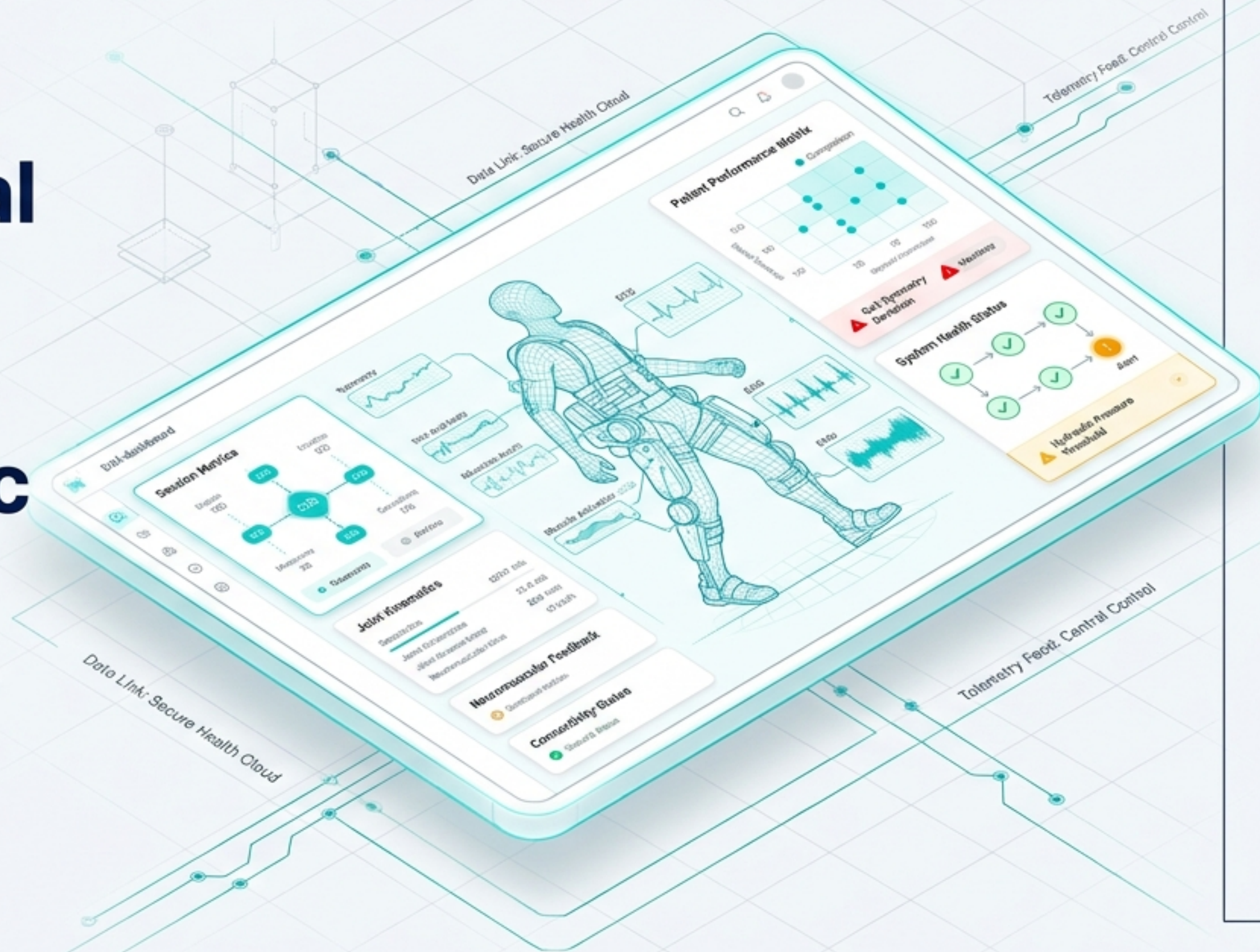


Version 3.0 | Internal Design Document

A Unified Clinical and Operational Platform for Singapore Public Healthcare

Intelligent Rehabilitation Robots
Dashboard (UC60-SG)

For SingHealth, NUHS, NHG Clusters



Better Questions Drive Safer Clinical Design

Assumption:

A therapist is always watching.



Implication:

A 23:00 night-shift therapist alone with 6 robots requires autonomous safety escalation. The robot auto-pauses.



Assumption:

Continuous cloud connectivity.



Implication:

TTSH's Lokomat frequently loses basement WiFi. We require an offline-first architecture.



OFFLINE

Assumption:

More alerts mean more safety.



