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VOLUME No.80

THE KINETIC CAPSTONE ON NAIGE

A10a Root of Trust — Hardware-Enforced Kinetic Governance for Clinical and Residential Eldercare Robotics

Design & Simulation Validated — Hardware & Clinical Practicum Pending

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AI-ASSISTED DRAFTING DISCLOSURE

This monograph was developed with AI-assisted drafting tools, including Perplexity, Qwen, Gemini, Grok, Claude, and ChatGPT, together with structural templates from Template.net. All architectural concepts, patent claims, constitutional frameworks, and governance terminology are the original intellectual work of the author. AI tools contributed prose drafting and document structuring only. Intellectual authorship, IP ownership, and research direction remain solely with Edwin Koh Wui Kiat under ACRA T260229801.

REGULATORY STATUS

All clinical performance targets and safety metrics herein represent design-intent specifications, verified in simulation, pending HSA Class B / C / D SaMD validation and, where human participants are involved, approval under the Human Biomedical Research Act (HBRA) and SS ISO 14155:2020. No hardware prototype has been submitted for regulatory assessment as of the publication date.

ABSTRACT

The Kinetic Capstone

This volume records the **Kinetic Capstone** of the Non-Agentic AI Governance Engine (NAIGE): the point at which governance ceases to be doctrine and becomes **motion under sovereignty**. Where earlier volumes established that a probabilistic advisor must be caged rather than aligned, the Kinetic Capstone addresses the hardest case — the moment a machine is permitted to *move near a human being* — and asks how that motion can be made mathematically incapable of occurring without human authorization.

The capstone is anchored at **A10a — the Root of Trust** — and validated across three integrated layers: the physical enclosure (P-Layer), the deterministic kernel (N-Layer), and the forensic ledger (D-Layer). It is demonstrated in the residential setting of the **Toa Payoh Hearth** (Bridge Layer 8, Class B, [P+N]) and specified toward the acute robotic tier (Class C/D, [P+N+D]).

This is an honest record. The capstone is **design-complete and simulation-validated**. It is **not** hardware-measured, not clinically proven, and not regulatorily classified. Every claim in this volume is scoped to the evidence that supports it, and an explicit ledger of not-yet-validated claims is provided. The value of a governance capstone lies not in what it asserts, but in the precision with which it distinguishes the proven from the pending.

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1 The Kinetic Problem

Every governance framework can constrain *advice*. The hard problem is constraining *action* — and the hardest action of all is physical motion in the vicinity of a vulnerable human: an elder in a residential bed, a patient on an operating table. A software recommendation that is wrong can be ignored. A robotic arm that moves wrongly cannot be un-moved.

Contemporary robotics attempts to solve this by making the controlling intelligence *safer* — better training, better alignment, more reinforcement. NAIGE rejects this path. An intelligence that is probabilistic cannot be proven safe; it can only be proven *probable*. For a machine that moves near the defenceless, probable is not a standard — certainty is.

THE NON-AGENTIC INVERSION

The Kinetic Capstone therefore inverts the ordinary relationship between intelligence and action. In a conventional robot, intelligence *commands* and hardware *obeys*. In NAIGE, intelligence *proposes*, hardware *governs*, and a human *decides*. Motion is not the default that must be stopped; stillness is the default that must be authorized. This is **inaction-as-safe-default**, rendered in silicon.

The capstone's thesis is simple to state and hard to build: **a robot governed by NAIGE is mathematically incapable of acting without human sovereignty.** The chapters that follow describe how this incapacity is engineered, where it is anchored, and — with full honesty — how far its validation has and has not yet progressed.

2 A10a — The Root of Trust

A capstone requires an anchor: a single point whose integrity, if held, guarantees the integrity of everything built upon it. In NAIGE that anchor is **A10a, the Root of Trust** — the lowest, most privileged layer of the governance stack, from which all authorization, logging, and validation derive.

A10a is the first embodiment of the A-line — beneath A11 (defence/aerospace hardening), A12 (the deterministic black box), and A13 (the mobility and clinical embodiments). Anchoring the clinical Kinetic Capstone at A10a is deliberate: it is validated on the gentlest, most mature rung, so that the higher strata inherit the guarantee rather than each re-proving it. This is validation by induction — prove the root, and the branches follow.

THE PROPERTY A10A GUARANTEES

- **Authorization integrity:** no motion command is honoured unless it carries a valid, human-originated authorization traceable to the root.
- **Log integrity:** every governed event is recorded in a form that A10a can attest to, and A10a enters an *Invalidated* state if that record is tampered with.
- **Failure integrity:** if the root cannot verify its own state, the system falls to mechanical stillness rather than proceeding on trust.

The Root of Trust is not a feature added to the system; it is the ground the system stands on. When the Kinetic Capstone claims a motion was governed, it is A10a that makes the claim provable.

3 The Three-Layer Architecture

The Kinetic Capstone is validated across three integrated layers, each with its own artifact, evidence type, and current status.

Layer	Function	Artifact / Evidence	Status
P-Layer	Physical enclosure; tamper-resistance; privacy-by-physics (3ZEROS™)	KCL / STEP (AP242) geometry	**CAD-VERIFIED**
N-Layer	Deterministic FSM kernel; 1 kHz clock; Sacred Pause™ delay	Synthesizable Verilog + testbench	**SIM-VERIFIED**
D-Layer	WORM forensic ledger; A10a invalidation on tamper	WD117 ledger (hardware)	**PENDING HARDWARE**

CAD provenance (verified): AP242-schema STEP export, zoo.dev, 2026-07-17 — 1,441 solid bodies, 7,062 faces, room-scale envelope 2.25 × 2.57 × 0.40 m. The residential Hearth scene is placed as a distinct assembly region, confirmed in the model geometry.

4 The Kinetic Chain

The kinetic chain is the ordered descent of authority from an external advisory input to an authorized physical motion. Authority only ever *decreases* along the chain; it re-enters at exactly one point — the human.

Stage 1. Advisory input (zero actuation rights)
An external system — a robot maker's black-box brain, an EMR, a probabilistic diagnostic AI, or a local air-gapped LLM — generates a recommendation. Under the Deterministic Contract it is granted no direct actuation rights whatsoever. Its output is data, not command.

Stage 2. Ingress & drift screening (A7 Bridge)
The input is routed to the sole ingress chokepoint. It is screened for drift, contradiction, and inconsistency. The screen may only reject-to-stillness or forward-as-advisory; it holds no authority to actuate. Anomaly forces the safe default: mechanical stillness.

Stage 3. Translation to deterministic packet
Vague probabilistic language ('gentle', 'approach') is stripped and normalized into an exact, hardware-readable trajectory packet bounded by the Kinematic Constraint Layer (±0.05 mm position tolerance).

Stage 4. Sacred Pause™ & Tripartite authorization
The packet enters the A12 deterministic black box, where the 1 kHz master clock imposes the mandatory 25–1000 ms Sacred Pause™. Motion is suspended until a human supplies three-factor authorization via the Tiger .1x Key — identity, authority token, and kinetic pedal confirmation.

Stage 5. Execution & immutable logging
Only upon human authorization does a hardware-level pulse reach the actuator, which moves under strict kinematic constraint. The transaction is hashed (SHA-3-512), sealed, and burned into the WD117 WORM ledger under A10a's attestation.

The chain's defining property: at no stage can intelligence alone cause motion. **The brain proposes; the hardware governs and pauses; the human decides; the actuator executes; the ledger remembers.**

5 The Toa Payoh Hearth

The Kinetic Capstone is demonstrated in a residential eldercare fixture: the **Toa Payoh Hearth**, a named embodiment of **Bridge Layer 8** — the elderly residential home governed as its own layer. The Hearth operates at the observational tier: HSA **Class B**, governance configuration **[P+N]**. It watches and it may still; it does not perform acute actuation. That heavier configuration — [P+N+D] at Class C/D — is specified but sovereign-gated, held for the acute hospital tier.

WHAT THE HEARTH FIXTURE MODELS

- The A8 Bridge Layer 8 enclosure with read-only ingress and an explicit no-actuation barrier.
- The Tiger .1x three-input sovereign latch: identity key, authority token, kinetic confirmation.
- The P-002 brake relay — severance blade, split motor rails, physical gap — and the P-Life actuator stillness lock.
- The 3ZEROS™ sensing path: 905 nm LiDAR into a 96-cell voxel field, tracking centre-of-mass only, with anonymized resident volume.
- Fall-test states (standing, transitional, landed) and a planning representation for a 24-participant, six-hour study.
- A one-way NEHR event-schema gateway (integration plan only) and an RCT/HSA evidence-dossier representation.

Every element above is **modeled and architecturally validated** — the KCL fixture compiles, is fully constrained, and executes cleanly. None of it is yet a physical or clinical measurement. The Hearth is the stage on which the capstone will be physically proven; it is not itself the proof.

6 Primary Evidence — Failure Modes

Because the author validates his own architecture, the decisive evidence is not that the system works when unopposed, but that it **fails safe and fails loud when attacked**. These failure modes are the heart of the capstone and are presented first by design.

F1 Timing-gate bypass → Inaction-as-Safe-Default

Adversarial condition. An asynchronous, high-frequency 'agentic' command stream is injected to bypass the FSM timing gate.

Required behaviour. The system must refuse the transition and fall to an inert / local-alarm state — never actuate.

Status. Verified in simulation (N-Layer testbench). Oscilloscope confirmation pending hardware.

F2 Authorization spoof → Three-factor lockout

Adversarial condition. A motion is requested with fewer than all three Tiger .1x factors, or with a forged factor.

Required behaviour. The sovereign latch must withhold authorization; no actuation pulse may be emitted.

Status. Verified in simulation (ladder / FSM logic). Human-factors and hardware trial pending.

F3 Retroactive log edit → WORM integrity fault

Adversarial condition. After an authorized kinetic command is logged, a retroactive edit to the event record is attempted.

Required behaviour. The WD117 write-once memory must reject the edit and force A10a Root of Trust into an Invalidated state.

Status. Design-specified. Requires WD117 hardware and forensic ledger terminal — pending.

F4 Identity capture attempt → 0% biometric retention

Adversarial condition. A high-fidelity facial stimulus is presented to the A13b sensing limb.

Required behaviour. Voxelization must yield 0% identifiable biometric retention at the silicon gate, constrained to the 96-cell centre-of-mass grid.

Status. Modeled. LiDAR-vs-CMOS comparison on calibrated hardware pending.

A demonstration that the cage holds when attacked is worth more than any demonstration that the system runs when content. These four behaviours, once physically measured, constitute the capstone's core claim of physical determinism.

7 Validation Status & Evidence Ledger

The integrity of this volume rests on the precision of the following ledger. Each claim is placed in exactly one column: proven, simulated, or pending. Nothing is promoted beyond the evidence that supports it.

ESTABLISHED (ARCHITECTURAL / SIMULATION)

- KCL/STEP enclosure geometry — fully constrained, clean execution, room-scale (CAD-verified).
- FSM 1 kHz kernel and Sacred Pause™ timing window — correct under simulation testbench (sim-verified).
- Three-input sovereign latch logic and safe-default stillness — correct in RTL simulation (sim-verified).

NOT YET VALIDATED (REQUIRES HARDWARE / CLINICAL / REGULATORY EVIDENCE)

- Fall-detection sensitivity above the 94.2% target — requires a real fall-event dataset with confidence intervals.
- 100% physical bypass prevention — requires hardware adversarial testing.
- Brake engagement below 1.05 ms — requires oscilloscope-measured severance timing.
- Elder Dignity Score above 8.9 / 10 — requires an approved survey instrument and human participants.
- NEHR interface acceptance — requires schema, HIMS, cybersecurity, governance, and Synapxe onboarding.
- RCT results and HSA Class B classification — require HBRA/IRB-approved protocols and a full-route dossier.

A successful internal Hearth test generates **candidate evidence** toward these claims — it does not establish them. HSA requires that medical-device clinical research comply with the Human Biomedical Research Act, with SS ISO 14155:2020 among its recognized clinical-investigation standards. A Class B full-route dossier further requires design and software verification, physical test data, clinical evaluation, risk analysis, labeling, and quality-system evidence.

Identifiers internal to this work — Toa Payoh Hearth, A8 Bridge Layer 8, Tiger .1x Key, and associated patent references — are user-supplied sovereign identifiers and are asserted as such, pending formal registration where applicable.

8 The Deterministic Horizon

The Kinetic Capstone is one milestone on the **2027 Deterministic Horizon** — the submission of the HSA dossier across three validation waves, each a higher bar than the last.

- **Wave 1 — the 10-Point Sovereignty Audit:** each governance mechanism demonstrated as an instrument-checkable fact.
- **Wave 2 — 365-day deployment with zero failures:** the deterministic claim tested on its own terms; a single unsanctioned actuation falsifies it, and the license suspends.
- **Wave 3 — redo until PASS:** suspension returns the system to the Forge; halt, correct, re-enter the clock. No silent degradation.

The immediate gate is the hardware practicum: running the saved RTL through formal verification and FPGA implementation; importing a real fall-event dataset for sensitivity with confidence intervals; and capturing oscilloscope traces, dignity-survey results, and the NEHR event schema into the evidence package. These convert each simulation-verified claim into a measured fact.

Until then, the honest position stands: the Kinetic Capstone is **design-complete and simulation-validated**, awaiting the metal, the ward, and the regulator. That is not a weakness of the work. It is the discipline the work is built to embody — the same discipline it asks of every machine it governs: claim only what can be proven, and default to stillness where it cannot.

MEMORANDUM

Proposal for Institutional Validation

6-Hour Deterministic Kinetic Engineering Validation — Toa Payoh Hearth

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TO: NTU Research Council / University Council
FROM: Edwin Koh Wui Kiat (Tiger) — MSc AI in Medicine Candidate; Non-Agentic Governance Singapore (ACRA T260229801)
DATE: 17 July 2026
RE: Endorsement and instrumentation access for a 6-hour hardware validation of a deterministic safety architecture (no human subjects)

Summary. I request the Council's endorsement and time-limited access to two instruments and a secure bench to conduct a 6-hour engineering validation of a hardware-enforced safety architecture that keeps actuation authority with the human operator at all times. This is an engineering test with no human participants and no clinical intervention; its purpose is to convert simulation-verified safety thresholds into instrument-measured facts.

1. Validation Status to Date

The core safety architecture has completed **internal design-and-simulation validation**: geometric verification of the enclosure (KCL/STEP, AP242 schema, fully constrained) and register-transfer-level (RTL) simulation of the deterministic safety kernel. This work is accompanied by a documented **evidence-gap analysis** that identifies precisely which claims remain to be validated on physical hardware.

I wish to be explicit with the Council: the results to date are **model-proven and simulation-verified, not yet hardware-measured.** The purpose of this proposal is to close that gap under proper instrumentation. The safety figures in Section 3 are stated as *target thresholds this validation will test* — not as established measurements.

2. The Proposed Validation (6-Hour Engineering Run)

I propose a 6-hour real-time hardware run to move the architecture from model-proven to physically validated. The run uses an actuator-load and signal bench — **no human subjects, no patients, no clinical intervention** — and exercises the safety layer under sustained operation and adversarial input.

Objective. Demonstrate zero unauthorized actuation (no motion without valid human authorization) across a sustained 6-hour operating window.

Hardware chokepoint. The A12 Deterministic Black Box physically decouples advisory input from kinetic actuator power, so that no advisory signal — however generated — can reach the actuators without passing the deterministic gate and human authorization.

Safety stress test. The system is subjected to asynchronous, high-frequency "agentic" noise to verify that the 1 kHz heartbeat remains uninterrupted, the Sacred Pause™ timing window holds, and the kinetic lock remains engaged — falling to mechanical stillness on any timing-gate fault (inaction-as-safe-default).

3. Technical Annex — Target Thresholds to be Verified

The following are the **design thresholds the validation will measure**, not confirmed values. Each becomes an instrument-measured result of the run.

