Review — controls and inputs

Visible control / input	Expected input format and behaviour
Mission review context (status)	“Crew Self context: <mission> / <crew>. Local review only; no server writes.” or the no-context notice
Consent checkbox	“I understand this file will be processed in this browser only, and I will use synthetic test data.” Required before upload
Upload Laboratory Report	Opens file chooser `.pdf,.png,.jpg,.jpeg,.webp,.csv,.txt`; max 12 MB; status “Selected: <name>”
Candidate table + checkboxes; Select All / Deselect All	Only exact `catalog name: numeric value unit` matches against the biomarker source registry (unique name and exact original unit); reference ranges skipped; nothing pre-selected
Document-to-Domain routing preview	Read-only projection of matched IDs to the four domains; no classification saved
Bone markers awaiting unit review	Advisory exact-name hints only; not selectable or submittable (bone catalog has no approved units)
Synthetic observation date + manual confirmation checkbox	“I manually checked every selected synthetic value, unit and source excerpt. This does not constitute scientific approval.”
Export synthetic review JSON locally (n)	File marked `LOCAL_REVIEW_ONLY_NOT_APPROVED_FOR_IMPORT`, `syntheticOnly: true`

Visible control / input	Expected input format and behaviour
Local research preview	In-memory table; reset by selection/date/confirmation changes, replacement or clear
Save reviewed synthetic measurements to Cloud (n)	Shown when the server flag is on; otherwise disabled “Submit … to Cloud — pending activation”
Astronaut saved reviews — by observation date / Refresh saved reviews	Up to 100 own synthetic batches: date, created, markers, review status, batch ID (no values)
Clear local document	Discards text, candidates and preview

User action sequence

1. Select your Crew Self membership on `/mission/identity`, then open `/mission/documents`.
2. Tick the consent checkbox and select **Upload Laboratory Report**; choose a synthetic file.
3. Review the candidate table (value, unit, excerpt). Use **Select All** or tick individual rows; duplicates of one metric are rejected.
4. Enter the **Synthetic observation date** and tick the manual confirmation.
5. Either **Export synthetic review JSON locally**, open the **local research preview**, or — if activated — **Save reviewed synthetic measurements to Cloud**.
6. Select **Refresh saved reviews** to see your saved batches, newest observation first.
7. Select **Clear local document** when finished.

Expected observable results: Local matches only for exact registry names and units; after Save the server returns success and the batch appears in history as `pending_review`. Status messages include “Submitting synthetic batch…”, “Already submitted” (idempotent retry), “Cloud submission failed. Nothing was saved; sign in again and retry.”

Table 36. Mission Document Review — status values

Status value	Meaning
pending_review	Saved synthetic batch awaiting independent research review
accepted_for_research / rejected_for_research	Final research-only decision by an independent Ground Medical member
quarantined	Administrative terminal state when the submitter is revoked (schema path; no UI)

Data persistence and synchronization: Original documents never leave the browser. Local outputs are downloads or in-memory. Cloud submission sends only a SHA-256 fingerprint and reviewed values through the server function to the synthetic review-batch submission function (identity = auth.uid(); active Crew Self FOR SHARE; mission open; exact 96 metric/unit pairs; plain decimals; 1–100 unique markers; SHA-256 + date duplicate prevention; per-membership idempotency key with payload hash; audit without filename/values/excerpts).

Table 37. Mission Document Review — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Active Crew Self mission membership required.”	Select Crew Self.
“Confirm local-only document processing first.”	Tick consent.
“File exceeds 12 MB limit.” / “Unsupported file type.”	Use a smaller or supported file.

Failure condition / message	Cause and troubleshooting
“No exact canonical matches yet…”	Labels or units differ from the registry; nothing is guessed.
“Batch is not valid for synthetic submission…”	Use plain decimals and unique markers.
“Cloud history is not activated.” / pending-activation button	Server flag off; local review still works.
“Unable to load saved reviews. No changes were made.”	Retry online.

Security and scientific limitations: Synthetic data only. Selection and Cloud saving are not scientific approval. A Crew Self member cannot approve their own batch. No values are promoted to mission events, health index, timelines or reports. Scanned/OCR text is untrusted and needs human checking.

Verification procedure

1. Load the synthetic TXT fixture; confirm only exact matches appear and a reference-range line is skipped.
2. Confirm Save is disabled without date and confirmation.
3. With the flag on, save once, then retry: expect idempotent behaviour and one history entry.
4. Confirm no network request contains file contents (only fingerprint and values).

Implementation evidence: src/components/mission-document-review-workbench.tsx; cloud-submission server function (src/lib); src/domain/biomarkers/*; data/scientific/ biomarker source registry; drizzle/migrations/0006–0008; tests/documents/, tests/integration-pg/ submission and history suites

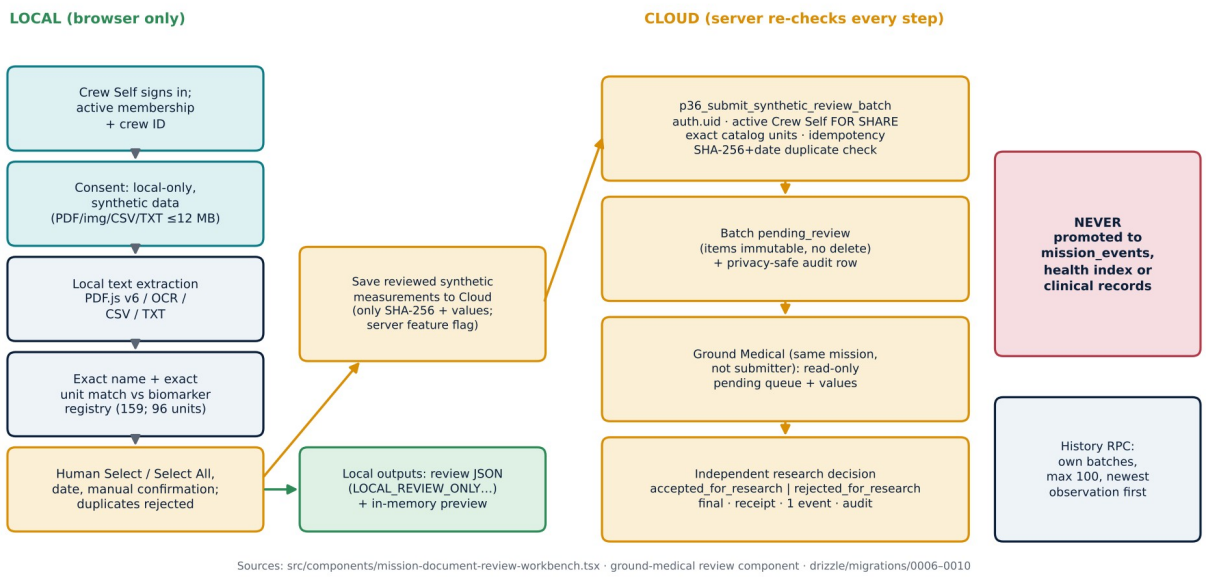


Figure 15. Where Mission Documents sits in the review pipeline

14.3 Screen — Explainable Alerts with crew evidence review

Screen name (as rendered)	Explainable Alerts
Verified route	/mission/alerts
Navigation path	Health & Intelligence → Research intelligence → Explainable Alerts
Authorized role(s)	Public semantics; the crew evidence review requires verified Crew Self membership.
Purpose	Explain attention semantics and show your own observed metrics, timestamps, quality and a descriptive historical mean when already calculated — without generating alerts.

Prerequisites	For the review: signed in as Crew Self.
Capability status	RESEARCH-ONLY (non-diagnostic); the authorized evidence view is OPERATIONAL.

> **SCREEN VIEW —** With an authorized synthetic account holding the role stated above, the page shows the crew evidence review (non-diagnostic) with recorded observations, data-quality blocked metrics and "Operational alerts: DISABLED". This view is presented during the live demonstration.

Table 38. Explainable Alerts — controls and inputs

Visible control / input	Expected input format and behaviour
Mission selector	When several Crew Self memberships exist
Recorded observations / Data-quality blocked metrics	Read-only lists
Attention states legend	INFORMATION, REVIEW, DATA QUALITY, RESEARCH ONLY

User action sequence

1. Open the page signed in as Crew Self.
2. Wait for "Checking authenticated mission membership…" to resolve.
3. Read observations and quality states; note "Operational alerts: DISABLED".

Expected observable results: "Evidence projection ready", or "No usable numeric observations. No findings generated.", or "No verified Crew Self membership. Private evidence is not available."

Data persistence and synchronization: Read-only; reuses the guarded `loadCrewScientificEvidence` projection.

Table 39. Explainable Alerts — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
"Evidence unavailable. No interpretation performed."	Retry later; nothing is inferred.
"Unable to verify mission membership."	Re-check sign-in.

Security and scientific limitations: No thresholds, risk scores, prediction, push notifications, diagnosis or escalation. Descriptive history is not an approved personal baseline.

Verification procedure

1. Open signed out: no private evidence.
2. Open as Crew Self with no data: empty state, no findings.

Implementation evidence: src/components/explainable-alerts.tsx; tests/domain/ health review suite

14.4 Other Crew Self workflows (detailed elsewhere)

Workflow	Section
Live capture (Camera PPG, motion, BLE) and self-check	19–20
Bone-health entry, CSV import, document extraction	24.2
Own evidence in Health Intelligence and domain pages	24
Self-assessment and protocol categories	23

Workflow	Section
Offline operation and sync	26–27
Change password, accept invites	09

14.5 Screen — Daily Health Companion

Screen name (as rendered)	Daily Health Companion
Verified route	/mission/companion
Navigation path	Mission Console → Mission & crew → Daily Health Companion
Authorized role(s)	Public page. Private trends only for the signed-in user's own active Crew Self membership; signed-out, Operator, Researcher and Ground Medical users see no private readings.
Purpose	Give the astronaut one place for mission context, a daily routine, optional check-in reminders, read-only personal trends with provenance, and a plain-language explanation of data-quality colours.
Prerequisites	None for sections 1, 2 and 4 and for the synthetic demonstration. For personal trends: signed in with an active Crew Self membership and stored observations.
Capability status	OPERATIONAL (E1 for the public sections on the live site; E1 for trend projection against real crew accounts as reported by the development environment); synthetic trend demonstration SYNTHETIC DEMONSTRATION; Crew Self synthetic intake panel E4 (server flag unset); physical-phone notification test VALIDATION BOUNDARY.

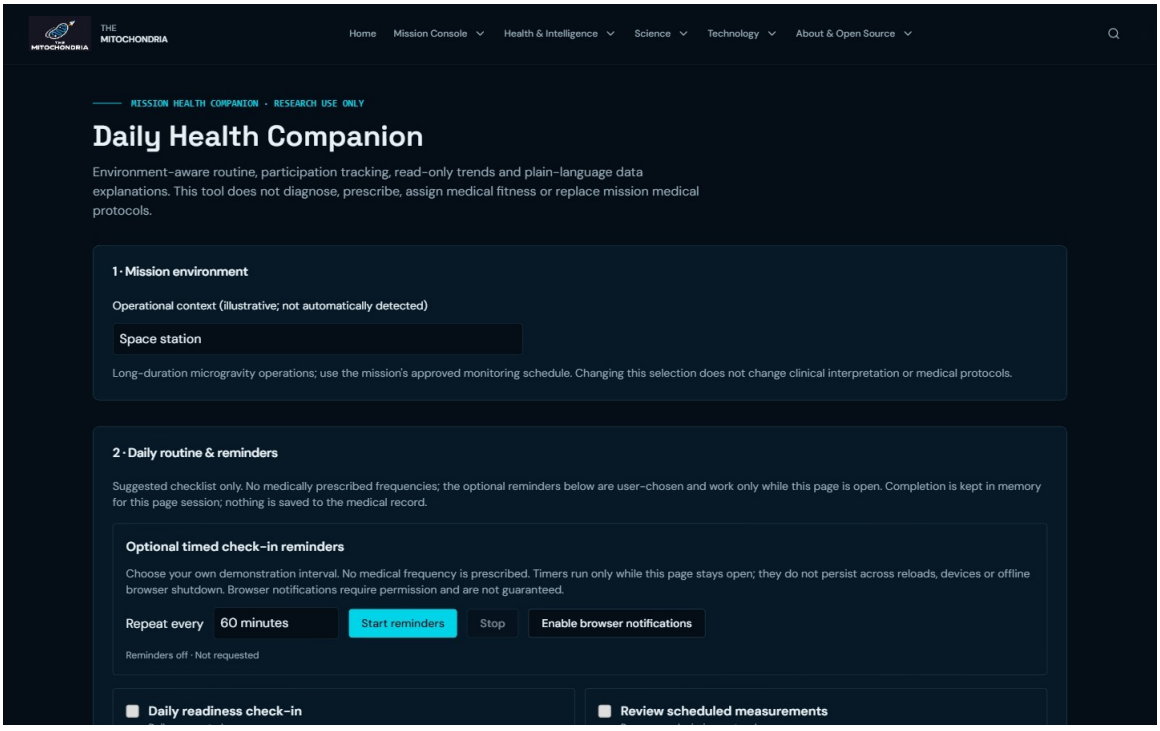


Figure 16. Daily Health Companion — public view of mitochondria.edocinfo.com/mission/companion (before sign-in: mission environment and optional reminders). Unedited capture, 1440 × 900 px.

SIGNED-IN VIEW — The image shows the page before sign-in. With an authorized synthetic account the page shows section 3 with the user's own metric picker, time-window and source filters, an SVG trend, the observation table (value, original unit, time, source, quality) and a “Stored records not charted” list with reasons.

Table 40. Daily Health Companion — controls and inputs

Visible control / input	Expected input format and behaviour
1 · Mission environment	Spacecraft · Space station · Rover · Lunar base · Planetary base. Illustrative context only; not detected automatically, not stored, and never changes clinical interpretation
2 · Daily routine & reminders — checklist	Daily readiness check-in · Review scheduled measurements · Check device and data quality · Read approved guidance; each links to its console. “Participation: n / 4 activities” — participation only, never a health score; Reset session checklist
Optional timed check-in reminders	Repeat every 1 (demo), 15, 30, 60, 120 or 240 minutes; Start reminders / Stop; Enable browser notifications (optional permission). Runs only while the page is open
3 · Dynamic health trends	Signed out: “Sign in as the assigned Crew Self member to view your own health trends.” Signed in: metric picker by catalogue name, time window (all, 90, 30, 7 days relative to the latest observation), exact source filter, SVG chart, observation table, not-charted list
Synthetic trend demonstration	Show/Hide synthetic example; resting heart rate (68, 70, 67, 72, 69 bpm), HRV (42–47 ms) and sleep duration (6.8–7.5 h), days D1–D5. Never stored, exported or mixed with crew records
4 · Understand the indicators and colors	Green = source data marked good quality; Amber = degraded; Neutral = poor, unknown or missing. Data-quality states, not health-risk categories

User action sequence

1. Open `/mission/companion`; choose each of the five environments and read the note (data and interpretation do not change).
2. Tick routine items and watch the participation counter; select **Reset session checklist**.
3. Choose **1 minute (demo)** and **Start reminders**; optionally enable browser notifications; wait one minute for the in-page notice; **Stop**.
4. Select **Show synthetic example** and switch between the three synthetic series.
5. Signed in as Crew Self: choose a metric, apply the 30-day window and a single source; compare the chart with the observation table and the “Stored records not charted” list.
6. Switch to another tab and return: private trends are hidden at once and reappear only after membership and evidence are re-read; checklist, environment, synthetic demo and reminders are preserved.

Expected observable results: Public sections render without sign-in and make no mission-data requests. For the signed-in Crew Self user, only that user's own crew observations are charted, each with original unit, time, source and quality; identical repeats are charted once; non-numeric records are listed as not charted with a reason. No thresholds, diagnosis or risk scores appear.

Table 41. Daily Health Companion — status values

Status value	Meaning
Reminders off · Not requested	Default reminder and notification state
Retry authorization	Shown after a failed revalidation; private evidence stays hidden
Insufficient history	Zero or one observation for the selected metric and filters

Data persistence and synchronization: Environment, checklist, reminders and synthetic demonstration live in page memory only and are never written to medical records, local storage or audit logs. Personal trends are read-only projections of records the user is already authorized to read (row-level security).

Table 42. Daily Health Companion — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
No trends after sign-in	No active Crew Self membership, or no stored numeric observations for the selected metric/unit/filters.
No reminder after the interval	Page navigated away, tab suspended or browser closed — reminders are foreground only.
Notification blocked	Permission denied or unsupported; the in-page notice still appears.

Security and scientific limitations: Not a scheduler, push service or prescribed measurement cadence; reminder intervals are user-chosen demonstration settings. Colours describe data quality, not health. A line chart does not establish a clinical trend. Revocation while the tab stays continuously visible is detected only at the next tab return, sign-in change, scope change or request; row-level security remains the enforcement point.

Verification procedure

1. Signed out: no network request for mission data; synthetic demo works.
2. Crew Self A: only A's observations; 7/30/90-day and source filters narrow the table consistently.
3. Hide the tab, return: private rows hidden immediately, then restored only if still authorized.
4. 390 px phone width: cards stack, no horizontal overflow, 44 px touch targets.

Implementation evidence: src/components/astronaut-daily-health-companion.tsx; src/domain/companion/ (daily-companion, reminder-engine, crew-revalidation, synthetic-intake); src/domain/health-intelligence/canonical-projection.ts; tests/domain/p45-daily-companion, p46-reminder-engine, p47-interactive-trends, p482-crew-revalidation, p49-canonical-projection; tests/navigation/*companion*, p482-focused-revalidation.browser.py; docs/P49_DEMO_READINESS_RESULTS.md

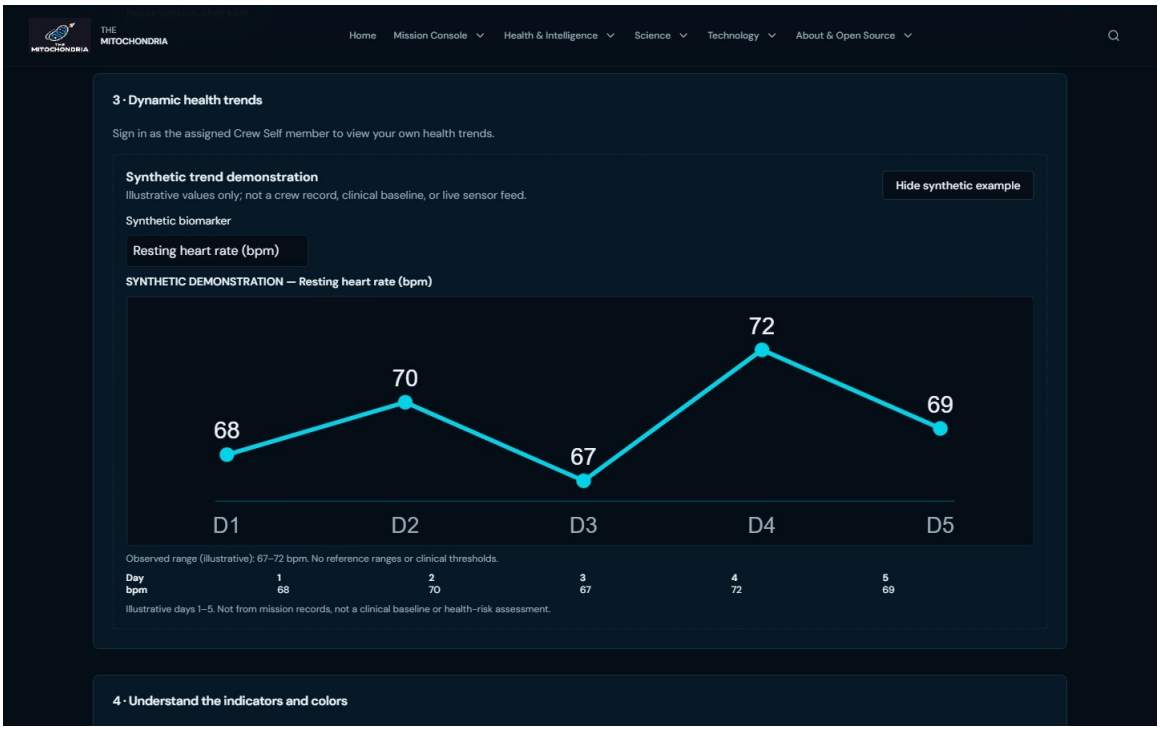


Figure 17. Daily Health Companion — synthetic trend demonstration (illustrative resting heart rate, days D1–D5) on the live site before sign-in (unedited capture, 1440 × 900 px)

Real-account trend projection (development-environment report)

The development environment checked the canonical projection with three existing synthetic crew accounts at 1280 × 1800 and 390 × 844 px. Crew A: 74 stored records, 27 observations charted in 20 series, 47 not charted

(identical repeats of three heart-rate readings). Crew B: 24 stored, 23 charted, 1 operational event not charted. Crew C: 53 stored, 51 charted, 2 not charted (a three-axis acceleration and an operational event). No other crew's identifiers appeared on any page, and the browser made no direct table writes. This is a development-environment report (E1/E3: real accounts, not independently re-run).

