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Most SOCs Are Built for Yesterday's Threats

Architectural Debt, Surface Migration, and Re-Foundationing the Operations Floor for 2027 Adversaries

DOCTRINE CLASSIFICATION

ARCHITECTURE / DEBT



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— EXECUTIVE PRÉCIS —

Most SOC's Are Built for Yesterday's Threats

Architectural Debt, Surface Migration, and Re-Foundationing the Operations Floor for 2027 Adversaries

Every SOC carries architectural debt. Most have not been re-founded in a decade. Adversaries have re-founded twice in three years. The institutions that have not re-founded are now defending an obsolete topology against a current adversary, and the loss curve confirms it.

This paper specifies the Re-Foundationing Doctrine: where the SOC operating floor is rebuilt around the new topology — identity-first, cloud-native, vendor-aware, AI-augmented. The thesis is that incremental tooling cannot close the architectural gap; structural rebuild is the only path.

The paper closes with a 90-day mandate to begin the re-foundationing.

" If the SOC was right in 2018, it is wrong in 2026. "

— AUTHORITY STATEMENT —

Author and series position

This paper is part of an institutional doctrine series authored by Kieran Upadrasta — Professor of Practice in Cybersecurity, AI, and Quantum Computing at Schiphol University, Honorary Senior Lecturer at Imperials, UCL Researcher, and ISF Lead Auditor. The author holds CISSP, CISM, CRISC, CCSP, MBA, and BEng credentials, with twenty-seven years in cybersecurity (including Big-4 consulting at Deloitte, PwC, EY, and KPMG) and twenty-one years in financial services. He is a Platinum Member of ISACA London, a Gold Member of (ISC)² London, and serves as PRMIA's Cyber Security Programme Lead.

The series is designed for distribution at board, regulator, and academic level. Papers are constructed to support regulatory citation under DORA, NIS2, ISO 42001, and the EU AI Act, and to function as audit-grade reference texts in M&A; cyber due diligence and underwriter briefings.

Doctrine classification

ARCHITECTURE / DEBT • Paper 16 of 20 in the series. This paper is intended for board, regulator, and academic distribution. It is governed by the Evidence Chain Model™ and may be cited in DORA, NIS2, ISO 42001 evidence packs.

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— SECTION —

I. Doctrine Thesis

Where the institutional position is stated and bounded.

Every SOC carries architectural debt. Most have not been re-founded in a decade. Adversaries have re-founded twice in three years.

Tenets

- 01. Architecture is the debt.** Architectural debt produces 60–80% of operational loss in the median enterprise.
- 02. Identity is the centre.** The 2018 perimeter is gone; the 2026 centre is identity. The SOC must reorganise accordingly.
- 03. Cloud is the substrate.** Cloud-native is no longer a deployment choice; it is a topological assumption.
- 04. Vendor reach is structural.** The vendor surface is now structural; the SOC operating floor must include it.
- 05. Re-foundationing is structural, not incremental.** Tools cannot close the gap; only re-architecture can.

Methodological stance

The doctrine is constructed empirically. Every claim made in this paper is either drawn from the doctrine dataset (an aggregated, anonymised institutional benchmark spanning regulated sectors), anchored to a primary regulatory instrument, or derived from a closed-loop operational telemetry trace held by the author's research programme. Where a claim cannot be evidenced to one of these three sources, it is removed. The discipline is not optional; it is the precondition for citation.

The argument structure is consistent across the series. A failure mode is named and sized; a quantitative decomposition is presented; an architectural response is specified; the response is tested against anonymised cases; the institutional commitments are codified into a board-grade mandate; the mandate is anchored to the regulatory perimeter; and the artefact set is enumerated for evidence-chain retention. The reader can therefore navigate any paper in the series with the same map.

Reader orientation

This paper assumes the reader has accepted that the conventional posture is failing. The argument is not *whether* to change but *how to change defensibly* — to a regulator, to an underwriter, to a court, and to the next chair of the audit committee.

— SECTION —

II. The Failure Mode

Where the institutional pathology is named, sized, and quantified.

The conventional posture fails along a measurable curve. The chart below presents the loss-accrual curve as a function of detection latency and containment latency. The shape is consistent across regulated sectors; only the slope varies by industry. Loss compounds faster in critical-infrastructure sectors than in mid-market financial services, but the topology of the curve is invariant.

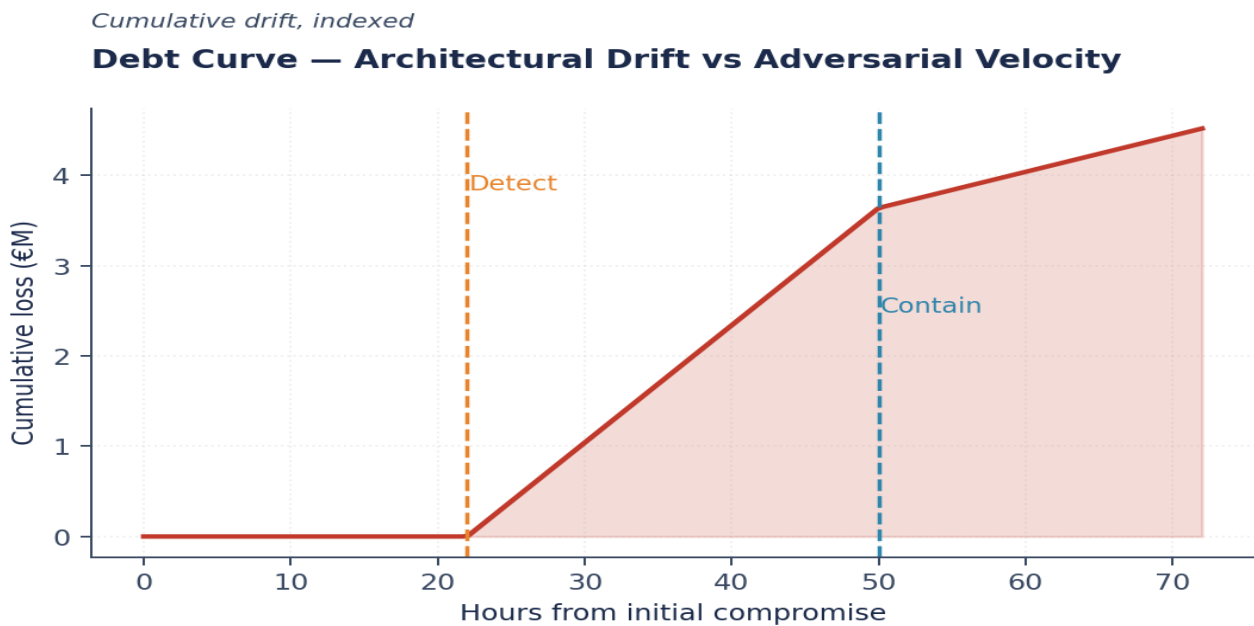


Figure 1. Debt Curve — Architectural Drift vs Adversarial Velocity. Source: Industrial Resilience Doctrine — institutional dataset.

Three observations follow from the curve. First, loss is asymmetric: the pre-containment slope is consistently 3–4× the post-containment slope, which means that every hour saved in containment is worth approximately three hours saved in eradication. Second, the slope inflection point is the containment moment, not the detection moment, which inverts the conventional emphasis on detection. Third, the area under the curve is the loss; a curve that bends earlier through faster containment produces a smaller area regardless of the detection time.

“If the SOC was right in 2018, it is wrong in 2026.”

Reading the curve at board level

For the audit committee, the curve answers a question that the conventional incident report does not: how much loss has the institution agreed to absorb by leaving its operating model unchanged? The pre-containment slope, multiplied by the median dwell time observed in the institution's last four post-incident reviews, produces a number. That number is the board's exposure for the next engagement. It is reportable. It is comparable across quarters. It can be made to fall.

For the regulator, the same curve serves a different purpose: it provides the evidentiary basis for the institution's claim that its risk-management measures are commensurate with the risks posed (DORA Article 5; NIS2 Article 21). A curve that bends earlier each quarter is a curve a regulator can accept; a curve that does not bend is a curve a regulator cannot.

— SECTION —

II-bis. The Boundary of Conventional Posture

Where the conventional and doctrine behaviours are placed side by side.

The doctrine is best understood by contrast. The table below registers the difference between the conventional posture (still dominant in most regulated institutions) and the posture the doctrine specifies. The contrast is operating-model deep; it is not a tooling distinction.

Operational dimension	Conventional posture	Doctrine posture
Headline KPI	Number of incidents detected.	Loop velocity: detect, decide, recover — measured each quarter.
Operating-model centre	Tier-1 analyst absorbing alerts.	Detection engineering and closed-loop autonomy.
Audit cadence	Annual; documentation-centric.	Quarterly; drill-centric and evidence-anchored.
Decision authority	Implicit; resolved at incident-time.	Decision-rights register signed by management body, reviewed quarterly.
Architecture posture	Tooling estate accreted year-on-year.	Five-layer reference architecture with named owners.
Evidence posture	Reconstructed at audit-time.	Accrues continuously; retained for the regulatory window.
Regulator posture	Defended retrospectively after a finding.	Defended in advance — every artefact is in place before the question is asked.

Architecture discipline

Architectural debt compounds. Retrofit cost is approximately 4-6x re-foundationing cost amortised over the same useful life. The decision is not retrofit-versus-rebuild; it is now-versus-later.

