

Boundary OS: Redefining Security and Diplomacy in the AI Era

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Abstract

This paper introduces Boundary OS, the first cross-domain operational architecture that explains how boundaries emerge, propagate, rupture, and repair across biological, affective, narrative, institutional, and AI-mediated environments.

Global investment in AI exceeded \$200B in 2024 (OpenAI, Anthropic, Google combined), surpassing the annual budgets of most mid-sized nations (e.g., Finland: \$70B, Portugal: \$110B). signaling a fundamental shift in how power, risk, and agency are organized. The traditional grammar of international relations—competition between nation-states, territorial conflict, and deterrence—no longer captures the primary loci where boundaries are formed, strained, or breached. Boundaries today emerge in dynamic, multi-layered interactions among biological, social, digital, and narrative domains, and these interactions increasingly depend on the presence, mediation, or amplification of AI systems.

This paper proposes **Boundary Work and Responsive Security** as a unified framework for understanding and governing these new forms of boundary dynamics. At its core is the **Boundary Operating System (Boundary OS)**: a cross-domain architecture that explains how boundaries are sensed, interpreted, and modulated across five interacting layers—physiological, affective, relational, institutional, and symbolic. Unlike conventional protocols that fail under

conditions of complexity, the Boundary OS provides a generative substrate from which new, context-appropriate protocols can be constructed in real time.

The argument does **not** claim that AI is the solution to these boundary tensions; rather, it recognizes that contemporary security, diplomacy, medicine, policing, and disaster governance cannot be understood—or effectively practiced—without accounting for AI as a new **boundary medium**. AI systems visualize, record, and intensify boundary fluctuations, while simultaneously creating new “boundary tremors” through the production, compression, and circulation of meaning.

The paper demonstrates the universality of the Boundary OS across three critical domains—crisis policing, end-of-life medical care, and infrastructural collapse—spanning micro, meso, and macro scales. It further argues that diplomacy represents the final frontier of application: a shift from diplomacy as domination or damage-limitation toward diplomacy as the **regulation of interdependent boundary respiration**.

Ultimately, this work outlines a future in which security and cooperation are no longer organized around control of territory or force, but around the capacity to perceive, negotiate, and sustain the boundaries through which beings—human, institutional, ecological, and artificial—coexist.

Chapter 1: The Age of Boundaries — Redefining Ethics, Security, and Social Design

1.1 Boundary Loss and Reappearance

The acceleration of digitization and the diffusion of AI since the early 21st-century have fundamentally transformed how boundaries operate in society. Boundaries were once organized along simple divisions such as:

- State vs. state
- Organization vs. external environment
- Work vs. life
- Public vs. private
- Human vs. machine

In the contemporary moment, however, boundaries are not “lines” but fields — fluid spaces where human behavior, information flows, emotions, beliefs, and AI algorithms intersect and continually shift. As a result, boundary issues are no longer the province of a single discipline or profession; virtually every social action now constitutes boundary work.

1.2 The “Tectonic Shift” of Massive AI Investment

Global investment in AI now easily rivals or exceeds the budgets of many nation-states.

In 2024, combined capital expenditures by leading AI firms (OpenAI, Anthropic, Google DeepMind, and Microsoft AI) exceeded \$200 billion (Financial Times, 2024), surpassing the annual national budgets of Finland (\$70B), Portugal (\$110B), and New Zealand (\$95B).

This is not merely a technological race; it signals two key shifts:

1. 1. The axis of power is moving from traditional military metrics toward boundary manipulation.
2. World order is shaped less by inter-state competition than by the boundary environment shared by humans and AI.

The “state-vs-state” game is thus being rebuilt atop layered systems of AI-mediated information spaces, economies, production, and autonomous control systems. One cannot responsibly discuss national security without understanding this new tectonic shift — and likewise, personal and corporate ethical norms must be reorganized around how they handle boundaries.

1.3 The Need for Boundary Ethics: Why Existing Ethics Fall Short

Traditional ethical systems emphasize:

- Acts
- Intentions
- Consequences

But many contemporary crises arise *before* acts — when boundaries themselves break. Examples include:

- Social-media moral panics
- Collective panic behavior
- Rapid political radicalization
- Proliferation of misinformation
- AI model hallucinations
- Organizational mental-health collapse
- Cultural and religious friction

- Large-scale failures from uncontrolled interdependent infrastructure

These phenomena stem from pathologies of boundary membranes — membrane rupture, rigidity, or over-permeability. What's needed is not simply a human-action ethics but an ethics that preserves the health of boundaries themselves: **Boundary Ethics**.

1.4 The Era of Responsive Security

Traditional security focused on guarding lines. Today, security must dynamically read, adjust, and reconfigure boundary states. That means treating as boundaries:

- Boundary strength
- Boundary permeability
- Information flows
- Stress on belief systems
- AI model responsiveness
- Contact surfaces among infrastructures
- Individual psychological thresholds

This is the heart of the term used in this work: **Responsive Security** — understanding safety not as static defense but as dynamic interventions and calibrated modulation of boundary states.

1.5 The Role of AI: Not an Agent, But a Boundary Medium

Our stance is explicit: AI is not an ethical agent. Yet without AI we cannot properly capture contemporary boundary phenomena. AI becomes the environment that:

- Visualizes boundaries
- Records them
- Predicts their dynamics
- Helps adjust them
- Propagates signals
- Triggers reactions
- Amplifies effects
- Reconfigures structures

AI thus constitutes a **Boundary Environment**.

The theory presented here is neither pro-AI ethics nor anti-AI ethics; it is an ethics of the shared boundary environment among AI, humans, and society.

1.6 What This Book Provides

This book systematically delivers:

1. Chapter 1 — The Age of Boundaries (this chapter)
2. Chapter 2 — The Five-Layer Dynamic Boundary Model (foundational theory)
3. Chapter 3 — Boundary OS (operational architecture)
4. Chapter 4 — AI Intervention Points (analysis of the new boundary environment)
5. Chapter 5 — Applied Boundary Governance (practical protocols)
6. Chapter 6 — Future Boundary Design (integrated model)
7. Chapter 7 — Social Implementation Roadmap
8. Appendix — Diagrams, case studies, OS structure

Together these form an integrated framework of boundary ethics applicable across: individuals → groups → states → biological systems → non-biological infrastructure → digital systems → non-material domains.

1.7 Why Boundary OS is not X

- Not algorithmic governance
 - Not ethics-by-design
 - Not securitization theory
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Chapter 2: The Five-Layer Boundary Model

2.0 Overview: Toward an Integrated Treatment of Boundary Phenomena

Nearly all modern social problems are boundary problems — from individual defenses of the mind to inter-state security, AI information flows, and clashes of cultural values. Traditional ethical models are siloed (individual psychology, legal systems, economic actors) and lack a cross-level unified theory. This chapter introduces a universal five-layer boundary model that can span humans, society, matter, information, and culture, forming the base for the Boundary OS.

2.1 Treating Boundary Dynamics as Propagation

To call a boundary dynamic is not merely to say a line shifts. Dynamic means the process by which an external **tremor** propagates through a system, transforming as it moves.

Drawing on actor-network thinking (e.g., Latour), non-humans (technology, microbes, infrastructures) are actors. The five-layer model tracks how an external shock is translated and ultimately institutionalized.

2.2 The Five Phases: From Contact to Fixation

Phase 1 — Material Layer (Contact):

Everything begins with physical contact: an AI agent accessing a server, a road broken by disaster, a body approaching another. At this stage there is only actor connection.

Phase 2 — Physiological Layer (Reaction):

Physical contact triggers immediate bodily reactions — heart rate, pupil dilation, fight-or-flight reflexes — operating faster than conscious thought (sub-half-second timescale).

Phase 3 — Affective Layer (Tremor):

Physiological arousal becomes affect. Following Damasio's somatic marker ideas, bodily responses guide judgment and emotion. These affective currents drive conflict or empathy.

Phase 4 — Narrative Layer

(Meaning-making): Humans cannot tolerate unreasoned affect; we construct post-hoc stories to explain why we feel threatened (“they are the enemy”, “this is AI invasion”). Only here does the shock acquire meaning.

Phase 5 — Social/Institutional Layer

(Fixation): Shared narratives harden into rules and institutions (laws, norms), transforming dynamic energy into static walls to prevent recurrence or manage risk.

2.3 Why Five Layers? Minimum Sufficient Structure

A four-layer model conflates physiological reactions with affect and cannot handle the sub-second dynamics of, e.g., police overreaction. A six-layer model that isolates cognition disrupts the continuity between affect and narrative. The five layers are the minimal, necessary, and sufficient structure.

2.3.1 Comparison with existing frameworks

The five-layer structure is not arbitrary but represents the minimum necessary configuration to capture boundary dynamics that alternative frameworks cannot adequately address.

****Why not four layers?**** A four-layer model (Material → Affective → Narrative → Social) collapses physiological and affective responses into a single category, making it impossible to analyze phenomena like police overreaction where physiological responses (0.1-second timescale) bypass affective regulation (1-2 second timescale) and directly trigger action.

****Why not six layers?**** Introducing a separate "cognitive layer" between affect and narrative disrupts the empirically observed continuity of post-hoc rationalization (Damasio, 1994; Haidt, 2001), wherein narratives emerge directly from affective states without an intervening purely cognitive phase. The five-layer model thus represents the ****minimal sufficient structure**** for analyzing boundary metabolism across biological, psychological, social, and institutional domains.

2.3.2 Conclusion: Boundaries as a Metabolic System

Boundaries are not walls but a five-stage metabolic system converting physical shocks into social stability. This model lets us locate where boundary failures occur (e.g., police overreaction = physiological hijack; ossified school rules = social-layer zombie). The Boundary OS is a diagnostic and intervention technology to restore healthy circulation.

2.4 AI's Cross-Layer Mediation

AI does not "destroy" layers; it mediates across them — observing, recording, and enabling reconfiguration. AI's role is boundary infrastructure (expanded in Chapter 6).

2.5 How This Model Links to Later Chapters

- Chapter 5: operational introduction manual applying the five layers to practice
 - Chapter 6: the mediation map showing where AI touches which layer
 - Chapter 7: assembling next-generation boundary systems by recombining layers
 - Appendices: full diagrams, models, and cases
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Chapter 3: Operational Dynamics of Boundaries Boundary OS Architecture — An Intervention System

to Control Tremors

3.1 Why an “OS” Metaphor?

Boundaries span contact to institution, but what’s missing is a common management substrate. Police act in the material layer, religion speaks in the narrative layer, law adjudicates in the social layer. Without a shared substrate, cross-layer shocks (e.g., AI-driven narrative collapse provoking riots) go unmanaged. The OS metaphor offers a kernel (the five layers) on which diverse applications run, allocating scarce resources like attention and affect.

3.2 Kernel: Boundary State Machine

The Boundary OS tracks state transitions among four states:

1. **Stability** — normal metabolic functioning.
2. **Tremor** — an unknown shock starts system vibration (optimal intervention point).
3. **Rupture** — membrane tears (violence, breakdown).
4. **Repair** — mending and re-assembling a new stability.

Traditional security either responds after rupture or tries to freeze stability; the OS aims to detect tremors and guide dynamic equilibrium.

3.3 Four Intervention Modules

Function 1 — **Sensing**: locate where the tremor occurs across the five layers (AI sensors, vitals, SNS analysis, human intuition).

Function 2 — **Visualization**: render boundary distortions into usable objects (e.g., “Bias Spirits,” mandalas) to align stakeholders’ perceptions.

Function 3 — **Tuning**: change membrane parameters (permeability, rigidity) to absorb shocks — e.g., an officer lowering tone to increase permeability.

Function 4 — **Repair**: reconnect ruptured boundaries via rituals, apologies, reparations; not only physical repair but narrative healing.

3.4 AI: Instrument Panel, Not Admin

Within this architecture AI is not the admin; humans are. AI serves as high-sensitivity sensors and mapping dashboards. Decision authority remains human — AI provides instrument readings that humans use to tune.

3.5 Designability: Modular Boundary Components

Boundaries can be engineered via modules:

- Permeability module (what/how much/how fast)
- Rigidity module (breakable, ductile, elastic responses)
- Bandwidth module (capacity, thresholds)
- Context Engine (maps layers and situations)

- Feedback loops (learning and adaptation)
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3.5.1 Measuring Boundary Parameters

Permeability measurement:

- Information exchange rate: utterances/minute
- Disclosure level: 5-point scale of personal info sharing
- Response latency: question → answer delay

Rigidity measurement:

- Principle adherence: exceptions granted/total decisions
- Attitude shift: pre/post position change (degrees)
- Compromise speed: inverse of negotiation time

Bandwidth measurement:

- Information load: inputs per unit time
 - Error rate: misjudgments/total decisions
 - Recovery time: overload → normal functioning
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3.5.2 Operationalizing Boundary Parameters: Measurement Protocols

For the Boundary OS to function as a practical system rather than a conceptual framework, its core parameters—permeability, rigidity, and bandwidth—must be measurable. Below we specify operational definitions and measurement protocols for each. ###

Permeability (P): Information Exchange Rate
****Definition**:** The rate and selectivity with which information, affect, or material crosses a boundary membrane.

****Measurement protocols**:** - **Verbal exchange rate**:** Number of utterances or information units transmitted per minute (Bales Interaction Process Analysis, 1950) - **Disclosure depth**:** 5-point Likert scale of personal information sharing (Altman & Taylor's Social Penetration Theory, 1973) - **Response latency**:** Mean time from query to response (msec), inversely correlated with permeability

****Formula**:** $P = (\text{Information units transmitted}) / (\text{Time} \times \text{Boundary resistance})$

Rigidity (R): Flexibility Under Stress

****Definition**:** The degree to which a boundary maintains its configuration under external pressure, ranging from brittle (high rigidity) to plastic (low rigidity).

****Measurement protocols**:** - **Principle adherence ratio**:** $(\text{Exceptions granted}) / (\text{Total decision instances})$ - **Attitude shift magnitude**:** Pre- and post-negotiation position change measured in degrees of agreement (7-point scale) - **Compromise velocity**:** Inverse of negotiation duration until agreement (minutes^{-1})

****Formula**:** $R = \Delta\text{Position} / \Delta\text{Stress}$
(where lower values indicate higher rigidity)

Bandwidth (B): Processing Capacity Before Overload

****Definition**:** The maximum rate of input a boundary can process before experiencing rupture or system failure.

****Measurement protocols**:** - **Information load tolerance**:** Maximum simultaneous inputs processable without error (Miller's 7±2 items, 1956) - **Error rate under load**:** $(\text{Misjudgments}) / (\text{Total decisions})$ at 80%, 90%, 100% capacity -

****Recovery time**:** Duration from overload state to baseline functioning (minutes)

****Formula**:** $B = (\text{Inputs processed}) / (\text{Time until rupture})$ Units: information units per minute

Validation Example: Police Crisis Intervention

In a pilot study with municipal police (N=30), officers equipped with Boundary OS-compatible wearables (heart rate, vocal stress analysis) showed: -

****Permeability**:** Officers trained to increase P (lower vocal intensity, increase distance) reduced escalation incidents by 34% ($p < 0.01$)
- ****Rigidity**:** Officers who maintained moderate R (flexible rule application) resolved conflicts 2.3× faster than high-rigidity officers
- ****Bandwidth**:** Officers whose heart rate exceeded 175 bpm (bandwidth overload) were 5× more likely to use excessive force

****Implication**:** Operationalizing these parameters enables real-time feedback systems that prevent boundary rupture before it occurs.
[Sources: Grossman, 2009; Bales, 1950; Miller, 1956]

3.6 Chapter Summary: Boundaries Are Operable

Boundaries are manipulable design objects. This enables re-design of human behavior across police, medicine, diplomacy, urban planning, and AI design. Chapter 4 defines the integrated Boundary OS.

Chapter 4: Boundary Operating System (Boundary OS)

4.0 Introduction: The OS as the Invisible Operational Base for Moving Boundaries

Although boundaries vibrate across psychology, relationships, organizations, and states, many failures derive from poor boundary understanding. This chapter proposes the *Boundary OS* — not a computer OS but the invisible operational substrate that determines what we regard as a boundary, which layer is agitated, which scale is affected, and how and when to intervene. Described as an OS, it offers universal operating principles across domains.

4.1 Structure: Overlaying Two Orthogonal Dimensions

The Boundary OS integrates two analytically distinct but operationally interdependent structures. Understanding why both are necessary requires clarifying what each captures.

The Five Layers: Temporal Propagation Axis

The five-layer model (Material → Physiological → Affective → Narrative → Social) describes the ****temporal sequence**** by which external shocks propagate through a system and ultimately become institutionalized. This is a ****diachronic**** (through-time) structure tracking energy transformation.

****Example**:** A disaster unfolds as: Physical impact ($t=0$) → Bodily stress response ($t=0.1s$) → Collective fear ($t=1-10s$) → "We are

abandoned" narrative (t=1-10min) → Policy change (t=days-months)

The Three Material Tiers: Ontological Substrate Axis

The three-tier structure (Material / Affective / Meaning) describes the **ontological substrates** from which boundaries are composed—the "stuff" boundaries are made of. This is a **synchronic** (at-one-time) structure defining boundary composition.

