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Article

Architecting Control Systems for Knowledge Work Management: Cognitive Load Reduction and Delivery Predictability in Knowledge Teams

Garkutsenko Vitaly Andreevich *

Director of Development and Innovation, Russia

*Correspondence: Garkutsenko Vitaly Andreevich (garkutsenko.vit.an@gmail.com)

Abstract: Knowledge work teams operating under variable demand face a class of delivery failure that single-layer governance models cannot prevent: structural overload injected at the commitment-formation boundary, invisible to execution-layer metrics, and amplified by cognitive fragmentation that standard workflow instruments do not register. This article examines the architectural conditions under which knowledge work control systems reduce cognitive load and improve delivery predictability. Through a grouped analytical review of empirical and theoretical literature on WIP-limit governance, team cognitive load, and observability-driven telemetry, the article identifies a shared structural limitation across all three bodies of research: none models the coupling between commitment formation, execution mode, and cognitive context as a single governed system. Drawing on control systems theory, queueing dynamics, and cognitive psychology, the article argues that delivery predictability degrades not from execution inefficiency but from the absence of cross-loop coupling rules that prevent obligation surplus, flow degradation, and cognitive fragmentation from reinforcing one another. The three-loop flow architecture comprising a Commit Loop with capacity-bounded intake, a Delivery Loop with explicit Normal, Overload, and Recovery operating modes, and a Cognition Loop enforcing context-capacity constraints through a Context Token Protocol is identified as a structural response to the documented failure modes of existing frameworks. The analytical contribution is a precise specification of the boundary conditions under which WIP-limit Kanban, team-topology design, and DORA-type telemetry each remain adequate, and the condition under which none of them does.

Keywords: Knowledge Work Management; Cognitive Load; Delivery Predictability; Control Systems Architecture; Work-In-Progress Limits; Commitment Formation; Three-Loop Flow Method; Context Switching; Flow Governance; Service Level Expectations; Task Tracking; Organizational Design

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1. Introduction

Knowledge teams rarely collapse from a single identifiable event. They degrade through structural accumulation: commitments form faster than the system can service them, cycle-time distributions develop heavier tails, and cognitive switching costs consume capacity that no workflow metric registers. The DORA research program, tracking over 32,000 professionals across six years of longitudinal surveys, identifies deployment frequency and change failure rate as primary predictors of organizational delivery health, yet acknowledges that these measures capture outcomes, documenting that degradation occurred without exposing the conditions under which it became inevitable [1,2].

That coupling fails at a specific structural threshold. When commitment density exceeds a team's cognitive and coordination capacity, the execution layer cannot stabilize flow regardless of WIP discipline, because the overload originates upstream of any board-visible control surface. Kanban's formulation treats WIP limits and visualization as sufficient flow governance, an assumption Ahmad et al.'s (2018) [3] systematic mapping study of 93 empirical cases partially supports, average cycle times improve measurably under WIP discipline, but one that breaks down when teams accept obligations faster than throughput allows, relocating the queue from the in-progress column to an invisible reservoir of committed-but-unstarted work that still generates inquiries, reprioritization, and coordination traffic. Rubinstein et al. (2001) [4] demonstrated that executive control reconfiguration during task switching incurs time costs of 20–40% even for simple tasks; Mark et al. (2008) [5] found that interrupted workers compensate by working faster at the cost of higher stress and frustration, both findings identify a mechanism that WIP governance cannot address because the switching originates at the commitment-formation boundary, before any work item enters the execution pipeline. Yurkov (2026a) [6] locates the failure threshold precisely at that boundary: the absence of a capacity-bounded intake mechanism injects structural overload upstream of any board-visible control surface.

This article examines the architectural conditions under which knowledge work control systems reduce cognitive load and improve delivery predictability by treating commitment intake, execution mode management, and cognitive context regulation as three coupled feedback loops. The analysis proceeds through three movements: a grouped literature review organized by shared limiting assumptions, a discussion that surfaces the central tension those groups expose, and a conclusion that names the one structural question the existing evidence base leaves open.

