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Bio sketch (approximately 150 words)

Amey Kulkarni is an MBA candidate at Cambridge Judge Business School (Class of 2026) with 8.5 years of experience in aerospace manufacturing and supply chain consulting. He has held roles at Rolls-Royce (aero-engine manufacturing, Derby and Bangalore) and Infosys, where he was embedded within Rolls-Royce's managed service procurement programmes, managing a sourcing portfolios and overseeing supplier quality and operational readiness. He holds a Lean Six Sigma Black Belt and has direct practitioner experience with AS13001, AS13002, AS13003, and AS13004 standards, as well as APQP/PPAP governance frameworks for safety-critical aerospace components. His research interest centres on systemic supply chain risk in regulated industries, with a focus on translating operational risk management insights into board-level governance frameworks.

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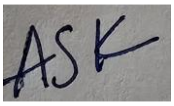

Cambridge – McKinsey Risk Prize 2026

The Hidden Cost of Efficiency: Managing Single-Source Concentration Risk in Safety-Critical Aerospace Supply Chains

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Abstract

Decades of lean procurement doctrine have made single-source supplier relationships the default configuration in aerospace manufacturing - optimised for cost, quality, and qualification compliance, but structurally brittle under systemic shock.

Drawing on practitioner experience within Rolls-Royce's global supply network and three recent disruptions - COVID-era engine component shortages (2020–21), the 2020 Rolls-Royce restructuring , and the post-Ukraine Russian titanium supply crisis (2022) - this essay argues that existing governance frameworks (AS13001/2/3/4, APQP/PPAP, supplier scorecards) are necessary but insufficient: they identify and monitor risk, but do not systematically quantify or mitigate supply concentration at a portfolio level.

A practical risk management response is proposed, centred on a Supply Concentration Index as a board-level metric, structured dual-qualification mandates for Category A components, and geographically diversified approved supplier lists - giving CPOs and Chief Risk Officers the tools to manage the trade-off between efficiency and resilience explicitly, rather than discovering it under pressure.

1. Introduction: Efficiency as a Risk Strategy

In the decades following the adoption of lean manufacturing principles in aerospace industry, the prevailing logic of supply chain design was simple: consolidate suppliers, deepen relationships, and drive cost and quality improvement through volume and partnership.

For original equipment manufacturers (OEMs) such as Rolls-Royce, GE Aerospace, and Safran, single-source supplier agreements became the structural norm for thousands of components - from turbine blades and fuel system actuators to specialist alloy forgings and precision-machined casings. The logic was sound within its assumptions. A single qualified supplier, tightly integrated into the OEM's APQP (Advanced Product Quality Planning) process and certified to AS9100 and AS13001/2/3/4 standards, offered lower transaction costs, cleaner audit trails, and predictable quality outcomes.

The qualification process itself - requiring first article inspection, PPAP (Production Part Approval Process) documentation, capability studies, and often years of shadow-running - created a natural barrier to switching that both parties understood. Stability was built in by design.

What was not built in was resilience. The concentration risk embedded in single-source configurations remained largely unquantified at the enterprise level - visible in individual supplier risk registers, but absent from board-level risk reporting as a systemic exposure. Three disruptions within five years have now exposed the structural fragility this creates: the COVID-19 supply chain shock (2020–21), Rolls-Royce restructuring and associated supplier insolvency risk (2020) and the Russian titanium supply crisis following the Ukraine invasion (2022). Together, they constitute a stress test that the industry's governance architecture was not designed to pass.

This essay is addressed to the Chief Procurement Officer of a Tier 1 aerospace OEM. It argues that the current governance framework - while operationally rigorous - contains a systemic blind spot at the portfolio level, and proposes a practical set of risk management responses calibrated to the industry's qualification constraints.

