COST ANALYSIS

Fighter Jet Program vs. SAM System

F-22 Raptor vs. S-400 Triumf: A Comprehensive Financial Assessment

Which Program Offers Better Value?

Strategic Defense Investment Analysis - March 2026

EXECUTIVE SUMMARY

This report provides a comprehensive cost analysis comparing two of the world's most advanced military programs: the Lockheed Martin F-22 Raptor fifth-generation fighter jet and the Russian S-400 Triumf surface-to-air missile system. The analysis examines acquisition costs, operating costs, lifecycle expenses, and weapon stockpile requirements to determine which system offers better value for defense investment.

Key Finding: The S-400 SAM system offers significantly lower total ownership costs than the F-22 fighter program. An S-400 battery costs approximately $500-600 million domestically (up to $1.25 billion for export customers) compared to the F-22's $350 million per aircraft (including R&D; amortization). When accounting for operating costs, the disparity widens dramatically: the F-22 costs approximately $85,000 per flight hour and requires 10-30 hours of maintenance per flight hour, while the S-400 has minimal operating costs during peacetime and can remain combat-ready for extended periods without significant expenditure.

However, the cost comparison must account for different operational roles: the F-22 provides offensive capability, air superiority, and global power projection, while the S-400 provides defensive capability over a fixed geographic area. A nation's specific defense requirements ultimately determine which system represents better value, but purely on a cost-per-engagement basis, the S-400 system offers superior cost efficiency.

Figure 1: Defense Investment - Comparing Program Costs

1. F-22 RAPTOR PROGRAM COSTS

1.1 Program Development and Acquisition

The F-22 Raptor program represents one of the most expensive fighter development efforts in history. Originally conceived in the 1980s as the Advanced Tactical Fighter (ATF) program, the U.S. Air Force planned to procure 750 aircraft at a total program cost of $44.3 billion. However, the end of the Cold War led to dramatic production cuts. By the time production ended in 2011, only 195 aircraft had been built (187 production aircraft plus 8 test aircraft), resulting in massive cost-per-unit inflation as development expenses were spread across a much smaller fleet.

The total F-22 program cost approximately $67.3 billion, comprising research, development, testing, evaluation, and production. When this total is divided across the 195 aircraft produced, the per-unit program cost reaches approximately $350 million per aircraft. The flyaway cost (the cost to produce each additional aircraft, excluding development) was approximately $143 million. This distinction is crucial: the flyaway cost represents what it would cost to build another F-22 today if production were restarted, while the program cost per unit reflects the actual historical investment per aircraft.

Cost Category	Amount	Notes
Total Program Cost	$67.3 billion	R&D;, testing, production
Aircraft Produced	195 units	187 production + 8 test
Unit Program Cost	$345 million	Total program divided by units
Flyaway Cost	$143 million	Production cost only
Operating Cost (CPFH)	$85,325/hour	FY 2024-2025 rate
Annual Operating Cost	$500-600M/fleet	Est. 250 flight hours/year each
Maintenance Ratio	10.5-30 hrs/hr	Improved from 30 to 10.5

Table 1: F-22 Raptor Program Cost Summary

1.2 Operating and Sustainment Costs

The F-22's operating costs represent a significant ongoing financial burden. According to the Congressional Budget Office and DoD comptroller data for FY2024-2025, the F-22 costs approximately $85,325 per flight hour to operate, making it one of the most expensive tactical aircraft in the U.S. inventory. This cost includes fuel, maintenance, spare parts, and support personnel. By comparison, the F-16 costs approximately $22,000-30,000 per flight hour, and even the newer F-35A has achieved costs of approximately $33,000 per flight hour in recent estimates.

The F-22 also requires substantial maintenance hours per flight hour. Early in the program, this ratio was reported at 30 maintenance hours per flight hour, though improvements have reportedly reduced this to approximately 10.5 hours. The aircraft's stealth coatings require specialized facilities, controlled environments, and trained technicians. The F-22 fleet is maintained at only a few bases with appropriate infrastructure, limiting operational flexibility and increasing logistics costs.

The U.S. Air Force has requested significant funding to keep the F-22 fleet viable through 2030 and beyond. The proposed FY2024-2028 spending includes $4.2 billion in procurement for upgrades plus $1.74 billion for related enhancements, representing a continuing investment of approximately $1-2 billion annually in modernization. Additionally, the Air Force plans $90 million for new sensor upgrades in upcoming budget cycles. These figures demonstrate that the F-22 requires sustained investment long after initial procurement.

1.3 Weapon Stockpile Costs

The F-22 carries its weapons internally to maintain stealth, with capacity for 6 AIM-120 AMRAAM missiles and 2 AIM-9 Sidewinder missiles (or 8 internal AMRAAMs in air-to-air configuration). The cost of equipping each F-22 with a full weapons load is substantial. The AIM-120D AMRAAM (the latest variant) costs approximately $1.2-1.5 million per missile, while the AIM-9X Sidewinder costs approximately $400,000-500,000 per unit. A full internal weapons load therefore costs approximately $8-10 million per aircraft.

For the F-22 fleet of 187 operational aircraft, a single weapons loadout for all aircraft would cost approximately $1.5-2 billion. However, air forces typically maintain weapons stockpiles far exceeding immediate loadout requirements. A reasonable stockpile for the F-22 fleet might include 3-4 missiles per internal bay position, representing 600-800 AIM-120s and 400-500 AIM-9s. This stockpile would cost approximately $800 million to $1.2 billion for AIM-120s plus $160-250 million for AIM-9s, totaling roughly $1-1.5 billion in missile inventory.