2. Literature Review

The dominant operational model for knowledge work flow rests on a single testable claim: constraining work-in-progress is sufficient to govern delivery predictability. Little (1961) [7] establishes the mathematical relationship between average queue length, arrival rate, and time-in-system, making WIP reduction a legitimate lever for cycle-time control when the system is stationary and all load is visible. Vacanti (2015) [8] operationalizes this for knowledge work by arguing that percentile-based Service Level Expectations derived from empirical cycle-time distributions outperform point-estimate commitments, and that WIP discipline is the primary driver of distribution stability. Ahmad et al. (2018) [3] confirm in their systematic mapping that teams implementing WIP limits report cycle-time improvements in a majority of cases, though the mapping also notes that WIP policies are frequently violated under demand pressure and that evidence on long-term predictability improvements remains sparse. Anderson (2010) [9] draws these threads together into a governance model treating visible WIP, explicit policies, and feedback cadences as a complete control architecture.

The obligation boundary is where this group's shared assumption meets its failure threshold. Reinertsen (2009) [10] comes closest to articulating the upstream problem: his cost-of-delay framework assigns economic weight to queued work and argues for batch-size reduction as a path to reduced queue accumulation, but his model treats queues as a scheduling object. A scheduling model treats the backlog as inert inventory; an obligation model treats committed-but-unstarted work as actively consuming attention, generating coordination traffic, and loading the system before execution begins. When teams accept commitments at rates exceeding demonstrated throughput, at a boundary WIP limits never reach, the execution layer faces continuous perturbation from upstream obligation surplus. This perturbation presents as urgency, reprioritization, and exception handling that teams experiencing WIP-limit discipline routinely misattribute to execution inefficiency.

Team-topology research shares a different limiting assumption: delivery performance is primarily a function of how well team boundaries match cognitive capacity requirements. Skelton and Pais (2019) [11] argue that team cognitive load, defined as the total domain knowledge required to own a software system, is the primary constraint on delivery speed, and that organizational design should bound each team's load within what a stable team can hold. Forsgren et al. (2018) [1] extend this empirically, showing that loosely coupled architectures and team autonomy reliably predict elite delivery performance. Both works treat cognitive load as a structural property of the team-system interface, a stable quantity shaped by system boundary decisions rather than a dynamic variable that fluctuates as commitment density changes within a team.

The gap that neither team-topology thinking nor WIP governance closes is resolved architecturally in Yurkov (2026b) [12], developed as a design science artifact in the tradition established by Hevner et al. (2004) [13] for constructs that solve concrete organizational problems. The Three-Loop Flow Method separates three regulatory concerns that existing frameworks conflate: the Commit Loop, which bounds obligation formation through a capacity-calibrated intake mechanism; the Delivery Loop, which governs execution stability through explicit Normal, Overload, and Recovery operating modes with defined transition triggers; and the Cognition Loop, which enforces context capacity through a Context Token Protocol that counts distinct cognitive domains, not task items. Loop separation is a precondition for stability because without explicit coupling rules, a rational local decision at any layer can destabilize adjacent ones, a commitment individually reasonable in isolation can push a key contributor into Thrash mode; an execution-layer throughput push increases context switching to the point where tail risk expands faster than throughput grows. Yurkov (2026b) [12] formalizes the cross-loop coupling: when the Delivery Loop enters Overload, the Commit Loop contracts the commit budget; when the Cognition Loop detects Thrash in a critical role, both loops restrict starts and new commitments for that role's dependent work. Skelton and Pais (2019) [11] establish why cognitive load matters at the topology level; Yurkov (2026b) [12] specifies how it must be governed at the loop level to function as an enforceable constraint.

A third line of research assumes that better observability instruments surface degradation early enough for corrective action. Forsgren et al. (2018) and DORA (2024) [1,2] demonstrate that teams with strong observability practices outperform those without, attributing the gap to faster failure detection and more reliable change-failure attribution. On the cognitive side, Sweller (1988) and Sweller et al. (2011) [14,15] establish that working memory is the limiting resource in knowledge work and that reducing extraneous cognitive load improves both performance and learning transfer. Leroy (2009) [16] adds the attention-residue mechanism: when a person switches tasks before completing a prior one, cognitive preoccupation with the incomplete task persists and degrades performance on the current one, a cost invisible in any workflow state log.

