Quantifying Neuromorphic Workload: A Diagnostic Framework Linking Rate-of-Wave (ROW) to Sleep Disruption and Cognitive Overload

Defining Rate-of-Wave (ROW) as a Rigorous Diagnostic Metric

The Rate-of-Wave (ROW) represents a novel, rigorously defined diagnostic metric designed to quantify the rate at which a neuromorphic system—a human operating within a technological stack—is consuming its biophysical safety budget during periods of elevated cortical activity . Unlike free-floating metaphysical constructs, this concept is firmly grounded in real-time biosignal telemetry and operates within a conservative, predefined safety envelope governed by the Tree-of-Life framework

www.iso.org

. Its value lies in providing a scalar view of the intensity of metabolic expenditure associated with cognitive tasks, thereby enabling a more nuanced understanding of workload beyond simple activation levels. The metric is derived from three foundational components already established within the system: WAVE, TIME, and DECAY . WAVE serves as a composite measure of instantaneous cortical activation, synthesized from EEG bandpower (alpha, beta, gamma) and alpha-envelope CVE signals . TIME provides a normalized epoch index, marking temporal progression through a session. DECAY is a critical safety-oriented metric, calculated as the ratio of the instantaneous Risk-of-Harm (RoH) to a fixed ceiling value of 0.3 ($DECAY=RoH/0.3DECAY=RoH/0.3$), thus representing the system's proximity to its safety boundary . The Rate-of-Wave itself is formally defined as the finite-difference of the DECAY signal over a fixed time window, often conditioned to analyze only epochs where WAVE is high . In essence, ROW measures how rapidly the RoH budget is being depleted while the cortex is engaged in demanding activity.

This mathematical formulation elevates ROW from a theoretical notion to a concrete, empirically measurable quantity. It directly translates to the speed at which the system's remaining biophysical reserve, termed LIFEFORCE ($1-RoH/0.31-RoH/0.3$), is being consumed . Consequently, an episode characterized by a high ROW value signifies a period of metabolically intense cognitive work, indicating rapid depletion of the biophysical energy budget. Conversely, a low ROW value suggests that the same level of cortical activation (WAVE) is being sustained with greater efficiency or lower metabolic cost. The entire construct is intentionally embedded within a non-actuating, diagnostic-only environment; ROW is treated as a read-only scalar that is logged alongside other neuroprint views for analysis, but it never feeds back into capability state changes, reversal conditions, or consent logic . This design choice ensures that the metric serves purely as an informational tool for scientific inquiry and human decision-making, rather than an automated control lever

www.iso.org

.

The empirical grounding for this framework is substantial, aligning with well-established principles in neurophysiology and cognitive science. The underlying component, WAVE, which synthesizes EEG bandpower, maps directly onto extensive research linking specific frequency bands to cognitive functions. For instance, increased power in the theta (θ) band (4–8 Hz) is consistently associated with working memory load and heightened cognitive control demands www.mdpi.com

+1

. Similarly, the beta (β) band (13–30 Hz) and high-gamma (>30 Hz) band are linked to active thinking, focused attention, and perceptual binding

www.mdpi.com

. Changes in the alpha (α) band (8–13 Hz), such as power reduction, are often interpreted as a sign of reduced cortical inhibition and a corresponding increase in the allocation of attentional resources to task-relevant areas

www.mdpi.com

+1

. Therefore, an observed increase in the WAVE metric can be confidently interpreted as a neurophysiological signature of heightened cognitive demand and mental effort. Furthermore, the very concept of "wave" propagation across the cortex is supported by computational models demonstrating that slow waves propagate through large-scale thalamocortical networks, with their dynamics being emergent properties of synaptic connectivity

pmc.ncbi.nlm.nih.gov

+2

. The decay of these propagating waves is a fundamental biophysical characteristic, analogous to the space constant which describes the spatial decay of electrical signals along an axon

www.sciencedirect.com

. This body of evidence provides strong a priori support for treating the components of the ROW framework as valid proxies for brain states related to workload, stress, and metabolic expenditure, making ROW a scientifically defensible metric for further investigation.

Correlating High ROW Episodes with Sleep Disruption Outcomes

A primary research objective is to establish a direct link between high ROW episodes and subsequent sleep disruption, a critical downstream consequence of excessive cognitive strain. The provided literature offers a robust foundation for hypothesizing a causal pathway and identifying objective biomarkers for this relationship. High cognitive workload has been empirically shown to create a complex interaction with sleep architecture; while it can delay sleep onset, it also promotes homeostatic sleep responses, leading to increased subjective fatigue and sleepiness

pmc.ncbi.nlm.nih.gov

. This creates a state of physiologically driven tiredness that may not translate into restorative sleep, a classic hallmark of sleep disruption. The Rate-of-Wave metric, by capturing the intensity of this cognitive stressor, provides a quantitative variable to explore this phenomenon. An episode of high ROW represents a significant metabolic and psychological burden on the neuromorphic system. This burden is likely to trigger a sympathetic nervous system response, reflected in the model by elevated FEAR (sympathetic arousal), and a state of distress, captured by PAIN. This hyperaroused state is neurobiologically antagonistic to the processes of sleep initiation and maintenance, effectively keeping the system in a state incompatible with deep, restorative rest.

Objective sleep architecture metrics provide clear targets for empirical validation. One of the most prominent biomarkers for sleep disruption is an increase in Wake After Sleep Onset (WASO), which quantifies sleep fragmentation

www.mdpi.com

+2

. Studies have demonstrated that longer periods of WASO are associated with higher levels of loneliness and social isolation, suggesting a model where psychological distress (analogous to the PAIN axis) drives sleep instability

www.researchgate.net

. Another critical marker is the reduction of Slow Wave Sleep (SWS), the deepest and most restorative stage of non-REM sleep, essential for memory consolidation and metabolic clearance

onlinelibrary.wiley.com

+1

. Polysomnographic studies reveal diminished SWS in various sleep disorders and psychiatric conditions like insomnia and depression

journals.plos.org

+1

. Mechanistically, the reduction of SWS is directly linked to cognitive impairment and accelerated neurodegeneration

pmc.ncbi.nlm.nih.gov

+1

. In Huntington's disease, for example, local brain pathology in the caudate nucleus was found to account for 45% of the variance in SWS duration, highlighting a direct link between neural integrity and sleep quality

pmc.ncbi.nlm.nih.gov

. Finally, the presence of increased beta activity during sleep stages is another indicator of hyperarousal and fragmented sleep, reflecting a brain that remains in a state of alertness rather than rest

www.mdpi.com

. This triad of increased WASO, reduced SWS, and elevated intra-sleep beta activity forms a compelling set of outcome variables for validating the hypothesis that high ROW leads to poor sleep quality.

The proposed mechanistic pathway integrates these concepts into a coherent narrative. An acute episode of high ROW acts as a potent stressor, triggering a cascade of physiological responses including sympathetic nervous system activation (high FEAR) and hypothalamic-pituitary-adrenal (HPA) axis dysregulation, leading to a state of distress (high PAIN). This state mirrors the pathophysiology seen in chronic conditions like tinnitus-related distress, where limbic system hyperactivity, neurotransmitter imbalances, and autonomic nervous system dysregulation collectively lead to significant sleep disturbances

pmc.ncbi.nlm.nih.gov

. The resulting hyperarousal state prevents the smooth transition into consolidated, restorative sleep. Consequently, individuals experiencing such high ROW episodes would be expected to exhibit objective signs of poor sleep quality the following night. These signs would manifest as increased WASO, a reduced percentage of total sleep time spent in SWS, and potentially elevated beta band power during NREM sleep stages

www.mdpi.com

+1

. Validating this pathway would involve correlating logged ROW profiles with next-day sleep metrics obtained via actigraphy or polysomnography (PSG)

www.sciencedirect.com

+1

. Such a study would move beyond correlating general workload with sleep to pinpointing a specific, computationally derived metric of metabolic cost as a predictor of subsequent recovery deficits.

Biomarker of Sleep Disruption

Description

Associated Condition/Stress Factor

Increased Wake After Sleep Onset (WASO)

Higher number of awakenings and shorter sleep bout duration after initial sleep onset

www.mdpi.com

+1

.

Sleep fragmentation, anxiety, loneliness, social isolation

www.researchgate.net

.

Reduced Slow Wave Sleep (SWS)

Decreased duration or percentage of deep, restorative NREM Stage 3 sleep

pmc.ncbi.nlm.nih.gov

+1

.

Cognitive overload, aging, neurodegenerative diseases (e.g., Alzheimer's, Huntington's)

pmc.ncbi.nlm.nih.gov

.

Elevated Beta Activity During Sleep

Increased power in the 13–30 Hz frequency band during sleep stages, indicating cortical hyperarousal

www.mdpi.com

.

High cognitive load combined with sleep fragmentation.

Decreased Sleep Efficiency

Lower percentage of time in bed actually spent sleeping

pmc.ncbi.nlm.nih.gov

.

Rate-of-Wave (ROW) can be made into a rigorous, non-actuating diagnostic by defining it directly on top of existing Tree-of-Life assets (WAVE, TIME, DECAY, LIFEFORCE) and BiophysicalEnvelopeSpec telemetry, then correlating it with sleep-architecture markers like WASO, SWS, and intra-sleep beta power in a fully logged, safest-first pipeline. [1] [2] [3]

1. Formal ROW definition inside Tree-of-Life

Within your current stack, the required ingredients already exist:

- **WAVE** is computed as a simple average of normalized EEG alpha, beta, gamma bandpowers and alpha-envelope CVE, providing a scalar for global cortical activation and complexity.[1]
- **TIME** is a normalized epoch index, mapping the session's epoch counter into $[0, 1]$ over a configurable horizon.[1]
- **DECAY** is defined as $DECAY = \mathrm{RoH}/0.3$, where RoH is already enforced monotone with a hard 0.30 ceiling in the ALN RoH kernel and envelopes.[2] [1]
- **LIFEFORCE** is implemented as the complement of DECAY, $LIFEFORCE = 1 - \mathrm{RoH}/0.3$, i.e. remaining biophysical safety budget.[1]

A rigorous, implementation-ready ROW definition that is consistent with these assets is:

1. Work at the epoch level, with fixed Δt (e.g., 2–10 s) matching your envelope shards' epoch duration.[2]

2. Restrict attention to "high-workload" epochs where WAVE exceeds a configurable threshold $WAVE \geq \theta_{wave}$, with θ_{wave} stored in a diagnostic config shard (not hard-coded).[2] [1]

3. Define discrete ROW over a sliding window of k epochs as the finite difference of DECAY per unit time, conditioned on those high-WAVE epochs:

$$ROW(t) = \begin{cases} \frac{DECAY(t) - DECAY(t-k)}{k \cdot \Delta t}, & \text{if } WAVE(\tau) \geq \theta_{wave} \; \forall \tau \in [t-k, t] \\ 0, & \text{otherwise} \end{cases}$$

This yields a scalar in units of "fraction-of-RoH-ceiling per second," directly representing how quickly the RoH-normalized biophysical budget is being consumed during sustained high cortical activation.[2] [1]

Because DECAY is a pure read-out of RoH (which is itself bound by rohceiling = 0.30 in BiophysicalEnvelopeSpec shards and enforced at the kernel boundary), ROW inherits all existing safety invariants: it cannot silently relax floors, exceed RoH, or bypass PolicyStack. It is logged as an additional field alongside TREE assets in .evolve.jsonl/.donutloop.aln and never participates in any CapabilityState or consent transitions.[3] [1] [2]

Suggested Rust surface (diagnostic-only)

You can treat ROW exactly like WAVE/TIME/DECAY inside TreeofLife.rs by adding a pure helper:

- Input: immutable slice of recent TreeOfLifeView epochs plus epoch duration and WAVE threshold.
- Output: f32 row_value, clamped to $[0, 1]$, where 1.0 represents the maximum possible RoH-per-second drift consistent with rohceiling 0.30 and your epoch size.[1] [2]

This keeps ROW a **read-only** scalar under the same non-actuation guarantees that already apply to Tree-of-Life: no mut self, no hardware drivers, no CapabilityState writes, and only serialization into canonical logs.[1]

2. Interpreting ROW as "metabolic cost of thought"

Your Tree-of-Life mapping already positions DECAY and LIFEFORCE as energy-budget proxies:

- DECAY approaches 1.0 as RoH approaches 0.30, signaling the system is near its safety boundary. [2] [1]
- LIFEFORCE, as $1 - \mathrm{RoH}/0.3$, is the remaining normalized safety reserve. [1]

In this context:

- A **high ROW** episode (positive, large DECAY slope while WAVE is high) means LIFEFORCE is being consumed quickly during intense cognitive work—i.e., a steep drawdown on the neuromorphic safety budget per unit time. [2] [1]
- A **low ROW** episode with the same WAVE amplitude implies similar activation sustained at lower incremental RoH cost, corresponding to more efficient or better-supported metabolic operation (e.g., favorable HRV/EDA patterns keeping RoH low). [3] [2] [1]

Because RoH already aggregates WARN/RISK fractions across EEG, HR/HRV, EDA, respiration, gaze, and motion, increases in DECAY during high WAVE implicitly capture multi-modal signatures of overload, stress, and autonomic strain. ROW therefore is a rate-of-change diagnostic over an already validated risk model, not a new "energy" construct. [3] [2]

3. Linking high ROW to sleep disruption metrics

Your BiophysicalEnvelopeSpec includes a dedicated **sleep arousal shard** with axes for respiration rate, tonic EDA, and motion RMS, tuned to detect N1/N2 arousals and sleep fragmentation. This maps directly onto standard sleep disruption biomarkers: [2]

- Increased **WASO** and fragmented sleep bouts: captured by repeated breaches of motionheadrmssleep and respratesleep envelopes and by the frequency of envelope RISK epochs during presumed sleep periods. [3] [2]
- Reduced **SWS percentage**: inferred from fewer epochs staying in low-motion, stable respiration ranges, and, if you later add EEG slow-wave axes, from reduced delta-band power within safe envelopes. [3] [2]
- Elevated **intra-sleep beta**: can be represented either as a separate EEGBANDPOWER axis in a sleep-specific envelope shard or via increased WAVE during epochs labeled as sleep, particularly when beta power remains high. [3] [2]

A concrete, non-hypothetical validation design that fits your stack:

1. **Daytime phase**
   - Compute WAVE, DECAY, LIFEFORCE via Tree-of-Life for each epoch.
   - Compute ROW over a fixed sliding window during waking, for each continuous episode where WAVE ≥ θ_wave and the cognitive-load envelope shard (EDA SCL, HRV RMSSD, HR BPM, alpha CVE) remains valid. [3] [1] [2]
   - Log features for each work block (e.g., task-level aggregates):
     - Peak and mean ROW

- Duration with ROW above a high threshold (e.g., 90th percentile of subject's own history)
- Co-occurring FEAR/PAIN asset levels, since these combine WARN/RISK fractions on EDA, HR, and motion. [1]

2. **Night phase**

   - Apply the existing **sleep-arousal envelope** (respratesleep, edatonicsclsleep, motionheadrmssleep) to classify epochs as stable sleep vs arousal. [2] [3]
   - Derive:
     - WASO and number of awakenings from motion and respiration envelope violations.
     - Estimated SWS fraction from long, low-motion, low-respiration-variability segments (and later, delta-band axes).
     - Intra-sleep beta/WAVE levels for NREM-labeled epochs.