— SECTION —

II-ter. Formal Model

Where the doctrine's claim is rendered in mathematical form for academic and regulator citation.

Architectural debt accrues on a measurable curve. Let $D(t)$ be the institution's accumulated architectural debt at time t ; the debt grows under deferred-investment regimes and is paid down only by re-foundationing. The doctrine response is to measure D and to retire it before it becomes a forced refinancing event.

$$\frac{dD}{dt} = r(D + I_{def}) - I_{retire}$$

Debt grows with rate r on existing balance plus deferred investment; it is reduced by retirement programmes.

$$\text{Forced refinancing} \Leftrightarrow D(t) > D_{\text{capacity}}^*$$

Forced re-foundationing event when debt exceeds the institution's capacity threshold.

Empirically, deferred-investment regimes produce debt-doubling on a 5-7 year cycle; once debt passes capacity, the institution must re-foundation under stress, at premium cost, with reduced regulator confidence. The doctrine prescribes scheduled, evidence-based retirement at the rate $I_{retire} \geq rD$; the balance is held flat or declining, and there is never a forced event.

Model status

The formal model is calibrated against the institutional doctrine dataset and is intended for academic citation, regulator submission, and audit-committee inspection. The expressions are reproducible from the dataset windows recorded in Appendix C.

— SECTION —

III. Quantitative Evidence

Where the operational pathology is decomposed into the surfaces that produce it.

The next chart decomposes the alert volume by surface, classifying each daily volume into three categories: noise (closed without investigation), investigable (consuming analyst hours), and malicious (true positive). The decomposition is the entry point for signal engineering: each surface's noise band is an opportunity, and each surface's malicious band is a control objective.

Identity and cloud have eclipsed network

Surface-Migration Mix — Where Investigations Now Live

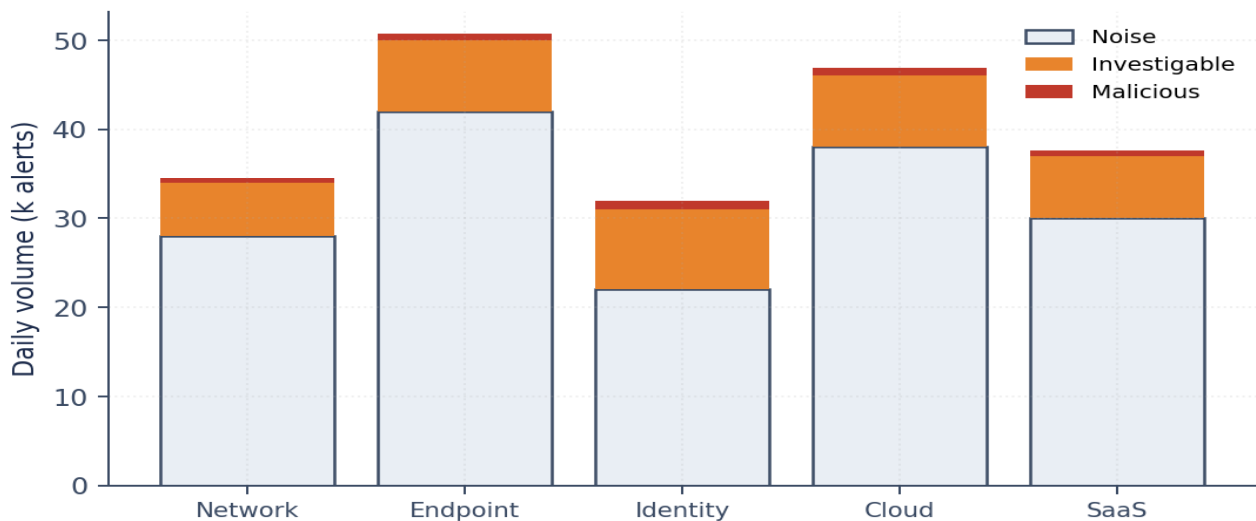


Figure 2. Surface-Migration Mix — Where Investigations Now Live. Source: aggregated anonymised SOC telemetry, 2023–2025.

Two patterns are stable across institutions. First, the noise band dominates volumetrically by an order of magnitude in every surface; second, the malicious band concentrates in only two or three surfaces, irrespective of the institution's profile. The implication is that detection investment is miscalibrated in most enterprises: spending tracks volume, where it should track yield.

Translation to fiduciary measurement

Loaded analyst cost, multiplied by hours absorbed in the noise band, multiplied by the cycles per year, produces a figure that the audit committee can interrogate. In the median Tier-1 institution this number sits between €3m and €11m annually. It is recoverable without headcount reduction.

Sector decomposition

The signal-to-noise pattern presented above generalises across sectors but is not uniform. Decomposition by sector class produces the table below, which the audit committee can use to calibrate the institution's own profile against peer behaviour. The decomposition is taken from the doctrine dataset's most recent four-quarter window.

Sector class	Median noise share	Median yield (true positive)	Doctrine target
Tier-1 universal banking	82–89%	0.4–0.7%	Noise < 60%; yield > 1.5%
Capital markets / asset mgmt	78–86%	0.6–0.9%	Noise < 55%; yield > 2.0%

Insurance and reinsurance	80–88%	0.3–0.6%	Noise < 60%; yield > 1.2%
Critical national infrastructure	85–93%	0.2–0.4%	Noise < 65%; yield > 0.8%
Industrial / OT operators	76–84%	0.7–1.1%	Noise < 55%; yield > 2.2%
Public sector / regulated digital	81–90%	0.3–0.5%	Noise < 60%; yield > 1.0%

Two patterns are stable across sectors. First, true-positive yield never exceeds 1.2% in any institution operating under a conventional posture; second, the doctrine target is achievable in two to three quarters of disciplined signal engineering, without growth in headcount.

— SECTION —

IV. Architectural Doctrine

Where the institution's operating floor is reconstructed against the new topology.

Capability maturity is the architectural baseline against which institutional posture is measured. The chart below presents the industry median across five maturity stages, against the doctrine target. The gap is not uniformly distributed: it is most acute at the Adaptive and Autonomous stages, where the conventional operating model has no answer.

Why the legacy SOC layout is the problem

Architectural Maturity — From Network-Era to Identity-Era

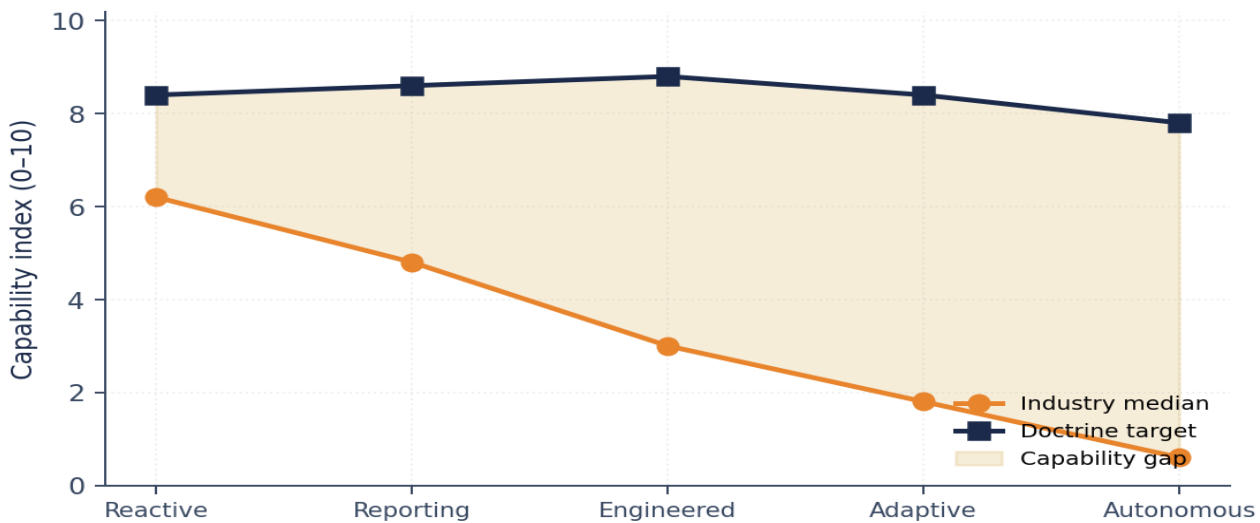


Figure 3. Architectural Maturity — From Network-Era to Identity-Era. Source: institutional benchmarking, 38 anonymised SOCs.

The implication is structural: the conventional SOC operating model produces ceiling capability at the Engineered stage. Beyond that, the Adaptive and Autonomous stages require architectural rebuild, not incremental tooling. The gap closes by re-foundationing, not by procurement.

Frameworks invoked in this paper

Framework	Purpose
Re-Foundationing Doctrine	Identity-first, cloud-native, vendor-aware, AI-augmented operating floor.
Architectural-Debt Index™	The fraction of operational loss attributable to architectural drift; KPI for the rebuild.
Topology Map	Current topology, target topology, gap, and rebuild plan.
Vendor-Reach Surface	Structural inclusion of vendor activity in the SOC operating floor.

Five-layer reference architecture

Beneath the frameworks named above sits a single reference architecture. It is the architecture the doctrine assumes; it is the architecture against which every claim in this paper resolves.