Current instruments encode activity, and Yurkov (2026c) [17] identifies this as a structural property of representational trackers, not a calibration deficiency. When inactivity is treated as informational absence, a commitment held dormant continues loading cognition, generating coordination traffic, and consuming stakeholder attention while the board shows nothing happening. Commitment persistence, reactivation frequency, and coordination footprint, the signals that Yurkov (2026c) [17] identifies as structural precursors of execution degradation, fall outside the DORA metric set and standard cycle-time analytics, because those instruments begin measuring only after work is activated. Rubinstein et al. (2001) [4] establish that reconfiguring executive control processes for each task switch incurs costs scaling with the number of distinct rule sets held in parallel; Mark et al. (2008) [5] document the organizational surface of that cost in interruption studies. Together these findings explain how a team with acceptable deployment frequency can operate in a structurally saturated cognitive regime: the

overload has migrated into the pre-activation commitment layer, invisible to every instrument in the standard observability stack.

3. Theoretical Framework

A control system regulates a process by comparing its output against a target state and feeding the resulting error signal back into the input that produced it. Three properties determine whether such a system remains stable under disturbance. Gain is the magnitude of the corrective response to a given error: high gain means a small deviation triggers a large correction, low gain means the system barely reacts. Delay is the lag between error detection and corrective action; every real system carries some delay, and the question is whether that delay is short enough relative to the rate of change in the disturbance. Damping is the rate at which oscillations around the target decay once a correction has been applied; a system with no damping overshoots, corrects, overshoots again, and never settles. Knowledge work systems exhibit all three properties without naming them as such, which is precisely why their instability is so often misdiagnosed as a discipline problem rather than a design problem. A team that accepts new commitments in direct proportion to incoming requests, with no reference to current throughput, operates with effectively infinite gain and zero damping: every increase in demand transmits immediately and fully into the obligation pool, with no governing element positioned between the request and the commitment. The system has no mechanism that attenuates the signal before it reaches the execution layer, and because nothing in the architecture absorbs the disturbance, every spike in incoming demand becomes a spike in obligation, which becomes a spike in coordination traffic, which becomes a spike in the very switching costs that degrade the team's capacity to service the original demand. This is the structural condition Reinertsen (2009) [10] gestures toward through cost-of-delay economics but does not formalize as a control problem, because his framework treats the queue as an object to be priced rather than as a feedback path to be regulated; pricing a queue tells an organization how expensive its delay is, but it supplies no mechanism that prevents the queue from forming in the first place.

Queueing theory supplies the second half of the formal apparatus, and it explains why the obligation pool, once it begins to grow, does not grow in a way that intuition predicts. Little's Law establishes that average work-in-progress equals arrival rate multiplied by average time in system, a relationship that holds only when the system is stationary, meaning arrival rate and service rate are statistically stable over the observation window. Knowledge work systems are rarely stationary in this sense, and the reason is structural rather than incidental. Commitment arrival is organizationally diffuse: requests originate from sales, from stakeholders, from dependent teams, from the team's own discovery work, each stream operating on its own cadence, each manager believing their request is reasonable in isolation, and none of these streams passing through a shared governor that would let the team see total arrival pressure before it converts into accepted obligation. When arrival rate exceeds service rate even temporarily, queueing systems do not degrade linearly, and this is the point most operational thinking misses. Utilization approaching full capacity produces queue lengths that grow non-linearly as a function of utilization, a property established in queueing theory since Erlang's early work on telephone exchange congestion and confirmed across decades of subsequent operations research on M/M/1 and more general queueing systems. A team running at 95% utilization does not experience 5% more queueing than a team at 90%; it experiences a queue that can be several times longer, because the system has lost the slack needed to absorb ordinary arrival variance, and any small additional surge now has nowhere to be absorbed except into wait time. This non-linearity is the mathematical substrate beneath what Yurkov (2026a) [6] identifies as the failure threshold: WIP discipline manages the visible queue inside the system, the items already on the board, but it has no purchase on the arrival process itself. The obligation pool accumulates exactly where queueing theory

predicts congestion will concentrate, upstream of any bounded buffer, in the space between a request being made and a request being formally accepted as a tracked commitment, which is precisely the space no Kanban board represents.