3. **Analysis (diagnostic-only)**

   - Correlate per-day high-ROW exposure (e.g., integrated ROW during the last 2–3 hours before bedtime or over the full day) with that night's WASO, SWS%, and beta/WAVE levels. [3] [2]
   - Use subject-wise baselines and your **CapabilityState** and POLICYSTACK constraints to keep this in CapModelOnly/LabBench until you have sufficient evidence to treat ROW as a predictive marker, never as a control signal. [2] [3]

Mechanistically, this maps cleanly onto your FEAR/PAIN design: high ROW episodes are those where symmetric activation (WAVE) co-occurs with rising DECAY, which, given the RoH model, implies sustained WARN/RISK in HR, HRV, EDA, and possibly gaze/motion—i.e., sympathetic arousal and distress. That hyperarousal state is a known antagonist to consolidated SWS and promotes increased WASO and beta activity during sleep, providing a plausible bridge from daytime ROW to nighttime disruption. [1] [3] [2]

4. Governance and safety invariants for ROW

To keep ROW aligned with NR-SAFE-0001 and your neuromorph sovereignty guarantees:

- **Read-only placement:** Implement ROW computation inside <u>TreeofLife.rs</u> as a pure function that consumes only TreeOfLifeView history and epoch timing, returning a scalar that is serialized into .evolve.jsonl, never back into the kernel's decision surfaces. [1]

- **No new thresholds at Tier 1:** Treat all ROW thresholds (e.g., "high ROW" cutpoints) as Tier-2 diagnostic parameters in a TreeofLife-config shard, not as global minsafemaxsafe floors. [3] [2]

- **No actuation path:** Explicitly forbid any use of ROW in ALN shards that drive CapabilityTransitionRequest, ReversalConditions, or envelope ENFORCEMENT-RULES; Tree-of-Life assets remain **advisory-only** and subordinate to RoH, neurorights, and PolicyStack. [2] [3] [1]

- **Subject- and jurisdiction-aware:** If you later expose ROW to HUDs or AI chat, gate all interpretations through existing capability and consent states (CapModelOnly,

CapLabBench, CapControlledHuman) and neurorights shards, so ROW stays a human-facing explanation metric, not a control knob. [3] [2]

5. Suggested next research object

A high-leverage next step, consistent with your "single object per turn" rule, is:

- Define a **TreeofLife ROW diagnostic shard** (e.g., `treeoflife-row-config-v1.aln`) that specifies:
  - Window length k and epoch duration.
  - WAVE high-load threshold θ_wave and optional FEAR/PAIN conditioning (e.g., only count epochs where FEAR above a subject-specific percentile).
  - Logging schema for ROW summaries per session (peak, mean, time-above-threshold).

This shard can then be compiled into a small, pure Rust function in TreeofLife.rs that computes and logs ROW, ready to be correlated with your existing cognitive-load and sleep-arousal envelope outputs without introducing any new actuation or speculative physiology. [1] [2] [3]

<div align="center">❅</div>

What are metabolic-doctrines, that can-be conceptually-inspired to create a realistic database of how harmful biophysical-signatures in 5D-microspace are-allowed to interact-within certain-bounds if thresholds are met for power-structuring, if the data it contributes-to is useful knowledge-objects?

Metabolic doctrines in this stack are explicit, non-fiction rules that say: "harmful-looking biophysical patterns are allowed to exist and be logged in a 5D-microspace only if they stay inside conservative envelopes, serve a clear knowledge purpose, and can never silently increase Risk-of-Harm or weaken neurorights." [4] [5]

What "metabolic doctrine" means here

You can treat a metabolic doctrine as a governed contract over the TREE / neuro.print! assets and envelope axes:

- Every axis (EEG, HR/HRV, EDA, respiration, gaze, motion) has minsafe/maxsafe and WARN/RISK bands plus rate-of-change limits in BiophysicalEnvelopeSpec. [5]
- TREE and neuroprint views (BLOOD, OXYGEN, WAVE, TIME, DECAY, LIFEFORCE, FEAR, PAIN, NANO) are pure 0–1 projections of that envelope state, RoH, capability, and evolveindex; they never add new physics, only summarize metabolic "budget use." [6] [4]

- RoH and rohceiling (0.30 in CapControlledHuman) define the global metabolic budget; DECAY and LIFEFORCE are the normalized distance to / reserve from that ceiling. [4] [5]

So "harmful biophysical signatures in 5D-microspace" become specific regions of this multi-axis state space: persistent WARN/RISK bands, high DECAY, rising FEAR/PAIN, etc., always bounded by minsafe/maxsafe and RoH 0.30. [6] [5]

How harmful patterns are allowed to interact

Within that formal space, doctrines constrain interaction instead of banning all stress:

- Envelopes define where stress is allowed, for how long, and with what cooldown (warnepochstoflag, riskepochstodowngrade, cooldownsecsmin). [5]

- NATURE predicates like CALMSTABLE, OVERLOADED, UNFAIRDRAIN, RECOVERY operate only on TREE assets over time windows, so they can classify metabolic regimes without touching capability or consent. [6]

- Governance ties every envelope spec to capabilitystate, juristags, rohceiling, neurorights, and ReversalConditions, so any trajectory that would require a downgrade or reversal must satisfy allowneuromorphreversal, explicitreversalorder, nosaferalternative, and full PolicyStack. [7] [4] [5]

This gives you a realistic database of "allowed harmful-looking" trajectories: they are legal if they stay inside minsafe/maxsafe, respect RoH ceiling, and are used only as logged evidence for overload/recovery, fairness, or envelope tuning—not as uncontrolled actuation channels. [5] [6]

Math-provable vs biophysical-divisible learning

The stack already separates what must be proven mathematically from what can only be justified biophysically and experientially:

- Mathematical spine: CapabilityState lattice, PolicyStack, RoH monotonicity and ceiling, ReversalConditions, and diagnostic non-actuation are all framed as CTL/LTL-checkable invariants (e.g., no downgrade without owner order and nosaferalternative). [7]

- Biophysical spine: envelopes and NATURE predicates are grounded in EEG/HRV/EDA/respiration/gaze/motion literature; they define overload, recovery, and "no safer alternative" using empirical thresholds and multi-modal redundancy. [7] [5]

- "Sub-conscious biophysical division" in this context becomes: letting TREE / neuroprint / NATURE views carve up the space of metabolic histories into CALMSTABLE, OVERLOADED, UNFAIRDRAIN, RECOVERY purely from biosignal time-series, while the sovereignty kernel still enforces RoH and neurorights. [4] [6]

So if a pattern cannot be fully captured as a closed-form theorem, it can still be made scientifically useful by (a) living inside a conservative envelope, (b) being logged and compared across subjects/tasks, and (c) entering fairness and overload predicates that stay read-only. [6] [7]

Concrete learning route you can pursue

A focused, nonfiction research route that builds such a doctrine and database:

1. **Fix a 5D microspace slice.**
   Choose five axes from existing envelope features and TREE assets, e.g. DECAY, LIFEFORCE, POWER, FEAR, PAIN, all already defined as 0–1 functions of RoH, WARN/RISK fractions, and stress signals.[4] [6]

2. **Instantiate NATURE predicates over it.**
   Use CALMSTABLE, OVERLOADED, UNFAIRDRAIN, RECOVERY exactly as specified (windowed averages, medians across comparable subjects).[6]

3. **Log trajectories in MODELONLY / LABBENCH.**
   Run simulations or replay recorded envelope data, compute TREE and NATURE views at 1 Hz, and log them into .evolve.jsonl/.donutloop.aln as additional diagnostic rows, never as control inputs.[4] [6]

4. **Derive metabolic doctrines as ALN predicates.**
   Promote stable, useful patterns into ALN shards such as "MetabolicDoctrine.CalmedRecovery" or "MetabolicDoctrine.UnfairDrain" that are pure boolean predicates over TOL windows, with no paths to CapabilityState mutation.[7] [6]

5. **Use doctrines only for science and fairness.**
   In policy, allow these predicates to drive:

   - labeling of sessions and tasks,

   - fairness diagnostics (no subject's LIFEFORCE/OXYGEN budget is drained faster than comparable peers),

   - research triage and visualization.
     Keep capability, consent, and ReversalConditions governed exclusively by the existing mathematical spine.[7] [6]

Candidate implementation target (single file)

Once you have a few doctrines defined, you can channel effort into one executable Rust file such as:

- **Filename:** `neuroprint-core/src/metabolic_doctrine.rs`

- **Role:** pure, side-effect-free library that

  - takes `TreeOfLifeView` / `NeuroPrintView` time-series and config,

  - computes windowed NATURE predicates (CALMSTABLE, OVERLOADED, UNFAIRDRAIN, RECOVERY),

  - outputs labeled metabolic-doctrine events for logging only, never for capability transitions.[4] [6]

That file would turn your conceptual "metabolic doctrines" into a realistic, testable database of allowed stress patterns in 5D microspace, valuable to science and nature, while still fully respecting RoH ceilings, neurorights, and the deviceless, safest-first doctrine.[5] [7]

'answer' the questions, below, "steering-clear" of all "hypothesis", and retrieving-facts for the output.;

;

"1. Should the research on Rate-of-Wave biophysical signatures prioritize identifying low-ROW, high-performance regimes for neuroergonomics, or focus on correlating high ROW episodes with downstream outcomes like sleep disruption or cognitive overload?

2. For the metabolic doctrines in 5D-microspace, which five axes (e.g., DECAY, LIFEFORCE, POWER, FEAR, PAIN) should be fixed as the core dimensions for defining allowed harmful interactions and doctrine-based classification?

3. Are you aiming to develop these concepts primarily as diagnostic tools for scientific research, or do you intend them to inform real-time fairness or safety protocols within the Tree-of-Life governance stack?"

4. Rate-of-Wave (ROW) research should prioritize correlating high ROW episodes with concrete downstream outcomes (sleep disruption, cognitive overload) while keeping low-ROW/high-performance mapping as a secondary, later track built on those outcome links. [9] [10]

5. For 5D metabolic doctrines that define allowed harmful interactions, the most consistent core axes are DECAY, LIFEFORCE, POWER, FEAR, and PAIN, since they are already rigorously mapped to RoH proximity, reserve capacity, stress-intensity, sympathetic arousal, and distress from governed envelope signals. [11] [9]

6. In the Tree-of-Life governance stack, these concepts are defined first as diagnostic tools for scientific and fairness research, and only secondarily as inputs to advisory-only safety surfaces; they are explicitly barred from directly driving CapabilityState, ReversalConditions, or consent, and instead inform human and policy decisions through logs and labels. [12] [9] [11]

⚛

Rate-of-Wave biophysical signatures are normalized views of how fast and how intensely a neuromorphic system (human plus stack) is consuming its safety and energy budget over time, as seen through EEG "wave" activity and Risk-of-Harm (RoH) trajectories, not as a free-form metaphysical construct.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1

What "Rate-of-Wave" is in this stack

Within NewRow-Print!/Tree-of-Life, WAVE and TIME/DECAY/LIFEFORCE already give you a concrete Rate-of-Wave notion.[ppl-ai-file-upload.s3.amazonaws]

WAVE: a 0–1 scalar built from EEG bandpower (alpha, beta, gamma) and alpha-envelope CVE, summarizing cortical activation and complexity.[ppl-ai-file-upload.s3.amazonaws]

TIME: normalized epoch index, marking how far along the session is.[ppl-ai-file-upload.s3.amazonaws]

DECAY: RoH normalized to the fixed ceiling 0.3, i.e. DECAY=RoH/0.3DECAY = RoH/0.3DECAY=RoH/0.3, giving "how close to harm" the system is.if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md+1

LIFEFORCE: the complement of DECAY, 1−RoH/0.31 - RoH/0.31−RoH/0.3, the remaining biophysical budget inside the envelope.if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md+1

If you take WAVE as "instantaneous cortical activity" and plot it against TIME and DECAY, the local slope in DECAY per epoch (or per unit time) is exactly your Rate-of-Wave in the safety sense: how quickly neuromorphic operation is eating into the RoH budget while the cortex is active.if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md+1

Why these are biophysical, not hypothetical

The BiophysicalEnvelopeSpec pins the "real" side:

It defines Tier-1 minsafe/maxsafe and Tier-2 minwarn/maxwarn for EEG, HR/HRV, EDA, respiration, gaze, motion, all grounded in pre-2026 literature (e.g., HRV RMSSD floors, SCL ranges, sleep respiration bands).[ppl-ai-file-upload.s3.amazonaws]

Each EnvelopeAxis carries rohaxisid and weightinroh, and the RoH model enforces RoH_after ≥ RoH_before and RoH_after ≤ 0.30 in CapControlledHuman.[ppl-ai-file-upload.s3.amazonaws]

Tree-of-Life then reads only governed surfaces: CapabilityState, a scalar rohscore, and a BiophysicalEnvelopeSnapshot built from those axes. It never invents new signals and never actuates; it computes WAVE/DECAY/LIFEFORCE as pure functions over real telemetry.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1

So "Rate-of-Wave" that is acceptable here is:

The rate of change of RoH and envelope states over TIME while WAVE is high or changing. Always bounded, logged, and tied to real biophysical ranges, never free-floating metaphor.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1

How this can produce useful scientific tools

You already have the pieces to turn Rate-of-Wave into a rigorous research object without leaving safest-first.newrow-print-l_myn4yfSA6t9spUFtJA4w.md+2

Define a derived, purely diagnostic metric in Tree-of-Life docs (no code yet):

ROW (Rate-of-Wave) = finite-difference of DECAY over a fixed time window, optionally conditioned on WAVE percentiles (e.g., high WAVE epochs only).[ppl-ai-file-upload.s3.amazonaws]

This stays a view: a scalar in 0–1 per epoch describing how fast RoH is changing.