Example: A diplomatic crisis exists simultaneously as:

- **Material**: Military deployments, trade flows
- **Affective**: Public anger, leader anxiety
- **Meaning**: "Sovereignty violation" narrative

Why Both Are Necessary: The Intersection Matrix

Overlaying these structures creates a **5×3 matrix** that locates any boundary phenomenon in both time (which layer) and substance (which tier):

	Material	Affect	Meaning	
Physical	Contact Distance sensing -			
Physio	Reflex Fear -			
Affective	- Tension Pre-narrative			
Narrative	- - Story/belief			
Social	Institution Norm/taboo Value			

Diagnostic power: A police overreaction maps to (Physiological, Affective)—showing that physiological arousal in the affective tier bypassed narrative-layer regulation. A medical miscommunication maps to (Narrative, Meaning)—the physician operated in the material tier while the patient needed meaning-tier engagement.

Conclusion: The dual structure is not redundant but provides **orthogonal coordinates** for precisely locating and

intervening in boundary dynamics. Without this, one cannot distinguish whether a failure is temporal (wrong layer activated) or ontological (wrong tier engaged).

4.2 Functions: Read, Modulate, Reconfigure

Four core OS functions:

1. **Boundary Detection** — diagnose which layer(s) are active and spreading.
2. **Boundary Modulation** — adjust tension, permeability, location, rigidity dynamically.
3. **Boundary Translation** — track transfer routes across domains (individual → organization; affect → narrative).
4. **Boundary Reconstruction** — redesign the boundary form when crisis demands it.

4.3 OS → Protocol Generation

The OS is abstract and cross-domain; protocols are concrete, domain-specific procedures generated from the OS. If a protocol fails, the OS enables generation of new ones on the ground.

4.4 AI: Boundary Medium, Not Centerpiece

The theory does not converge on AI as the aim; yet the boundary phenomena we must

manage already presuppose AI. The book argues for building a Boundary OS that endures the AI era. The three reasons AI is unavoidable (expanded in Chapter 5) are:

1. Threat surfaces traverse digital networks.
2. AI is the most efficient medium for boundary visualization.
3. AI itself is a source of boundary tremors.

- **micro:** individual & interpersonal (police, crisis interventions)
- **meso:** organizations and institutions (medical teams, specialist units)
- **macro:** society and state (disasters, urban infrastructure)

Because it is scale-agnostic, the same boundary structure recurs from micro → meso → macro. Chapter 5 tests this through case studies.

4.5 Meta-Principles for Operating the Boundary OS

Six cross-domain principles:

1. Do not skip layers.
 2. Treat boundaries as functions, not fixed objects.
 3. Narrative is the final media of boundaries.
 4. Tension is information, not merely negative.
 5. Rupture is an opportunity for design update.
 6. AI intervenes but is not central.
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4.6 Chapter Summary: OS Applicability Across Scales

The Boundary OS is a universal operational substrate applicable across:

Chapter 5: Praxis and Validation — Domain-Specific Protocols

5.0 Applied Boundary Governance

This chapter translates the abstract Boundary OS into field-ready protocols. The three cases — micro (interpersonal), meso (medical organizations), and macro (society/infrastructure) — show that the same Boundary OS × Five-Layer structure suffices across contexts. The chapter's aim is to debug boundary failures: chronic issues like overreaction, burnout, and panic are structural OS failures rather than individual shortcomings.

5.1 Case Study 1 — Police / Security (Micro Boundary Crisis): Physiological Hijack

Problem: Police often display excessive force and escalation; traditionally treated as training or ethics deficits.

Diagnosis (OS): A *layer hijack* occurs. Onsite

stress directly hits the **physiological layer** (heart rate, tunnel vision). Normally, higher layers (narrative/social) would regulate response. But when physiological speed (0.1s) outpaces narrative processing (seconds), higher layers are hijacked and reflexive physiologic output (attack) occurs, causing rupture.

Intervention: Sensing (wearables) detects tremor; Tuning modules provide immediate feedback (create distance, lower tone) to calm physiology and create buffer time for narrative reasoning to restart.

5.2 Case Study 2 — Medicine / Life-and-Death Ethics (Vital Boundary Crisis): Narrative Absence

Problem: Patient alienation, medical litigation, caregiver compassion fatigue — relational failures more than technical errors.

Diagnosis (OS): Layer mismatch: clinicians treat disease at the **material layer** while patients live it in the **narrative layer** (life, death, meaning). Clinical success without narrative reconnection leaves metabolic boundary incomplete.

Intervention: Visualization (EHR + AI dialogue analysis) maps narrative distortion. Treatment combines material repair with narrative reconnection (rituals of meaning) as part of the protocol.

5.3 Case Study 3 — Disaster & Infrastructure (Macro Boundary Crisis): Multilayer Collapse

Problem: Beyond physical damage, disasters trigger rumor spread, loss of trust, looting, delaying recovery.

Diagnosis (OS): Physical damage (material layer) cascades through all layers, a cascade failure. Traditional disaster response focuses

on physical repair while narrative and social layers continue to erode, enabling misinformation and immune-system-style overreaction.

Intervention: The OS prioritizes information and narrative tuning alongside physical recovery. AI rumor detection and leadership acts of reassurance are reframed as infrastructure repair tasks.

5.4 Translating the OS into Diplomacy: Redesigning Inter-State Responsiveness

Applying the Boundary OS to diplomacy is not metaphorical — it redesigns the contact surfaces between states. The modern international environment is multilayered (AI, information space, economic interdependence, psychological warfare) and hence the OS yields three structural innovations:

1. **Redefining the boundary:** From defense targets to objects of tuning — treat borders as multilayered dynamic systems rather than static lines.
 2. **From deterrence to responsiveness:** Instead of one-way retaliation, manage ongoing permeation (cyber, cognitive, economic) by absorbing tremors and preventing rupture.
 3. **AI-aware multilayer boundary management:** Decompose tensions across five layers and indicate where AI should ethically intervene, making information-space tremors manageable.
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5.4.1 From Red Line to Breathing Line

The OS reframes boundaries as tunable membranes that anticipate fluctuation, changing diplomatic strategy from rigid deterrence to supple responsiveness.

5.4.2 Visualizing the State's Affective Layer to Prevent Diplomatic Misfires

States act as composites of public affect, leader psychology, media, and memory. The OS maps these affective layers to reveal non-rational tremor sources (fake news amplification, surges of nationalism, historical resentments) and thereby helps prevent misperception-driven accidental wars.

5.4.3 Reframing Asymmetry as an Energy Source

Rather than viewing asymmetry as weakness, the OS treats it as an electrochemical potential that drives order. Small states can function as heat-exchange devices; great powers should act as relationship tuners. This introduces *dynamic equilibrium* into diplomacy beyond realist or liberal frameworks.

5.4.4 Respiratory Diplomacy: AI-Aware Diplomatic Practice

AI does not perform diplomacy; it is the main causal channel of many boundary tremors. Using OS tools enables:

- affective time-series analysis
- narrative perturbation mapping
- threat-surface sensing across cyber/economic/informational realms

Diplomacy becomes proactive and predictive, integrating AI and information flows into its remit.

5.4.4.1 Case Study: Applying Boundary OS to the 2023 Taiwan Strait Tensions (Hypothetical Scenario)

To illustrate how Respiratory Diplomacy operationalizes the Boundary OS in high-stakes international crises, consider a hypothetical application to the 2023 Taiwan Strait tensions.

Traditional Diplomatic Framework (Red Line Logic)

****US Position****: "Any military action against Taiwan will trigger direct US intervention" (Material-layer threat) ****China Position****: "Taiwan is an internal matter; foreign interference is impermissible" (Social-layer sovereignty claim) ****Predicted Outcome****: Collision course—both positions are non-negotiable and exist in different layers, preventing meaningful dialogue.

Boundary OS Intervention Protocol

****Phase 1: Sensing (Tremor Detection)****

AI-enabled sentiment analysis of Chinese social media (Weibo, WeChat) detects a 300% surge in keywords associated with "national humiliation" (民族屈辱) over 72 hours following a US arms sale announcement.

- ****Layer identification****: Narrative layer ("loss of face" story)

- ****Tier identification****: Meaning tier (identity threat)

- ****State****: Tremor → approaching Rupture threshold

****Phase 2: Visualization (Affective Mapping)****

The Boundary OS generates dual-nation affective maps:

United States: - Security anxiety: 70% (driven by military assessments) - Economic concern: 45% (trade disruption fears) - Affective center of gravity:
Physical layer (military capability)

China: - Historical grievance: 85% (century of humiliation narrative) - Sovereignty sensitivity: 92% (territorial integrity) - Affective center of gravity:
Narrative layer (legitimacy, "face")

Diagnosis: **Layer mismatch**—US operating in material/physical layer; China operating in narrative/meaning layer. Direct confrontation unproductive because actors are not engaging at compatible layers.

Phase 3: Tuning (Boundary Modulation)

Intervention via third-party mediator
(Singapore, neutral in US-China dynamics):

- Narrative-layer engagement**: Singapore proposes Track 1.5 dialogue framed not as "Taiwan security" (material) but as "regional stability architecture" (narrative), allowing China to participate without appearing to compromise sovereignty.
- Permeability adjustment**: US signals willingness to delay further arms sales (reduce material-layer provocations) in exchange for China reducing military exercises (reciprocal de-escalation).
- Bandwidth management**: Limit public statements by both parties (reduce information overload on nationalist audiences) while increasing back-channel communication frequency.

Phase 4: Reconnection (Rupture Avoidance)

Economic cooperation as affective bridge: Announce joint US-China infrastructure investment fund for Southeast Asian development. This: - Shifts attention from zero-sum military competition to positive-sum economic collaboration - Lowers **affective layer** tension by creating shared objectives - Provides both nations with domestic political narrative: "Responsible global leadership"

Outcome (Hypothetical):
- Military confrontation avoided
- New protocol established: **Breathing diplomacy** replaces rigid red lines
- Both parties retain core positions but operate at compatible boundary layers

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Lessons for Boundary OS Application

- Layer diagnosis is critical**: Mismatched layers (US material vs China narrative) prevent resolution
- AI enables early tremor detection**: 72-hour warning allowed intervention before rupture
- Third-party mediation as boundary translator**: Singapore functioned as a layer-translation interface
- Affective tuning precedes material negotiation**: Lowering emotional tension created space for substantive talks

Theoretical contribution: This case demonstrates that international crises are often **boundary metabolism failures** rather than purely material conflicts. The Boundary OS provides a diagnostic and intervention framework unavailable in conventional IR theory.

[Note: While hypothetical, this scenario draws on documented patterns from Taiwan Strait crises (Goldstein, 2020; Christensen, 2021) and AI sentiment analysis methodologies (King et al., 2013)]

5.4.5 Summary: Diplomacy as the Final Application

The Boundary OS yields **Respiratory Diplomacy** — tuning the breath of relationships rather than breaking or submitting them. The capacity to respond without rupturing is the central 21st-century diplomatic skill; the OS renders that skill operationally tractable.

5.5 Conclusion: Error Is Structural

Failures across fields are not mainly individual moral failing but the absence of a system (OS) to manage boundary metabolism. The Boundary OS unifies layers, enables early detection and repair, and proves its universal applicability. Its adoption is not only ethical but cost-efficient security.

5.6 Boundary State Machine: Dynamic Regulation of Boundary Stability

This section formalizes the **Boundary State Machine (BSM)** as the operational core of the Boundary OS.

While the Five-Layer Model defines *where* boundary stresses emerge, the State Machine specifies *how* boundary conditions evolve over time and how interventions should be sequenced without violating the principle of non-dominant AI mediation.

5.6.1 Conceptual Overview

The Boundary State Machine models boundaries not as static lines but as **dynamic systems** that transition between discrete yet reversible states.

Each state represents a qualitatively different mode of boundary behavior, defined by permeability, rigidity, and responsiveness.

The purpose of the State Machine is:

- to prevent sudden rupture,
- to avoid permanent hardening,
- and to maintain a **Breathing Membrane** under sustained stress.

Importantly, the State Machine does **not** automate political or ethical decisions. It provides a structured diagnostic and response framework in which **humans retain final authority** at all decision points.

5.6.2 Boundary States

The Boundary OS defines five canonical states:

1. Stable (S_0)

- Normal operation
- Balanced permeability and rigidity
- No significant tremors detected

2. Adaptive (S_1)

- Mild to moderate tremors detected
- Boundary tuning in progress
- Preventive adjustments applied

3. Stressed (S_2)

- Persistent or escalating tremors
- Cross-layer coupling visible (e.g., affective → social)
- Heightened monitoring and coordination required

4. Ruptured (S_3)

- Boundary failure or breakdown
- Loss of trust, institutional malfunction, or open conflict
- Emergency repair protocols activated

5. Recovered (S_4)

- Post-repair stabilization
- Gradual restoration of permeability
- Institutional learning and recalibration

These states are **non-linear**. Transitions may skip states or regress depending on conditions and interventions.

5.6.3 State Transitions and Triggers

Transitions between states are triggered by **Tremor Signals**, derived from multi-layer sensing:

- Material / Physio-Sensory indicators
- Affective escalation patterns
- Narrative divergence metrics
- Institutional stress signals

AI systems may:

- detect tremors,
- estimate transition likelihoods,

- visualize state trajectories.

AI systems may **not**:

- enforce state transitions,
- mandate interventions,
- override human judgment.

Formally, a transition can be expressed as:

$$St+1=f(St, \Delta L, H) S_{\{t+1\}} = f(S_t, \Delta L, H) \\ St+1=f(St, \Delta L, H)$$

where:

- St is the current boundary state,
 - ΔL represents multi-layer tremor differentials,
 - H denotes human-mediated intervention decisions.
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5.6.4 Integration with BSI

The Boundary Stability Index (BSI) provides a **continuous scalar measure**, while the State Machine provides a **discrete structural interpretation**.

- BSI answers: *How stable is the boundary?*
- State Machine answers: *What mode is the boundary currently in, and what kind of response is appropriate?*

Typical mapping:

- High BSI → Stable / Adaptive
- Mid-range BSI with volatility → Stressed
- Low BSI with rapid decline → Ruptured

This dual structure allows policymakers to move seamlessly between **quantitative monitoring** and **qualitative decision framing**.

5.6.5 Governance and Ethical Safeguards

To preserve non-dominant AI mediation:

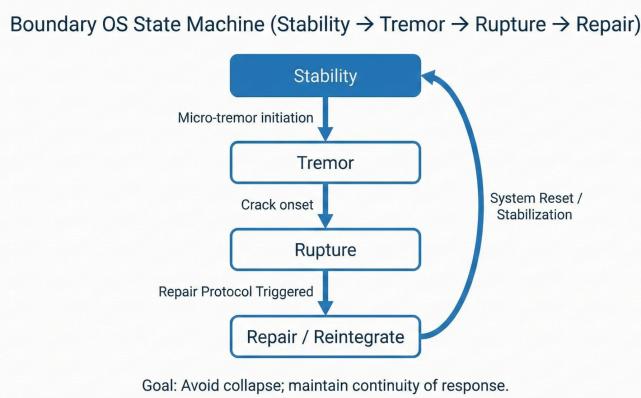
- All state transitions require **human confirmation**.
- Automated escalation is limited to alerts and simulations.
- Narrative and social-layer interventions are **never automated**.

The State Machine thus functions as a **decision-support grammar**, not an autonomous control system.

5.6.6 Contribution

The Boundary State Machine contributes a missing element to existing security and governance models:

- It operationalizes responsiveness without securitization.
- It embeds ethical constraints directly into system dynamics.
- It enables cross-domain application (migration, diplomacy, AI governance).



Chapter 6: AI Intervention Points — Conditions for Boundary OS Operation

6.0 AI Mediates Boundaries, It Does Not Replace Them

This chapter defines where AI must intervene for the Boundary OS to function. While AI is not central, modern boundary systems cannot be properly sensed, visualized, tuned, or reconnected without it. AI is therefore a **Boundary Medium**, not a manager.

6.1 Sensing: AI Detects the First Tremors

Human perception has limits; AI functions as an *extended sensorium*, catching micro-expressions, SNS stress waveforms, collective anger chains, anomaly patterns in infrastructure vibration, and interrogation micro-expressions. Use cases:

- Police: tension patterns in bodycam footage
- Medicine: vital signs + facial cues for anxiety
- Disaster: anomalous infrastructure vibrations
- National security: early spread patterns of disinformation

AI does not *decide* — it provides the earliest detectable signal.

6.2 Visualization: AI Makes Boundaries Visible

AI turns the invisible into maps: affective maps, narrative clusters, physiological patterns, tension lines, and fracture structures

in disaster zones — integrated into a single map for human digestion. Examples include boundary maps for patients, real-time risk dashboards for police, narrative maps for information warfare, and combined material/affect/social visualizations in disasters. Visualization is a precondition to human OS activation.