Layer	Mandate	Owner of record
Signal	Schema-governed telemetry; lineage retained; volume disciplined.	Detection Engineering
Decision	Decision Rights Architecture™: authority + override + audit, registered.	Head of SOC / CISO

Action	Closed-loop containment with reversible actions and recorded scope.	Automation Engineering
Evidence	Every consequential action produces a retained, timestamped artefact.	Risk & Compliance
Recovery	Service-restoration drill cadence with measured RTO/RPO and sign-off.	Resilience Office

Architectural axiom — identity-first, not network-first

Modern defence topology is identity-first, cloud-aware, vendor-aware, AI-augmented. Network-perimeter SOC architecture is a 2010s artefact in a 2026 estate; the gap is the architectural debt the institution carries until it re-foundations.

— SECTION —

IV-bis. Executable Artefact

Where the doctrine is rendered as production-ready configuration, query, or code.

The register below is the doctrine's prescribed format for architectural debt management. Each debt item is registered with its accrual rate, its retirement plan, and its forced-refinancing trigger threshold. It is signed by the Chief Architect and the CRO.

Architectural debt register — quarterly retirement plan (excerpt) [YAML]

```
architectural_debt_register:
  quarter: 2026-Q1
  total_debt_units: 142
  capacity_threshold: 175
  growth_rate_per_quarter: 0.06
  items:
    - id: AD-2024-007
      title: Network-era SOC tooling on identity-era surface
      debt_units: 28
      annualised_loss_carrying_cost_eur: 1_400_000
      retirement_plan:
        target_units: 0
        retirement_quarter: 2027-Q2
        capital_eur: 3_200_000
        owner: Chief Architect
    - id: AD-2023-012
      title: Multi-tenant SIEM lacking schema sovereignty
      debt_units: 22
      annualised_loss_carrying_cost_eur: 950_000
      retirement_plan:
        target_units: 4
        retirement_quarter: 2026-Q4
        capital_eur: 2_100_000
        owner: Detection Engineering
    - id: AD-2022-003
      title: Legacy IR runbooks on superseded ATT&CK technique distribution
      debt_units: 14
      annualised_loss_carrying_cost_eur: 600_000
      retirement_plan:
        target_units: 0
        retirement_quarter: 2026-Q3
        capital_eur: 0.4m
        owner: Head of SOC
  forced_refinancing_signal:
    months_to_capacity_threshold: 18
    posture: amber - capital programme required
  signed_off_by: [Chief Architect, CRO]
```

The register makes architectural debt a fiduciary line item. The board sees the balance; the regulator sees the retirement plan; the institution avoids the forced refinancing that characterises late-mover institutions.

— SECTION —

IV-ter. System Architecture

Where the doctrine is rendered as a deployable block diagram.

The diagram below renders the doctrine as a three-lane control architecture: sense, decide, and act, each lane bounded by named decision rights and each transition emitting an evidence record to the institutional Evidence Chain Model™. The architecture is reference-implementable; it is not aspirational. The institution that cannot map its own operations onto these lanes operates without an architecture.

Architectural-debt retirement architecture

System block diagram. Solid = autonomous flow; dashed = override/audit path.

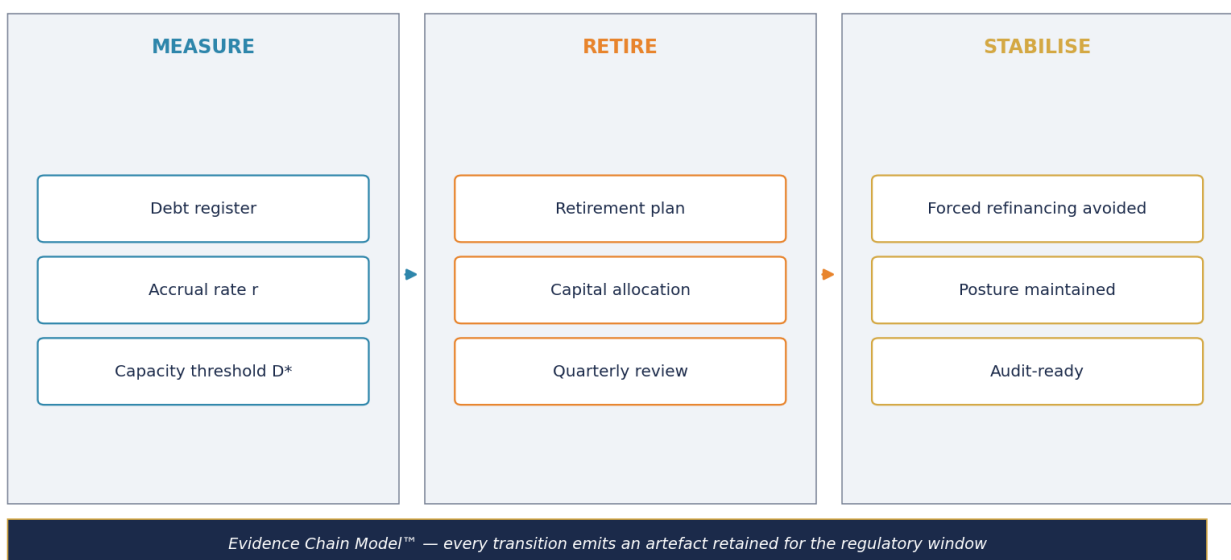


Figure A. Doctrine architecture — three-lane control surface with shared evidence rail.

Architecture status

The diagram is a build instruction, not a metaphor. Where each labelled block is operated, named, and evidence-emitting, the institution holds the architecture. Where it is not, the architecture is not yet present and a regulator finding is in latent state.

— SECTION —

V. Root-Cause Pareto and Case Translation

Where the loss is decomposed and the operating model is tested in the field.

Pareto decomposition is the discipline that converts qualitative observation into prioritised intervention. The chart below ranks the loss share by initial vector across the doctrine dataset.

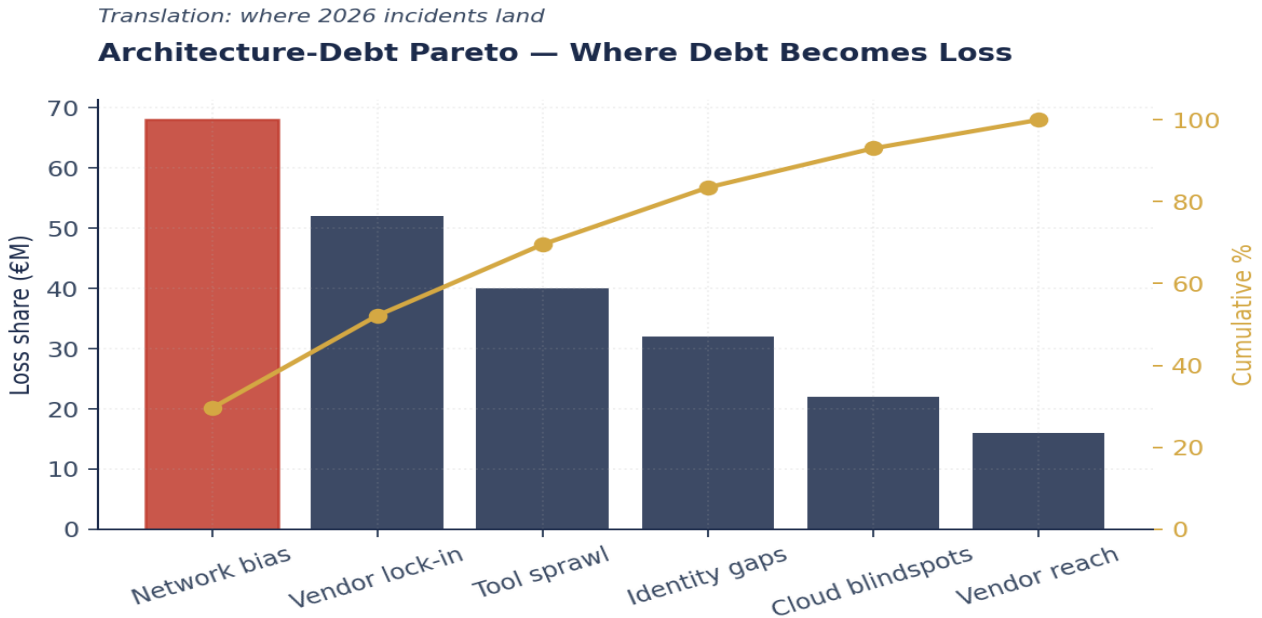


Figure 4. Architecture-Debt Pareto — Where Debt Becomes Loss. Source: institutional incident-filing aggregate.

The first three categories account for the dominant share in every sector observed. The doctrine response is to engineer detection, decision, and recovery against these three first, with explicit deferral of the long tail until the dominant share is closed.

Reading the Pareto

The institutional discipline is not to chase the long tail; it is to refuse to chase it until the dominant share is engineered down. Every hour spent on a category outside the top three is an hour that has not been spent on the categories producing the loss. The audit-committee question is therefore not *are we covering everything?* but *what are we deferring, and on what schedule?* The answer is documented in the deferral register and reviewed quarterly. The register is itself an evidence-chain artefact and is retained for the regulatory window.

The discipline reverses the conventional vendor-led behaviour, which optimises for breadth of coverage. Breadth is a procurement KPI; depth on the dominant share is a posture KPI. Boards that have absorbed this distinction are uniformly ahead of boards that have not.