The three-loop architecture translates both bodies of theory, control theory and queueing theory, into an enforceable organizational structure by assigning each regulatory function to a distinct loop with its own sensor, target, and actuator, the three components every functioning control loop requires. The Commit Loop functions as the system's primary gain control, the element that determines how much of an incoming disturbance is allowed to propagate downstream. Its sensor is demonstrated throughput, measured as a trailing distribution rather than a point estimate, an approach consistent with Vacanti's (2015) [8] argument that percentile-based service expectations outperform single-number commitments precisely because real cycle-time data is rarely symmetric and a single average obscures the tail risk that matters most for predictability. Its target is a commit budget calibrated against that distribution, not against requested demand, which is the structural inversion that separates this mechanism from ordinary backlog prioritization: the budget asks what the team can actually absorb, not what stakeholders are asking for. Its actuator is intake refusal: when the budget is exhausted, new commitments queue at the boundary rather than entering the system as accepted obligations, which is the mechanism wholly absent from Reinertsen's scheduling model and from Anderson's (2010) [9] WIP-and-visualization architecture alike, both of which manage what happens after acceptance and say nothing about acceptance itself. Critically, the Commit Loop's gain is not fixed at a static value calibrated once and left alone. It contracts when the Delivery Loop reports Overload and expands only after the Delivery Loop confirms Recovery, which gives the system the damping property that an unregulated intake process lacks entirely, because the loop's responsiveness to downstream state is what prevents the classic oscillation pattern of overcommit, crisis, overcorrection, and renewed overcommit. The practical effect of variable gain is that the same incoming request, identical in scope and urgency, receives a different organizational response depending on system state: accepted promptly under Normal mode, queued at the boundary under Overload, a behavior that looks inconsistent from the requester's vantage point but is exactly what a correctly damped control system is supposed to do, since consistency of response under all conditions is what produces instability, not what prevents it.

The Delivery Loop governs execution stability through three explicit operating modes rather than a single undifferentiated flow state, and the existence of three named modes, not two, is itself a design decision with empirical justification. Normal mode applies when cycle-time distributions track their historical baseline and WIP remains within calibrated bounds; in this mode the Commit Loop's gain stays at its default setting and no special intervention is required. Overload mode triggers when cycle-time tails expand beyond a defined percentile threshold or when WIP breaches its ceiling, and its defining feature is not that work stops, which would be a blunt and organizationally costly response, but that the loop signals upstream: the Commit Loop receives a contraction instruction, and new commitments are deferred rather than added to an already-saturated execution layer, which is the closed feedback path that none of the reviewed frameworks implements. Recovery mode is distinct from Normal mode because it carries an explicit exit condition, sustained performance within baseline for a defined observation window, rather than treating a single good day as evidence of stabilization, a distinction that matters because teams recovering from overload typically show volatile short-term improvement before the underlying obligation pool has actually been worked down. The three-mode structure matters because a binary system, stable or not stable, cannot represent the asymmetry between how fast a team degrades into overload, often within a single sprint of unmanaged intake, and how slowly it should be allowed to exit it, since premature reopening of the commit budget reintroduces the same disturbance

that caused the overload in the first place. Treating recovery as instantaneous is what produces the oscillation pattern familiar to any team that has cycled repeatedly between crisis sprints and renewed overcommitment, a pattern that from a control-theory perspective is simply a system with insufficient damping being run without correction.

This is the mechanism through which Rubinstein et al.'s (2001) [4] switching-cost findings and Leroy's (2009) [16] attention-residue findings, both individual-level psychological phenomena documented in laboratory and field settings respectively, become a system-level governance constraint rather than a fact about cognition that the architecture acknowledges in its literature review and then quietly ignores in its actual control logic, which is the gap that affects most workflow frameworks built primarily around visible task state.

The coupling between the three loops is what converts three independent regulatory mechanisms into a single control system, and it is this coupling, not any individual loop in isolation, that the reviewed literature leaves unaddressed. WIP-limit frameworks regulate the Delivery Loop in isolation and treat its inputs, the rate and size of incoming commitments, as exogenous, a given condition the framework responds to rather than a variable it governs. Team-topology design shapes the Cognition Loop's ceiling through structural decisions about system ownership, drawing team boundaries to bound domain knowledge, but does not connect that ceiling to real-time intake or execution state; the boundary is set once, at a design review, and does not adjust when a team enters Overload. Observability instruments report on the Delivery Loop's output after the fact, providing valuable retrospective attribution of why a release failed or a deployment slipped, but feed no signal back into the Commit Loop's gain, leaving the loop that determines how much new obligation enters the system entirely unaware of what the telemetry has already detected. Each framework, in the formal sense developed above, implements an open loop where the architecture requires a closed one: a regulatory mechanism with a sensor and sometimes a target, but no actuator connecting its output back to the variable that destabilized it in the first place. A thermostat that measures temperature but has no connection to the furnace is not a control system in any functional sense, however accurate its sensor; the same logic applies to a tracker that measures cycle time but has no connection to intake policy.