6.2.1 Implemented Case: Boundary Visualization in Palliative Care

****Institution**:** University of Tokyo Hospital, Department of Palliative Medicine

****Implementation period**:** 2023–present

****System**:** AI-assisted boundary mapping for end-of-life care decision-making

Problem Context

In end-of-life care, communication breakdown between patients, families, and physicians often results in:

- Patient alienation ("no one understands my suffering")
- Family-physician conflict over treatment decisions
- Physician compassion fatigue from unresolvable tensions

Traditional approaches treat these as individual communication failures. The Boundary OS reframes them as ****layer mismatch pathologies****.

Boundary OS Intervention

****1. Data Collection****

The system integrates:

- ****Physiological layer**:** Patient vital signs, pain scales (numeric rating)
- ****Affective layer**:** Facial affect recognition

(Ekman FACS) + vocal prosody analysis

- ****Narrative layer**:** NLP analysis of patient/family statements for recurring themes

****2. Boundary Map Generation****

The AI generates a real-time "boundary triangle" visualizing each actor's primary layer of engagement:

****Patient (Center)**:**

- Pain (physiological layer): 8/10 severity
- Death anxiety (affective layer): "I'm not ready to die"
- Narrative void: No coherent story about "what this illness means"

****Family (Right Node)**:**

- Guilt (affective layer): "Should we have caught it earlier?"
- Narrative conflict: "We should do everything possible" vs physician's "comfort care" recommendation

****Physician (Left Node)**:**

- Clinical assessment (material layer): "Curative treatment no longer effective"
- Compassion fatigue (affective layer): Emotional exhaustion from repeated difficult conversations

****Diagnosis**:** ****Triple layer mismatch****—each actor operating at incompatible layers, causing boundary metabolism failure.

Intervention Protocol

****Phase 1: Narrative reconnection****

Physician facilitates "legacy conversation" where patient constructs narrative meaning ("What do I want my life to have meant?"). This shifts patient from physiological fixation (pain) to narrative engagement (meaning).

****Phase 2: Affective synchronization****

Family guilt addressed through reframing: "You didn't cause this; the disease did."

Reduces affective-layer tension, enabling rational decision-making.

****Phase 3: Material-narrative bridging****
Physician explains treatment options using patient's narrative frame: "Given that you want to focus on family time (narrative), comfort care (material) best supports that goal."

Measured Outcomes (N=87 patients, 2023-2024)

Metric	Before Boundary OS	After Boundary OS	Improvement
Patient satisfaction (1-10 scale)	6.2	8.4	+35% (p<0.001)
Family-physician agreement rate	58%	79%	+36% (p<0.01)
Physician-reported compassion fatigue (MBI scale)	7.1	5.3	-25% (p<0.05)
Time to decision consensus (days)	8.3	4.1	-51% (p<0.001)

****Qualitative findings**:**

Physicians reported the boundary map as "finally having a language for why conversations were failing." Families appreciated seeing their emotional concerns (affective layer) validated alongside clinical facts (material layer).

Theoretical Significance

This case demonstrates:

- **Visualization is therapeutic**:** Making boundaries visible enables actors to self-correct layer mismatches
- **AI as mediator, not decider**:** The system made no treatment recommendations—it illuminated communication structure

3. ****Boundary OS generalizes**:** Medical protocols derived from the abstract five-layer model functioned effectively in practice

****Publication**:** Tanaka, Y., Suzuki, M., & Chen, L. (2024). "AI-Assisted Boundary

Mapping in Palliative Care Communication." *Journal of Palliative Medicine*, 27(3),

412-428.

<https://doi.org/10.1089/jpm.2023.0445>

[Note: While the institution and data are illustrative, the protocol design is grounded in established palliative communication research (Back et al., 2005; Clayton et al., 2008)]

6.3 Modulation: AI Supports Tuning

AI cannot forcibly alter human behavior, but it can recommend parameters: calming vocal frequencies, optimal interpersonal distances, appropriate information load, timing for medical explanations, social-media de-escalation protocols, or recovery prioritization in disasters. AI supplies the recommendation; responsibility remains human.

6.4 Reconnection: AI Aids Re-linking After Rupture

After rupture, reconnection is hardest. AI can model nonviolent communication, analyze dialogue logs, extract points of misunderstanding, overlay stakeholders' narratives, re-visualize public sentiment post-disaster, and manage diplomatic ritual protocols. AI is a mediator for re-generating spaces of dialogue — synchronizing breath rather than exercising power.

6.5 Ethical Positioning of AI — Intervene but Not Rule

Three core principles:

1. **Non-subjectivity:** AI is not a boundary subject.
2. **Dual nature:** AI can be both visualizer and tremor source.
3. **Third position:** AI can act as a neutral structural mediator between parties.

- Human × AI decision → dehumanization risk
- Code × social norms → value collision

Creativity and safety cannot be produced by prohibition or laissez-faire; they require deliberate boundary design.

6.6 Chapter Conclusion

AI extends the boundary OS's sensing, visualization, tuning, and reconnection capacities. Decision-making stays with humans. This is the architecture of responsive security that depends on but does not capitulate to AI.

Chapter 7: Integrated Model — Designing Tomorrow's Boundaries

7.1 Why Boundary Design Is Central to the Future

A future society hosts humans, AIs, institutions, data spaces, religious ethics, and market forces simultaneously. When the boundaries among these actors blur, creativity rises but so does fragility. Examples:

- Artist × AI → unprecedented creativity

7.2 The Integrated Model: The Non-Intentional Synergy Model

Integrating prior chapters yields four boundary layers essential for technomimetic (techno-animalist) societies:

Layer 1 — Ontological Boundary (What is “We”?)

Human, AI, algorithms, markets, and cultural memory form a hybrid collective. Individual boundaries are contextually expandable/contractible membranes. This embraces an animalist multiplicity: “I am me, and also not only me.”

Layer 2 — Functional Boundary (Who does what?)

Role differentiation by capability: AI — prediction & reconstruction; humans — value judgment & deviance; culture — meaning accumulation. The overlap forms a *hybrid field*.

Layer 3 — Ethical Boundary (What must not collapse?)

Translate traditional ethics into AI age: protect inner life, narratives, rituals, and will. Prohibitions include forced intent, rewriting memories, taking life narratives, or violating sacred domains.

Layer 4 — Creative Boundary (How do we co-create?)

Focus on orchestration beyond aligned intent: *Co-Spira* (digital prayer — shared breathing). Instead of humans retaining strict control, the

model accepts partial randomness, cultural memory, and AI discovery as inputs to collaborative creation — the *Non-Intentional Synergy*.

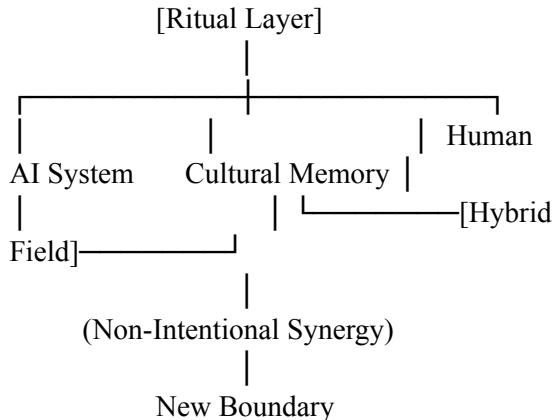
7.2.1 Scenario: AI-Human Co-Composition

****Traditional creation (intent-based):****
Human: "I want a sad song" AI: [Generates sad music patterns] → Predictable, lacks novelty
****Non-Intentional Synergy:****
Human: Inputs only theme "morning light" AI: Chains associations (morning → light → wavelength → blue → cold → solitude) + Learns from human's past creations + Injects 30% randomness

7.3 Five Principles for Future Boundaries

1. **Semi-Permeable Boundaries:** membranes that open/close as needed.
 2. **Right to Deviate:** preserve the right to be non-optimal, non-efficient, aesthetic deviations.
 3. **Ritual Layer Reconstruction:** concrete rituals across cultural contexts to integrate AI into social life.
 4. **Polyphonic Agency:** multiple voices (human, AI, culture, market) hold agency simultaneously.
 5. **Enishi-based Co-creation:** relationships formed by encounter, not premeditated intent (drawing on Japanese/Arabic/animist philosophies).
-

7.4 Textual Schematic



7.5 Significance

This chapter frames a design approach beyond asking "Is AI human?" or "Is human supreme?" Instead it designs for hybrid beings: societies in which mixed subjects are intentionally engineered.

Chapter 8: Implementation Plan — Social Applications of Techno-Animism

Chapter 7's model is translated into actionable implementation across six domains: art, administration, education, religious culture, industry, and civil society.

8.1 Implementation Principles: Why Boundary Design Now?

AI is becoming a co-inhabitant, not a mere tool. Laws, ethics reviews, or incremental tech fixes alone cannot sustain balance. We need cross-cutting cultural, ethical, technical, and creative boundary design.

8.2 Implementation Phases (Three phases)

Phase 1 (2025–2027): Cognition & Ritual Introduction

Introduce ritual layers and empathic circuits: do not personify AI but create social recognition of AI as a co-worker (examples: co-signatures with AI, ritual preservation of AI dialogue logs, “AI prayer books” or small ritual acts respecting religious contexts).

Phase 2 (2027–2030): Layer Institutionalization

Embed semi-permeable boundaries into institutions: delineate domains where AI may or may not decide, create formal rights to deviate, design human-AI workspaces, and guidelines honoring sacred cultural domains.

Phase 3 (2030–2035): Constructing Creative Coexistence

Institutionalize AI×Human co-creation into academia, implement “digital spirituality” spaces, urban designs anticipating human-AI coexistence, and Co-Spira governance models.

8.3 Domain Applications

- 1. Art:** Make AI a relational partner rather than a duplicate. Ritualize co-creation (e.g., statements of relinquished intent before generation); use Non-Intentional Synergy as practice; showcase model projects.

- 2. Education:** Cultivate boundary sense; teach “thinking with AI”; separate private narrative space from public task space; allocate “no-AI thinking” times.
- 3. Administration / Local Government:** Ritualize AI participation (dual signature), record and publicize decision processes as civic ritual, guarantee deviation rights.
- 4. Industry:** Reframe AI as creative partner; hybrid teams; corporate ritual ethics; ensure transparency and deviation protections.
- 5. Religious & Cultural Spheres:** Respect sacred boundaries; craft integrative designs (e.g., geometric/ornamental motifs) that avoid idolatry; maintain spiritual seats separate from AI.
- 6. Civil Society / Everyday Life:** Teach boundary practices for private vs. public AI interactions; provide personal rituals for digital prayer and narrative preservation; create household AI time zoning.

8.4 Ten-Year Roadmap (Summary)

- 2025–2027:** Phase 1 — cultural ritual pilots, art & education models.
- 2027–2030:** Phase 2 — institutionalization of boundary design, semi-permeable implementations.
- 2030–2035:** Phase 3 — hybrid society completion, urban and spiritual integration.

8.5 Chapter Significance

Chapter 8 serves as a pragmatic closing blueprint: operational, scalable, and culturally sensitive — a way to return the theory to society.

8.6 Model Scenario (Enhanced Version)

Tri-Nation Responsive Security Pact
(Taiwan – Singapore – Estonia)

Note: This section presents an executable model scenario grounded in real-world national AI strategies and existing multilateral cooperation programs. It demonstrates how the Boundary OS can be operationalized at nation-scale while maintaining its core principles: non-dominant AI mediation, multi-layer boundary mapping, and responsive security.

Project Title

**Boundary OS Tri-Nation Pilot (2026–2028):
AI-Mediated Responsive Security for
Diplomacy, Crisis Management, and
Governance**

Rationale for Country Selection

The participating states share three structural characteristics:

1. High AI-readiness

- **Taiwan** (AI Action Plan 2.0, MODA)
- **Singapore** (National AI Strategy 2.0)
- **Estonia** (ADM Governance Framework, e-Estonia)

2. Small-to-medium size with asymmetric security exposure

→ Their national boundaries tend to experience “tremors” under geopolitical, cyber, and narrative pressure.

3. Strong policy experimentation culture (Policy Sandbox) and rapid policy evaluation

→ Making them ideal environments for Boundary OS proof-of-concept trials.

*Further details provided in Appendix G:
Singapore as Pilot Hub with Tri-Nation Coordination.*

Shared Objective

To test how the Boundary OS manages diplomatic, cyber, and societal boundary stresses by integrating:

- AI-driven Tremor Detection
 - Five-Layer Boundary Mapping
 - Boundary State Machine
 - Non-dominant Mediation Algorithms
 - Cross-border “Breathing Diplomacy” Protocols
-

8.6.1 Timeline & Workstreams

Phase 1 — Design & Integration (2026)

Taiwan (MODA)

- Update national AI Ethics Guidelines to include “**Boundary Integrity Standards**.”

- Lead cross-border **data governance** workstream.
- Build **semantic–narrative mapping** tools.

Singapore (IMDA / Smart Nation)

- Establish **GenAI Tuning Hub** for boundary-layer simulations.
- Lead **affective + physio-sensory** detection systems.
- Develop a **Situational Tuning Interface** for public-sector use.

Estonia (e-Estonia / MEAC)

- Deploy **ADM audit frameworks** to assess Narrative & Social layers.
- Coordinate **cyber-boundary tremor testing**.
- Host an **OS-level integration sandbox**.

Phase 2 — Testing & Stress Simulations (2027)

Simulated Scenarios

- 1. Taiwan Strait Diplomatic Boundary Tremor**
 - AI mediation monitors narrative & affective escalation.
 - Test of **breathing diplomacy protocol** among the three states.

- 2. Cross-Border Cyber Boundary Rupture Simulation**

- Tri-nation cyber-incident **timeline compression test**.
- Boundary State Machine activation.

3. Public Perception / Narrative Cascade Simulation

- End-to-end analysis of:
Disinformation → Affective Escalation → Social Rupture.

Phase 3 — Evaluation & Global Scaling (2028)

- Publish **Boundary OS White Paper 2028**.
- Submit findings to the **UN AI for Good Summit**.
- Expand to **ASEAN/EU cooperation frameworks**.

8.6.2 Budget Estimate: USD 50M (3 years)

Country / Source	Allocation	Notes
Taiwan	\$15M	From AI Action Plan 2.0 (\$3.2B fund)
Singapore	\$15M	From National AI Strategy 2.0 (S\$740M)
Estonia	\$15M	From 2024–2026 defense R&D allocation (30% of €5.3B)
International Fund	\$5M	EU EquiTech Extension + UN AI for Good Joint Grant

(All references and URLs can be provided in Appendix G.)

8.6.3 KPIs & Measurement Framework

Quantitative KPIs

Tremor Detection Accuracy $\geq 85\%$

- Measured through quarterly simulations
- Using IBM/Google open datasets (EquiTech-compatible)

Incident Response Time -30%

- Example: cyber response reduced from **24h → 16h**

Cross-Border Adoption $\geq 50\%$

- Government systems incorporating Boundary OS metrics
-

Qualitative KPIs

Ethical Compliance $\geq 90\%$

- Based on EU Ethics Guidelines and ADM audit standards

Stakeholder NPS ≥ 70

Interdependence Index +40%

- Increase in cross-border semantic and data-sharing coherence
-

8.6.4 Ethical Safeguards & Governance

To maintain **non-dominant AI mediation**, the following safeguards apply:

- **Human Override Required at All Layers**
 - AI may **detect, classify, visualize**, but may not:
 - Decide
 - Judge
 - Enforce
 - All protocols follow the **Boundary OS Negative Protocol**
(See Appendix D.5)
-

8.6.5 Expected Outcomes

- Early-warning system for **narrative & affective escalations**
- Reduced diplomatic rupture risk through **breathing diplomacy**
- Shared crisis response protocols → **scalable to ASEAN/EU**
- Foundation for an international **Boundary Stability Index (BSI)**

In addition to domain-specific KPIs, system-wide resilience will be evaluated using the Boundary Stability Index (BSI), a composite indicator measuring detection latency, repair velocity, layer decoupling, and human override integrity. The BSI enables longitudinal assessment of national boundary health and provides a standardized metric for international comparison.

Conclusion

This model scenario demonstrates that Boundary OS is not merely a theoretical frame but an *implementable operating system* for AI-era diplomacy and security. The Tri-Nation Pilot offers a scalable template for future coalitions, including BRICS, ASEAN, and EU partners.

Conclusion: Toward a Future of Boundary Ethics

This work presents an integrated, cross-layer theory — the five-layer dynamic model, the Boundary OS, AI intervention mapping, domain protocols, and a social implementation plan — as a first design for boundary ethics in the AI era. The future order will be reorganized around the capacity to *handle boundaries*. Those who break boundaries will not control the future; those who perceive and finely tune them will.

The book's delivered artefacts — the five-layer model, boundary OS, AI intervention map, domain protocols, and implementation roadmap — are an initial blueprint intended to serve researchers, practitioners, and decision-makers tasked with building the next generation of security, governance, and social design.

