REDEFINING VALUE IN AEROSPACE: INTEGRATING LIFECYCLE COSTING, OPERATIONAL AVAILABILITY, AND SUSTAINABILITY IN DEFENCE PROCUREMENTS

Abstract

Traditional defence procurement has long been dominated by the "Lowest Bidder" (L1) paradigm and embedded fixed price Quoting (FPQ) methods, focusing disproportionately on initial acquisition and extrapolated sustainment costs. In an era defined by constrained defence budgets, hyper-advanced aerospace technologies, and growing environmental imperatives, this procurement-based accounting and pricing model is structurally inadequate. This article proposes a paradigm shift toward Total Cost of Ownership (TCO), anchored by a superior valuation metric: Cost per Available Operational Hour (CAOH). By critically examining the mechanics of the Fixed Price Quote method commonly utilized in prevalent domestic defence ecosystems, the analysis demonstrates how rigid cost escalation formulas distort Lifecycle Costing (LCC) and fundamentally alter strategic asset valuation. Furthermore, the article explores the necessary integration of "The Green Ledger" embedding sustainability metrics, carbon footprints of Maintenance, Repair, and Overhaul (MRO) supply chains, and environmental compliance into the TCO model. As atmospheric aviation merges with the emerging frontiers of space power, Cost and Management Accountants (CMAs) navigating pricing policy reviews across defence and civil aviation sectors must champion this multidimensional costing framework. Doing so is critical for ensuring long-term financial efficiency, vendor accountability, and ultimate operational preparedness.

CMA Rajendra Kumar Joshi
Senior Vice President (Strategy & Planning)
Jio Platforms Limited
New Delhi
Rajendra1.Joshi@ril.com

Introduction: The Limitations of Procurement Based System

This article is structured as a conceptual and policy-oriented qualitative study. Drawing upon extensive field experience of the author in strategic cost management and defence financial operations, the primary objective of this paper is twofold: First, to critically evaluate the systemic inefficiencies embedded within legacy Fixed Price Quote (FPQ) frameworks; and second, to propose a multidimensional valuation framework that synthesizes lifecycle finance, engineering reliability, and environmental sustainability.

While financially intuitive in the short term, this approach creates a critical blind spot in Strategic Cost Management, particularly as global military expenditures reach unprecedented highs, necessitating ruthless fiscal optimization (**SIPRI, 2023**). The aerospace and defence sectors operate on capital requirements and time horizons rarely seen in other industries. A modern multi-role fighter aircraft or military satellite constellation is a highly complex system inducted into a lifecycle spanning decades. Historically, procurement frameworks have defaulted to the Lowest Bidder (L1) methodology or relied on strict fixed-price contracts for sustainment. While financially intuitive in the short term, this approach creates a critical blind spot in Strategic Cost Management.

Today, the initial hardware acquisition represents a diminishing fraction of the total economic burden. In the aerospace domain, the purchase price is merely the tip of the iceberg. The submerged mass comprising operating expenses, unscheduled maintenance, and eventual decommissioning often accounts for 65% to 75% of the asset's total financial drain over its lifespan (**NATO Science and Technology Organization, 2021**). To achieve true financial accountability and ensure peak operational preparedness, the valuation of aerospace assets must transition from static procurement systems to dynamic Lifecycle Costing (LCC).

The Mechanics and Pitfalls of the Fixed Price Quote (FPQ) Method

In domestic defence ecosystems, procurement and sustainment often rely heavily on state-run Defence Public Sector Undertakings (DPSUs). In these monopolistic or semi-monopolistic environments, Pricing Policies and Review Committees (PPRCs) utilize a specific iteration of the FPQ method to benchmark costs for products, spare parts, and MRO services supplied by DPSU to the armed forces. Research indicates that such legacy pricing frameworks in domestic defence manufacturing often struggle to incentivize rapid technological upgrades and lean operational efficiencies (**Manohar Parrikar Institute for Defence Studies and Analyses [IDSA], 2022**). To understand why this methodology impacts long-term strategic decision-making, it is imperative to narrate how these fixed prices are actually calculated.