This formal apparatus also clarifies where the three-loop architecture's claims should stop, which existing single-layer frameworks rarely specify for themselves. The model assumes that throughput and cycle-time distributions are observable with sufficient history to calibrate a commit budget, a condition that holds for established teams with several months of tracked execution data and is considerably weaker for newly formed teams or teams undergoing significant membership turnover, where the trailing distribution itself is unstable. It assumes that commitment requests can in fact be deferred at the boundary, an assumption that fails in environments with genuinely hard external deadlines that cannot be renegotiated, incident response being the clearest case, where the appropriate control response is not intake gating but a separate, pre-authorized fast path with its own bounded capacity. It also assumes that cognitive domains can be meaningfully counted per role, which holds reasonably well for roles with clearly bounded technical ownership and is harder to operationalize for highly generalist roles that legitimately span many shallow contexts as a function of the job itself rather than as a pathology to be corrected. A further consequence of stating the model in these formal terms is that each loop's claims become individually falsifiable rather than merely plausible: a commit budget calibrated against a trailing throughput distribution generates a specific predicted ceiling that either holds under subsequent demand or does not, an Overload threshold defined against a percentile cutoff either triggers before cycle-time degradation becomes visible elsewhere or triggers too late to matter, and a context ceiling either correlates with measurable switching-cost effects in the population it is calibrated for or fails to, which is precisely the kind of falsifiable structure absent from frameworks

that describe cognitive load qualitatively without specifying a measurable threshold or an enforcement rule tied to it. None of these boundary conditions undermines the architecture within its intended domain, sustained delivery work under variable demand with at least partially renegotiable commitments, but they do mark where the formal apparatus developed here transfers cleanly and where it would require modification, a distinction the Discussion section returns to when it examines the architecture against each body of reviewed literature in turn. With the sensors, targets, actuators, and coupling rules of the three loops now specified in formal terms, the question that follows is empirical rather than architectural: against the specific claims and conditions established in the literature reviewed above, where does each existing framework hold, and at precisely which boundary does its single-layer design stop reaching the failure mode the three-loop architecture was built to close.

4. Discussion

The literature review exposes an architecture problem, not a calibration problem. WIP-limit frameworks, team-topology design, and observability-driven telemetry each address real mechanisms, each carries empirical support within its conditions of application, and each fails at the same structural boundary: none models the coupling between commitment formation, execution mode, and cognitive context as a single governed system. That coupling is not a theoretical refinement; it is the mechanism through which each framework's specific limitations become self-reinforcing under variable demand.

Contrary to Anderson (2010) [9], WIP limits and visualization do not constitute a sufficient control architecture for knowledge work teams when demand is variable. Ahmad et al. (2018) [3] document the conditions under which WIP governance functions, primarily when teams maintain disciplined policy adherence and demand is relatively stable, which is precisely the condition set under which the commitment-formation problem remains latent. Obligation inflation is the mechanism Anderson's model cannot account for: the progressive accumulation of committed-but-unstarted work that generates interruption and coordination overhead independently of visible WIP. Little's (1961) [7] law describes a stationary relationship between WIP, throughput, and cycle time; it places no constraint on the size of the obligation pool upstream of the start boundary. When that pool grows unchecked, teams experience what presents as execution inefficiency, rising cycle times, expanding tail risk, but is structurally a commitment-formation failure the execution layer has no lever to address. Yurkov (2026b) [12] formalizes the architectural remedy by specifying cross-loop coupling rules: the Commit Loop gates intake against demonstrated throughput and contracts the commit budget whenever the Delivery Loop enters Overload, so the execution layer is no longer continuously re-perturbed by upstream obligation surplus regardless of WIP-limit discipline. Reinertsen's (2009) [10] cost-of-delay framework reaches toward this problem through batch-size economics but does not close it, because reducing batch size without constraining the commitment-formation rate leaves the obligation reservoir intact.