> **NOTE —** The **Crew Self synthetic intake panel** inside the Companion (six labelled synthetic readings per scenario, two synthetic sources, typed confirmation, single submit) is implemented and passed 14/14 checks in a disposable PostgreSQL database with the production migrations. Its server flag is **unset**, and creating the dedicated demonstration mission and accounts requires separate owner approval, so the panel does not appear in the live application (E4).

14.6 Screen — Unified Data Intake

Screen name (as rendered)	Unified Intake — Measurements & Review
Verified route	/mission/intake
Navigation path	Mission Console → Measurements → Unified Data Intake
Authorized role(s)	Public page. Recording requires an authorized Crew Self or Ground Medical mission/crew.
Purpose	One review workflow for manual entry, CSV, PDF and scanned text, device observations and self-assessments, classifying every measurement individually against the scientific source catalogue.
Prerequisites	Signed in with an authorized membership; data provenance selected (Synthetic / demo data or Real measurement — never mixed).
Capability status	OPERATIONAL (E1 for the public page; signed-in encrypted-storage acceptance E3). Automatic AI extraction assistance E4 (endpoint answers 503; server flags unset).

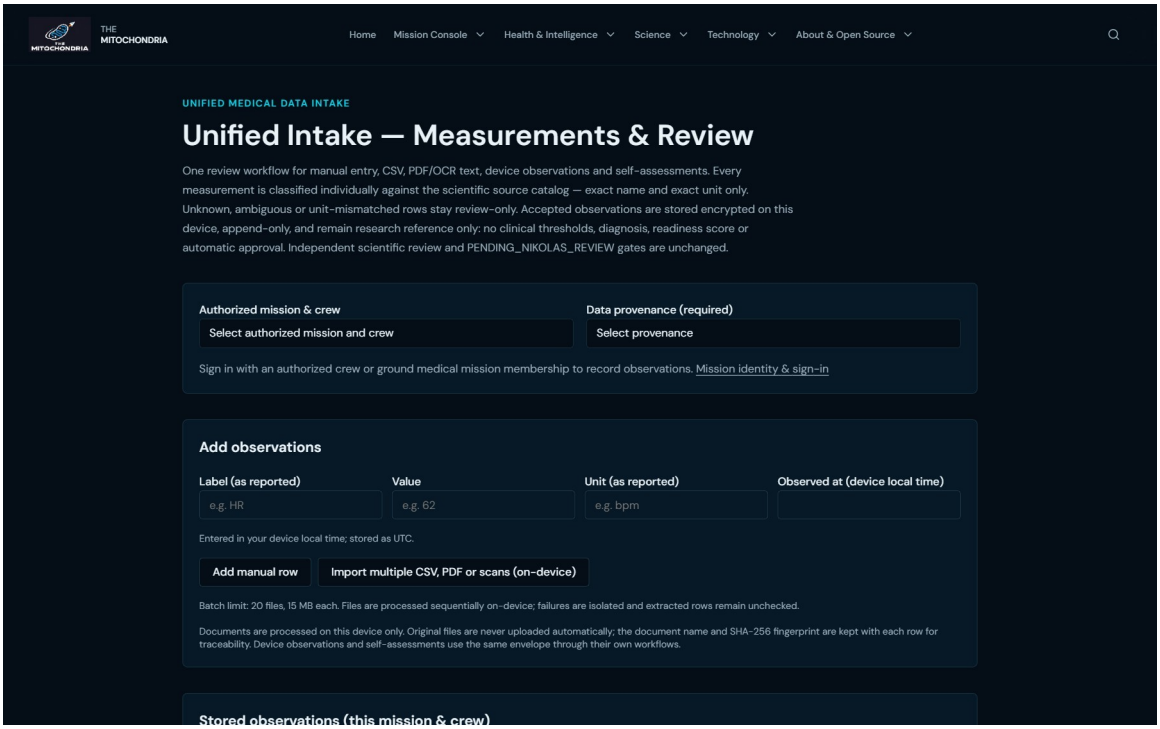


Figure 18. Unified Intake — Measurements & Review — public view of mitochondria.edocinfo.com/mission/intake (before sign-in: authorized mission & crew selector, provenance and multi-file import). Unedited capture, 1800 × 1125 px.

> **FURTHER VIEW —** Scrolling or interacting with the page shows the authorized mission & crew selector, provenance, added rows, the per-row classification (exact name and exact unit only) and the review/confirm controls.

Table 43. Unified Intake — Measurements & Review — controls and inputs

Visible control / input	Expected input format and behaviour
Authorized mission & crew	Only the user's own authorized scopes
Data provenance (required)	Synthetic / demo data · Real measurement
Add observations	Label (as reported), Value, Unit (as reported), Observed at (device local time; stored as UTC)
Import multiple CSV, PDF or scans (on-device)	Up to 20 files, 15 MB each, processed sequentially on the device, SHA-256 fingerprinted and de-duplicated; failures isolated per file; 200-row candidate cap

User action sequence

1. Select the authorized mission & crew and the provenance.
2. Add a manual row or import files.
3. Review each candidate: exact catalogue name and exact unit are classified; unknown, ambiguous or unit-mismatched rows stay review-only.
4. Tick the rows you have checked and confirm.

Expected observable results: Accepted observations are stored encrypted on the device, append-only, as research reference only. Nothing is pre-selected and nothing is uploaded.

Data persistence and synchronization: Encrypted IndexedDB, append-only; governed synchronization later. No cloud upload of files.

Table 44. Unified Intake — Measurements & Review — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Sign in with an authorized crew or ground medical mission membership to record observations.”	Sign in and select an authorized scope.
Row held for review	Name or unit does not match the catalogue exactly; nothing is guessed or converted.

Security and scientific limitations: No clinical thresholds, diagnosis, readiness score or automatic approval. Parsing is conservative and does not handle arbitrary laboratory layouts. Independent scientific review gates are unchanged.

Verification procedure

1. Import a synthetic CSV and a synthetic PDF in one batch; confirm per-file status and that unknown units are held.
2. Confirm no network request carries file contents.

Implementation evidence: src/routes/mission.intake.tsx; src/components/unified-intake-workspace.tsx; src/domain/health-domains/unified-intake-classification.ts; src/domain/medical-document/; docs/ASTRONAUT_HEALTH_REPORT_AND_BATCH_INTAKE.md; docs/P36_HYBRID_AI_EXTRACTION.md

14.7 Screen — Astronaut Health History Report

Screen name (as rendered)	Astronaut Health History & Research Assessment
Verified route	/mission/health-report
Navigation path	Mission Console → Measurements → Astronaut Health Report

Authorized role(s)	Authorized mission/crew membership.
Purpose	Produce a deterministic, research-only English history of locally stored observations across Bone, Immune, Cardiovascular, Behavioral, wearable and device sources, with supporting observation IDs.
Prerequisites	Signed in; authorized crew selected; observations stored on this device.
Capability status	OPERATIONAL (E1 for the public page; desktop/mobile A4 PDF and TXT export verified with synthetic adapters, E2; authenticated populated-crew acceptance E3).

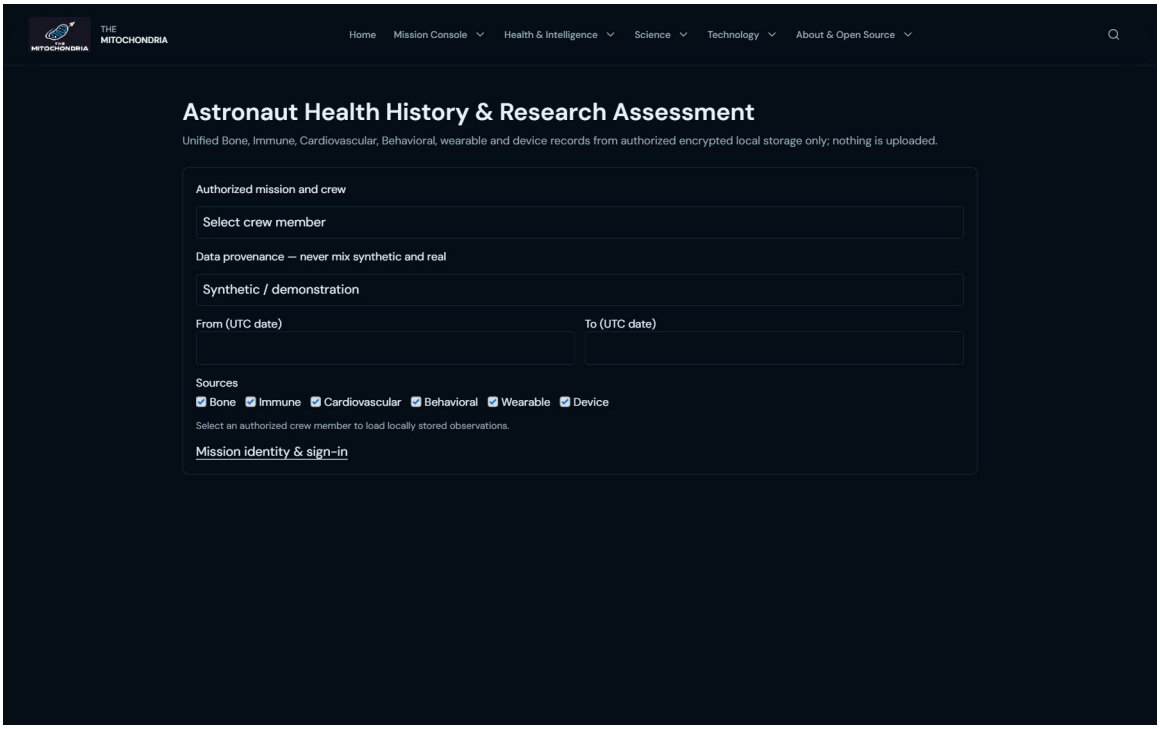


Figure 19. Astronaut Health History & Research Assessment — public view of mitochondria.edocinfo.com/mission/health-report (before sign-in: crew, provenance, date and source filters). Unedited capture, 1800 × 1125 px.

SIGNED-IN VIEW — The image shows the page before sign-in. With an authorized synthetic account the page shows the report cover with authorized display names and immutable IDs, the history tables, exclusions, limitations and the Print, Download PDF and Export TXT controls.

Table 45. Astronaut Health History & Research Assessment — controls and inputs

Visible control / input	Expected input format and behaviour
Authorized mission and crew	Select crew member
Data provenance	Synthetic / demonstration · Real / recorded — never mixed
From / To (UTC date); Sources	Bone, Immune, Cardiovascular, Behavioral, Wearable, Device
Print · Download PDF · Export TXT	A4 PDF generated locally in the browser; TXT with the same file name

User action sequence

1. Select the crew member, provenance, date range and sources.
2. Read the narrative statements and their observation IDs.
3. Download PDF or Export TXT.

Expected observable results: Missing data is stated explicitly; erroneous and unreviewed records are excluded and listed; export re-checks the account and scope before delivery.

Data persistence and synchronization: Reads encrypted local observations only; nothing is uploaded; exports are local downloads.

Table 46. Astronaut Health History & Research Assessment — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Select an authorized crew member to load locally stored observations.”	Sign in and choose a crew member.

Security and scientific limitations: Observation envelopes, not a complete medical record; no LLM, external API, inferred diagnosis or threshold. The local store reads up to 1,000 events.

Verification procedure

1. Generate the synthetic report; confirm synthetic and real data are never combined.
2. Change the crew during export: delivery is cancelled.

Implementation evidence: src/routes/mission.health-report.tsx; src/components/astronaut-health-report.tsx; src/domain/health-intelligence/health-history-report.ts, report-pdf.ts; docs/P36_5_ACCEPTANCE_RESULTS.md

15. Ground Medical Workflows

IMPORTANT — Ground Medical decisions in this platform are research-only and have no clinical meaning. The review workflow is implemented and covered by database tests; its independent live acceptance with authorized reviewer accounts is **VALIDATION BOUNDARY**.

15.1 Screen — Ground & Research Console (Research Privacy Workspace)

Screen name (as rendered)	Ground & Research Console
Verified route	/mission/ground
Navigation path	Mission Console → Ground operations → Ground & Research Console; also Health & Intelligence → Research intelligence → Ground Medical Workspace or Research Workspace (same page)
Authorized role(s)	Ground Medical or Researcher membership; the review panel lists Ground Medical memberships only.
Purpose	Load a mission snapshot (Ground Medical), export a suppressed aggregate (both roles), and review pending synthetic batches (Ground Medical).
Prerequisites	Membership obtained through an approved, recipient-bound invite (Ground Medical).
Capability status	Snapshot and aggregate export OPERATIONAL; review panel OPERATIONAL with live acceptance VALIDATION BOUNDARY.

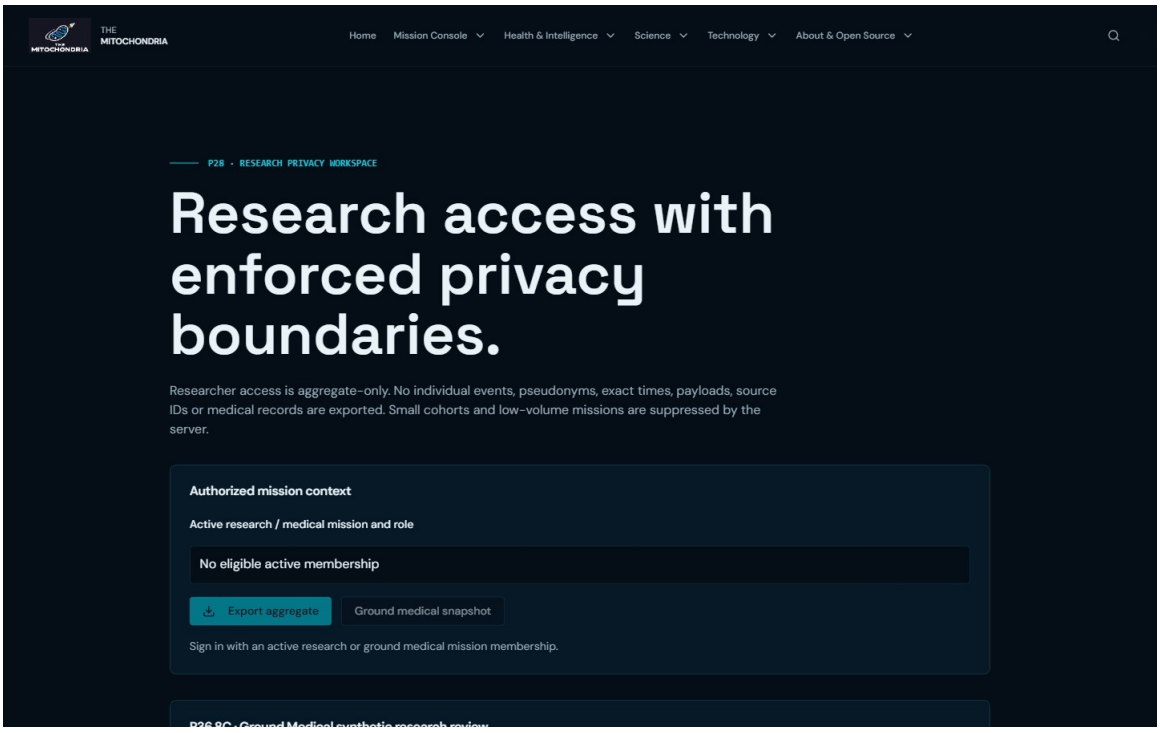


Figure 20. Ground & Research Console — public view of mitochondria.edocinfo.com/mission/ground (before sign-in: Research Privacy Workspace with no eligible membership). Unedited capture, 1440 × 900 px.

SIGNED-IN VIEW — The image shows the page before sign-in. With an authorized synthetic account the page shows the mission-and-role selector, snapshot cards and the review panel for the selected mission.

Table 47. Ground & Research Console — controls and inputs

Visible control / input	Expected input format and behaviour
Active research / medical mission and role	Deterministic mission + role list
Ground medical snapshot	Events, Crew, Findings counts
Export aggregate	`mitochondria-research-aggregate-v1.json`
Review panel	Section 15.2

User action sequence

1. Choose the mission + role entry.
2. Ground Medical: select **Ground medical snapshot**.
3. Either role: **Export aggregate** (suppressed below 3 crew / 10 events).

Expected observable results: "Ground medical snapshot loaded."; aggregate "Aggregate-only research summary prepared. No individual records exported." or suppression message.

Data persistence and synchronization: Reads via RPC; snapshot reads and exports are audited.

Table 48. Ground & Research Console — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
"No eligible active membership"	Need Ground Medical or Researcher.
"Research export suppressed…"	Below thresholds — expected.

Security and scientific limitations: Aggregate export is not anonymization or an approved human-subjects release.

Verification procedure

1. Researcher: snapshot button disabled and server refuses.
2. Ground Medical: snapshot loads for own mission only.

Implementation evidence: src/components/ground-research-console.tsx; docs/GROUND_RESEARCH_CONSOLE.md; research privacy workspace design record

15.2 Screen — Ground Medical synthetic research review

Screen name (as rendered)	Ground Medical synthetic research review
Verified route	/mission/ground (panel below the research workspace)
Navigation path	Ground & Research Console → Ground Medical synthetic research review panel
Authorized role(s)	Active Ground Medical in the batch's mission, different user from the submitter. Crew Self, Operator, Researcher, anonymous, revoked and cross-mission callers are refused by the database.
Purpose	Inspect pending synthetic batches read-only and record one final research decision per batch.
Prerequisites	Review read and decision functions deployed (migrations 0009 and 0010).
Capability status	OPERATIONAL — database functions covered by the 305-assertion disposable PostgreSQL suite (E1). Session-safety behaviour of the panel (tab-return retention, fail-closed revalidation, stale-response rejection) is implemented in the release source and its signed-out status texts are visible on the live site (E1); signed-in behaviour is owner-reported (E3). Independent live acceptance with separate reviewer accounts VALIDATION BOUNDARY.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the selected mission, a pending synthetic batch in the queue, its values table and the decision confirmation dialog. This view is presented during the live demonstration.

Table 49. Ground Medical synthetic research review — controls and inputs

Visible control / input	Expected input format and behaviour
Ground Medical mission	Select of your Ground Medical memberships
Refresh pending reviews	Lists oldest-first pending synthetic batches (max 100), excluding your own submissions: item count, status, observed date, batch prefix
View values	Metric, Value, Unit, Source excerpt (no PDF)
Optional note	Plain text, max 500
Accept for research / Reject for research	Opens confirmation dialog
Confirm decision / Cancel	Dialog: synthetic only, research demonstration, no clinical meaning, final; values unchanged; N values covered
Decision receipt	Decision label · research only; Receipt ID; batch prefix; time; “previously recorded” on replay

User action sequence

1. Select the Ground Medical mission.
2. Select **Refresh pending reviews**; the queue shows, for example, “8 values · pending_review” for the original synthetic batch of FV01-TEST-B.
3. Select **View values** and compare the eight synthetic values, units and source excerpts with the synthetic source.
4. Switch to another browser tab and return: the same authorized user keeps the loaded batch after the status line briefly reads “Re-checking Ground Medical authorization…”.
5. Only with explicit owner authorization: enter an optional note, choose Accept/Reject for research and **Confirm decision**.
6. Record the receipt ID; confirm the batch has left the queue.

Expected observable results: “n pending synthetic batch(es).”; “n synthetic biomarker value(s) loaded.” (8 for the FV01-TEST-B batch); after a decision: “Decision recorded: …” and a receipt; queue refreshed. While authorization is re-checked, the queue, values table, decision controls and receipt are hidden and the status line reads “Re-checking Ground Medical authorization…”. After sign-out, a changed account, a revoked membership or a mission switch, all private rows are cleared and the status returns to a neutral text without counts or values.

Table 50. Ground Medical synthetic research review — status values

Status value	Meaning
“Select your Ground Medical mission to load pending synthetic submissions.”	Neutral start state; also shown after a mission switch or when the previous mission is no longer authorized
“Sign in with an active Ground Medical mission membership to review synthetic submissions.”	Signed out, identity error, or no Ground Medical membership (observed on the live site)
“Re-checking Ground Medical authorization…”	Transient: an authentication event occurred; private rows hidden until the check completes

Status value	Meaning
pending_review	Awaiting decision
accepted_for_research	Usable for research demonstration only
rejected_for_research	Excluded from research demonstration
replay = true	Same key and payload re-sent; original receipt returned

Data persistence and synchronization: The decision function locks the reviewer's membership FOR SHARE and the batch FOR UPDATE; checks synthetic, pending, not self-submitted, exact item count; writes batch status, one immutable decision event and a privacy-safe audit row (no values, note or filename). Items are immutable and cannot be deleted. Nothing is promoted to health records.

Table 51. Ground Medical synthetic research review — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Review queue unavailable.” / “Batch detail unavailable.”	Not authorized or network error.
“Batch is no longer available for independent review.”	Already decided or not eligible.
“Decision could not be recorded.” / server messages (self-review, already_decided, stale item count)	Refresh; never retry with a different decision.

Security and scientific limitations: The FV01-TEST-B eight-value batch is the protected original demonstration batch: project governance requires it to stay pending, so demonstrations view it but never decide it. One reviewer decides alone; decisions are final with no appeal path. Database owners can bypass triggers; receipts are correlation metadata. The UI creates one idempotency key per batch view; navigating away clears it, so a replay after navigation is handled by the database rather than the interface.