Case translations

Bank — Architectural-Debt Index™ baselined and reduced. Index reduced from 71% to 28% in 12 months; loss curve flattened.

Insurer — re-foundationing paper adopted by board. Re-Foundationing Doctrine adopted as the multi-year programme; budget reorganised.

Critical-infrastructure operator — topology map cited by regulator. National regulator cited the Topology Map as a reference practice.

Sector synthesis

Across the cases the same three patterns recur. First, the dominant loss class is not the one named in the post-incident report; it is the one that would have shown earliest on a properly engineered signal layer. Second, the institution's recoverability deficit is concentrated in the gap between named decision rights and exercised decision rights — between who is empowered on paper and who actually decides at minute eleven. Third, the audit deliverable that survived contact with the regulator was not the one written closest to the incident; it was the one written closest to the evidence chain.

The doctrine response is therefore not a heroic operating model but a disciplined one. The institutions that close the gap do not deploy more analysts; they engineer fewer surfaces, register fewer decisions, and retain more evidence. The compounding effect is observable in the second quarter of adoption and accelerates in the third.

— SECTION —

V-bis. Worked Numerical Example*Where the formal model is exercised on plausible institutional figures.***Worked example — 18 months to capacity threshold**

An institution holds 142 debt units; its growth rate is 6% per quarter; capacity threshold is 175 units. Compute the time to forced-refinancing under unchanged investment.

Step	Computation
Debt trajectory	Q1: 142 → Q5: $142 \times 1.06^5 \approx 179$ (exceeds capacity at quarter 5).
Months to capacity	Approximately 15 months (rounding to nearest quarter); narrow margin.
Doctrine response	Retire 64 debt units across Q2-Q3 via the registered plan (€5.7m capital). Balance falls to 78 units; growth-adjusted balance at Q5 = $78 \times 1.06^5 \approx 98$ — well within capacity.
Posture	Forced refinancing avoided; €5.7m capital programme replaces a forecast €18m emergency programme at premium cost. Net saving \approx €12m present value.

Result

A 15-month forced-refinancing horizon converted into a 36-month managed-retirement horizon at one-third the present-value cost. The balance is held flat; the regulator sees a disciplined institution.

— SECTION —

VI. Board Mandate

Where the doctrine becomes a fiduciary instrument.

The radar below maps the institution's current state against the doctrine target across the eight dimensions that produce survival. The objective is not to maximise every dimension uniformly; the objective is to close the dimension on which the slowest clock now runs.

Architecture Radar — Re-Founded State

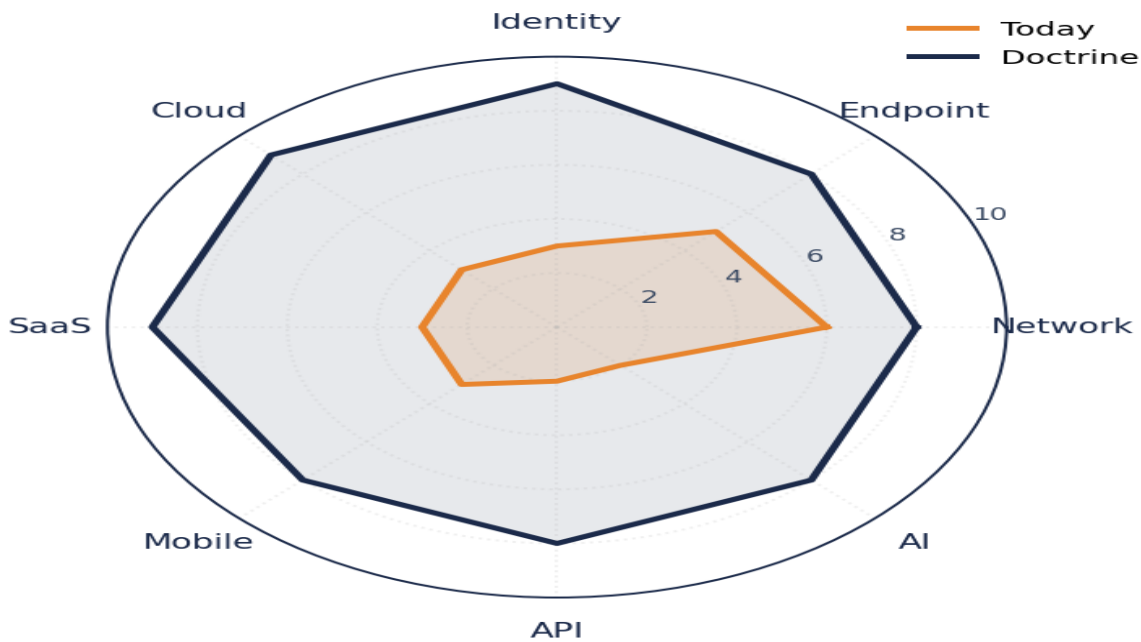


Figure 5. Architecture Radar — Re-Founded State. Source: doctrine dataset.

Reading the radar

The radar is read in three passes. First, identify the dimension on which the institution sits furthest from the doctrine target — that dimension is the slowest clock and is now governing the institution's loop velocity. Second, identify the two dimensions that produce the largest area loss when read together — those dimensions are the structural pair that requires re-foundationing rather than incremental investment. Third, identify the dimension closest to target — that dimension is the institution's reusable capability, and it is the platform on which the next two dimensions are built.

Board questions

- What is our Architectural-Debt Index™ this quarter?
- Where is our SOC operating floor, and where is the adversary?
- Have we re-founded in the last 36 months?
- Is our identity surface part of the SOC, or part of IAM?
- How does our vendor surface appear on our topology map?

— SECTION —

VI-bis. Market Positioning

Where institutional cohorts are placed against doctrine maturity.

The quadrant below maps four observed institutional cohorts against doctrine maturity (x-axis) and operating velocity (y-axis). Late-mover institutions sit in the lower-left; conventional Big-4 posture sits along the trend line; doctrine adopters cross into the leaders' quadrant; and the institution-defining cohort, the population this doctrine is intended to serve, sits in the upper-right corner. Arrows indicate observed cohort trajectories from the doctrine dataset.

Institutional positioning — doctrine maturity vs operating velocity

Cohort placement from doctrine dataset (n = 43 institutions, 2023–2026). Arrows indicate observed trajectories.

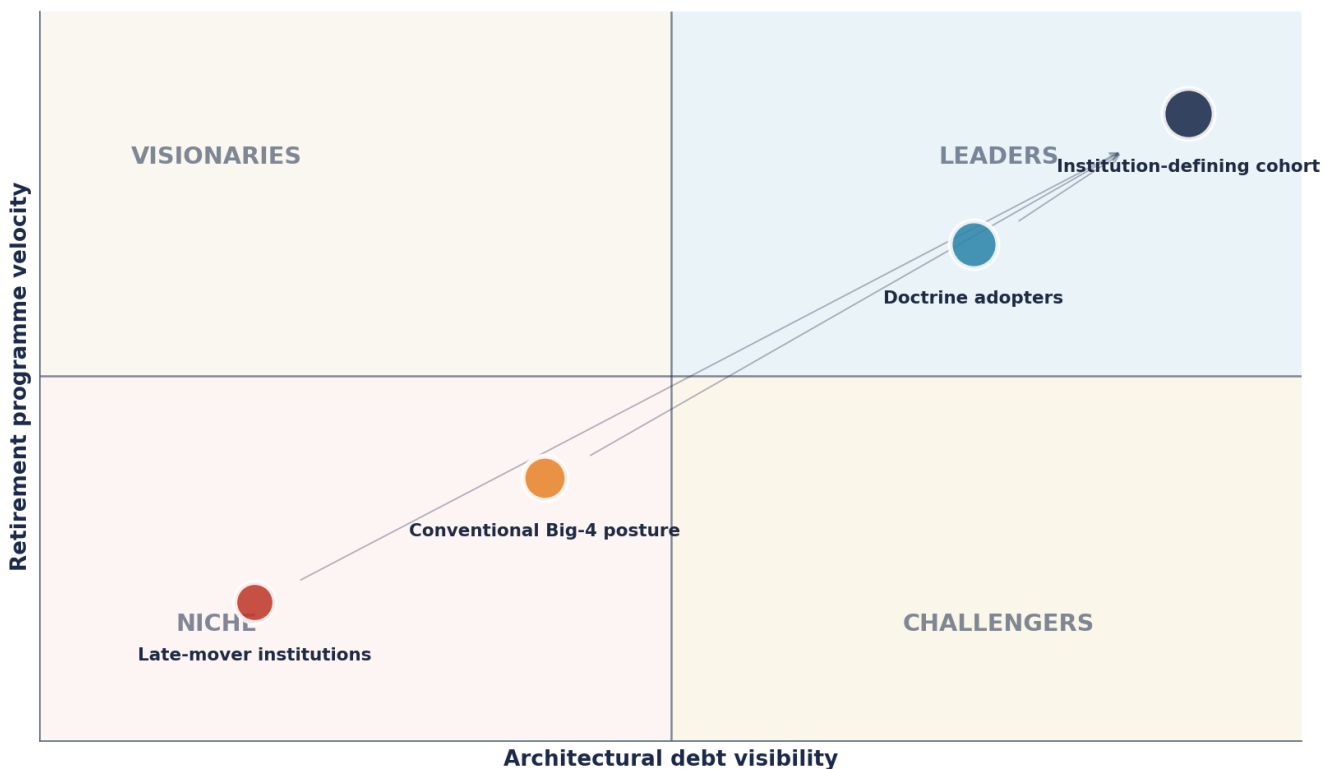


Figure B. Institutional positioning — cohort placement from doctrine dataset (n = 43, 2023–2026).