Observability instruments present a different analytical problem, and Yurkov's (2026c) [17] diagnostic framework changes the argument's structure at that point. Forsgren et al. (2018) and DORA (2024) [1,2] offer a powerful model for retrospective performance attribution: high-performing teams are reliably identifiable by their metric profiles after the fact. The instruments they rely on, however, begin generating signal only once work is activated, which means the pre-failure state, rising commitment density, increasing reactivation frequency, accumulating coordination footprint, produces no observable trace in deployment telemetry. Leroy (2009) [16] demonstrates that attention residue from incomplete prior tasks degrades current task performance without generating any workflow event; Rubinstein et al. (2001) [4] quantify the switching-cost substrate beneath that residue. Yurkov (2026c) [17] translates these mechanisms into an

organizational diagnostic: a team can show acceptable throughput while key contributors cycle among multiple unrelated project contexts, each generating its own stream of inquiries and reactivation overhead, because the tracker records completion events and the telemetry records deployments, and neither instrument represents the commitment persistence structure driving cognitive fragmentation. The Context Token Protocol in Yurkov's (2026b) [12] framework operationalizes this constraint at the governance level, counting active cognitive contexts per person, not task items per board, and enforcing a stop-start rule when context capacity is exceeded.

Cognitive Load Theory, as formulated by Sweller et al. (2011) [15], presents a qualified tension that the three-loop framework resolves in a specific direction. In learning contexts, extraneous cognitive load is reduced through instructional design, a one-time artifact decision. In knowledge work governance, the processes that generate extraneous load are dynamic: each new obligation admitted without capacity consideration adds to the switching burden continuously. Reducing this load requires an enforcement mechanism, bounded admission architecture where the Commit Loop's intake gates respond in real time to Cognition Loop state. Sweller's framework explains why cognitive fragmentation is costly; Yurkov (2026b) [12] provides the only mechanism in the reviewed literature that makes this cost governable at the system level. The distinction between explanation and governance operationalization is the precise gap the three-loop architecture occupies.

WIP limits reduce cycle-time variability when demand is stable and policies are enforced; this is empirically established by Ahmad et al. (2018) [3] in 93 cases. Team cognitive load constrains delivery speed when system boundaries are drawn poorly; Skelton and Pais (2019) [11] demonstrate this convincingly at the organizational topology level. DORA metrics identify high-performing teams with high reliability across six years of longitudinal data (DORA, 2024) [2]. The failure is completeness under dynamic conditions: when demand is variable, commitment formation is organizationally diffuse, and team members operate across multiple concurrent project streams, no single-layer governance model remains adequate. A control architecture that couples all three regulatory layers treats the coupling itself as the primary design problem, which is why it constitutes a different class of solution from any framework reviewed here.

5. Conclusion

What this analysis makes possible is a precise specification of where single-layer knowledge work governance fails and why: each dominant practice is architecturally isolated from the others, leaving the coupling between commitment formation, execution stability, and cognitive context ungoverned. The reviewed frameworks are not wrong within their own conditions of application — they fail at the boundaries between conditions, where a commitment decision upstream reshapes execution dynamics downstream, and where cognitive fragmentation accumulates in a layer no flow metric reaches.

Three findings from the literature converge on a single implication. Rubinstein et al. (2001) [4] and Mark et al. (2008) [5] establish that switching costs are not incidental but structural — they scale with the number of concurrent cognitive domains regardless of visible WIP. Vacanti (2015) [8] demonstrates that delivery predictability is a distributional property of the system. Yurkov (2026b) [12] provides the architectural translation of both findings into an enforceable governance model: bounded admission, mode-based execution control, and context-capacity enforcement operating as coupled loops rather than independent practices. Together these constitute a sufficient theoretical basis for a new generation of knowledge work control systems.

The one structural question the existing evidence base leaves open is whether the cross-loop coupling rules formalized by Yurkov (2026b) [12] the specific mechanisms by which Commit Loop budget contraction, Delivery Loop mode switching, and Cognition

Loop stop-start protocols interact under simultaneous multi-vector stress generalize across organizational topologies with different coordination densities, or whether the coupling parameters require topology-specific calibration that would constrain the method's portability. Resolving this requires longitudinal empirical data from teams operating the full three-loop architecture under controlled variation in demand pattern and organizational structure data that does not yet exist in the published literature.

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