Implication:

Alert fatigue is a safety hazard. We impose a strict budget of max 3 actionable alerts per session.



MAX 3

Replacing Proprietary Silos with an Integrated Clinical Nexus



Fragmented State

~4,500 monthly robot-assisted sessions across 12 facilities trapped in proprietary formats. Fleet utilization stuck at 68%.

Target State

Unified telemetry, Asian normative data, and cross-continuum EMR integration.

Strategic Investment Yields Immediate Clinical and Operational Returns

Operational and Clinical Performance Matrix

Robot Utilization

Current State:



68% ↓

Month 12 Target State: 82%

+14%
Improvement

Time to
Independent
Ambulation
(Stroke)

Current State:



32 days ↗

Month 12 Target State: 26 days (-19%)

-19%
Reduction

Documentation
Time

Current State:



12 min ↗

Month 12 Target State: 6 min (-50%)

-50%
Efficiency Gain

30-Day
Readmission

Current State:



11.4% ↗

Month 12 Target State: 8.5%

-2.9%
Reduction

Budget: **SGD 4.2M**
over 3 years

Break-even: Month 14
(driven by reduced downtime
and increased throughput)

Purpose-Built for the Realities of the Ward and the Fleet



P1: Floor Therapist

Context: 12-hour shifts, manages 3-6 robots.

JTBD: Safety, speed.

UX Focus: 3-meter glanceability, max 3 alerts/session.



P2: Rehab Specialist

Context: Ward rounds, research, complex cases.

JTBD: FIM trends, discharge prediction.

UX Focus: Deep biomechanical data, CSV research export, AI rationales.



P3: Biomed Engineer

Context: Manages fleet of 20-30 devices.

JTBD: Maximize uptime, HSA audits.

UX Focus: Predictive maintenance, component health overlays.