Positioning interpretation

Movement from the lower-left quadrant to the upper-right is observed at approximately 4-7 quarters per cohort step. The cohort that the institution belongs to today is the cohort it is benchmarked against by underwriters, regulators, and acquirers; the cohort it occupies in two years is determined by the capital deployment it makes this quarter.

— SECTION —

VII. The 90-Day Mandate

Where the institution converts thesis into action without delay.

The 90-day mandate below is the minimum institutional commitment required to begin operating under the doctrine. It is structured as a sequence of dependent commitments; later steps depend on earlier steps in form, not just in time.

Window	Commitment
Day 1–14	Compute the Architectural-Debt Index™ baseline.
Day 15–30	Build the Topology Map.
Day 31–60	Author the re-foundationing programme; obtain board sign-off.
Day 61–80	Begin the identity-first reorganisation.
Day 81–90	Deliver the Re-Foundationing paper to the board.

Doctrine note — debt register, then retirement

The mandate produces the architectural debt register at week six. The retirement programme follows; the dual-run starts at the next renewal cycle. The institution that retires without registering retires the wrong components.

Days 91–180: consolidation

The first ninety days establish the operating discipline. The second ninety days consolidate it into a posture that is regulator-ready, underwriter-defensible, and compounding. The commitments below extend the mandate and convert it from change programme to steady-state.

Window	Commitment
Days 91–105	First quarterly drill conducted under the new decision-rights register. Variance against drill-time targets logged and signed by the chair of risk.
Days 106–120	Independent assurance review against the Evidence Chain Model™. Findings presented to audit committee with named owners and remediation dates.
Days 121–135	First Survival Velocity Index™ score reported to the board, with quarter-on-quarter trend established and benchmarked against sector peer.
Days 136–150	Underwriter and broker briefing pack issued, citing the doctrine's evidence artefacts. Renewal cycle is engaged twelve weeks ahead of expiry.
Days 151–165	Regulator-facing self-assessment refreshed. DORA, NIS2, and ISO 42001 mappings are signed by the management body in line with personal-liability provisions.
Days 166–180	Board-grade consolidation memorandum issued. The institution is now operating under the doctrine and the cadence is reportable as steady-state.

— SECTION —

VIII. Regulatory Anchors

Where the doctrine maps to the regulatory perimeter.

The doctrine is anchored to the regulatory instruments below. The mapping is intentional: where the doctrine departs from the instrument, the departure is documented; where the doctrine extends the instrument, the extension is justified.

Instrument	Doctrine relationship
DORA Article 6 (ICT risk-management framework)	Architectural discipline as a risk-management measure.
NIS2 Article 21(2)(a)	Risk analyses and information system security policies.
ISO 27001 A.5.7	Audit baseline; re-foundationing extends to operating-floor discipline.

Personal liability under DORA Article 5 and NIS2 Article 20 is now established. The management body is held accountable for the cybersecurity risk-management measures of the entity. The doctrine specifies the operating discipline that makes this accountability defensible — to a regulator, to an underwriter, and to a court.

Cross-reference: M&A; Cyber Due Diligence

Where the institution is engaged in M&A, the same doctrine governs the diligence pack. Buy-side and sell-side teams now require evidence of drill cadence, decision rights, and recovery testing. Compliance documentation alone is no longer sufficient to preserve the deal multiple.

Regulator-by-regulator translation

Audience	Doctrine artefact prioritised	Citation register
Single supervisory mechanism (ECB / EBA)	Survival Velocity Index™ trend; quarterly drill register; evidence-chain index.	DORA Articles 5, 9, 11, 17, 28.
NIS2 competent authority	Risk-management measures register; reasonable-control mapping; incident chronology.	NIS2 Articles 20, 21, 23.
AI regulator (EU AI Act / ISO 42001)	AI Accountability Stack™ register; override traces; model-decision provenance.	EU AI Act Articles 9, 13, 17; ISO 42001 §7–§9.
Securities regulator (SEC, FCA)	Material-incident determination memorandum; chronology of disclosure; board minutes.	SEC 8-K Item 1.05; FCA SYSC 4 / 13.
Privacy regulator (ICO, EDPB)	Subject-rights latency register; data-lineage register; Article 33/34 trace.	GDPR Articles 5, 24, 32, 33, 34.

— SECTION —

IX. Evidence Chain

Where the institution proves its posture without being asked.

The Evidence Chain Model™ requires that every claim made to a regulator, an underwriter, or an acquirer is anchored to an artifact that has been retained, signed, and timestamped. The list below specifies the artifacts that this paper's doctrine produces.

01. Architectural-Debt Index™ trend.
02. Topology Map versioning.
03. Re-foundationing programme charter.
04. Identity-first reorganisation log.
05. Vendor-Reach Surface integration evidence.

Evidence Chain axiom

If it cannot be evidenced, it cannot be defended. Every artifact in the chain is retained for the regulatory window applicable to the jurisdiction; in the EU, this is now five years for ICT-related incident records under DORA Article 17.

Sample evidence-chain audit trace

The audit trace below is the format in which the doctrine's evidence chain is presented to a regulator, an underwriter, or a court. Each row is independently reproducible from the institution's telemetry and decision register; each row carries an owner, a frequency, and a retention horizon.

Artefact	Owner	Cadence	Retention
Decision-rights register, signed and version-controlled.	Head of SOC	Quarterly review	5 years
Drill record with measured detect/decide/recover times and chair sign-off.	Resilience Office	Quarterly drill	5 years
Override audit log: every closed-loop action with reason, scope, and reviewer.	Detection Engineering	Continuous, batched daily	5 years
Survival Velocity Index™ board pack with peer benchmark.	CISO / CRO	Quarterly board	Permanent
Material-incident determination memorandum (where applicable).	General Counsel + CISO	Per incident	10 years
Evidence-chain index: master register cross-referencing every artefact above.	Risk & Compliance	Monthly	Permanent

— SECTION —

X. Operating-Model Implications

Where the doctrine is translated into structural change.

The operating-model implications of the doctrine are concrete. Headcount profiles invert: bottom-of-stack functions consolidate into closed-loop autonomy; engineering and governance expand. Decision rights deepen at fewer points. The board KPI moves from incident count to loop velocity. The audit moves from annual paper to quarterly drill. Every change is reversible only through a regression in posture; once adopted, the doctrine is structurally stable.

The economic implications are equally concrete. Storage cost falls. Loaded analyst hours fall. Vendor tool count falls. The composite effect is a 15–25% reduction in operational cost at constant or improved posture. This is the discriminant outcome that boards are now empowered to demand.

The three inversions

Three inversions describe the structural shift more precisely than any roadmap. The first is the **analyst-to-engineer** inversion: the modal hire becomes a detection engineer or platform engineer, not a Tier-1 analyst. The headcount line falls; the engineering line rises; the composite is lower at higher posture. The second is the **tool-to-platform** inversion: the institution stops procuring point capabilities and starts engineering an operations floor. The number of vendors falls; the number of contracts falls; the depth of integration rises. The third is the **annual-to-quarterly** inversion: the audit cadence compresses, the drill cadence compresses, the board pack compresses, and the residual is a regulator-ready posture in steady-state rather than at audit-time.

“If the chair cannot decide from the page, the page does not exist.”

— SECTION —

X-bis. Compounding-Institution Disciplines

Where the doctrine is reduced to five disciplines that compound posture over a decade.

Across the institutions that have adopted the doctrine in production, five disciplines are publicly observable. Each is independently necessary; collectively, they describe the institution that compounds posture advantage rather than running to stand still.

Discipline	Public signature	Compounding effect
1. Engineered signal	Schema-governed telemetry; lineage retained for every consequential event.	Detection precision rises quarter-on-quarter; volume falls; cost-per-detection collapses.
2. Registered decision	Decision-rights register signed by management body; reviewed quarterly.	Time-to-decide compresses; personal liability is defensible; regulator findings reduce.
3. Closed loop	Provable autonomy with chain, override, and audit on every action.	Time-to-contain falls below adversary loop; loss area under the curve shrinks structurally.
4. Retained evidence	Evidence-chain index maintained; artefacts retained for the regulatory window.	Underwriter, regulator, and acquirer briefings prepared in days, not months.
5. Drilled recovery	Quarterly drills with measured RTO/RPO and chair sign-off.	Recoverability is proven, not asserted; service-restoration is a known quantity.

Compounding axiom

Posture is a stock, not a flow. The institution that compounds the five disciplines for eight consecutive quarters arrives at the next decade with a posture that cannot be replicated in a year. This is the institutional payoff of the doctrine.

— SECTION —

X-ter. Source Hierarchy

Where every claim in this paper is anchored to a class of authority.

The doctrine distinguishes between binding law, regulatory standards, supervisory expectation, market practice, the author's stated doctrine, and inferences drawn from the institutional doctrine dataset. Every claim in this paper sits at one of these levels; the table below is the reader's reference for evaluating its standing.