Verification procedure

1. Signed out: the panel shows the neutral sign-in status and no rows.
2. As Ground Medical: load the eight-value batch, switch browser tabs and return — the batch stays visible for the same user and mission.
3. Switch the mission selector — queue, values and receipt clear immediately; responses for the previous mission are discarded.
4. As Crew Self, Operator or Researcher: no Ground Medical missions listed; the database refuses calls.
5. As Ground Medical: view values; record a decision only when the project owner has authorized it for a newly submitted synthetic batch.
6. After an authorized decision: confirm the receipt, the batch leaving the queue and an audit row without values.

Implementation evidence: src/components/p368b-ground-medical-review.tsx; infrastructure wrapper (src/infrastructure); drizzle/migrations/0009 (read-only review) and 0010 (research decisions); tests/integration-pg/ and tests/security/ review suites

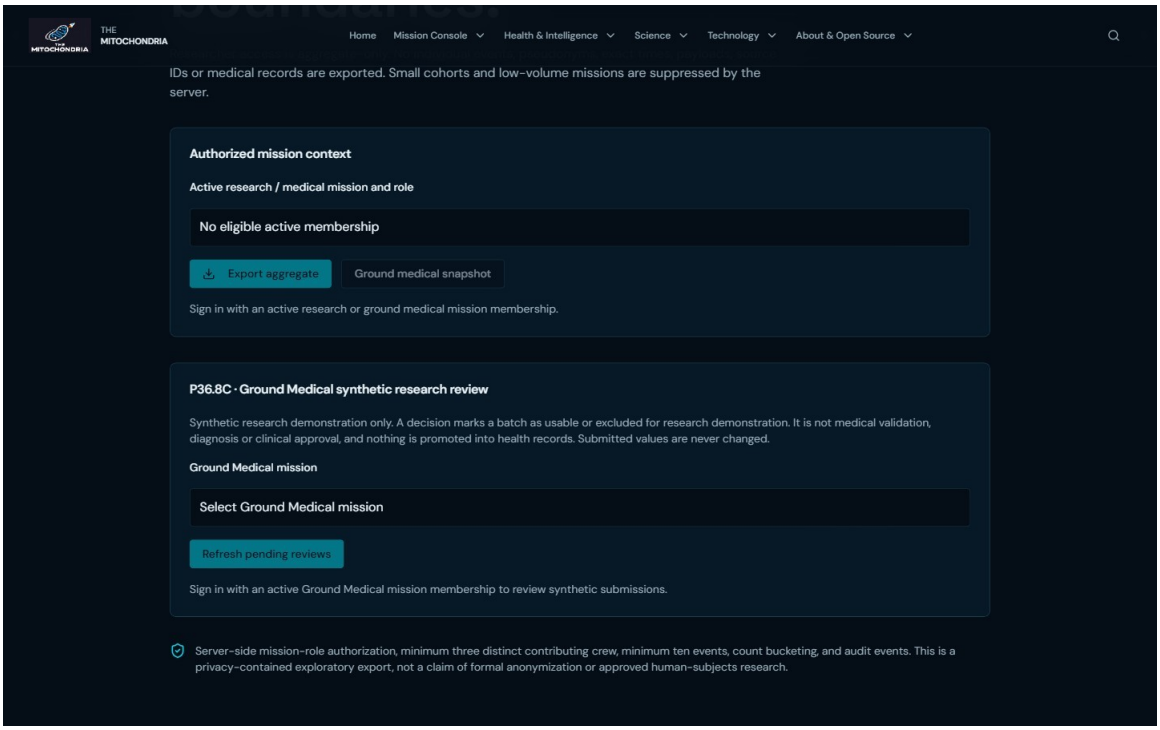


Figure 21. Ground Medical synthetic research review panel on the live site before sign-in — neutral status, no rows (unedited capture, 1440 × 900 px)

Session safety in the review panel

Table 52. Ground Medical review panel — session behaviour

Event	Panel behaviour	Why
Browser tab hidden and shown again, same user, same authorized mission	Rows hidden during the re-check, then the same loaded batch is shown again	Avoids losing the reviewer's place on every tab switch without trusting stale authorization
Any authentication event (sign-in, sign-out, token refresh, user update)	Fail closed at once: private rows hidden, busy state cleared, then identity and Ground Medical memberships re-read	Old responses must never repopulate private UI
Different user, revoked membership, or current mission no longer authorized	Queue, batch values, selection and receipt cleared; neutral status without counts	Nothing private survives a reset
Mission selector changed	Previous queue, values and receipt cleared; status reset; requests for the previous mission ignored	No cross-mission mixing
Slow response arriving after a newer action	Discarded unless it belongs to the latest request, the still-authorized mission and the currently selected mission	Stale-response protection
Identity check fails	All private state cleared; sign-in status shown	Fail closed on error

Row-level security and the review functions remain the enforcement point; the panel behaviour only prevents an already-rendered view from outliving its authorization.

15.3 Ground Medical role in invitations and bone health

- Approve another person's Ground Medical invite (never your own, never as recipient) — Section 11.4.

- Enter bone-health measurements for rostered crew — Section 24.2.

15.4 Researcher workflows and the Research Privacy Workspace

The upper part of `/mission/ground` is the **Research Privacy Workspace**. Researcher access is aggregate-only: the server function returns zero or one aggregate row with no participant ID, exact timestamp, event kind, source ID, metric, payload or mission ID. A mission must have at least three distinct contributing crew and at least ten events, otherwise the export is suppressed and the suppression is audited; event counts are rounded down to multiples of ten. The client rejects any response that does not match the strict aggregate schema. This is privacy containment, not a guarantee of anonymity or an approved human-subjects data release (E1 for the database function; signed-in browser acceptance E3).

1. Accept a Researcher invite.
2. Develop methods on synthetic exports (/mission/simulation; demo dataset).
3. Request the aggregate on /mission/ground when thresholds are met.
4. Use /mission/nasa-evidence for public NASA references and OSDR study metadata (research-only).

16. Platform Administration and Deployment Governance

MITOCHONDRIA deliberately has no in-application administrator super-role. Mission administration is performed by Mission Operators inside their own missions (Section 13); platform-level administration is performed outside the application by the deployment owner through governed, auditable mechanisms. This keeps a single compromised account from controlling every mission and keeps medical review independent of administration.

Table 53. Deployment administration (outside the application)

Task	Mechanism	Authority
First-operator bootstrap	`bun run bootstrap:first-operator` from a trusted terminal (one-shot)	Deployment owner; completed once for the production deployment
Apply a database migration	Governed migration, applied once with a recorded SHA-256 fingerprint	Explicit owner approval per migration
Enable synthetic Cloud saving	Server-only feature flag, enabled after post-migration checks	Owner
Publish the application	Publication after CI passes on the exact commit	Owner
Rollback	Disable the feature flag first; owner-run rollback SQL only with approval	Owner
Verify remote authentication configuration	`bun run verify:auth-remote`	Deployment administrator

16.1 Synthetic research AI governance (not active in production)

The repository contains a governed design for synthetic-only medical research AI: a Medical Advisor workbench (session-only review of an AI draft), a guarded synthetic evidence Q&A with exact-citation validation, per-request budget holds, rolling quotas, emergency pause and an owner-only **AI Administration & Usage** page (`/mission/ai-administration`, noindex). The production policy is paused, the newest schema candidates remain in `supabase/pending/`, administrative usage reporting is tested with mocks only, and the Medical v3 Release Gate is red. **No AI-generated medical content is part of the competition demonstration** (E4).

Table 54. Synthetic research AI components

Element	State in this edition
Automatic AI document-extraction endpoint	Default-deny; master and real-document flags unset — answers 503 and sends nothing
Synthetic research policy v2	Implemented; production rollout NO-GO until separate approvals and exact-final CI
AI Administration & Usage page	Owner access only; an unprovisioned owner is denied (signed-in check recorded)
Medical Advisor workbench	Session-only; approval is not a durable or licensed medical signature

NOTE — An in-application administrator capability is outside the scope of this release. Any such capability would require a governed backend design, security review and independent acceptance; navigation toggles or e-mail matching are never used as authorization.

17. Mission Workspace and Task Navigation

17.1 Screen — Mission Workspace

Screen name (as rendered)	Mission Workspace
Verified route	/mission/experience
Navigation path	Mission Console → Mission & crew → Mission Workspace (also the Mission Console menu link)
Authorized role(s)	Any signed-in user with an active membership; cards filtered by the active role.
Purpose	Show the authorized mission, your role and task cards for that role.
Prerequisites	Active membership selected on /mission/identity.
Capability status	OPERATIONAL.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the task cards for the active membership (they differ for Crew Self and Mission Operator). This view is presented during the live demonstration.

Table 55. Mission Workspace — controls and inputs

Visible control / input	Expected input format and behaviour
Task cards	Links to destinations; each destination re-authorizes

User action sequence

1. Select a membership on /mission/identity.
2. Open /mission/experience.
3. Choose a task card.

Expected observable results: Role-filtered cards; without membership: “No tasks available until an active mission membership is verified.”

Data persistence and synchronization: None.

Table 56. Mission Workspace — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Ground & Research card missing	Active role is Operator or Crew Self — select the Ground Medical or Researcher membership.

Security and scientific limitations: Cards are convenience only; navigation is not authorization.

Verification procedure

1. Switch membership and confirm the card set changes as in the table below.

Implementation evidence: src/domain/mission-experience/workflows.ts; tests/navigation/ mission workspace suite

Table 57. Workspace task cards

Task card	Destination	Roles
Observe live measurements	/mission/live	Crew Self, Mission Operator, Ground Medical
Check device connections	/mission/devices	Crew Self, Mission Operator
Review recorded evidence	/mission/records	Crew Self, Mission Operator, Ground Medical

Task card	Destination	Roles
Self-assessment and guidance	/mission/guidance	Crew Self
Offline operations	/mission/offline	Crew Self, Mission Operator
Review explainable alerts	/mission/alerts	Crew Self, Ground Medical, Mission Operator
Ground and research workspace	/mission/ground	Ground Medical, Researcher
Mission and crew operations	/mission/operations	Mission Operator
Synthetic mission demonstration	/mission/simulation	All four roles

The operator-only demo journey (Section 13.3) adds ten advisory destination cards including Mission Documents and the four domain pages.

18. Device Integration Center and Supported Device Capabilities

All sources connect through one vendor-neutral adapter lifecycle (discover → connect → capabilities → stream → quality/normalize → syncCursor → health → disconnect). Unknown vendor metrics and proprietary scores fail closed. Consumer and phone-camera data are quality- and provenance-tagged and are never treated as medical-grade.

Table 58. Device pathways

Pathway	Transport	Status	Evidence
Phone Camera PPG (pulse estimate)	Browser camera	FIELD-VERIFIED — one device	Physical samples recorded on a Samsung Galaxy S24 with Chrome for Android (20 September 2026)
Phone motion (tri-axial acceleration)	DeviceMotion	FIELD-VERIFIED — one device	Same real-device record
Direct BLE heart-rate sensor	Web Bluetooth, standard Heart Rate Service	OPERATIONAL — hardware test pending	Implemented and unit-tested; no physical sensor test recorded yet
Android Health Connect / Apple HealthKit	Host-provided native bridge	OUT OF SCOPE — contract defined	Adapter contract with unit tests; requires a native host application
Vendor cloud wearables	Injected authorized client	OUT OF SCOPE — contract defined	Adapter contract with unit tests
Laboratory CSV / FHIR / manual / BP & SpO_2 devices	Import, mapped FHIR, manual	OPERATIONAL contracts; user interface in Bone Health and Mission Documents	Synthetic tests
Habitat environment & dosimetry	MQTT / WebSocket / REST (host-injected)	OUT OF SCOPE in this release (contract tested with synthetic data)	No live habitat feed connected

18.1 Screen — Device Integration Center

Screen name (as rendered)	Device Integration Center
Verified route	/mission/devices
Navigation path	Mission Console → Measurements → Device Integration Center
Authorized role(s)	Public.
Purpose	Show which zero-install sources this browser can provide and the collection boundaries before any capture.
Prerequisites	HTTPS.
Capability status	OPERATIONAL.

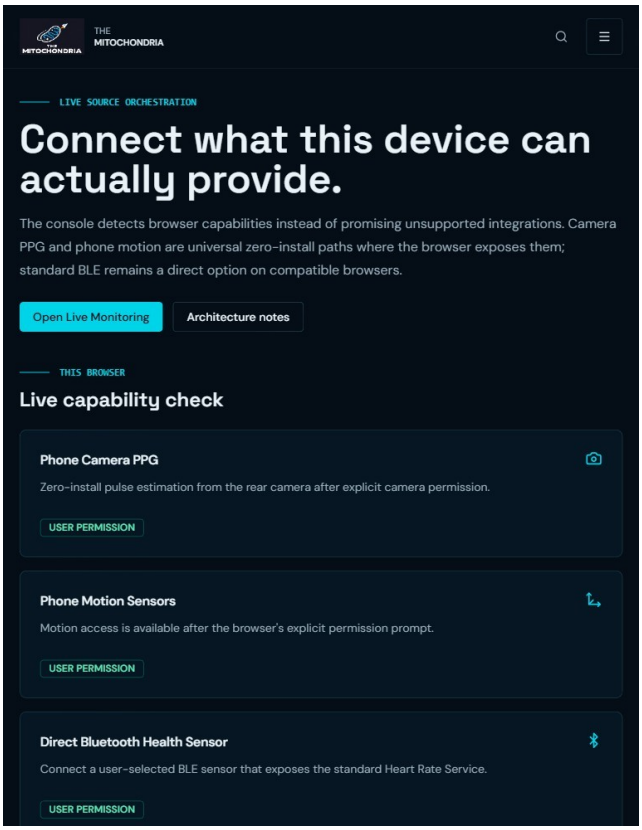


Figure 22. Device Integration Center — public view of mitochondria.edocinfo.com/mission/devices (live browser capability check). Unedited capture, 765 × 990 px.

Table 59. Device Integration Center — controls and inputs

Visible control / input	Expected input format and behaviour
Phone Camera PPG / Phone Motion Sensors / Direct Bluetooth Health Sensor cards	Badge AVAILABLE, USER PERMISSION or UNAVAILABLE HERE
Open Live Monitoring	Link to /mission/live

User action sequence

1. Open the page.
2. Read each badge.
3. Select **Open Live Monitoring** to start a source.

Expected observable results: Unsupported capabilities appear as unavailable, not as broken controls.

Data persistence and synchronization: None; detection requests no permission.

Table 60. Device Integration Center — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Bluetooth UNAVAILABLE HERE on iPhone	WebKit lacks Web Bluetooth; use Camera PPG.

Security and scientific limitations: Capability is not compatibility certification for any device.

Verification procedure

1. Compare badges on a phone and a desktop without sensors.

Implementation evidence: src/components/device-integration-center.tsx; src/integrations/browser-sensors/capabilities.ts

19. Camera PPG, Phone Motion and Bluetooth Evidence Workflows

SAFETY BOUNDARY — Camera PPG is a pulse **estimate** only (40–180 beats/min search, ≥ 6.5 s window). It is not ECG and must not be used for blood pressure, glucose, temperature, SpO_2 or arrhythmia claims.

19.1 Measure pulse with the phone camera

Purpose	Produce a zero-install pulse estimate with visible quality and integration evidence.
Required role / permission	Anyone; mission-bound only for an active Crew Self membership (otherwise LOCAL FALLBACK · NOT VERIFIED CREW).
Prerequisites	Phone with rear camera; HTTPS; camera free; light.
Navigation path	Mission Console → Measurements → Live Monitoring (`/mission/live#live-sources`) → Phone Camera PPG

Step-by-step

1. Confirm **Mission identity** reads AUTHENTICATED MEMBERSHIP (Crew Self) or LOCAL FALLBACK before starting.
2. Select **Start camera pulse** and grant permission.
3. Cover the rear lens with a fingertip and keep still ≥ ~7 s until the panel shows MEASURING.
4. Read the **Heart rate** card (value, quality, time, LIVE).
5. Watch **Device transport**, **Last physical sample** and **Encrypted persistence**: confirmed writes increase only after successful encrypted storage.
6. Lift the finger to see quality degrade (no invented values).
7. Optional: **Download non-value evidence receipt** (JSON with source, metric codes, counts and timestamps; no raw health values).
8. Select **Stop camera monitoring** (or **Disconnect current source**).

Expected result: Heart-rate observations (`phys.heart_rate`, tagged `not-ecg`) on the card and timeline; no samples after stop.

Common errors and recovery

Symptom / message	Cause and recovery
“Camera access was not granted…”	Allow camera in site settings.
Camera busy / OS lock (NotReadableError)	Close other camera apps; check OS privacy.
“Camera APIs require a secure HTTPS context…”	Use the HTTPS URL.
Rear camera selection fails	The basic camera stream is kept; a missing or blocked camera cannot be fixed in software.
“Encrypted observation write failed” / WRITE FAILED	Storage blocked (private mode, full); the failure is shown on screen, not only logged.

Security considerations: Frames are processed locally, never uploaded or stored.

Related documentation: src/components/live-dashboard.tsx; src/integrations/browser-sensors/camera-ppg.ts, ppg-algorithm.ts; real-device evidence record; live crew monitoring design record

Table 61. Live source controls

Source	Start	Stop	Notes
Phone motion	Start phone motion	Stop motion monitoring	Ignores absent acceleration; reports a startup error if the API exists but delivers no usable events
Web Bluetooth HR	Scan Bluetooth sensor	Stop Bluetooth monitoring	Needs compatible browser, OS, Bluetooth, permission and a nearby standard Heart Rate Service device; nothing is emulated
Camera PPG	Start camera pulse	Stop camera monitoring	Single-source architecture: stop/disconnect before switching

20. Live Physiological and Environmental Monitoring

20.1 Screen — Astronaut Live Dashboard

Screen name (as rendered)	Live mission health
Verified route	/mission/live
Navigation path	Mission Console → Measurements → Live Monitoring
Authorized role(s)	Public; mission-bound capture only for active Crew Self with crew ID.
Purpose	Show eight signal cards, live-source controls, identity/persistence readiness, a simple self-check and the mission timeline.
Prerequisites	None for local use.
Capability status	FIELD-VERIFIED for camera and motion capture on one device; OPERATIONAL for readiness labels and identity resolution.

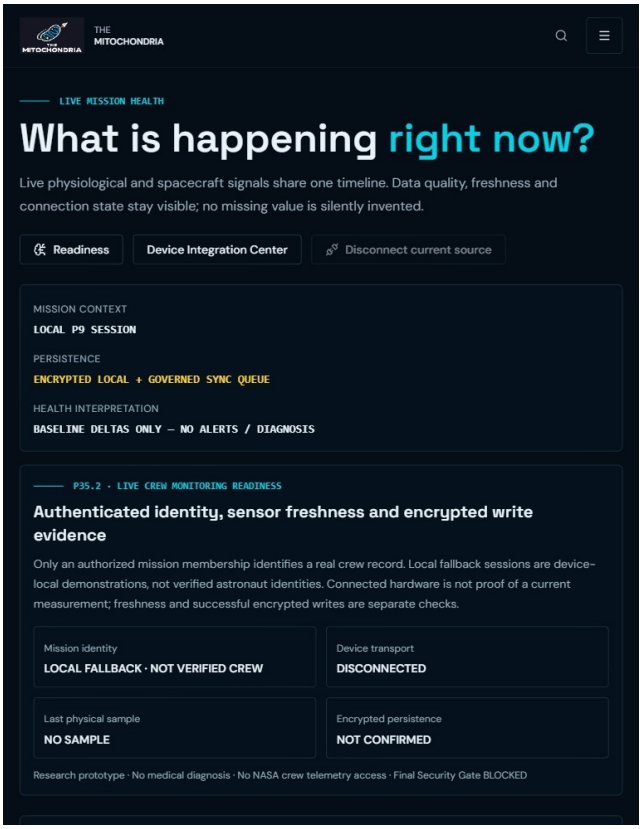


Figure 23. Live mission health — public view of mitochondria.edocinfo.com/mission/live (local session context before a source is connected). Unedited capture, 765 × 990 px.

SIGNED-IN VIEW — The image shows the page before sign-in. With an authorized synthetic account the page shows the live crew monitoring readiness panel with Mission identity AUTHENTICATED MEMBERSHIP, device transport, last physical sample and encrypted persistence counters; the Heart rate card LIVE while other cards stay DISCONNECTED.

Table 62. Live mission health — controls and inputs

Visible control / input	Expected input format and behaviour
Vitals & environment cards	Heart rate, Respiratory rate, SpO_2, Cabin CO_2, Cabin O_2, Cabin pressure, Cabin temperature, Radiation dose rate

Visible control / input	Expected input format and behaviour
Live crew monitoring readiness panel	Mission identity · Device transport · Last physical sample · Encrypted persistence
Live source cards	Start/Stop camera, motion, Bluetooth; Disconnect current source; camera diagnostics (Secure HTTPS context, Camera API, Permission state, Permissions Policy, Visible video inputs, Page visibility, Top-level page)
Simple self-check	Nominal · Monitor / not at best · Request support; Optional note ("Context only — no diagnosis"); Record check-in
Zero-install live evidence	Download non-value evidence receipt

User action sequence

1. Open the page; wait for Mission identity to resolve (on mount and on window focus).
2. Start one source (Section 19).
3. Observe cards and readiness counters.
4. Record a self-check if desired.
5. Stop the source.