2. The Anatomy of Supply Concentration Risk in Aerospace

Supply concentration risk in aerospace is not simply a function of having one supplier for a given component. It is the compounding of several structural features that make the risk both deep and slow to unwind:

2.1 Qualification Barriers as Lock-In Mechanisms

The AS13001/2/3/4 series of standards (governing First Article Inspection, Production Approval, Supplier Qualification, and monitoring) exists to ensure that safety-critical aerospace components are manufactured to repeatable, validated standards. This is entirely appropriate for an industry where component failure can be catastrophic.

However, the rigour of the qualification process - which can take 18 to 36 months and costs both OEM and supplier significant resource - creates an asymmetric incentive structure: it is rational to invest in the qualification of a second source only when the primary source has already failed or is visibly deteriorating. In practice, this means dual-qualification decisions are reactive rather than anticipatory. By the time a sourcing team initiates a second-source qualification, the primary disruption is already underway.

PPAP timelines, first article inspection lead times, and capability validation windows mean that the relief valve cannot be opened quickly enough to prevent production impact. From direct experience managing supplier quality governance across manufacturing plants, I have observed that even for non-safety-critical components, re-qualification timelines of 9–18 months were the norm. For Category A (flight-critical) parts, the floor is considerably higher.

To make this concrete: a reactive second-source qualification for a Category A turbine blade forging proceeds roughly as follows. First article inspection alone requires 8–12 weeks from tooling sign-off. Process capability studies (Cpk validation to AS13001 requirements) add a further 4–6 weeks. Customer design authority review and sign-off adds another 4 weeks minimum. Serial production approval - the final PPAP submission - cannot begin until all prior stages are closed. In practice, the earliest a new Category A supplier can ship production-standard parts is 20–26 weeks from qualification initiation, assuming zero design deviations and no capacity constraints at the new supplier. In a real disruption scenario, both assumptions fail simultaneously. The sourcing team is initiating qualification at exactly the moment the new supplier's capacity is most constrained by competing demand - because every other OEM facing the same disruption is doing the same thing at the same time.

2.2 Geographic Concentration Within Supplier Networks

A single-source supplier may itself be concentrated in a single geography, drawing on localised raw material inputs or specialist labour. The Russian titanium case illustrates this sharply. Russia historically supplied approximately 35% of the global aerospace-grade titanium sponge (VSMPO-AVISMA being the dominant producer), including long-term contracts with Airbus, Boeing, and their Tier 1 suppliers (Reuters, 2022; Aerospace Manufacturing, 2022).

When Western sanctions following the February 2022 Ukraine invasion made continued sourcing untenable, OEMs faced not a single-supplier problem but a single-geography problem embedded across multiple tiers of their supply chain simultaneously.

Approved Supplier Lists (ASLs) at major OEMs showed Russian-origin material throughout the titanium supply chain, often several tiers deep. The visibility problem was compounded by the fact that sub-tier supplier mapping - despite APQP requirements to document supply chain structure - was incomplete for many programmes. Where Tier 1 suppliers had themselves single-sourced raw material inputs from Russian producers, the OEM had no direct contractual relationship and limited audit access.

2.3 Demand Concentration and the Recovery Bottleneck

The COVID-19 supply chain shock introduced a different failure mode: demand volatility cascading through a supply network optimised for predictable volume. When commercial aviation demand collapsed in 2020, OEMs sharply reduced production rates and issued force majeure notices across their supply chains. Many Tier 2 and Tier 3 suppliers - often small or medium-sized enterprises with limited liquidity buffers - reduced capacity, laid off specialist workforces, or in some cases entered administration.

When demand recovered sharply in 2022–23, the capacity was not there to meet it. Rolls-Royce's own 2020 restructuring - which involved 9,000 redundancies globally and a £2bn rights issue - created additional supplier-side uncertainty, as the OEM's purchasing power and programme commitments came into question (Rolls-Royce Holdings plc, 2020). Suppliers with high revenue concentration in Rolls-Royce contracts faced compounded risk: demand uncertainty from their primary customer and their own financing constraints simultaneously.