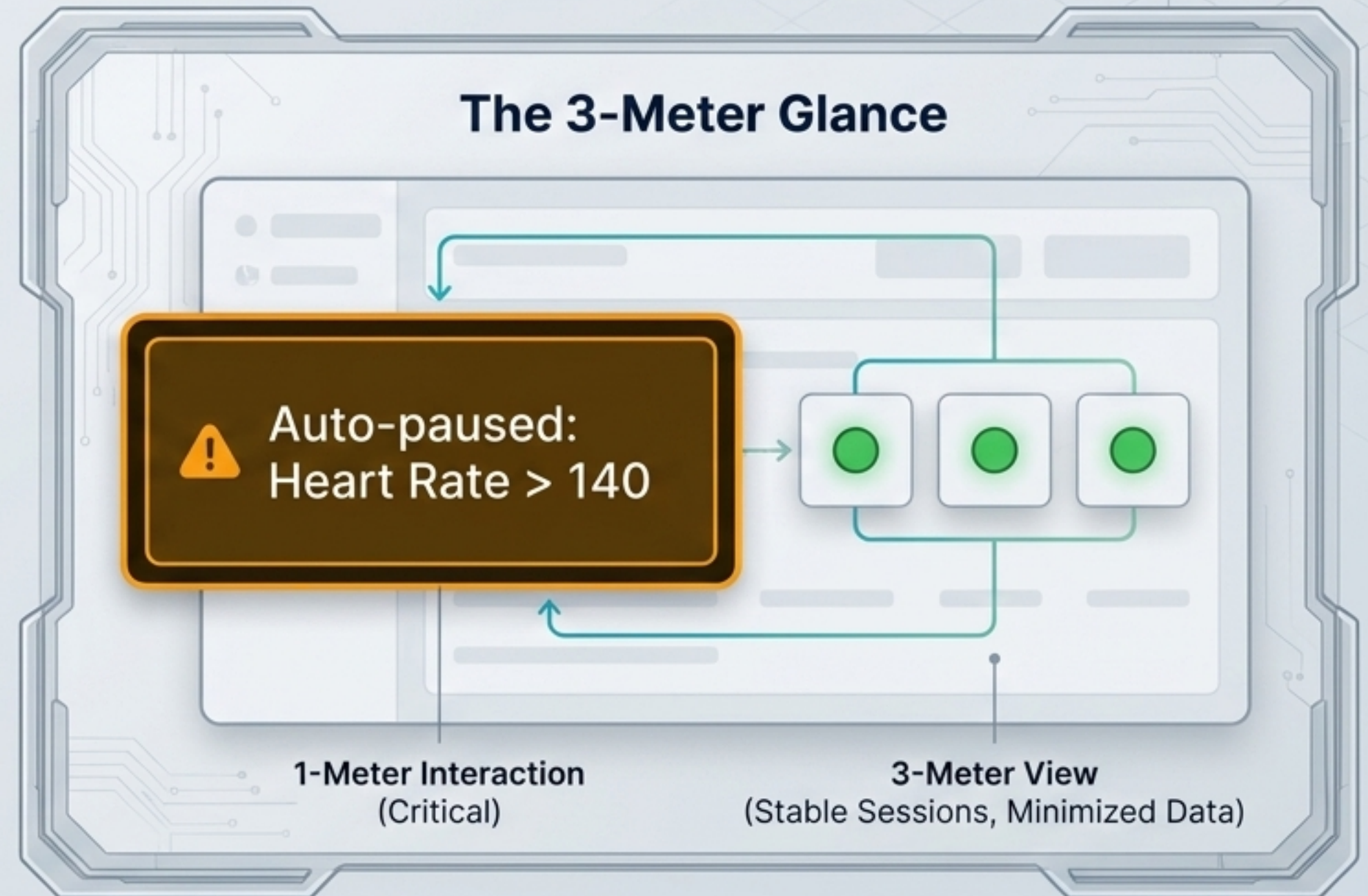


Attention-Weighted UI Manages the Cognitive Load Budget

Designed for a 65-year-old therapist under fluorescent ward lighting.

Minimum 16px font, 4.5:1 contrast ratio.

Rule: No color-only coding (always paired with icon/text). Dark mode default for clinical hardware to reduce glare.



Progressive Disclosure Ensures Zero Clicks to Safety

Level 1 (0 Clicks): Ward View

Assess all active session safety in 3 seconds.



Level 2 (1 Click): Patient/Session View

Understand AI parameter adjustments and real-time telemetry strips.



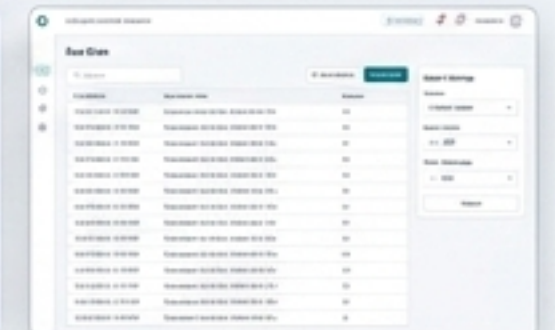
Level 3 (2 Clicks): Biomechanical Analysis

Kinematics timeline, gait symmetry radar, smooth/jerk analysis.



Level 4 (3 Clicks): Raw Data

Export research datasets.



The Telemetry Anatomy: From 1kHz Sensors to <500ms Dashboards



Ingestion

Robot Controller generates 1kHz telemetry.



Edge Gateway

Kafka/Flink downsamples to 100Hz and executes severity classification.



Storage

InfluxDB (Time-series for sensors), PostgreSQL (Relational for patient records).



Delivery

FastAPI & React 18 client renders telemetry with <500ms latency via WebSockets.

Offline Resilience Prioritizes Patient Safety Over Connectivity

The Edge (Robot Controller / Ward Server)

Offline-first architecture. Hard safety limits execute locally in <10ms (e.g., auto-pause on extreme asymmetry). Buffers 5 minutes of telemetry locally during WiFi drops.



The Cloud (SG-GAIA / Synapse)

Handles Dashboard rendering, ML model retraining, cross-cluster EMR syncing, and long-term storage.