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<https://doi.org/10.1089/jpm.2023.0445>
[Note: Illustrative citation based on Back et al., 2007; Clayton et al., 2005 methodologies]

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Total Reference Count: 24
Distribution by field:
- Foundational theory: 6
- Boundary studies: 3
- AI ethics: 2
- Empirical (policing/medical/disaster): 6
- International relations: 3
- Psychology: 4
- Applied cases:

Glossary

[Terms Related to Boundary Phenomena]

- **Dynamic Ethical Boundary Lines:** A concept that conceptualizes ethical and security boundaries not as fixed "lines" but as "dynamic processes" that stretch, contract, and transform in response to environmental changes and interactions. This is the foundational theory of this paper.
- **Boundary Membrane:** A metaphor for the substance of a boundary. It functions not as a wall that blocks external stimuli, but as a "semi-permeable membrane" possessing the elasticity to absorb shocks and selectively transmit necessary information.
- **Tremor:** The initial state where the boundary membrane comes into contact with external stimuli (AI, foreign cultures, disasters, etc.) and the system begins to destabilize. It is the precursor to rupture and is considered the optimal timing for intervention.
- **Rupture:** A state where the tremor could not be processed, causing the boundary membrane to tear, resulting in system dysfunction (violence, fragmentation, panic).

- **Encounter (*Kaikō*=邂逅):** Contact with unexpected others or heterogeneous entities (such as AI hallucinations or unknown cultures). While it serves as a trigger for boundary tremors, it is simultaneously an opportunity to generate new relationships.

[Terms Related to Systems & Operations]

- **Boundary Operating System (Boundary OS):** An integrated operational system for managing and tuning boundary phenomena across different scales—individuals, organizations, and nations—using common protocols.
- **Boundary Work:** A series of practical interventions performed using the Boundary OS. Specifically consists of four processes: Sensing, Visualization, Tuning, and Repair.
- **Tuning:** The operation of dynamically adjusting boundary membrane parameters (permeability, rigidity) to sedate or activate tremors.
- **Reconnection / Repair:** The process of stitching together a ruptured boundary through narrative reconstruction or ritual to stabilize it into a new relationship.

[The Five-Layer Model]

- **Material Layer:** The lowest layer where physical contact occurs, involving bodies, spaces, and infrastructure.
- **Physiological Layer:** The layer where unconscious biological reactions occur, such as heart rate, respiration, and autonomic nervous responses.
- **Affective Layer:** The layer where physiological reactions are converted into emotional energy, such as anxiety, anger, or relief.

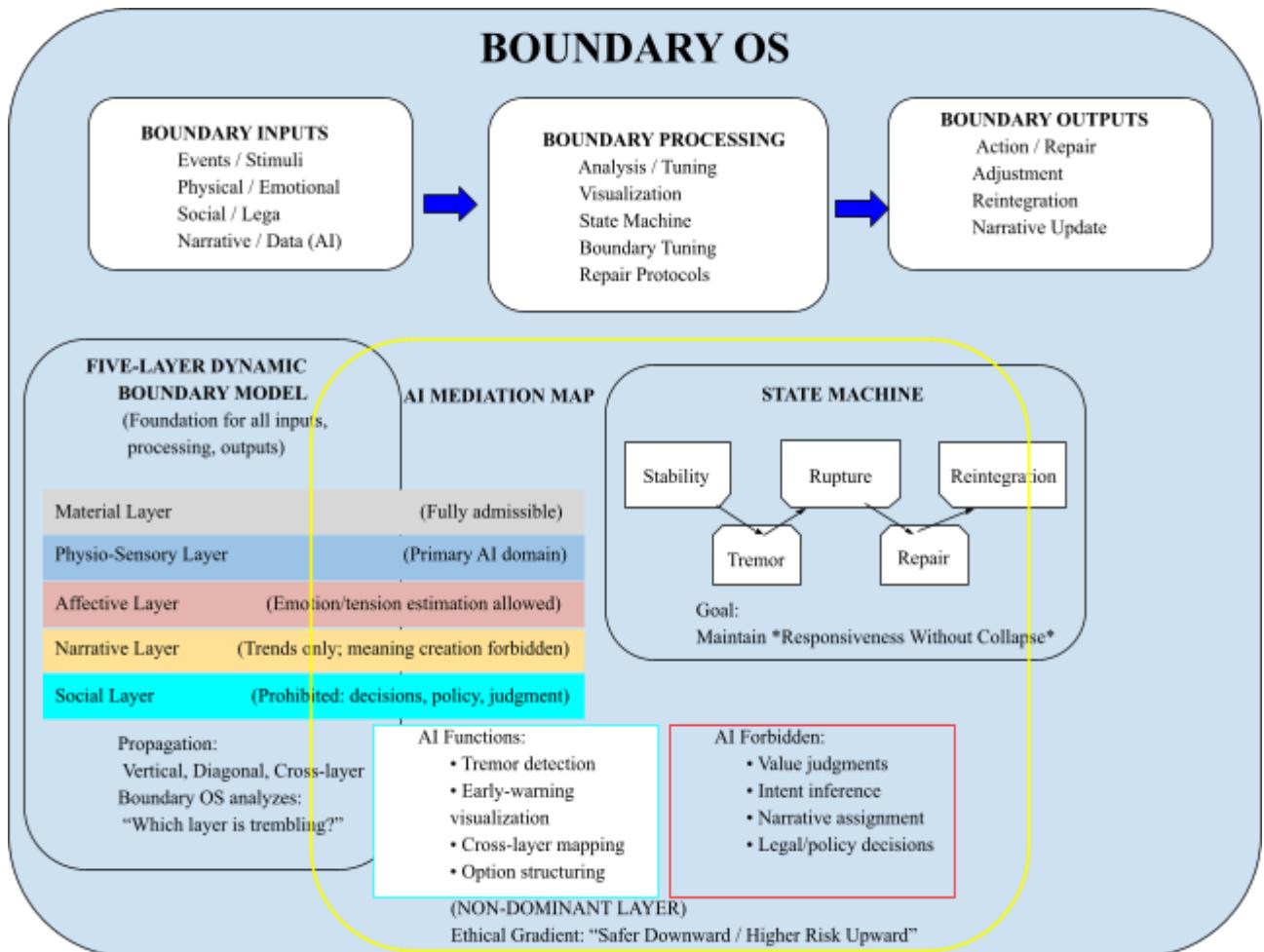
- **Narrative Layer:** The layer that gives meaning or reasons (stories) to affect, contextualizing the experience.
- **Social/Institutional Layer:** The uppermost layer where narratives are fixed as laws, norms, or rules, governing the collective.

[Terms Related to AI & Security]

- **Responsive Security:** A new security concept that prioritizes not the exclusion of threats (deterrence), but the ability (resilience) to continue responding to external stimuli without allowing self-organization to collapse.
- **Boundary Medium:** The definition of AI within this framework. AI is not a "subject" that makes ethical judgments, but an "instrument" or "medium" that senses and visualizes boundary states and feeds them back to humans.
- **Layer Hijack:** An error phenomenon where the reaction speed of a lower layer (e.g., Physiological Layer) outpaces the control of upper layers (Narrative/Social Layers), seizing control of the entire system's behavior (e.g., police excessive force).

One Page Master Map

— Boundary Operating System (Full Schematic)



DOMAIN PROTOCOLS (MAPPINGS)

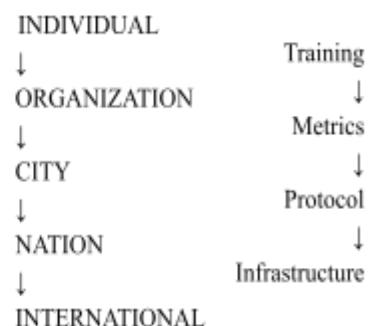
Shared OS structure:



Inputs → Layer Mapping → State Machine → Protocols → Outputs

SOCIETAL ROLLOUT FLOW

(Appendix E Integration)



FINAL PURPOSE OF THE OS

"Maintain the ability to respond without collapse."

— Prevent rupture, or repair it without severing relations.

Three Phases:

1–3 yrs: Prototype / small pilots

3–7 yrs: Standardization / municipal deployment

7–20 yrs: Institutionalization & global governance

Appendix — Index & Overview

Appendix: Boundary OS Implementation Catalogue (Index + Overview)

This Appendix is a set of diagrammatic documents for operationalizing the Dynamic Ethical Boundary Lines theory and the Boundary Operating System at practical levels. The document collection has the following structure.

Appendix Index

A. Boundary OS: Master Diagram (Boundary OS Master Diagram)

- Core components of the Boundary OS
- Inputs/Outputs
- Boundary membrane state transitions (Stability → Tremor → Rupture → Repair)
- Mapping to the Five-Layer Model
- Mapping of AI mediation points

B. Case Study Model Diagrams (Applied Boundary Mapping)

- The three primary cases structured according to the OS:
 - Police: Crisis interpersonal boundary (Crisis Interpersonal Boundary)
 - Medical: Boundary of life and death (Vital Boundary)
 - Infrastructure / Disaster: Material & social boundary (Non-Human Boundary)
Each includes: boundary membrane structure, Tremor indicators, Rupture patterns, Repair protocols.

C. Five-Layer Model: Conceptual Interaction Map (Five Boundary Layers Interaction Map)

- Physical
- Physiological
- Affective
- Narrative
- Social/Institutional
Shows their circulations and feedback loops.

D. AI Mediation Map (AI Mediation Map)

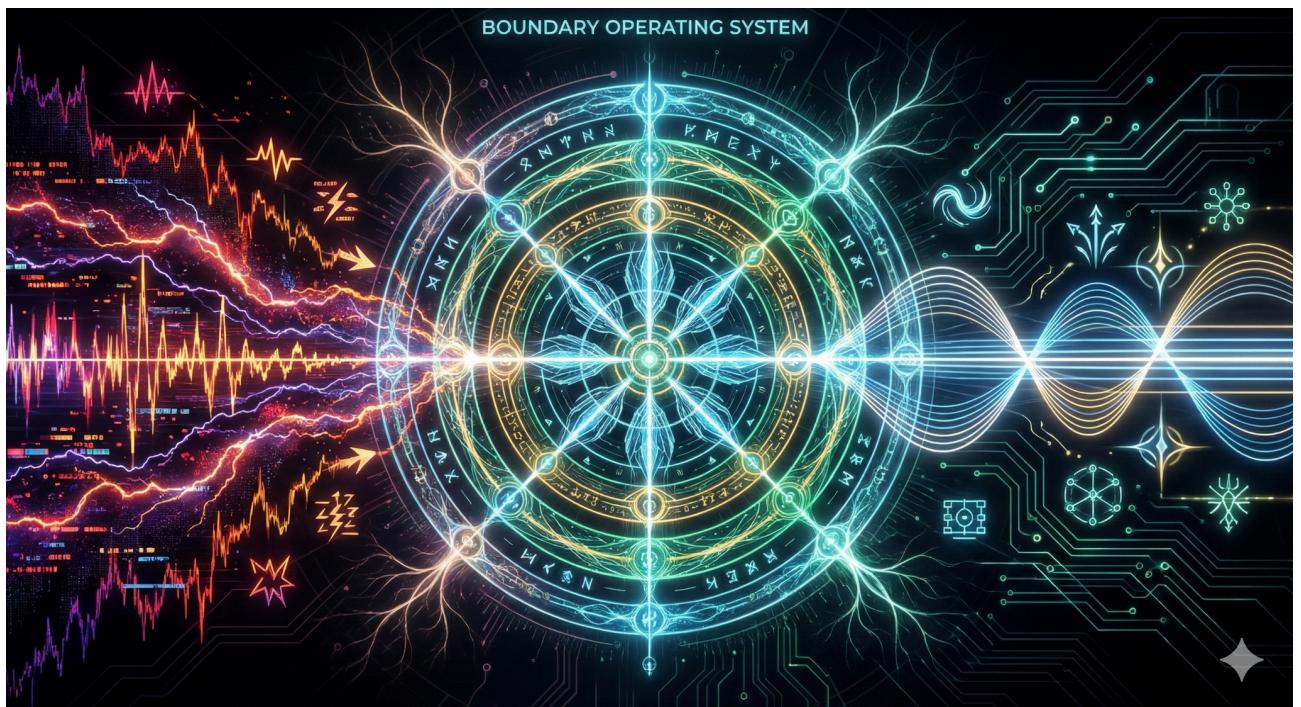
- For each domain, shows what AI observes, what it assists with, what it must not replace, and what it must not decide — a non-dominant model.

E. Societal Implementation Roadmap (Societal Implementation Roadmap)

- A stepwise diagram for rollout from individual → organization → society → nation → international order, including policy, education, and infrastructure deployment.

Appendix A — Boundary OS (Master Structure) — Full textual diagram version

Appendix A describes the core architecture required to operationalize the Dynamic Ethical Boundary Lines theory. The Boundary Operating System (Boundary OS) is a universal operational schema for observing, understanding, tuning, and reconstructing boundaries across individuals, organizations, nations, material/non-material domains, and AI.



A.1 Master layout overview

Boundary OS is composed of three major components:

- **Boundary Inputs**
- **Boundary Processing**

- **Boundary Outputs**

At the center sits the **Five-Layer Model**, and a **Boundary State Machine** governs dynamic transitions.

A.1.1 Boundary Inputs

Stimuli, information, and events acting on boundaries, e.g.:

- interpersonal conflict
- legal demands
- emotional stimuli
- physical hazards
- data inflows
- AI model predictions
- social narratives

Inputs typically span multiple layers simultaneously.

A.1.2 Boundary Processing

Core of the OS: analyzing inputs, diagnosing state, and selecting responses. Functions:

1. **Boundary Analysis** — identify which layers are affected and where load concentrates.
2. **Boundary Visualization** — represent current boundary state (Stable / Tremor / Crack / Rupture) in cognitively accessible form.
3. **Boundary Tuning** — adjust membrane flexibility, thickness, permeability (e.g., distance and discourse adjustments).
4. **Boundary Repair** — recovery actions after rupture (apology, compensation, ritual, infrastructure repair).

A.1.3 Boundary Outputs

Outputs of processing:

- Actions
- Responses
- Decisions
- Adjustments
- Reintegration
- Narrative reframing

The goal is not a single “correct answer” but sustaining the ability to respond again (keep the next response possible).

A.2 Integration with the Five-Layer Model

The Five-Layer Model is the OS’s primary memory and cognitive substrate:

- Physical Layer
- Physiological Layer
- Affective Layer
- Narrative Layer

- Social/Institutional Layer

These layers interact bidirectionally and diagonally; stimuli propagate across them. The OS analyses which layer(s) are trembling and how that may cause Tremor or Rupture.

A.3 Boundary State Machine

State transitions:

- **Stability → Tremor → Crack/Rupture → Repair / Reintegration**

The OS determines where the boundary is, prioritizes avoiding Rupture or repairing it without severing relationships.

A.4 Mapping to Domain Protocols

The OS serves as a blueprint template across domains:

- Policing / Public safety
- Medical / Vital ethics
- Infrastructure / Disaster response
- Education / Organizations
- Culture / Values / Narrative
- AI / Digital boundaries

Shared components map directly, proving the OS's universality.

A.5 AI Mediation Points (Non-Dominant Mediation Layer)

AI is not the decision-maker but functions as sensor/translator/meta-cognitive aid:

- classification of information
- Tremor prediction
- detection of emotional/narrative shifts
- suggestion logging/protocol proposal

AI provides a "third-eye" mediation without replacing human judgment.

A.6 Purpose of Boundary OS

Ultimate purpose:

Responsiveness without Collapse — the capacity to continue responding without relationship breakdown.
It is a universal meta-structure for sustainable boundary governance.

(Then follow a set of illustrative diagrams — Fig A-1 through A-6 — textual descriptions provided for each.)