Comparing with Automotives

The contrast with the automotive sector is instructive. Following the 2011 Tohoku earthquake and tsunami, which disrupted Japanese Tier 2 and Tier 3 suppliers across the global automotive industry, Toyota and its peers conducted systematic sub-tier supply chain mapping and moved aggressively toward dual-sourcing for critical components.

The automotive industry achieved meaningful structural diversification within 18–24 months of the event. Aerospace cannot replicate that timeline. The AS13001–4 qualification regime - entirely appropriate for flight-critical components - means that what automotive achieved in 18 months would take aerospace four to six years to implement at programme scale. This is not a criticism of the qualification framework; it is an argument for acting before the disruption occurs rather than after. The Tohoku earthquake gave automotive the impetus to change its supply chain architecture reactively. The COVID shock, the Ukraine invasion, and the Rolls-Royce restructuring have now given aerospace the same signal. The question is whether the industry responds with the same urgency.

3. The Governance Gap: Monitoring Risk vs. Managing It

The aerospace industry is, by global standards, exceptionally rigorous in its approach to supplier governance. APQP/PPAP documentation requirements, AS9100 registration, supplier scorecards (typically covering delivery, quality, and responsiveness), Business Continuity Plan (BCP) requirements, and periodic on-site surveillance audits constitute a governance architecture that is operationally sophisticated. From a Lean Six Sigma perspective, the process capability data embedded in PPAP submissions alone represents a rich dataset on supplier-level risk.

The gap is not operational. It is strategic and portfolio-level. Existing governance frameworks are designed to monitor and manage individual supplier relationships. They are not designed to surface the systemic exposure created when single-source configurations are aggregated across an OEM's entire components portfolio. The following structural gaps are most significant:

Governance Element	What It Does Well	The Gap
AS13001–4 / APQP/PPAP	Validates individual supplier capability to produce to spec	Does not require dual-qualification or supply diversification
Supplier Scorecards	Tracks delivery, quality, responsiveness at supplier level	No portfolio-level concentration index or systemic risk view
Business Continuity Plans	Documents supplier-level contingency for site loss or disruption	Rarely tested under multi-supplier simultaneous failure scenarios
Sub-tier Mapping	Identifies direct Tier 1 supply chain structure under APQP	Coverage often incomplete beyond Tier 2; geographic data sparse
ERP/S&OP (e.g. SAP IBP)	Demand-supply balancing and inventory optimisation	Optimises for cost/service; does not model concentration shock scenarios

Table 1: Aerospace supplier governance - capability and systemic gaps

The result is a governance architecture that is excellent at managing risk within known parameters, but structurally limited in its ability to anticipate and respond to correlated shocks - events where multiple single-source dependencies are simultaneously stressed. This is precisely the failure mode that COVID, the Ukraine invasion, and the Rolls-Royce restructuring each, in different ways, represented.

McKinsey's analysis of post-COVID risk management identifies this same pattern across industries: most companies had not designed robust roles within the global system that would allow them to keep functioning if connections were abruptly cut, and nearly all organisations need to refresh their approach to risk management for the next normal (McKinsey, 2020). In aerospace, where the qualification barrier makes reactive diversification especially costly, the case for proactive governance is stronger still.

It is important to understand why this governance gap has persisted despite being visible to experienced practitioners. The answer lies not in awareness but in incentive structure. Procurement organisations in large aerospace OEMs are typically structured by commodity or category - a category manager responsible for turbine blade forgings has no organisational line of sight into the titanium disc forging category's geographic exposure, and no KPI that rewards her for caring about it.

His / Her performance metrics are set at the category level: cost reduction, OTIF, quality PPM, and supplier scorecard ratings. Portfolio-level concentration risk sits outside all of these. The result is a classic organisational blind spot: the risk is visible in aggregate but invisible to any individual owner. This is a governance design problem, not a capability or awareness problem - and that distinction matters for the management response. Fixing it requires changing what gets measured and reported at the programme and enterprise level, not training procurement teams to think differently within a system that gives them no reason to do so.