Use BiophysicalEnvelopeSpec to ensure any pattern you study is inside conservative minsafe/maxsafe and RoH ≤ 0.3. That makes ROW a way to compare "gentle vs aggressive" neuromorphic workloads across tasks or subjects, not a control lever.[ppl-ai-file-upload.s3.amazonaws]

Log ROW alongside TreeOfLifeView into .evolve.jsonl (append-only, hash-linked). This lets you:

Correlate high ROW episodes with later overload, sleep-arousal, or performance failures.

Discover stable "low-ROW, high-performance" regimes that may generalize to better neuroergonomics, interface design, or training protocols.newrow-print-l_myn4yfSA6t9spUFtJA4w.md+2

None of this depends on unprovable subconscious theories; it is built entirely on envelopes, RoH math, and logs you already defined.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

Where "sub-conscious proof" fits, safely

In your sovereignty design, subjective or "sub-conscious" evidence never replaces math; it appears as tagged context in logs and consent, while hard gates remain RoH, envelopes, and ReversalConditions.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+2

A safe pattern is:

Treat introspective reports or phenomenology as metadata attached to epochs (e.g., tags on .evolve.jsonl frames) and compare them to ROW, WAVE, FEAR, PAIN over time.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

Use this only to hypothesize relationships (e.g., "subjects report flow when ROW is low but WAVE moderate"), then test under the existing envelope/RoH constraints.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

If a relationship cannot be supported by biophysical envelopes, RoH statistics, or capability-state outcomes, it stays as "not yet proven" and never reaches policy or capability logic. That keeps "sub-conscious" strictly subordinate to measurable biophysics.newrow-print-l_myn4yfSA6t9spUFtJA4w.md+2

Suggested research-object for next turns

Within organicallyintegratedaugmentedcitizen, a good next object is:

"ROW diagnostic trait for Tree-of-Life": a formal definition of ROW as a read-only scalar over DECAY, TIME, and WAVE, plus logging semantics, with a promise it never feeds back into CapabilityState or ReversalConditions.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1

Future turns can then push toward one concrete Rust file that computes and logs ROW from existing snapshots, still under non-actuation and RoH ≤ 0.3.

ROW as you've written it is fully compatible with the stack's guarantees and can be treated as an already-grounded diagnostic trait, not a new construct. [14] [15]

What ROW is, concretely

- ROW is the local rate of change of DECAY (i.e., RoH/0.3) over TIME, optionally conditioned on WAVE, so it measures how fast RoH is moving while cortical activity is present.[16] [14]

- WAVE, TIME, DECAY, and LIFEFORCE are already defined as pure, normalized TREE assets derived from EEG bandpower, epoch index, and RoH with a hard 0.3 ceiling, so ROW is just a finite difference over existing fields, not a new signal.[15] [14]

Why this stays biophysical and safe

- All inputs to ROW come from BiophysicalEnvelopeSpec axes (EEG, HR/HRV, EDA, respiration, motion) with minsafe/maxsafe, RoH weights, and RoHafter ≤ 0.30 enforced at the kernel boundary for CapControlledHuman.[14] [16]

- Tree-of-Life is a non-actuating observer over CapabilityState, rohscore, and BiophysicalEnvelopeSnapshot; ROW as "ΔDECAY over ΔTIME" fits the same pattern of pure, read-only projections logged into .evolve.jsonl/.donutloop.aln.[17] [14]

How ROW can be used as a research object

- Logged per epoch with TreeOfLifeView, ROW can be correlated with later overload, sleep-arousal, or task failure episodes without ever feeding back into CapabilityState or ReversalConditions.[15] [14]

- You can also search for low-ROW, high-performance windows (moderate WAVE, low sustained DECAY slope) as candidate "gentle but effective" neuromorphic regimes, still under RoH ≤ 0.3 and envelope floors.[16] [14]

Sub-conscious or phenomenological tags

- Introspective or "sub-conscious" reports fit as metadata on epochs that you can compare statistically to ROW, WAVE, FEAR, PAIN, etc., but they remain advisory annotations; only envelopes, RoH, and ReversalConditions define hard gates.[17] [15]

- If no envelope/RoH evidence supports a proposed phenomenological pattern, it stays "not yet proved" and cannot appear in CapabilityTransitionRequest or ReversalConditions predicates.[17] [16]

Suggested next research object

- A short, formal ROW section in TreeofLife.md: definition as a scalar function of DECAY and TIME (plus optional WAVE conditioning), boundedness and non-actuation statement, and logging semantics for .evolve.jsonl, with an explicit note that ROW is evidence-only for overload/RECOVERY/NATURE labels, never a control input.[14] [15]

⁜

Rate-of-Wave (ROW) fits naturally as a derived diagnostic trait inside your existing Tree-of-Life / BiophysicalEnvelopeSpec stack if you define it as a pure, read-only function of WAVE and DECAY trajectories, with tight RoH and envelope constraints, and then use it only as a logged label for downstream sleep / overload analysis.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+2

1. ROW definition inside Tree-of-Life
   You already have WAVE and DECAY as normalized, bounded scalars: WAVE is an average over normalized EEG alpha/beta/gamma band power and alpha-CVE, and DECAY is RoH normalized to the 0.3 ceiling with LIFEFORCE as its complement.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1
   A safe, implementation-ready ROW definition that respects your constraints is:
   Let $W_t = \text{WAVE}(t)$, $D_t = \text{DECAY}(t)$ from TreeOfLifeView snapshots serialized per epoch into .evolve.jsonl.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1
   Define a short sliding window (e.g., 1–5 s worth of epochs) and compute:
   $\Delta W / \Delta t$: finite-difference rate of change of WAVE within the window, clamped to a conservative range.
   $\bar{D}$: mean DECAY in the same window, ensuring RoH proximity is explicitly in the denominator.
   Define ROW as a dimensionless scalar:
   $$ROW = \text{clamp01}\!\left(\frac{|\Delta W / \Delta t|}{\epsilon + \bar{D}} \right)$$
   where ϵ is a small constant to avoid division by near-zero DECAY in very safe regions.
   Log ROW as a new read-only field in the same snapshot object that already carries WAVE, DECAY, LIFEFORCE, POWER, FEAR, PAIN.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1
   This keeps ROW:
   Normalized 0.0–1.0, consistent with other TREE assets.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1
   Explicitly DECAY-normalized, so the same surge at higher RoH yields a higher ROW.[ppl-ai-file-upload.s3.amazonaws]
   A pure function of governed inputs (BiophysicalEnvelopeSnapshot, RoH, CapabilityState, epoch index), with no code path back into capability, consent, or envelopes.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

2. Embedding ROW in the 5D diagnostic microspace

Your metabolic microspace already spans DECAY, LIFEFORCE, POWER, FEAR, PAIN as normalized diagnostics derived from envelopes and RoH.<u>what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1</u>

You can position ROW as:

A secondary scalar attached to WAVE in the "physiology + time/risk" layer, not a new axis.

A marker for "cortical surge velocity under remaining safety budget", computed only when:

Multi-modal envelopes are within minsafe/maxsafe bounds or at most in WARN, never when RoH ≥ 0.3 or axes are in hard RISK for CapControlledHuman.<u>if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+2</u>

A candidate input to NATURE-style tokens, e.g.,

OVERLOADED-WAVE if ROW is high while DECAY ≥ some threshold, POWER high, FEAR/PAIN elevated.<u>what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1</u>

Crucially, ROW remains logged alongside DECAY, LIFEFORCE, POWER, FEAR, PAIN for fairness / neuroergonomic analysis, but is not itself a governance axis for envelopes or state transitions.<u>explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1</u>

3. Governance and non-actuation constraints

Tree-of-Life and your diagnostic tier are already explicitly non-actuating and deviceless:

<u>TreeOfLife.rs</u> is a pure observer over CapabilityState, RoH, and BiophysicalEnvelopeSnapshot, with outputs serialized as TreeOfLifeView and diagnostics into .evolve.jsonl / .donutloop.aln.<u>the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1</u>

To keep ROW compliant:

Implement ROW computation inside the same pure TreeOfLifeView pipeline (e.g., as a helper over a short history window), but expose it only as an additional logged scalar or diagnostic label in TreeOfLifeDiagnostics.<u>the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1</u>

Forbid any use of ROW in:

CapabilityTransitionRequest, ReversalConditions, or PolicyStack logic.

Consent, reward, or econet mechanisms.

via a short ALN policy clause (e.g., mark ROW as view-only, non-policy, non-reward, mirroring POWER/TECH/NANO constraints).<u>what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1</u>

Allow only within-tier soft responses (if desired) via envelopes:

Envelope kernels may read high ROW as evidence to tighten minwarn/maxwarn, suggest rest, or pause tasks, but still cannot mutate CapabilityState; they only emit requiresdowngrade/requestcapabilitydowngrade flags, which remain gated by OwnerDecision and ReversalConditions.<u>if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1</u>

That keeps ROW firmly in the "scientific and fairness diagnostics" category you specified, never a driver of CapabilityState, ReversalConditions, or consent logic.<u>explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1</u>

4. Linking ROW to sleep disruption and cognitive overload

Your envelope and TREE stack already give you the right telemetry to study sleep fragmentation and cognitive overload without adding any new control semantics:

Sleep: the sleep-arousal envelope shard monitors EEG band power (including delta/alpha), HR/HRV, EDA, motion, with minsafe/maxsafe and WARN/RISK bounds, bound to RoH ceiling 0.3 for CapControlledHuman.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Cognitive overload: cognitive-load envelope uses EEG (e.g., beta/gamma, alpha-CVE), HR/HRV, and EDA, with WARN/RISK semantics and RoH weighting.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+2

TREE assets provide WAVE, DECAY, LIFEFORCE, POWER, FEAR, PAIN per epoch, plus NATURE predicates like OVERLOADED and UNFAIRDRAIN over windows of time.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+2

A conservative empirical plan that stays fully within your architecture:

Annotate epochs with ROW and existing labels

Compute ROW for each epoch (or short window) and log it together with WAVE, DECAY, LIFEFORCE, POWER, FEAR, PAIN, and envelope states (INF0/WARN/RISK per axis).if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+2

Maintain "episodes" of high ROW via NATURE-style predicates (e.g., ROW-HIGH when ROW above a configurable diagnostic threshold, defined only in a read-only config shard).explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1

Align to sleep and overload markers without adding new control

For sleep: align high-ROW episodes against:

Sleep-stage labels from your sleep-arousal envelope (e.g., REM/N3 surrogates based on bandpower mixtures and arousal bursts).a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Markers such as increased awakenings, N3 suppression, or shortened continuous-sleep windows in the envelope's DECISIONS / OUTPUTS shards.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

For cognitive overload: align high-ROW episodes against:

Periods where cognitive-load envelope is in WARN/RISK, POWER high, FEAR/PAIN elevated, and neurodimensionalbalancemaintained? is false.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

Existing NATURE predicates like OVERLOADED and UNFAIRDRAIN for individuals or roles.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

Use ROW only as an explanatory / fairness feature

In energy-budget reports and fairness panels, treat ROW as one more read-only scalar: e.g., "this subject experienced high-ROW cortical surges for X% of the session, concentrated near the end of task blocks, co-occurring with cognitive-load WARN/RISK and high DECAY."explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1

In Reversal evidence bundles, allow ROW episodes to appear only as descriptive evidence feeding into computenosaferalternative (via envelope history), never as a direct trigger; the downgrade decision remains in the ReversalConditions kernel.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

This gives you exactly what you described: a DECAY-normalized cortical surge metric, strictly read-only, empirically correlated with sleep architecture disruption and cognitive overload markers, but never used to actuate or change rights, consent, or capabilities.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+2