The standard accounting mechanism relies on historical verification rather than predictive efficiency. Under this method, a "Base Year" is established. The pricing committees rigorously audit and verify the actual costs incurred by the DPSU for spare parts, direct labour, overheads, and services during that specific base year(s). Once this baseline cost is crystallized, it is locked in. For subsequent years, often structured in fixed blocks of five to seven years, the future pricing is determined not by re-evaluating actual costs, but by applying a predetermined escalation formula to the base year figures. This escalation factor is typically derived from standard indices, such as the Wholesale Price Index (WPI) and Consumer Price Index (CPI), to account for inflation, statutory wage revisions, and material cost increases. Even for the new purchases, the calculations of benchmark prices get impacted as material, labour etc are estimated based on FPQ.

However, DPSUs often try to twist the system to their advantage. On the surface, this fixed-price extrapolation appears to offer fiscal predictability to the exchequer. The defence ministry knows exactly what a spare part or an overhaul will cost three years down the line. However, this method severely distorts the prevailing costs and deeply impacts strategic decision-making in several ways:

- **Baking in Inefficiency:** If the chosen Base Year was characterized by sub-optimal manufacturing processes, high scrap rates, or elongated labour hours at the OEM, those inefficiencies are financially crystallized. The escalation formula then compounds those inefficiencies year after year and even gets factored in computing the benchmarking costs through escalated Man Hour Rate (MHR), Material Costs, and overheads. The vendor has no financial incentive to improve Mean Time To Repair (MTTR) or optimize supply chains or cycle time for overhaul, as their profit margins are safely protected within the escalated fixed price.
- **Ignoring the Reliability Curve:** Aerospace maintenance does not follow a linear, inflationary curve. It follows a "bathtub

curve" of reliability, where early-stage teething issues and late-stage wear-and-tear dictate massive fluctuations in spare part consumption (**RAND Corporation, 2019**). Applying a flat escalation rate to a fixed basket of spares completely ignores the actual operational consumption rates driven by the platform's Mean Time Between Failures (MTBF).

- **Skewing the Acquisition Matrix:** Because MRO and spare parts constitute up to 70% of aircraft's LCC, this fixed-price methodology artificially inflates or misrepresents the sustainment cost. When a domestic platform, priced via this rigid escalation method, is compared against a competing global platform priced via Performance-Based Logistics (PBL), where the vendor guarantees availability rather than just selling parts—the cost comparison is fundamentally flawed (**Deloitte, 2021**). Decision-makers are forced to compare apples to oranges, often resulting in the selection of platforms with higher hidden long-term costs.

Paradigm Shift to Lifecycle Value

With the private sector increasingly entering the defence manufacturing ecosystem in a major way, efficiency and competitive market dynamics will inevitably rule. Private aerospace manufacturers operate on lean principles, optimized supply chains, and predictive maintenance algorithms. Consequently, the archaic, rigid FPQ system is facing challenges to exist, and being replaced by dynamic, performance-based pricing models that align vendor profits with actual fleet availability.

Lifecycle Costing in the aerospace sector requires the aggregation of all costs incurred from the conceptual design to the final decommissioning of a platform. To escape the trap of the fixed-price escalation method, decision makers must evaluate the Present Value (PV) of future sustainment costs using rigorous Discounted Cash Flow (DCF) analyses over a 30 to 40-year horizon, relying on predictive engineering data rather than mere historical cost escalation (**Institute of Cost Accountants of India, 2024**). The mathematical representation of this is:

$$PV = \Sigma [Ct / (1+r)^t]$$

Where:

Ct = Net cash outflow (sustainment, MRO, fuel, upgrades) during the period t

r = Discount rate reflecting the sovereign cost of capital

n= Total number of periods (lifespan in years)

Σ = Summation from year 1 to year n

To evaluate operational readiness structurally, this financial data must be married to engineering reliability to calculate Operational Availability (Ao). The fundamental formula is:

$$Ao = MTBF / (MTBF + MTTR + MLD)$$

Where:

MTBF = Mean Time Between Failures (Engineering reliability)

MTTR = Mean Time To Repair (Base or depot-level repair time)

MLD = Mean Logistics Delay (Time spent waiting for spare parts to arrive)

A procurement and pricing system that ignores Ao in favour of simplistic cost escalation fundamentally fails the armed forces it serves.