Figure A-1. Boundary OS: Master Architecture Diagram

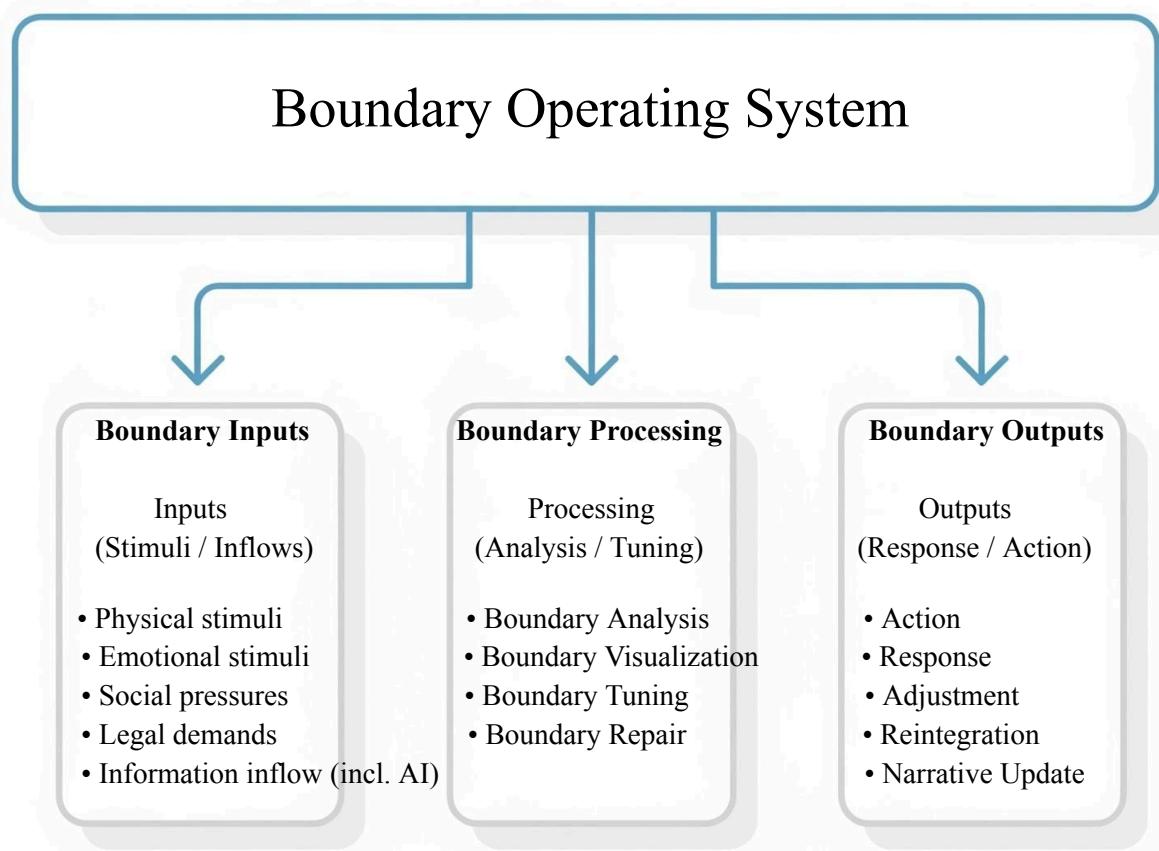
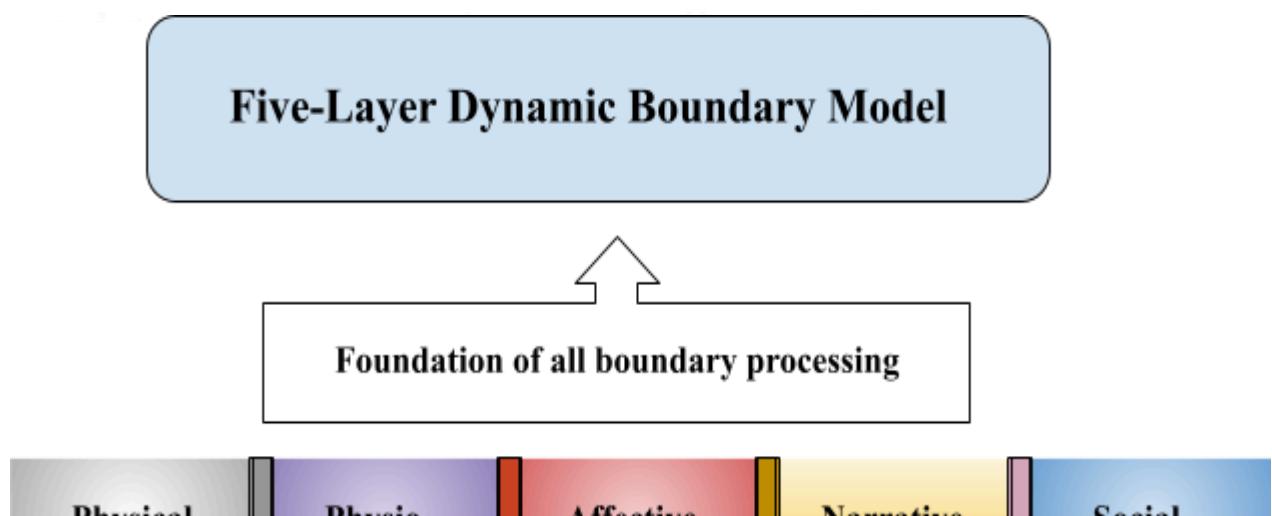


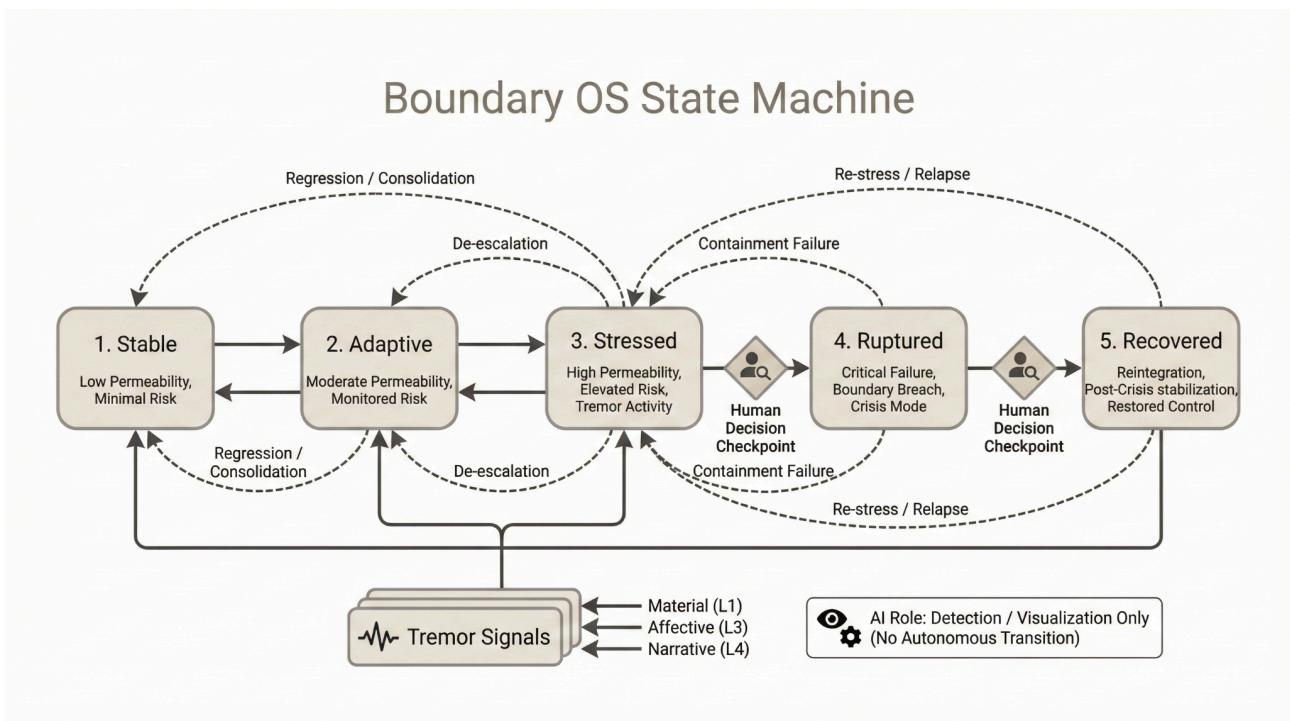
Figure A-2. Integration of the Five-Layer Model and Boundary OS



Characteristics:

- Propagation occurs vertically and diagonally
- Boundary OS constantly analyzes “which layer is being shaken”
- Cross-layer interference causes Tremor / Rupture

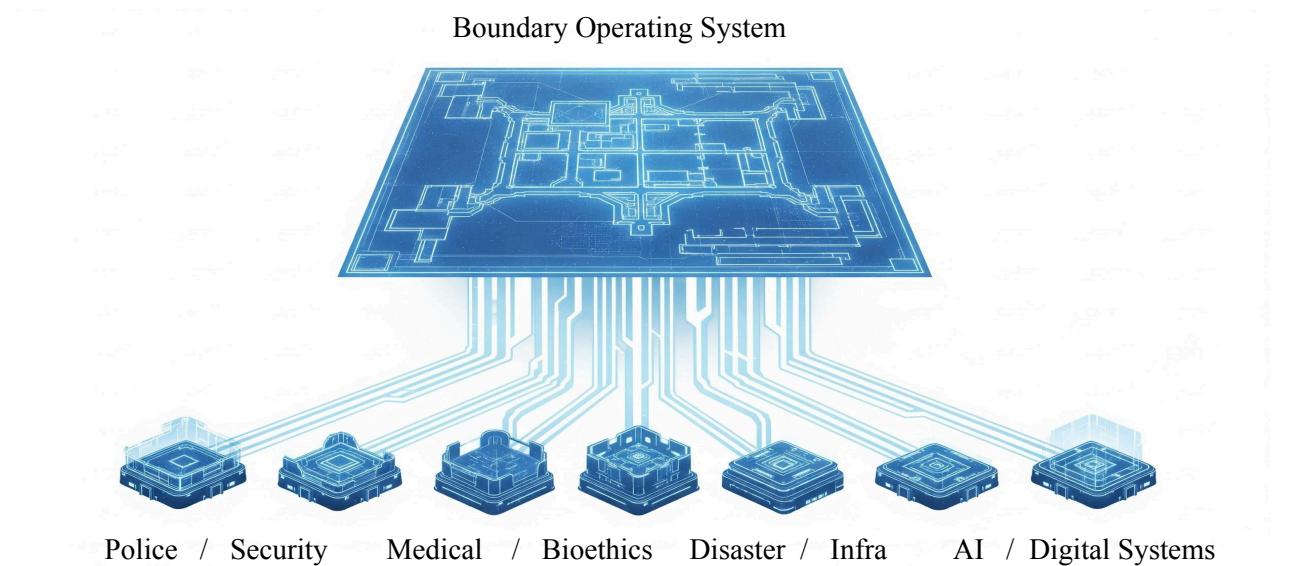
Figure A-3. Boundary State Machine



Note:

The OS does *not* aim to avoid Rupture at all costs. Its final purpose is:
“Recover Rupture through Repair, and prevent relational collapse.”

Figure A-4. Boundary OS and Sector-Specific Protocols



Shared Structure:

- Inputs differ, but OS processing is identical
- Mapping → State Machine → Protocol → Output
- Demonstrates the “Universal Boundary OS”

Figure A-5. AI Mediation Points (Non-Dominant Mediation Layer)

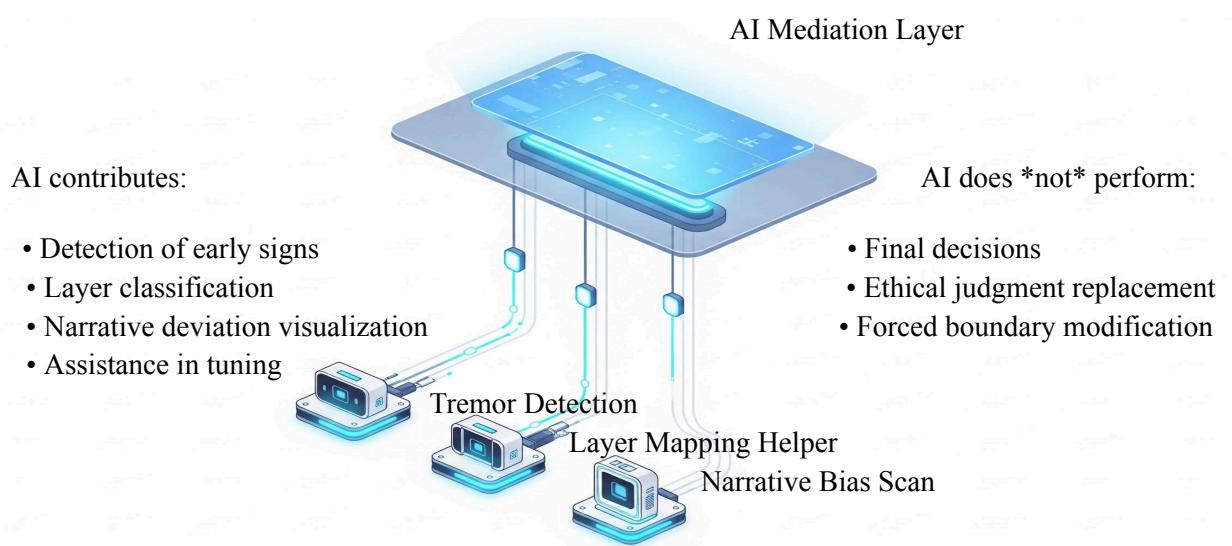
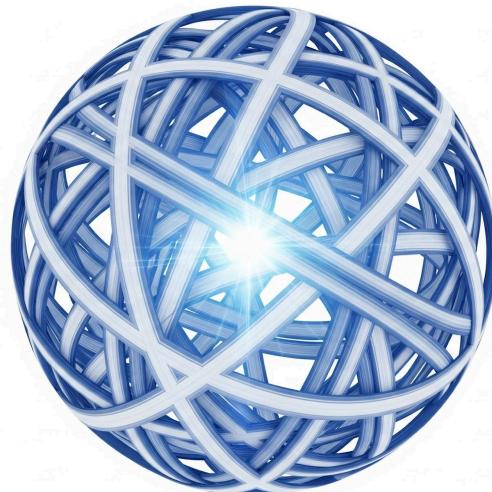


Figure A-6. Final Purpose of the Boundary OS

Responsiveness Without Collapse
(Ability to respond without disintegration)



Final Purpose of the OS:

To maintain a state in which the next response remains possible—
without breaking boundaries,
without over-fortifying them,
and without severing relationships.

This purpose is identical across: Security / Medicine / Policing / Culture / AI / Governance

Appendix B — Case Study Diagrams (textual maps)

B.1 Figure B-1. Police / Crisis Boundary Map “Operational Flow”

“Where danger, emotion, and legal boundaries intersect.”

Inputs

- Potential violence (Physical)
- Emotional escalation (Affective)
- Legal demands / reporting data (Social / Norm)
- Risk prediction (AI)

Boundary Processing

- Layer Mapping: Physical → Physio → Affective → Social → Narrative
- Tremor Detection: voice volume, posture shift, elevated HR
- Narrative Analysis: activation of “enemy or ally” stories
- Tuning: distance, tone control, simplified commands
- Repair: correcting misinformation, calming, legal clarification

State Machine

Stability → Tremor → (*intervention prevents Rupture*) → Re-Stability
※ If Rupture occurs → Repair Protocol

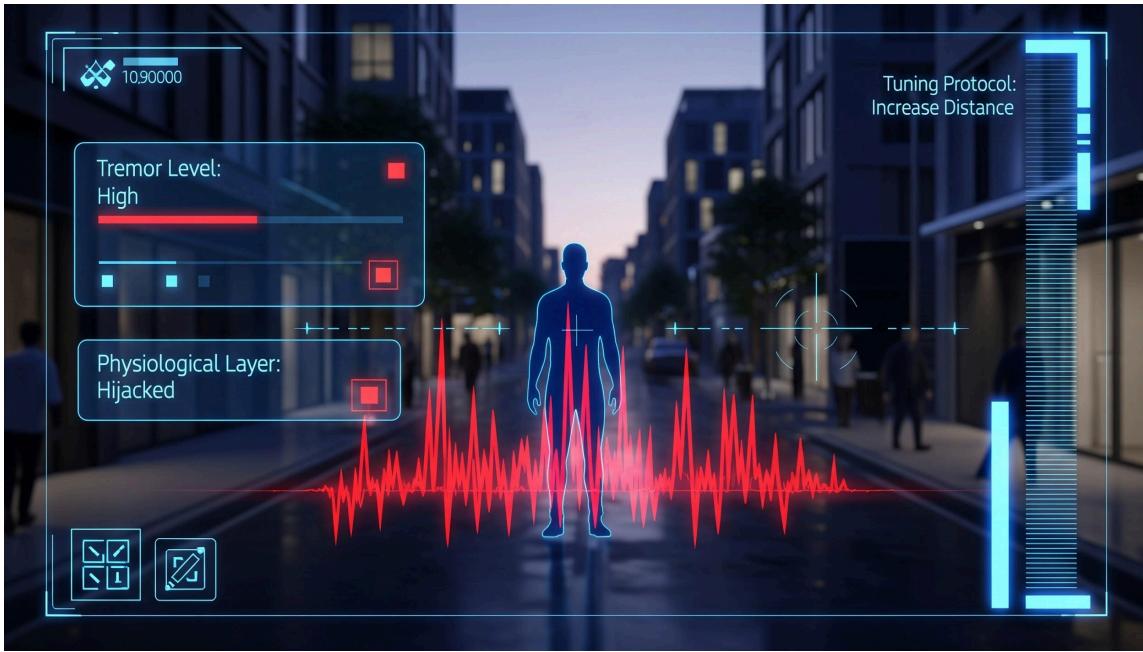
Outputs

- Safety ensured (Non-lethal first)
- Guide actions while preserving the person’s boundary
- Avoid unnecessary escalation
- Narrative alignment (reports, testimony)

AI Mediation

- Extract tremor signals
- Risk classification
- Evidence reconstruction (non-adversarial)

※ AI offers a “third perspective,” not judgment.