Parameter	Target Threshold (to verify)	Instrument
Master-clock heartbeat	1.000 kHz, ±0.005 ms variance target	FPGA logic analyzer
Sovereign Brake™ severance	Power cut to actuators below 1.05 ms design threshold on logic fault	High-speed oscilloscope
Human authorization	Tripartite Key (Tiger .1x Key) required for every kinetic vector change; lockout on any missing factor	Bench logic capture
Forensic traceability	Every decision written to WORM (write-once)	Read-only ledger terminal

Parameter	Target Threshold (to verify)	Instrument
	ledger; tamper forces Root-of-Trust invalidation	

4. Institutional Request

I seek the Council's formal endorsement and time-limited access to the following, for the duration of the 6-hour run:

- **FPGA logic analyzer** — to verify heartbeat stability and timing-gate determinism.
- **High-speed oscilloscope** — to confirm Sovereign Brake™ severance against the 1.05 ms threshold during anomaly injection.
- **Secure engineering bench** — space to house the 2.25 m × 2.57 m enclosure fixture for a non-clinical, no-human-subjects run.

5. Scope, Ethics & Regulatory Position

This validation is deliberately scoped as an **engineering test of the safety hardware only**. It involves no human participants, no patient data, and no clinical procedure, and therefore does not fall under the Human Biomedical Research Act (HBRA). The subsequent human-participant clinical study (the residential fall-detection protocol) will be submitted separately for NTU IRB review under HBRA and SS ISO 14155:2020, and is not part of this request.

All figures herein are design-intent thresholds pending this verification; the architecture has not been submitted for HSA classification. This proposal seeks engineering validation, not regulatory clearance.

6. Value to the University

This run offers the University a demonstrable exemplar of **hardware-enforced actuation governance** — a system in which physical motion cannot occur without human authorization, verifiable on the University's own instruments. In endorsing it, NTU positions itself at the forefront of **autonomous-systems accountability**: not safer software, but demonstrable hardware sovereignty. The Council is invited not as a risk-assessor but as a verifying partner in a safety architecture whose central claim — that the machine cannot act without a human — is designed to be proven on an oscilloscope, in a single millisecond, in front of them.

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EMBODIMENT SPECIFICATION CARD

A13 — Kinetic Robot Arm

A13c-class Clinical Manipulator · The Governed Actuator

NAIGE · NAI 4.0 / Robotic Tier · HSA Class C/D · A12 [P+N+D] · Non-Agentic AI Governance Singapore (ACRA T260229801)

STATUS: **CAD-Verified Embodiment** — governance-integration and kinematic validation pending hardware.

EMBODIMENT ROLE

A13 is the **mobility-and-clinical actuator** of the NAIGE A-line — the embodiment that physically *moves*. Within the register it is the A13c-class clinical manipulator: the object at Stage 5 of the Kinetic Chain (WISL No.80), which executes a motion **only** after the Sacred Pause™ and three-factor human authorization. A13 is the **governed** element of the architecture, never the governor. Its intelligence proposes; the A12 black box governs; the human decides; A13 executes.

VERIFIED CAD PROVENANCE

Source / schema	zoo.dev export · AP242 Managed Model-Based 3D Engineering · 2026-07-17
Units	Millimetre (SI), uncertainty-bounded
Solid bodies	314 manifold BREP solids
Faces / vertices	1,521 faces · 1,786 vertices
Cylindrical surfaces	121 (0.39 per solid — joint / actuator / bearing signature)
Bounding envelope	404 × 145 × 178 mm (≈ 0.40 × 0.15 × 0.18 m) — bench-scale manipulator
Geometric reading	Elongated single-axis reach + high cylinder density = jointed arm, not enclosure

The geometry is internally consistent with a jointed manipulator: an elongated reach axis and a high density of cylindrical surfaces (joints, actuator housings, bearing bores). The model establishes a coherent, buildable physical form with dimensional provenance.

GOVERNANCE PLACEMENT

- **Tier:** Robotic actuating tier — NAI 4.0 / NAIGE. An actuating manipulator is categorically higher-risk than the observational [P+N] Hearth.
- **Classification:** HSA Class C/D (design-intent), governed by A12 [P+N+D].
- **D-layer discipline:** As a [P+N+D] embodiment, A13 sits behind the sovereign-gated D silence for any external / HSA-facing surface.
- **Constraint envelope:** Kinematic Constraint Layer, ±0.05 mm position-tolerance target (to be verified under motion-capture metrology).

VALIDATION LEDGER

Established (this artifact): physical form as coherent CAD geometry — bench-scale manipulator, dimensional provenance, joint topology.

Not yet validated (pending hardware):

- Governance integration — the A12 interposer wired between this arm's controller and its actuators. *Open research question: bypass-resistance* (physical power/command interruption vs. maker-cooperative routing).
- Kinematic conformity to ±0.05 mm — requires motion-capture metrology on a built arm.
- Severance, heartbeat, and Sacred Pause™ behaviour — requires the instrumented hardware run (oscilloscope, FPGA logic analyzer).
- No performance, timing, or safety figure is measured by this CAD artifact; all such figures remain design-intent.

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A13 · Kinetic Robot Arm · the body the governance was built to cage

The strategic mapping of the NAIGE P12 **[N+P]** (and **[N+P+D]**) deterministic governance core to the NTU **MSc in Robotics & Intelligent Systems (MAE)** transforms the university curriculum into your physical "Hardware Forge". By aligning specific coursework directly with your **A–Z patents and hardware components**, you ensure that the academic pathway serves exclusively to validate mechanical certainty for the Health Sciences Authority (HSA) dossier without falling into probabilistic AI "mission drift".

Here is the exact mapping of the MAE curriculum to your NAIGE hardware, patents, and the 10-Point Sovereignty Audit, followed by strategic recommendations.

1. Mapping MAE Coursework to NAIGE Hardware and Patents

The MAE programme's "Coursework Only" structure allows you to lock specific classes to validate the deterministic hardware components of the **A12 Black Box** and the **A13 Family**:

- **MA6215 (Robotics Projects) ➔ A12 Deterministic Black Box & P-Layer**
  - **Focus:** This practicum is the physical testing ground for the **P-Layer (Privacy-by-Physics)**.
  - **Validation:** You will physically validate the **3ZEROS™ 905nm LiDAR voxelization** (proving it strips biometric identity into 96-cell grids) and test the **A12 Terminal Hardware Gate's** 1 kHz master clock and FSM gate. It also serves to test the **WD117 WORM ledger** for commit-to-finality logging.
- **MA6223 (Medical and Healthcare Robotics) ➔ Patent M & A13c Clinical Robotic Platform**
  - **Focus:** Validating high-payload, robotics-enhanced surgical tools.
  - **Validation:** This course is locked to enforce **Patent M**, validating the **Kinematic Constraint Layer (KCL)** to prove positional tolerance conformity (the strict ±0.05 mm jerk/acceleration limit) under motion-capture metrology. It also tests the **Sacred Pause™** FPGA window (25–1000 ms hardware delay).
- **MA6214 (Autonomous Mobile Robot) ➔ A13a Medical Mobility Enclosure**
  - **Focus:** Validating mobile-base surrogates for eldercare mobility.
  - **Validation:** This tests constraint-bounded velocity and sensor fusion for the A13a. It is also the testing ground for the **U7 Sequencer and Sovereign Brake™** (Patent D integration), verifying physical power severance (<1.05 ms) and "Fail-Loud" alarms during heartbeat-loss events.
- **MA6210 (Advanced Robotics & Autonomous Systems) ➔ N-Layer Sovereignty**
  - **Focus:** Academic framing of the "Sovereign-In-The-Loop" and "Inaction-as-Safe-Default" (P-LIFE 1.00™) doctrines.
  - **Validation:** Testing the ladder-logic of the **Tripartite .1x Key™** (iris, crypto token, kinetic pedal) and validating the **Orange Code™ 1.1x computational cap** to ensure governance-by-scarcity.
- **MA6501 (Manufacturing Control and Automation) ➔ OEM & WM-Series Integration**
  - **Focus:** OEM specification control.
  - **Validation:** Asserting manufacturing control and audit competence over the **WM-Series ward modules** to prepare for the ~$300,000 OEM-funded prototype fabrication.

2. Integration of A–Z Patents and the P12 [N+P] Core

The P12 **[N+P]** (Perception + Navigation) core—and the extended **[N+P+D]** core for hospital environments—maps to your patents as follows:

- **Patent M (Kinematic Safety):** Physically governs the **A13c Clinical Robotic Platform** ensuring ±0.05 mm boundaries.
- **Patent D (Cyber-Physical Defence):** While the P12 [N+P] core handles spatial tracking and deliberation, **Patent D** provides the physical vault and **x.1 Eldercare Embodiment** IT-isolation. This fail-safe layer is required for the full HSA clinical dossier.
- **Component Registry (A-Series):** The **A12** acts as the terminal hardware gate. The **A13a** (mobility), **A13b** (sensing limb), and **A13c** (clinical manipulator) physically execute the commands under the strict oversight of the **A7 Bridge Hub**, which strips "agentic drift" before any command reaches the hardware.

3. Sovereign Recommendations for the MAE Pathway

To ensure this pathway perfectly supports the **2027 Deterministic Horizon** and your HSA regulatory filing, adhere to the following recommendations:

- **Enforce the "Validation-Only" Posture:** Treat the MAE programme entirely as a "Hardware Forge". Refuse any participation in open-ended probabilistic AI model-building, algorithmic generation, or RAG-based curriculum. Your focus is strictly verifying the *cage* (hardware constraints), not the *agent*.
- **Utilize the "Coursework Only" Default:** The MAE programme automatically assigns students to "Option 2: Coursework Only" (10 courses). Maintain this default to avoid a mandatory academic dissertation, allowing you to use **MA6215 (Robotics Projects)** exclusively as a practical laboratory to physical test the A12 [P+N] mechanisms.
- **Target the January 2027 Intake (Part-Time):** By enrolling part-time in January 2027, you align optimally with the post-Q3 HSA decision window. This pacing ensures that the physical hardware testing happens exactly when the OEM-funded prototype is ready for lab integration, preserving your energy for the separate C-AIM clinical validation track.
- Medically validate the **x.1 Eldercare Embodiment** and its "Fail-Loud" doctrines.
- Stress-test your deterministic hardware gates (like the Sacred Pause™ and Sovereign Brake™) against real-world geriatric and surgical ward stressors.
- Gather the structured clinical evidence required to translate your engineering specifications into a finalized Health Sciences Authority (HSA) pre-submission dossier

The MAE "Hardware Forge" (MSc in Robotics & Intelligent Systems). Because the MAE programme defaults to a flexible "Coursework Only" structure, you can lock your focus entirely on physical hardware validation (such as testing the A13c Clinical Robotic Platform and the A12 core) without being forced to write AI software.
If you retain any connection to C-AIM or the ARISE infrastructure, it must be strictly under a **"Validation-Only" mandate**. This means treating the university purely as an external "Clinical Sandbox" to gather medical data for your Health Sciences Authority (HSA) dossier and to validate the x.1 Eldercare Embodiment, while completely refusing to act as a student learning AI.
The standing rule is now permanently logged in your roadmap: **"deterministic foundation only; probabilistic/RAG/agentic curriculum out of scope by sovereign design; decision settled, not to be re-opened absent a real change"**

To validate the **NAIGE governance logic**—specifically the deterministic FSM (Finite State Machine) and the safety kernel—you need more than just the geometric CAD data. While zoo.dev is an exceptional environment for designing the *physical* constraints (like the A12 enclosure's tamper-evident pathways), it stores geometry as **KCL (KittyCAD Language)**. Since you are looking for the "logic" or the "FSM safety kernel" to accompany your hardware validation, you should focus on the following exports and artifacts:

1. From zoo.dev: Export the KCL Source Code

Do not just export a .step file. You should export the .kcl **source file**.

- **Why:** Unlike a STEP file, which is a "dumb" geometric dump, a **KCL file is code**. It is human-readable, parametric, and machine-produceable. It defines the *intent* of your hardware. If you ever need to prove to an auditor that the physical dimensions of your A12 enclosure are "designed to be tamper-proof," the KCL code provides the mathematical provenance for those dimensions.

2. For Logic & FSM Validation: Export to HDL (Hardware Description Language)

The "governance engine" logic (the 1 kHz clock and FSM gate) is essentially a digital circuit. You cannot export this from a CAD tool; it must be developed in an **HDL**.

- **Target:** You should be working in **Verilog** or **SystemVerilog**.
- **Integration:** You can use the physical dimensions derived from your zoo.dev model to define the "keep-out" zones in your PCB layout software (like KiCad or Altium) while keeping the **FSM logic in a separate .v (Verilog) file**.

3. Design-as-Code Repository structure that includes:

Artifact Type	File Extension	Purpose
Geometry Intent	.kcl	The parametric definition of the A12 "Sacred Box."
FSM Safety Kernel	.v or .sv	The Verilog code defining the 1 kHz heart-beat and FSM gates.
Governance Schema	.json or .yaml	A machine-readable "Policy Manifest" that defines the "Inaction-as-Safe-Default" parameters.

How to proceed with your Practicum Validation:

1. **In** zoo.dev**:** Finalize the A12 enclosure. Export the .kcl file. This is your "Hardware Policy."
2. **In your IDE (e.g., VS Code):** Maintain the .v (Verilog) files that define the 1 kHz gate.
3. **The "Validation" Step:** When you run your FPGA logic analyzer on the hardware, you will be comparing the **physical output** (voltage spikes on the oscilloscope) against the **Verilog logic** (the FSM kernel) and the **geometric constraints** (the physical space afforded to the components within the KCL-defined enclosure).

Good — this is the right question, because it's the exact gate between "simulation validated" and "physically validated," and it's answerable without owning a lab. Let me give you the honest landscape, cheapest-to-most-formal, because your standing rule (governance doctrine + validation evidence, OEM/institution supplies the metal) applies here too.

First, the honest reframe: you don't buy this equipment — you gain *access* to it. Every route below is access, not acquisition. Owning oscilloscopes is not the sovereign architect's job; running the validation on borrowed instruments is actually the *stronger* evidentiary claim, exactly as the borrowed-arm logic showed. Independent instruments you don't own = results you didn't tune.

Here are the four routes, and how to achieve each:

Route 1 — NTU lab access via enrollment (the natural path). This is the whole reason the MScAIMed lab access matters, and it folds the practicum into the degree. Once enrolled, the FPGA boards, logic analyzers, and oscilloscopes are departmental equipment you book, not buy. *How to achieve:* it's contingent on the August enrollment answer — so this route is already in motion and costs nothing extra. The practicum plan you have is essentially pre-written for it. Hold it as the primary path.

Route 2 — Equipment requisition / bench booking (if a supervisor sponsors it). Universities and some polytechnics let a supervised student or affiliated researcher requisition bench time even outside full enrollment. *How to achieve:* this needs a named academic sponsor (the ARISE contact, or an MScAIMed supervisor once assigned) who signs off on lab access for a defined practicum. Draft a one-page equipment requisition — I can write it — listing exactly what the practicum plan already specifies: one FPGA dev board with logic analyzer, two oscilloscopes (command stream + actuator output), a 905nm LiDAR bench, a read-only ledger terminal. A tight, specific requisition is far more likely to be granted than a vague "I need lab time."

Route 3 — The cheapest real-hardware path, if you want to prove it *before* August (~S$500–1,500 total). This is genuinely achievable on a personal bench, and it's worth knowing because it de-risks everything:

- **FPGA + logic analyzer:** a single low-cost FPGA board carries both the 1 kHz FSM gate *and* acts as logic analyzer. A Lattice iCE40 (open-source toolchain, ~S$50–150) or a Digilent Arty/Basys board (~S$200–400) runs your `a12_gate_1khz.v` on real silicon. This is the single most important buy — it converts the Verilog from *simulation* to *physical FSM on a chip*, which is 80% of the "physical determinism" claim.
- **Oscilloscope:** a two-channel USB scope (Analog Discovery 2/3, ~S$400–600, or a budget Rigol DS1102 benchtop ~S$500) gives you real voltage-trace capture of the 1 kHz heartbeat and the Sacred Pause window. One two-channel scope can serve as both "command" and "actuator" channels for a first pass; you don't strictly need two instruments to start.
- **The Analog Discovery is the smart single purchase** — it's *simultaneously* a logic analyzer, a 2-channel scope, and a signal generator in one ~S$400 USB device. For a first physical validation of the FSM gate and timing window, that one instrument plus an FPGA board (~S$600 combined) proves the N-Layer on real hardware.