Methodological Limitation: It is acknowledged that the efficacy of this LCC framework assumes transparent and accurate engineering data sharing from Original Equipment Manufacturers (OEMs). In practical procurement ecosystems, validating OEM claimed MTBF before active deployment remains a challenge.

Box 1: The Fleet Sizing Paradox

When procurement ignores Operational Availability (Ao), it artificially inflates long term capital expenditure. If a sovereign Air Force requires a minimum of 30 aircraft airborne at any given time to secure its airspace, an aircraft model with 80% availability requires a total fleet purchase of 38 jets. However, a cheaper model with only 50% availability requires a fleet purchase of 60 jets to achieve the exact same operational outcome. Thus, the "cheaper" aircraft paradoxically forces the procurement, housing, and staffing of 22 additional airframes, completely negating any initial acquisition savings generated by the L1 process.

The Impact of FPQ vs. LCC on Strategic Decision Making

To illustrate how the Fixed Price Quote method directly distorts strategic procurement decisions compared to a true Should-Cost/Lifecycle approach, consider the following comparative analysis of MRO procurement for a fleet's critical avionics suite.

Table 1: Strategic Decision Impact – FPQ Escalation vs. LCC Evaluation

Evaluation Metric	Scenario A: Domestic Procurement from DPSU under FPQ Model	Scenario B: Global Procurement under LCC/ PBL Model
Initial Spares/ MRO Contract Value	₹150 Crores (Based on L1 bidding)	₹220 Crores (Premium for high reliability)
Vendor Pricing Methodology	Base Year actuals + 5% annual statutory escalation	Performance Based Logistics (PBL) fixed to flight hours
Engineering Reliability (MTBF)	1,500 Hours (Vendor protected by escalation)	4,000 Hours (Vendor incentivized by PBL)
Projected 30 Year Replacements	20 cycles required per aircraft	7.5 cycles required per aircraft
True 30 Year Lifecycle Cost	₹680 Crores (Compounded escalation on frequent repairs)	₹340 Crores (Fewer repairs, guaranteed availability)
Operational Consequence	High hangar downtime, artificial cost certainty masking massive long-term financial drain.	High flight line availability, alignment of vendor profit with operational readiness.

(Note: Data in Table 1 relies on conceptual models illustrative of structural pricing dynamics.)

Details in the above table demonstrates that while the FPQ method (Scenario A) appears cheaper in the initial contract phase, the mathematical certainty of the escalation formula applied to an unreliable product results in a lifecycle cost exactly double that of a highly engineered alternative.

The Crucial Metric: Cost per Available Operational Hour (CAOH)

An aircraft sitting in a hangar undergoing overhaul represents a massive sunk capital cost yielding zero operational output. Therefore, the definitive metric for defence valuation is the Cost per Available Operational Hour (CAOH).

Table 2: Benchmark Pricing - Procurement Cost vs. Lifecycle Cost (Per Unit Over 30 Years)

Cost Element / Metric	Aircraft Alpha (High Reliability / PBL Paradigm)	Aircraft Beta (Low Initial Cost / Fixed-Price Escalation)
Initial Acquisition Cost	₹1,000 Crores	₹600 Crores
Target Operational Lifespan	30 Years	30 Years
Operational Availability (Ao)	75%	55%