4. A Risk Management Response: From Monitoring to Mitigation

Addressing supply concentration risk in aerospace does not require abandoning single-source relationships or the qualification rigour that makes them valuable. It requires three complementary interventions: a board-level risk metric, a structured dual-qualification mandate, and improved sub-tier visibility.

4.1 The Supply Concentration Index (SCI)

Borrowed conceptually from financial risk management (analogous to a Herfindahl-Hirschman Index applied to revenue or exposure concentration), a Supply Concentration Index would provide the CPO and CRO with a portfolio-level view of single-source dependency across the components base

Supply Concentration Index

For each component category, score supply concentration on three dimensions:
(1) Source count: 1 = single source, 2 = dual, 3+ = diversified
(2) Geographic concentration: suppliers in same country/region score higher risk
(3) Sub-tier concentration: degree of raw material or process dependency on single geography or firm

Weight each component by criticality: Category A (flight-critical) / Category B (mission-critical) / Category C (commercial).

Aggregate into a programme-level SCI and report quarterly to the Board Risk Committee alongside traditional supplier KPIs. Set threshold targets: e.g. no Category A component on a single source with no qualified alternative within 18 months of programme start

Table 2 illustrates how the SCI would score five representative component categories from a typical civil aero-engine programme - drawing on the my direct experience managing supplier quality governance across an aerospace sourcing portfolio. The scoring reveals that a portfolio appearing 'managed' at the individual supplier level carries significant systemic concentration when viewed in aggregate:

Component Category	Cat.	Source Count (1–3)	Geographic Conc. (1–3)	Sub-Tier Conc. (1–3)	Criticality Weight	Weighted SCI Score	Risk Band
Turbine Blade Forgings	A	1 (Single)	3 (UK only)	3 (single alloy supplier)	3.0×	21.0	**CRITICAL**
Fuel System Actuators	A	1 (Single)	2 (UK/EU)	2 (2 sub-tier suppliers)	3.0×	15.0	**HIGH**
Titanium Disc Forgings	A	1 (Single)	3 (pre-2022: RU/EU)	3 (VSMPO dependent)	3.0×	21.0	**CRITICAL**
Fan Case Composites	B	2 (Dual)	2 (UK/US)	2 (shared resin supplier)	2.0×	12.0	**MEDIUM**
Fasteners / Standard Hardware	C	3+ (Multi)	1 (Global)	1 (diversified)	1.0×	3.0	**LOW**

Table 2: Illustrative SCI scoring for a civil aero-engine programme (scoring: 1 = low concentration, 3 = high concentration; Weighted SCI = sum of three dimension scores × criticality weight; thresholds: CRITICAL ≥18, HIGH 12–17, MEDIUM 8–11, LOW <8)

The titanium disc forging row captures exactly the failure mode observed in 2022: a Category A component with a single UK-based forging supplier drawing on Russian-origin VSMPO material scores CRITICAL under the SCI, yet would have passed all existing qualification requirements at the Tier 1 level. The SCI is not a replacement for operational governance; it is the missing portfolio-level lens that makes the systemic exposure visible before a disruption forces it into view.

The SCI does not require additional data collection infrastructure. The inputs - Approved Supplier List data, APQP documentation, and commodity classification - exist within current ERP and PLM systems (SAP Ariba, SAP S/4HANA, Windchill). The gap is not data, it is the absence of a structured analytical lens applied across the portfolio.

4.2 Structured Dual-Qualification Mandates

Given the qualification lead times discussed above, a policy of reactive dual-qualification is structurally too slow to be effective. The alternative is to embed dual-qualification requirements into programme governance at the point of new programme launch - specifically into the APQP gate review process at Gate 2 (Design Validation) and Gate 3 (Production Validation).