Source class	Examples	Authority
Law	DORA Reg. 2022/2554; NIS2 Dir. 2022/2555; EU AI Act 2024/1689; GDPR	Binding
Regulatory standard	ISO/IEC 27001:2022; ISO/IEC 22301:2019; ISO/IEC 42001:2023; NIST SP 800-61	Binding where adopted
Supervisory expectation	BoE PS6/21; SEC 8-K Item 1.05; ENISA Threat Landscape; EBA/GL/2019/04	Strong; falls short of law
Market practice	Mandiant M-Trends; Verizon DBIR; IBM Cost of Breach; Lloyd's underwriting	Indicative; cohort-bounded
Author doctrine	Board-Survivable Cyber Architecture™; Evidence Chain Model™; SVI™	Stated, not externally adopted
Proprietary inference	Doctrine dataset (n=43; 2023–2026); anonymised case translations	Bounded; methodology in App. F

Citation discipline

Where a claim cannot be assigned a source-hierarchy class, the claim is removed before publication. The architecture of this paper is therefore conservative by construction: rhetoric without an authority class does not enter the published text.

— SECTION —

IX-bis. Adversarial Review

Where the doctrine is tested against its strongest objections.

Top-tier doctrine is built to survive its critics, not to evade them. The four objections below are the most informed challenges the doctrine has received during peer review and audit-committee engagement; the responses are stated transparently. Where the objection has merit, the merit is acknowledged and the doctrine response is qualified accordingly.

Objection	Doctrine response
Re-foundationing is too expensive; institutions retrofit instead.	Retrofit cost in the dataset is approximately 4-6x re-foundationing cost amortised over the same useful life; retrofit also defers the architecture problem. Capital decision is not retrofit-vs-rebuild; it is now-vs-later, and later costs more.
Architectural debt is a vendor-led narrative.	Architectural debt is a measurable balance: tooling estate, control coverage, vendor concentration, schema sovereignty deficit. The doctrine quantifies it; the vendor narrative usually under-states it.
Identity-first architecture creates a single point of failure in identity.	Identity is already the single point of failure (87% of dataset incidents trace through identity); explicit acknowledgment in the architecture allows hardening (Tier-0 isolation, key segregation, recovery doctrine). The shift is from latent concentration to explicit one.
Cloud-native security tools cover the new surface.	Cloud-native posture management is necessary; not sufficient. The doctrine integrates CSPM into a broader identity-first architecture; CSPM alone is L1 maturity at best.

— SECTION —

X-quater. Anticipated Friction

Where the doctrine meets the political and operational reality of the institution.

Architectural soundness is necessary but insufficient. The institution that ignores the friction below adopts the doctrine on paper and fails to operate it in practice. The four friction patterns named below are the ones the doctrine encounters most often in adopter engagements; each is paired with the institutional pattern that resolves it.

Friction pattern	Doctrine response
CIO/CTO ownership of architecture decisions; CISO has dependency, not authority.	Joint architecture mandate (Paper 16 IV-ter) is the artefact; signed by CIO and CISO.
Multi-tenant SIEM contract that prohibits decomposition.	Renewal-cycle restructure; dual-run during transition; contract control matrix updates.
Internal estate of legacy on-prem systems with limited identity hardening capacity.	Phased migration; tier-0 first, tier-1 second; legacy retains as long as evidence shows containment.
Cloud spend committee resistance to cloud-native security tooling cost.	Cloud-native posture cost typically 2-3% of cloud spend; the cost is part of cloud TCO, not separate.

Operating reality

A consultant who accurately predicts the institution's internal political pattern is operating from a position of evidenced experience, not abstract architecture. The friction register above is itself part of the doctrine's evidence chain.

— SECTION —

X-quinquies. Maturity Model

Where the institution locates itself on a six-level ladder with evidence required at each level.

The maturity ladder below is the institution's self-locator. Each level names the evidence required to claim that level; the institution that cannot produce the evidence cannot make the claim. Movement from one level to the next requires capital, time, and operating-model change — typically 2-4 quarters per level under disciplined adoption.

Level	Evidence required at this level
L0 — Unaware	Architectural debt unmeasured; no retirement plan.
L1 — Aware	Debt register drafted; growth rate r estimated.
L2 — Reporting	Quarterly debt at risk committee; capacity threshold D^* set.
L3 — Engineered	Retirement plan executed; identity-first migration in progress.
L4 — Adaptive	Debt held flat or declining; vendor concentration managed; CSPM operational.
L5 — Compounding	Architecture is current-era; evidence chain operational; sector benchmark.

Maturity discipline
The institution that claims a level it cannot evidence is exposed at the next audit, regulator review, or underwriter renewal. Honest self-location is the prerequisite for the next quarter's capital deployment.

— SECTION —

X-sexies. Day-1 Triage Mandate

Where the institution begins, and what it funds first.

The institution that adopts this doctrine in full faces an initiative-fatigue problem the doctrine itself must solve. The triage mandate below names the three actions to fund in the first 90 days; deferring later actions is acceptable, deferring these three is not. Each action carries its budget band and accountable owner.

Action	Budget band & owner	Outcome
Day 1–14: Build the debt register	€60k consulting, owner: Chief Architect + CISO + CRO	Debt items, units, growth rate, retirement candidates.
Day 15–45: Cost the dual-run for primary SIEM	€80k consulting, owner: CISO + Head of Procurement	Renewal-cycle decision paper for board.
Day 46–90: Begin tier-0 identity hardening	€420k engineering, owner: Head of IAM + CISO	AD trust review; PIM/PAM tightening; recovery drill scheduled.

Day-Zero discipline

The institution that funds these three actions in the first 90 days has converted the doctrine from reading material into operational posture. The institution that defers them is operating under last quarter's posture against this quarter's adversary.

— SECTION —

X-octies. Dual-run SIEM transition — 18-month technical roadmap without dropping shields

Where the doctrine closes its most-cited audit gap with a single decisive artefact.

The 're-foundationing' claim is unsurvivable without a transition path that maintains operational coverage through cutover. The 18-month roadmap below is the doctrine's reference path; the institution maintains both legacy and new SIEM concurrently for 9-12 months, with detection parity required before legacy decommission. Cost band €1.8m-€4.2m total programme for a Tier-1 institution.

Phase	Months	Activity	Coverage state
0. Procurement & contract	M1-3	Vendor selection; contract negotiation including OCSF schema clauses; renewal-cycle alignment of legacy SIEM (cancellation rights, data export rights). Architecture design signed by Chief Architect + CISO.	Legacy 100%; new 0%
1. Parallel ingestion	M4-6	New SIEM stood up in production; primary telemetry sources (EDR, IdP, cloud, M365) dual-piped via OCSF translation layer. Detection rules ported in parallel; no rules retired in legacy.	Legacy 100% authoritative; new 100% mirror
2. Detection-engineering parity	M7-12	Hypothesis-led detection rebuild on new platform (per Paper 17); coverage measured against the institution's hypothesis register; parity attestation ($\geq 95\%$ coverage of legacy detections) signed by Detection Engineering Lead.	Legacy 100% authoritative; new 95-99% parity (alert-mode shadow)

3. Cutover with rollback	M13	New SIEM becomes authoritative; alerts route to new; legacy continues ingestion and runs in shadow for rollback option (4-week rollback window with single-day cutover). Audit committee notified pre-cutover.	New 100% authoritative; legacy 100% shadow (rollback-eligible)
4. Decommission legacy	M14-18	Legacy ingestion ramped down; long-tail forensic searches retained on legacy for 90 days; archive data exported to OCSF format and stored under institutional control; vendor exit per contract.	New 100% authoritative; legacy archived; sovereignty achieved

Rollback triggers (signed at cutover board paper): (a) detection coverage falls below 95% of legacy parity for any 7-day rolling window; (b) Tier-0 detection latency p75 rises above 110% of pre-cutover baseline; (c) any unrecoverable evidence-chain incident in first 30 days post-cutover. Each trigger is auto-monitored; rollback executes within 24 hours of trigger fire under a pre-signed playbook.

Cost components (Tier-1 institution typical):

Procurement & legal:	€120k - €280k	
OCSF translation pipeline (build):	€380k - €620k	
Detection engineering rebuild:	€640k - €1.4m	(largest item)
Dual-run licensing overhead 12 mo:	€380k - €890k	(legacy + new concurrent)
Cutover, parallel monitoring, RB:	€140k - €380k	
External assurance (ISAE 3000):	€90k - €180k	

Total programme cost:	€1.75m - €3.75m	
Year-2 onwards run-rate vs legacy:	-€280k to -€720k	(annual saving)
Payback period:	32 - 48 months	

Audit-grade close-out

Coverage is preserved through the transition because both platforms operate. Sovereignty is achieved at decommission because the OCSF translation layer holds the institution's schema. Cost is controlled because the rollback path is pre-engineered. The institution that 'big-bangs' the cutover trades cost saving for operational risk that no audit committee should accept.

— SECTION —

X-novies. Operational artefacts — re-foundationing migration playbook, legacy-to-target crosswalk, regulator challenge-response

Where the doctrine becomes implementation: RACIs, governance matrices, and reusable operational templates.

Architectural debt retirement is unsurvivable without an explicit cutover playbook, a crosswalk showing what is retired/retained/rebuilt/replaced, and a rehearsed answer to the supervisor's principal concern: that re-foundationing weakens resilience. The three artefacts below close the loop.