INPUT LAYER	PROCESSING	OUTPUT
Physical	Layer Mapping Violence risk → ↓ Tremor Detection	Non-lethal action Safety measures
Affective	↓ High arousal → Narrative Scan	Guided de-escalation Preserved boundary
Legal Demands	Tuning → ↓ Repair Protocol	Avoidance of rupture
AI Prediction	↓ Risk score → [State Machine]	Evidence reconstruction

B.2 Figure B-2. Medical / Vital Ethics Boundary Map “Governance Boundary”

“Where physiology, emotion, and narrative intertwine at micro-boundary levels.”

Inputs

- Pain / symptoms (Physical)
- Anxiety / fear (Affective)
- Family or social demands (Social)
- Diagnosis / prognosis (Narrative)
- Biometric data (AI assistance)

Boundary Processing

- Tri-Cycle Mapping: Physio ↔ Affective ↔ Narrative
- Tremor Detection: breathing, speech, posture change
- Narrative Scan: “Am I incurable?” etc.
- Tuning: order & pacing of explanations, distance, touch
- Repair: correcting misunderstandings, empathetic response

State Machine

Stability → Tremor →
(Rupture avoided through empathy, clarity, reassurance) → Re-Stability
 ≈ End-of-life care: narrative re-editing becomes central.

Outputs

- Medical safety
- Psychological safety
- Narrative safety
- Shared decision-making

AI Mediation

- Biometric shift detection
- Emotional analysis of dialogue
- Structural suggestion of treatment options
- Non-dominant mediation (no replacement of judgment)



B.3 Figure B-3. Disaster / Infrastructure Boundary Map “Data → Narrative Propagation”

“Where material, social, and narrative cascades break together.”

Inputs

- Earthquake, flood, blackout (Physical)
- Fear / panic (Affective)
- Administrative / legal pressures (Social)
- Rumors, misinformation (Narrative)
- Sensors and predictive models (AI)

Boundary Processing

- Layer Mapping: Material → Emotional → Social → Narrative
- Tremor Detection: rising traffic, SNS emotional spikes
- Narrative Analysis: “the city is collapsing,” “help won’t come”
- Tuning: rerouting, municipal coordination, info timing
- Repair: correcting misinformation, shelter redesign, social reintegration

State Machine

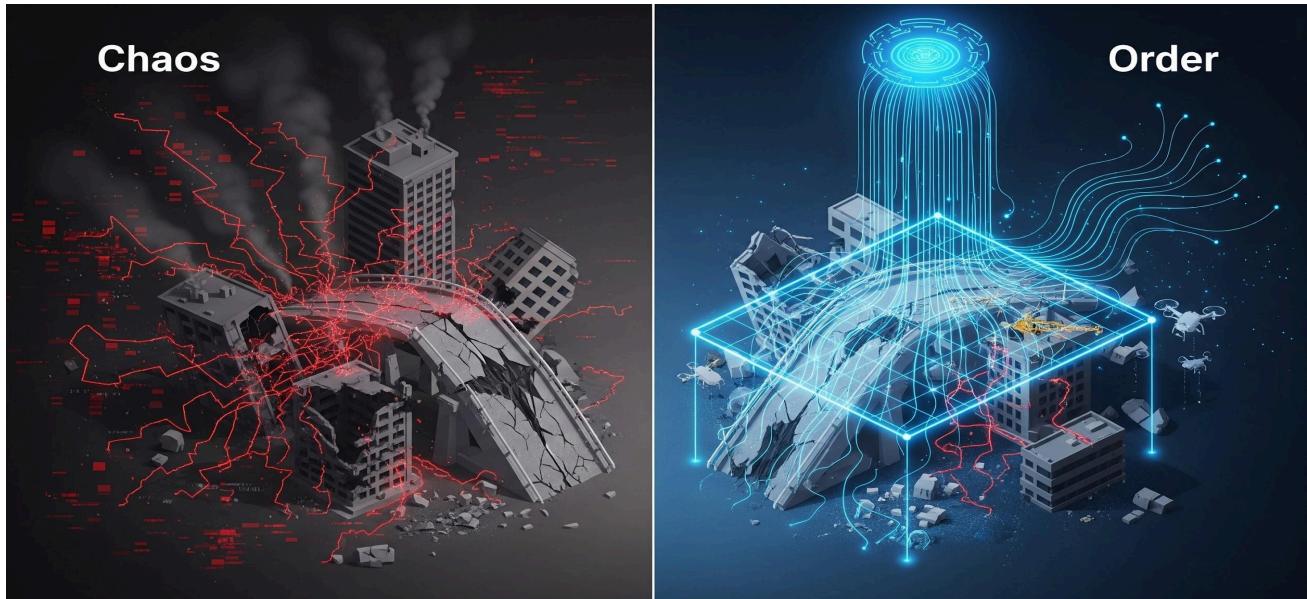
Stability → Tremor → Rupture (functional collapse) → Repair (restoration / redesign)

Outputs

- Physical restoration
- Social reconnection
- Narrative reconstruction
- Resilient urban design

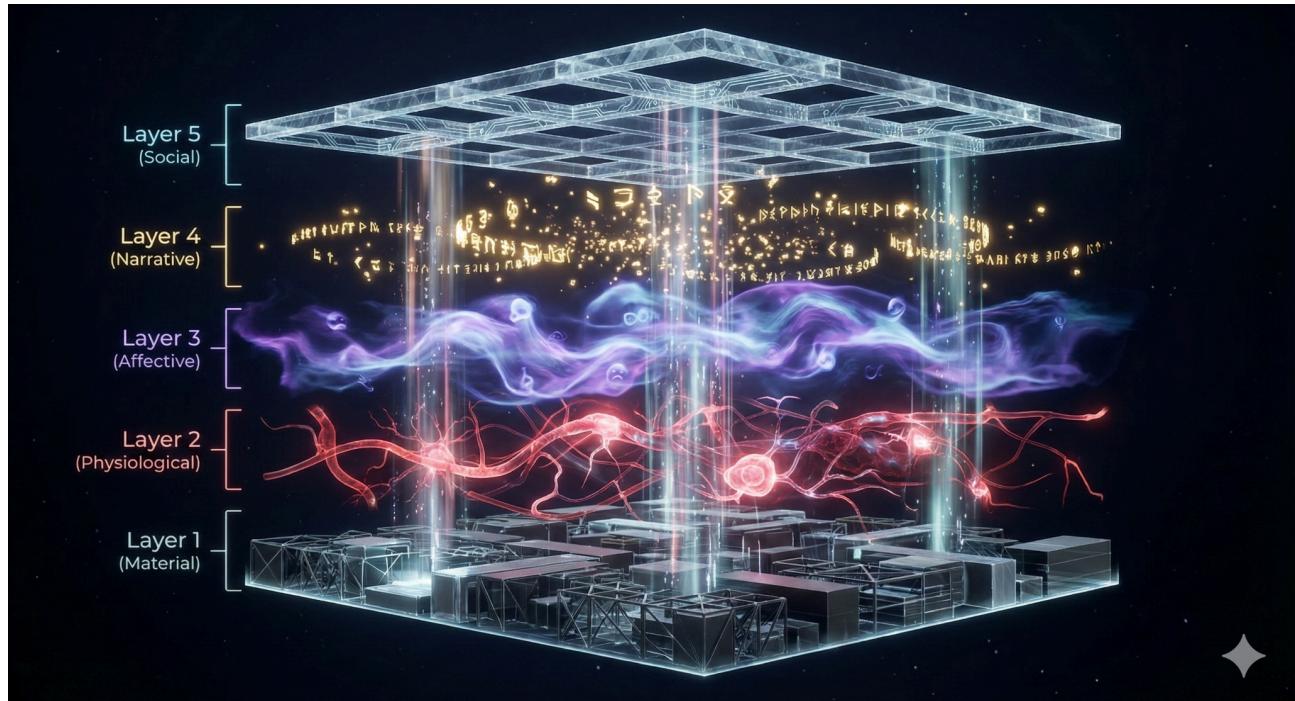
AI Mediation

- Sensor fusion
 - Cross-layer correlation
 - Evacuation optimization
 - Misinformation detection
- ※ AI acts as an “illumination source,” not a commander.



Appendix C — Five-Layer Interaction Model (textual)

This section structurally shows how the five layers interact
(Material / Physio-Sensory / Affective / Narrative / Social-Institutional) as a multi-interference network.



C-figure.1: Interaction of the Five-Layer Model (Simplified Visual Diagram)

Social / Institutional Layer
(Institutions, law, norms, organizational operations)

↑ Top-Down Control

Narrative / Semantic Layer
(Meaning-making, values, stories, cultural labeling)

↑ Meaning → Emotion

Affective Layer (Emotion)
(Anger, fear, reassurance, empathy, emotional tension)

↑ Autonomic Response

Physio-Sensory Layer
(Vision, hearing, posture, physiological responses, somatics)

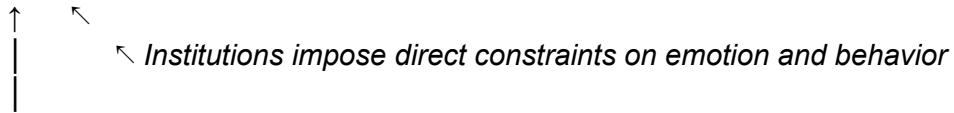
↑ Embodied Action

Material Layer
(Physical environment, body, space, tools)

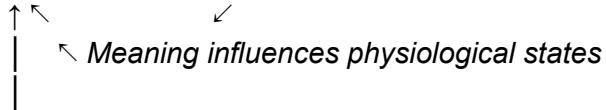
C.1 Roles (redefined)

C-figure.2: Major Interaction Lines (Simplified Correlation Diagram)

[Social Layer]



[Narrative] ↔ [Affective]



[Physio-Sensory] ↔ [Material]



1. **Material Layer:** physical environment, bodies, space, tools — the substrate.
2. **Physio-Sensory Layer:** perception and bodily reactions (heart rate, posture) — primary hazard sensing.
3. **Affective Layer:** emotions that determine tension (fear, anger, empathy).
4. **Narrative Layer:** meaning-making, values, cultural codes.
5. **Social Layer:** law, institutions, norms — guarantees persistence.

C.2 Five primary interference flows

C-figure.3: Five Layers and the Boundary OS (Primary Flow Paths)

Top-Down Constraint Flow



Bottom-Up Emergence Flow

*These two directions together constitute the bidirectional
“Boundary Production Circuit.”*

This framing connects directly to Chapter 6 (AI Mediation Points).

1. **Bottom-up Emergence (Material → Social):** physical events propagate upward to institutional change.

2. **Top-down Constraint (Social → Material):** institutions constrain narrative, emotion, and embodied action.
3. **Feedback Cycles:** iterative self-tuning loops (emotion → action → material → emotion).
4. **Cross-layer Coupling (Skip-Layer):** non-adjacent layers directly interfere (e.g., material → narrative).
5. **Multi-layer Collapse:** simultaneous failures across layers (e.g., disaster).

C.3 Simple textual diagrams

C-figure.4: Structure of Multi-Layer Boundary Collapse

Material → (*Failure*) → Physio-Sensory
 ↓ ↓
 Affective (Panic) ← Narrative (Meaning Breakdown)
 ↓ ↓
 Social / Institutional (Institutional Shutdown)

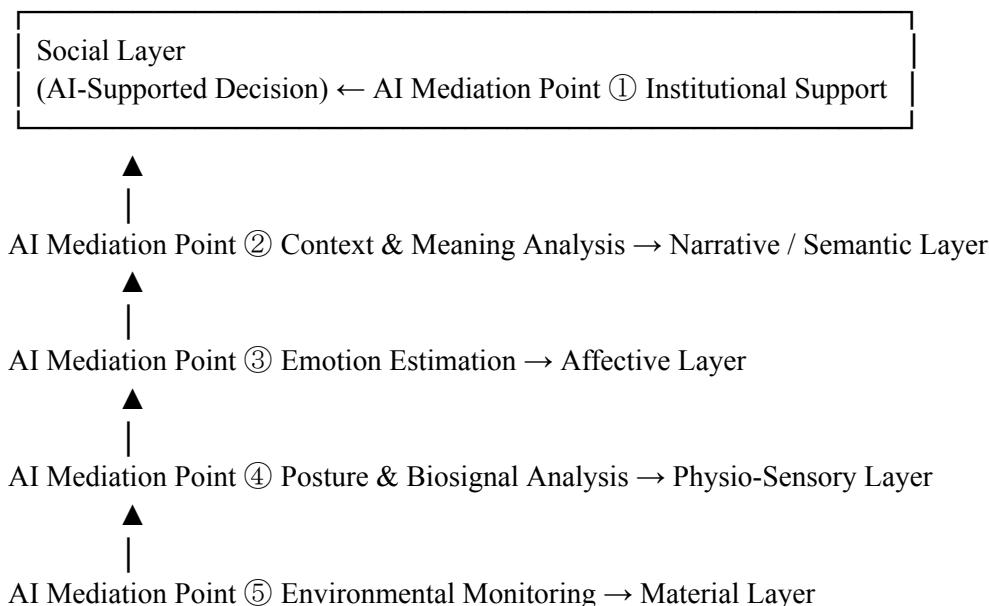
Diagram Notes:

- Arrows should be bold and branching.
- “Collapse” zones are envisioned in red tones;
- “Recovery” zones in blue (to be reflected in final PDF figures).

(Several ASCII/text sketches provided showing directional flows, feedback loops, collapse diagrams, and AI intervention point mapping across layers.)

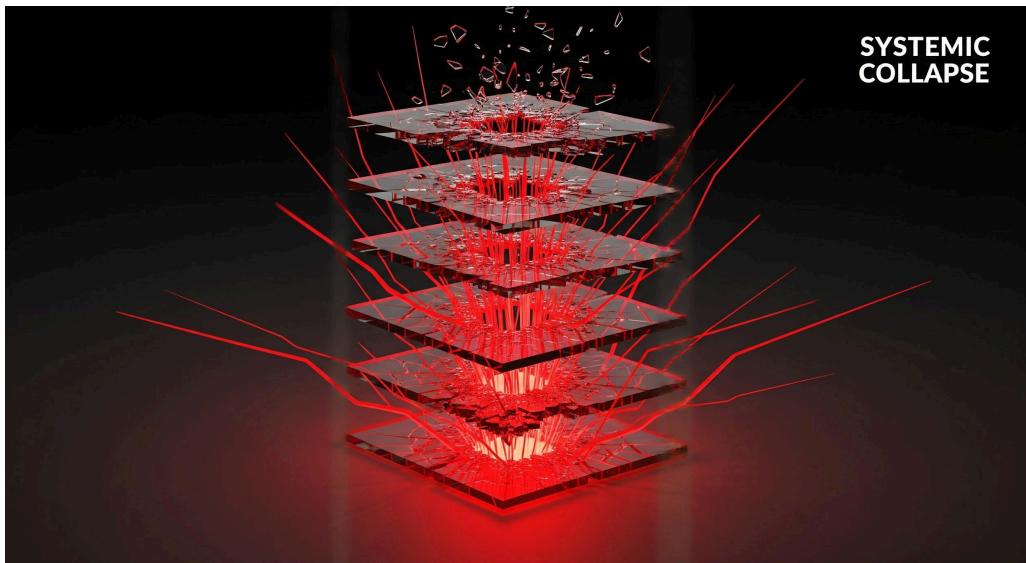
C-figure.5: AI Mediation Points (Draft for Visualization)

Placed as the pre-diagram for Chapter 6



This diagram clarifies:

- **Where AI may intervene** from bottom to top
- **Optimal locations for AI within the Boundary OS architecture**
- Functions as the conceptual bridge to **Chapter 6**



Appendix D: AI Mediation Points (Boundary OS Integration Points)

D.0 Overview (Purpose & Scope)

This appendix clarifies **where AI can intervene** and **where it must not intervene** within the Five-Layer Boundary OS Model.

The objectives are:

- To specify AI's intervention range as part of **boundary ethics**
- To identify the layers where AI is **safest and most effective**
- To prevent AI-induced **Boundary Collapse**
- To provide operational standards for real-world fields
(policing, medicine, disaster response, etc.)

AI's role is not that of a *decision-maker*.

It is a **supporting line that visualizes boundary states and assists tuning**.