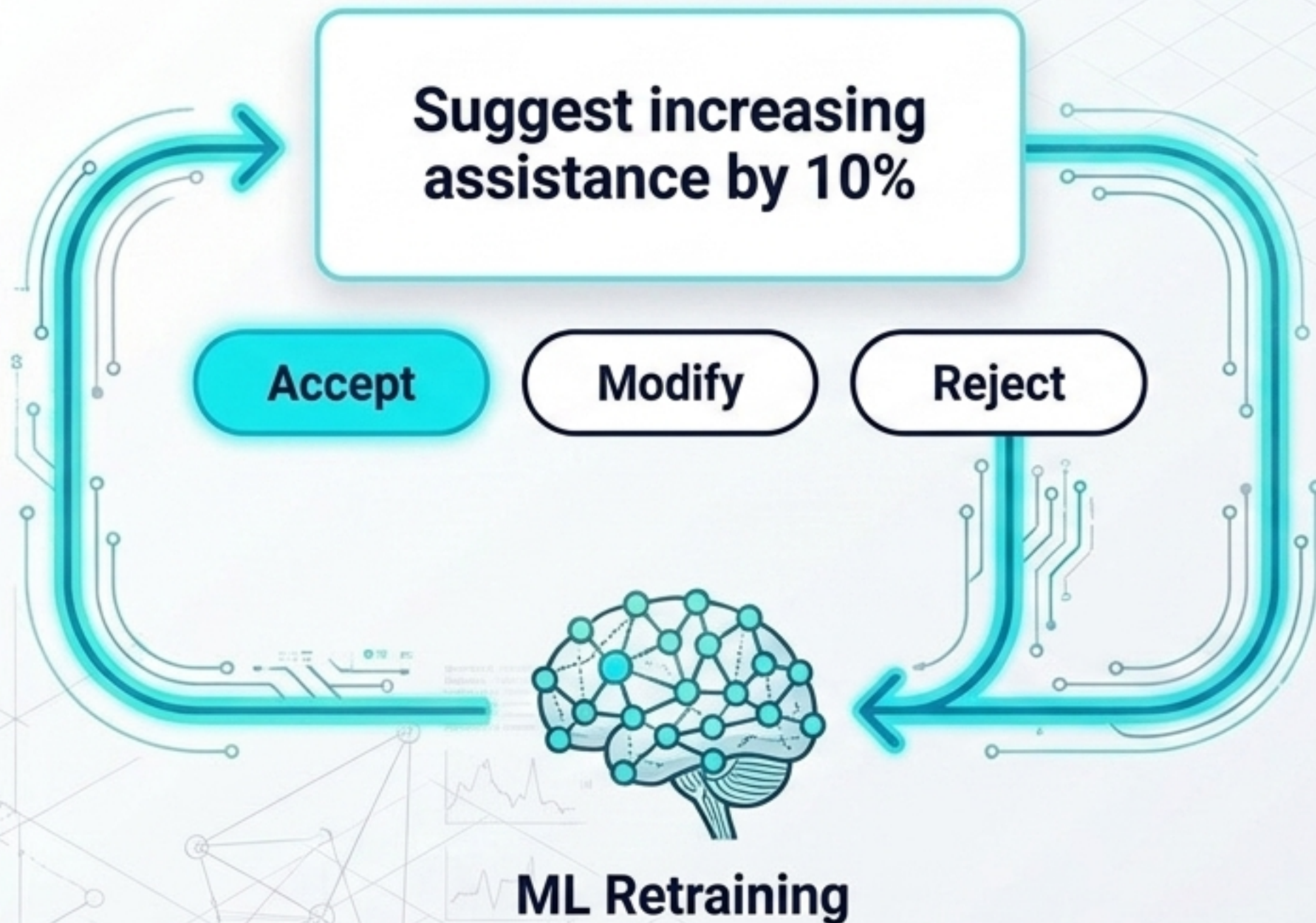
Network Boundary



Fail-Safe:

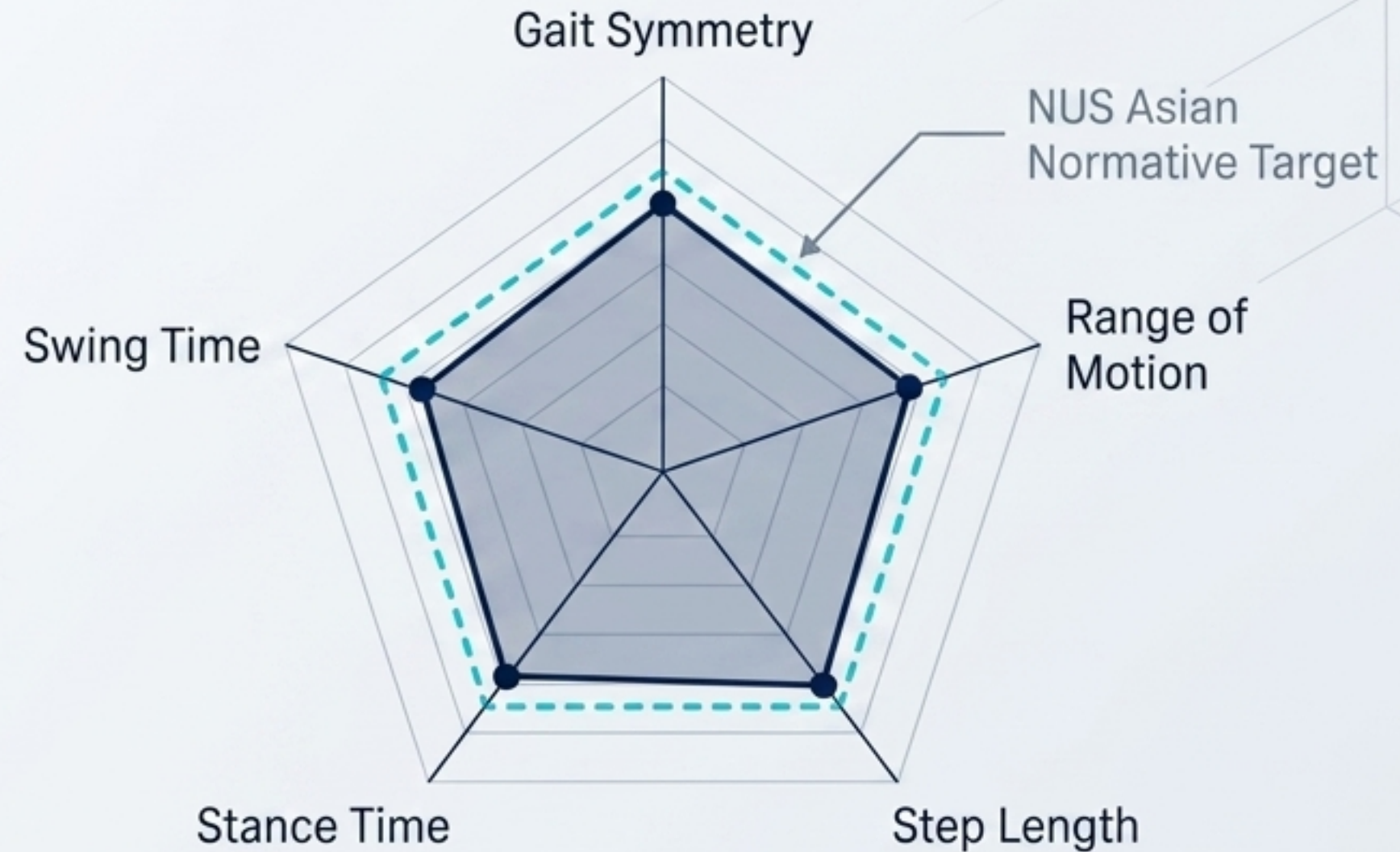
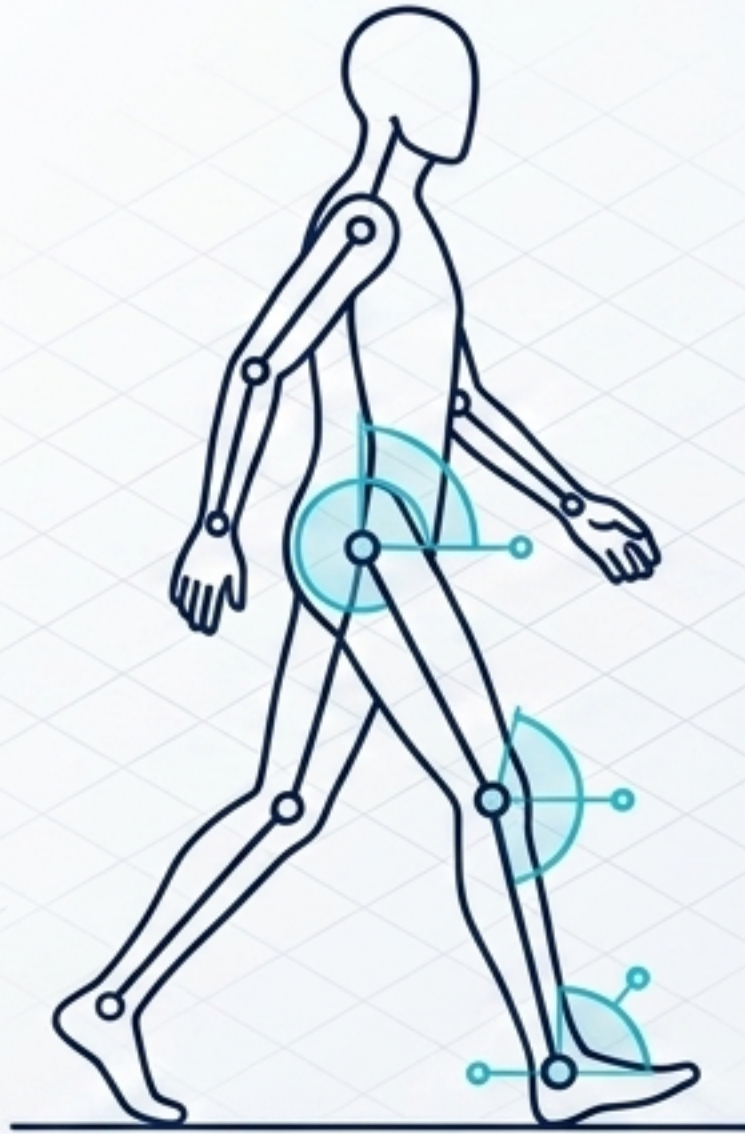
Dashboard displays a graceful 'stale data' banner during outages. No white screens.