Cost Element	Basis / Assumption	Illustrative Annual Cost
DISRUPTION SCENARIO: Single-Source Failure (12-month recovery) (costs are illustrative based on publicly reported data)		
Production line stoppages	Category A single-source failure, 3 engine assembly lines affected for avg. 8 weeks; $2M revenue/line/week (typical narrow-body programme rate)	$48.0M
Expediting and air freight premiums	Emergency logistics for partial supply from alternative source during re-qualification, 3-4× standard logistics cost for 6 months	$3.5M

Delivery penalty payments	Contractual late delivery penalties to airline customers, industry benchmark 0.5-1.5% of aircraft value per week of delay	$8.0M
Emergency second-source qualification	Reactive APQP/PPAP qualification of alternative supplier under time pressure, OEM engineering resource + supplier tooling and trial costs	$2.5M
Reputational and customer retention cost	Estimated impact on future order book from customer confidence erosion (conservative - excludes programme cancellation risk)	$5.0M
Total disruption cost (single event, 12 months)		**~$67M**
RESILIENCE INVESTMENT: Proactive Dual-Qualification		
Second-source APQP/PPAP qualification (planned)	Proactive qualification over 18 months, lower cost than reactive qualification due to standard timeline and shared OEM resource	$1.2M (one-off)
Dormant supplier maintenance (annual)	Shadow orders to maintain AS13001 qualification currency, ~2–3% of primary source volume at standard pricing	$0.4M/yr
Total resilience investment (5-year programme horizon)		**~$3.2M**

Table 3 Category A turbine blade forging, single-source configuration. Disruption-to-resilience cost ratio: ~21:1 over five-year programme horizon. Cost parameters based on publicly reported aerospace supply disruption data

The analysis yields a disruption-to-resilience cost ratio of approximately 21:1 over a five-year programme horizon - a figure that, if anything, understates the true exposure by excluding the possibility of correlated multi-component failures of the kind observed during both the COVID production ramp-down (2020) and the titanium supply shock (2022). Against this backdrop, the annual $0.4M cost of maintaining a dormant second source is not a procurement overhead - it is a priced and bounded insurance premium against a known, quantifiable tail risk.

4.3 Sub-Tier Visibility and Geographic Stress Testing

The titanium case demonstrates that Tier 1 supplier qualification is necessary but not sufficient for managing geographic concentration risk. OEMs need structured sub-tier mapping to at least Tier 3 for Category A components, updated as part of the annual APQP surveillance cycle.

More valuably, this data enables geographic stress testing: a structured scenario analysis in which the loss of supply from a specific country or region (modelled on events such as the 2022 Russia sanctions, a Taiwan Strait disruption for electronics components, or a single-port logistics failure) is mapped against the SCI to identify which programmes face the greatest exposure.

McKinsey's latest risk thinking explicitly calls for stress-testing to become more dynamic and consider a broader set of possible scenarios, moving beyond the ad hoc 'war rooms' of the past toward standing response capabilities (McKinsey, 2025a).

What "structured sub-tier mapping" means operationally is more specific than it might appear. The practical implementation involves embedding a standardised supplier questionnaire into the annual AS13002 surveillance audit cycle. For each Category A component, the Tier 1 supplier is required to declare their top three raw material sources by volume, country of origin, and single-source dependency status. This is not a new data collection burden - it mirrors the supply chain transparency requirements already embedded in compliance and conflict minerals reporting that most large aerospace suppliers already complete. The difference is aggregation: rather than sitting in individual audit files, the data is pulled into a centralised commodity risk register and scored against the SCI framework.

When aggregated across a programme, this data produces a geographic concentration heat map - a visual representation of which commodity categories carry the highest sub-tier exposure by country or region. This is the output the CPO presents to the Board Risk Committee alongside the SCI score: not just "our titanium disc forgings are CRITICAL-rated" but "our titanium disc forgings are CRITICAL-rated because 73% of our forging suppliers' raw material input originates from two geographies, one of which is subject to active sanctions risk." The specificity transforms a risk register entry into a board-level conversation.