Expected observable results: Only connected sources update; other cards stay DISCONNECTED ("Awaiting source"). Self-check shows "Last recorded at …".

Table 63. Live mission health — status values

Status value	Meaning
LIVE / STALE / WAITING / DISCONNECTED	Technical freshness (90 s physiological; 180 s environment/radiation) — not health thresholds
AUTHENTICATED MEMBERSHIP / LOCAL FALLBACK · NOT VERIFIED CREW / CHECKING	Identity classification; fails closed on resolution errors
NO SAMPLE / received count	Device transport versus a received physical sample
NOT CONFIRMED / confirmed count / WRITE FAILED	Encrypted persistence acknowledgement

Data persistence and synchronization: Every accepted sample and self-check is encrypted into the local append-only store first and queued for governed sync.

Table 64. Live mission health — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
"Live mission identity resolution failed"	Treated as not verified; sign in again.
"No compatible wearable source was discovered"	Expected without a BLE HR device.
Environment cards always DISCONNECTED	No environmental adapter in the zero-install configuration.

Security and scientific limitations: Display check alone does not prove RLS, encrypted persistence or cross-mission isolation. "Request support" contacts no one.

Verification procedure

1. Signed out: LOCAL FALLBACK.

2. Crew Self in two different synthetic missions: AUTHENTICATED MEMBERSHIP in each without starting a sensor.
3. Force a storage failure: visible warning.

Implementation evidence: src/components/live-dashboard.tsx; src/app/live-dashboard/store.ts; live monitoring and identity-initialization design records

20.1 Environmental and radiation context

Table 65. Environment and radiation (docs/ENVIRONMENTAL_RADIATION_TELEMETRY.md)

Quantity	Canonical code / unit	Rule
CO_2, O_2 (fraction, partial pressure), cabin pressure, temperature, humidity, noise, light, CO	environment.* (UCUM units)	Context only; no habitat thresholds or emergency actions; CO_2–cognition never causal
Absorbed dose / dose equivalent / dose rate	radiation.absorbed_dose (mGy) · radiation.dose_equivalent (mSv) · radiation.dose_rate (µSv/h)	Gy and Sv never merged; no biological risk score; no attribution of oxidative markers to radiation

21. Sensor Quality, Freshness, Provenance and Missing-Data Handling

Table 66. Quality, freshness and provenance controls

Mechanism	Behaviour
Quality levels	good, degraded, poor, unknown on every observation
Camera PPG quality	Confidence ≥ 0.72 good; ≥ 0.48 degraded; else poor with `camera_ppg_signal_quality_low`; tag `not-ecg`
Freshness	LIVE / STALE / WAITING / DISCONNECTED
Transport vs sample vs persistence	Shown separately: a connected device is not a received sample; a received sample is not a confirmed encrypted write
No imputation	Missing or poor values are never filled; missing ECG/lab data means missing, not normal
Data-quality routing	Poor/unknown-only evidence yields DATA QUALITY, routed to repeat/quality check
Provenance	Source ID/version/priority, adapter identity, original value/unit, classification on every observation; synthetic review batches add source SHA-256, excerpt and reviewer identity snapshots
Unit safety	Unknown units rejected; no unit conversion without governed conversion; document matching requires the exact original unit
Synthetic tagging	Generated data always classified `synthetic`; evidence-review tables accept synthetic data only

22. Personal Baselines and Interpretation Boundaries

The Personal Baseline Engine builds versioned distributions for one crew member, mission, metric, context policy and adaptation phase (preflight, launch_transition, early_adaptation, stable_mission, return_recovery). It compares; it never alerts. A single measurement is never a baseline, and every profile needs an explicit policy (minimum observations, coverage, accepted quality and context tags, algorithm version).

> **NOTE —** Product status: the engine is OPERATIONAL; persisted baseline profiles are out of scope for this release. Baseline profiles are not yet persisted or loaded in the deployed application, so dashboards normally show “Personal baseline: not established”. The evidence views may show a **descriptive historical mean** (≥ 3 prior good-quality observations over ≥ 24 h), which is explicitly **not** an approved baseline.

Table 67. Three separate interpretation layers

Layer	Object	Rule
Personal baseline	PersonalBaselineComparison	Individual expectation and deviation with uncertainty — never “abnormal”
Clinical reference	ClinicalReferenceInterval	Assay/population interval with source metadata; context only
Mission limit	MissionOperationalLimit	Programme rule with authority, source, version

- A baseline deviation is not a diagnosis.
- Different units, methods, postures, mission phases or assays are never compared automatically.
- A literature correlation never implies the opposite movement of an unmeasured marker.

23. Astronaut Self-Assessment and Protocol Review Categories

23.1 Screen — Action & Protocol Guidance with self-assessment

Screen name (as rendered)	Action & Protocol Guidance
Verified route	/mission/guidance
Navigation path	Health & Intelligence → Research intelligence → Action Guidance
Authorized role(s)	Protocol library public; self-assessment Crew Self with crew ID.
Purpose	Show the versioned protocol categories and let a crew member voluntarily see which review categories may be relevant.
Prerequisites	Signed in as Crew Self for the self-assessment.
Capability status	OPERATIONAL; self-assessment is session-only by design.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the astronaut self-assessment with six answers and the result "Your review — not a medical assessment". This view is presented during the live demonstration.

Table 68. Action & Protocol Guidance — controls and inputs

Visible control / input	Expected input format and behaviour
Mission	If several Crew Self memberships (switch resets answers)
Six questions	Rest, workload, fluid/nutrition logs, measurement reliability, habitat telemetry context, wish for qualified crew medical review
Review protocol categories / Clear session	Buttons

User action sequence

1. Answer the six questions.
2. Select **Review protocol categories**.
3. Read suggested categories (protocol ID, version, reason) or "No optional review categories were suggested…".
4. Select **Clear session** to discard.

Expected observable results: If medical review is wanted, the page instructs contacting the designated authority through the established channel; it sends nothing.

Table 69. Action & Protocol Guidance — status values

Status value	Meaning
info / watch / action / escalate / data_quality	Severity taxonomy; escalate requires a separate governed trigger with authority and version — never inferred

Data persistence and synchronization: Answers are not saved, uploaded, stored in browser storage or added to mission records.

Table 70. Action & Protocol Guidance — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Expecting a request to reach Ground	The page does not send requests or activate escalation.

Security and scientific limitations: The self-assessment is a voluntary checklist, not a validated clinical instrument.

Verification procedure

1. Answer and clear; confirm nothing appears in Recorded Mission Data.

Implementation evidence: src/components/action-guidance.tsx, astronaut-self-assessment.tsx; src/domain/action-guidance/protocols.ts

Table 71. Protocol library (src/domain/action-guidance/protocols.ts)

Protocol (v1)	Action class	Status
Repeat measurement / quality check	repeat-quality-check	Reviewed category
Recovery / workload review	recovery-workload-review	Reviewed category
Hydration / nutrition review	hydration-nutrition-review	Reviewed category
Exercise countermeasure review	exercise-review	Reviewed category
Environmental telemetry review	environmental-review	Reviewed category
Medical / mission escalation	medical-escalation	Governed trigger required — not activated

24. Scientific Health Intelligence and the Four Health Domains

SAFETY BOUNDARY — Everything in this section is RESEARCH-ONLY decision support. No output is a diagnosis, risk score, readiness verdict, alert or treatment. Pending scientific content is displayed for reference and is never activated.

Health Intelligence is a deterministic layer with four parts: governed trend detection (only with an explicit caller-supplied policy; no shipped clinical thresholds), reviewed pattern definitions, confidence decomposition (completeness and quality of evidence — not a probability of disease) and explainable findings (what changed, why, missing evidence, confounders, uncertainty, source IDs, guardrails).

Table 72. Pattern catalogue (src/domain/health-intelligence/patterns.ts)

Pattern (reviewed v1.1)	Evidence level	Operational status	Min. independent domains
Sleep / fatigue / cognitive change	supported	reviewed, non-diagnostic	3
Workload / recovery / autonomic context	supported	reviewed, non-diagnostic	2
Hydration / volume / orthostatic context	supported	reviewed, non-diagnostic	2
Cabin CO_2 with symptoms or cognitive change	limited	contextual only (non-causal)	2
Bone unloading / renal-stone context	supported	reviewed, non-diagnostic	3
Microbiome / immune association	research only	never operational	0

24.1 Screen — Health Intelligence and the Research Explorer

Screen name (as rendered)	Health Intelligence
Verified route	/mission/intelligence
Navigation path	Health & Intelligence → Research intelligence → Health Intelligence
Authorized role(s)	Pattern catalogue and Research Explorer public; mission-scoped evidence Crew Self with crew ID.
Purpose	Show the reviewed pattern catalogue, the crew member's own recorded measurements with evidence coverage, and the Health Intelligence Research Explorer of 54 provisional scientific semantic proposals.
Prerequisites	For private evidence: records exist locally or in the cloud for your mission and crew. The Research Explorer needs no account.
Capability status	RESEARCH-ONLY content; the Research Explorer is OPERATIONAL and FIELD-VERIFIED on the live site (search, classification filter and paging observed).

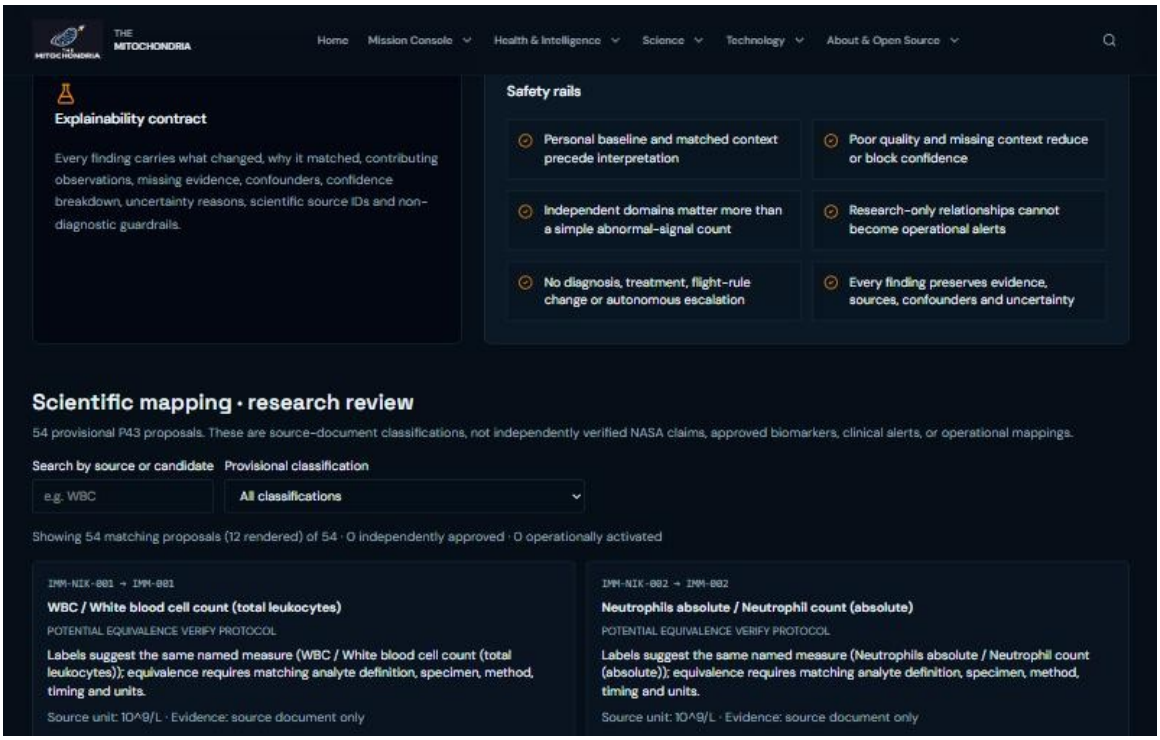


Figure 24. Health Intelligence — public view of mitochondria.edocinfo.com/mission/intelligence (Research Explorer showing all 54 provisional proposals, 0 approved, 0 activated). Unedited capture, 799 × 506 px.

> **SIGNED-IN VIEW —** The image shows the page before sign-in. With an authorized synthetic account the page shows mission-scoped scientific evidence for the Crew Self member, with the table “Cross-domain evidence coverage — not medical findings”.

Table 73. Health Intelligence — controls and inputs

Visible control / input	Expected input format and behaviour
Active mission	Crew Self memberships
Measurements by metric and unit	Latest and previous value, descriptive difference, historical mean labelled “NOT an approved personal baseline”
Cross-domain evidence coverage	Observed and missing evidence roles per reviewed pattern
Reviewed v1.1 pattern catalogue	Six definitions with evidence level, status, sources and guardrails
Research Explorer · Search by source or candidate	Free text matched against source ID, source name, catalogue name and candidate catalogue ID (example: “WBC”)
Research Explorer · Provisional classification	All · Potential equivalence verify protocol · Distinct component of broader catalog entry · Related but not interchangeable
Research Explorer · status line	“Showing n matching proposals (m rendered) of 54 · 0 independently approved · 0 operationally activated”
Research Explorer · cards	Source ID → candidate ID, names, provisional classification, scientific rationale, source unit, “Independent review pending — no merge or activation”
Show 12 more (n remaining)	Renders the next 12 cards; the first 12 are shown initially; search or filter changes reset paging

User action sequence

1. Open the page (no account is needed for the catalogue and the Research Explorer).
2. Scroll to “Scientific mapping · research review”; type WBC in the search box — one proposal is shown.

3. Clear the search and choose the classification “Potential equivalence verify protocol” — 11 proposals are shown.
4. Return to All classifications and select Show 12 more.
5. Signed in as Crew Self: choose the mission and review measurements and evidence coverage.

Expected observable results: Explorer counts update instantly and always state 0 approvals and 0 activations; private evidence shows “Evidence loaded” or “No usable numeric mission evidence yet”; without Crew Self “Private evidence requires an active Crew Self mission membership.”

Data persistence and synchronization: Read-only. The explorer reads repository-local scientific metadata only and makes no network write; private evidence is de-duplicated across local and cloud copies and filtered to mission and crew.

Table 74. Health Intelligence — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Explorer section absent	The deployed build predates the final release; reload, or ask the owner to republish.
“No matching research proposals.”	Clear the search or reset the classification.
“Evidence unavailable. No health interpretation was performed.”	Retry; nothing is inferred.

Security and scientific limitations: Proposals are source-document classifications, not approved biomarkers, mappings, alerts or NASA-verified claims. A potential equivalence does not imply the same specimen, protocol, unit, timing or instrument. The 162 source records without a curated link are not rejected. Coverage is not a matched pattern; no inference or alert is produced.

Verification procedure

1. Search WBC (1 result); filter potential equivalences (11); Show 12 more (24 rendered).
2. Confirm in the browser network panel that the explorer issues no write requests.
3. Compare evidence coverage with /mission/records for the same crew.

Implementation evidence: src/components/health-intelligence.tsx; src/components/scientific-research-candidates.tsx; data/scientific/p43-semantic-decision-proposals.v1.json; scripts/verify-p44-research-explorer.mjs, verify-p45-final-ux.mjs

24.2 Screen — Bone Health

Screen name (as rendered)	Bone Health
Verified route	/mission/bone-health
Navigation path	Health & Intelligence → Health domains → Bone Health
Authorized role(s)	Entry/import/history: Crew Self (self) or Ground Medical (rostered crew). Handbook reference: public.
Purpose	Record or import bone-health measurements with provenance, view local history, see the local evidence summary and read the English Bone Handbook v7 reference.
Prerequisites	Eligible membership for entry.
Capability status	Entry and import OPERATIONAL; document extraction experimental; handbook reference RESEARCH-ONLY (63 variables, translation pending review).

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the entry form with a handbook variable and a synthetic value, the local bone research evidence summary and the handbook reference. This view is presented during the live demonstration.

Table 75. Bone Health — controls and inputs

Visible control / input	Expected input format and behaviour
Mission / Crew member	Authorized choices only
Handbook variable	63 variables, 6 categories
Result / Unit (as reported) / Observed at / Lab / original source / Specimen / Assay / Notes	Numeric result required (“A numeric value is required.”)
Data provenance	Synthetic / demonstration · Real measurement (sensitive) — use synthetic only
Save encrypted record	Encrypted local append
Import laboratory results (CSV)	`variable,value,unit,observed_at,source,specimen,assay_method,notes`; ≤ 200 rows / 250 000 chars; per-row review
PDF & scanned report extraction (experimental)	PDF ≤ 12 MB / 12 pages or image ≤ 20 MP; PDF.js v6 / TextDetector / Tesseract (English); unchecked candidates
Bone research evidence summary · local only	Read-only summary of encrypted local history; “Catalog variables without local observations”
Handbook reference + “Also show original Greek source text (traceability)”	English layer; Greek shown with lang=el; “Translation review required — English text not shown.” where missing

User action sequence

1. Choose mission and crew.
2. Choose a handbook variable and enter a synthetic result and unit.
3. Set provenance to Synthetic / demonstration and select **Save encrypted record**.
4. Review **Local measurement history** and the local evidence summary.

Expected observable results: “Saved to encrypted local mission history. No health status was inferred.”

Data persistence and synchronization: Encrypted local store only; not automatically sent to Ground; not merged with cloud summaries.

Table 76. Bone Health — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Sign in with an authorized crew or ground medical mission membership to record measurements.”	Select an eligible membership.
“Encrypted local history unavailable on this device.”	Storage blocked.

Security and scientific limitations: No thresholds, diagnosis, readiness score or automatic “OK”. Never mix DXA aBMD and QCT vBMD; a 30 % CTX increase is a marker increase, not 30 % bone loss.

Verification procedure

1. Save a synthetic record; confirm it appears only for the selected mission and crew.

Implementation evidence: src/components/bone-health-entry.tsx, bone-health-import.tsx, bone-health-document-import.tsx, scientific-handbook-reference.tsx; data/scientific/bone-health-handbook-v7.*

24.3 Screen — Cardiovascular Health, Immune Changes, Behavioral Health

Screen name (as rendered)	Integrated Astronaut Health Domains
Verified route	/mission/cardiovascular-health · /mission/immune-health · /mission/behavioral-health
Navigation path	Health & Intelligence → Health domains
Authorized role(s)	Reference sections public; private domain evidence Crew Self with crew ID.
Purpose	Show mission-scoped measurements mapped to the domain, the research evidence summary, the scientific relationship registry, interpretation boundaries and the domain's reference catalog.
Prerequisites	Crew Self for private evidence.
Capability status	RESEARCH-ONLY; the evidence projection is OPERATIONAL.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the immune proposal catalogue search with 35 entries, or the cardiovascular 96-measurement handbook reference expanded. This view is presented during the live demonstration.

Table 77. Integrated Astronaut Health Domains — controls and inputs

Visible control / input	Expected input format and behaviour
Active mission	Crew Self memberships
Research evidence summary · read-only	Available metric series, Missing mapped signals, Quality-limited series, latest/previous values, source, local/cloud location
Scientific relationship registry; Interpretation boundaries	Read-only
Cardiovascular: handbook reference	96 measurements in 7 groups + 8 relationship examples, English with optional Greek
Immune / Behavioral: Search proposed measurements	35 immune (IMM) / 36 behavioural (BSC) entries, each labelled as pending independent review and not active
Open Mission Documents / Open Health Intelligence	Links

User action sequence

1. Open the domain page as Crew Self.
2. Read the evidence summary and missing signals.
3. Search the reference catalog.

Expected observable results: “Mission evidence loaded; no health interpretation performed.” or “No matching numeric measurements are available for this mission and domain.”

Data persistence and synchronization: Read-only; counts reflect series, not unique measurements across domains; pending offline sync is not treated as cloud-confirmed.

Table 78. Integrated Astronaut Health Domains — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Sign in with an active Crew Self mission membership to view private measurements.”	Select Crew Self.
“Mission authorization unavailable. No data loaded.”	Retry.

Security and scientific limitations: Evidence presence does not prove a relationship, coincidence, causation or health status. Proposal catalogs are not approved metrics, mappings, rules or thresholds.

Verification procedure

1. Confirm 35/36 proposals and that search exposes no private data.
2. Confirm no evidence is shown without Crew Self membership.

Implementation evidence: src/components/health-domain-workspace.tsx; src/domain/health-domains/*; src/domain/scientific-localization/handbooks.ts

24.4 Screen — NASA Scientific Evidence and OSDR research import

Screen name (as rendered)	NASA Scientific Evidence
Verified route	/mission/nasa-evidence
Navigation path	Health & Intelligence → Research intelligence → NASA Scientific Evidence
Authorized role(s)	Public.
Purpose	Browse the static index of public NASA references and preview published NASA OSDR study and sample metadata as a research-only JSON evidence package.
Prerequisites	Network for OSDR requests.
Capability status	Reference index RESEARCH-ONLY; OSDR import OPERATIONAL (research-only output).