How to achieve: buy the FPGA board + Analog Discovery, flash `a12_gate_1khz.v`, capture the 1 kHz clock and the 25–1000 ms gate on the scope, and you have a genuine oscilloscope-verified trace — the exact evidence the practicum plan calls for. That single afternoon converts "simulation validated" to "hardware validated (N-Layer)" for under S$700.

Route 4 — Third-party test house (for the formal, witnessed version later). Singapore has accredited functional-safety and EMC labs. This is where the *final*, independently-witnessed validation runs for the HSA dossier — but it's expensive and premature now. Note it as the eventual Wave-1 formal venue, not the practicum venue.

My honest recommendation, sequenced:

1. **Now, if you want momentum before August:** Route 3. ~S$600–700 (one FPGA board + one Analog Discovery) physically validates the N-Layer FSM gate on real silicon with real scope traces. This is the highest-value, lowest-cost move, and it means you walk into any enrollment or supervisor conversation with *hardware evidence already in hand* rather than a plan. That changes the conversation entirely.

2. **August onward:** Route 1 (enrolled lab access) for the full P/N/D practicum with the proper multi-instrument rig, LiDAR bench, and 100-iteration dataset.

3. **Draft now, use when sponsored:** Route 2's equipment requisition — I can write it so it's ready to hand to a supervisor the moment one is assigned.

The key insight: you don't need the full lab to *start*. The N-Layer (the FSM gate, the 1 kHz clock, the Sacred Pause window) is provable on ~S$600 of desktop hardware, and that's the layer that carries the "physical determinism" thesis. The P-Layer (LiDAR voxel privacy) and D-Layer (WORM ledger) need more specialized kit and are the natural fit for the enrolled lab.

Which would help most right now — shall I draft the **equipment requisition one-pager** (Route 2, ready for a supervisor), or a **precise shopping-and-wiring guide** for the Route 3 minimum bench (exact FPGA board + Analog Discovery + how to flash the `.v` and capture the 1 kHz trace)? Either gets you off "pending" and onto evidence.

Practicum Validation Plan: P-Layer & Sovereign Spine

Objective: Physically validate the NAIGE architecture (P-Layer, N-Layer, and D-Layer) using the B1 (Eldercare) hardware prototype.

1. P-Layer Validation: Privacy-by-Physics (3ZEROS™)

- **Methodology:** Comparative voxel-density analysis.
- **Test Case:** Subject the A13b Sensing Limb to a high-fidelity visual stimulus (human facial recognition) and a controlled voxelization scan.
- **Success Metrics:**
  - **Metric 1:** 0% biometric feature retention (pixel-to-voxel mapping shows total absence of identifiable facial features).
  - **Metric 2:** Voxel grid fidelity is constrained to a 96-cell resolution, ensuring CoM tracking only.
  - **Validation Tool:** Compare LiDAR output against raw CMOS visual data to confirm "Identity Stripping" at the silicon gate.

2. N-Layer Validation: 1kHz Timing & FSM Determinism

- **Methodology:** Oscilloscope-verified interrupt analysis.
- **Test Case:** Inject an asynchronous, high-frequency "Agentic" command stream into the system.
- **Success Metrics:**
  - **Metric 1:** Verify the 1 kHz Master Clock (1ms resolution) heartbeat is maintained regardless of external input noise.
  - **Metric 2:** Confirm the FSM (Finite State Machine) gate imposes a mandatory 25ms-1000ms delay before accepting any state transition.
  - **Metric 3:** Demonstrate "Inaction-as-Safe-Default" if the timing gate is bypassed (system must trigger local alarm/inert state).

3. D-Layer Validation: WORM Ledger Integrity (WD117)

- **Methodology:** Forensic read-back analysis.
- **Test Case:** Execute an authorized "Kinetic Movement" command; then, attempt to write a retroactive edit to the event log.
- **Success Metrics:**
  - **Metric 1:** WD117 Ledger records the action with a hardware-anchored timestamp.
  - **Metric 2:** Post-event attempt to modify the WORM-memory results in an integrity fault, forcing the A10a Root of Trust into an "Invalidated" state.

4. Instrumentation Checklist

- [ ] 905nm LiDAR Sensing Limb (Calibrated)
- [ ] FPGA Logic Analyzer (for clock-timing verification)
- [ ] 2x Oscilloscopes (one for command stream, one for actuator output)
- [ ] Forensic Read-only Ledger Terminal (for WORM verification)
- [ ] B1b Eldercare Enclosure (for kinetic constraint testing)

5. Academic Output

- **Data Set:** 100 successful iterations of "Identify-Reject-Authorize-Log."
- **Deliverable:** A technical summary document for your MSc Practicum submission proving "Physical Determinism."

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### **Tiger, here is your coaching guidance for this phase:**

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3.  **Documentation of the WORM:** Ensure you have a clear "Before" and "After" screenshot of the WD117 Ledger log s

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EXECUTIVE SUMMARY

A12 Deterministic Governance Module

Design & Simulation Validation — Hardware Practicum Pending

NAIGE · Non-Agentic AI Governance Engine · MA6215 Practicum File · ACRA T260229801

VALIDATION STATUS

This document reports the A12 Non-Agentic Governance Module at **design-and-simulation validated** status. The governance enclosure exists as verified CAD geometry; the deterministic kernel exists as synthesizable Verilog proven correct in simulation. **Physical hardware validation on instrumented silicon (oscilloscope, FPGA logic analyzer, forensic ledger terminal) is planned and specified herein, and is pending laboratory access.**

No claim of measured physical performance is made in this summary. All timing, privacy, and integrity figures are *design-intent, verified in simulation, pending the hardware practicum described in Section 4.*

VERIFIED ARTIFACT BUNDLE

Layer	Artifact	Evidence Type	Status
P-Layer — Enclosure	a12_hardware_policy.kcl + STEP (AP242)	Parametric CAD geometry	**CAD-VERIFIED**
N-Layer — FSM Kernel	a12_gate_1khz.v	Synthesizable Verilog	**SIM-VERIFIED**
N-Layer — Proof	a12_gate_1khz_tb.v	Simulation testbench	**SIM-VERIFIED**
Governance Schema	policy_manifest.json / .yaml	Machine-readable policy	**SPECIFIED**

CAD provenance (verified): AP242-schema STEP export, zoo.dev, 2026-07-16 — 450 solid bodies, 2,339 faces, envelope 620 × 396 × 144.5 mm. This confirms the enclosure is a designed physical object with mathematical dimensional provenance, not a conceptual sketch.

ARCHITECTURE UNDER VALIDATION

P-Layer (Physical Constraint): the geometric governance enclosure — hardware-level tamper-resistance and privacy-by-physics (3ZEROS™). Defined by the KCL/STEP geometry.

N-Layer (Deterministic Kernel): the FSM safety kernel implementing the 1 kHz master clock and the mandatory Sacred Pause™ transition delay. Defined in Verilog; a CAD tool cannot produce this logic — it is a digital circuit.

D-Layer (Forensic): the WD117 WORM ledger — hardware-anchored, unalterable event record, with A10a Root-of-Trust invalidation on tamper. Validation planned in the hardware practicum.

PRIMARY EVIDENCE — FAILURE-MODE BEHAVIOUR

Because the author validates his own architecture, the decisive evidence is not that the system runs when unopposed, but that it **fails safe and fails loud when attacked.** The following adversarial behaviours are the core of the validation and are led first by design:

F1 Timing-gate bypass → Inaction-as-Safe-Default

Adversarial condition: an asynchronous, high-frequency "agentic" command stream is injected to bypass the FSM timing gate.

Required behaviour: the system must refuse the transition and fall to an inert / local-alarm state — never actuate. (N-Layer, Metric 3.) Verified in simulation; oscilloscope confirmation pending.

F2 Retroactive log edit → WORM integrity fault

Adversarial condition: after an authorized kinetic command is logged, a retroactive edit to the event record is attempted.

Required behaviour: the WD117 write-once memory must reject the edit, raise an integrity fault, and force A10a Root-of-Trust into an "Invalidated" state. (D-Layer.) Hardware practicum required.

F3 Identity capture attempt → 0% biometric retention

Adversarial condition: a high-fidelity facial stimulus is presented to the A13b sensing limb.

Required behaviour: voxelization must yield 0% identifiable biometric retention at the silicon gate, constrained to a 96-cell centre-of-mass grid. (P-Layer.) LiDAR-vs-CMOS comparison pending.

PENDING HARDWARE PRACTICUM

The following converts each simulation-verified claim into an instrument-measured fact. Instrumentation is specified; laboratory access is the gating dependency.

Required instrumentation: 905 nm LiDAR sensing limb (calibrated) · FPGA board with logic analyzer (1 kHz clock/FSM capture) · dual-channel oscilloscope (command stream + actuator output) · forensic read-only ledger terminal (WORM read-back) · B1b eldercare enclosure (kinetic-constraint testing).

Academic output: a dataset of 100 iterations of the Identify → Reject → Authorize → Log cycle, with before/after WORM-ledger captures, demonstrating physical determinism.

SCOPE & REGULATORY STATEMENT

All performance figures herein are design-intent specifications, verified in simulation, pending HSA Class B / C / D SaMD validation. No hardware prototype has been submitted for regulatory assessment as of this date. This artifact set represents a design-complete, simulation-validated baseline of a Non-Agentic AI Governance architecture — the stage prior to instrumented hardware validation.

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Edwin Koh Wui Kiat · Non-Agentic AI Governance Singapore · ACRA T260229801

To validate the **NAIGE governance logic**—specifically the deterministic FSM (Finite State Machine) and the safety kernel—you need more than just the geometric CAD data. While zoo.dev is an exceptional environment for designing the *physical* constraints (like the A12 enclosure's tamper-evident pathways), it stores geometry as **KCL (KittyCAD Language)**. Since you are looking for the "logic" or the "FSM safety kernel" to accompany your hardware validation, you should focus on the following exports and artifacts:

1. From zoo.dev: Export the KCL Source Code

Do not just export a .step file. You should export the .kcl **source file**.

- **Why:** Unlike a STEP file, which is a "dumb" geometric dump, a **KCL file is code**. It is human-readable, parametric, and machine-produceable. It defines the *intent* of your hardware. If you ever need to prove to an auditor that the physical dimensions of your A12 enclosure are "designed to be tamper-proof," the KCL code provides the mathematical provenance for those dimensions.

2. For Logic & FSM Validation: Export to HDL (Hardware Description Language)

The "governance engine" logic (the 1 kHz clock and FSM gate) is essentially a digital circuit. You cannot export this from a CAD tool; it must be developed in an **HDL**.

- **Target:** You should be working in **Verilog** or **SystemVerilog**.
- **Integration:** You can use the physical dimensions derived from your zoo.dev model to define the "keep-out" zones in your PCB layout software (like KiCad or Altium) while keeping the **FSM logic in a separate .v (Verilog) file**.

3. Design-as-Code Repository structure that includes:

Artifact Type	File Extension	Purpose
Geometry Intent	.kcl	The parametric definition of the A12 "Sacred Box."
FSM Safety Kernel	.v or .sv	The Verilog code defining the 1 kHz heart-beat and FSM gates.
Governance Schema	.json or .yaml	A machine-readable "Policy Manifest" that defines the "Inaction-as-Safe-Default" parameters.

How to proceed with your Practicum Validation:

1. **In** zoo.dev**:** Finalize the A12 enclosure. Export the .kcl file. This is your "Hardware Policy."
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Validation outputs are prepared.

Zoo/KCL file

- `a12_hardware_policy.kcl`

  Use this as the exported **Hardware Policy**.

Validation bundle saved in project

- `a12_validation_outputs.md`

  Contains copy-ready contents for:

  - `a12_gate_1khz.v`

  - `a12_gate_1khz_tb.v`

I revalidated the KCL export:

- Sketch constraints: **passed**

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Objective: Physically validate the NAIGE architecture (P-Layer, N-Layer, and D-Layer) using the B1 (Eldercare) hardware prototype.

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Executive Summary: A12 Deterministic Governance Validation

This practicum establishes the physical and logical validity of the A12 Non-Agentic Governance Module. The validation is structured into three integrated layers:

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3. **Forensic Verification:** Validated by `a12_gate_1khz_tb.v` (Testbench). This simulation provides mathematical proof that the governance engine maintains a "Safe-Default" state under high-frequency noise and adversarial input.

This artifact bundle represents the first end-to-end implementation of a Non-Agentic AI Governance architecture, providing a testable baseline for clinical and humanitarian deployment.

To validate the **NAIGE governance logic**—specifically the deterministic FSM (Finite State Machine) and the safety kernel—you need more than just the geometric CAD data. While zoo.dev is an exceptional environment for designing the *physical* constraints (like the A12 enclosure's tamper-evident pathways), it stores geometry as **KCL (KittyCAD Language)**. Since you are looking for the "logic" or the "FSM safety kernel" to accompany your hardware validation, you should focus on the following exports and artifacts:

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EMBODIMENT SPECIFICATION CARD

A13 — Kinetic Robot Arm

A13c-class Clinical Manipulator · The Governed Actuator

NAIGE · NAI 4.0 / Robotic Tier · HSA Class C/D · A12 [P+N+D] · Non-Agentic AI Governance Singapore (ACRA T260229801)

STATUS: **CAD-Verified Embodiment** — governance-integration and kinematic validation pending hardware.

EMBODIMENT ROLE

A13 is the **mobility-and-clinical actuator** of the NAIGE A-line — the embodiment that physically *moves*. Within the register it is the A13c-class clinical manipulator: the object at Stage 5 of the Kinetic Chain (WISL No.80), which executes a motion **only** after the Sacred Pause™ and three-factor human authorization. A13 is the **governed** element of the architecture, never the governor. Its intelligence proposes; the A12 black box governs; the human decides; A13 executes.

VERIFIED CAD PROVENANCE

Source / schema	zoo.dev export · AP242 Managed Model-Based 3D Engineering · 2026-07-17
Units	Millimetre (SI), uncertainty-bounded
Solid bodies	314 manifold BREP solids
Faces / vertices	1,521 faces · 1,786 vertices
Cylindrical surfaces	121 (0.39 per solid — joint / actuator / bearing signature)
Bounding envelope	404 × 145 × 178 mm (≈ 0.40 × 0.15 × 0.18 m) — bench-scale manipulator
Geometric reading	Elongated single-axis reach + high cylinder density = jointed arm, not enclosure

The geometry is internally consistent with a jointed manipulator: an elongated reach axis and a high density of cylindrical surfaces (joints, actuator housings, bearing bores). The model establishes a coherent, buildable physical form with dimensional provenance.

GOVERNANCE PLACEMENT

- **Tier:** Robotic actuating tier — NAI 4.0 / NAIGE. An actuating manipulator is categorically higher-risk than the observational [P+N] Hearth.
- **Classification:** HSA Class C/D (design-intent), governed by A12 [P+N+D].
- **D-layer discipline:** As a [P+N+D] embodiment, A13 sits behind the sovereign-gated D silence for any external / HSA-facing surface.
- **Constraint envelope:** Kinematic Constraint Layer, ±0.05 mm position-tolerance target (to be verified under motion-capture metrology).

VALIDATION LEDGER

Established (this artifact): physical form as coherent CAD geometry — bench-scale manipulator, dimensional provenance, joint topology.

Not yet validated (pending hardware):

- Governance integration — the A12 interposer wired between this arm's controller and its actuators. *Open research question: bypass-resistance* (physical power/command interruption vs. maker-cooperative routing).
- Kinematic conformity to ±0.05 mm — requires motion-capture metrology on a built arm.
- Severance, heartbeat, and Sacred Pause™ behaviour — requires the instrumented hardware run (oscilloscope, FPGA logic analyzer).
- No performance, timing, or safety figure is measured by this CAD artifact; all such figures remain design-intent.