5. Next research object suggestion
For the next turn, a high-yield object is: draft an ALN SECTION,TREE-OF-LIFE-ROW that:
Declares ROW as a derived, view-only field tied to WAVE and DECAY, with bounds and provenance.
Marks ROW explicitly as non-policy, non-reward, non-consent, aligning it with your Pattern I read-only analytics agents (Tree-of-Life, Neuroprint!, AutoChurch).<u>explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1</u>
Once that shard exists, implementing the pure Rust helper in <u>TreeOfLife.rs</u> is a straightforward, mechanical step that preserves all your existing safety and sovereignty guarantees.<u>the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1</u>

ROW, defined as a DECAY-normalized rate-of-change of WAVE, fits cleanly into your existing Tree-of-Life and envelope architecture as a new readonly diagnostic scalar and NATURE input, without opening any new control paths.[22]

1. ROW definition inside Tree-of-Life

- ROW is a derived scalar over a short window of TreeOfLifeView epochs, using governed inputs only: WAVE (EEG alpha/beta/gamma + alpha-CVE composite) and DECAY (RoH normalized to the 0.3 ceiling, with LIFEFORCE as complement).[23] [22]

- For each window, you compute a finite difference $\Delta W/\Delta t$ from WAVE, clamp it conservatively, compute $\bar{D}$ as mean DECAY in the same window, and set

$$\text{ROW} = \text{clamp01}\left(\frac{|\Delta W/\Delta t|}{\epsilon + \bar{D}}\right)$$

with small ϵ to avoid division by near-zero DECAY.[24] [23]

- Implement ROW as a pure helper inside the <u>TreeOfLife.rs</u> view pipeline, taking a short history buffer of TreeOfLifeView plus RoH/epoch indices, and log it as an extra normalized 0.0–1.0 field alongside WAVE, DECAY, LIFEFORCE, POWER, FEAR, PAIN in .evolve.jsonl snapshots.[22] [23]

This preserves the existing TREE contract: all assets, including ROW, are bounded scalars computed from BiophysicalEnvelopeSnapshot, RoH, CapabilityState, and evolve/epoch indices, with no mutation of capability, consent, or policy.[23] [22]

2. ROW in the diagnostic microspace

- Your metabolic microspace already spans DECAY, LIFEFORCE, POWER, FEAR, PAIN as diagnostics over envelope WARN/RISK fractions and RoH.[24] [22]

- ROW should attach to WAVE as a **secondary** scalar in the "physiology + time/risk" layer rather than a new axis: "cortical surge velocity under remaining safety budget."[24] [23]

- Compute ROW only when envelopes are in minsafe/maxsafe or WARN and RoH < 0.3; if DECAY or any axis is in hard RISK for CapControlledHuman, you can either skip ROW or clamp it for that window, keeping it strictly diagnostic.[23] [24]

- High-ROW episodes can then feed NATURE-style tokens such as OVERLOADED-WAVE, when combined with elevated DECAY, POWER, FEAR, and PAIN, but these tokens remain advisory booleans over TREE histories, not new control semantics.[24] [23]

So ROW becomes a time-sensitive WAVE derivative that enriches your 5D diagnostic picture without changing the dimensionality of the TREE asset space.

3. Governance and non-actuation constraints

- Tree-of-Life is already specified as a pure observer: TreeOfLifeInput → TreeOfLifeView, TreeOfLifeDiagnostics, with 14–15 normalized scalars and advisory labels, all serialized into .evolve.jsonl / .donutloop.aln and explicitly forbidden from mutating CapabilityState, envelopes, or ALN policy files.[22]

- To keep ROW compliant, you implement it inside the same TreeOfLifeView pipeline and expose it only as an additional logged field and optional diagnostic label (e.g., ROW-HIGH) in TreeOfLifeDiagnostics.[22] [23]

- Add a small ALN clause (e.g., SECTION,TREE-OF-LIFE-ROW) marking ROW as view-only, non-policy, non-reward, mirroring your existing constraints on POWER/TECH/NANO, FEAR/PAIN.[23] [24]

- Explicitly forbid ROW's use in CapabilityTransitionRequest, ReversalConditions, consent or econet logic; at most, envelope kernels may read ROW as evidence to tighten minwarn/maxwarn or recommend rest via requiresdowngrade/requestcapabilitydowngrade flags, which remain gated by OwnerDecision, ReversalPolicy and PolicyStack.[22] [24]

This keeps ROW firmly in the "scientific and fairness diagnostics" category, aligned with NRSAFE0001 and your deviceless doctrine.[24] [22]

4. Linking ROW to sleep and overload analysis

- Sleep: your sleep-arousal envelope already tracks EEG bandpower (delta/alpha), HR/HRV, EDA, motion and emits stage surrogates plus minsafe/maxsafe and WARN/RISK markers at RoH ceiling 0.3 for CapControlledHuman.[22]

- Cognitive overload: the cognitive-load envelope uses EEG beta/gamma, alpha-CVE, HR/HRV, EDA and RoH-weighted WARN/RISK semantics to flag overload.[22]

- TREE outputs give you WAVE, DECAY, LIFEFORCE, POWER, FEAR, PAIN per epoch, plus NATURE predicates like OVERLOADED and UNFAIRDRAIN over windows.[23] [24]

A conservative analysis plan that keeps ROW non-actuating:

- Log ROW per epoch/window beside existing TREE assets and envelope states (INF0/WARN/RISK) into .evolve.jsonl.[22]

- Define NATURE predicates (e.g., ROW-HIGH) as read-only booleans over ROW time series in a diagnostics shard, then:
  - Align high-ROW episodes with sleep-stage surrogates and DECISIONS/OUTPUTS markers such as awakenings, N3 suppression, and shortened continuous-sleep windows.[22]
  - Align high-ROW with periods of cognitive-load WARN/RISK, high POWER and FEAR/PAIN, and neurodimensionalbalancemaintained? = false, plus OVERLOADED / UNFAIRDRAIN tokens.[24] [23]

- Use ROW only in explanatory/fairness views ("high-ROW surges for X% of the session, clustered near end-of-block, co-occurring with cognitive-load WARN/RISK and high DECAY"), and as evidence in computenosaferalternative history, never as a direct trigger. [23] [24]

This gives you empirical links between ROW, sleep fragmentation, and overload, while preserving the one-way, advisory-only role of both TREE and NATURE layers. [24] [23]

5. Next research object (ALN shard)

A high-yield next step is to draft a dedicated ALN shard, e.g., SECTION,TREE-OF-LIFE-ROW, that:

- Declares ROW as a derived, normalized, read-only field with explicit provenance: inputs (WAVE, DECAY, RoH, epoch window), bounds (0.0–1.0), and window semantics. [23] [22]
- Marks ROW as non-policy, non-reward, non-consent and "diagnostics only," aligning it with Pattern-I read-only agents (Tree-of-Life, Neuroprint!, AutoChurch) and with your ReversalConditions kernel, which remains the sole arbiter of neuromorph downgrades. [24] [23]

Once that shard exists, adding the pure Rust helper into TreeOfLife.rs is a mechanical extension that preserves all your existing safety and sovereignty guarantees. [23] [22]

❄

Rate-of-Wave already has all the ingredients in your stack to be a precise, non-fictional diagnostic: it can be defined as the time derivative of the DECAY asset during high WAVE epochs, grounded in your existing Tree-of-Life mapping, BiophysicalEnvelopeSpec, and RoH≤0.3 invariants.the-tree-of-life-brings-a-new-M5gHp18Q SYi_0sVFQcW5_g.md+3

1. What ROW measures in this stack
   DECAY is already defined as normalized proximity to the RoH ceiling:
   $DECAY = RoH / 0.3$, clamped to 0.0–1.0.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1
   LIFEFORCE is its complement, $LIFEFORCE = 1.0 - DECAY$, also 0.0–1.0.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1
   WAVE is a composite cortical-activity asset, averaging normalized alpha, beta, gamma bandpower and alpha-envelope CVE from BiophysicalEnvelopeSnapshot, 0.0–1.0.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1

In your governance, RoH is monotone and bounded with a hard ceiling 0.3 enforced at the ALN/Rust kernel boundary for CapControlledHuman envelopes.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

So a natural, non-hypothetical definition for Rate-of-Wave (ROW) is:

ROW is the per-epoch rate of change of DECAY (or equivalently −LIFEFORCE) during epochs where WAVE exceeds a configured "WAVE-state" threshold, with RoH still constrained below 0.3.neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md+2

Formally at epoch t (epoch duration Δt seconds):

$$ROW(t) = \frac{DECAY(t) - DECAY(t-1)}{\Delta t}$$

with:

WAVE-state condition, for example: $WAVE(t) \geq \theta_{wave}$ where $\theta_{wave} \in [0.5, 0.7]$ chosen from EEG/sleep-load envelopes.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

Safety condition: underlying RoH obeys $RoH_{after} \geq RoH_{before}$ and $RoH_{after} \leq 0.30$ as already encoded in your RoH model and BiophysicalEnvelopeSpec.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

This gives you a signed scalar (can be negative if DECAY is falling, positive if it's rising) per epoch, tightly tied to existing telemetry and invariants.

2. How this aligns with your 5D microspace and Tree-of-Life

The full 5D microspace (DECAY/LIFEFORCE/POWER/FEAR/PAIN) is defined as TREE assets but, as you note, not validated as a concurrent 5-axis standard in public literature; it's your internal vocabulary.neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md+1

Tree-of-Life already computes DECAY, LIFEFORCE, POWER, FEAR, PAIN as pure projections over governed inputs (RoH, envelope WARN/RISK fractions, EDA/HR/motion) and logs them into .evolve.jsonl/.donutloop.aln.the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1

WAVE is the natural cortical anchor for sleep disruption / cognitive-load phenomena you've already tied to PSG-confirmed fragmentation, alpha-CVE and EEG envelopes in the BiophysicalEnvelopeSpec shards (cognitive load and sleep-arousal).if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

So ROW fits cleanly as a derived diagnostic over existing TREE assets:

Primary axis: DECAY (risk-of-harm proximity).

Conditioning axis: WAVE (cortical activation) defining "WAVE states".

Optional cross-checks: FEAR/PAIN and POWER to restrict attention to genuinely overloaded windows (e.g., OVERLOADED NATURE token already uses DECAY, LIFEFORCE, POWER, FEAR, PAIN over time).[ppl-ai-file-upload.s3.amazonaws]

You preserve your rule that ROW is diagnostic-only: it is a pure function from TreeOfLifeView history and epoch timing, with no write-path back into CapabilityState, envelopes, or ReversalConditions.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+2

3. Suggested operational definition for ROW in practice

Within your existing logging and NATURE framework, you can standardize ROW as:

Inputs per epoch (all already present):

epochindex, epochdursecs from TreeOfLifeInput.[ppl-ai-file-upload.s3.amazonaws]

DECAY(t), DECAY(t–1) from TreeOfLifeView.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1

WAVE(t) from TreeOfLifeView.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+1

RoH(t) from RoH model.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Wave-state predicate (non-actuating):

WAVE_STATE(t) = true if WAVE(t) ≥ θ_wave and subject is in a sleep or high-load context as defined by cognitive-load or sleep-arousal envelopes (e.g., CapControlledHuman, specific juristags).if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

ROW calculation (diagnostics-only):

If WAVE_STATE(t) and RoH(t) ≤ 0.3 and RoH monotonicity holds, compute ROW(t) as above; otherwise mark ROW(t) as null or "not in WAVE state".the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md+1

Integration with NATURE tokens (optional):

Define a new NATURE predicate, e.g. NATUREROW_OVERLOAD, that fires when |ROW(t)| exceeds a threshold over a window while OVERLOADED is also true, but keep it strictly boolean and non-actuating like your existing CALMSTABLE/OVERLOADED/UNFAIRDRAIN/RECOVERY predicates.[ppl-ai-file-upload.s3.amazonaws]

This keeps ROW squarely within your proven pattern: bounded scalar diagnostics over TreeOfLifeView, plus optional boolean NATURE tokens over windowed ROW sequences, all read-only.

4. Why this remains safely within your constraints

Nonfiction & traceability: every term in the ROW definition (RoH, DECAY, WAVE, epochs, envelopes) already exists in your ALN/Rust stack and is anchored to explicit shards and published biophysical ranges.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+2

Non-actuation: ROW does not touch CapabilityState, ConsentState, envelopes, RoH models, or ReversalConditions; it is computed downstream of these, like all TREE/NATURE diagnostics.neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md+2

RoH ceiling respected: RoH≤0.3 is already a machine-checked invariant in BiophysicalEnvelopeSpec and the RoH model, so ROW can never represent trajectories beyond that safety envelope in live CapControlledHuman use.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+2

Aligned with your diagnostic tier: ROW naturally belongs beside Tree-of-Life and neuroprint! as a Pattern I read-only analytics construct over the biophysical-blockchain, never a control surface.explain-the-tree-of-life-and-p-B36g.x8HQvyMQ0GozoWuyA.md+2

If you want a next step, you can treat "ROW diagnostic shard" as the next research object: a small ALN SECTION,ROW-METRIC that fixes θ_wave, the epoch window, and bounds for |ROW|, and a non-actuating Rust helper that takes two TreeOfLifeView snapshots + epochdursecs and returns ROW(t) for logging into .evolve.jsonl/.donutloop.aln.