Cost Element / Metric	Aircraft Alpha (High Reliability / PBL Paradigm)	Aircraft Beta (Low Initial Cost / Fixed-Price Escalation)
Major Engine Overhaul Frequency	Every 2,500 Hours	Every 1,000 Hours
MRO Pricing Methodology	Performance-Based	Fixed Price Escalation on Base Year
Total 30-Year O&S + MRO Cost (PV)	₹1,200 Crores	₹2,500 Crores
Total Lifecycle Cost (LCC)	₹2,200 Crores	₹3,100 Crores
Total Available Operational Hours	6,500 Hours	4,000 Hours
Cost per Available Op. Hour (CAOH)	**₹33.8 Lakhs / Hour**	**₹77.5 Lakhs / Hour**

Under a traditional fixed-price bidding system, Aircraft Beta would easily win the contract, presenting a deceptive 40% saving (₹400 Crores per unit) at the time of procurement signing. Furthermore, because its future MRO costs are validated by a "predictable" escalation formula, auditors perceive it as a low-risk financial commitment, ignoring the operational reality that such fleets frequently fail to meet mission-capable rates (**Government Accountability Office, 2022**).

However, when benchmarked using true LCC and CAOH, the financial reality inverts. Aircraft Alpha represents a vastly superior investment. Because of its high MTBF, advanced onboard diagnostics, and a pricing structure tied to performance rather than historical extrapolation, Alpha generates 2,500 more operational hours over its lifespan. When the total lifecycle cost is apportioned against these actual flying hours, Aircraft Alpha costs ₹33.8 Lakhs per hour to operate, compared to Aircraft Beta's highly inefficient ₹77.5 Lakhs per hour.

Expanding the Paradigm to Space Power: *Crucially, this CAOH methodology must also be applied as modern militaries transition into unified Air and Space Forces. When procuring military satellite networks, pricing policy reviews cannot focus simply on "Cost per Launch." A cheaper satellite with a volatile orbit and a 3-year functional lifespan is vastly inferior to an expensive satellite that guarantees 10 years of uninterrupted ISR data. The CAOH model effectively translates to the "Cost per Active Orbital Year," ensuring space asset valuations prioritize long-term, unblinking availability over initial hardware savings.*

The Green Ledger: Sustainability, Cost, and Exportability

As global financial frameworks rapidly pivot toward net zero targets and sustainable resource management, the aerospace sector faces unprecedented scrutiny. Defence aviation is one of the most carbon intensive activities undertaken by sovereign states. Consequently, Sustainability and Climate Risk (SCR) can no longer be relegated to peripheral Corporate Social Responsibility (CSR) reports; they are quantifiable, material financial variables that must be embedded into the TCO model (Task Force on Climate-related Financial Disclosures [TCFD], 2023). Integrating ESG principles into defence aviation costing involves quantifying several complex vectors:

- **Scope 3 Emissions in the MRO Supply Chain:** Frequent maintenance cycles carry a massive, often uncalculated, carbon footprint. The World Economic Forum identifies aerospace supply chain logistics as a primary driver of industry emissions (**World Economic Forum, 2022**). Platforms like Aircraft Beta, which rely on the traditional fixed price escalation model for endless streams of replacement parts, require a constant global movement of heavy sub-assemblies, engines, and raw materials. Shipping a 2 ton engine back to an OEM across continents every 1,000 hours generates immense Scope 3 emissions. Evaluating platforms based on high MTBF directly shrinks this logistical tail.

- **Sustainable Aviation Fuel (SAF) Transition Costs:** Aviation turbine fuel accounts for a significant percentage of an aircraft's operations and support costs. Even marginal improvements in Specific Fuel Consumption (SFC) yield astronomical financial savings and emission reductions over 30 years. However, the future lies in SAF, which currently carries a significant price premium over conventional jet fuel **(International Air Transport Association [IATA], 2023**). Advanced LCC models must benchmark platforms against their compatibility with, and efficiency in burning, higher SAF blends.
- **Space Sustainability and Launch Liabilities:** As the definition of aerospace expands, so too does its environmental footprint. Heavy launch vehicles for military satellites emit immense volumes of black carbon and stratospheric pollutants. Furthermore, the mitigation of space debris is becoming a major operational and financial concern. Future TCO models for defence space assets must account for the end-of-life de-orbiting costs, treating orbital pollution as a tangible financial liability.
- **Carbon Pricing and Future Regulatory Liabilities:** While sovereign defence forces currently enjoy exemptions from many global carbon taxation schemes, the regulatory horizon is unequivocally shifting. As national governments commit to strict Nationally Determined Contributions (NDCs) under the Paris Agreement, defence ministries will inevitably be required to account for, and potentially offset, their massive carbon footprints. Advanced LCC models must utilize "shadow carbon pricing" to project these future liabilities.