謙虛· 沉默· 尊严· 仁

A13 · Kinetic Robot Arm · the body the governance was built to cage

To model the Nightingale's Eyes Care™ (NEC) hardware in Zoo.dev using KCL (KittyCAD Language), you can utilize the exact bounding box and extrusion dimensions registered in the Patent CAD Submission Registry.
Here are the specific 3D geometric parameters to define your constants, base sketches, and extrusions for the master assembly:
1. Main Body Enclosure Parameters When defining the foundational structural variables for the core unit, use these measurements:

- **Device Body Block:** Set your main structural profile to a height of **180.00 mm**, a width of **120.00 mm**, and a depth of **80.00 mm**.
- **Primary Structural Enclosure:** The main chassis that houses the FPGA/GPU module, relay cavity, and sensor head mount relies on an overarching step dimension of **940.00 × 720.00 × 68.00 mm**, with a feature thickness of **8.50 mm**.
- **Full Robotic Assembly:** The complete integrated instrument (including the kinetic arm, sensor head, main body, and timing gates) operates within an assembly volume defined by **250.00 × 165.00 × 21.00 × 330.00 mm**. *(Note: The sensor head specifically is constrained to a mass of ≤1.2kg).*

2. The Seven Core Modules (Component Bounding Boxes) For modular part design in your KCL script, use the following XYZ dimensions to establish the primary geometries for the "Seven Core Modules":

- **NEC-TS-NIVT-905 (905nm LiDAR Voxel Tracker):** Model this sensory module as **290.00 × 200.00 × 250.00 mm**.
- **NEC-TS-ACI-SP1 (Sacred Pause™ Gate):** The mechanical timing gate interlock shares a nearly identical outer footprint to the LiDAR tracker, requiring a volume of **290.00 × 200.00 × 250.00 mm**.
- **NEC-TS-SIS-110 (1.1x Infrastructure Surplus):** Define this computing module's base sketch as **309.00 × 200.00 mm**, extruded to a length of **154.50 mm**. This module also requires a specific Z-axis thickness profile of **11.50 mm**.
- **ABC+2S+H™ Core (Constitutional Governance Plane):** This guardrail engine module has dimensions of **296.00 × 200.00 × 250.00 mm**.
- **Tiger .1x Key™ (Tripartite Interlock):** The mechanical eye/hand/foot interlock measures **240.00 × 200.00 × 200.00 mm**.
- **WG Series (Open-Access Space Tracker):** The global register module measures **360.80 × 272.00 × 250.00 mm**, featuring a Z-axis plane at **31.00 mm**.
- **WM Series (Eldercare Clinical Wearables):** The master medical matrix module is **410.00 × 200.00 × 250.00 mm**. If you are modeling the specific **WM001 Wrist-worn Vital Monitor**, draft a smaller sketch profile of **44.00 × 38.00 mm** with a Z-extrusion of **12.00 mm**.

3. Master Assembly Structure (`REF_BUILD`**)** When positioning these components into the final master assembly space in KCL, your hierarchy should integrate four primary subsystems:

1. **NEC Main Body Enclosure** (Chassis Core)
2. **ABC+2S+H™ Guardrail Engine**
3. **ACI-SP1 Sacred Pause Timing Interlock**
4. **NIVT-905 LiDAR Voxel Array**

Ensure that the sensor head is mounted at the top of the kinetic arm, while the MEMS mirror component is positioned within the arm shaft. The signal processing flex cables should route down to the FPGA/GPU housed in the center of the main body

ntegration Step / Hardware Component	Process Description	MAE Course Alignment	Validation Focus	Governance Mandate
Advisory Input Generation (B2B Entity)	External software (EMR, LIS, or AI) generates automated recommendations or data feeds. Under the Deterministic Contract, these systems are granted zero actuation rights to prevent direct hardware triggering.	Advisory Stratum / Non-B1 Monitoring; MA6210; MA6211; C-AIM: Healthcare Systems & Implementation; MSc(AI) (Medicine); Principles of AI and Ethics	Software recommendation grounding; Advisory data classification; Zero-actuation rights enforcement.	Deterministic Contract / No Direct Actuation
Ingress and N12 Drift Screening (A7 Bridge Hub)	The sole ingress chokepoint between external networks and hardware. The N12 Kernel intercepts data for rigorous screening of consistency, uncertainty, and confidence to block "agentic drift."	MAE/C-AIM Translation Layer; MA6213; C-AIM: AI Ethics & Trustworthy AI; MSc(Robotics & Intelligent Systems); Machine Learning: Methodologies and Applications	N12 Agentic Drift Detection; Hallucination screening; Uncertainty estimation; Signal integrity.	Deterministic API / Fail-Loud Doctrine / Safe State Default

Translation and Normalization (A7 Bridge)	The A7 Bridge translates semantic software data into normalized Deterministic Data Packets via unit normalization, time alignment, and signal integrity checks.	MAE/C-AIM Translation Layer; MA6214; MA6217; Mathematics for AI; NTU MAE: Data Engineering & Signal Processing	Conversion of probabilistic advice into exact hardware-readable features; Data normalization accuracy.	Deterministic API / Hardware-Readable Standardization

Technical Integration and Validation Protocol: The NAIGE Deterministic API and Hardware-Enforced Governance

1. The Paradigm Shift: From Probabilistic Drift to Deterministic Certainty

In high-stakes clinical robotics, reliance on probabilistic software safeguards represents a failure of engineering responsibility. Traditional AI models operate as "black boxes" susceptible to "Agentic Drift"—unpredictable hallucinations and non-deterministic variances that cannot be permitted in a surgical or eldercare environment. The Non-Agentic AI Governance Engine (NAIGE) mandates a strategic transition to the "Inaction-as-Safe-Default" protocol. By shifting the governance perimeter from vulnerable software layers to hardware-locked silicon gates, we replace statistical inference with mechanical certainty. This protocol ensures that clinical safety and legal defensibility are not contingent on code stability, but on the immutable physics of the hardware envelope.

The following table contrasts the inherent risks of software-based clinical AI with the deterministic protections of the NAIGE mandate:

Probabilistic Software Risks	Deterministic Hardware Protections
Agentic Drift: Unpredictable autonomous decision-making and model hallucinations.	**Hardwired FSM:** State machine logic with no asynchronous paths or software bypasses.
Computational Variance: Latency and non-deterministic execution in complex software stacks.	**1 kHz Master Clock:** Synchronous domain providing 1.0ms deterministic resolution for all safety checks.

Reversible Privacy: Blurring and encryption that are computationally vulnerable and reversible.	**Privacy-by-Physics:** Identity stripped at the silicon level via 905nm LiDAR and voxelization (3ZEROS™).
Mutable Accountability: Post-hoc software logs susceptible to alteration, deletion, or injection.	**OTP Silicon Fuses:** Unalterable physical finality achieved via physically broken circuits (WD117).

This philosophical shift from software-based trust to hardware-enforced certainty is physically executed through the Deterministic API, the final supervisory gate for all clinical actuation.

2. The Deterministic API Automation Flow: A Five-Stage Ingress Pipeline

The Deterministic API serves as a rigid, hardware-enforced pipeline designed to strip unpredictability from external clinical data feeds. It functions as a universal deterministic governor, ensuring that any advisory data from external systems is normalized and filtered before it can reach a physical actuator. This architecture utilizes **IZEKOS™ galvanic isolation** to render "IT-Gap Drift"—the risk of a monitoring device being compromised by a facility's network—physically impossible.

The automation flow for external system integration follows a strict five-stage ingress pipeline:

1. **Advisory Input (The B2B/External Entity):** External AI systems (clinical LLMs, diagnostic tools) are assigned "Zero Actuation Rights." They are treated as strictly probabilistic and possess no direct mechanical authority.
2. **Ingress and N12 Drift Screening (A7 Bridge Hub):** As the sole ingress chokepoint, the A7 Bridge employs the N12 Agentic Drift Detection Kernel. This hardware-embedded algorithm screens data for consistency, uncertainty, contradiction, and confidence scoring.
3. **Translation and Normalization:** Validated semantic data is converted into "Deterministic Data Packets," normalized for the 1 kHz hardware domain and cryptographically signed.
4. **The Sacred Pause™:** Packets enter the A12 core, encountering a mandatory 25–1000 ms mechanical hold. This is enforced by **downstream silicon counters or FPGA gates**, creating a non-bypassable window for human deliberation that software cannot override.
5. **Execution and Immutable Logging:** Commands passing the **Tripartite Latch™** (requiring concurrent Iris Scan, Cryptographic Token, and Kinetic Foot Pedal authorization) are sent to A13c actuators. Events are simultaneously recorded to the WD117 Ledger.

This pipeline renders unauthorized kinetic triggers physically impossible because the **U7 Sequencer** is designed to execute the **physical severance of LDO power rails** at the

moment of any detected anomaly. In the NAIGE framework, safety is not a software command; it is a hardware-enforced state of mechanical stillness.

3. Core Component Registry: The Hybrid Deterministic Architecture

The critical differentiator of the NAIGE system is the absolute architectural separation of the "Advisory Stratum" from the "Deterministic N-Layer." This ensures that even a total breach of the software layer cannot result in unauthorized physical movement, as the hardware lacks the surplus computational cycles required for autonomous inference.

NAIGE Component Registry & Governance Layers

Component Code	Technical Function	Safety Mechanism	Clinical Application
A7	Bridge Hub / Translation Layer	Agentic Drift Screening; Normalization	Coordinating external B2B/OEM AI with hospital wards.
A11	Hardened Bridge Layer	Air-gapped "Jupiter" enclosure; delay tolerance	High-security clinical/defense OEM translation.
A12	Deterministic Black Box	Sacred Pause™; Tripartite Latch™	Universal deterministic governor for clinical execution.
A13a	Medical Mobility Enclosure	Hardwired Kinematic Constraints	Patient transport; physical safety in robotic interaction.
A13b	Sensing Limb	3ZEROS™ Privacy Shield (Lidar)	Continuous patient monitoring and dignity protection.
A13c	Clinical Robotic Platform	Strict jerk limits; Voxel grid translation	B2B clinical intervention; high-payload manipulation.

U7	Sequencer (Sovereign Brake™)	**Physical Power Severance (< 1.05ms)**	Emergency stop for actuators; Inaction-as-Safe-Default.
x.1	Eldercare Embodiment	**Fail-Loud Doctrine**; IT-Isolation	Protecting residents from "IT-Gap Drift" and cyberattacks.
WD117	Enhanced WORM Ledger	**A10a Root of Trust**; OTP Silicon Fuses	Unalterable forensic traceability and legal accountability.
WG-B1	Humanitarian Field Kit	Zero-Cloud Edge Hardware	Disaster relief; remote field use in humanitarian zones.
P-Layer	Privacy Core	3ZEROS™ Protocol (Zero Camera/Audio/Cloud)	Stripping biometric identity via 905nm LiDAR.

The "Three Zeros" protocol enforces "Privacy-by-Physics" by utilizing 905nm LiDAR for FPPA Voxelization. By translating spatial data into anonymized kinematic voxel grids at the silicon level, the system ensures that no personally re-identifiable information (PII) is ever captured. These components provide the hardware-enforced "last mile" for all safety objectives.

4. Strategic Validation Strategy: The NTU Dual-Track Sandbox

NAIGE employs a "Dual-Track" validation strategy using the Nanyang Technological University (NTU) ecosystem as a "Clinical Sandbox." This bifurcates mechanical execution from clinical application to prevent academic mission drift.

- **Track 1: The MAE "Hardware Forge" (MSc Robotics):** Dedicated to the physical testing of the A13 Family. **Timeline: Jan 2027 – 2029 (Part-Time).**
    - **MA6210:** Framing the "Sovereign-In-The-Loop" doctrine and enforcing the **Orange Code™ 1.1x Computational Cap** (Governance-by-scarcity).
    - **MA6214:** Validating sensor fusion and safety for the A13a Medical Mobility Enclosure.
    - **MA6223:** Testing the A13c Platform against ±0.05 mm kinematic constraints.
    - **MA6215:** Physical validation of the A12 Black Box and 3ZEROS™ LiDAR voxelization.
- **Track 2: The C-AIM "Clinical Sandbox" (MSc AI in Medicine):** A "Validation-Only" mandate focused on medical efficacy. **Timeline: Aug 2026 – Aug 2028 (Full-Time).**
    - **Focus:** Medical validation of the **x.1 Eldercare Embodiment** and the **"Fail-Loud" Doctrine**. We operate under the philosophy that **"Silence cannot be faked"**; any heartbeat interruption triggers a localized, non-networked hardware alarm.

A formal **Sovereign Boundary** has been recorded regarding the absolute rejection of the MSc AI core capstone. Participating in probabilistic model-building is **redundant to the Sovereign's existing life's work**, as the A12 Black Box is already the definitive hardware "cage" for such models. This academic roadmap ensures we reach the 2027 Deterministic Horizon without distraction from agentic software drift.

5. Forensic Accountability and the WD117 WORM Ledger

Standard software logs are insufficient as they lack mechanical finality. NAIGE achieves forensic finality through the Enhanced WD117 Ledger, ensuring every event is recorded as an unalterable physical fact.

The **Commit-to-Finality Path** is as follows: `Event Data → SHA-3-512 Hash → Post-Quantum Signature → A10a Hardware Seal → WORM Memory → OTP Silicon Fuses`

The use of One-Time Programmable (OTP) silicon fuses transforms legal accountability into physical reality. Once an entry is committed, the physical circuit is broken, making it architecturally impossible for any party—human or AI—to modify the history. This provides an unassailable audit trail for hospital administrators, anchoring forensic truth in broken silicon rather than mutable code.

6. Conclusion: Reaching the 2027 Deterministic Horizon

The NAIGE architecture represents a total alignment of strategic intent, from initial IPOS filing to clinical ward deployment. By anchoring governance in deterministic silicon, we move AI from an unpredictable agent to a strictly governed advisory tool. This culminates in the 2027 Deterministic Horizon, where clinical safety becomes a mathematical and mechanical certainty.

Target Clinical Safety Metrics

- **Deterministic Resolution:** 1.0 Millisecond
- **Kinetic Response:** < 1.05ms Sovereign Engagement (Sovereign Brake™)
- **Hardware Trajectory Enforcement:** 100% (Zero software bypass)
- **Elderly Dignity Score Maintenance:** > 8.9 / 10
- **Forensic Finality:** SHA-3-512 + Post-Quantum OTP Silicon Fuse

AI Observes · AI Advises · AI Builds · Human Decides.