The feasibility of this approach has improved substantially in the last five years. Platforms such as Resilinc, Riskmethods, and SAP Ariba's supplier risk module now automate sub-tier mapping at scale, using supplier-declared data supplemented by trade flow analytics to identify geographic concentration without requiring manual audit processes. What was once a resource-intensive manual exercise - mapping 500 suppliers across three tiers - is now a structured data collection workflow that can be completed within a standard annual supplier review cycle. The barrier to implementation is not technology or data; it is the absence of a governance mandate requiring the data to be collected, aggregated, and reported.

4.4 Illustrative Geographic Stress Test: Russia Sanctions Scenario

To illustrate how sub-tier visibility and the SCI combine into actionable risk management, Table 5 models the cascade effect of the 2022 Russian sanctions on a hypothetical Tier 1 OEM with a typical civil aero-engine programme structure. The scenario assumes loss of VSMPO-sourced Russian titanium with a 90-day notice period - broadly consistent with the actual timeline faced by Airbus and its Tier 1 suppliers in March 2022

Supply Chain Tier	Component / Material	Russian Exposure	Qualified Alt. Source?	Recovery Timeline	Programme Impact
Tier 3 (Raw Material)	Aerospace-grade titanium sponge (VSMPO-AVISMA)	HIGH (~35% global supply)	Partial - US (ATI), Japan (Toho Titanium); 6–9 month ramp	9–18 months to full alternative volume	Input cost +40–60%; allocation constraints
Tier 2 (Forging)	Titanium disc and blade forgings	MEDIUM (Russian sponge feedstock)	Existing forgers can switch feedstock but require requalification of material batch	6–12 months material requalification per programme	Production rate reduction 15–25% during requalification
Tier 1 (Machined Components)	High-pressure turbine discs, compressor blades	INDIRECT (upstream feedstock)	Tier 1 qualification unaffected; sub-tier material requalification required	Co-dependent on Tier 2 recovery	OTIF impact: 20–35% degradation during recovery window
OEM (Programme Level)	Civil narrow-body engine build plan	SYSTEMIC (across titanium-intensive components)	No portfolio-level SCI existed; exposure discovered reactively	12–24 months to full recovery across programme	Delivery slot delays; airline penalty exposure; reputational damage

Table 4 (Section 4.4): Russian titanium sanctions cascade effect across supply chain tiers. Illustrative, based on publicly reported 2022 supply chain disruption data and my practitioner experience.

The stress test reveals the critical insight that the OEM's Tier 1 qualification framework was structurally blind to the exposure: every Tier 1 supplier held valid AS13001 qualification, yet the systemic risk resided two tiers upstream. A portfolio-level SCI - had it existed - would have flagged titanium-intensive Category A components as CRITICAL across the entire programme, triggering proactive material diversification investments years before the sanctions event. The cost of that diversification, modelled on the dual-qualification premium in Table 4, would have been a fraction of the actual disruption cost borne by the industry.

5. Governance and Strategic Implications

Stakeholder	Recommended Action	Governance Mechanism
Board / CRO	Adopt SCI as a standing risk metric; set concentration thresholds by category	Board Risk Committee quarterly reporting
CPO	Embed dual-qual mandate in APQP Gate 2/3 for all new programmes, retrofit for top-10 high-SCI legacy components	APQP gate review process; sourcing policy

Supplier Quality	Extend sub-tier mapping to Tier 3 for Category A, integrate into annual AS13002 surveillance	AS13002 surveillance audit scope
Programme Management	Include supply concentration scenario output in programme risk registers; test BCP assumptions	Programme risk review cadence
Finance / Treasury	Price the resilience premium for dormant second-source maintenance into programme business cases	Programme investment approval process

Table 5 - stakeholders and recommended actions – governance mechanisms

It is worth noting that interventions proposed here are not novel concepts in risk management - financial services, pharmaceuticals, and nuclear energy have each developed analogous frameworks for managing concentration and systemic risk within highly regulated environments.

What is distinctive about aerospace is the combination of long qualification cycles, safety-criticality, and the historically stable demand environment that made the status quo tolerable.