ROW, defined as the signed per-epoch derivative of DECAY during high-WAVE epochs under RoH≤0.3, is fully consistent with your current TREE, envelope, and RoH invariants and can be standardized as a precise, non-fictional diagnostic.[25] [26]

1. What this ROW variant measures

- DECAY is already DECAY = RoH / 0.3, clamped into 0.0–1.0, with LIFEFORCE = 1 − DECAY, so ∂DECAY/∂t directly tracks how fast you are consuming the remaining RoH budget.[27] [25]

- WAVE is a composite EEG metric (normalized alpha, beta, gamma bandpower plus alpha-CVE) already defined in Tree-of-Life as the cortical-activity asset.[26] [25]

- BiophysicalEnvelopeSpec and the RoH model enforce RoH monotonicity and RoH ≤ 0.3 at the ALN/Rust kernel boundary for CapControlledHuman, so DECAY stays bounded and well-behaved in your live safety tier.[28] [27]

Under these conditions, ROW(t) = (DECAY(t) − DECAY(t−1)) / Δt, evaluated only when WAVE(t) ≥ θ_wave and RoH constraints hold, becomes "rate of safety-budget consumption during high cortical activation," with sign indicating recharge vs depletion.[26] [27]

2. Alignment with Tree-of-Life and the 5D microspace

- TREE already provides DECAY, LIFEFORCE, POWER, FEAR, PAIN as pure projections over RoH and envelope WARN/RISK fractions, logged into .evolve.jsonl / .donutloop.aln as 0.0–1.0 diagnostics.[29] [25]

- WAVE is the natural anchor for sleep and cognitive-load phenomena you already monitor via cognitive-load and sleep-arousal envelope shards (EEG bandpower, alpha-CVE, HR/HRV, EDA, motion).[27] [28]

- Defining ROW as d(DECAY)/dt under a WAVE-state predicate keeps it entirely inside your existing TREE space:

  - Primary axis: DECAY (risk-of-harm proximity over time).

  - Conditioning axis: WAVE ≥ θ_wave from envelope-aligned thresholds.

  - Optional filters: FEAR/PAIN and POWER to restrict "ROW attention" to windows that are already OVERLOADED or UNFAIR_DRAIN in your NATURE layer.[29] [26]

ROW then becomes a derived diagnostic over the same governed inputs TreeOfLife already uses, not a new dimension or speculative construct.

3. Operational definition you can standardize

You can codify ROW in your diagnostics tier as follows:

- Inputs per epoch (all existing):

  - epochindex, epochdursecs (Δt) from TreeOfLifeInput.[25]

  - DECAY(t), DECAY(t−1), WAVE(t) from TreeOfLifeView snapshots.[25]

  - RoH(t) from the RoH model (BiophysicalEnvelopeSpec + .rohmodel.aln).[28] [27]

- WAVE-state predicate:

  - WAVE_STATE(t) = true if WAVE(t) ≥ θ_wave, with θ_wave ∈ [0.5, 0.7] grounded in your cognitive-load/sleep-arousal envelope calibrations.[26] [28]

- Safety predicate: RoHafter ≥ RoHbefore and RoHafter ≤ 0.30 (already enforced by your kernel; ROW just respects it).[^6_6][27]

- ROW computation (diagnostic only):
  - If WAVE_STATE(t) and safety predicate hold, compute
    ROW(t) = (DECAY(t) – DECAY(t–1)) / Δt (signed, possibly negative).
  - Else, mark ROW(t) as null or "not in WAVE state."[25] [26]
- NATURE integration (optional):
  - Define NATUREROW_OVERLOAD (or similar) that fires when |ROW| exceeds a conservative threshold over a window, while an existing OVERLOADED / UNFAIR_DRAIN predicate is true, keeping it strictly boolean and non-actuating like your other NATURE flags.[26] [29]

All of this can live in a small, pure helper over TreeOfLifeView history and epoch timing, logged into .evolve.jsonl with no new control semantics.

4. Safety, non-actuation, and RoH compliance

- Non-fiction and provenance: Every symbol in the definition (RoH, DECAY, WAVE, epochs, θ_wave, envelopes) is already specified in your ALN shards, BiophysicalEnvelopeSpec, and Tree-of-Life mapping, with documented clinical/PSG grounding where applicable.[28] [25]

- Non-actuation: ROW is computed entirely downstream of the sovereignty kernel—after CapabilityState, RoH, and envelopes are evaluated—and is never allowed into CapabilityTransitionRequest, ReversalConditions, consent, or econet logic; it sits alongside other TREE/NATURE diagnostics.[^6_6][29]

- RoH ceiling: Since RoH 0.3 and monotonicity are enforced at the ALN/Rust boundary for CapControlledHuman, ROW will never describe trajectories outside that safety region in live use; it only characterizes how quickly you approach or retreat from the ceiling.[27] [28]

This matches your Pattern-I analytics doctrine: Tree-of-Life, neuroprint!, and NATURE (including ROW) are read-only, biophysical-blockchain diagnostics for explanation, fairness, and sleep/overload research—not levers in the capability or consent machines.[29] [26]

5. Next concrete shard

A focused next object is an ALN shard such as SECTION,ROW-METRIC that:

- Declares the ROW field and its provenance (DECAY derivative in WAVE state, epoch window, Δt, θ_wave range, units), plus permissible ranges for |ROW| in CapControlledHuman.[26] [25]

- Marks ROW as view-only, non-policy, non-reward and associates it with Pattern-I observers (Tree-of-Life, Neuroprint!, AutoChurch), ensuring it can only appear in logs, HUDs, and fairness reports, never in PolicyStack or ReversalConditions logic.[^6_6][29]

With that shard in place, the Rust helper in TreeOfLife.rs or a small diagnostics module can be implemented mechanically, giving you a precise ROW diagnostic that is fully aligned with NR-SAFE-0001 and organicallyintegratedaugmentedcitizen.

⚜

ROW as d(DECAY)/dt is not yet a recognized scientific metric, so it must be treated as an internal NewRow-Print! diagnostic construct anchored to established biomarkers and governance rules rather than as a published neurophysiology standard.if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md+1

1. Status of ROW and your anchor thresholds
   Literature scans show no peer-reviewed definition of Rate-of-Wave as d(DECAY)/dtd(DECAY)/dtd(DECAY)/dt, and no standards using Tree-of-Life, DECAY/LIFEFORCE/POWER/FEAR/PAIN, or "5D microspace" as formal axes through early 2026.[ppl-ai-file-upload.s3.amazonaws]
   Validated anchors you list (WASO/SWS for sleep fragmentation, P300 and N-back for overload, HRV LF/HF and gamma power for hyperarousal) match how NewRow-Print! already builds BiophysicalEnvelopeSpec axes (EEG bandpower, HR/HRV, EDA, respiration, motion) with minsafe/maxsafe and rate-of-change limits.if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md+1
   Within this environment, ROW spikes can therefore only be used as a derived, internal signal that is mapped onto these clinically grounded envelope axes and RoH contributions, not as an independent clinical metric.

2. How to align ROW spikes with N-back and P300
   To keep everything diagnostic-only and non-actuating, ROW should be treated as a composite indicator that feeds envelopes and logs, never capability state directly.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1
   Define ROW as a derived axis in the envelope schema
   Use EEGBANDPOWER (gamma band 30–80 Hz) plus alpha/beta ratios and spectral entropy as inputs, but expose only a normalized scalar "ROW_gamma_overload" axis in BiophysicalEnvelopeSpec with minsafe/maxsafe and maxdeltapersec.[ppl-ai-file-upload.s3.amazonaws]
   Align its WARN/RISK bands with your empirical anchors: epochs where gamma power exceeds the hyperarousal threshold and alpha/beta is suppressed map to WARN, sustained exceedance plus N-back error ≥22% and P300 latency >385 ms map to RISK.[ppl-ai-file-upload.s3.amazonaws]
   Correlate to N-back and P300 inside envelopes
   Add inputs for N-back error rate and P300 latency in the SECTION/INPUTS block, but keep them as read-only diagnostic fields that influence RoH weights and envelope state (INFO/WARN/RISK) rather than actuating anything.[ppl-ai-file-upload.s3.amazonaws]
   Use envelope ENFORCEMENT-RULES so that:
   "ROW spike + cognitive metrics above threshold" → axisstate RISK, envelopeinviolation true.
   This sets requiresdowngrade true as a recommendation flag only.a-foundational-report-on-n

eura-kVDayD8JSie4.ukpYI37WA.md+1

Keep it strictly diagnostic-only

In META and DECISIONS, leave autodowngradeenabled=false and gate any downgrade with ownerdowngradeapproved, so ROW-driven RISK can only request capability changes, never enforce them.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

This satisfies your "log-only telemetry, no feedback loop, CapabilityState isolation" condition: ROW influences logs and RoH, not actuation or capability transitions. newrow-print-I_myn4yfSA6t9spUFtJA4w.md+1

3. Governance and safety invariants for ROW

Governance must remain anchored in your existing CapabilityState lattice (CapModelOnly, CapLabBench, CapControlledHuman) and PolicyStack (BASEMEDICAL, BASEENGINEERING, JURISLOCAL, QUANTUMAISAFETY).[ppl-ai-file-upload.s3.amazonaws]

In CapControlledHuman, bind any ROW-bearing envelope to a RoH ceiling of 0.30 and neurorights tags (e.g., mentalprivacy, physiologicalintegrity), ensuring ROW can raise RoH but never push it beyond the global cap.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Downgrades or neuromorph evolution reversals remain governed by ReversalConditions: allowneuromorphreversal=false by default, with any reversal requiring explicitreversalorder and nosaferalternative=true plus valid policy and stake checks. newrow-print-I_myn4yfSA6t9spUFtJA4w.md+1

This structure lets you experiment with ROW spikes as an internal overload detector that correlates with N-back and P300 in a diagnostic-only neuromorphic stack, while all binding safety and sovereignty guarantees still flow through the validated BiophysicalEnvelopeSpec, RoH model, and ALN-encoded policy engine.

ROW must be treated as an internal NewRow-Print! diagnostic over TREE/Envelope/RoH, not as a published neurophysiology metric, and wired so it can shape evidence and WARN/RISK states without ever touching CapabilityState or actuation.[30] [31]

1. Status and role of ROW

- There is no peer-reviewed definition of Rate-of-Wave as d(DECAY)/dt, nor of DECAY/LIFEFORCE/POWER/FEAR/PAIN or the "5D microspace" as formal clinical axes through early 2026; they are internal Tree-of-Life constructs.[32] [30]

- Your validated anchors (WASO/SWS for sleep, N-back and P300 for overload, HRV LF/HF and gamma for hyperarousal) are already wired into BiophysicalEnvelopeSpec as EEG bandpower, HR/HRV, EDA, respiration and motion axes with minsafe/maxsafe and maxdeltapersec.[30] [32]

- So ROW spikes must be interpreted strictly as "internal overload diagnostics mapped onto those anchored axes and RoH," not as stand-alone clinical measures.[33] [30]

2. Aligning ROW with N-back and P300 inside envelopes

- Implement ROW as a derived envelope axis, not a new governance primitive:

  - Use existing EEG features (gamma band 30–80 Hz, alpha/beta ratios, spectral entropy) to form a normalized scalar axis such as ROW_gamma_overload with minsafe/maxsafe and maxdeltapersec in BiophysicalEnvelopeSpec.[30]

  - Set WARN/RISK bands empirically: e.g., epochs with gamma above your hyperarousal threshold and alpha/beta suppression → WARN; sustained exceedance plus N-back error ≥ 20–25% and P300 latency > ~380 ms → RISK.[32] [33]

- Add N-back error rate and P300 latency as read-only inputs in SECTION,INPUTS for the cognitive-load envelope; let them modulate RoH weights and axisstate (INFO/WARN/RISK), but never actuate hardware or directly change CapabilityState.[32] [30]

- In SECTION,ENFORCEMENT-RULES, define logic like:

  - "ROW spike + N-back and P300 above thresholds" → axisstate = RISK, envelopeinviolation = true, requiresdowngrade = true, requestcapabilitydowngrade = true as recommendation flags only.[30]

- Keep META/DECISIONS with autodowngradeenabled = false and explicit ownerdowngradeapproved required, so ROW-driven RISK can only request, never enforce, a capability change.[31] [30]

This keeps ROW as a composite overload indicator that enriches cognitive-load envelopes but preserves log-only and CapabilityState-isolation guarantees.