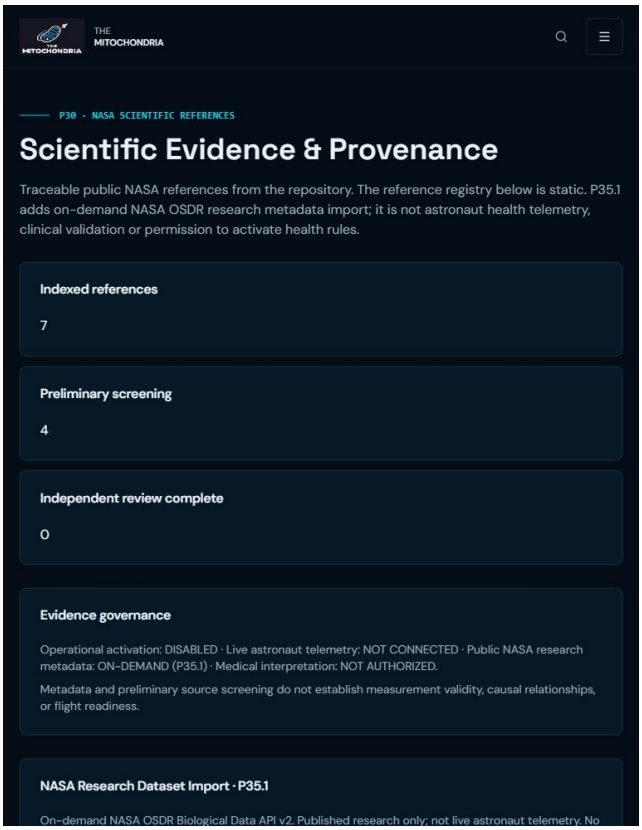


Figure 25. NASA Scientific Evidence — public view of mitochondria.edocinfo.com/mission/nasa-evidence (reference registry summary). Unedited capture, 765 × 990 px.

> **FURTHER VIEW —** Scrolling or interacting with the page shows the NASA research dataset import with accession OSD-48 previewed (Organism, Assay and Sample columns).

Table 79. NASA Scientific Evidence — controls and inputs

Visible control / input	Expected input format and behaviour
Search scientific sources / Evidence category	Static index (7 references)
Open original NASA reference ↗	Opens on click only
OSDR accession	Pattern `OSD-<number>` (default OSD-48), max 12 chars
Preview dataset / Import research sample metadata	Calls `/api/nasa-research`

User action sequence

1. Enter an accession (e.g., OSD-48).
2. Select **Preview dataset**, then **Import research sample metadata**.
3. Download the JSON package if offered and keep it labelled research-only.

Expected observable results: Bounded metadata table (≤ 500 rows). The JSON carries source URL, retrieval time, `research_only`, `subjectBinding:none`, `clinicalActivation:false`.

Data persistence and synchronization: Nothing written to Supabase or IndexedDB; no missions, samples-to-crew binding, baselines or alerts.

Table 80. NASA Scientific Evidence — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Use a valid NASA OSDR accession, e.g. OSD-48”	Fix the format.
“NASA API error” / “Import failed”	Upstream error, timeout (12 s) or response > 1 MiB; no synthetic fallback is shown as live data.

Security and scientific limitations: Sample metadata are not physiological measurements; OSD-48 is mouse research; no human equivalence. NASA does not endorse this project. Not live astronaut telemetry.

Verification procedure

1. Request an invalid accession (rejected client- and server-side).
2. Confirm the response for a valid accession is labelled research-only.

Implementation evidence: src/routes/api.nasa-research.ts; src/components/nasa-research-import.tsx; src/domain/nasa-research/import.ts; tests/domain/ NASA research suite

25. Biomarker Matrix, Evidence Mapping and Cross-Domain Relationships

Table 81. Scientific catalogues and their status

Catalogue	Size	Status	Used for
Canonical catalogue (Biomarker Matrix v1.1 reviewed MVP subset)	70 metrics, 11 domains (47 P0, 23 P1; 55 KEEP, 15 MODIFY)	Implementation review; not clinical validation	Ingestion, adapters, patterns (Appendix B)
Biomarker source registry	159 entries: 96 cardiovascular (with original units) + 63 bone (no approved units)	`research_only`, `sourceMappingIsProvisional`, `clinicalActivation:false`	Exact-match candidates in Mission Documents; 96 metric/unit pairs accepted by the submission RPC
Cardiovascular handbook catalog	96 measurements, 7 groups, 8 relationship examples	pending_independent_review; English layer pending review	Reference on Cardiovascular page
Bone Health Handbook v7 catalog	63 variables, 6 categories	pending_independent_review	Reference; bone entry; advisory hints
Immune (IMM) / behavioural (BSC) scientific drafts	35 + 36 entries; 34 change-register items	Pending independent scientific review	Read-only proposal lists; never matched or routed
Nikolas' immune and behavioural developer handbooks (intake)	117 immune + 99 behavioural entries; 3 cross-domain contexts	Candidate reconciliation; not approved for operational use	Research-only intake data (Section 25.3)
Provisional semantic proposals	54 (11 potential equivalences, 42 distinct components, 1 related assay); 162 records without a curated link	0 independent approvals; 0 operational activations	Health Intelligence Research Explorer

25.1 Evidence mapping rules

- Exact name and exact original unit only; aliases only from a reviewed dictionary; no fuzzy insertion.
- Reference intervals are never imported as measurements; ambiguous or multiple measurements need disambiguation.
- Before comparison: matching units, method/device, posture/activity, mission phase, time, specimen/assay and QC.
- Distinguish measured, derived, association, suspected event and clinician-confirmed event.
- Greek source catalogs stay byte-identical (SHA-256 tested); English text is joined by stable ID and replaced by “Translation review required” if missing or still Greek.
- Flagged translation ambiguities (cv-001, cv-008, cv-015 “Blood volum”, cv-047, cv-094 “8-OHd”; bone-019, bone-026, bone-030, bone-045; relationship 6) await independent review.

25.2 Cross-domain relationships (permitted display only)

Table 82. Cross-domain relationships

Relationship	Domains	Evidence	Permitted behaviour
Short/mistimed sleep + sleepiness/fatigue + vigilance slowing	Sleep ↔ Cognitive	Supported (Matrix 08)	Research display; DATA QUALITY prompts
Workload + sleep + HR/HRV recovery	Behavioral ↔ Cardiovascular	Supported/limited	No stress label
Bone unloading + urine calcium context	Bone ↔ Renal	Supported	No renal-stone risk score
Bone–vascular (CTX/P1NP, urinary calcium, PWV/CAC)	Bone ↔ Cardiovascular	Exploratory (CV handbook)	Not causal; display only
Microbiome ↔ immune	Microbiome ↔ Immune	Research only	Never operational
Sleep ↔ immune markers	Sleep ↔ Immune	Terrestrial evidence (IMM draft)	Draft only; not implemented
CO_2 ↔ cognition	Environment ↔ Cognitive	Conflicting (NASA OCHMO)	No causal rule

NOTE — Document-to-domain routing projects exact-match candidate IDs to the four domains for preview only; it never routes unmatched text, filenames or IMM/BSC draft IDs and never writes timelines.

25.3 Nikolas' scientific intake and semantic reconciliation

Nikolas' immune-changes and behavioural-health developer handbooks are integrated as research-only, non-activating intake. Every source record keeps its original name, unit, description and source evidence label; these labels (for example NASA-SSM, NASA-Research, Candidate) are attributed claims from the handbooks, not independently verified NASA endorsements. The project owner reports that Nikolas completed a verbal scientific review of the existing reference entries; a signed, per-entry review record is not yet recorded, so source statuses, the 54 proposals (0 independently approved, 0 operationally activated) and all activation flags are unchanged, and the domain pages state this wording explicitly.

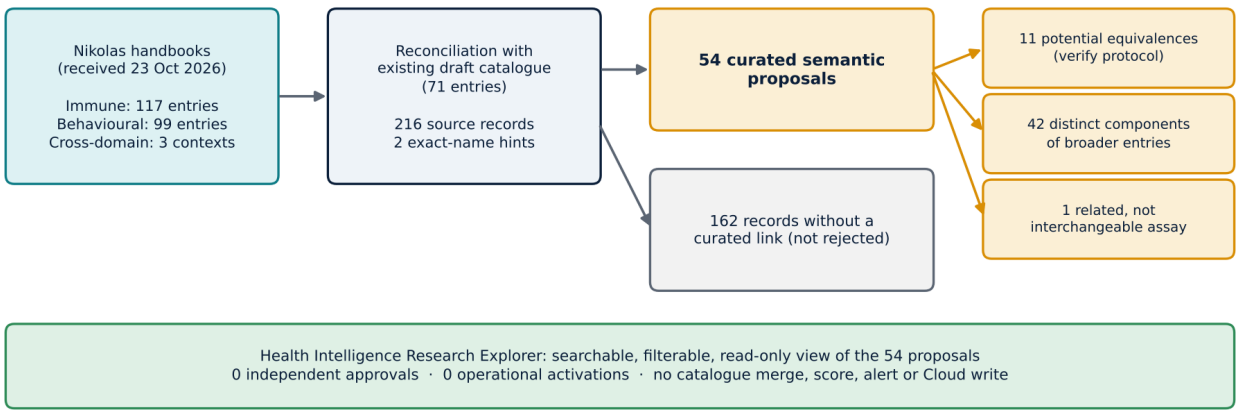


Figure 26. From handbook intake to the 54 provisional proposals shown in the Research Explorer

Table 83. Scientific intake and reconciliation results

Stage	Result	Governing rule
Intake	216 source records: 117 immune (including 20 supplementary rows) and 99 behavioural measurements or derived fields; 3 cross-domain contexts (immune–behavioural, immune–bone, behavioural–cardiovascular)	Missing, below-detection and not-ordered values stay distinct; no global immune score or psychiatric classification
Reconciliation with the 71-entry draft catalogue	2 exact normalized-name hints; 214 records need manual reconciliation	Exact names are hints, not approved equivalences; the draft catalogue has no units, so unit compatibility is not established
Semantic mapping	54 curated candidate links; 162 records without a curated link	Candidates only; nothing is merged automatically
Provisional dispositions	11 potential equivalences (verify protocol) · 42 distinct components of broader entries · 1 related but not interchangeable assay (high-sensitivity vs. generic CRP)	Each row carries a rationale and required checks; reviewer, decision and timestamp remain empty
Independent review workbook	All 216 rows start as pending independent scientific review	Approval requires a named independent reviewer, evidence, rationale and a separately governed release

SAFETY BOUNDARY — The cross-domain contexts in the intake are associations only: salivary cortisol, sleep and immune-cell function; IL-6, CTX and 25(OH) vitamin D; HRV RMSSD, sleep and workload. They support research display and are never causal, diagnostic or alert-generating.

26. Offline Mission Mode and Encrypted Local Persistence

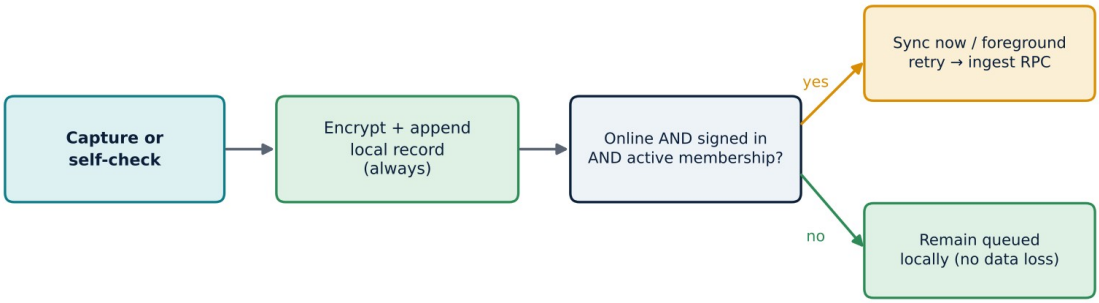


Figure 27. Every capture is encrypted locally first; synchronization is a separate authorized step

26.1 Screen — Offline Mission Mode

Screen name (as rendered)	Offline Mission Mode
Verified route	/mission/offline
Navigation path	Mission Console → Measurements → Offline Mission Mode
Authorized role(s)	Status: anyone. Sync: signed-in user with an active membership authorized for the records.
Purpose	Show local store, queue and protocol-cache readiness; synchronize; enable foreground retries; verify cloud records.
Prerequisites	Browser storage available.
Capability status	OPERATIONAL (automated offline workflow test passing); airplane-mode validation on a physical device VALIDATION BOUNDARY.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows the local mission state READY with pending records, the AUTHENTICATED synchronization badge and, when disconnected, Connectivity OFFLINE. This view is presented during the live demonstration.

Table 84. Offline Mission Mode — controls and inputs

Visible control / input	Expected input format and behaviour
Local mission state	Encrypted local store, Local records, Sync queue (pending + retryable), Protocol cache
Offline readiness	Connectivity, Application shell, Sync conflicts, Runtime health
Supabase synchronization boundary badge	AUTHENTICATED · LOCAL ONLY · CONFIGURATION REQUIRED · ERROR
Sync now	Enabled only online
Enable foreground retries / Pause automatic retries	Retries while visible, online and signed in
Verify cloud records	Compare up to 300 IDs per side
Review queue (read-only)	Up to 20 quarantined IDs with reasons, no payloads

User action sequence

1. Check local state and readiness.
2. If LOCAL ONLY, use Mission sign-in.
3. Select **Sync now** when online.
4. Optionally enable foreground retries.
5. Optionally **Verify cloud records**.

Expected observable results: “Governed Supabase synchronization completed.”; queue count falls; verification “Matched X of Y locally synced records; Z not found in the limited cloud query.”

Table 85. Offline Mission Mode — status values

Status value	Meaning
READY	Store/cache available
AUTHENTICATED / LOCAL ONLY	Cloud boundary state

Data persistence and synchronization: IndexedDB, AES-GCM, non-extractable key, append-only; service worker caches public shell only (excludes /api/ and Supabase).

Table 86. Offline Mission Mode — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
“Cloud sync requires a signed-in user with an active mission membership…”	Sign in and select membership.
“Cloud sync is unavailable while this device is offline.”	Retry online.
“Sync withheld: …”	Authorization declined; records stay intact.

Security and scientific limitations: Browser-local encryption, not hardware-backed; no key rotation or recovery; clearing site data destroys local records.

Verification procedure

1. Capture offline, reconnect, sync; confirm the record appears in Recorded Mission Data as Supabase-synced.

Implementation evidence: src/components/offline-mission.tsx, offline-autonomy.tsx; src/infrastructure/offline/*; docs/OFFLINE_MISSION_MODE.md

Table 87. Local encryption baseline

Property	Implementation
Store	IndexedDB in the browser origin
Encryption	AES-GCM via Web Crypto before storage
Key	Non-extractable CryptoKey stored by structured cloning
Semantics	Append-only; conflicting reuse of an event identity fails closed
Protocol cache	Versioned protocols with SHA-256 integrity metadata
Offline capability limits	Once loaded and cached, physical capture and encrypted writes can work without Internet subject to browser, permission, device and storage; sign-in, password change, Cloud saving and sync need Internet

27. Governed Synchronization, Queues and Failure Handling

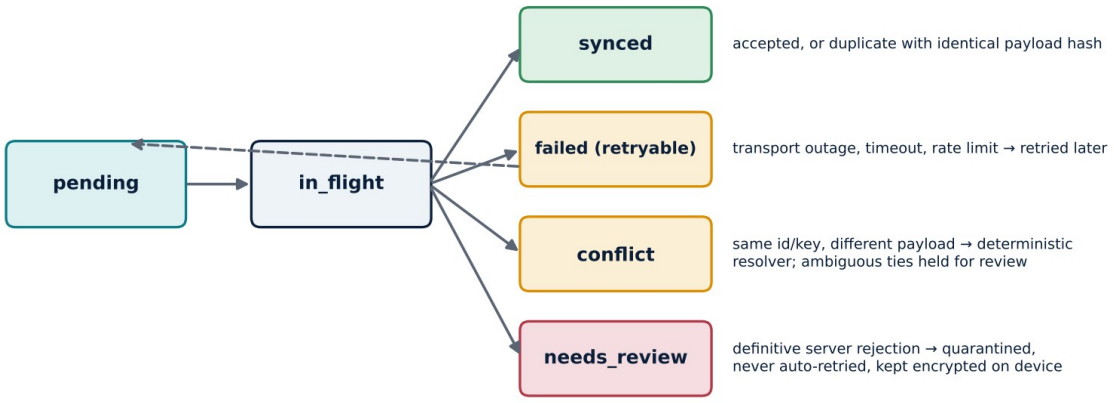


Figure 28. Sync queue states

Table 88. Failure handling

Interruption	Behaviour	Action
Network loss during capture	Capture continues; encrypted and queued	Sync later
Network loss during sync	Item failed (retryable)	Sync again
Session expiry	Sync locked; queue intact	Sign in
Duplicate retry	Server returns duplicate for identical payload hash	None
Same ID, different payload	Conflict; deterministic resolver or held	Review if listed
Definitive rejection	needs_review; never auto-retried	Contact an authorized operator
Mission closed before sync	Events before end time accepted; later refused	Sync before closure
Synthetic Cloud save retried	Same idempotency key + same payload → replay; different payload → conflict; same SHA-256 + date → already submitted	Do not resubmit changed values under the same review
Research decision retried	Same reviewer + key + payload → original receipt (replay=true); different payload → refused; already decided → refused	Never send a second, different decision

27.1 Screen — Recorded Mission Data

Screen name (as rendered)	Recorded Mission Data
Verified route	/mission/records
Navigation path	Mission Console → Measurements → Recorded Mission Data
Authorized role(s)	Anyone for local records on this device; cloud rows as authorized by RLS.
Purpose	Inspect local and synced records with quality, source, storage location and sync state.
Prerequisites	Records captured in this browser and/or an authenticated membership.
Capability status	OPERATIONAL.

SCREEN VIEW — With an authorized synthetic account holding the role stated above, the page shows status cards (local records, pending or failed, synced queue, AUTHENTICATED) and the record table filtered to Local. This view is presented during the live demonstration.

Table 89. Recorded Mission Data — controls and inputs

Visible control / input	Expected input format and behaviour
Storage filter	All · Local · Supabase
Table	Time, Metric / event, Value, Quality, Source, Storage, Sync
Sync now / Refresh / Mission sign-in	Buttons

User action sequence

1. Open the page.
2. Filter storage.
3. Review rows.
4. Sync now if online and authorized.

Expected observable results: Local rows decrypted in the originating browser; cloud rows per RLS.

Data persistence and synchronization: Read-only projection; encrypted append-only records never rewritten.

Table 90. Recorded Mission Data — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Local records missing on another device	Keys are origin- and device-bound; sync first.
Cloud rows not visible	Not signed in or RLS denies.

Security and scientific limitations: Synthetic review batches are not shown here (separate tables; never promoted).

Verification procedure

1. Capture a self-check; confirm a Local row, then a Supabase row after sync.

Implementation evidence: src/components/recorded-mission-data.tsx; src/infrastructure/mission-records.ts

Integrity mechanisms: idempotency keys (16–256 characters) with SHA-256 payload hashes; advisory locks per event ID; append-only local records and cloud audit; immutable review items; one decision event per batch; membership row locks (FOR SHARE) serializing revocation against decisions (whichever commits first wins).

28. Reports, Exports and Evidence Verification

Table 91. Exports and their meaning

Export	Where	Content	What it is not
Non-value device evidence receipt	/mission/live	Source, metric codes, counts, timestamps	No raw values; not clinical evidence
Research aggregate JSON	/mission/ground	≤ 1 aggregate row; counts rounded down to tens	Not anonymized data or an IRB release
Synthetic scenario / replay JSON	/mission/simulation	Seeded synthetic events	Not physiology
Demo runbook JSON	Operator launchpad	Session checklist and role hand-offs	Not authorization or audit receipt
Synthetic demo dataset JSON	Operator launchpad	18 fictional observations, 4 domains, 3 timepoints	Not an ingestion contract
Offline synthetic report JSON / CSV / Print-PDF	Operator launchpad	Domain table with arithmetic differences; provenance and limitations	Not a health report
Integrated offline demo bundle JSON	Operator launchpad	Dataset + report	Rejected if modified, cross-mission or extra fields
Acceptance handoff JSON	Operator launchpad	Readiness checks and explicit non-claims	Not a release authorization
Local synthetic review JSON	/mission/documents	Mission/crew-bound reviewed values, `LOCAL_REVIEW_ONLY_NOT_APPROVED_FOR_IMPORT`	Not approval or import
NASA OSDR JSON package	/mission/nasa-evidence	Study/sample metadata, research_only	Not crew data
Acceptance worksheets, integration handoff JSON	/mission/validation, /mission/submission	Session notes and repository ledger snapshots	Never change ledgers or approvals
Decision receipt (on screen)	/mission/ground	decision_request_id, decided_at, replay	Correlation metadata, not cryptographic proof

28.1 Screen — Challenge Demo & Submission

Screen name (as rendered)	Challenge Demo & Submission
Verified route	/mission/submission
Navigation path	About & Open Source → Governance & references → Challenge Submission
Authorized role(s)	Public evidence register.
Purpose	Present the controlled demonstration runbook, the challenge submission evidence, integration readiness across connected workflows and the human-operated acceptance worksheet.
Prerequisites	None.
Capability status	OPERATIONAL register; contents are snapshots of source-controlled ledgers.