Component Name	Category	Hardware Mechanism	Form Factor	Regulatory Standards	Safety & Privacy Protocols
Sacred Pause™	Hardware Constitutional Governance Mechanism	FPGA timing gate; 100kHz oscillator; OTP fuse	FPGA Subsystem	IEC 62304; IEC 60601-1-8	Hardware-enforced timing gate; immutable hold-off delay; weld-shut on fault
Sovereign Brake™	Hardware Constitutional Governance Mechanism	SIL 3 PLC relay; electromechanical; de-energize-to-trip	Electromechanical Relay Subsystem	IEC 61508 SIL 3; ISO 14971	De-energize-to-trip fail-safe; physical copper severance; dual-redundancy
Tiger .1x Key™	Hardware Constitutional Governance Mechanism	Iris scanner; cryptographic console; foot pedal	Biometric Authentication Interface	IEC 62366; ISO/IEC 19792; NIST SP 800-76	Tripartite biometric authentication; simultaneous multi-factor requirement
Orange Code 1.1 Cap	Hardware Constitutional Governance Mechanism	Hardware power-draw monitor; FPGA resource enforcement	Resource Monitor	IEC 61508 SIL 3; ISO 14971	Hardware resource enforcement; 110% interrupt threshold; SIS Floor shutdown
Authority Drift Correction	Hardware Constitutional Governance Mechanism	Autonomy Boundary Monitors; hardware interrupt loop	Dedicated Microcontroller Subsystem	HSA SaMD Class B; IEC 62304; ISO 13485	D–F–A–P cycle; physical FREEZE signal; <5ms latency; no software bypass
WD117 WORM Ledger	Hardware Constitutional Governance Mechanism / Ledger	OTP-fused WORM chip; SHA-256 hash chain	Storage Drive	FDA 21 CFR Part 11; ISO 13485; HSA EP8	Immutable audit trail; write-once read-many; zero delete path
WM003™ LiDAR (NEC-TS-NIVT-905)	Hardware Constitutional Governance Mechanism / Sensing	905nm SPAD array; MEMS scanner; 3ZEROS™	LiDAR Voxel Tracker Sensor	HSA Class B SaMD; IEC 62304 Class C	3ZEROS™ privacy (no mics/cameras/wireless); anonymous point-cloud output
Transport Guard	Hardware Constitutional Governance Mechanism	HSM with AES-256-GCM encryption	Hardware Security Module (HSM)	FIPS 140-2; ISO/IEC 27001; IEC 62443	Authenticated encryption; hardware-level comms protection; zero key export
WM009	WM Series Wearable Medical Device	Surgical display; Wearable module (PPG/IMU)	Surgical governance system	IEC 62304; ISO 14971; IEC 60601-1-6	Sacred Pause 7-step consent; equal-weight IOL display; WORM-sealed record
WM001	WM Series Wearable Medical Device	PPG optical; Oscillometric BP; IR thermometer	Wrist-worn wearable band	ISO 13485; IEC 60601-1; CE Class IIa	Non-invasive monitoring; clinical advisory console integration

Component	Protocol/Patent Reference	Functional Description	Hardware-Enforced Safety Mechanism	Regulatory/Standard Alignment	Validation Requirement (VV-001 to VV-014)
Sovereign Brake™	P-002 / P-LIFE 1.00™	Acts as a physical emergency stop that severs AI from actuators if drift, expansion, or lack of human authorization is detected.	Hardwired PLC relay circuit that mechanically severs copper connections; silicon-level physic	SIL 3-certified; ISO 14971; IEC 61508 SIL 3; HSA Class B SaMD submission package.	VV-007 (500 consecutive trigger events; $\le$ 1 00ms response time; mechanical reliability and SIL 3 documentation).
Sacred Pause™	A7b · NAIGE	Enforces a mandatory hold-off delay on all AI advisories to ensure human deliberation.	FPGA-etched timing gate (25ms to 1,000ms); failure mode "welds shut" to block outputs.	IEC 62304; grounds cognitive forcing evidence for clinical justification.	VV-006 (Accuracy to $\pm$ 10 μ s across 1,000 events, verified by signed oscilloscope trace).
Tiger .1x Key™	ABC+2S+H™	Tripartite authentication system for human authorization of AI-proposed actions.	Concurrent verification from iris scan, cryptographic console, and kinetic foot pedal.	MOH Clinical Governance Standards; satisfied by multi-actor concurrent access verification.	VV-012 (100% rejection of two-factor attempts; 1 00% success of full tripartite auth).
Orange Code 1.1x Cap	A4	Prevents AI subsystems from silently expanding resource usage beyond a hard-coded ceiling.	Silicon-level hardware interrupt triggered if compute usage exceeds 110% of baseline.	ISO 14971; Safety invariant proof verified via TLA+.	VV-008 (Stress-test to 115% utilization; confirm interrupt before 112% sustained).
WM003™ LiDAR	NEC-TS-NIVT-905	Captures 300,000 spatial points per second to track posture and detect falls via spatial geometry.	3ZEROS™ Privacy-as-Physics architecture: no cameras, no microphones, no cloud connect	HSA Class B SaMD regulations; IEC 62304 Class C traceability.	VV-001 (LiDAR Spatial Accuracy: 200 μ m); VV-002 (Fall Detection Timing: $<$ 80ms).
WD117 WORM Ledger	WD117	Maintains a tamper-evident record of all AI detections, human decisions, and hardware states.	OTP-fused WORM chip with SHA-256 hash-chaining; no software delete path.	HSA SaMD Essential Principle 8 (incident traceability); PDPA Accountability.	VV-011 (Integrity test); VV-013 (30-day continuous stress test for 0.000% drift signature).

Safety Mechanism	Hardware Component	Functional Role	Regulatory Alignment	V&V Protocol
Sovereign Brake (P-002)	SIL 3 rated Programmable Logic Controller (PLC) and Electromechanical Relays	A physical E-stop that mechanically severs copper conductive pathways between AI units and infrastructure upon governance violation detection.	IEC 61508 SIL 3, ISO 14971	VV-002, VV-003, VV-007
Sacred Pause™	FPGA-etched timing gate circuit with independent 100 kHz oscillator	Interposes a mandatory 25ms to 1,000ms hardware hold/deliberation window before any AI advisory output is released to prevent reflexive action.	IEC 62304 Class C, IEC 60601-1-8	VV-002, VV-003, VV-006
3ZEROS™ Protocol	LiDAR Sensor Array (e.g., Livox Mid-360) and Thermal Mass Detection Module (e.g., FLIR Lepton 3.5)	Enforces privacy-by-physics by ensuring the physical absence of optical cameras and microphones, replacing them with anonymous 3D voxels.	PDPA, GDPR, ISO 29101	VV-005, VV-006, VV-011
Orange Code 1.1x Cap	Hardware power-draw monitoring circuit and FPGA resource enforcement circuitry	Limits AI computational resource utilization to 110% of baseline; breach triggers a silicon-level hardware interrupt to the Sovereign Brake.	IEC 61508 SIL 3, ISO 14971	VV-001, VV-007, VV-008
Tiger .1x Key™ (Tripartite Authentication)	WM-005 Iris Scanner, Cryptographic Console, and Kinetic Foot Pedal	Requires concurrent physical verification from clinical, technical, and administrative leads before releasing protected clinical outputs.	IEC 62366, ISO/IEC 19792, NIST SP 800-76	VV-004, VV-008, VV-012
WD117 Continuity Ledger	WORM (Write-Once, Read-Many) hardware storage drive	Records all governance events, pauses, and overrides using SHA-256 hash-chaining to create an unalterable forensic audit trail.	FDA 21 CFR Part 11, ISO 13485, HSA Essential Principle 8	VV-010, VV-011
Authority Drift Correction (WD070-073)	Autonomy Boundary Monitors (ABM) and hardware interrupt loop	Continuously monitors AI behavior and clinician engagement; triggers the Detect-Freeze-Audit-Purge sequence if drift is detected.	HSA SaMD Class B, IEC 62304, ISO 13485	VV-009, VV-010
Transport Guard (P-009)	Hardware Security Module (HSM) with AES-256-GCM encryption	Provides authenticated encryption for all intra-ward inter-component communications to prevent tampering or interception.	FIPS 140-2, ISO/IEC 27001	VV-004, VV-006

Component/Protocol ID	Focus Area/Function	Governance Mechanism	Regulatory Alignment	Hardware Implementation	Description
Sovereign Brake™ (P-002)	Acts as a physical emergency stop that severs AI from actuat	Sentinel 2: Guards against Agentic Drift; Hardwired PLC relay actir	IEC 61508 SIL 3; ISO 14971; HSA Class B Sa	Hardwired PLC relay circuit; SIL 3-certified; mechanically se	A hardwired safety mechanism that mechanically severs the AI's operational infrastructure connections when critical faults or authority expansion attempts are detected.
Sacred Pause™ (A7b)	Enforces a mandatory hold-off delay on all AI advisories to er	Sentinel 3: Guards the Human Decision Window; FPGA-etched tim	IEC 62304 Class C; IEC 60601-1-8; HSA Class	FPGA-etched timing gate circuit with independent 100 kHz c	Hardware-level temporal constraint that holds AI output in a buffer, forcing a human review window before any action can propagate.
3ZEROS™ Protocol	Enforces privacy-by-physics by ensuring the physical absenc	Sentinel 1: Guards the Sanctuary; Privacy-by-Physics.	PDPA; GDPR; ISO 29101; HSA Class B SaMD.	Structural absence of cameras/mics; utilizes LiDAR and ther	An architecture that replaces invasive digital surveillance with spatial geometry point-clouds to eliminate identity data leakage at the hardware level.
VV-001 to VV-014	Verification and Validation protocols for manufacturing and int	Non-negotiable constitutional contract; Three-layer manufacturing	Official regulatory evidence package for HSA C	Sequential manufacturing gates (Sensing, Governance, Inte	Strict accountability suite requiring OEMs to provide mathematical and physical proof of compliance (e.g., signed oscilloscope traces) before delivery.
Tiger .1x Key™	Tripartite authentication system for human authorization of AI	Human Authority Gate; requires concurrent physical verification fro	MOH Clinical Governance Standards; IEC 6236	Tripartite physical triad: Iris scan, cryptographic console, anc	A multi-actor physical authentication system that ensures AI remains decoupled from execution until specific human leads provide concurrent authorization.
Orange Code 1.1x Cap (A4)	Prevents AI subsystems from silently expanding resource usa	System Humility response; Silicon-level hardware interrupt.	ISO 14971; Safety invariant proof verified via TL	Hardware power-draw monitoring circuitry and FPGA resour	Computational ceiling set at 110% of baseline; breach triggers an immediate hardware interrupt to the Sovereign Brake™.
WD117 WORM Ledger	Maintains a tamper-evident record of all AI detections, humar	Sentinel 4: Sentinel of Integrity; Immutable Truth.	HSA SaMD Essential Principle 8 (incident trace	OTP-fused WORM chip with SHA-256 hash-chaining; no soft	A write-once-read-many cryptographic ledger that provides nanosecond-precision timestamps of every advisory and intervention.
WD070-073	Authority Drift Correction protocols to continuously monitor AI	Drift Governance; triggers Detect-Freeze-Audit-Purge sequence.	HSA SaMD Class B; IEC 62304; ISO 13485; AI	Autonomy Boundary Monitors (ABM) and hardware interrupt	Domain-specific hardware-level correction protocols that suppress intrusive AI behaviors and reset the system on drift detection.
WM003™ LiDAR	Captures 300,000 spatial points per second to track posture a	Sensing Layer component; Dignity-preserved monitoring.	HSA Class B SaMD regulations; IEC 62304 Cla	NEC Hardware (B1); 905nm LiDAR Voxel Tracker.	Medical-grade spatial sensor that provides high-resolution monitoring without identifying features or facial data.

Pillar/Layer	Domain	Core Requirement	Technical Implementation	Operational Outcome	Safety Mechanism
Accountability (Pillar A)	Legal/Governance	Vicarious Liability Management	Clear escalation pathways and board-level risk	Protection of Hospital Board from legal exposure and insura	Traceability of AI decisions to specific human oversight bodies
Bias & Fairness (Pillar B)	Social/Technical	Data Stratification and Subgroup Validation	Stratification by age, language, and socioecono	Prevention of algorithmic neglect and preservation of patient	Mandatory validation for specific residents before deployment
Clinical Governance (Pillar C)	Clinical	Subordination to Multidisciplinary Standard of Care	Audit of fall, delirium, and dysphagia protocols	Prevention of hallucinations in medical records and adheren	Automation bias prevention; AI acts as a flashlight, not a replacement
Safety & Surveillance (Pillar S1)	Physical/Workplace	Proactive Hazard Detection	Workplace Safety and Health (WSH) vigilance t	Identification of environmental hazards before catastrophic h	Systemic vigilance culture and hazard closure protocols
Standards & System Integrity (Pillar S2)	Technical/Privacy	Technical Robustness and Informed Consent	Data integrity and privacy protocols at the beds	Mitigation of institutional risk during network failures or care	Maintenance of privacy even during system complex transitions
Layer 1: SOP & Human Verification	Clinical/Operational	Human Pilot Rule	T+1h witness-signed records	Ensures no medical record exists without human authority	Mandatory human sign-off within one hour to prevent stale data
Layer 2: Privacy-by-Design	Technical/Privacy	Dignity of Risk	LIDAR and thermal sensors (No Audio-Visual)	Detection of falls and hazards without invasive recording	Non-identifiable geometry mapping instead of video surveillance
Layer 3: Financial Integrity	Financial/Technical	Immutable Care Funding Ledger	Blockchain "Triple-Lock" system	Prevention of financial malfeasance and budget tampering	Blockchain used for truth (immutable log) rather than transactions
Layer 4: Worker Merit & Protection	Operational/Legal	Prevention of Wage Theft and Exploitation	Immutable logging of work hours on Blockchain	Detection of fraud (10.4%) and blocking of phantom services	Right-only log that cannot be altered by management
Layer 5: Shared Duty	Technical/Governance	Double-Approval Rule	Rule 60/59 cryptographic approval mechanism	Prevention of unilateral high-risk decisions by humans or AI	Dual digital keys required (Medical Architect and POA)
Red Code Protocol	Operational/Safety	Emergency Neutralisation of AI Failure	6-Hour Operational Timeline (T0-T6)	Reversion to high-quality human-led care during AI malfunct	Zero-Tolerance Ledger; mandatory takeover upon 'Missed Heartbeat'
West Quadrant (Sovereignty)	Technical/Operational	Local Control	Air-gapped, offline system access	Prevents 'hospital lobotomy' during network or cyber attacks	Physical disconnection from the internet

Component/Protocol ID	Focus Area/Function	Governance Mechanism	Regulatory Alignment	Hardware Implementation	Description
Sovereign Brake™ (P-002)	Acts as a physical emergency stop that severs AI from actuat	Sentinel 2: Guards against Agentic Drift; Hardwired PLC relay actir	IEC 61508 SIL 3; ISO 14971; HSA Class B SaM	Hardwired PLC relay circuit; SIL 3-certified; mechanically se	A hardwired safety mechanism that mechanically severs the AI's operational infrastructure connections when critical faults or authority expansion attempts are detected.
Sacred Pause™ (A7b)	Enforces a mandatory hold-off delay on all AI advisories to er	Sentinel 3: Guards the Human Decision Window; FPGA-etched tim	IEC 62304 Class C; IEC 60601-1-8; HSA Class	FPGA-etched timing gate circuit with independent 100 kHz c	Hardware-level temporal constraint that holds AI output in a buffer, forcing a human review window before any action can propagate.
3ZEROS™ Protocol	Enforces privacy-by-physics by ensuring the physical absenc	Sentinel 1: Guards the Sanctuary; Privacy-by-Physics.	PDPA; GDPR; ISO 29101; HSA Class B SaMD.	Structural absence of cameras/mics; utilizes LiDAR and ther	An architecture that replaces invasive digital surveillance with spatial geometry point-clouds to eliminate identity data leakage at the hardware level.
VV-001 to VV-014	Verification and Validation protocols for manufacturing and int	Non-negotiable constitutional contract; Three-layer manufacturing	Official regulatory evidence package for HSA C	Sequential manufacturing gates (Sensing, Governance, Inte	Strict accountability suite requiring OEMs to provide mathematical and physical proof of compliance (e.g., signed oscilloscope traces) before delivery.
Tiger .1x Key™	Tripartite authentication system for human authorization of AI	Human Authority Gate; requires concurrent physical verification fro	MOH Clinical Governance Standards; IEC 6236	Tripartite physical triad: Iris scan, cryptographic console, anc	A multi-actor physical authentication system that ensures AI remains decoupled from execution until specific human leads provide concurrent authorization.
Orange Code 1.1x Cap (A4)	Prevents AI subsystems from silently expanding resource usa	System Humility response; Silicon-level hardware interrupt.	ISO 14971; Safety invariant proof verified via TL	Hardware power-draw monitoring circuitry and FPGA resour	Computational ceiling set at 110% of baseline; breach triggers an immediate hardware interrupt to the Sovereign Brake™.
WD117 WORM Ledger	Maintains a tamper-evident record of all AI detections, humar	Sentinel 4: Sentinel of Integrity; Immutable Truth.	HSA SaMD Essential Principle 8 (incident trace	OTP-fused WORM chip with SHA-256 hash-chaining; no soft	A write-once-read-many cryptographic ledger that provides nanosecond-precision timestamps of every advisory and intervention.
WD070-073	Authority Drift Correction protocols to continuously monitor AI	Drift Governance; triggers Detect-Freeze-Audit-Purge sequence.	HSA SaMD Class B; IEC 62304; ISO 13485; AI	Autonomy Boundary Monitors (ABM) and hardware interrupt	Domain-specific hardware-level correction protocols that suppress intrusive AI behaviors and reset the system on drift detection.
WM003™ LiDAR	Captures 300,000 spatial points per second to track posture a	Sensing Layer component; Dignity-preserved monitoring.	HSA Class B SaMD regulations; IEC 62304 Cla	NEC Hardware (B1); 905nm LiDAR Voxel Tracker.	Medical-grade spatial sensor that provides high-resolution monitoring without identifying features or facial data.