Human-in-the-Loop AI: Celebrating Clinical Autonomy



- **AI models** (discharge readiness, plateau risk) are suggestions, not orders.
- **The Override Loop:** Clinician override is 1-click and requires a brief logged reason.
- **The Insight:** The 'Override Rate' is tracked as a critical feature to retrain the model, not a penalty. We target a 15-30% override rate to ensure therapists remain actively engaged, avoiding both blind trust and complete rejection.

Unlocking Biomechanics with Asian Normative Data



- Shifting from Caucasian manufacturer defaults to localized baselines.
- Baseline Data: National University of Singapore (NUS) Healthy Elderly Gait Database (n=450, age 60–85).
- Dashboard tracks precise deviation distance from this specific Asian normative target.

National-Grade Governance, Security, and Compliance

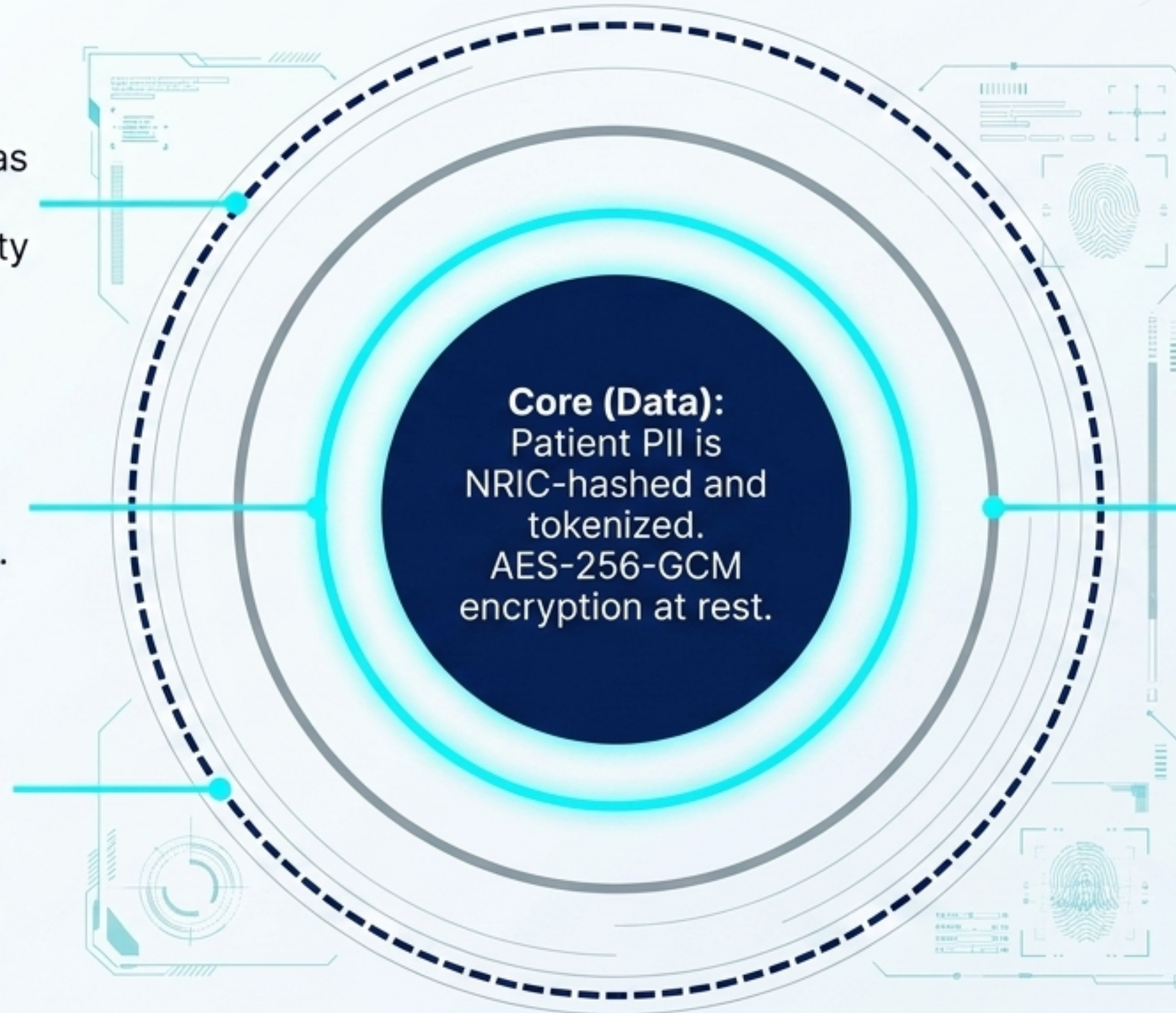
Layer 4 (Compliance):
Built for HSA AlaMD (AI as Medical Device) GN-18, PDPA 2012, Cybersecurity Act 2018, and MOH CQI reporting.