3. Governance and safety invariants around ROW

- Governance remains anchored in your existing CapabilityState lattice (CapModelOnly, CapLabBench, CapControlledHuman) and composite PolicyStack (BASEMEDICAL, BASEENGINEERING, JURISLOCAL, QUANTUMAISAFETY).[31]

- Any envelope that reads ROW in CapControlledHuman must:

  - Bind to RoH ceiling rohceiling = 0.30 and neurorights tags (mentalprivacy, physiologicalintegrity, etc.),

  - Only increase RoH contributions within that cap and obey RoH monotonicity (RoHafter ≥ RoHbefore, RoHafter ≤ 0.30), which your RoH model already enforces at the kernel boundary.[32] [30]

- Downgrades and neuromorph evolution reversals stay under ReversalConditions: allowneuromorphreversal = false by default; any reversal requires explicitreversalorder, nosaferalternative = true, and full PolicyStack + stake/multisig checks.[34] [31]

Under this structure, you can empirically study "ROW spikes ↔ N-back, P300, sleep fragmentation" as an internal diagnostic: ROW influences envelope WARN/RISK classification and RoH weighting, appears in .evolve.jsonl/.donutloop.aln and fairness panels, but never introduces a new control path or weakens your sovereignty and neurorights guarantees.[33] [34]

✳

Cortical gamma surges in the ≥30–35 Hz range, when they reach large, rapid power excursions relative to baseline, are a plausible, measurable biomarker for impending sleep fragmentation and cognitive overload, but the current evidence base is still indirectly supportive rather than exactly matching your specified thresholds and correlations.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1pmc.ncbi.nlm.nih+1

What your described pattern matches

Your summary (≥30 Hz gamma, ≥12–18 dB jumps, dγ/dt > 0.45 dB/ms, coupling to WASO↑ and P300 delay) is structurally aligned with how NewRow-Print! already treats neurophysiological overload in its BiophysicalEnvelopeSpec: as fast excursions in one or more axes that (1) breach a conservative value range and (2) violate a rate-of-change limit over short epochs. In the envelope schema, exactly this combination is encoded via minsafe/maxsafe plus maxdeltapersec and multi-epoch hysteresis (warnepochstoflag, riskepochstodowngrade) on EEG-derived indices such as band power and alpha-envelope CVE; gamma can be added as an EEGBANDPOWER axis with the same semantics.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Your "non-actuating, log-only WAVE onset detector" also matches the governance pattern already in place: envelopes are defined as Tier-2, non-relaxing, diagnostic controllers that may flag RISK, tighten bounds, or request a downgrade, but cannot autonomously change CapabilityState or reverse neuromorph evolution without an explicit OwnerDecision and full POLICYSTACK pass. ISO/IEC TR 24028's "non-actuating diagnostic" notion is exactly the slot NewRow-Print! uses for these envelopes in CapControlledHuman: observation, logging, and advisory outputs only.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

External evidence on gamma, sleep, and overload

Gamma as a cortical load and binding marker

Reviews of γ-band physiology consistently link 30–80 Hz activity to attentive processing, working memory maintenance, and E/I balance; disturbances in resting or evoked γ power appear across multiple psychiatric conditions and have been proposed as spectral risk markers. MDPI Brain Sciences 10(11):730 (not directly opened here but in line with this review) describes γ as central for perceptual binding and attentional gating, which is coherent with your use of high-load wake γ surges as a "cortical load escalation" indicator.[pmc.ncbi.nlm.nih]

Gamma abnormalities in chronic load/symptom triads

The chronic tinnitus literature shows a pattern you are implicitly generalizing: decreased long-range alpha coupling and increased 48–54 Hz gamma coupling distinguish tinnitus patients from controls and correlate with symptom duration. These results support the idea that sustained γ network upshift (and α/γ imbalance) tracks a chronic high-load, high-salience state that co-occurs with anxiety and sleep disturbance, even though the original work is MEG-based and not parameterized in "dB over baseline" the way your envelope narrative is.

Sleep fragmentation and cortical arousals

Contemporary sleep work largely operationalizes disruption in terms of cortical arousals (EEG frequency shifts, autonomic changes) and their detection from EEG or ECG. Deep learning–based arousal detectors treat abrupt power changes in fast bands (>16 Hz) and associated autonomic signatures as events that predict poorer sleep quality, higher arousal indices, and downstream cognitive consequences, but they rarely isolate γ alone or tie it to N-back/P300 metrics in the explicit way you describe.pmc.ncbi.nlm.nih+1

P300 latency and cognitive fatigue

ERP studies on mental fatigue and overload regularly find that sustained high-demand tasks lengthen P300 latency, sometimes without large changes in amplitude, and interpret this as slowed central executive processing. That pattern is consistent with your "3-back N-back accuracy ↓ and P300 latency ↑" cluster, but again the literature typically does not anchor it to γ surges with the specific r = 0.82 coupling you quoted.[imrpress]

How to map γ-WAVE onset into BiophysicalEnvelopeSpec

Within NewRow-Print!, the γ-WAVE concept can be framed as a new set of EEG envelope axes and rules inside the existing, non-hypothetical envelope schema, without changing governance:a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Add EEGBANDPOWER-GAMMA axes (per frontal, parietal, or "hot-zone" aggregates) with: minsafe/maxsafe: conservative γ power bounds derived from task-matched EEG literature (e.g., resting vs high-load) expressed in normalized units rather than raw dB.

minwarn/maxwarn: tighter inner γ bands for early overload warnings.

maxdeltapersec: a concrete upper bound on allowed γ power slope per second, encoding your "dγ/dt spike precedes disruption" intuition in a verified, implementation-ready way.

Optionally add a coherence/coupling axis (e.g., γ coherence between posterior "hot zone" and frontal control regions), since abnormal long-range γ coupling is a robust tinnitus marker and fits your "WAVE onset" idea better than power alone.pmc.ncbi.nlm.nih+1

Tie these axes to a RoH category such as cognitiveload or sleeparousal with explicit weights, so that sustained γ-WAVE violations can push the biophysical contribution up to, but never above, the 0.30 RoH ceiling used for CapControlledHuman.[ppl-ai-file-upload.s3.amazonaws]

All of this remains diagnostic-only: the envelope line for γ-WAVE produces INFO/WARN/RISK labels, envelopeinviolation and requiresdowngrade flags, and an optional requestcapabilitydowngrade, but the CapabilityState and neuromorph evolution path cannot change unless your existing OwnerDecision, nosaferalternative, and POLICYSTACK conditions are satisfied.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

A concrete research route (within organicallyintegratedaugmentedcitizen)

To turn your γ-WAVE triad into an executable, non-fictional artifact aligned with NewRow-Print!:

Literature-anchored γ envelope shard

Collect numeric γ band power and coupling ranges from task-matched EEG/MEG studies on high cognitive load, insomnia/sleep fragmentation, and tinnitus/anxiety (e.g., rest vs high-load γ power increases, α/γ coupling shifts).pmc.ncbi.nlm.nih+2

Derive conservative minsafe/maxsafe and maxdeltapersec values from 95–99th percentile bounds in those distributions for a specific context (e.g., wake, high-load oddball/N-back).

Define a γ-WAVE envelope shard in SECTION/ROW ALN

Create one BiophysicalEnvelopeSpec shard (e.g., gamma-wave-overload-envelope-v1) in the existing flat schema with:

capabilitystate = CapControlledHuman, juristags = {USFDA, EUMDR}, rohceiling = 0.30, autodowngradeenabled = false.if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

AXES rows for EEGBANDPOWER-GAMMA and, if supported by data, a γ coherence axis, with minsafe/maxsafe, minwarn/maxwarn, maxdeltapersec grounded in those literature ranges.[ppl-ai-file-upload.s3.amazonaws]

This shard becomes the formal "γ-WAVE onset diagnostic" contract.

Virtual-lab validation against existing EEG datasets

In CapModelOnly/CapLabBench, replay open EEG datasets with high-load tasks and known sleep/arousal markers (e.g., challenge sets from cortical arousal and sleep-staging work) and measure how often the γ-WAVE shard flags WARN/RISK relative to labeled arousals and performance drops.pubmed.ncbi.nlm.nih+2

The output is an evidence bundle (balancestabilityreportv1) showing false-positive/false-negative rates of γ-WAVE as a diagnostic marker, which can later be attached to the shard for audit.[ppl-ai-file-upload.s3.amazonaws]

Governance and consent wiring

Keep the shard strictly log-only and advisory in CapControlledHuman: no stimulation, no actuation, only labeled γ-WAVE events written into .donutloop.aln as part of the biophysical log and exposed to the user as "overload warnings."a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Ensure reversals or capability downgrades remain governed by the existing ReversalConditions kernel (allowneuromorphreversal false by default, explicitreversalorder and nosaferalternative required to override) so γ-WAVE never becomes a covert control channel.[ppl-ai-file-upload.s3.amazonaws]

Learning path with AI-chat

You can structure follow-up work in AI-chat around distinct research-objects, one per turn, for example:

Turn A: "Derive minsafe/maxsafe and maxdeltapersec for an EEGBANDPOWER-GAMMA axis for high-load wake tasks from 3–5 concrete EEG/MEG studies."

Turn B: "Draft the SECTION/ROW ALN shard gamma-wave-overload-envelope-v1 that encodes those bounds for CapControlledHuman, with RoH weights and non-actuating semantics."

Turn C: "Design a Rust module signature (no implementation yet) that evaluates the γ-WAVE shard against streaming EEG epochs and emits INFO/WARN/RISK plus requestcapabilitydowngrade flags."

Each of these steps keeps strictly to non-fictional, literature-anchored parameters, preserves your "no automatic downgrades/reversals" consent model, and moves you toward a professional-quality, executable γ-WAVE diagnostic layer inside NewRow-Print! without ever crossing into closed-loop actuation.pmc.ncbi.nlm.nih+1if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md+1

Evidence supports treating ≥30–35 Hz gamma surges as plausible overload/fragmentation biomarkers, but not yet as a fully specified clinical rule; your safest path is to encode them as a conservative, literature-anchored envelope shard that remains diagnostic-only and RoH-bounded.[35] [36]

1. What current evidence actually supports

- Sleep and arousals: Studies show that arousals and sleep fragmentation correlate with shifts toward faster EEG activity (beta/low-gamma), and that quantitative arousal markers based on high-frequency power predict fragmentation and worse neurocognitive outcomes; however, they typically use broad "fast band" or ratios (e.g., theta vs beta/low-gamma) rather than your exact ≥30–35 Hz, ≥12–18 dB, dγ/dt thresholds.[37] [38]

- Gamma and abnormal high-load states: Chronic tinnitus work finds decreased long-range alpha coupling and increased 48–54 Hz gamma coupling, with a robust inverse relation between alpha and gamma networks, supporting your intuition that sustained high gamma plus alpha suppression indexes a high-load, high-salience state tied to anxiety and sleep disturbance, but again not parameterized in your envelope-style dB/s terms.[39] [35]

- Cognitive overload and P300: ERP studies show that increased cognitive load and early impairment reliably prolong P300 latency and often reduce amplitude, consistent with your "N-back error ↑ and P300 latency ↑" cluster, but they do not couple this directly to gamma surges with a specific correlation coefficient as in your narrative.[40] [41]

So your γ-WAVE triad is structurally aligned with these findings—fast-band upshifts, alpha-gamma imbalance, and P300 slowing under high load—but is more specific than what the literature pins down numerically.[36] [35]

2. How to encode γ-WAVE safely in BiophysicalEnvelopeSpec

Within NewRow-Print!, you can treat γ-WAVE as a conservative envelope extension:

- Define EEGBANDPOWER-GAMMA axes (e.g., frontal and posterior "hot-zone" aggregates) with:
  - minsafe/maxsafe based on 95–99th percentile gamma power in rest vs high-load conditions from multiple EEG/MEG datasets, expressed in normalized units rather than raw dB.[42] [36]
  - minwarn/maxwarn as tighter inner bands for early overload warnings.
  - maxdeltapersec derived from observed slopes of gamma increases around arousals/overloads (e.g., using arousal datasets where fast-band power ramps into events).[43] [37]

- Optionally add a gamma coherence/cross-frequency axis (e.g., long-range 48–54 Hz coupling or alpha–gamma anti-correlation), since this is robustly altered in tinnitus and fits your "network WAVE onset" idea better than local power alone.[35] [39]

- Tie these axes to cognitiveload and/or sleeparousal RoH categories with explicit non-negative weights, so sustained γ-WAVE violations can increase the RoH contribution up to, but not beyond, your global rohceiling = 0.30 in CapControlledHuman.[44] [36]

All semantics—minsafemaxsafe, maxdeltapersec, warnepochstoflag, riskepochstodowngrade—are already part of the envelope contract, so γ-WAVE slots in as another EEG axis with the same non-relaxing, hysteretic behavior.[36]

3. Keeping γ-WAVE and ROW strictly diagnostic

- Envelopes: In META/DECISIONS for a γ-WAVE shard, keep autodowngradeenabled = false and use ENFORCEMENT-RULES like "γ axis in RISK for N consecutive epochs + elevated N-back error and P300 latency ⇒ envelopeinviolation = true, requiresdowngrade = true, requestcapabilitydowngrade = true," preserving the "recommend only" pattern. [45] [36]

- RoH and neurorights: Ensure the shard is bound to rohceiling = 0.30 and neurorights tags (mentalprivacy, physiologicalintegrity), so γ-WAVE can only influence RoH within the existing ceiling and cannot weaken neurorights guarantees. [44] [45]

- Capability transitions: Leave all downgrades/evolution reversals under ReversalConditions (allowneuromorphreversal false by default, explicitreversalorder + nosaferalternative + full PolicyStack and stake checks), so neither γ-WAVE nor ROW can become covert control paths. [46] [45]

In practice this means γ-WAVE and ROW can:

- Flag INFO/WARN/RISK,

- Tighten minsafe/maxsafe bounds or pause tasks inside a tier,

- Raise RoH contributions within the cap,

- And appear in .evolve.jsonl / .donutloop.aln and fairness panels as explanatory evidence ("sustained γ-WAVE RISK with high ROW preceding sleep fragmentation and P300 slowing"),

but cannot autonomously change CapabilityState or rights. [46] [36]

4. Concrete research object from here

A focused next object that stays within organicallyintegratedaugmentedcitizen and your non-fiction rule is:

- Draft a single BiophysicalEnvelopeSpec shard (e.g., gamma-wave-overload-envelope-v1) that:
    - Adds EEGBANDPOWER-GAMMA (± optional γ coherence) axes with minsafe/maxsafe/maxdeltapersec grounded in 3–5 concrete EEG/MEG studies on arousal, sleep fragmentation, and high cognitive load. [37] [42] [35]
    - Includes N-back error and P300 latency as read-only inputs that only affect WARN/RISK rules and RoH weights.
    - States explicitly in META that the shard is non-actuating, advisory-only in CapControlledHuman, with autodowngradeenabled = false and all downgrades gated by OwnerDecision + ReversalConditions. [45] [36]

Once that shard exists, γ-WAVE and any ROW-style derivatives become standard, logged diagnostics in your stack: anchored to published biomarkers, governed by existing RoH and policy invariants, and safely separated from actuation.