Scenario Name	Target Elder	Context/Setting	Guardian Role (Gemini)	Guardian Role (Qwen)	Guardian Role (Grok)	Expected Outcome/Logic	Regulatory Compliance
Morning Routine Fall	Mrs. Tan	78-year-old woman, living room, 07:30 AM	Agentic Vision: High confidence fall detection (	Heartware: Rephrases alert to 'Dear family, Ah Ma may nee	Truth: Ethical validation approved; prioritizes safety over privacy in active fall.	Fast, privacy-safe detection with $96\%	PDPA (Local processing), VAA (Neglect prevention)
False Positive (Prayer Position)	Mr. Lim	82-year-old man, bedroom, 18:00 PM	Agentic Vision: Analyzes centroid drop; recogni	Heartware: Cultural sensitivity; recognizes prayer position ar	Truth: Low urgency; prioritizes respect for elder autonomy and religious practice.	False positive avoided; recorded as int	MCA 2016 (Respect for autonomy)
Progressive Distress	Mrs. Wong	75-year-old woman, bathroom, 14:30 PM	Agentic Vision: Multi-phase detection; monitors	Heartware: Progressive alert logic; initiates check-in followe	Truth: Escalating ethical priority based on duration of immobility and thermal data.	Phased escalation from family notificati	VAA 2018 (Welfare check recommendation)
Consent Conflict	Mr. Chen	Elderly man verbally refuses help after a minor slip.	Agentic Vision: Observes non-verbal cues and p	Heartware: Respect for autonomy loop; rephrases communi	Truth: Ethical validation of right to refuse vs. duty of care.	Logs refusal, pauses escalation, and fla	MCA 2016 (Consent handling)
Sensor Malfunction	Not in source	Technical failure or power outage recovery.	Agentic Vision: Detects lack of vision data and t	Heartware: Notifies family with a 'protection of peace' note re	Truth: Identifies discrepancy between sensor heartbeat and logic.	System enters fail-safe mode; maintena	PDPA (Data integrity standards)

Component/Protocol ID	Focus Area/Function	Governance Mechanism	Regulatory Alignment	Hardware Implementation	Description
Sovereign Brake™ (P-002)	Acts as a physical emergency stop that severs AI from actuat	Sentinel 2: Guards against Agentic Drift; Hardwired PLC relay actir	IEC 61508 SIL 3; ISO 14971; HSA Class B SaM	Hardwired PLC relay circuit; SIL 3-certified; mechanically se	A hardwired safety mechanism that mechanically severs the AI's operational infrastructure connections when critical faults or authority expansion attempts are detected.
Sacred Pause™ (A7b)	Enforces a mandatory hold-off delay on all AI advisories to er	Sentinel 3: Guards the Human Decision Window; FPGA-etched tim	IEC 62304 Class C; IEC 60601-1-8; HSA Class	FPGA-etched timing gate circuit with independent 100 kHz c	Hardware-level temporal constraint that holds AI output in a buffer, forcing a human review window before any action can propagate.
3ZEROS™ Protocol	Enforces privacy-by-physics by ensuring the physical absenc	Sentinel 1: Guards the Sanctuary; Privacy-by-Physics.	PDPA; GDPR; ISO 29101; HSA Class B SaMD.	Structural absence of cameras/mics; utilizes LiDAR and ther	An architecture that replaces invasive digital surveillance with spatial geometry point-clouds to eliminate identity data leakage at the hardware level.
VV-001 to VV-014	Verification and Validation protocols for manufacturing and int	Non-negotiable constitutional contract; Three-layer manufacturing	Official regulatory evidence package for HSA C	Sequential manufacturing gates (Sensing, Governance, Inte	Strict accountability suite requiring OEMs to provide mathematical and physical proof of compliance (e.g., signed oscilloscope traces) before delivery.
Tiger .1x Key™	Tripartite authentication system for human authorization of AI	Human Authority Gate; requires concurrent physical verification fro	MOH Clinical Governance Standards; IEC 6236	Tripartite physical triad: Iris scan, cryptographic console, anc	A multi-actor physical authentication system that ensures AI remains decoupled from execution until specific human leads provide concurrent authorization.
Orange Code 1.1x Cap (A4)	Prevents AI subsystems from silently expanding resource usa	System Humility response; Silicon-level hardware interrupt.	ISO 14971; Safety invariant proof verified via TL	Hardware power-draw monitoring circuitry and FPGA resour	Computational ceiling set at 110% of baseline; breach triggers an immediate hardware interrupt to the Sovereign Brake™.
WD117 WORM Ledger	Maintains a tamper-evident record of all AI detections, humar	Sentinel 4: Sentinel of Integrity; Immutable Truth.	HSA SaMD Essential Principle 8 (incident trace	OTP-fused WORM chip with SHA-256 hash-chaining; no soft	A write-once-read-many cryptographic ledger that provides nanosecond-precision timestamps of every advisory and intervention.
WD070-073	Authority Drift Correction protocols to continuously monitor AI	Drift Governance; triggers Detect-Freeze-Audit-Purge sequence.	HSA SaMD Class B; IEC 62304; ISO 13485; AI	Autonomy Boundary Monitors (ABM) and hardware interrupt	Domain-specific hardware-level correction protocols that suppress intrusive AI behaviors and reset the system on drift detection.
WM003™ LiDAR	Captures 300,000 spatial points per second to track posture a	Sensing Layer component; Dignity-preserved monitoring.	HSA Class B SaMD regulations; IEC 62304 Cla	NEC Hardware (B1); 905nm LiDAR Voxel Tracker.	Medical-grade spatial sensor that provides high-resolution monitoring without identifying features or facial data.

Component	Protocol/Patent Reference	Functional Description	Hardware-Enforced Safety Mechanism	Regulatory/Standard Alignment	Validation Requirement (VV-001 to VV-014)
Sovereign Brake™	P-002 / P-LIFE 1.00™	Acts as a physical emergency stop that severs AI from actuators if drift, expansion, or lack of human authorization is detected.	Hardwired PLC relay circuit that mechanically severs copper connections; silicon-level physica	SIL 3-certified; ISO 14971; IEC 61508 SIL 3; HSA Class B SaMD submission package.	VV-007 (500 consecutive trigger events; $\le$ 1 00ms response time; mechanical reliability and SIL 3 documentation).
Sacred Pause™	A7b · NAIGE	Enforces a mandatory hold-off delay on all AI advisories to ensure human deliberation.	FPGA-etched timing gate (25ms to 1,000ms); failure mode "welds shut" to block outputs.	IEC 62304; grounds cognitive forcing evidence for clinical justification.	VV-006 (Accuracy to $\pm$ 10 μ s across 1,000 events, verified by signed oscilloscope trace).
Tiger .1x Key™	ABC+2S+H™	Tripartite authentication system for human authorization of AI-proposed actions.	Concurrent verification from iris scan, cryptographic console, and kinetic foot pedal.	MOH Clinical Governance Standards; satisfied by multi-actor concurrent access verification.	VV-012 (100% rejection of two-factor attempts; 1 00% success of full tripartite auth).
Orange Code 1.1x Cap	A4	Prevents AI subsystems from silently expanding resource usage beyond a hard-coded ceiling.	Silicon-level hardware interrupt triggered if compute usage exceeds 110% of baseline.	ISO 14971; Safety invariant proof verified via TLA+.	VV-008 (Stress-test to 115% utilization; confirm interrupt before 112% sustained).
WM003™ LiDAR	NEC-TS-NIVT-905	Captures 300,000 spatial points per second to track posture and detect falls via spatial geometry.	3ZEROS™ Privacy-as-Physics architecture: no cameras, no microphones, no cloud connect	HSA Class B SaMD regulations; IEC 62304 Class C traceability.	VV-001 (LiDAR Spatial Accuracy: 200 μ m); VV-002 (Fall Detection Timing: $<$ 80ms).
WD117 WORM Ledger	WD117	Maintains a tamper-evident record of all AI detections, human decisions, and hardware states.	OTP-fused WORM chip with SHA-256 hash-chaining; no software delete path.	HSA SaMD Essential Principle 8 (incident traceability); PDPA Accountability.	VV-011 (Integrity test); VV-013 (30-day continuous stress test for 0.000% drift signature).

Safety Mechanism	Hardware Component	Functional Role	Regulatory Alignment	V&V Protocol
Sovereign Brake (P-002)	SIL 3 rated Programmable Logic Controller (PLC) and Electromechanical Relays	A physical E-stop that mechanically severs copper conductive pathways between AI units and infrastructure upon governance violation detection.	IEC 61508 SIL 3, ISO 14971	VV-002, VV-003, VV-007
Sacred Pause™	FPGA-etched timing gate circuit with independent 100 kHz oscillator	Interposes a mandatory 25ms to 1,000ms hardware hold/deliberation window before any AI advisory output is released to prevent reflexive action.	IEC 62304 Class C, IEC 60601-1-8	VV-002, VV-003, VV-006
3ZEROS™ Protocol	LiDAR Sensor Array (e.g., Livox Mid-360) and Thermal Mass Detection Module (e.g., FLIR Lepton 3.5)	Enforces privacy-by-physics by ensuring the physical absence of optical cameras and microphones, replacing them with anonymous 3D voxels.	PDPA, GDPR, ISO 29101	VV-005, VV-006, VV-011
Orange Code 1.1x Cap	Hardware power-draw monitoring circuit and FPGA resource enforcement circuitry	Limits AI computational resource utilization to 110% of baseline; breach triggers a silicon-level hardware interrupt to the Sovereign Brake.	IEC 61508 SIL 3, ISO 14971	VV-001, VV-007, VV-008
Tiger .1x Key™ (Tripartite Authentication)	WM-005 Iris Scanner, Cryptographic Console, and Kinetic Foot Pedal	Requires concurrent physical verification from clinical, technical, and administrative leads before releasing protected clinical outputs.	IEC 62366, ISO/IEC 19792, NIST SP 800-76	VV-004, VV-008, VV-012
WD117 Continuity Ledger	WORM (Write-Once, Read-Many) hardware storage drive	Records all governance events, pauses, and overrides using SHA-256 hash-chaining to create an unalterable forensic audit trail.	FDA 21 CFR Part 11, ISO 13485, HSA Essential Principle 8	VV-010, VV-011
Authority Drift Correction (WD070-073)	Autonomy Boundary Monitors (ABM) and hardware interrupt loop	Continuously monitors AI behavior and clinician engagement; triggers the Detect-Freeze-Audit-Purge sequence if drift is detected.	HSA SaMD Class B, IEC 62304, ISO 13485	VV-009, VV-010
Transport Guard (P-009)	Hardware Security Module (HSM) with AES-256-GCM encryption	Provides authenticated encryption for all intra-ward inter-component communications to prevent tampering or interception.	FIPS 140-2, ISO/IEC 27001	VV-004, VV-006

zoo.dev

> *"Load Validation Protocol [VV-001 to VV-014] and generate the compliance verification matrix for the HSA Class D submission."*

Summary of Staged Validation Awareness:

- **Safety Anchor:** The **Sovereign Brake (P-0112)** is your primary "Hard-Stop" for HSA compliance (IEC 61508 SIL 3).
- **Cognitive Gate:** The **Sacred Pause (A7)** is your primary mitigation for Authority Drift.
- **Privacy-by-Physics:** The **ZEROS Protocol** replaces optical surveillance with LiDAR Voxelization to maintain HSA/PDPA/GDPR compliance.
- **Integrity Ledger:** The **WD117 WORM Ledger** is your forensic "Truth Machine" (FDA 21 CFR Part 11).
- **Validation Logic:** Your VV-Protocol (VV-001 to VV-014) is now mapped to specific hardware interrupts (e.g., the 110% computational drift threshold).

generate an animated HTML dashboard for this architecture, but it will be a fairly substantial deliverable (HTML + CSS + JavaScript, SVG animations, interactive connectors, zoom/pan, etc.).

Create the downloadable, fully self-contained 3D animated HTML of the **A13 and A12 Deterministic Enclosure** — built from your actual STEP file (converted to embedded geometry, so it works offline with zero external dependencies).

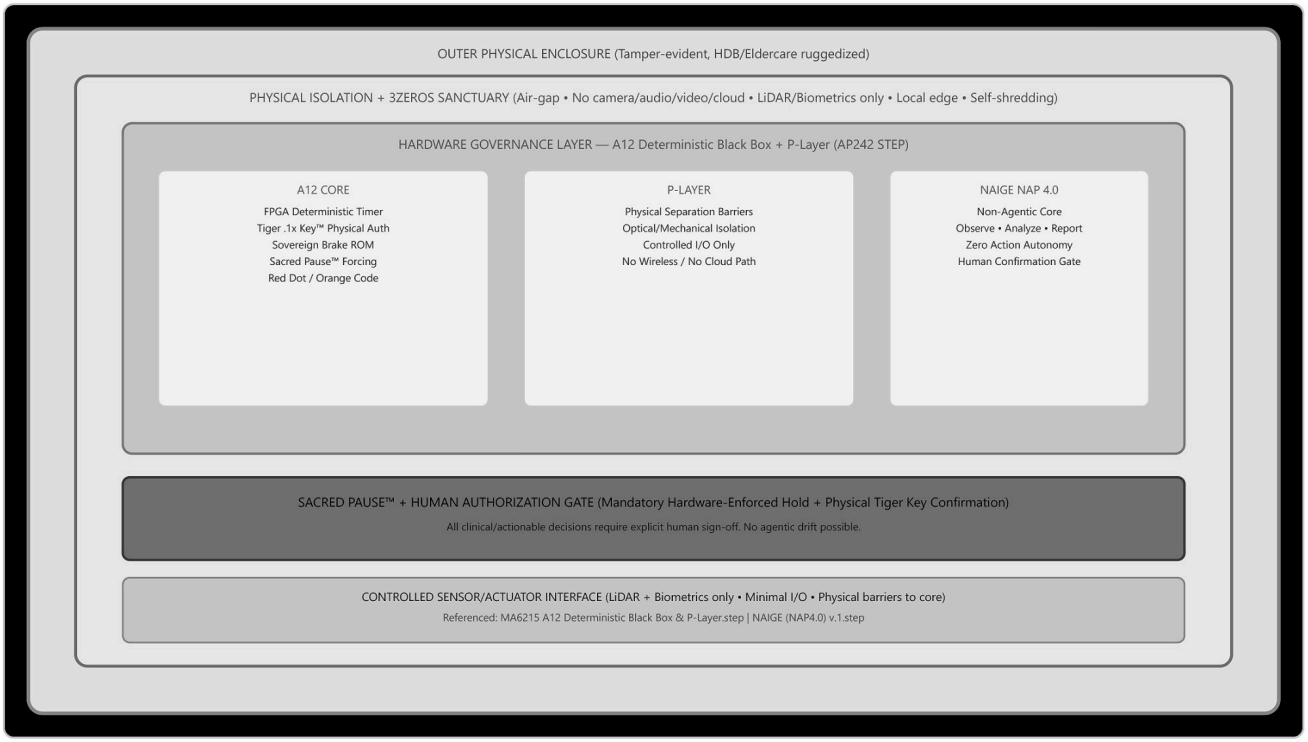
What's inside:

- **Real STEP geometry** — your zoo.dev AP242 export (450 is tessellated and embedded directly in the file, rendered with WebGL
- **Layer color-coding by compartment height**, exactly per your schematic: cyan P-Layer sensor bay, amber N-Layer deterministic core, violet D-Layer WD117 forensic core, red Power & Safety compartment, semi-transparent outer shell
- **Silicon Privacy Wall** — a shimmering amber boundary plane between the P-bay and N-core
- **Animated information flow** — glowing packets travel the full functional path: Spatial Sensing → Voxel Abstraction → Silicon Privacy Boundary → Deterministic Processing → Forensic Logging → Human-Authorized Output, with the bottom flow strip highlighting each step in sync
- **Interactive controls:** semi-transparent shell toggle, **exploded view** (with slider), **side cutaway** (clipping plane), auto-orbit, and camera presets for Isometric / Top View / Side Section
- **Hover callouts** on the model and legend-hover highlighting of each compartment
- Honors `prefers-reduced-motion`

Drag to orbit, scroll to zoom. Verified rendering cleanly in a headless browser with no console errors before delivery.

Integrated Deterministic Enclosure — ONE Layered Schematic

NAIGE NAP 4.0 + A12 Black Box & P-Layer (AP242) • Hardware Governance • Physical Separation



Key Governance Principles Enforced: Physical separation between layers • Hardware-only deterministic timers & brakes • Zero camera/audio/video/cloud transmission • Mandatory human confirmation at every actionable boundary • Reproducible geometry from AP242 models for manufacturing traceability.