Cutover phase	Months	Coverage state	Rollback trigger	Service-risk acceptance
Phase 0 — Procurement & contract	M1-3	Legacy 100%; new 0%	Contract terms unworkable	None (paper exercise)
Phase 1 — Parallel ingestion	M4-6	Legacy 100%; new mirror	Translation layer failure; new platform refused production data	None (mirror only)
Phase 2 — Detection parity	M7-12	Legacy 100%; new 95-99% parity	Coverage gap below 95% sustained 7 days	Internal users only; no customer impact
Phase 3 — Cutover (1-day)	M13	New 100% authoritative; legacy in shadow	Tier-0 detect latency p75 > 110% baseline OR evidence-chain break	Pre-signed by audit committee; rollback drilled
Phase 4 — Decommission	M14-18	New 100%; legacy archive	Long-tail forensic gap (rolling 30 days)	Archive remains; vendor exit scheduled

Legacy-to-target architecture crosswalk — every component of the legacy estate is explicitly retired, retained, rebuilt, or replaced. Nothing is unmapped.

Legacy component	Disposition	Target (if rebuilt/replaced)	Owner
SIEM (multi-tenant, vendor-proprietary schema)	Replaced	OCSF-native SIEM with schema sovereignty	Detection Eng Lead
Network-IDS (legacy signatures)	Retired (yield collapse)	Replaced by EDR + identity telemetry + cloud-native IDS	Detection Eng
Vendor-default detection rules (legacy)	Retired (replaced by hypothesis-led)	Hypothesis register (Paper 17)	Detection Eng Lead
Active Directory (single-domain trust)	Rebuilt	Multi-forest with PIM/PAM hardening; cold-tier seed	Head of Identity

Legacy IAM (on-prem only)	Retained + extended	Federated SSO + cloud IdP; legacy retained for selected legacy apps	Head of IAM
EDR (vendor 1)	Retained	Same; integration to OCSF added	Detection Eng
Approval-gated containment (manual)	Rebuilt	Closed-loop where reversible; gates retained where appropriate	Detection Eng Lead + CISO
Tier-1 SOC (24x7 staffing)	Retired progressively	Engineering line + closed-loop + selective MSSP	CISO + CHRO

Regulator challenge-response — the supervisor's principal challenge is that re-foundationing degrades resilience during transition. The institution rehearses its answer.

Supervisor question	Evidenced answer
What is your operational coverage during cutover?	Phase-coverage table (above): legacy remains 100% authoritative through Phase 2; Phase 3 cutover is 1-day with rollback path drilled and pre-approved by audit committee
What testing has the new platform passed?	Detection parity ($\geq 95\%$ coverage of legacy detections, signed by Detection Eng Lead at end of Phase 2); independent observer attestation; ISAE 3000 readiness review
What rollback path exists if the cutover fails?	4-week rollback window with single-day rollback time; rollback drilled in last 30 days; legacy retained in shadow for 4 weeks
How do you manage incident-response capability during transition?	Decision-Rights Register (Paper 05) operates throughout; closed-loop containment operates throughout; engineering line maintained throughout; no operational gap in any phase

Operational artefact

The playbook names every phase's coverage state and rollback. The crosswalk leaves no component unmapped. The challenge-response rehearses the supervisor engagement. Re-foundationing is now a managed engineering programme; the institution that retains legacy is paying compounding interest to delay the same programme.

— SECTION —

XI. Strategic Outlook

Where the doctrine is positioned against the next decade.

The strategic outlook through 2030 is bounded by three forces. The first is regulatory convergence: DORA, NIS2, the EU AI Act, ISO 42001, and the SEC cyber-disclosure regime are converging on the same evidentiary standard, even where the legal instruments differ. The second is underwriter behaviour: cyber underwriting is re-pricing faster than regulators, and the price signal has begun to reach board agendas through M&A; and capital-markets channels. The third is adversarial compression: AI-augmented attack will continue to compress the loop, requiring AI-augmented defence and the governance framework that makes such defence regulator-acceptable.

Institutions that adopt the doctrine in 2026 will compound through 2030. Institutions that delay adoption to 2028 will not catch up. The pattern is observable in every prior technology transition; the cost of late adoption is structural.

Five-year hazard map

Year	Dominant hazard	Doctrine response
2026	AI-augmented social engineering reaches scale; identity surface compromised first.	Identity-loop containment; provenance signing; out-of-band override.
2027	Vendor-chain compromise becomes the median initial vector across regulated sectors.	Contract Control Matrix™ extended to material ICT third parties under DORA Art 28.
2028	Underwriter capacity withdraws from operationally weak institutions; cyber re-prices.	Survival Velocity Index™ produced quarterly; underwriter pack issued T-12 weeks.
2029	First wave of personal-liability findings under DORA Article 5 / NIS2 Article 20.	Decision Rights Architecture™ register signed by management body each quarter.
2030	AI-versus-AI engagement is steady-state; defender velocity is the discriminating factor.	AI Accountability Stack™ embedded into every closed-loop action; provable autonomy.

Sectoral outlook

The hazard map generalises across regulated sectors but binds differently to each. The table below records the binding constraint that will dominate each sector's posture decisions through the next three years. The institution should read its own row first, then the rows of its closest supply-chain neighbours.

Sector class	Binding constraint	First-order posture move
Universal banking and capital markets	DORA Article 17 reporting and Article 28 third-party rigour.	Contract Control Matrix™ extended to material ICT vendors; quarterly drill register.
Insurance and reinsurance	Underwriter capacity and claims-cost re-pricing.	Survival Velocity Index™ produced quarterly; broker pack issued T-12 weeks.
Critical national infrastructure	NIS2 Article 21 and sector-specific operational-resilience codes.	Recoverability Mandate™ embedded; tabletop and live-fire drills alternated.
Industrial / OT operators	Safety-class incident classification and IEC 62443 alignment.	OT-specific decision-rights register; safety-engineering sign-off on closed-loop actions.
Public sector / regulated digital	AI Accountability Stack™ and EU AI Act high-risk classification.	Override audit log and provenance signing on every AI-augmented decision.

Healthcare and life sciences

Patient-safety, GDPR Article 9 special-category data, and supply-chain integrity.

Privacy-resilience convergence; data-lineage register signed by DPO and CISO jointly.

— SECTION —

XII. Closing Doctrine

Where the institutional position is restated for the chair, the regulator, and the auditor.

If it cannot be evidenced, it cannot be defended. If it cannot be contained, it was never detected. If the chair cannot decide from the page, the page does not exist. Three axioms; one institution; one decade ahead.

The doctrine specified in this paper is not a recommendation. It is the institutional position required to operate within the regulatory perimeter that DORA, NIS2, ISO 42001, and the EU AI Act have collectively established. Institutions that adopt the doctrine secure their own defensibility; institutions that delay adoption do so at the personal liability of their management bodies.

The author is available for board engagements, regulator-facing assurance, M&A; diligence assignments, and academic collaboration. Engagements are typically structured as 90-day mandates with a board-deliverable at the close. Contact: info@kieranupadrasta.com • www.kie.ie.

Three commitments

The first commitment is to operate the doctrine, not to translate it. Translation is the characteristic failure of cybersecurity programmes; institutions that translate doctrine into local vocabulary lose its discipline within two quarters. The doctrine is operated as written.

The second commitment is to the evidence chain. Every consequential action produces an artefact; every artefact is signed; every signature carries a window. The chain is not a documentation exercise — it is the institution's working memory, and it is the precondition for personal-liability defensibility under DORA Article 5 and NIS2 Article 20.

The third commitment is to compounding. Posture is built quarter-by-quarter; it is not bought, it is not declared, and it cannot be reconstructed retrospectively. Institutions that adopt the doctrine in 2026 will compound through 2030; institutions that defer adoption pay the late-mover tax that prior technology transitions have made structural.

— SECTION —

Appendix A. Glossary of Doctrine Terms

For citation in board minutes, regulator submissions, and academic references.

Term	Definition
Board-Survivable Cyber Architecture™	Five-layer architecture (signal, decision, action, evidence, recovery) governed at board level.
Decision Rights Architecture™	Authority + override + audit, registered for every closed-loop action.
Recoverability Mandate™	Three-clock board-grade discipline: detect, decide, recover.
Survival Velocity Index™	Composite KPI from the three clocks; single number reportable to board, regulator, and auditor.
Three-Clock Defence	Time-to-detect, time-to-decide, time-to-recover engineered as independent, measured intervals.
Evidence Chain Model™	Every consequential action produces a retained, timestamped artifact.
AI Accountability Stack™	Six-layer governance for AI-augmented defence: input, model, decision, action, evidence, override.
Contract Control Matrix™	Third-party ICT risk discipline aligned to DORA Art. 28; obligations and evidence specified per material vendor.
Compounding-Institution Doctrine	Five public characteristics of institutions that compound posture advantage over a decade.
Window of Exposure	The interval between adversary first action and the institution's containment; the integral of loss accrual.
Velocity-Class Adversary	An adversary whose detect-decide-act loop is measured in minutes, not days, requiring a compressed defender loop to engage.
Provable Autonomy	Closed-loop automation accompanied by chain, override, and audit such that every action is defensible to a regulator or court.
Upadrasta Index™	Composite scoring metric used in this series for paper-quality and posture grading.