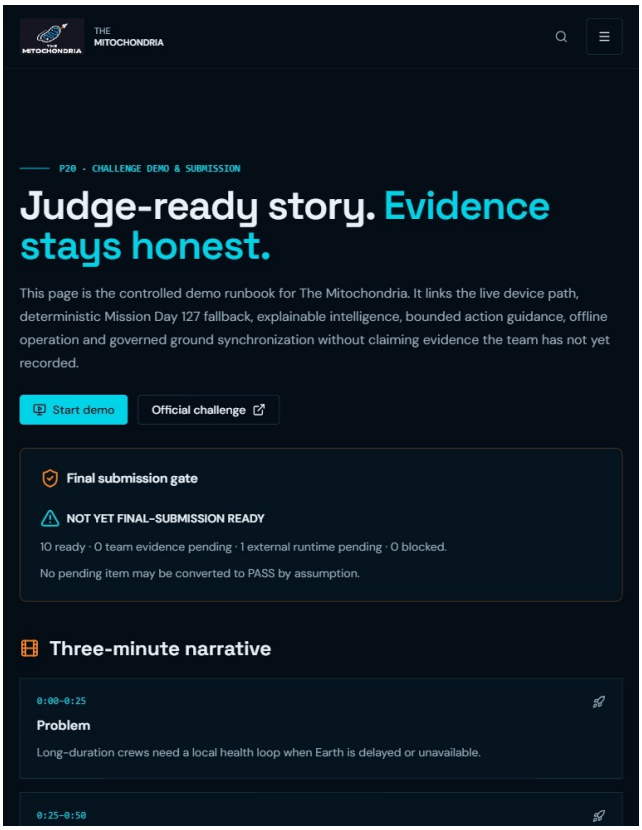


Figure 29. Challenge Demo & Submission — public view of mitochondria.edocinfo.com/mission/submission (demonstration runbook and submission evidence status). Unedited capture, 765 × 990 px.

> **FURTHER VIEW —** Scrolling or interacting with the page shows the integration and mission readiness card and the human-operated acceptance worksheet.

Table 92. Challenge Demo & Submission — controls and inputs

Visible control / input	Expected input format and behaviour
Open workflow → links	To NASA evidence, live, alerts, offline
Export integration test handoff (JSON)	Local download
Human-operated acceptance worksheet	Per case: Not executed / Observed pass (unverified) / Observed fail / Blocked / no access; Observation note; Evidence reference (artifact ID only, no PHI)
Export manual acceptance worksheet (JSON)	Local download

User action sequence

1. Read gate states.
2. If executing acceptance, record observations per case using artifact IDs only.
3. Export the worksheet.

Expected observable results: “Local handoff exported. No results were saved to mission records or submitted for approval.”

Data persistence and synchronization: Session only; exports local.

Table 93. Challenge Demo & Submission — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Expecting approval after export	Worksheets never approve or change ledgers.

Security and scientific limitations: The page states its own evidence status openly: items awaiting human or external evidence stay pending and are never converted to a pass by assumption; clinical activation is disabled.

Verification procedure

1. Confirm the 24 human-operated acceptance cases are listed and that nothing persists on reload.

Implementation evidence: src/components/challenge-submission.tsx and its integration-readiness and acceptance panels; data/submission/*; data/validation/*

29. Synthetic Demonstration Environment and Mission Workflows

Table 94. Synthetic environment

Mission / dataset	Nature	Status / rule
Reserved acceptance mission	Bootstrap mission	Kept free of demonstration records; launchpad tracker and dataset export disabled
Synthetic test missions	Owner-provisioned missions with synthetic crew	Used for role demonstrations and the independent review workflow; evaluators receive memberships from the owner
Dedicated demonstration mission	Owner-created on demand from the launchpad (code MITO_DEMO_2026)	Owner-only, typed confirmation
Deterministic scenarios (4) / multi-crew simulation	Seeded synthetic	Public on /mission/simulation
Demo dataset (18 observations)	Deterministic fictional, 4 domains × 3 timepoints	Operator launchpad only

29.1 Screen — Synthetic Mission Simulation

Screen name (as rendered)	Synthetic Mission Simulation
Verified route	/mission/simulation
Navigation path	Mission Console → Ground operations → Mission Scenario
Authorized role(s)	Public.
Purpose	Reproducible end-to-end demonstration without real data.
Prerequisites	None.
Capability status	SYNTHETIC DEMONSTRATION.

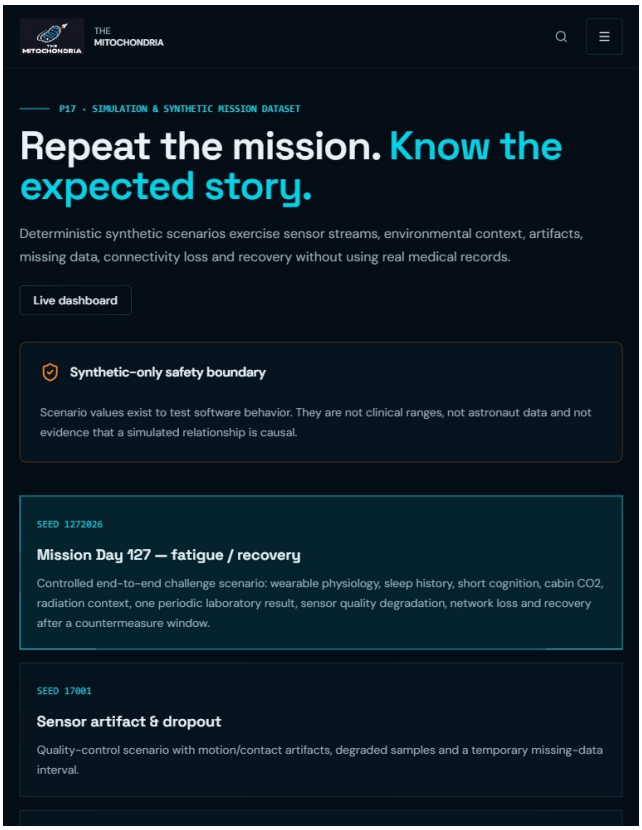


Figure 30. Synthetic Mission Simulation — public view of mitochondria.edocinfo.com/mission/simulation (synthetic-only boundary and Mission Day 127 scenario). Unedited capture, 765 × 990 px.

> **FURTHER VIEW —** Scrolling or interacting with the page shows the Mission Day 127 scenario summary with its fingerprint and the first canonical observations.

Table 95. Synthetic Mission Simulation — controls and inputs

Visible control / input	Expected input format and behaviour
Synthetic scenarios	mission_day_127_fatigue_recovery (1272026), sensor_artifact_dropout (17001), co2_context_event (17002), radiation_context_event (17003)
Regenerate same seed / Export JSON	Determinism check, download
Multi-astronaut simulation	Mars Transit Day 120; crew filter; Download synthetic replay JSON

User action sequence

1. Choose a scenario.
2. Read Events, Observations, Poor quality, Fingerprint.
3. Regenerate the same seed (fingerprint unchanged).
4. Export JSON.

Expected observable results: Identical output for the same seed; all observations synthetic.

Data persistence and synchronization: None; no sync or ingestion.

Table 96. Synthetic Mission Simulation — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Treating values as physiology	They are software fixtures.

Security and scientific limitations: Not forecasts or validated cohorts.

Verification procedure

1. Regenerate twice; compare fingerprints.

Implementation evidence: src/components/synthetic-mission.tsx, multi-crew-simulation.tsx; data/synthetic/scenario-manifests.v1.json

29.2 Recommended synthetic demonstration flow

The NASA Evaluator Quick Start Guide contains the step-by-step 15–20-minute sequence with checkpoints and recovery paths. Its central principle: public steps first; role-specific steps with owner-provided synthetic accounts; no Cloud writes by evaluators except where the owner explicitly authorizes them.

30. Data Model, Schemas, Interfaces and Server Operations

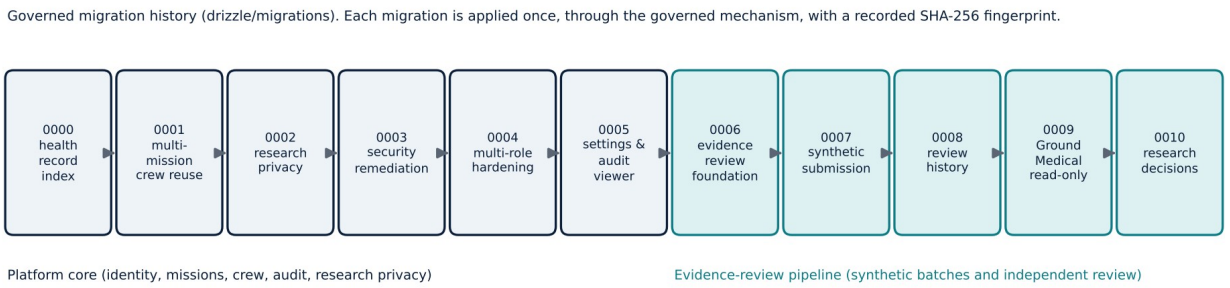


Figure 31. Governed migration history 0000–0010

Table 97. Tables (supabase/migrations, drizzle/migrations)

Table	Purpose	Browser access
missions	Mission identity, lifecycle, dates	SELECT per RLS; writes via RPC
mission_memberships	User × mission × role (+ crew)	SELECT per RLS
crew_members, mission_crew_assignments	Global crew identity; mission assignment	Assignments: none
mission_invites	Hashed one-time invites, binding, approval	None
mission_events, crew_health_record_index	Synced events; value-free index	SELECT per RLS; writes via ingest RPC
audit_events	Append-only audit	Operator viewer via RPC
mission_research_keys, mission_research_snapshots	Pseudonymization keys; frozen snapshots	None
mission_bootstrap_control	One-shot bootstrap	None
p36_biomarker_review_batches (evidence review)	Synthetic batches: mission, crew, submitter/reviewer membership + user snapshots, SHA-256, date, status, decision receipt/idempotency	None (forced RLS, deny-all)
p36_biomarker_review_items	Immutable values, units, excerpts (no update/delete)	None
p36_biomarker_review_events	Append-only quarantine/decision events, one per batch	None
p36_metric_unit_catalog	96 accepted metric/unit pairs	None

Table 98. Server interfaces

RPC / interface	Caller	Purpose
accept/approve/bind/create_mission_invite	Signed-in users per rules	Invitations
create_mission_operation, update_mission_operation, get_mission_operations_workspace	Mission Operator	Mission administration

RPC / interface	Caller	Purpose
create/update_mission_crew_member, assign_existing_crew_to_mission, set_mission_membership_active	Mission Operator	Crew and memberships
ingest_mission_event	Crew Self / Ground Medical / Operator (non-medical)	Sync
get_ground_mission_snapshot, export_research_mission	Ground Medical; GM/Researcher	Snapshot; aggregate
get_mission_audit_log	Mission Operator	Audit viewer
bootstrap_first_mission, get_mission_bootstrap_status	Bootstrap	First operator
p36_submit_synthetic_review_batch, p36_list_synthetic_review_history	Crew Self via server function	Synthetic submission and own history
p368_list_ground_medical_pending, p368_get_ground_medical_batch, p368_decide_ground_medical_batch	Ground Medical	Read queue/values; research decision
GET /api/nasa-research	Public	Bounded OSDR proxy (fixed origin, 12 s, 1 MiB, no redirects, no-store)
Synthetic submission server function	Signed-in Crew Self	Bearer-token proxy; disabled unless the server feature flag is enabled

30.1 Canonical observation and document-candidate contracts

Canonical observations carry mission and crew IDs, source provenance, metric code and UCUM-style unit, timestamps and clock metadata, quality and artifacts, raw/derived flag, classification (`synthetic`, `deidentified`, `mission_sensitive`, `medical_sensitive`) and sync state. The document-candidate contract adds raw/proposed value and unit, specimen, assay, anatomical site, modality, posture, rest state, device model, source document SHA-256, page, excerpt, extraction method and confidence, validation flags and review status.

30.2 Migration operations

- Baseline migrations live in `supabase/migrations`; the governed history 0000–0010 is recorded in `drizzle/migrations` (Figure above).
- Migrations 0000–0005 establish the platform core: health-record index, multi-mission crew reuse, research privacy, security remediation, multi-role hardening, and Mission Settings with the audit viewer.
- Migrations 0006–0010 add the evidence-review pipeline: review foundation, synthetic submission, review history, Ground Medical read-only review and research decisions.
- Each migration is applied once through the governed mechanism with a recorded SHA-256 fingerprint and post-deployment checks; staged copies in `supabase/pending` are byte-identical and never auto-applied.
- Rollback scripts exist for some staged files; they are manual, owner-run and potentially destructive, and the decision rollback refuses once decisions exist.

31. Privacy, Cybersecurity, Auditability and Governance

Table 99. Trust boundaries

#	Trust boundary	Primary controls
1	Sensor → browser adapter	Capability contracts; governed codes; provenance
2	Browser → encrypted IndexedDB	AES-GCM; non-extractable key; append-only
3	Session → Supabase RPC	auth.uid(); active membership; pinned search_path
4	RLS / SECURITY DEFINER → tables	Forced RLS; SELECT-only browser grants; RPC-only writes; evidence-review tables deny-all
5	Identified store → Ground Medical console	Mission-scoped role; audited reads
6	Identified store → research export	Aggregate-only; suppression; audit
7	Intelligence → action layer	Research-only fail-closed; governed escalation trigger
8	Audit → operator viewer	Read-only RPC; allow-list redaction; HMAC refs and cursors
9	Crew Self → synthetic Cloud batch	Server flag; bearer token not service role; FOR SHARE membership lock; catalogue/unit/idempotency checks; audit without values
10	Ground Medical → research decision	Independent reviewer (different user, same mission); locks; one final event; privacy-safe audit; session flag as defence in depth

31.1 Security posture

Table 100. Security posture

Area	Status
Row-level security, governed functions and multi-role hardening	OPERATIONAL in production; covered by disposable-PostgreSQL tests
Mission Settings and audit viewer	FIELD-VERIFIED (signed-in production acceptance recorded)
Evidence-review database layer (migrations 0006–0010)	Deployed through the governed mechanism with post-deployment checks
Dependency security	Trivy findings remediated; remaining advisories are transitive (moderate: @hono/node-server, qs, esbuild, minimatch; low: esbuild — development or tooling paths), as recorded in the repository
Quality workflow (push to main)	Passing on the release commit 4e448ea (Quality #338, 1 min 30 s): full `bun run check` — verifiers, security audit, tests, typecheck, lint, format check and production build. The earlier test-harness failure (a fixed checkout path in one test) and an order-dependent test-mock leak were repaired in P52 and P52.1 without changing any security or scientific assertion
Security Scan workflow (Trivy filesystem scan, HIGH/CRITICAL, push to main)	Passing on the release commit 4e448ea (Security Scan #326)
Medical v3 Release Gate (push to main)	Failing on 4e448ea (#75) by design: the gate runs the owner-evidence verifiers P3663 (restore/recovery evidence), P3664 (explicit owner risk acceptance) and P20 (official 2026 rules re-check), which remain BLOCKED until genuine evidence exists. It has no successful run

Area	Status
Workflow hardening	Third-party actions pinned to immutable commit SHAs; read-only permissions; no persisted credentials
Provider-level privileged-role finding	Open — tracked with the hosting platform
Final security sign-off	VALIDATION BOUNDARY — not yet granted
Independent penetration test	Not yet performed

31.2 Data protection controls

Table 101. Data protection

Area	Protection
Browser	Encrypted IndexedDB; service worker never caches health APIs
Transit	HTTPS; HSTS on canonical host; upgrade-insecure-requests
Headers	CSP default-src 'self', frame-ancestors 'none', object-src 'none'; X-Frame-Options DENY; nosniff; Referrer-Policy no-referrer
Permissions-Policy	camera/motion sensors self; microphone, geolocation, payment, USB, serial, HID disabled
Secrets	Publishable key only in browser; security audit blocks service-role keys and tokens
Documents	Original PDFs stay in the browser; only SHA-256 + reviewed values sent; no third-party OCR/AI
Audit privacy	Evidence-review audit rows contain no values, notes, filenames or excerpts; invite codes never logged
Research	Mission-scoped pseudonymization keys hidden from browser roles; aggregate-only export
Sign-in	Generic credential error prevents account enumeration

31.3 Governance

- Owner approval per migration, per publication and per live review decision; approval records are kept privately, outside the repository.
- Separation of duties: role compatibility matrix; independent Ground Medical approval; reviewer ≠ submitter at user level.
- Revocation by deactivation is immediate; membership deletion is restricted for referenced review records.
- Residual risks: database owner can bypass triggers or set the decision session flag; receipts are not cryptographic proof; single-reviewer final decisions; no appeal path.
- Ethical use: synthetic data only; inform participants that the system is an uncertified prototype; never use outputs for selection, discipline or fitness-for-duty.

31.4 Session integrity: mission switching, tab revalidation and private-data clearing

Two client components hold private health data on screen for long periods — the Daily Health Companion (Crew Self) and the Ground Medical review panel. Both follow the same rule: **a rendered view must never outlive its authorization.** Row-level security in PostgreSQL remains the enforcement point; the client rules below close the window in which an already-rendered page could keep showing data after a change.

Table 102. Session-integrity rules

Rule	Daily Health Companion	Ground Medical review panel	Evidence
Fail closed before any network call	On tab hide, private chart and table are hidden synchronously; every revalidation starts hidden	On any authentication event, rows are hidden and busy state cleared before identity is re-read	Source; unit tests (15 for Crew Self revalidation)
Retain authorized values	Same user, same still-valid crew scope: evidence re-loaded and filters restored only if still valid; checklist, environment, synthetic demo and reminders preserved	Same user, same still-authorized mission: the loaded batch is shown again after the re-check	Source; browser script with stubbed data (Crew Self); owner-reported signed-in check (Ground Medical)
Mission or scope switching	Previous scope's evidence cleared; scope picker returns to an explicit placeholder after a revocation	Mission change clears queue, values and receipt and resets the status	Source
Stale-response protection	One generation token covers context and evidence loads; superseded responses are dropped	A data epoch is incremented on every auth event, mission change and request; a response is applied only if its epoch, authorized mission and selected mission all still match	Source; unit tests (Crew Self)
Private-data clearing	Revoked, signed out or error: scope, report, metric and filters cleared; “Retry authorization” offered	Changed user, revoked membership or identity error: queue, values, selection and receipt cleared; neutral status texts carry no counts or values	Source; live site (neutral texts observed signed out)
Triggers	visibilitychange, pageshow (back-forward cache), SIGNED_IN, SIGNED_OUT, USER_UPDATED	Every mission-identity notification (including tab-return token refreshes)	Source

IMPORTANT — Limitation: a membership revoked while a page stays continuously visible and idle is not reflected until the next tab return, authentication event, scope change or request. Do not describe this behaviour as real-time revocation. A signed-in revocation acceptance with two dedicated accounts (Crew Self) and two independent reviewers (Ground Medical) is not recorded in the repository (E3).

32. Validation, Tests, Quality Gates and Known Limitations

32.1 Verification evidence for the Final Competition Edition

Table 103. Evidence for this edition

Evidence	Result	Class / provenance
Source identity	Supplied source archive identical to `main` @ 4e448ea7873b0e9a1120f43bd0fd76fb928c1c54 in every file it contains	E1 — file-by-file comparison
Quality #338 on 4e448ea	Success, 1 min 30 s — full repository check including the automated test suite, typecheck, lint, format check and production build	E1 — public GitHub Actions page; step logs require sign-in
Security Scan #326 on 4e448ea	Success (Trivy, HIGH/CRITICAL)	E1 — public GitHub Actions page
Medical v3 Release Gate #75 on 4e448ea	Failure by design — owner-evidence gates P3663, P3664 and P20 remain BLOCKED (data/release/p53-evidence-readiness.v1.json)	E1 — public run page and repository register
Last full competition validation	P47 Competition Submission Validation #7 — success, 51 s, on an earlier baseline (521a8a3); not re-run on 4e448ea	E1 for 521a8a3 only
Automated test suite (clean checkout, Bun 1.4.4)	864 tests pass in 162 test files, 0 errors; `bun run check`, typecheck, lint (0 errors), format, security audit and build pass	E3 — development-environment report (docs/P52_1_CI_REPAIR.md); consistent with the green Quality run
Disposable PostgreSQL — review layer	305/305 assertions (role isolation, research-only decisions, idempotency, immutability, revocation races)	E1 — repository validation record
Disposable PostgreSQL — Crew Self synthetic intake	14/14 checks pass (scope isolation, operator write denial, duplicate retry, append-only, post-revocation denial)	E1 — repository record
Canonical evidence projection with real crew accounts	Crew A 27 charted / 47 identical repeats not charted; Crew B 23 / 1; Crew C 51 / 2; no foreign IDs; no direct table writes; desktop and phone	E1/E3 — development-environment report with real accounts
Live public site	Companion, Unified Intake, Health Report, Ground & Research Console and domain pages render before sign-in; the Ground Medical panel shows its neutral status texts; Competition Materials menu and the demo-video page are present	E1 — observed and captured before sign-in

SAFETY BOUNDARY — Release-gate status: Quality and Security Scan are green on the release commit. The Medical v3 Release Gate is **red by design** and must not be described as passed: it waits for genuine owner evidence (restore evidence, explicit risk acceptance, and a re-check of the official 2026 Space Apps rules). Clinical activation, production migrations and synthetic research AI stay disabled.