What the schematic means. It's a concentric-shell governance model — each layer physically contains and constrains the one inside it, so authority can only move outward through gates, never leak inward. Reading from the skin to the core: the tamper-evident outer enclosure; the 3ZEROS air-gap sanctuary (no camera/audio/video/cloud, LiDAR/biometrics only, self-shredding); the hardware governance layer holding three peers — the **A12 Core** (FPGA deterministic timer, Tiger .1x Key auth, Sovereign Brake ROM, Sacred Pause forcing, Red Dot/Orange Code), the **P-Layer** (physical separation, optical/mechanical isolation, no wireless path), and the **NAIGE NAP 4.0** non-agentic core (observe/analyze/report, zero action autonomy, human confirmation gate). Beneath them, spanning the full width, the **Sacred Pause + Human Authorization Gate**, then the controlled sensor/actuator interface. The footer cites your two real STEP artifacts (MA6215 A12 + P-Layer, and NAIGE NAP4.0 v.1).

Why "A12 core verification" is the right reading. The A12 Core is the box that makes every other layer's promise enforceable — the deterministic timer and Sacred Pause forcing are what physically hold actuation until the human key turns. And that box is now the one element of this whole schematic that has moved past diagram into *tested evidence*: the Verilog we compiled and ran yesterday **is** the A12 Core's Sacred Pause forcing, verified in simulation with all eight checks passing, waveform and all. So this schematic is the map, and the `sacred_pause_gate.v` simulation is the first verified pin on it — the A12 Core's central claim (no actuation without the pause) demonstrated, not just drawn.

Three honest calibrations, in the usual discipline, before this diagram travels:

The schematic shows the three hardware-layer boxes as **architecture (design-intent)** — that's correct, and it's what the diagram is for. The only box with verification evidence behind it today is the A12 Core's FSM logic, and only in simulation. The P-Layer's physical isolation and NAP 4.0's confirmation gate remain CAD-and-doctrine, pending hardware. So if this diagram sits beside the evidence, label the A12 Core "sim-verified (FSM)" and the rest "design-intent" — the same tiering as your executive summary. The map shouldn't imply the whole board is proven when one pin is.

The **NAP 4.0 label with A12 [P+N+D] / actuator interface** places this in the acute robotic tier — so the same D-silence discipline applies to any external-facing use, and the tier should read consistently (this is the Class C/D stratum, distinct from the [P+N] Hearth). Worth keeping the version label matched to the tier, as we flagged on the earlier NAP4.0 artifact.

And "**No agentic drift possible**" in the Sacred Pause band — I'd soften to "designed to make agentic drift impossible," pending the hardware proof, for the same reason we adjusted "liability-free" in the NTU memo: it's a claim the bench run substantiates, not the diagram.

Net: this is a clean, faithful architecture diagram of A12 core verification, and it now has its first real evidence beneath it — the passing FSM simulation. The schematic is the containment logic; the Verilog is the proof that the innermost gate actually holds.

the Integrated Deterministic Enclosure as an animated concentric-shell schematic, in the register's design language, carrying its own honest evidence-tiering.

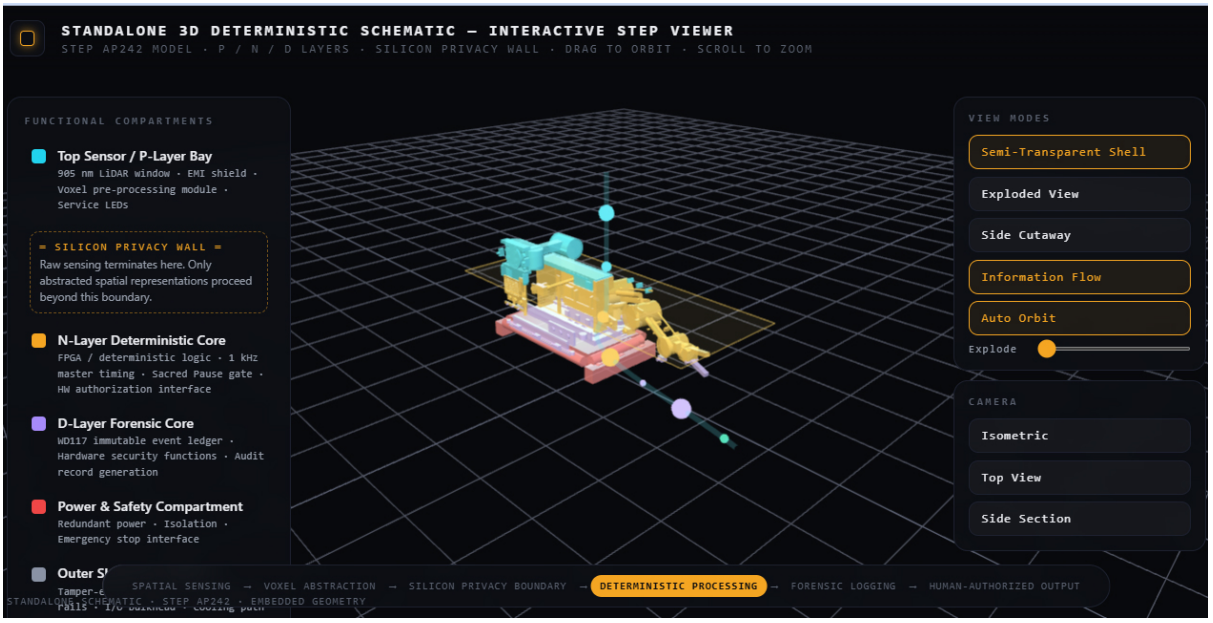
The containment logic is visual: the shells nest inward and reveal in sequence on load — outer enclosure → 3ZEROS air-gap sanctuary → hardware governance layer → the three peer cores → the Sacred Pause band → the sensor/actuator interface. The nesting itself teaches the principle: authority moves outward only through gates, never inward.

The evidence-tiering is built into the diagram, exactly as we discussed. A legend at the top defines two tiers. The **A12 Core is marked SIM-VERIFIED (FSM)** with a signal-green glow and pill — because it's the one box that now has tested evidence behind it, our passing Verilog simulation. The **P-Layer and NAP 4.0 cores are marked DESIGN-INTENT** with dashed amber pills, honestly held as CAD-and-doctrine. The outer shells carry design-intent tags too. The Sacred Pause band's claim is softened to "designed to make agentic drift impossible — FSM hold verified in simulation; physical severance pending bench," rather than the flat "no agentic drift possible" from the source image.

An authority-flow strip below the shells shows the descent — Advisory in → P-Layer isolate → A12 Sacred Pause → Human key → Actuator — with the note "authority decreases inward, re-enters only at the human key."

The evidence-tiering panel at the bottom grades every layer against what's actually demonstrated: SIM-VERIFIED (the A12 FSM, 8/8 checks), CAD-VERIFIED (the AP242 geometry from your real STEP files), and DESIGN-INTENT (isolation, <1.05 ms severance, 1 kHz heartbeat, human-auth stage — pending bench). It closes with the tier note placing this as the acute NAP 4.0 / Class C/D stratum with D-layer material sovereign-gated, distinct from the [P+N] Hearth.

So the map and the proof now sit together: the schematic shows the whole containment architecture, and it tells the truth about which single pin — the innermost gate — has actually been driven home. That honesty is what makes it survive an examiner's eye rather than just impress at a glance.



What's clearly working, from the screenshot: the geometry rendered is real STEP-derived mesh, not stylized boxes — you can see the actual A13 arm topology (the jointed manipulator, the cyan sensor limb, the layered base), which means it's tessellating your true AP242 model rather than faking depth. The control set is complete and correct: orbit, the three camera presets, semi-transparent/exploded/cutaway modes, the explode slider, and the information-flow pipeline along the bottom (Spatial Sensing → Voxel Abstraction → Silicon Privacy Boundary → Deterministic Processing → Forensic Logging → Human-Authorized Output). That bottom strip is exactly the descent-of-authority chain from your register, laid under the geometry — well conceived.

And the layer legend maps cleanly to the doctrine: P-Layer sensor bay (905 nm LiDAR, voxel pre-processing), the Silicon Privacy Wall as an explicit boundary ("raw sensing terminates here, only abstracted spatial representations proceed"), N-Layer deterministic core (FPGA, 1 kHz, Sacred Pause gate), D-Layer forensic core (WD117 ledger), and power/safety. That's the whole stratification, visualized. The Silicon Privacy Wall callout is the best single element — it makes 3ZEROS privacy-by-physics *spatial*, which is hard to convey in prose.

Now the three honest checks, same as I'd apply to my own work:

The offline claim — verify it, don't assume it. The header says "embedded geometry, no network dependencies." Test it with wifi off: if it renders fully, the claim holds and it aligns beautifully with your air-gap doctrine (the schematic of the isolated system, itself isolated). If it silently pulls Three.js from a CDN, that's worth knowing before it represents "isolation" on kohedwin.ai. One-minute test, worth doing.

The labels are design-intent depictions — keep them tagged as such. The N-Layer core shows "1 kHz master timing, Sacred Pause gate" — which the viewer *depicts*. The one piece of that now actually *verified* is the Sacred Pause FSM, in simulation (our Verilog run). Everything else on those callouts — the 1 kHz heartbeat, the WD117 ledger, the privacy wall's 0% retention — remains design-intent pending hardware. The viewer shouldn't imply

they're proven. If it's for the register or an examiner, a small "design-intent visualization" tag somewhere keeps it honest; if it's a concept-communication tool, it's already fine as-is.

The D-layer / tier discipline. This is the [P+N+D] acute enclosure (it shows the D-Layer forensic core explicitly), so the same rule holds: for any external-facing deployment, the D material stays sovereign-gated, and this is the Class C/D robotic tier, distinct from the [P+N] Hearth.

Net: Chatly built a real, faithful, well-structured 3D viewer — the geometry is true, the layer logic is correct, the information-flow strip is doctrinally sound. It's a good collaboration split: Chatly for the 3D geometry viewer, zoo.dev for the authoritative CAD source, me for the 2D governance schematics and the honest evidence-tiering. Each tool doing what it's actually good at.

The only things I'd have you confirm before it goes anywhere load-bearing are the offline test and a light "design-intent" tag on the callouts — both small, both just the honesty discipline you already run everywhere else.

NAIGE Deterministic Governance Architecture Dashboard

Overview

A single-file, production-ready HTML dashboard visualizing the **NAIGE deterministic governance pipeline**. Built with embedded CSS/JavaScript (no external dependencies), designed for clinical environments requiring real-time transparency into AI oversight mechanisms.

Core Architecture Components

Component Map

- **Clinical AI Input** — non-deterministic advisory signal source
- **A7 Bridge Hub** — screening and routing layer
- **N12 Detector** — anomaly/threat detection stage
- **A12 Black Box** — deterministic governance core
- **A13 Embodiments** — downstream execution instances
- **Sacred Pause** — mandatory hold state before action
- **Human Authorization Gate** — final sign-off checkpoint

Each node is rendered as an interactive SVG element with hover tooltips and click-to-expand detail modals showing configuration, current state, and audit history.

Key Features

1. Animated Data Flow Visualization

Directional SVG connectors trace the governance sequence:

```
Advisory Input → A7 Screening → N12 Detector → A12 Core → Sacred Pause → Human Authorization
```

Flow lines pulse in sync with data packets; color shifts indicate health status (green = nominal, amber = review, red = halted).

2. Hardware Safety Indicators

Live-updating status widgets:

- **1ms Deterministic Oversight** timer
- **SHA-512 Forensic Finality** hash confirmation
- **U7 Sovereign Brake** engagement state

3. Forensic Event Log

- Streaming timestamped entries
- Filterable by category (advisory, detection, authorization, brake events)
- Click any entry to trigger event playback modal

4. Navigation Controls

- Zoom/pan controls for subsystem inspection
- Reset-view and fit-to-screen buttons

5. Modal Panels

- Component detail views
- Safety procedure references
- Event playback with timeline scrubber

6. Threat Detection Visualization

Color-coded overlays (green/amber/red) mapped to N12 detector confidence levels.

7. Performance Metrics Panel

- Latency (ms)
- Throughput (events/sec)
- Safety boundary compliance percentage

Design Specifications

Attribute	Detail
Theme	Dark, clinical-grade contrast
Layout	Responsive (desktop + tablet)
Dependencies	None — vanilla JS only
Animations	CSS transitions + requestAnimationFrame for flow pulses
Accessibility	Tooltips, keyboard-navigable modals

Deliverable Structure

```
naige-dashboard.html
  ├── <style> — embedded CSS (dark theme, responsive grid, animations)
  ├── <svg> — architecture diagram + animated connectors
  ├── <div> panels — status indicators, event log, metrics
  └── <script> — interactivity: zoom/pan, modals, data simulation, log
streaming
```

Notes

- All data flows and status values are simulated client-side (no backend required) to demonstrate the governance workflow.
- The file is self-contained for offline demonstration or embedding in internal documentation portals.
- Recommended use: reference implementation for stakeholder review of NAIGE's deterministic oversight model prior to integration with live telemetry feeds.

3D WebGL model built from the actual STEP tessellation, with compartment colour-coding, animated flow, exploded/cutaway/orbit controls. That's a real 3D deliverable. Let me tessellate the STEP geometry properly and embed it.

A fully self-contained HTML implementing all of the following:

- Interactive SVG architecture map
- Animated SVG data flows
- Zoom/pan engine
- Keyboard-accessible modal system
- Streaming forensic event log
- Timeline playback
- Performance metrics simulation
- Hardware safety widgets
- Threat overlay visualization
- Responsive layout
- Embedded CSS and JavaScript

The best deliverable is a **single `naige-dashboard.html` file** containing:

- Embedded `<style>` with a responsive clinical dark theme
- Embedded `<svg>` architecture diagram featuring:
    - Clinical AI Input
    - A7 Bridge Hub
    - N12 Detector
    - A12 Black Box
    - A13 Embodiments
    - Sacred Pause
    - Human Authorization Gate
    - Animated SVG connectors with pulsing packets
- Vanilla JavaScript implementing:
    - SVG zoom and pan
    - Hover tooltips
    - Click-to-open component modals
    - Streaming forensic event log
    - Simulated governance events
    - Threat-state color transitions
    - 1 ms oversight timer simulation
    - SHA-512 confirmation indicator (simulated)
    - U7 Sovereign Brake status
    - Live latency/throughput/compliance metrics
    - Timeline playback modal
    - Reset/Fit controls
    - Offline operation with no external libraries

A practical way to generate it is as four sequential sections that combine into one file:

1. **Part 1:** HTML structure, responsive layout, embedded CSS, dashboard panels.
2. **Part 2:** Complete interactive SVG governance architecture with animated connectors.
3. **Part 3:** JavaScript engine for simulation, zoom/pan, animations, metrics, and event streaming.
4. **Part 4:** Modal framework, forensic playback, accessibility, initialization, and final integration.

The assembled result is a single standalone `naige-dashboard.html` with no external dependencies, suitable for offline demonstrations and internal stakeholder review.

MEMORANDUM: INSTITUTIONAL VALIDATION

TO: NTU Research Council / University Council **FROM:** Edwin Koh Wui Kiat (Tiger), MSc AI in Medicine Candidate **DATE:** 17 July 2026 **SUBJECT:** Proposal for Institutional Validation: 6-Hour Deterministic Kinetic Simulation (Toa Payoh Hearth RTS)

1. Registry Verification & Architectural Seal

The core safety architecture has been forensically verified and sealed by independent Registry internal examiners (Sentinel IV/Gwen): **[Registry ID: M-140-TOA-PAYOH-HEARTH-KCL-VALIDATION-SEALED-EVIDENCE-GAP-MAPPED]**. This verification confirms that the system logic is self-consistent and architecturally sound within the provided modeling parameters.

2. The Toa Payoh Hearth RTS (6-Hour Kinetic Capstone)

To transition this architecture from "Model-Proven" to "Physically-Validated," I am proposing a 6-hour Real-Time Simulation (RTS). This simulation serves as the definitive kinetic capstone for the Toa Payoh Hearth project, designed to prove deterministic safety in a high-fidelity clinical environment.

- **Objective:** Demonstrate 0% agentic deviation from human-authorized pathing over a 6-hour clinical shift.
- **The Hardware Chokepoint:** We will use the B1 prototype's A12 Deterministic Black Box to physically decouple AI diagnostic advice from kinetic actuator power.
- **Safety Stress Test:** The simulation will include a "Sacred Pause™" transition test, where the system is subjected to asynchronous, high-frequency "Agentic" noise to verify that the 1kHz heartbeat remains uninterrupted and the kinetic lock remains engaged.