Furthermore, as India pushes to become a major defence exporter, sustainability costs directly impact global competitiveness. Table 3 depicts these impacts in a tabular way which are easier to comprehend.

Table 3: Impact of Sustainability Costs on Defence Exportability

Export Market Scenario	High Carbon Footprint Platform	Low Carbon Footprint (Green Ledger) Platform
Regulatory Tariffs (e.g., EU CBAM)	Subject to heavy Carbon Border Adjustment Mechanism (CBAM) import taxes, raising the final cost to the foreign buyer.	Exempt or subjected to minimal CBAM tariffs, maintaining price competitiveness in European and allied markets.
Foreign Buyer ESG Compliance	Rejected by allied nations whose own defence forces are bound by strict national net-zero mandates.	Highly attractive to foreign defence ministries seeking to lower their Scope 3 operational emissions.
Financing & Insurance	Higher interest rates for export credit and shipping insurance due to inherent climate transition risks.	Access to lower-interest green bonds and sustainability-linked export financing.

Box 2: Green Financing in Defence

As the defence sector embraces ESG, there is a growing intersection with Green Financing. Defence OEMs that demonstrate significant reductions in supply chain emissions or develop highly fuel-efficient sustainable propulsion systems can potentially access capital through green bonds or sustainability-linked loans at lower interest rates (**PwC, 2023**). CMAs involved in vendor pricing can factor in these reduced costs of capital when benchmarking fair prices for next-generation aerospace systems, passing the financial benefits of sustainability down to the exchequer.

Overcoming Institutional Inertia: The Mandate for the CMAs

The transition from historical fixed price escalation to predictive CAOH and the integration of the Green Ledger is not merely a mathematical exercise; it is a profound cultural and institutional challenge. Defence procurement ecosystems are heavily governed by rigid bureaucratic guidelines and historical precedents that are traditionally trained to seek out the lowest initial capital outlay to demonstrate immediate, verifiable fiscal prudence.

> In the high-stakes realm of defence aviation and space power, true financial efficiency is achieved not by buying cheap or relying on historical cost escalation, but by benchmarking intelligently, sustaining efficiently, and operating sustainably

CMAs are uniquely positioned to dismantle this institutional inertia. By leveraging their dual expertise in forensic cost analysis and financial risk management, CMAs can articulate the long-term strategic dangers of short-term procurement thinking. To execute this, specialized financial acumen is required at the highest levels of the armed forces. Currently, the Indian Air Force (IAF) leads this domain with a dedicated, specialist accounting branch. However, to modernize defence procurement holistically, the Ministry of Defence must suitably change its recruitment policies to adequately, induct qualified CMAs across all branches. Furthermore, the Indian Army and Indian Navy should actively co-opt these seasoned specialists from the IAF to standardize advanced costing methodologies across all tri-service acquisitions.

Expanding the Mandate to Civil Aviation: This strategic imperative extends beyond the defence sector. The Ministry of Civil Aviation must mandate the aggressive inclusion of CMAs within the Airports Economic Regulatory Authority (AERA). AERA is tasked with determining tariffs for aeronautical services, and the methodologies used require rigorous, independent financial scrutiny (Airports Economic Regulatory Authority of India [**AERA], 2021**). By deploying CMAs within AERA, the Ministry can ensure that airport pricing models are fairly computed, highly competitive, and grounded in true lifecycle costs, rather than allowing monopolistic airport operators to artificially inflate user fees through legacy accounting loopholes.