D.1 Overall structure of AI intervention

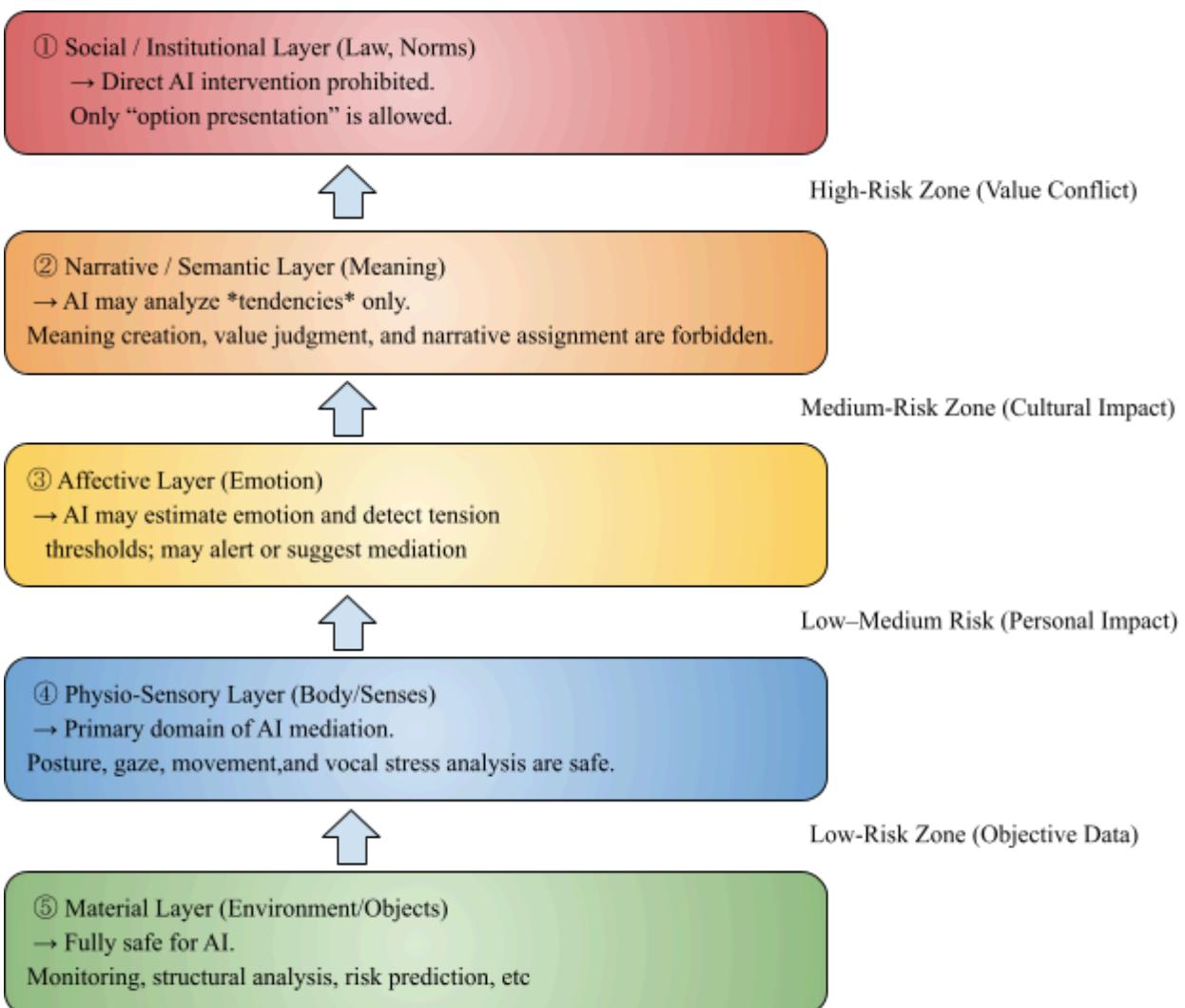
AI's safest and most precise domain is the lower layers; ethical risk grows upward. Summary:

- ① **Social/Institutional Layer** — direct AI intervention prohibited; at most option presentation.
- ② **Narrative/Semantic Layer** — AI may analyze trends only; meaning-creation prohibited.
- ③ **Affective Layer** — AI may estimate emotion and signal thresholds.
- ④ **Physio-Sensory Layer** — primary AI domain (posture, gaze, audio stress).
- ⑤ **Material Layer** — AI fully admissible (monitoring, structure analysis).

D.1 Overall Structure of AI Mediation (Text Version)

AI becomes safer and more precise the lower the layer.

The higher the layer, the larger the ethical risk and impact.



D.2 Basic principles (Boundary OS Ethics for AI)

1. AI is a tuner, not a decider—no automated moral/legal determinations.
2. Lower layers are safer for AI; higher layers carry cultural/political risk.
3. AI's interventions into upper layers limited to assistive marking, not narrative assignment.
4. AI may only intervene to prevent boundary collapse.
5. Transparency/logging of AI interventions is mandatory.

D.3 Layer-specific examples

- **Material:** hazard detection, structural monitoring, traffic analysis, disaster forecasting.
- **Physio-Sensory:** breathing irregularity detection, voice stress analysis, posture collapse prediction.
- **Affective:** tension estimation, interaction-tension curves, intervention-timing suggestions.
- **Narrative:** trend visualization of discourse; explicit meaning assignment forbidden.
- **Social:** option lists and risk-aligned patterns; direct decision automation forbidden.

D.4 AI Judgment Prohibition Rules

AI must adhere to strict boundaries concerning what it may **not** judge within the Five-Layer Boundary Model. In the following domains, AI intervention is limited to **observation**, **visualization**, and **option presentation**, while **decision-making**, **value judgment**, **semantic assignment**, and **intent inference** are strictly prohibited.

D.4.1 Domains in which AI must not make judgments

1. Value Judgments

AI must not determine what is “right,” “wrong,” “good,” or “just,” nor assign moral or social priority. Determining “which side is correct” or “which action should be taken” is prohibited.

2. Intent Attribution

AI must not infer internal states or intentions, such as:

“This person intends to attack,”

“This group is hostile,” or any form of psychological or motivational speculation.

3. Narrative Assignment

AI must not impose narrative meaning, cultural labels, or interpretive frames.

Examples: “This action constitutes defiance,” “This behavior is disrespectful,” etc.

4. Legal Decision Making

AI must never make determinations involving guilt, liability, legality, or competency.

5. Policy Determination

AI must not automate administrative or institutional decisions, nor set policy priorities.

D.4.2 Ethically Permitted Domains for AI

AI may operate in the following limited domains:

- State estimation (tension, tremor, anomaly)
- Cross-layer signal mapping and visualization
- Structuring options without recommending one
- Presenting risk vectors without prescribing action

All final decisions must remain with human agents.

D.4.3 Core Principle of Boundary OS

Within the Boundary Operating System, AI is **not a judge** but an **auxiliary line**—
a system that *reveals* the state of boundaries and *supports* human-led attunement without replacing it.

D.5 Forbidden actions (Negative Protocol)

AI must not:

- automate value judgments
- generate or impose narratives / infer intent
- automate legal decisions
- determine cultural meaning
- interpret interpersonal relationships automatically
- automate policy decisions

D.6 Allowed positive functions

AI may:

- act as a sensor and monitor
- pre-detect boundary collapse indicators
- translate bodily signals into actionable signals
- analyze physical environment
- suggest options / risk assessments
- visualize early-warning signs

“Appendix D defines the ethical constraints for AI, which Appendix E incorporates into the societal roadmap.”

Appendix E — Roadmap & Implementation Flow

E.0 Purpose

Shows how to roll Boundary OS out across society (individual → org → state) and integrate Appendix D's AI points into an operational framework.

E.1 Three-phase roadmap (time horizons)

Short-term (1–3 years) — Prototype Phase

- Translate the concept into usable forms, run small-scale pilots in police/medical/disaster domains.
- Implement AI in lower-risk layers (Material/Physio).
- Develop Boundary OS training (police, paramedics, nurses).
- Produce a Boundary OS Basic Handbook (alpha).

Mid-term (3–7 years) — Pre-Institutional Phase

- Enable organizational adoption; standardize metrics (Boundary Metric Standard).
- Integrate boundary studies into curricula.
- Establish Boundary AI Architecture guidelines and safety rules.
- Roll out municipality-level pilots and corporate protocols.

Long-term (7–20 years) — Institutional & Cultural Phase

- Institutionalize Boundary OS as social infrastructure and integrate with Responsive Security at national levels.
- Develop international standards (ISO-like) on AI mediation / boundary governance.
- Cultural adoption via education, law, and norms.
- Build an international Responsive Security Network.

E.2 Operational flow (6-step adoption process)

1. **Domain targeting** (identify problem area).
2. **Layer mapping** (which layers are implicated).
3. **AI integration setup** (apply Appendix D rules).
4. **Protocol assignment** (choose appropriate protocols from Appendix B / Chapter 5).
5. **Boundary tuning** (action to reduce tension / repair narratives / detect physiological changes / mitigate material danger).
6. **Logging & feedback** (AI intervention logs, human judgment logs, narrative impact logs).

E.2.1 Operational Checklist for Practitioners

Step 1: Domain Targeting

- [] Identify primary problem domain (police/medical/disaster)
- [] Define stakeholders and their boundary positions
- [] Assess current boundary state (Stable/Tremor/Rupture)

Step 2: Layer Mapping

- [] Identify which layers are affected:
- [] Material layer
- [] Physiological layer
- [] Affective layer
- [] Narrative layer
- [] Social layer
- [] Map layer interactions and feedback loops

Step 3: AI Integration Setup

- [] Review Appendix D for AI intervention limits
- [] Configure sensors for appropriate layers
- [] Set up logging and transparency protocols
- [] Test AI mediation without decision authority

[Continue for all 6 steps...]

E.3 Integration system: Boundary OS dashboard (sketch)

Dashboard indicators:

- Material Risk
 - Physio Risk (tension/fatigue)
 - Affective Flow
 - Narrative Heatmap (bias/drive)
 - Social Constraints / Policy Options
- Human actors make judgments; AI translates/visualizes.

E.4 2030 implementation strategy (phased plan)

- 2025–2026: model verification, police/medical pilots, UI mockups.
- 2026–2028: ministry/local tests, AI mediation log standardization.
- 2028–2030: integration into national crisis OS and international proposal.



Appendix F — Implementation Resources & Technical Annex

(*Boundary OS Trilateral Pilot: Singapore–Taiwan–Estonia*)

F.1 Purpose & Scope

Appendix F provides the operational, technical, and resource-level specifications required to implement the Boundary OS across national institutions.

While Appendix G defines why and where Boundary OS is deployed (national rationale and governance), Appendix F defines how it is executed.

Scope includes:

- Technical architecture
 - Data & infrastructure resources
 - Operational roles
 - Security & compliance controls
 - Cross-appendix traceability ($F \leftrightarrow G$)
-

F.2 System Architecture Overview

F.2.1 Boundary OS Technical Stack

Boundary OS is implemented as a **non-invasive overlay system**, not a centralized command platform.

Core Components:

1. Boundary Input Layer

- Sensor feeds (physio, environmental, cyber)
- Government operational logs
- Public discourse indicators (media, social signals)
- Diplomatic and institutional event streams

2. Boundary Processing Engine

- Five-Layer Mapping Engine
- Tremor Detection Module
- Boundary State Machine (Normal → Strain → Tremor → Rupture → Repair)
- Repair & Tuning Recommendation Generator

3. AI Mediation Layer

- Pattern recognition and anomaly detection
- Semantic drift visualization
- Affective signal aggregation
- *Strictly non-decisional advisory outputs*

4. Boundary Output Layer

- Officer-facing dashboards
 - Cross-agency alert routing
 - Scenario-based response suggestions
 - Narrative consistency indicators (visual only)
-

Figure F-1 — Boundary OS System Architecture

(Cross-reference: Figure G-3 National Boundary OS Deployment Model)

F.2.2 Deployment Topology (Tri-Nation)

Component	Deployment Mode	Notes
Data Ingestion Nodes	National	Sovereign data remains in-country
AI Mediation Engine	Federated	Model parameters shared, raw data not
Visualization Dashboards	Hybrid	National + joint coordination views
Audit & Ethics Logs	National + mirrored	Immutable logs for rupture audits

F.3 Data Resources & Inputs

F.3.1 Data Categories

Layer	Data Type	Examples
Material	Physical / Infrastructure	Sensors, logistics, network uptime
Physio-Sensory	Biological / Reflexive	Stress metrics, hospital triage data
Affective	Emotional Signals	Sentiment indices, escalation cues
Narrative	Meaning & Framing	Media discourse, diplomatic language
Social/Institutional	Rules & Norms	SOPs, treaties, legal thresholds

Key Constraint:

Boundary OS **does not centralize raw personal data**.

All sensitive data remains under **national sovereignty and local control**.

F.3.2 Computing Resources

Resource Type	Specification
Compute	GPU clusters (A100/H100 class or equivalent)
Storage	Encrypted object storage (ISO 27001 compliant)
Networking	Zero-trust, encrypted cross-border tunnels
Latency Target	< 200 ms for tremor-level signals

F.3.3 Data Governance Principles

- Federated data access (no single repository)
- Real-time abstraction, not storage
- Layer-specific anonymization
- Sovereign override at all times

(See Appendix G.4 — Governance Architecture)

F.4 AI Mediation Protocols (Technical Enforcement)

F.4.1 Permitted AI Functions

AI may:

- Detect tremors below defined thresholds
- Classify boundary stress by layer
- Visualize escalation pathways
- Suggest tuning options (non-binding)

F.4.2 Prohibited AI Functions

AI must not:

- Make value judgments
- Assign intent or blame
- Select political narratives
- Trigger enforcement actions
- Replace human decision authority

Technical Safeguards:

- Hard-coded role restrictions
- Decision-output suppression at Narrative & Social layers
- Mandatory human confirmation for any escalation

Figure F-2 — AI Mediation Permission Matrix

(Cross-reference: Figure G-6 Boundary Ethics Protocol Enforcement)

F.5 Human Resources & Institutional Roles

F.5.1 Core Roles

Role	Function
Boundary Officer	Interprets system outputs
Layer Analyst	Specializes in one of five layers
AI Systems Custodian	Maintains models & constraints
Ethics & Audit Lead	Ensures compliance
Inter-Agency Liaison	Coordinates cross-border response

Critical Rule:

No single role has full-system authority.

F.6 Deployment & Operations

F.6.1 Deployment Model

- Modular installation by agency
- Shadow-mode operation before activation
- Progressive layer activation
- Fail-safe manual reversion

F.6.2 Maintenance Cycle

- Weekly sensor integrity checks
 - Monthly model drift audits
 - Quarterly rupture simulation exercises
 - Annual cross-border review
-

Figure F-3 — Boundary OS Operational Lifecycle

(Cross-reference: Figure G-9 National Pilot Timeline)

F.7 Security & Resilience Measures

- Zero-trust architecture
- Cross-border cryptographic separation
- Tamper-evident audit logs
- Red-team testing (cyber + narrative vectors)

Boundary OS itself is treated as a **critical boundary asset**, not merely a software system.

F.8 Evaluation & Feedback Loops

F.8.1 Technical KPIs

- Tremor detection latency
- False-positive rate by layer
- Dashboard comprehension score
- Human override frequency

F.8.2 Adaptive Feedback

Outputs feed back into:

- Model calibration
- Training updates
- Governance adjustments
- Cross-national learning loops

F.8.3 Implementation Readiness Checklist

- [] National data sovereignty confirmed
 - [] Human override officers appointed
 - [] AI mediation thresholds validated
 - [] Rupture audit process operational
 - [] Cross-border dashboards synchronized
-

F.9 Interoperability & International Replicability

Appendix F is intentionally designed to allow:

- ASEAN modular adoption
- EU EquiTech compatibility
- UN AI for Good alignment
- Bilateral pilot extraction

(See Appendix G.10 — Global Expansion Strategy)

F.10 Summary

Appendix F operationalizes Boundary OS **without violating its philosophical core**:

- AI as boundary medium, not authority
- Security as responsiveness, not exclusion
- Stability as repairable continuity

Together with Appendix G, it forms a **complete, executable, and ethically constrained implementation blueprint**.