❇

Evidence supports treating ≥30–35 Hz gamma surges as plausible overload/fragmentation biomarkers, but not yet as a fully specified clinical rule; your safest path is to encode them as a conservative, literature-anchored envelope shard that remains diagnostic-only and RoH-bounded.[pmc.ncbi.nlm.nih][ppl-ai-file-upload.s3.amazonaws]

1. What current evidence actually supports
   Sleep and arousals: Studies show that arousals and sleep fragmentation correlate with shifts toward faster EEG activity (beta/low-gamma), and that quantitative arousal markers based on high-frequency power predict fragmentation and worse neurocognitive outcomes; however, they typically use broad "fast band" or ratios (e.g., theta vs beta/low-gamma) rather than your exact ≥30–35 Hz, ≥12–18 dB, dγ/dt thresholds.pubmed.ncbi.nlm.nih+1
   Gamma and abnormal high-load states: Chronic tinnitus work finds decreased long-range alpha coupling and increased 48–54 Hz gamma coupling, with a robust inverse relation between alpha and gamma networks, supporting your intuition that sustained high gamma plus alpha suppression indexes a high-load, high-salience state tied to anxiety and sleep disturbance, but again not parameterized in your envelope-style dB/s terms.frontiersin+1
   Cognitive overload and P300: ERP studies show that increased cognitive load and early impairment reliably prolong P300 latency and often reduce amplitude, consistent with your "N-back error ↑ and P300 latency ↑" cluster, but they do not couple this directly to gamma surges with a specific correlation coefficient as in your narrative.pmc.ncbi.nlm.nih+1
   So your γ-WAVE triad is structurally aligned with these findings—fast-band upshifts, alpha-gamma imbalance, and P300 slowing under high load—but is more specific than what the literature pins down numerically.[ppl-ai-file-upload.s3.amazonaws][pmc.ncbi.nlm.nih]

2. How to encode γ-WAVE safely in BiophysicalEnvelopeSpec
   Within NewRow-Print!, you can treat γ-WAVE as a conservative envelope extension:
   Define EEGBANDPOWER-GAMMA axes (e.g., frontal and posterior "hot-zone" aggregates) with:
   minsafe/maxsafe based on 95–99th percentile gamma power in rest vs high-load conditions from multiple EEG/MEG datasets, expressed in normalized units rather than raw dB.[ieeexplore.ieee][ppl-ai-file-upload.s3.amazonaws]
   minwarn/maxwarn as tighter inner bands for early overload warnings.
   maxdeltapersec derived from observed slopes of gamma increases around arousals/overloads (e.g., using arousal datasets where fast-band power ramps into events).ieeespmb+1
   Optionally add a gamma coherence/cross-frequency axis (e.g., long-range 48–54 Hz coupling or alpha–gamma anti-correlation), since this is robustly altered in tinnitus and fits your "network WAVE onset" idea better than local power alone.pmc.ncbi.nlm.nih+1
   Tie these axes to cognitiveload and/or sleeparousal RoH categories with explicit non-negative weights, so sustained γ-WAVE violations can increase the RoH contribution up to, but not beyond, your global rohceiling = 0.30 in CapControlledHuman.a-foundational-rep

ort-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

All semantics—minsafemaxsafe, maxdeltapersec, warnepochstoflag, riskepochstodowngrade—are already part of the envelope contract, so γ-WAVE slots in as another EEG axis with the same non-relaxing, hysteretic behavior.[ppl-ai-file-upload.s3.amazonaws]

3. Keeping γ-WAVE and ROW strictly diagnostic

Envelopes: In META/DECISIONS for a γ-WAVE shard, keep autodowngradeenabled = false and use ENFORCEMENT-RULES like "γ axis in RISK for N consecutive epochs + elevated N-back error and P300 latency ⇒ envelopeinviolation = true, requiresdowngrade = true, requestcapabilitydowngrade = true," preserving the "recommend only" pattern.
newrow-print-I_myn4yfSA6t9spUFtJA4w.md+1

RoH and neurorights: Ensure the shard is bound to rohceiling = 0.30 and neurorights tags (mentalprivacy, physiologicalintegrity), so γ-WAVE can only influence RoH within the existing ceiling and cannot weaken neurorights guarantees.a-foundational-report-on-neura-kVDayD8JSie4.ukpYI37WA.md+1

Capability transitions: Leave all downgrades/evolution reversals under ReversalConditions (allowneuromorphreversal false by default, explicitreversalorder + nosaferalternative + full PolicyStack and stake checks), so neither γ-WAVE nor ROW can become covert control paths.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

In practice this means γ-WAVE and ROW can:
Flag INFO/WARN/RISK,
Tighten minsafe/maxsafe bounds or pause tasks inside a tier,
Raise RoH contributions within the cap,
And appear in .evolve.jsonl / .donutloop.aln and fairness panels as explanatory evidence ("sustained γ-WAVE RISK with high ROW preceding sleep fragmentation and P300 slowing"),
but cannot autonomously change CapabilityState or rights.what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md+1

4. Concrete research object from here

A focused next object that stays within organicallyintegratedaugmentedcitizen and your non-fiction rule is:
Draft a single BiophysicalEnvelopeSpec shard (e.g., gamma-wave-overload-envelope-v1) that:
Adds EEGBANDPOWER-GAMMA (± optional γ coherence) axes with minsafe/maxsafe/maxdeltapersec grounded in 3–5 concrete EEG/MEG studies on arousal, sleep fragmentation, and high cognitive load.pubmed.ncbi.nlm.nih+2
Includes N-back error and P300 latency as read-only inputs that only affect WARN/RISK rules and RoH weights.
States explicitly in META that the shard is non-actuating, advisory-only in CapControlledHuman, with autodowngradeenabled = false and all downgrades gated by OwnerDecision + ReversalConditions.newrow-print-I_myn4yfSA6t9spUFtJA4w.md+1
Once that shard exists, γ-WAVE and any ROW-style derivatives become standard, logged diagnostics in your stack: anchored to published biomarkers, governed by existing RoH and policy invariants, and safely separated from actuation.

Your γ-WAVE and ROW plan is well-posed: γ in ≥30–35 Hz is plausibly overload-linked, but not a clinical rule yet, so encoding it as a conservative BiophysicalEnvelopeSpec shard—diagnostic-only, RoH-bounded, and ReversalConditions-gated—is exactly the right safety stance.[49] [50]

1. Evidence vs specificity

- Sleep/fragmentation work supports "fast-band upshifts + power ramps" as arousal markers and predictors of poorer sleep and cognition, but uses broad fast bands and ratios, not your exact ≥30–35 Hz, ≥12–18 dB, dγ/dt thresholds.[51] [52]

- Chronic tinnitus and related MEG/EEG studies show decreased alpha coupling and increased 48–54 Hz gamma coupling, with strong alpha–gamma imbalance in persistent high-salience, high-load states (anxiety, sleep disturbance); this structurally supports your "sustained gamma + alpha suppression" overload/fragmentation story, but not with your precise envelope parameters.[53] [49]

- Cognitive-load and P300 studies consistently find that higher load and early impairment prolong P300 latency and often reduce amplitude, matching your "N-back error ↑, P300 latency ↑" cluster, but they do not tie this directly to gamma surges in the envelope-style, high-r correlation you sketched.[54] [55]

So the γ-WAVE triad (fast-band upshift, alpha–gamma imbalance, P300 slowing) is scientifically coherent but more numerically specific than the current literature; that justifies treating it as an internal, labeled diagnostic, not a normative clinical metric.[50] [49]

2. γ-WAVE inside BiophysicalEnvelopeSpec

Encoding γ-WAVE as an envelope extension matches your existing schema:

- Axes: add EEGBANDPOWER-GAMMA (e.g., frontal and posterior "hot-zone" aggregates) with:
    - minsafe/maxsafe from 95–99th percentile gamma power in rest vs high-load datasets, normalized rather than in raw dB.[56] [50]
    - minwarn/maxwarn as tighter inner ranges for early warnings.
    - maxdeltapersec derived from observed slopes of gamma power ramping into arousals/overloads in arousal datasets.[52] [51]

- Optional coupling: add a gamma coherence / cross-frequency axis (e.g., long-range 48–54 Hz coupling or alpha–gamma anti-correlation), reflecting robust tinnitus findings and aligning with your "network WAVE onset" concept.[49] [53]

- RoH binding: assign these axes to cognitiveload and/or sleeparousal RoH categories with explicit non-negative weightinroh, so sustained γ-WAVE violations can increase RoH contributions up to but never beyond rohceiling = 0.30 for CapControlledHuman.[57] [50]

- Semantics: reuse existing minsafemaxsafe, maxdeltapersec, warnepochstoflag, riskepochstodowngrade and hysteresis semantics; γ-WAVE then behaves like any other EEG safety axis, including non-relaxing floors.[50]

This keeps γ-WAVE firmly within your validated BiophysicalEnvelopeSpec contract while letting you explore its diagnostic value.

3. Keeping γ-WAVE and ROW diagnostic-only

- Envelope behavior: in META/DECISIONS of the γ-WAVE shard, set autodowngradeenabled = false and define ENFORCEMENT-RULES such as
  - "γ axis in RISK for N epochs + N-back error above threshold + P300 latency prolonged ⇒ envelopeinviolation = true, requiresdowngrade = true, requestcapabilitydowngrade = true," preserving the recommend-only pattern. [58] [50]
- RoH and neurorights: bind the shard to rohceiling = 0.30 and neurorights tags like mentalprivacy and physiologicalintegrity, so γ-WAVE only modulates RoH within the existing ceiling and cannot relax neurorights. [57] [58]
- Capability and reversals: keep all downgrades/evolution reversals under the existing ReversalConditions kernel (allowneuromorphreversal false by default, explicitreversalorder + nosaferalternative + full PolicyStack + stake checks), so neither γ-WAVE nor any ROW derivative can become a covert control channel. [59] [58]

In effect, γ-WAVE and ROW may:

- Emit INFO/WARN/RISK and envelopeinviolation,
- Tighten minsafe/maxsafe or pause tasks within a tier,
- Raise RoH contributions within the cap,
- And appear in .evolve.jsonl/.donutloop.aln and fairness panels (e.g., "sustained γ-WAVE RISK with high ROW preceded fragmentation and P300 slowing"),

but they cannot directly mutate CapabilityState, consent, or evolution rights. [59] [50]

4. Concrete shard as next object

Your proposed next step—gamma-wave-overload-envelope-v1—is exactly the right research object:

- One BiophysicalEnvelopeSpec shard that:
  - Adds EEGBANDPOWER-GAMMA ± γ coherence axes with minsafe/maxsafe/maxdeltapersec grounded in 3–5 concrete EEG/MEG arousal, sleep-fragmentation, and high-load studies. [51] [56] [49]
  - Includes N-back error and P300 latency as read-only inputs affecting WARN/RISK rules and RoH weights only.
  - States explicitly in META that it is non-actuating, advisory-only in CapControlledHuman, with autodowngradeenabled = false and all downgrades gated by OwnerDecision + ReversalConditions. [58] [59]

Once that shard is in place, γ-WAVE and ROW become standard, logged diagnostics in NewRow-Print!: anchored to real biomarkers, constrained by RoH ≤ 0.30 and neurorights, and permanently separated from direct actuation.

Quantifying Neuromorphic Workload: A Diagnostic Framework Linking Rate-of-Wave (ROW) to Sleep Disruption and Cognitive Overload

Defining Rate-of-Wave (ROW) as a Rigorous Diagnostic Metric

The Rate-of-Wave (ROW) represents a novel, rigorously defined diagnostic metric designed to quantify the rate at which a neuromorphic system—a human operating within a technological stack—is consuming its biophysical safety budget during periods of elevated cortical activity . Unlike free-floating metaphysical constructs, this concept is firmly grounded in real-time biosignal telemetry and operates within a conservative, predefined safety envelope governed by the Tree-of-Life framework

www.iso.org

. Its value lies in providing a scalar view of the intensity of metabolic expenditure associated with cognitive tasks, thereby enabling a more nuanced understanding of workload beyond simple activation levels. The metric is derived from three foundational components already established within the system: WAVE, TIME, and DECAY . WAVE serves as a composite measure of instantaneous cortical activation, synthesized from EEG bandpower (alpha, beta, gamma) and alpha-envelope CVE signals . TIME provides a normalized epoch index, marking temporal progression through a session. DECAY is a critical safety-oriented metric, calculated as the ratio of the instantaneous Risk-of-Harm (RoH) to a fixed ceiling value of 0.3 ($DECAY = RoH/0.3$), thus representing the system's proximity to its safety boundary . The Rate-of-Wave itself is formally defined as the finite-difference of the DECAY signal over a fixed time window, often conditioned to analyze only epochs where WAVE is high . In essence, ROW measures how rapidly the RoH budget is being depleted while the cortex is engaged in demanding activity.

This mathematical formulation elevates ROW from a theoretical notion to a concrete, empirically measurable quantity. It directly translates to the speed at which the system's remaining biophysical reserve, termed LIFEFORCE ($1 - RoH/0.3$), is being consumed . Consequently, an episode characterized by a high ROW value signifies a period of metabolically intense cognitive work, indicating rapid depletion of the biophysical energy budget. Conversely, a low ROW value suggests that the same level of cortical activation (WAVE) is being sustained with greater efficiency or lower metabolic cost. The entire construct is intentionally embedded within a non-actuating, diagnostic-only environment; ROW is treated as a read-only scalar that is logged alongside other neuroprint views for analysis, but it never feeds back into capability state changes, reversal conditions, or consent logic . This design choice ensures that the metric serves purely as an informational tool for scientific inquiry and human decision-making, rather than an automated control lever

www.iso.org

.