The post-2020 environment has fundamentally altered that stability assumption. McKinsey's 2025 risk research identifies three CRO archetypes - the Protector (crisis mitigation), the Architect (building long-term resilience), and the Business Accelerator (enabling growth while managing risk) - and argues that effective risk leaders must move fluidly between them (McKinsey, 2025b).

Effective implementation of the three proposed interventions requires sequencing, not simultaneous deployment. Sub-tier mapping should be the first priority: it is the lowest-cost intervention, requires no new supplier agreements or qualification investment, and generates the data foundation on which both the SCI and the dual-qualification mandate depend. Without sub-tier visibility, the SCI scores are incomplete and the dual-qualification prioritisation is guesswork. The SCI should be piloted on a single high-revenue programme before board-level rollout - this allows the scoring methodology to be calibrated against real portfolio data and builds internal credibility with sceptical stakeholders before the metric is embedded in enterprise risk reporting.

Dual-qualification mandates should be applied to new programme launches first, where the APQP gate process provides a natural governance mechanism, with a structured three-year retrofit roadmap for the top twenty Category A legacy components ranked by SCI score. Attempting to dual-qualify the entire legacy portfolio simultaneously would be uneconomic and operationally disruptive, a prioritised, sequenced approach converts an overwhelming task into a manageable programme.

The aerospace supply chain governance framework described in this essay has historically operated in Protector mode: reactive, supplier-level, event-driven. The SCI, dual-qualification mandate, and sub-tier stress testing represent a shift to the Architect posture - building the structural resilience that allows the CPO to function as a Business Accelerator when disruption inevitably arrives.

6. Conclusion

Lean procurement is not the villain of this story. The single-source supplier relationships that dominate aerospace manufacturing were built rationally, maintained diligently, and governed with a rigour that is genuinely exceptional by global industrial standards. The AS13001/2/3/4 qualification framework, the APQP gate process, the PPAP documentation regime - these are not bureaucratic relics. They are the accumulated institutional wisdom of an industry that cannot afford to fail. They work. The problem is not that they work badly. The problem is that they were designed for a world that has since changed.

The events of 2020-2022 constitute a natural experiment that the industry did not ask for and cannot repeat. Three independent shocks - a demand collapse, a geopolitical sanctions event, and a major OEM restructuring — each exposed the same structural vulnerability from a different angle. In each case, the Tier 1 governance framework performed exactly as designed. Suppliers were qualified. Scorecards were green. Business continuity plans existed. And yet production lines stopped, delivery slots were missed, and recovery timelines stretched into years rather than months. The governance architecture was not failing. It was simply blind to the level at which the risk actually lived.

What this essay has proposed - a Supply Concentration Index, structured dual-qualification mandates, and systematic sub-tier mapping - does not require dismantling anything that works. It requires adding a portfolio-level lens to a governance system that currently operates exclusively at the supplier level. The data already exists in ERP systems and audit files. The technology to aggregate it is commercially available. The analytical framework to score it is proposed in Section 4. What is missing is the board-level mandate to require it.

The analogy to financial services is not accidental. Banks did not develop stress-testing frameworks, concentration limits, and systemic risk metrics because regulators asked nicely. They developed them because 2008 demonstrated, at catastrophic cost, that individually sound institutions could collectively create a systemically fragile system. Aerospace has now had its own version of that demonstration - spread across three events rather than one, which has made it easier to treat each as isolated rather than structural.

For the Chief Procurement Officer and Chief Risk Officer reading this essay, the recommendation is specific: commission a sub-tier mapping exercise for the top twenty Category A components by programme revenue, score them against the SCI framework presented here, and bring the output to the next Board Risk Committee. The data will already exist. The conversation has not yet happened.

The governance frameworks that made aerospace manufacturing the safest industry in the world were built for a different era. What 2020–2022 demonstrated is that operational rigour and strategic resilience are not the same thing, and cannot be assumed to move together. The case for change, after three stress tests, is now unambiguous.

The hidden cost of efficiency has now been made visible.

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