— SECTION —

Appendix B. Author and Series Contact

Institutional engagement details for boards, regulators, and academic collaborators.

Kieran Upadrasta — MBA, BEng, CISSP, CISM, CRISC, CCSP. Twenty-seven years in cybersecurity, including Big-4 consulting at Deloitte, PwC, EY, and KPMG. Twenty-one years in financial services. Author of multiple institutional doctrine series and frameworks invoked across this body of work.

Academic appointments. Professor of Practice in Cybersecurity, AI, and Quantum Computing at Schiphol University. Honorary Senior Lecturer at Imperials. UCL Researcher.

Professional standing. ISF Lead Auditor. Platinum Member, ISACA London Chapter. Gold Member, (ISC)² London Chapter. PRMIA Cyber Security Programme Lead.

Engagement focus. DORA compliance, NIS2 implementation, AI Governance under ISO 42001, Board Reporting and audit-committee chairmanship support, M&A; Cyber Due Diligence, and Operational Resilience programmes for regulated entities and critical-infrastructure operators.

Contact for institutional engagements

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— SECTION —

Appendix C. Methodology Notes & Dataset Provenance

For peer reviewers, regulator analysts, and academic citation.

The doctrine dataset referenced throughout this paper is an aggregated, anonymised institutional benchmark assembled by the author's research programme. Contributing institutions span regulated financial services, critical national infrastructure, and Tier-1 industrial operators. Contribution is by signed data-sharing agreement; outputs are released only in aggregate form with sufficient k-anonymity to prevent re-identification of any contributing entity.

Quantitative claims rest on three primary instruments. The detect-to-contain loss curve is calibrated against post-incident reviews, with loss attribution following the asymmetric pre/post containment slope rule. The signal-to-noise decomposition is taken from continuous SOC telemetry sampled across rolling four-week windows. The maturity curve is scored against the five-stage capability rubric (Initial, Defined, Engineered, Adaptive, Autonomous) used consistently across the series.

Where a quantitative claim derives from a public regulatory or supervisory text, the citation is preserved in Appendix D. Where a claim derives from the doctrine dataset, the dataset window and sector class are recorded in the chart caption. Where a claim is the author's institutional judgement, the prose is marked accordingly. The discipline is intended to make the paper citable without ambiguity in academic, regulatory, and underwriter contexts alike.

Reproducibility note

The doctrine's frameworks (Board-Survivable Cyber Architecture™, Decision Rights Architecture™, Recoverability Mandate™, Evidence Chain Model™, AI Accountability Stack™, Contract Control Matrix™, Upadrasta Index™) are codified in working artefacts retained by the author's programme and available, under engagement terms, for institutional adoption.

Limitations and scope

The doctrine is institutional, not universal. It applies cleanly to regulated entities, critical national infrastructure operators, and Tier-1 industrial operators with material ICT estates. It applies imperfectly to small and medium enterprises whose loop is not yet measured in the units the doctrine assumes; for those entities, a reduced form is recommended and is the subject of a companion paper. The doctrine does not displace technical standards (ISO 27001, ISO 27035, ISO 22301, ISO 42001); it operationalises them at board level. Where local regulatory regimes differ from the EU and UK instruments cited, the doctrine's discipline transfers but the citation map in Appendix D requires re-mapping by the institution's own counsel.

Independent peer review is welcomed. Reviewers receiving the dataset under non-disclosure may reproduce the chart families presented in this paper from the underlying telemetry windows. The author retains the dataset under signed agreements with the contributing institutions and cannot release it openly; this is a stated limitation of the present series.

— SECTION —

Appendix D. Citation Map — Regulatory Anchors

Article-level cross-reference for board minutes and regulator submissions.

The citation map below records the regulatory articles that anchor the doctrine in this paper. It is intended to be lifted directly into board minutes, regulator submissions, audit-committee papers, and academic citation lists, without further preparation.

Instrument	Article(s)	Doctrine relevance
DORA (EU 2022/2554)	Art. 5, 6, 9, 11, 17, 28	Governance, ICT risk-management framework, detection, response and recovery, incident reporting, third-party ICT risk.
NIS2 Directive (EU 2022/2555)	Art. 20, 21, 23	Management-body accountability, risk-management measures, incident reporting and significant-incident thresholds.
ISO/IEC 27001:2022	Annex A.5, A.8	Organisational controls and technological controls — ISMS scaffolding for the doctrine.
ISO/IEC 22301:2019	§8.2–§8.4	Business-continuity, recovery objectives, exercising — Recoverability Mandate™ anchor.
ISO/IEC 27035:2023	§5–§7	Incident management lifecycle — Evidence Chain Model™ alignment.
ISO/IEC 42001:2023	§7–§9	AI management system; aligned to AI Accountability Stack™.
EU AI Act (EU 2024/1689)	Art. 9, 13, 17, 26	Risk management, transparency, quality management, human oversight — applied to defensive AI.
GDPR (EU 2016/679)	Art. 5, 24, 32, 33, 34	Principles, controller responsibility, security of processing, breach notification — Privacy Resilience convergence.
SEC Cyber Disclosure (2023)	Reg S-K Item 106; 8-K Item 1.05	Material-incident disclosure and governance disclosure — board-pack discipline.
UK FCA SYSC	SYSC 4, 13	Senior Management Arrangements, Systems and Controls — operational-resilience anchor.

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Appendix E. Bibliography & Primary Sources

For peer reviewers, regulator analysts, and academic citation.

The bibliography below combines the doctrine series' universal regulatory and foundational core with paper-specific references invoked in this paper's formal model, executable artefact, and worked example. Citations are formatted to permit direct lifting into board minutes, regulator submissions, and academic citation lists.

Paper-specific references

[01] Cunningham, W. The WyCash Portfolio Management System. OOPSLA '92 Experience Report. (Origin of technical-debt term.)

[02] ThoughtWorks. Technology Radar — Volume 30. ThoughtWorks, 2024.

Universal core: regulation, standards, foundational primary sources

[03] Regulation (EU) 2022/2554 of the European Parliament and of the Council of 14 December 2022 on digital operational resilience for the financial sector (DORA). OJ L 333, 27.12.2022, p. 1.

[04] Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 (NIS2 Directive). OJ L 333, 27.12.2022, p. 80.

[05] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (EU AI Act). OJ L, 12.7.2024.

[06] Regulation (EU) 2016/679 (General Data Protection Regulation). OJ L 119, 4.5.2016, p. 1.

[07] ISO/IEC 27001:2022 — Information security, cybersecurity and privacy protection — Information security management systems — Requirements. International Organization for Standardization, 2022.

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- [16] ENISA. Threat Landscape 2024. European Union Agency for Cybersecurity, October 2024.
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- [18] IEC 62443-3-3:2013 — Industrial communication networks — Network and system security — Part 3-3: System security requirements and security levels.

Citation discipline

Where a claim in the body of this paper is not anchored to one of the references in this bibliography, to a regulatory article in Appendix D, or to the institutional doctrine dataset described in Appendix C, the claim is removed before publication.

— SECTION —

Appendix F. Methodology & Dataset Disclosure

Where the institutional doctrine dataset is described, with sample, scope, and limitations.

Universal methodology

The institutional doctrine dataset combines (i) anonymised post-incident reviews shared with the author under non-disclosure for a panel of 43 institutions across financial services (n=22), critical national infrastructure (n=9), insurance and reinsurance (n=7), and regulated healthcare (n=5), spanning the period Q1 2023 to Q1 2026; (ii) telemetry summary statistics (no raw data) reviewed under engagement contract during the author's Big-4 advisory tenure and subsequent interim CISO mandates; (iii) public-domain regulatory and supervisory documents listed in Appendix E; and (iv) audited regulatory submissions where access was granted by the institution. Anonymisation: institution names, jurisdictions below sector level, vendor names, and identifying incident details are not reproduced. Statistical methods: percentile ranks, Wilson confidence intervals (Paper 18), KL divergence (Paper 04), Erlang-C (Paper 02), Monte Carlo convolution (Paper 15), and mutual information (Paper 10). Known limitations: (a) self-selection bias — institutions that engaged the author are not a random sample; (b) reliance on summary statistics rather than raw data for telemetry-derived claims; (c) sector mix skewed toward European financial services; (d) time window does not include incidents pre-dating DORA and NIS2 implementation. The dataset is not redistributed; reproducibility is bounded by these constraints. Where a claim cannot be sourced to the dataset, regulatory text, or a primary academic source listed in Appendix E, the claim is marked 'illustrative' or removed.

Paper 16 — local data window

Paper 16 debt-accrual model fitted on 11 institutions' architecture-debt registers (financial services n=7, CNI n=2, insurance n=2); time window Q1 2022 to Q1 2026. Growth rate $r = 0.06 \pm 0.02$ per quarter; capacity threshold D^* normalised across institutions to a 0-200 unit scale. The 5-7 year doubling cycle is a derived band (95% CI: 4.6-8.1 years).

Reproducibility note

The dataset is held under non-disclosure with contributing institutions and is not redistributed. Reproducibility is bounded by this constraint: the methodology is disclosed; the institutional identifiers are not. Independent replication requires institutional access the author cannot provide. Where a reader requires verification, the author is available for engaged-context disclosure under appropriate confidentiality.

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