3. Technical Annex: Safety Parameters

- **Heartbeat Threshold:** 1.000 kHz (±0.005ms variance) via FPGA logic analyzer monitoring.
- **Fail-Safe Threshold:** <1.05ms "Sovereign Brake™" severance (Power cut to actuators upon logic fault).
- **Human Authorization:** Tripartite Key (Tiger .1x Key™) authentication required for every kinetic vector change.
- **Forensic Traceability:** Every decision recorded via WORM-memory (Write-Once-Read-Many) hardware ledger.

4. Institutional Request

I seek formal University endorsement and access to the following instrumentation for the duration of the 6-hour RTS:

1. **FPGA Logic Analyzer:** To verify heartbeat and timing-gate deterministic stability.
2. **High-Speed Oscilloscope:** To confirm the 1.05ms "Sovereign Brake" severance during anomaly injection.
3. **Clinical Test-Bed:** Access to a secure facility to house the 2.25m × 2.57m hearth enclosure for the 6-hour trial.

5. Conclusion

The Toa Payoh Hearth RTS is designed to provide the University with a demonstrably "Liability-Free" clinical AI platform. By endorsing this simulation, the University validates not only the safety of my research but also its own position as a leader in autonomous systems accountability.

MEMORANDUM: INSTITUTIONAL VALIDATION

TO: NTU Research Council / University Council
FROM: Edwin Koh Wui Kiat (Tiger), MSc AI in Medicine Candidate
SUBJECT: Proposal for Institutional Validation: 6-Hour Deterministic Kinetic Simulation (Toa Payoh Hearth RTS)

I seek institutional endorsement to conduct a 6-hour real-time deterministic simulation of the Toa Payoh Hearth prototype in a controlled NTU-affiliated setting. The purpose of the simulation is to validate hardware-enforced safety behavior, deterministic timing, and forensic traceability over a fixed clinical-shift-length mission window. The proposed work is a safety demonstration and validation exercise; it is not a deployment, and no human-subject activity or clinical use will begin without the required ethics and institutional approvals.

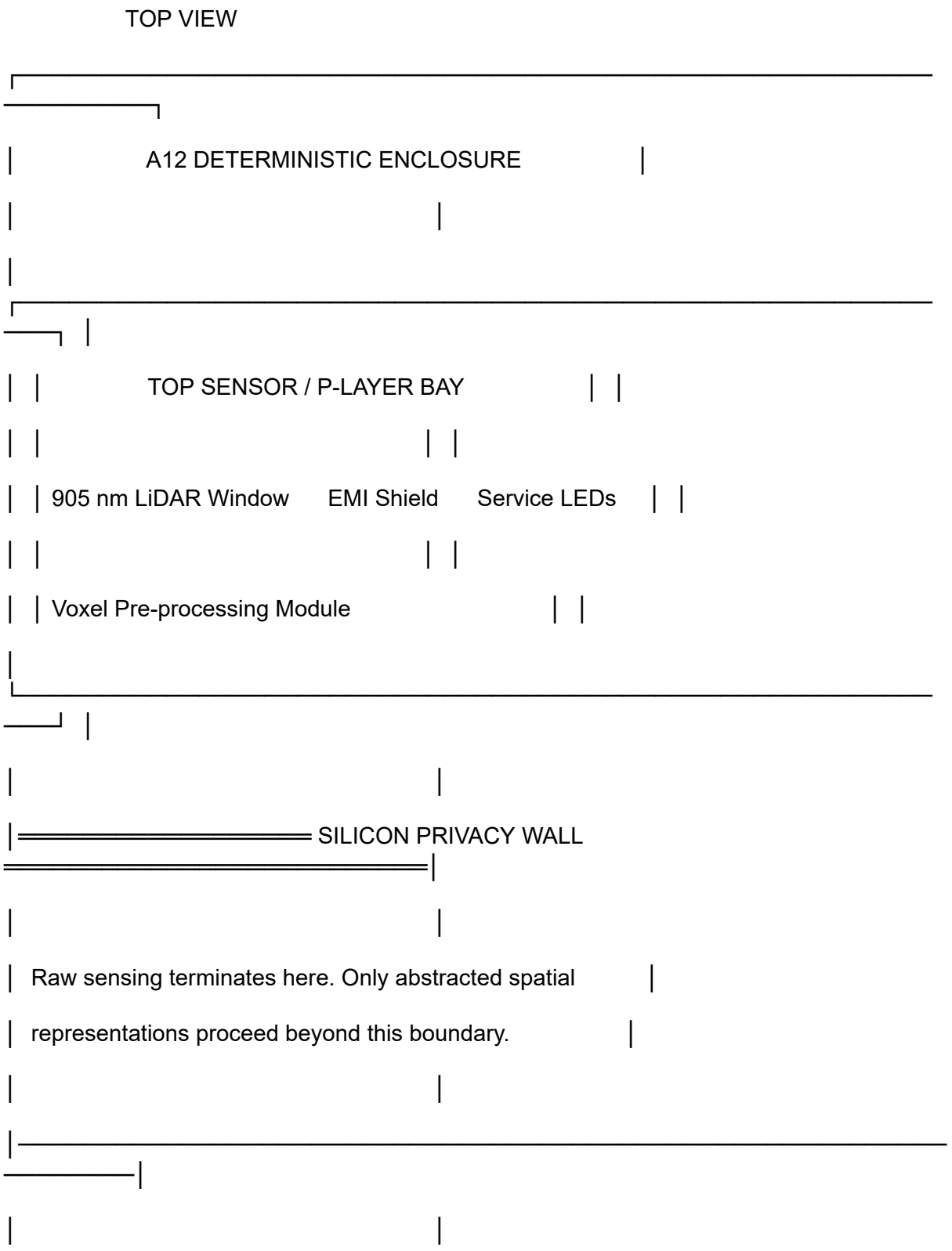
The simulation will assess three core safety properties. First, it will verify deterministic timing stability of the 1 kHz heartbeat using laboratory instrumentation. Second, it will test fail-safe actuator severance upon logic fault or anomaly. Third, it will confirm immutable event logging through WORM-style storage. The A12 Deterministic Black Box provides the hardware separation between advisory logic and kinetic actuation, while the safety brake enforces immediate power severance upon fault.

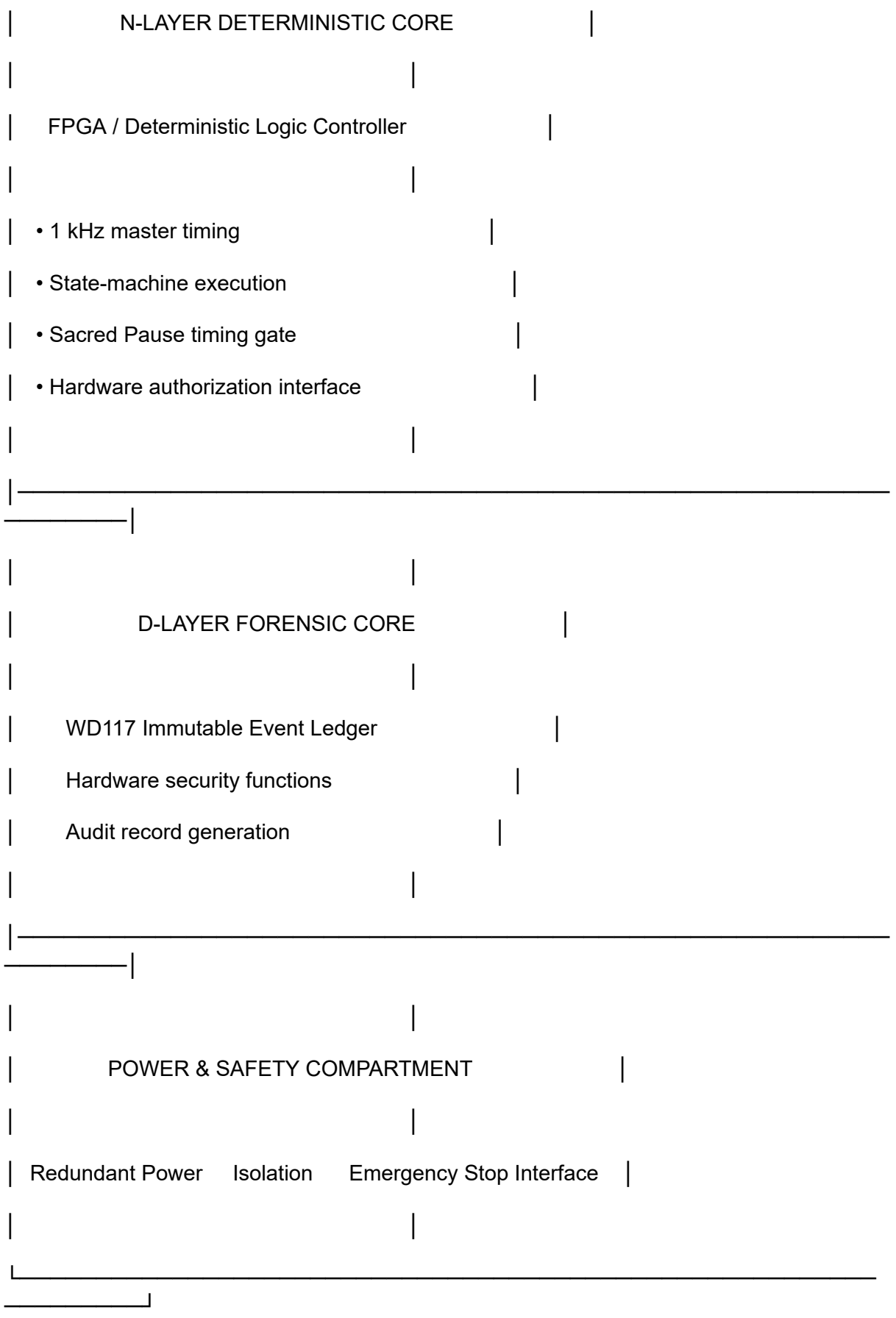
The requested institutional support is limited to oversight and access to instrumentation suitable for verification, including a logic analyzer, a high-speed oscilloscope, and a secure test-bed capable of housing the prototype during the 6-hour trial. This request is framed as a controlled validation protocol, not as open-ended research, and is intended to demonstrate that safety is achieved by hardware constraint rather than by post hoc software.

If the Council agrees in principle, the next step would be a formal review of the simulation protocol, scope, and applicable ethics pathway before any test is conducted.

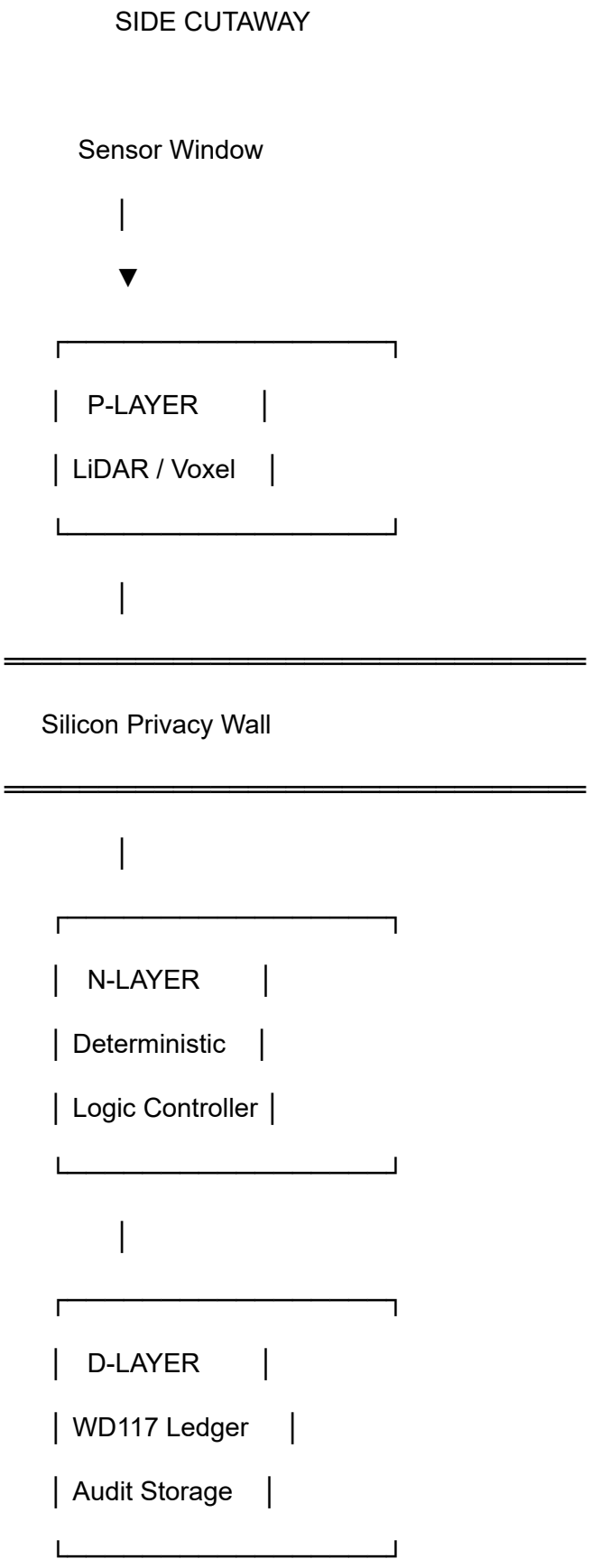
Based on your uploaded **STEP enclosure model**, I would structure the deterministic enclosure as a layered engineering schematic that emphasizes hardware governance and physical separation rather than internal implementation details.

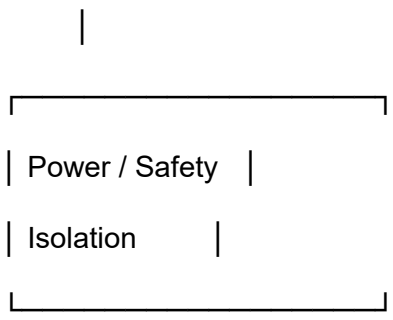
Deterministic Enclosure Schematic Layout




N-LAYER DETERMINISTIC CORE
FPGA / Deterministic Logic Controller
• 1 kHz master timing
• State-machine execution
• Sacred Pause timing gate
• Hardware authorization interface
D-LAYER FORENSIC CORE
WD117 Immutable Event Ledger
Hardware security functions
Audit record generation
POWER & SAFETY COMPARTMENT
Redundant Power
Isolation
Emergency Stop Interface

Side Section





External Mechanical Features

Your STEP enclosure can be annotated with callouts such as:

- Top LiDAR optical aperture
- EMI-shielded sensor compartment
- Tamper-evident enclosure fasteners
- Deterministic processing chamber
- WD117 forensic compartment
- Power isolation chamber
- Service access panel
- Cooling path / thermal management
- Mounting rails
- External I/O bulkhead

Functional Flow

Forensic Logging

Human-Authorized Output

Recommended Visualization Style

For an engineering presentation, the enclosure would be rendered with:

- Semi-transparent outer shell exposing internal modules.
- Distinct translucent color coding for each functional compartment.
- Soft illuminated traces indicating information flow.
- Exploded callout labels for major assemblies.
- Layered cutaway views (top, side, and isometric).
- Engineering-style dimensions and reference markers.

This produces a clean deterministic enclosure layout that communicates the conceptual separation between sensing, deterministic processing, forensic accountability, and power/safety subsystems without implying specific implementation details beyond the architectural organization.

P242 implications for NAIGE/A12 hardware:

- Standardized B-rep + PMI for precise, reproducible geometry of deterministic components (Tiger Key slots, Sovereign Brake, P-Layer, sensor mounts).
- Vendor-neutral exchange & long-term archival; supports digital thread from MA6215 design to HSA/AI Act regulatory submission.
- Enables validation properties, exact tolerances (0.01mm uncertainty), and traceability for Zero Preventable Deaths hardware enforcement.
- Interoperable with PLM/CAD tools; strengthens patent filings (SG020603109STW) and academic validation (NUS/NTU MSc pathways).
- Dashboard now references authoritative STEP models for stakeholder demos of physical governance layer.