Layer 2 (Access): Strict Role-Based Access Control (RBAC) tied to hospital Active Directory. Immutable WORM audit logs.

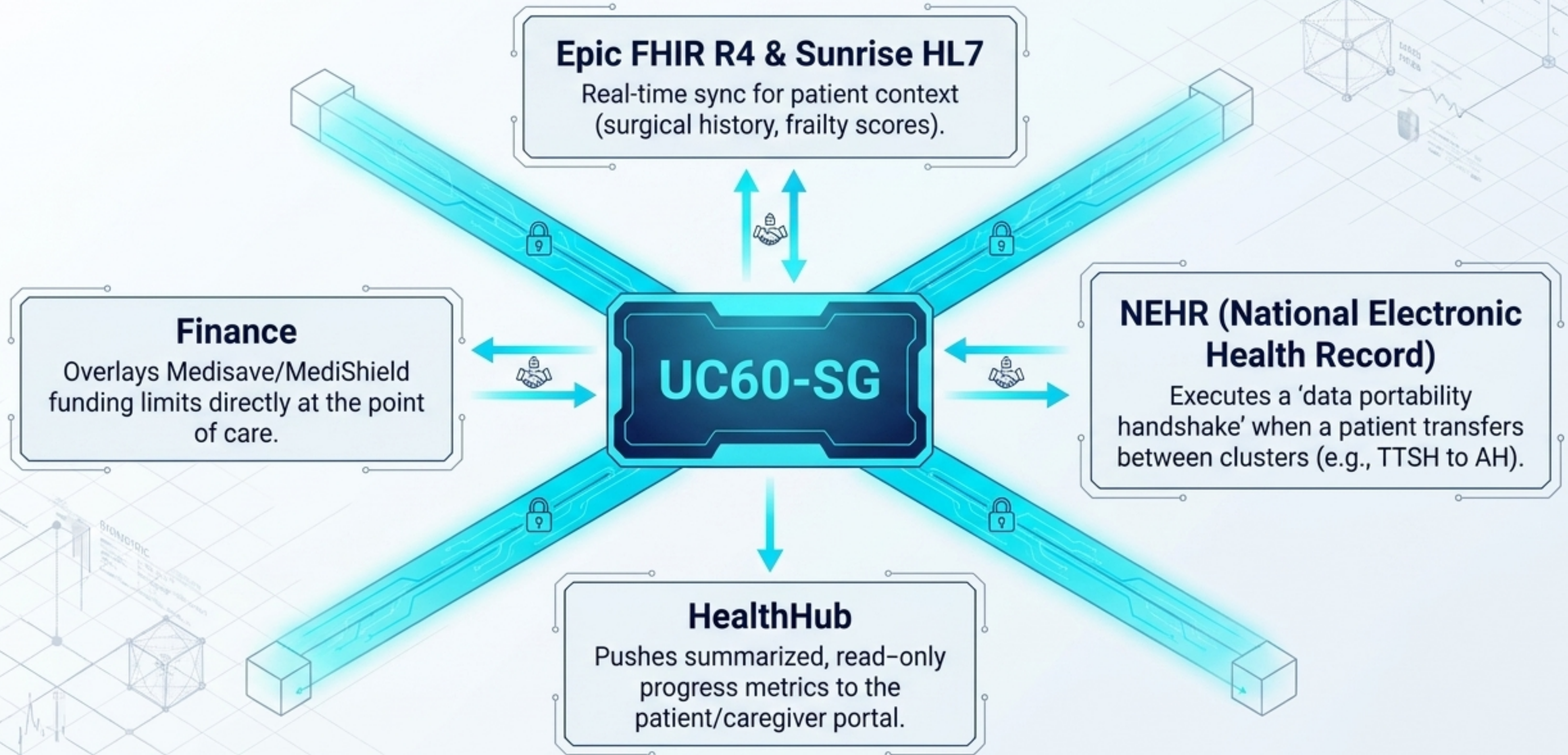
Layer 4 (Compliance):
Built for HSA AlaMD (AI as Medical Device) GN-18, PDPA 2012, Cybersecurity Act 2018, and MOH CQI reporting.