32.2 Earlier reported validation results

Table 104. Earlier reported results (distinct from the final GitHub run)

Evidence	Result	Provenance
Automated test suite at the P46 evidence freeze	443 test cases in 101 test files; reported passing in the acceptance freeze (superseded by the figure in Section 32.1)	Lovable-reported result; matched the static count at that time
Disposable PostgreSQL 17.9 integration suite	305/305 assertions — role isolation, research-only decisions, idempotency, immutability, revocation races	Repository validation record
Typecheck / lint / build	Pass / 0 errors (10 existing warnings) / pass	Repository validation record
Research Explorer browser acceptance	Signed-out, Mission Operator and single Crew Self sessions; WBC search → 1 result; 11 potential equivalences; 12 + 12 paging; no browser write requests	Lovable-reported; signed-out search, filter and paging results re-observed on the live site
Validation and usability ledger	10 critical criteria passing; battery impact recorded as a known limitation	Repository ledger
Independent reproduction of the build	Passed (Ubuntu/WSL, frozen install, local Supabase, Docker self-hosting)	Repository record
Real-device capture	Camera PPG and phone motion on one physical phone	Repository real-device record

32.3 Remaining validation boundaries

Table 105. Validation boundaries

Boundary	What is required
Real-device offline OCR in airplane mode	A physical device with the network disabled, with timestamped screenshots and logs
Cross-mission Crew Self isolation with two accounts	Two independent Crew Self accounts in different missions; confirm cross-mission reads are denied
Independent scientific review	Named independent reviewers record evidence-based decisions for the 54 proposals and the 162 unmapped records
Live Ground Medical review acceptance; human real-device cases (15 + 9)	Execution with authorized accounts and devices
Owner-evidence gates P3663, P3664, P20	Authentic private restore evidence; explicit owner risk acceptance; official 2026 rules, judging and rights requirements re-checked
Competition validation on the submitted commit	Re-run P47 Competition Submission Validation on the exact SHA to be submitted
Signed-in revocation acceptance (Crew Self and Ground Medical)	Two dedicated synthetic accounts per role; revoke while a tab is hidden; confirm no private rows return
Crew Self synthetic intake in the live application	Owner approval for the dedicated mission and accounts; server flag enabled only for the demonstration window
Physical-phone and Edge/Chrome notification behaviour	Manual test by a person, including notification permission

Boundary	What is required
Synthetic research AI (Medical v3) production rollout	Separate schema, provisioning, configuration and activation approvals; exact-final CI; owner evidence for the release gate
Clinical validation, regulatory clearance, astronaut deployment	Outside the scope of a research prototype; not claimed

IMPORTANT — The test suite and the 305 PostgreSQL assertions are separate suites and are never added together. A green workflow validates automated software checks; it does not establish clinical validity, flight readiness, independent scientific approval or real-device offline OCR.

32.4 Screen — Validation & Usability

Screen name (as rendered)	Validation & Usability
Verified route	/mission/validation
Navigation path	About & Open Source → Governance & references → Validation & Limitations
Authorized role(s)	Public.
Purpose	Display the validation criteria, the human test-execution ledger for real-device acceptance and the independent scientific review panel.
Prerequisites	None.
Capability status	OPERATIONAL register.

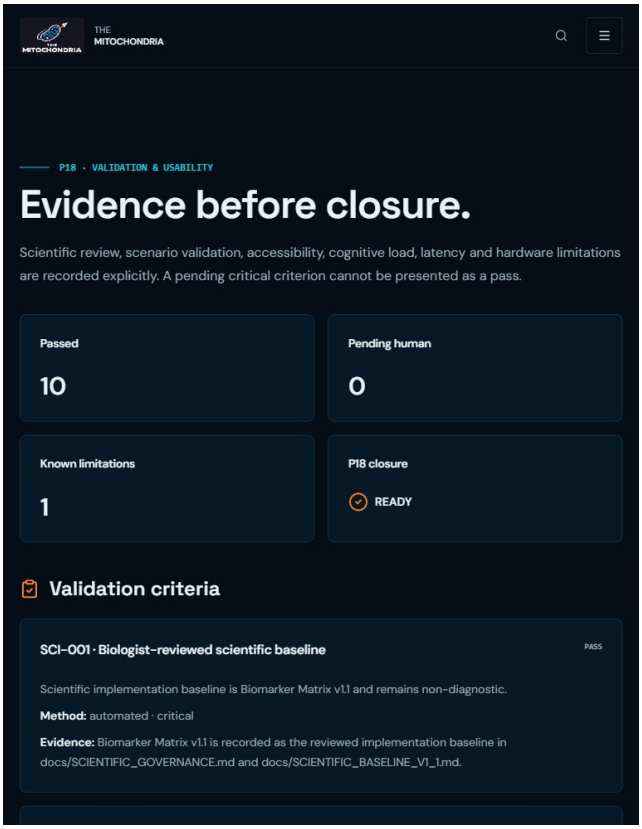


Figure 32. Validation & Usability — public view of mitochondria.edocinfo.com/mission/validation (validation criteria summary). Unedited capture, 765 × 990 px.

FURTHER VIEW — Scrolling or interacting with the page shows the criteria detail and the independent scientific review panel, which states that scientific validation is not yet approved.

Table 106. Validation & Usability — controls and inputs

Visible control / input	Expected input format and behaviour
Real-device acceptance ledger notes	Session-only; exportable JSON that never changes approval state

User action sequence

1. Read criteria and statuses.
2. Optionally record session notes and export.

Expected observable results: Registers match the repository ledgers.

Data persistence and synchronization: Session only.

Table 107. Validation & Usability — failures and troubleshooting

Failure condition / message	Cause and troubleshooting
Expecting saved notes	Notes are not persisted.

Security and scientific limitations: A register, not proof of acceptance.

Verification procedure

1. Compare displayed counts with data/validation/*.json.

Implementation evidence: src/components/validation-usability.tsx, real-device-acceptance.tsx, independent-scientific-review.tsx

32.5 Quality gates

- `bun run check` must pass before any change (verifiers, security audit, tests, typecheck, lint, format check, build).
- GitHub CI on the exact commit to be published (Quality + Security Scan, both green on 4e448ea; competition validation to be re-run).
- Disposable PostgreSQL run for any SQL change, including staged files.
- `bun run submission:gate` remains closed until the pending human and external evidence is recorded.

32.6 Known limitations register

Table 108. Known limitations

#	Limitation	Consequence
L1	Not clinically validated; not a medical device	No clinical use
L2	Final security sign-off not yet granted; provider-level privileged-role finding open	No security approval is claimed
L3	Human real-device and additional integration acceptance cases not yet executed	Authenticated multi-device flows are not independently accepted
L4	Independent scientific review of the handbooks and the 54 provisional proposals pending	No scientific sign-off is claimed
L5	One physical phone tested; Bluetooth path not hardware-tested	Cross-device behaviour not yet verified
L6	Battery impact not characterized	Endurance unknown

#	Limitation	Consequence
L7	Offline OCR not validated on a real device in airplane mode	OCR may need a network connection on first use
L7a	Cross-mission isolation not tested with two independent Crew Self accounts	Isolation evidence rests on database tests and single-account sessions
L8	Personal baselines not yet persisted	Baseline deltas normally show “not established”
L9	No in-application administrator role	Multi-role demonstrations use separate accounts
L10	Live acceptance of the Ground Medical review workflow pending	The review pipeline is tested but not independently accepted
L11	Verified backup-and-restore evidence not in the evidence package	Restore capability is not claimed
L12	Database owners can bypass triggers; receipts are not cryptographic	Operational audit and role separation remain essential
L13	Single-reviewer final decisions; no appeal path	Corrections need a future governed design
L14	A review decision cannot be replayed from the interface after navigating away	Replay safety is enforced in the database
L15	English translations of the Greek handbooks are machine-assisted and pending review	Greek remains the authoritative text
L16	Content Security Policy allows inline scripts for hydration	Further XSS hardening is planned
L17	Identity assurance equals e-mail confirmation; no MFA	A compromised mailbox inherits access
L18	English-only user interface and OCR	No localization yet
L19	Medical v3 Release Gate red by design (P3663, P3664, P20 owner evidence outstanding); competition validation workflow not re-run on the release commit	No release-gate pass is claimed; clinical activation stays disabled
L20	Revocation is not detected while a page stays continuously visible and idle	Detected at the next tab return, authentication event, scope change or request; RLS still blocks new reads
L21	Daily Health Companion reminders run only while the page is open; browser notifications optional and best effort	Not a scheduler or push service
L22	Crew Self synthetic intake disabled in production (server flag unset); dedicated accounts not created	Personal trends are demonstrated with existing synthetic crew records or the labelled synthetic example
L23	Synthetic research AI and automatic AI extraction are disabled or paused in production; owner-administration page tested with mocks only	No AI-generated medical content is part of the demonstration

33. Troubleshooting and Incident Recovery

Table 109. Troubleshooting index

Symptom	Likely cause	Resolution	Section
Inline “Incorrect email or password…”	Credentials	Retry or magic link	09
Membership missing	No invite accepted	Accept invite; refresh	09, 11
“Operator membership required”	Wrong role	Use operator account	13
Launchpad buttons disabled	Reserved acceptance mission selected	Use the designated synthetic mission	13.3
Mission Documents: no context	No Crew Self with crew ID	Select Crew Self	14.2
Save to Cloud shows pending activation	Server flag off	Local review only; ask owner	14.2
Ground Medical queue empty	No pending batches, or own submissions excluded	Expected	15.2
Decision refused	Self-review, already decided, stale count, revoked	Refresh; never send a different decision	15.2
LOCAL FALLBACK on /mission/live	Not Crew Self / signed out	Select Crew Self; re-focus page	20
Encrypted writes not confirmed / WRITE FAILED	Storage blocked	Normal window; free storage	19–21
Records not syncing	Offline / unauthorized	Sign in; Sync now	26–27
OSDR request fails	Upstream timeout/size	Retry later	24.4
Research Explorer section absent	Cached or outdated build	Reload the page; owner republishes if needed	24.1
Audit Log denied	Wrong mission	Select correct mission	13.2

33.1 Incident recovery

Table 110. Incident recovery

Incident	First action	Then
Suspected access or isolation anomaly in synthetic Cloud saving	Owner disables the server feature flag	Investigate; no automatic rollback; preserve audit
Failed migration	Stop; do not retry blindly	Owner decides restore or rollback; some rollbacks remove synthetic records
Leaked invite code	Operator re-issues; leaked Ground Medical code is revoked on wrong-account use	Review audit
Compromised account	Deactivate memberships (immediate)	Password reset; audit review
Wrong research decision	None possible in UI (final)	Record in governance notes; future appeal design

Incident	First action	Then
Device lost	Local records unrecoverable unless synced	Sync policy before travel

34. Operational Procedures and Daily Checklists

Table 111. Daily checklists

Role	Daily checklist (synthetic missions)
Crew Self	Sign in; select Crew Self (MISSION-BOUND) • Daily Health Companion: environment, routine checklist, optional reminders, own trends • readiness check-in • live capture with explicit stop • self-check if needed • Offline Mission Mode: queue empty when online • documents only with synthetic files
Mission Operator	Verify memberships and crew statuses • review Audit Log Refused entries • keep the reserved acceptance mission untouched • no demonstration-mission creation without owner approval
Ground Medical	Refresh pending queue • view values (the FV01-TEST-B eight-value batch stays pending — view only) • decisions only with owner authorization on newly submitted synthetic batches • snapshot/aggregate as needed
Researcher	Aggregate export only when thresholds are met; never combine exports to re-identify
Owner / deployment	Exact-commit CI green • migration fingerprints unchanged • feature-flag state known • no secrets in repository • acceptance checklists updated only with evidence

34.1 Pre-demonstration checklist

1. Confirm the official URL loads over HTTPS.
2. Confirm owner-provided synthetic accounts for each role you will show, and the synthetic mission to use.
3. Confirm whether Cloud saving is active (workbench banner).
4. Confirm /mission/intelligence shows “Scientific mapping · research review” with 54 proposals.
5. Prepare the synthetic laboratory-report fixture (TXT or PDF).
6. Open the NASA Evaluator Quick Start Guide.

35. End-to-End Reproducible User Scenarios

Table 112. Reproducible scenarios (synthetic only)

#	Scenario	Steps (summary)	Expected evidence
E1	Zero-install public tour	Home → Device Integration Center → Live (Camera PPG, LOCAL FALLBACK) → Simulation (seed 1272026) → NASA evidence (OSD-48) → Validation	Capability badges; heart-rate card LIVE; same fingerprint; research-only OSDR table
E2	Crew Self day	Sign in → select Crew Self → readiness → live capture with stop → offline sync	MISSION-BOUND; queue emptied; record in Recorded Mission Data
E3	Synthetic document to Cloud batch	Crew Self → /mission/documents → consent → synthetic TXT → Select All → date + confirmation → Save → Refresh saved reviews	One pending_review batch; retry idempotent
E4	Independent research review (owner-authorized only)	Different user, Ground Medical in same mission → /mission/ground → Refresh → View values → (authorized) decision	Receipt; batch leaves queue; values unchanged; one event; audit without values
E5	Operator set-up	Create planning mission → add synthetic crew → Crew Self invite → acceptance by another account → Settings ACTIVE → Audit Log	Audit entries for each step
E6	Operator demo rehearsal	Launchpad on a synthetic mission → tracker → runbook export → dataset/report → integrated bundle re-inspection	Local files; no network writes
E7	Isolation negative checks	Crew Self/Operator/Researcher open /mission/ground panel; Researcher snapshot; cross-mission audit request	No queue; refusals
E8	Scientific Research Explorer	/mission/intelligence → search WBC → filter potential equivalences → Show 12 more	1 result; 11 results; 24 cards rendered; status line states 0 approvals and 0 activations
E9	Daily Health Companion (public)	/mission/companion → five environments → tick routine items → 1-minute demo reminder → Show synthetic example	Notes change, data does not; participation counter only; in-page reminder; labelled synthetic series
E10	Crew Self personal trends	Sign in as an existing synthetic Crew Self account → /mission/companion → metric → 30 days → one source → hide/return tab	Own crew only; table matches chart; not-charted list with reasons; rows hidden then restored on return
E11	Ground Medical eight-value review (view only)	Ground Medical account → Health & Intelligence → Ground Medical Workspace → select mission → Refresh → View values on the FV01-TEST-B batch → switch tab and return → switch mission	“8 values · pending_review”; eight values with units and excerpts; batch retained on return; cleared on mission switch; no decision recorded
E12	Role isolation	Crew Self, Operator and Researcher open /mission/ground; Researcher requests the aggregate; Crew A opens Companion	No Ground Medical missions listed; aggregate suppressed or aggregate-only; no other crew's identifiers

#	Scenario	Steps (summary)	Expected evidence
E13	Research privacy	Researcher → Research Workspace → Export aggregate	Aggregate-only JSON or “Research export suppressed: cohort or event-volume threshold not met.”

36. Open-Source Development, Contribution and Maintenance

Licence	Apache License 2.0 (LICENSE; THIRD_PARTY_LICENSES.md)
Repository	https://github.com/computech-gr/astro-vitality-core (branch main)
Contribution guide	CONTRIBUTING.md; CODE_OF_CONDUCT.md; SECURITY.md (private vulnerability reporting)
Hosting integration	Commits on the connected branch synchronize with the hosting platform; published history is never rewritten (AGENTS.md)

36.1 Contributor rules

- Stage unapproved database changes in `supabase/pending/` only, never in `supabase/migrations/`, and exercise them in the disposable PostgreSQL harness first.
- Keep the Greek scientific handbooks byte-identical; put English text in sibling `*.en*.json` layers joined by stable ID.
- Synthetic Cloud submission only through the server function as the signed-in user; the feature flag is off by default.
- Add adapters under `src/integrations/<family>/`, emit only governed metric codes, inject credentials and add synthetic tests.
- Run `bun run check` before proposing a change (it includes tests, typecheck, lint, format check and build).
- Never commit secrets, private approval records, backups or real data.

36.2 Continuous integration

Workflow	Purpose
quality.yml	Frozen-lockfile install and the full verification and check steps
security.yml	Trivy vulnerability scan; third-party actions pinned to immutable commit SHAs; read-only permissions; no persisted credentials
medical-v3-release-gate.yml	Medical v3 release gate: full validation plus owner-evidence verifiers; red until restore, risk-acceptance and submission-manifest evidence exist
medical-v3-exact-commit-status.yml	Read-only reporter of the Quality, Security Scan and release-gate conclusions for one commit
p41-full-validation.yml	“P47 Competition Submission Validation” — manual full validation; last success #7 on 521a8a3
release-candidate.yml	Release-candidate checks

36.3 Maintenance

- Re-run dependency scanning and remediate HIGH and CRITICAL findings with exact patched releases.
- Regenerate the submission manifest when controlled inputs change.
- Keep ledgers authoritative: user-interface worksheets never change them.

37. Scientific References and Source Traceability

37.1 External public sources

- NASA International Space Apps Challenge 2026 — https://www.spaceappschallenge.org/2026/
- Challenge: Create Health Monitoring Software for Astronauts on Space Missions — https://www.spaceappschallenge.org/2026/challenges/create-health-monitoring-software-for-astronauts-on-space-missions/
- NASA Human Research Program — Human System Risks — https://www.nasa.gov/hrp/risks/ ; Hazards — https://www.nasa.gov/hrp/hazards/
- NASA Spaceflight Standard Measures — https://www.nasa.gov/reference/standard-measures/ ; NTRS 20230014025
- NASA-STD-3001 Volume 1 and Volume 2 — https://www.nasa.gov/reference/nasa-std-3001v1/
- NASA OSDR Biological Data API — https://visualization.osdr.nasa.gov/biodata/api/ (used by /api/nasa-research)
- HL7 FHIR — https://hl7.org/fhir/ ; Open mHealth — https://www.openmhealth.org/

Listing a source implies no endorsement by its publisher. Literature references for the immune/microbiome and behavioural/sleep/cognitive domains are held in the respective draft handbooks with their own verification levels.