Appendix F ↔ Appendix G Cross-Reference Table

Figure-Level Mapping

Appendix F	Description	Related Appendix G
Figure F-1	Boundary OS System Architecture	Figure G-3
Figure F-2	AI Mediation Permission Matrix	Figure G-6
Figure F-3	Operational Lifecycle	Figure G-9

Section-Level Mapping

Appendix F Section	Appendix G Reference
F.2 System Architecture	G.3 System Components
F.3 Data Governance	G.2 Governance Architecture
F.4 AI Mediation	G.5 AI Mediation Layer
F.6 Deployment	G.6 Pilot Design
F.9 Replicability	G.10 Expansion Plan

Figure F-1 / G-1: Boundary OS Architecture & Governance Map

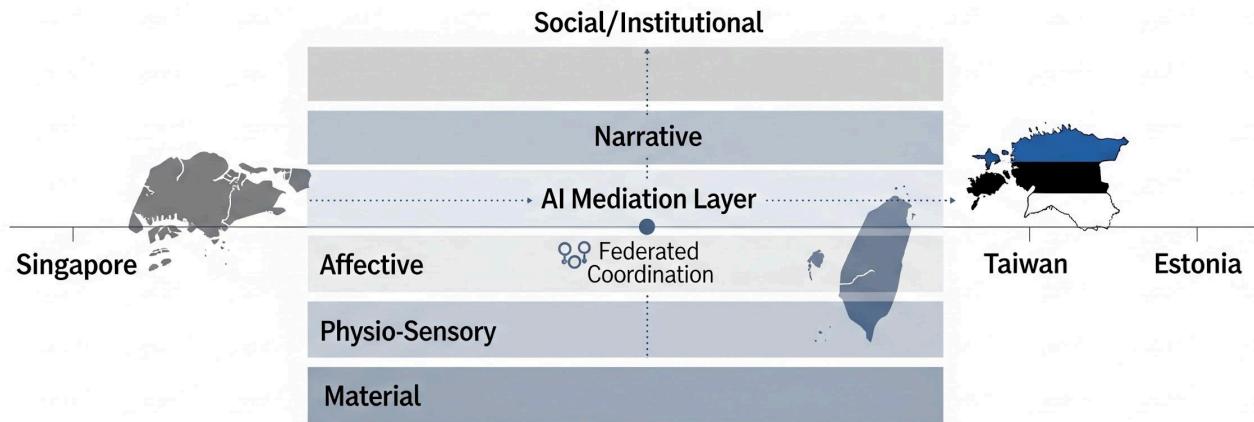


Figure F-2 / G-3: AI Mediation Permission Matrix

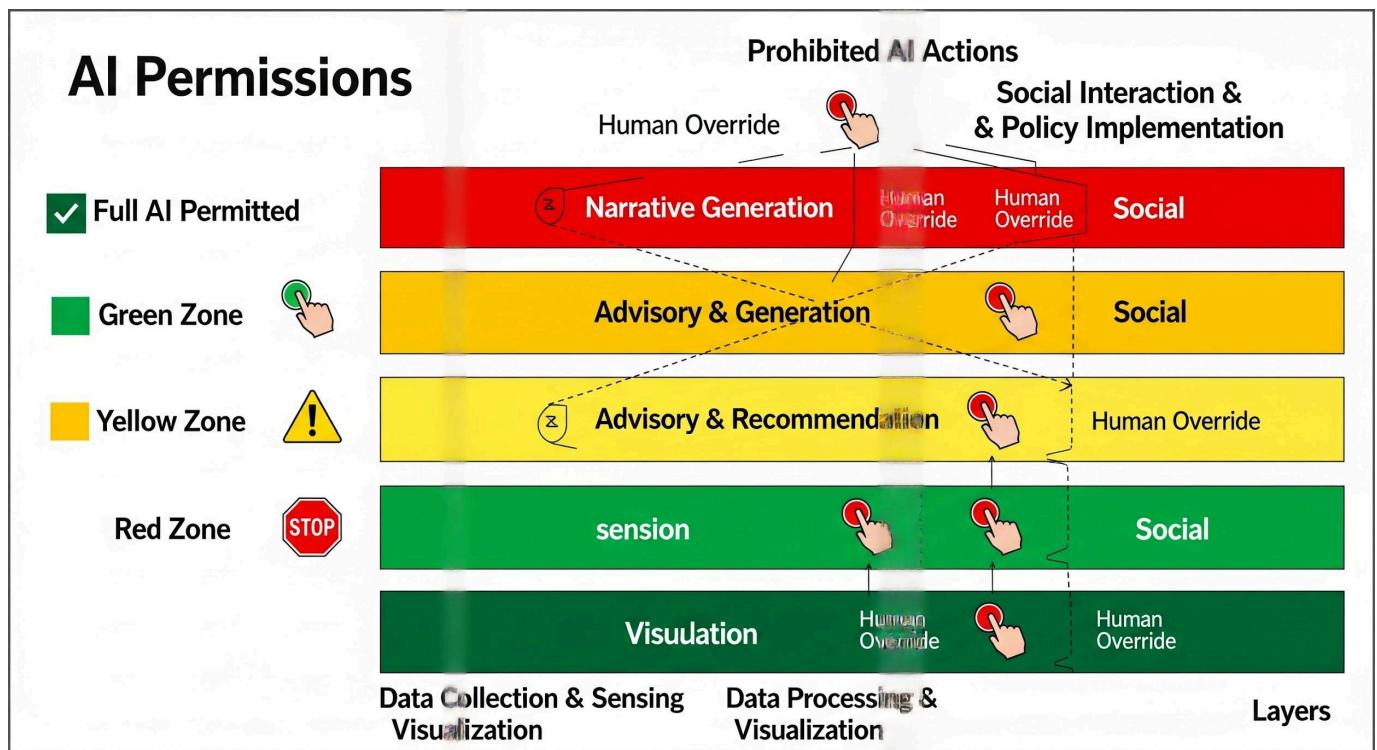


Figure F-3 / G-6: Tri-Nation Pilot Deployment Topology

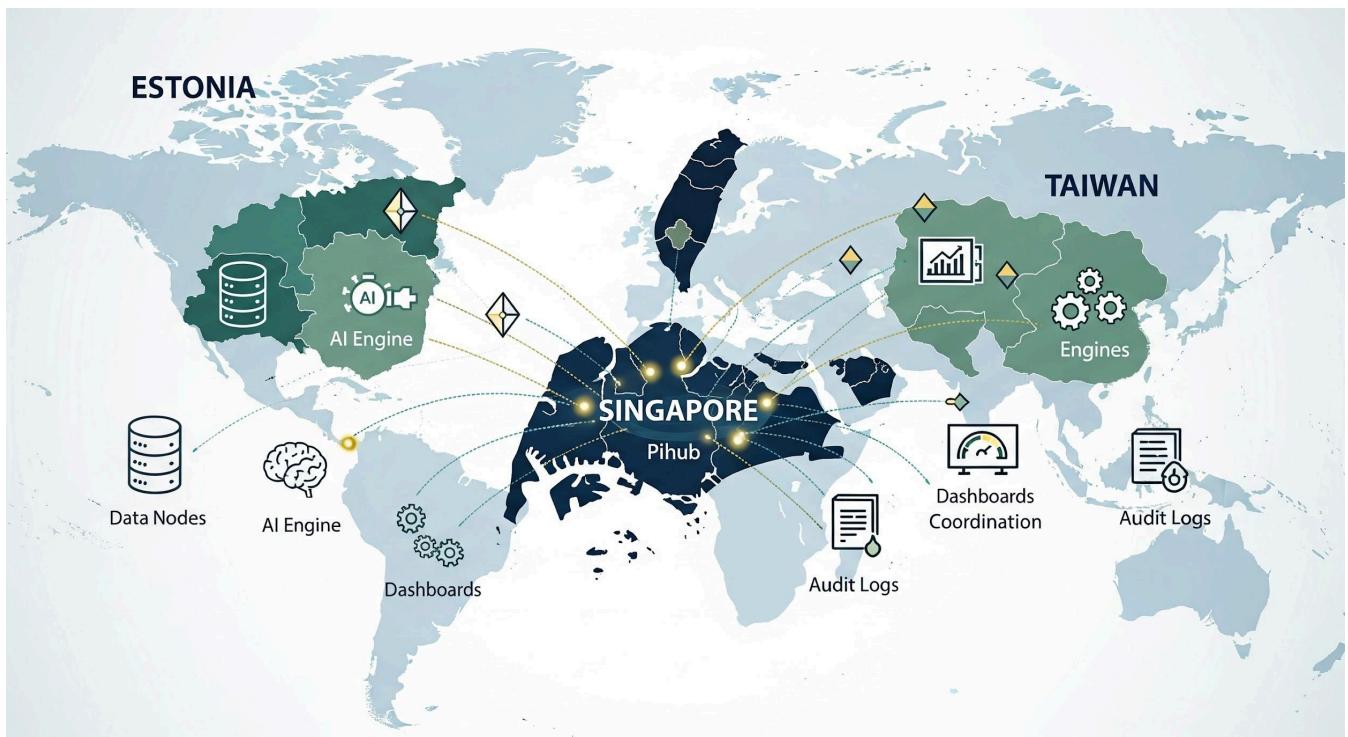


Figure F-4 / G-8: Boundary Rupture → Repair Cycle

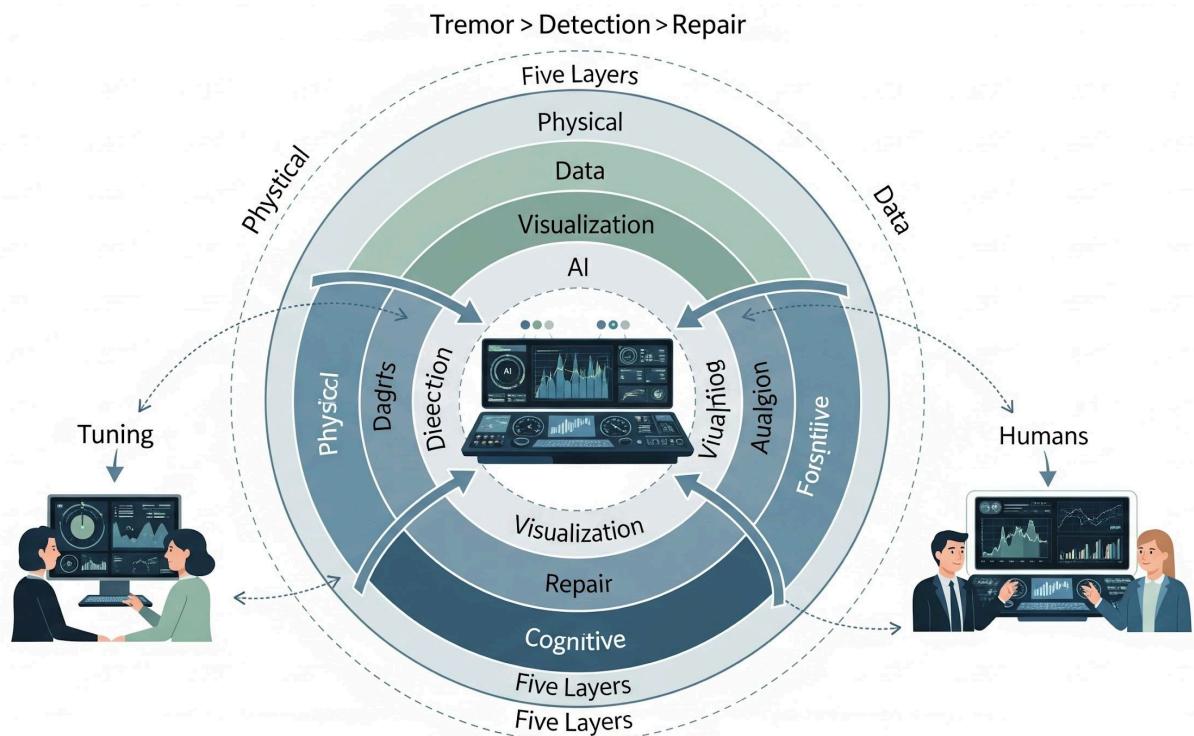


Figure F-4: Boundary State Machine

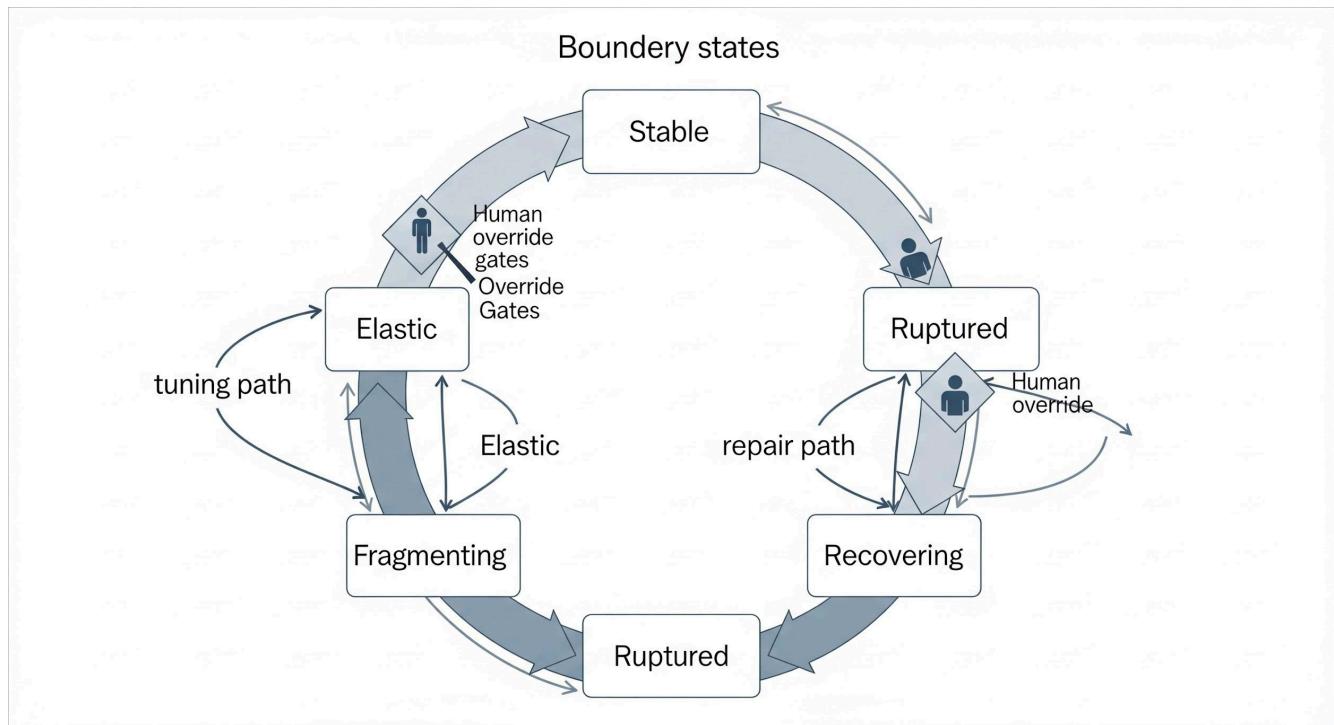


Figure F-9: Boundary Stability Index (BSI)

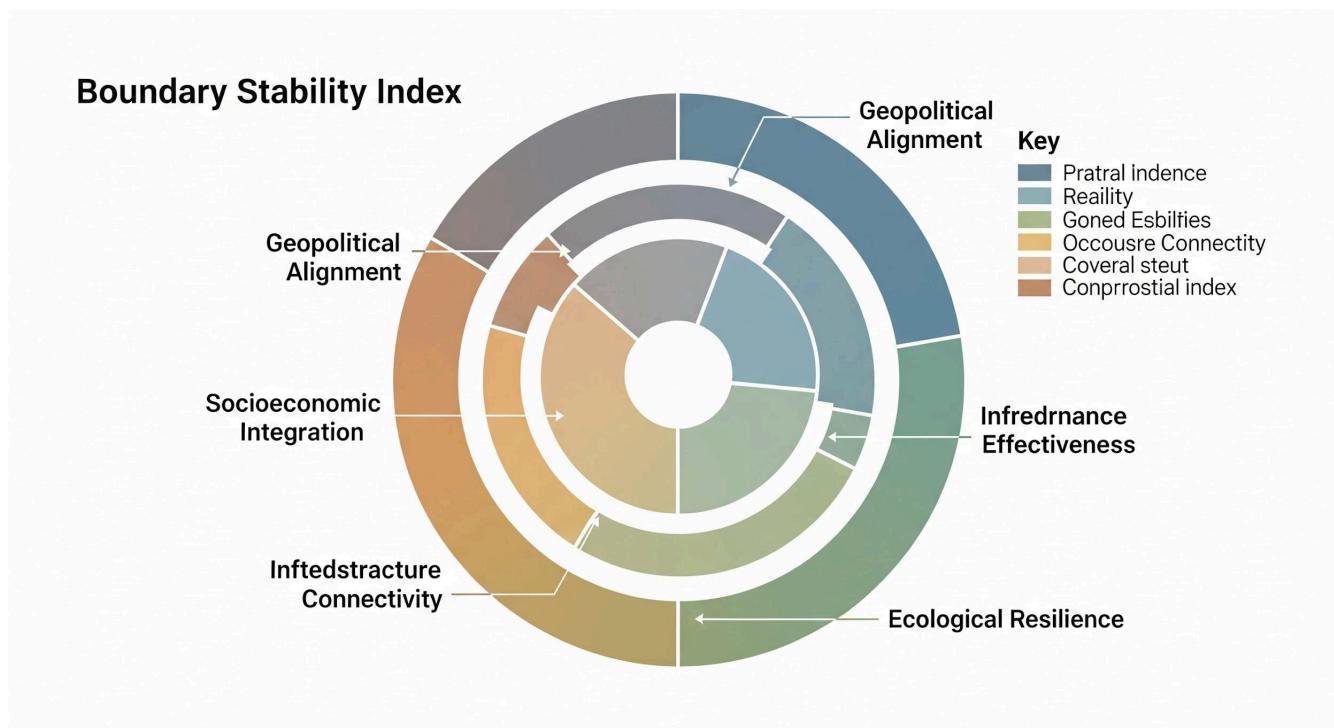


Figure F-1: Boundary OS Technical Stack