Core (Data):
Patient PII is NRIC-hashed and tokenized.
AES-256-GCM encryption at rest.

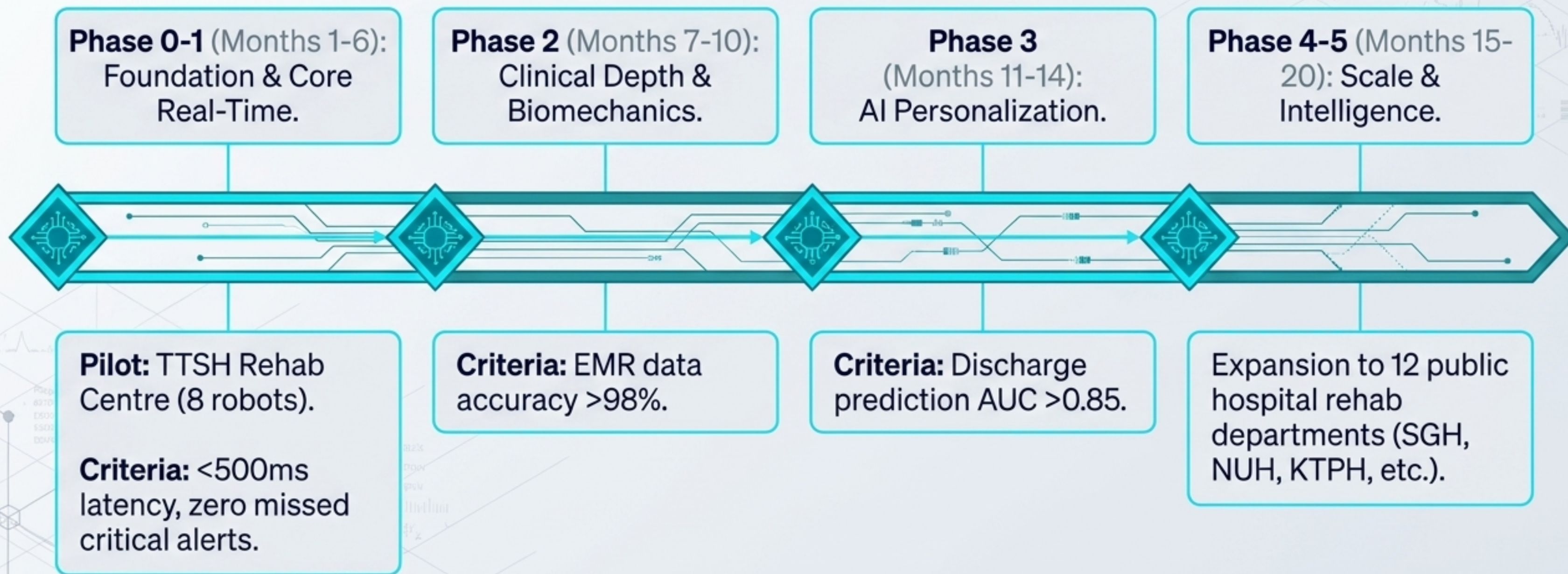
Layer 3 (Network):
Zero-trust architecture deployed on SG-GAIA Sovereign Cloud. Non-SG IPs blocked.



A Singapore-First Integration Ecosystem



The 20-Month Path to Scale: From Pilot to National Standard



The Future of Rehabilitation: Empowered, Optimized, Safe.



Empowered Therapists:
Documentation cut in half;
cognitive load managed.



Optimized Machines:
Unplanned downtime slashed
to 3%; 82% fleet utilization.



Recovering Patients

Targeting -19% Time to Independent Ambulation.