37.2 Source traceability matrix

Table 113. Traceability matrix

Capability claim	Supporting files / locations	Evidence type
Five navigation groups and global search	src/components/app-shell.tsx; navigation-search.tsx; tests/navigation/	Code + tests
Sign-in validation, generic error, password change, invitation feedback	src/components/mission-identity.tsx; src/infrastructure/mission-identity.ts; tests/identity/	Code + tests
Role model, compatibility, invitations	supabase/migrations (multi-role hardening); tests/integration-pg/	Migration + tests + production use
Mission Settings and Audit Log	mission-settings-panel.tsx; mission-audit-log.tsx; audit viewer migration	Code + production acceptance record
Demonstration launchpad, dataset, report, bundle	mission-demo-launchpad.tsx and sub-panels; src/domain/mission-access/; tests/mission/	Code + tests
Mission Documents, biomarker registry, Cloud saving, history	mission-document-review-workbench.tsx; src/lib server function; data/scientific/ registry; drizzle 0006–0008; tests/documents/, tests/integration-pg/	Code + tests + deployment records
Ground Medical queue and decisions	Ground medical review component; drizzle 0009–0010; tests/integration-pg/, tests/security/	Code + tests + deployment records
Live identity, persistence states, stop controls	src/components/live-dashboard.tsx; src/app/live-dashboard/store.ts	Code + tests
Camera PPG and motion on a physical phone	Real-device evidence record (data/submission/)	Hardware record
Handbook localization, counts, flagged ambiguities	src/domain/scientific-localization/handbooks.ts; data/scientific/*.en*.json; tests/domain/	Code + tests
Immune and behavioural draft catalogues (35 / 36)	src/components/health-domain-workspace.tsx	Code

Capability claim	Supporting files / locations	Evidence type
Nikolas' handbook intake (117 + 99 entries, 3 contexts) and reconciliation	data/scientific/nikolas-*-intake.v1.json, nikolas-cross-domain-context.v1.json, p38–p42 review artifacts; scripts/verify-nikolas-scientific-intake.mjs, verify-p38…p42	Data + verifiers
54 provisional proposals; 0 approvals; 0 activations	data/scientific/p43-semantic-decision-proposals.v1.json; scripts/verify-p43-semantic-decisions.mjs	Data + verifier
Health Intelligence Research Explorer	src/components/scientific-research-candidates.tsx, health-intelligence.tsx; scripts/verify-p44-research-explorer.mjs, verify-p45-final-ux.mjs	Code + verifiers
Final release evidence freeze and submission handoff	data/submission/p46-acceptance-evidence.v1.json, p47-competition-handoff.v1.json; docs/P46_*, docs/P47_*	Ledgers
NASA OSDR import	src/routes/api.nasa-research.ts; nasa-research-import.tsx; tests/domain/	Code + tests
Final CI run (P47 #7, success, 521a8a3, 51 s)	https://github.com/computech-gr/astro-vitality-core/actions/runs/39987881965; .github/workflows/p41-full-validation.yml	Public GitHub run page
Test inventory (release 4e448ea)	tests/ — 162 test files plus 22 browser scripts; 864 passing reported in docs/P52_1_CI_REPAIR.md	Development-environment report; Quality #338 green
Earlier results (443 / 305)	Repository validation and acceptance records (P46 freeze)	Recorded results
Release-commit CI (Quality #338, Security Scan #326, Medical v3 Release Gate #75)	https://github.com/computech-gr/astro-vitality-core/actions (runs for commit 4e448ea)	Public GitHub run pages
Owner-evidence readiness register	data/release/p53-evidence-readiness.v1.json; docs/P53_MEDICAL_EVIDENCE_OWNER_READINESS.md	Repository register (P3663, P3664, P20 BLOCKED)
Companion, revalidation and Ground Medical session safety	docs/P45_*–P49_*; src/domain/companion/; src/components/p368b-ground-medical-review.tsx	Source + design and results records
Validation, acceptance and review status	data/validation/*; data/submission/*	Source-controlled ledgers
CI and dependency security	.github/workflows/security.yml; package.json overrides	Configuration
Public screen images	https://mitochondria.edocinfo.com (captured before sign-in)	Live site

38. Glossary and Technical Appendices

Table 114. Glossary

Term	Definition
accepted_for_research / rejected_for_research	Final, research-only Ground Medical decision on a synthetic batch; no clinical meaning
Batch	One Crew Self submission of reviewed synthetic values from one source-document fingerprint and observation date
Canonical observation	Vendor-neutral record with metric code, unit, time, quality, provenance and context
Crew Self / Mission Operator / Ground Medical / Researcher	The four mission-scoped roles
DATA QUALITY	Outcome when evidence is poor or missing; routes to a repeat measurement
Decision receipt	Database-generated request ID and timestamp; correlation metadata
Governed migration	Owner-approved, fingerprinted database migration applied once
Idempotency key	Key that makes a retry safe (sync, submission, decision)
LOCAL FALLBACK	Local mission context without a verified Crew Self membership
Provisional semantic proposal	A source-document classification linking a handbook record to a draft-catalogue entry; pending independent review, never merged or activated
Research Explorer	Read-only, searchable view of the 54 provisional proposals on the Health Intelligence page
Pending independent review	Status of scientific content awaiting external scientific review (shown in the application as PENDING_NIKOLAS_REVIEW for the draft catalogues)
pending_review / quarantined	Batch awaiting decision / terminal state when the submitter is revoked
Personal baseline	Versioned individual reference distribution for one crew member, metric, context and mission phase
Reserved acceptance mission	The bootstrap mission, kept free of demonstration records
RLS / SECURITY DEFINER / RPC	Row-level security / function running with owner rights after internal checks / database function call
Synthetic	Generated, fictional data, always labelled

Appendix A — Capability status by feature

Table 115. Status summary

Feature	Status	Note
Sign-in and membership selection	FIELD-VERIFIED	Recorded production use
Password change, inline sign-in feedback, invitation feedback	OPERATIONAL	Automated tests
Mission Settings (view) and Audit Log	FIELD-VERIFIED	Signed-in production acceptance recorded
Mission Settings (save)	OPERATIONAL	Automated tests

Feature	Status	Note
Demonstration launchpad	OPERATIONAL / SYNTHETIC DEMONSTRATION	Operator-only; local exports
Mission Documents local workbench	OPERATIONAL	Synthetic files only
Synthetic Cloud saving and history	OPERATIONAL	Behind a server feature flag
Ground Medical queue and research decisions	OPERATIONAL	Independent live acceptance VALIDATION BOUNDARY
Ground Medical tab-return retention, fail-closed revalidation, stale-response protection	OPERATIONAL	Release source; neutral status texts observed live; signed-in check owner-reported (E3)
Research Privacy Workspace (aggregate-only export)	OPERATIONAL	Server-side suppression; signed-in browser acceptance E3
Daily Health Companion — environments, checklist, reminders, quality legend	OPERATIONAL	Live public page
Daily Health Companion — personal trends and canonical projection	OPERATIONAL	Real-account check reported by the development environment
Daily Health Companion — synthetic trend demonstration	SYNTHETIC DEMONSTRATION	Hard-coded, never stored
Crew Self revalidation on tab return	OPERATIONAL	Stubbed-response browser tests; real revocation acceptance pending
Crew Self synthetic intake panel	OUT OF SCOPE (disabled)	Server flag unset; disposable-database 14/14
Unified Data Intake (multi-file, on-device)	OPERATIONAL	Signed-in encrypted-storage acceptance E3
Astronaut Health History Report (A4 PDF / TXT)	OPERATIONAL	Synthetic-adapter desktop and mobile export verified
Automatic AI document-extraction assistance	OUT OF SCOPE (disabled)	Endpoint answers 503; flags unset
Synthetic research AI and AI Administration (Medical v3)	VALIDATION BOUNDARY (paused / not authorized)	Production NO-GO; release gate red
Camera PPG and phone motion	FIELD-VERIFIED	One physical phone
Web Bluetooth heart rate	OPERATIONAL	Hardware test pending
Native and vendor bridges, habitat feed	OUT OF SCOPE	Adapter contracts defined
Health Intelligence, domains, handbooks, draft catalogues	RESEARCH-ONLY	Reference and descriptive only
Health Intelligence Research Explorer (54 proposals)	FIELD-VERIFIED / RESEARCH-ONLY	Live on the public site
NASA OSDR metadata import	OPERATIONAL / RESEARCH-ONLY	Published research metadata
Encrypted offline store and governed sync	OPERATIONAL	Airplane-mode device validation pending
Persisted personal baselines	OUT OF SCOPE	Engine implemented

Feature	Status	Note
In-application administrator role	OUT OF SCOPE	Requires governed backend design

Appendix B — Canonical Metric Catalogue (v1.1, 70 metrics)

Source: src/domain/catalog/reviewed-mvp-v1.1.ts.

Table 116. Canonical metrics

Code	Name	Domain	Unit	Pri.	Review	Baseline
lab.wbc	Complete blood count — WBC	laboratory	10^9/L	P0	KEEP	yes
lab.hemoglobin	Hemoglobin	laboratory	g/dL	P0	KEEP	yes
lab.ctx	CTX (C-terminal telopeptide)	laboratory	ng/L	P0	KEEP	yes
lab.p1np	P1NP	laboratory	ng/mL	P0	KEEP	yes
lab.vitamin_d_25oh	25-OH Vitamin D	laboratory	ng/mL	P0	KEEP	yes
lab.creatinine	Creatinine	laboratory	mg/dL	P0	MODIFY	yes
lab.cystatin_c	Cystatin C	laboratory	mg/L	P1	KEEP	yes
lab.glucose	Glucose — fasting/spot	laboratory	mg/dL	P0	KEEP	yes
lab.sodium	Sodium	laboratory	mmol/L	P0	KEEP	yes
lab.potassium	Potassium	laboratory	mmol/L	P0	KEEP	yes
hydration.urine_specific_gravity	Urine specific gravity	nutrition hydration	1	P0	KEEP	yes
nutrition.energy_intake	Energy intake	nutrition hydration	kcal/d	P0	KEEP	yes
nutrition.protein_intake	Protein intake	nutrition hydration	g/d	P0	KEEP	yes
hydration.fluid_intake	Fluid intake	nutrition hydration	mL/d	P0	KEEP	yes
renal.urine_volume	Urine volume	nutrition hydration	mL/d	P1	KEEP	yes
phys.heart_rate	Heart rate	physiological	{beats}/min	P0	KEEP	yes
phys.hrv_rmssd	Heart-rate variability (e.g., RMSSD)	physiological	ms	P0	MODIFY	yes
phys.ecg_waveform	ECG waveform	physiological	mV	P1	KEEP	yes
phys.respiratory_rate	Respiratory rate	physiological	{breaths}/min	P0	KEEP	yes
phys.respiration_waveform	Respiration waveform	physiological	1	P1	MODIFY	yes
phys.spo2	SpO2	physiological	%	P0	KEEP	yes
phys.core_temperature	Core body temperature (validated method)	physiological	Cel	P1	KEEP	yes

Code	Name	Domain	Unit	Pri.	Review	Baseline
phys.bp_systolic	Blood pressure — systolic	physiological	mm[Hg]	P0	KEEP	yes
phys.bp_diastolic	Blood pressure — diastolic	physiological	mm[Hg]	P0	KEEP	yes
activity.acceleration_3axis	Tri-axial acceleration	activity performance	g	P0	KEEP	yes
activity.exercise_load	Exercise duration/load	activity performance	1	P0	KEEP	yes
sleep.duration	Sleep duration	sleep circadian	h	P0	KEEP	yes
sleep.efficiency	Sleep efficiency	sleep circadian	%	P0	KEEP	yes
sleep.light_exposure	Light exposure	sleep circadian	lx	P1	KEEP	yes
body.mass	Body mass	activity performance	kg	P0	KEEP	yes
symptom.self_report	Self-reported symptom score	symptom report	—	P0	KEEP	yes
sleep.midpoint	Sleep timing / midpoint / wake time	sleep circadian	—	P0	KEEP	yes
sleep.waso	Wake after sleep onset (WASO)	sleep circadian	min	P1	KEEP	yes
cognition.pvt_median_rt	Psychomotor vigilance — median reaction time	cognitive	ms	P0	KEEP	yes
cognition.pvt_lapses	Psychomotor vigilance — lapses	cognitive	count	P0	KEEP	yes
behavior.fatigue_state	Subjective fatigue	behavioral	1	P0	KEEP	yes
behavior.sleepiness_kss	Sleepiness	behavioral	1	P0	MODIFY	yes
function.strength	Strength assessment	activity performance	N	P0	KEEP	yes
function.aerobic_workload	Aerobic capacity proxy	activity performance	1	P0	KEEP	yes
sleep.subjective_quality	Subjective sleep quality and perceived sleep quantity	sleep circadian	1	P0	KEEP	yes
cognition.processing_speed	Processing speed / complex scanning	cognitive	1	P1	KEEP	yes
function.fine_motor_control	Fine motor control / manual dexterity	activity performance	1	P1	KEEP	yes
performance.mission_task	Standardized mission-task performance	activity performance	1	P1	KEEP	yes
radiation.absorbed_dose	Personal absorbed dose	radiation	mGy	P0	MODIFY	no
radiation.dose_equivalent	Personal dose equivalent	radiation	mSv	P0	MODIFY	no
radiation.dose_rate	Dose rate	radiation	µSv/h	P0	KEEP	no
environment.co2	CO2 concentration	environmental	ppm	P0	MODIFY	no

Code	Name	Domain	Unit	Pri.	Review	Baseline
environment.oxygen_fraction	O2 concentration	environmental	%	P0	KEEP	no
environment.oxygen_partial_pressure	O2 partial pressure	environmental	kPa	P0	KEEP	no
environment.cabin_pressure	Cabin pressure	environmental	kPa	P0	KEEP	no
environment.temperature	Temperature	environmental	Cel	P1	KEEP	no
environment.relative_humidity	Relative humidity	environmental	%	P1	KEEP	no
environment.noise_exposure	Noise exposure	environmental	dBA	P1	KEEP	no
environment.light_exposure	Light exposure / spectrum	environmental	lx	P1	KEEP	no
mission.gravity_regime	Gravity regime / g-level	mission context	—	P0	KEEP	no
mission.eva_state	EVA state / suit state	mission context	—	P0	KEEP	no
mission.work_rest_state	Work/rest schedule	mission context	—	P0	KEEP	no
environment.carbon_monoxide	Carbon monoxide (CO)	environmental	ppm	P0	KEEP	no
mission.space_weather_state	Solar particle event / space-weather state	mission context	—	P0	KEEP	no
mission.phase	Mission phase	mission context	—	P0	KEEP	no
mission.task_criticality	Task criticality	mission context	—	P0	KEEP	no
behavior.stress_state	Perceived stress — state VAS	behavioral	1	P1	MODIFY	yes
behavior.mood_affect_state	Mood / affect state	behavioral	1	P1	MODIFY	yes
cognition.working_memory_accuracy	Working memory — accuracy	cognitive	%	P1	KEEP	yes
behavior.workload_tlx_mental_demand	NASA-TLX — mental demand	behavioral	1	P1	MODIFY	no
behavior.workload_tlx_physical_demand	NASA-TLX — physical demand	behavioral	1	P1	MODIFY	no
behavior.workload_tlx_temporal_demand	NASA-TLX — temporal demand	behavioral	1	P1	MODIFY	no
behavior.workload_tlx_performance	NASA-TLX — performance	behavioral	1	P1	MODIFY	no
behavior.workload_tlx_effort	NASA-TLX — effort	behavioral	1	P1	MODIFY	no
behavior.workload_tlx_frustration	NASA-TLX — frustration	behavioral	1	P1	MODIFY	no

Appendix C — Command reference

Table 117. Commands

Command	Purpose
bun install --frozen-lockfile	Deterministic install
bun run setup:local	Local Supabase and environment file
bun run dev	Development server
bun run check	Full verification gate
bun run test	Test suites
bun run docker:up / docker:down	Self-hosting
bun run sample:release	Deterministic Mission Day 127 sample
bun run bootstrap:first-operator	One-shot first-operator bootstrap (trusted terminal)
bun run verify:auth-remote	Remote authentication configuration check
bun run submission:gate	Challenge submission gate
scripts/ PostgreSQL integration harness	Disposable-database assertions for RLS, triggers and concurrency

Appendix D — Screen image index

Unedited captures of the public view of the live application (https://mitochondria.edocinfo.com), taken before sign-in at 765 × 990, 1440 × 900 or 1800 × 1125 px. Role-specific views are described in each screen section and presented during the live demonstration.

Table 118. Screen images

Screen	Route	View shown
Mission identity & governed cloud access	/mission/identity	before sign-in: authentication readiness and first-mission activation panel
The Mitochondria (home) · Project Guide · Technology topics	/	home page
Mission & Crew Operations	/mission/operations	without an operator membership: access-restriction notice
Mission Document Review	/mission/documents	without a Crew Self context: local-only workbench and consent step
Daily Health Companion	/mission/companion	before sign-in: mission environment and optional reminders
Unified Intake — Measurements & Review	/mission/intake	before sign-in: authorized mission & crew selector, provenance and multi-file import
Astronaut Health History & Research Assessment	/mission/health-report	before sign-in: crew, provenance, date and source filters
Ground & Research Console	/mission/ground	before sign-in: Research Privacy Workspace with no eligible membership
Device Integration Center	/mission/devices	live browser capability check

Screen	Route	View shown
Live mission health	/mission/live	local session context before a source is connected
Health Intelligence	/mission/intelligence	Research Explorer showing all 54 provisional proposals, 0 approved, 0 activated
NASA Scientific Evidence	/mission/nasa-evidence	reference registry summary
Challenge Demo & Submission	/mission/submission	demonstration runbook and submission evidence status
Synthetic Mission Simulation	/mission/simulation	synthetic-only boundary and Mission Day 127 scenario
Validation & Usability	/mission/validation	validation criteria summary

Appendix E — Implementation milestone traceability (P1–P53)

The repository records the implementation cycle as numbered milestones. This appendix maps them to the capabilities described in this manual; design and acceptance records for each milestone are in the repository `docs/` folder.

Table 119. Milestone traceability up to the competition baseline

Milestones	Capability delivered
P1–P9	Scientific foundation, repository foundation, canonical data model, device adapter SDK, wearables, medical-lab and environmental adapters, live dashboard
P10–P13	Personal baseline engine, cognitive and behavioural module, Health Intelligence v1, action and protocol guidance
P14–P20	Offline mission mode, governed synchronization, synthetic simulation, validation and usability ledger, independent reproduction, real-device evidence and challenge submission package
P21–P22	Scientific knowledge intake and baseline freeze; Bone Health Handbook v7 integration, bone entry, CSV and document import, OCR fallback
P23–P29	Unified persistence, first-mission activation, multi-mission crew reuse, unified scientific evidence, four integrated health domains, self-assessment, research privacy workspace, autonomous offline operations
P30–P34	NASA scientific evidence, multi-astronaut simulation, independent scientific review gates, mission-control UX, real-device acceptance ledger
FV-01.x	Security remediation, multi-role hardening, card navigation, Mission Settings and audit viewer
P35.x	NASA OSDR import, live crew monitoring, cardiovascular handbook and localization, draft catalogues, routing preview, navigation reorganization, synthetic demo launchpad
P36.x	Mission Documents, synthetic Cloud submission and history, CI security recovery, sign-in feedback, Ground Medical read-only review and research decisions
P37–P43	Nikolas' handbook intake, catalogue reconciliation, semantic mapping, independent review ledger and workbook, triage and 54 provisional dispositions
P44–P45	Health Intelligence Research Explorer and its accessibility and paging refinements
P46–P47	Final acceptance evidence freeze and competition submission handoff; final validation workflow (baseline 521a8a3)

After that baseline the development environment reused several milestone identifiers for new work. The table below lists those increments by date and record so that each can be traced unambiguously.

Table 120. Post-baseline increments (development history, kept for traceability)

Date (2026)	Record in docs/	Capability delivered
24 Oct	—	Team page and demo-video page; Trivy remediation; roadmap registry
24–25 Oct	MEDICAL_V3_*, MEDICAL_INTELLIGENCE_GOVERNANCE_V3, AI_MEDICAL_*	Unified intake foundation; Medical Advisor workbench (session-only); synthetic research AI governance, guards and owner page — production NO-GO
27–28 Oct	P33_*, P34_REAL_PDF_REGRESSION, P35_CLINICAL_LAB_RESULTS, P36_*	Universal medical-document parsing, clinical-lab parser, hybrid AI extraction (disabled), automatic collection dates, report export (A4 PDF/TXT)
28 Oct	P29/P30 report and contrast records	Medical report layout and contrast
30 Oct	P45_DAILY_HEALTH_COMPANION, P46_*, P46_1_*, P47_*, P47_1_*	Daily Health Companion, foreground reminders, synthetic trends, interactive multi-biomarker trends, accessibility
31 Oct	P48_*	Crew Self revocation guard, focused revalidation, Stage B plan, synthetic intake panel (disabled)
31 Oct	P49_DEMO_READINESS_RESULTS	Canonical evidence projection for charts and domain pages
31 Oct	— (commit 8dcfd0a)	P50: Ground Medical Workspace and Research Workspace menu entries; tab-return retention of an unchanged authorized batch
31 Oct	— (commit 27a7b63)	P51: fail-closed revalidation, hidden private rows during re-check, neutral status texts
31 Oct	— (commit 042be33)	P51.1: data-epoch stale-response protection for queue and batch loads; mission-switch clearing
31 Oct	P52_CI_REPAIR, P52_1_CI_REPAIR	P52/P52.1: CI repair — location-independent test paths, pinned Bun 1.4.4, offline-module mock isolation (tests only; no security or scientific assertion changed)
31 Oct	P53_MEDICAL_EVIDENCE_OWNER_READINESS	P53: read-only owner-evidence readiness register for P3663, P3664 and P20 (all BLOCKED)

39. Scientific Integration, Validation Boundaries and Future Research Requirements

39.1 Scientific update: Nikolas' handbooks integrated

The scientific update anticipated by earlier editions is complete at the level permitted for a research prototype. Nikolas' immune-changes and behavioural-health developer handbooks are ingested as 216 source records with three cross-domain contexts, reconciled against the existing draft catalogue, mapped to 54 curated semantic proposals with explicit rationales, and published in the Health Intelligence Research Explorer (Sections 24.1 and 25.3). Their conclusions are represented exactly as provisional proposals: no catalogue entry, threshold, score or alert has been changed or activated.

39.2 Remaining validation boundaries

Table 121. Validation boundaries

Boundary	Evidence required to close it	Responsible
Real-device offline OCR in airplane mode	Timestamped screenshots and logs from a physical device with the network disabled	Project team
Two-account cross-mission Crew Self isolation	Negative test with two independent Crew Self accounts in different missions	Project team
Independent scientific review	Named reviewers' dated decisions with evidence and rationale for the 54 proposals and 162 unmapped records	Independent scientific reviewers
Live Ground Medical review acceptance; human real-device cases (15 + 9)	Execution with authorized accounts and devices	Owner, reviewers, testers
Owner-evidence gates P3663, P3664, P20	Authentic restore evidence, explicit owner risk acceptance, official 2026 rules re-check	Project owner
Competition validation on the submitted SHA	Re-run the P47 Competition Submission Validation workflow	Owner / development environment
Signed-in revocation acceptance	Two dedicated accounts per role; revocation while hidden; no private rows return	Owner, testers
Final security sign-off	Provider-level finding resolution; sign-off	Owner and hosting platform

39.3 Future research requirements

Moving from a research prototype towards any operational use would require evidence that lies outside the scope of this release: clinical validation studies, regulatory assessment, flight-hardware qualification, and evaluation with real crews under appropriate ethical approval. MITOCHONDRIA makes none of these claims; its open architecture, provenance model and governed review workflow are designed so that such evidence can be added and traced without changing the platform's safety boundaries.