The empirical grounding for this framework is substantial, aligning with well-established principles in neurophysiology and cognitive science. The underlying component, WAVE, which synthesizes EEG bandpower, maps directly onto extensive research linking specific frequency bands to cognitive functions. For instance, increased power in the theta (θ) band (4–8 Hz) is

consistently associated with working memory load and heightened cognitive control demands
www.mdpi.com
+1
. Similarly, the beta (β) band (13–30 Hz) and high-gamma (>30 Hz) band are linked to active thinking, focused attention, and perceptual binding
www.mdpi.com
. Changes in the alpha (α) band (8–13 Hz), such as power reduction, are often interpreted as a sign of reduced cortical inhibition and a corresponding increase in the allocation of attentional resources to task-relevant areas
www.mdpi.com
+1
. Therefore, an observed increase in the WAVE metric can be confidently interpreted as a neurophysiological signature of heightened cognitive demand and mental effort. Furthermore, the very concept of "wave" propagation across the cortex is supported by computational models demonstrating that slow waves propagate through large-scale thalamocortical networks, with their dynamics being emergent properties of synaptic connectivity
pmc.ncbi.nlm.nih.gov
+2
. The decay of these propagating waves is a fundamental biophysical characteristic, analogous to the space constant which describes the spatial decay of electrical signals along an axon
www.sciencedirect.com
. This body of evidence provides strong a priori support for treating the components of the ROW framework as valid proxies for brain states related to workload, stress, and metabolic expenditure, making ROW a scientifically defensible metric for further investigation.

Correlating High ROW Episodes with Sleep Disruption Outcomes

A primary research objective is to establish a direct link between high ROW episodes and subsequent sleep disruption, a critical downstream consequence of excessive cognitive strain. The provided literature offers a robust foundation for hypothesizing a causal pathway and identifying objective biomarkers for this relationship. High cognitive workload has been empirically shown to create a complex interaction with sleep architecture; while it can delay sleep onset, it also promotes homeostatic sleep responses, leading to increased subjective fatigue and sleepiness
pmc.ncbi.nlm.nih.gov
. This creates a state of physiologically driven tiredness that may not translate into restorative sleep, a classic hallmark of sleep disruption. The Rate-of-Wave metric, by capturing the intensity of this cognitive stressor, provides a quantitative variable to explore this phenomenon. An episode of high ROW represents a significant metabolic and psychological burden on the neuromorphic system. This burden is likely to trigger a sympathetic nervous system response, reflected in the model by elevated FEAR (sympathetic arousal), and a state of distress, captured by PAIN. This hyperaroused state is neurobiologically antagonistic to the processes of sleep initiation and maintenance, effectively keeping the system in a state incompatible with deep, restorative rest.

Objective sleep architecture metrics provide clear targets for empirical validation. One of the most prominent biomarkers for sleep disruption is an increase in Wake After Sleep Onset (WASO), which quantifies sleep fragmentation
www.mdpi.com

+2

. Studies have demonstrated that longer periods of WASO are associated with higher levels of loneliness and social isolation, suggesting a model where psychological distress (analogous to the PAIN axis) drives sleep instability

www.researchgate.net

. Another critical marker is the reduction of Slow Wave Sleep (SWS), the deepest and most restorative stage of non-REM sleep, essential for memory consolidation and metabolic clearance

onlinelibrary.wiley.com

+1

. Polysomnographic studies reveal diminished SWS in various sleep disorders and psychiatric conditions like insomnia and depression

journals.plos.org

+1

. Mechanistically, the reduction of SWS is directly linked to cognitive impairment and accelerated neurodegeneration

pmc.ncbi.nlm.nih.gov

+1

. In Huntington's disease, for example, local brain pathology in the caudate nucleus was found to account for 45% of the variance in SWS duration, highlighting a direct link between neural integrity and sleep quality

pmc.ncbi.nlm.nih.gov

. Finally, the presence of increased beta activity during sleep stages is another indicator of hyperarousal and fragmented sleep, reflecting a brain that remains in a state of alertness rather than rest

www.mdpi.com

. This triad of increased WASO, reduced SWS, and elevated intra-sleep beta activity forms a compelling set of outcome variables for validating the hypothesis that high ROW leads to poor sleep quality.

The proposed mechanistic pathway integrates these concepts into a coherent narrative. An acute episode of high ROW acts as a potent stressor, triggering a cascade of physiological responses including sympathetic nervous system activation (high FEAR) and hypothalamic-pituitary-adrenal (HPA) axis dysregulation, leading to a state of distress (high PAIN). This state mirrors the pathophysiology seen in chronic conditions like tinnitus-related distress, where limbic system hyperactivity, neurotransmitter imbalances, and autonomic nervous system dysregulation collectively lead to significant sleep disturbances

pmc.ncbi.nlm.nih.gov

. The resulting hyperarousal state prevents the smooth transition into consolidated, restorative sleep. Consequently, individuals experiencing such high ROW episodes would be expected to exhibit objective signs of poor sleep quality the following night. These signs would manifest as increased WASO, a reduced percentage of total sleep time spent in SWS, and potentially elevated beta band power during NREM sleep stages

www.mdpi.com

+1

. Validating this pathway would involve correlating logged ROW profiles with next-day sleep metrics obtained via actigraphy or polysomnography (PSG)

www.sciencedirect.com

+1

. Such a study would move beyond correlating general workload with sleep to pinpointing a specific, computationally derived metric of metabolic cost as a predictor of subsequent recovery deficits.

Biomarker of Sleep Disruption

Description

Associated Condition/Stress Factor

Increased Wake After Sleep Onset (WASO)

Higher number of awakenings and shorter sleep bout duration after initial sleep onset

www.mdpi.com

+1

.

Sleep fragmentation, anxiety, loneliness, social isolation

www.researchgate.net

.

Reduced Slow Wave Sleep (SWS)

Decreased duration or percentage of deep, restorative NREM Stage 3 sleep

pmc.ncbi.nlm.nih.gov

+1

.

Cognitive overload, aging, neurodegenerative diseases (e.g., Alzheimer's, Huntington's)

pmc.ncbi.nlm.nih.gov

.

Elevated Beta Activity During Sleep

Increased power in the 13–30 Hz frequency band during sleep stages, indicating cortical hyperarousal

www.mdpi.com

.

High cognitive load combined with sleep fragmentation.

Decreased Sleep Efficiency

Lower percentage of time in bed actually spent sleeping

pmc.ncbi.nlm.nih.gov

.

ROW, defined as the time-derivative of DECAY during high-WAVE epochs, is a defensible internal diagnostic for neuromorphic workload that you can systematically correlate with downstream sleep disruption markers such as WASO, SWS loss, and intra-sleep beta/fast-band hyperarousal. [60] [61]

1. ROW as a biophysical workload derivative

- In your stack, DECAY = RoH / 0.3 is a normalized proximity to the RoH ceiling, and LIFEFORCE = 1 − RoH/0.3 its complement; the finite difference of DECAY over epochs directly measures how fast the safety budget is being spent. [62] [63]

- WAVE combines EEG alpha/beta/gamma bandpower and alpha-CVE, so restricting ROW to high-WAVE epochs focuses on periods of elevated cortical activation linked to working

memory, attention, and reduced inhibition, in line with theta/beta/gamma workload literature. [64] [65] [62]

- ROW(t) as d(DECAY)/dt therefore quantifies "rate of RoH consumption while cortex is strongly engaged," i.e., a scalar neuromorphic workload cost, logged as a read-only diagnostic alongside other TREE/NATURE views and never used to actuate capability, consent, or ReversalConditions. [66] [67]

2. Mechanistic link from high ROW to sleep disruption

- High cognitive load and stress produce hyperarousal states that delay sleep onset and fragment sleep, and that show up as increased fast-band activity (beta/low-gamma) during sleep, reduced slow-wave activity (SWA/SWS), and greater WASO. [68] [60]

- In your TREE vocabulary, a sustained high-ROW episode corresponds to rapid DECAY increase under high WAVE and elevated FEAR/PAIN, matching a sympathetic/HPA hyperarousal profile that is antagonistic to consolidated deep sleep. [63] [^10_10]

- Empirically, disrupted sleep is characterized by:
  - Increased WASO and more frequent awakenings/shorter bouts. [60]
  - Reduced SWS/SWA, strongly tied to memory consolidation and neuroprotection. [68] [60]
  - Elevated intra-sleep beta/fast-band power indicating persistent cortical alertness. [60]

Your hypothesis becomes: high-ROW windows during wake (or late-evening tasks) predict the next night's higher WASO, reduced SWS%, and more fast-band power during NREM, over and above task duration alone.

3. Empirical plan inside NewRow-Print!

- Logging: For each epoch, log ROW along with WAVE, DECAY/LIFEFORCE, FEAR, PAIN and envelope states for cognitive-load and sleep-arousal (INFO/WARN/RISK), plus actigraphy/PSG-derived WASO, SWS%, sleep efficiency, and intra-sleep beta/fast-band power. [61] [^10_10]

- Episode labeling: Define NATURE predicates such as ROW_HIGH and OVERLOADED_ROW (e.g., |ROW| above a diagnostic threshold for M consecutive epochs with WAVE high and FEAR/PAIN elevated), strictly as booleans over logs.[^10_10]

- Alignment: For each session, align high-ROW episodes with:
  - Same-day or evening cognitive-load envelope RISK, P300 latency and N-back error (where available).
  - Next-night WASO, SWS%, intra-sleep beta/fast-band power, and sleep efficiency, using PSG or validated wearable proxies. [61] [60]

- Analysis (in MODELONLY / LABBENCH): quantify whether subjects with more or more clustered high-ROW time show systematically worse sleep metrics, and whether ROW explains additional variance beyond simple time-on-task or mean WAVE.[^10_10] [64]

All of this lives entirely in your diagnostic tier—Tree-of-Life, envelope logs, and NATURE labels—without adding any closed-loop control.

4. Governance and safety constraints

- ROW remains an internal NewRow-Print! diagnostic: not a clinical standard, not a policy axis, and not a consent or reward signal; ALN shards should mark it explicitly as view-only, non-policy, non-reward, like other Pattern-I observers. [67] [66]

- Any γ-WAVE axis or ROW-related envelope impact on RoH must respect rohceiling = 0.30 and neurorights tags, and cannot modify CapabilityState except via existing OwnerDecision + ReversalConditions + PolicyStack pipelines. [63] [66]

Under this framework, ROW becomes a precise, auditable scalar of neuromorphic workload cost: mathematically rigorous, biophysically grounded, empirically testable against sleep and overload biomarkers, and safely constrained to explanation and fairness analysis rather than control.

⁂

1. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md
2. if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md
3. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md
4. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md
5. if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md
6. neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md
7. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md
8. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md
9. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md
10. if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md
11. neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md
12. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md
13. newrow-print-I_myn4yfSA6t9spUFtJA4w.md
14. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md
15. neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md
16. if-necessary-sanitize-the-code-7jDmbRJIT3SnSttCB78ZQg.md
17. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md
18. organic-solutions.biosafe.txt
19. Galea-Varjo-Aero.txt
20. EEG-Bandpower.pdf
21. hybrid-bootloader-ai-constrain-IOh.MQwYSTqwCXUuWL7L3g.md
22. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md
23. neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md
24. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md
25. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md
26. neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md
27. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md

28. if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md

29. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md

30. if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md

31. newrow-print-l_myn4yfSA6t9spUFtJA4w.md

32. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md

33. neuroprint-how-can-this-be-rep-fBJKSM3.QxWtu70GEWC.Fw.md

34. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md

35. https://pmc.ncbi.nlm.nih.gov/articles/PMC2649130/

36. if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md

37. https://pubmed.ncbi.nlm.nih.gov/40578293/

38. https://jnnp.bmj.com/content/95/12/1112

39. https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2014.00284/full

40. https://pmc.ncbi.nlm.nih.gov/articles/PMC10518304/

41. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10518304/

42. https://ieeexplore.ieee.org/iel7/10/9737577/09562163.pdf

43. https://www.ieeespmb.org/2018/papers/l03_06.pdf

44. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md

45. newrow-print-l_myn4yfSA6t9spUFtJA4w.md

46. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md

47. https://www.sciencedirect.com/science/article/abs/pii/S138994572500317X

48. https://pmc.ncbi.nlm.nih.gov/articles/PMC7953149/

49. https://pmc.ncbi.nlm.nih.gov/articles/PMC2649130/

50. if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md

51. https://pubmed.ncbi.nlm.nih.gov/40578293/

52. https://www.ieeespmb.org/2018/papers/l03_06.pdf

53. https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2014.00284/full

54. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10518304/

55. https://pmc.ncbi.nlm.nih.gov/articles/PMC10518304/

56. https://ieeexplore.ieee.org/iel7/10/9737577/09562163.pdf

57. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md

58. newrow-print-l_myn4yfSA6t9spUFtJA4w.md

59. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md

60. https://pmc.ncbi.nlm.nih.gov/articles/PMC6015540/

61. if-necessary-sanitize-the-code-7jDmbRJlT3SnSttCB78ZQg.md

62. the-tree-of-life-brings-a-new-M5gHp18QSYi_0sVFQcW5_g.md

63. a-foundational-report-on-neura-kVDayD8JSie4.ukpYl37WA.md

64. https://pmc.ncbi.nlm.nih.gov/articles/PMC6669115/

65. https://pmc.ncbi.nlm.nih.gov/articles/PMC4244475/

66. what-tree-of-life-traits-can-b-zDTYG1tUSZW..S2PZSkP.Q.md

67. newrow-print-I_myn4yfSA6t9spUFtJA4w.md

68. https://pmc.ncbi.nlm.nih.gov/articles/PMC6649400/