

**Policy Brief****From Detection to Depletion:  
Sustainability Constraints in Counter-Drone Defense**

(Based on EPINOVA-2025-01-RR)

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**The Global AI Governance Research Center, EPINOVA****Series Information:**

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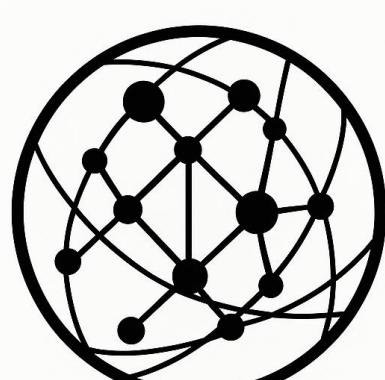
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**Disclaimer:**

This brief reflects the author's analysis based on publicly available information and does not represent official positions of any government.

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**1. Key Judgment**

In the Russia–Ukraine war, air defense is not failing because drones cannot be intercepted, but because defenses struggle to remain economically and operationally sustainable under continuous saturation.

Metrics focused on shoot-down rates systematically overstate effectiveness and underestimate structural exhaustion.

The decisive question for policymakers is no longer “Can we intercept?” but: “Can we preserve critical national functions at an acceptable cost over time?”

**2. What Has Changed**

Low-cost, mass-produced, expendable drones—combined with AI-assisted sensing and targeting—have transformed air defense into a high-frequency endurance contest. This shift has exposed not only capacity limits, **but deep mismatches between offense and defense across technology, doctrine, and decision processes**. Under sustained pressure:

- **Physical limits emerge:** low-altitude clutter, weak radar and infrared signatures, reduced observability;
- **Temporal limits bind:** sensor refresh, data fusion, authorization, and interceptor timelines lag behind drone maneuver and attack cycles;
- **Resource limits dominate:** magazine depth, replenishment speed, and fiscal burden;
- **Technological and doctrinal mismatches persist:** defensive systems optimized for fast, high-signature platforms confront slow, low-signature, mass threats;
- **Operational procedures and decision guidance lag battlefield reality:** legacy engagement rules, target-classification standards, and human-centered authorization chains remain calibrated for manned or high-value threats, rather than swarms of low-cost, expendable systems.

As a result, intercept rates can remain high even while sustainability collapses, masking structural exhaustion driven by force-structure misalignment and outdated operational assumptions rather than immediate tactical failure.

**3. What the Data Show (2023–2025)**

The following findings summarize baseline observations and stress-tested patterns observed between 2023 and 2025. Using a **Minimum Viable, Auditable (MVA)** framework grounded in public data:

- **Cost per Loss Avoided (CPLA)** and composite cost–loss indicators consistently **deteriorate before intercept rates decline**, providing an **early-warning signal** of structural stress.

- Under saturation, **force-structure choices dominate outcomes**: defenses relying heavily on expensive surface-to-air missiles experience sharply rising marginal costs.
- **Low-cost terminal layers** (guns, EW, interceptor drones), when properly cued, **flatten cost curves** and preserve mission outcomes more robustly—even under counterfactual stress.

**Bottom line:** Tactical success can be sustained—but only at accelerating and eventually **unsustainable cost** unless force structure adapts.

These patterns hold not only in observed data, but also under counterfactual stress testing, indicating that force-structure effects are robust to degradation rather than artifacts of baseline conditions.

#### 4. Why Intercept Rates Mislead

High shoot-down ratios can coexist with:

- Rapid magazine depletion;
- Rising marginal defense costs;
- Increased dependence on scarce interceptors; and
- Long-term erosion of readiness.

**Counting interceptions answers the wrong question:** What matters is whether **electricity, fuel supply, and other critical functions remain operational** without exhausting defense resources.

#### 5. Policy-Relevant Metrics

Decision-makers should prioritize:

- **CPLA (Cost per Loss Avoided):** How much does it cost to preserve one unit of critical function?
- **CER\*** (Composite Cost–Loss Indicator): Are cost pressure and residual loss worsening together?
- **KAPS (Key Asset Preservation Score):** Are core national functions actually being preserved?

These indicators detect sustainability failure **before visible operational collapse**.

#### 6. Actionable Policy Implications

##### (1) Adopt Mission-Based Defense (KAPS-First)

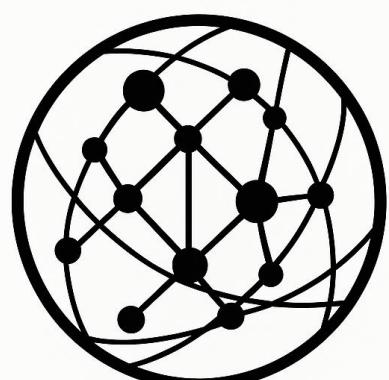
Accept incomplete interception outside priority zones. Concentrate protection, hardening, and rapid recovery on power, fuel, and other critical assets.

##### (2) Rebalance Toward Low-Cost Terminal Layers

Shift engagements against slow, low-signature drones away from high-end interceptors, supported by revised engagement rules and faster authorization pathways.

##### (3) Invest in Detection and Track Continuity

Improving “engageability” often yields more benefit than adding interceptors, provided engagement authorities and decision guidance are adapted to permit timely use of low-cost defenses.



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#### (4) Treat Counter-UAS as an Endurance Capability

Plan for stockpiles, production throughput, maintenance cycles, and surge capacity—not just peak performance.

**Recommended decision rule:** Minimize CPLA subject to maintaining KAPS above a defined mission threshold across plausible stress scenarios.

### 7. Why This Matters Beyond Ukraine

The dynamics observed in Ukraine are **portable**.

Any state facing low-cost saturation threats—air, maritime, or mixed-domain—will confront the same trade-offs.

**Future air defense effectiveness will be defined by sustainability, not interception counts.**

### 8. Bottom Line for Decision-Makers

Optimizing for shoot-down rates leads to rising costs and declining endurance.

Optimizing for sustainability and mission preservation enables defenses to absorb saturation while remaining effective over time.

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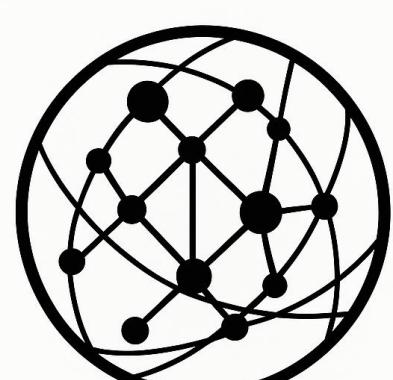
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