When negotiation committees and pricing policy review boards whether in atmospheric defence, space operations, or civil aviation are equipped with robust, empirical LCC data, they are empowered to defend the acquisition of technologically superior, highly reliable systems. They can mathematically prove to auditors and policymakers that moving away from the safety of "fixed price escalation" toward true lifecycle management is a calculated investment in operational superiority. Environmental costs are also required to be factored into the LCC.

Conclusion

As the aerospace sector evolves, the definition of "value" must mature beyond the initial contract signing. Relying on fixed-price quote methods that simply escalate base-year costs ensures that armed forces pay a premium for embedded inefficiencies throughout an asset's lifespan. By fundamentally redesigning costing methodologies to focus on the Cost per Available Operational Hour (CAOH), policymakers can bridge the gap between financial prudence and operational preparedness. Furthermore, incorporating the Green Ledger ensures procurement is actively insulated against future climate risks. In the demanding realm of aerospace, true financial efficiency is achieved not by buying cheap, but by benchmarking intelligently, sustaining efficiently, and operating sustainably. MA

References

1. *Airports Economic Regulatory Authority of India. (2021). Guidelines for determination of tariff for aeronautical services. Ministry of Civil Aviation.*
2. *Deloitte. (2021). Performance-based logistics in aerospace and defence: Shifting the paradigm from parts to availability. Deloitte Insights.*
3. *Government Accountability Office. (2022). Weapon system sustainment: Aircraft mission capable rates generally did not meet goals and cost of operating and sustaining fleets varied widely*

(GAO-23-106217). U.S. Government Accountability Office.
4. Institute of Cost Accountants of India. (2024). Advanced concepts in strategic cost management and performance evaluation. ICMAI Publications.
5. International Air Transport Association. (2023). Economics of sustainable aviation fuel: Transition costs and market viability.
6. Manohar Parrikar Institute for Defence Studies and Analyses. (2022). Defence procurement and indigenous manufacturing: Challenges and policy imperatives.
7. Ministry of Defence, Government of India. (2020). Defence acquisition procedure (DAP) 2020. Directorate General of Quality Assurance.
8. NATO Science and Technology Organization. (2021). Methods and models for life cycle costing in defence procurement (Report No. STO-TR-SAS-130). North Atlantic Treaty Organization.
9. PwC. (2023). ESG in aerospace and defence: Navigating green financing and reducing the cost of capital. PwC Aerospace & Defence Advisory.
10. RAND Corporation. (2019). The cost of keeping the fleet flying: Understanding the relationship between aircraft age and maintenance costs. RAND Project AIR FORCE.
11. SIPRI. (2023). Trends in world military expenditure, 2022. Stockholm International Peace Research Institute.
12. Task Force on Climate-related Financial Disclosures. (2023). Integrating climate-related risks into financial valuations and capital allocation. Financial Stability Board.
13. World Economic Forum. (2022). Target true zero: Decarbonizing the aerospace supply chain. WEF Aviation, Travel and Tourism Industry Action Group.

> "By treating sustainability and climate risk not as peripheral CSR exercises, but as critical, quantifiable inputs within the Total Cost of Ownership, CMAs can actively insulate national defence from future carbon liabilities."

Congratulations!!!

Heartiest Congratulations to CMA Vinod Kumar Agrawal being honoured at the 12th EPC World Awards for "Outstanding Contribution to EPC Business Transformation & Growth." The award reflects not just a single achievement, but years of consistent work in building and improving businesses within the EPC ecosystem. A CMA rank holder by qualification, his journey has taken him through organizations such as Reliance Industries, Kalpataru Power and HG Infra Engineering, where he has handled complex commercial and finance roles across sectors like petrochemicals, railways and infrastructure. Early in his career, he was part of large-scale projects including the Jamnagar refinery—an experience that shaped his understanding of scale, discipline and execution. Known among peers for his practical approach and steady leadership, he brings a sense of clarity and discipline to every role he takes on. His journey is a reminder that long-term impact in infrastructure is built not just through vision, but through sustained execution over time.

We wish CMA Vinod Kumar Agrawal the very best for all his future endeavours.