Missile Type	Unit Cost	Quantity per F-22	Loadout Cost
AIM-120D AMRAAM	$1.2-1.5 million	6 internal	$7.2-9 million
AIM-9X Sidewinder	$400,000-500,000	2 internal	$0.8-1 million
AIM-260 (Future)	Est. $2-3 million	6 internal (planned)	$12-18 million

Table 2: F-22 Weapon Loadout Costs

1.4 Total F-22 Program Cost Summary

Combining acquisition, operating, and weapons costs, the F-22 program represents a massive ongoing investment. For a fleet of 187 operational aircraft operating for 20 years with typical utilization rates:

- Acquisition: $67.3 billion (sunk cost, already spent)

- 20-Year Operating Cost: ~$10-12 billion (250 flight hours/year at $85K/hour)

- 20-Year Maintenance/Sustainment: ~$15-20 billion

- Weapon Stockpile: ~$1-1.5 billion

- Upgrades/Modernization: ~$5-10 billion over 20 years

Total 20-Year Lifecycle Cost: $100-115 billion

2. S-400 TRIUMF PROGRAM COSTS

2.1 System Acquisition

The Russian S-400 Triumf represents a fundamentally different cost structure from the F-22. The S-400 is a ground-based air defense system comprising multiple components: command post vehicles, acquisition radars, engagement radars, and mobile launchers. The system is typically sold as batteries or regiments, with costs varying significantly between domestic Russian procurement and export customers.

For domestic Russian forces, an S-400 battery reportedly costs approximately $500 million, including 8 launchers, associated radars, command post, and an initial load of 32 missiles. For export customers, the price increases dramatically due to profit margins, training, support infrastructure, and geopolitical factors. India's purchase of 5 S-400 batteries cost approximately $5.4 billion ($1.08 billion per battery), while Turkey's acquisition of 4 batteries cost approximately $2.5 billion ($625 million per battery). The export price range is typically $500 million to $1.25 billion per battery depending on configuration, negotiations, and included support.

Cost Element	Domestic Price	Export Price
S-400 Battery (8 launchers, radars, CP)	~$500 million	$500M - $1.25 billion
Additional Launcher	~$15-20 million	$20-30 million
9M96E Missile (short-range)	$300,000-500,000	$500,000-800,000
48N6 Missile (medium-range)	$1-2 million	$2-3 million
40N6 Missile (long-range)	$2-3 million	$3-5 million
Missile Load (32 per battery)	$30-50 million	$50-80 million

Table 3: S-400 Triumf Cost Components

2.2 Operating and Sustainment Costs

The S-400's operating costs are fundamentally different from the F-22's. As a ground-based system, the S-400 does not require fuel for flight operations, has no airframe fatigue considerations, and can remain in standby mode for extended periods with minimal cost. The primary operating costs include personnel salaries, periodic testing, radar maintenance, and occasional training exercises involving missile firings. Estimated annual operating costs for an S-400 battery range from $5-15 million, compared to approximately $30-40 million annually for a single F-22 aircraft (assuming 250-300 flight hours per year).

This represents a dramatic cost differential: maintaining an S-400 battery in operational readiness costs roughly the same as operating 1-2 F-22 sorties. The S-400's maintenance requirements are also significantly lower than the F-22's, as it does not require specialized climate-controlled hangars or the constant attention to stealth coatings that characterize fifth-generation fighter maintenance. The system can be operated by a smaller crew (approximately 20-30 personnel per battery) compared to the hundreds of personnel required to support a squadron of F-22s.

2.3 Missile Stockpile Costs

A standard S-400 battery carries 32 missiles in its launchers, with additional missiles typically stored at the battery level. The S-400 employs multiple missile types for different engagement scenarios, and stockpile costs depend on the mix of missiles selected. The 9M96 series (short-to-medium range) costs approximately $300,000-500,000 per missile; the 48N6 series (medium-to-long range) costs approximately $1-2 million per missile; and the extended-range 40N6 costs approximately $2-3 million per missile.

A typical missile loadout for one battery might include 16 x 48N6 missiles ($16-32 million), 8 x 40N6 missiles ($16-24 million), and 8 x 9M96 missiles ($2.4-4 million), totaling approximately $35-60 million per battery loadout. For a stockpile supporting multiple reloads (say, 3-4 combat loads per battery), the missile inventory cost would be approximately $100-200 million per battery. This is comparable to or slightly less than the F-22's weapon stockpile costs, but provides significantly more engagement opportunities (96-128 missiles per battery versus 8 per F-22).

2.4 Total S-400 Program Cost Summary

For a nation acquiring 5 S-400 batteries (comparable regional air defense coverage):

- Acquisition (5 batteries): $2.5-6.25 billion (export price)

- 20-Year Operating Cost: $500 million - $1.5 billion ($5-15M per battery/year)

- Missile Stockpile (5 batteries, 3 reloads each): $500 million - $1 billion

- Training and Support: $200-400 million over 20 years

Total 20-Year Lifecycle Cost: $3.7-9.2 billion

3. COST COMPARISON: DIRECT ANALYSIS

Cost Metric	F-22 Raptor	S-400 Battery	Winner
Unit Acquisition Cost	$143M flyaway / $345M program	$500M-$1.25B per battery	S-400 (per engagement capability)
Annual Operating Cost	$30-40M per aircraft	$5-15M per battery	S-400
Cost Per Flight Hour	$85,325	N/A (ground system)	S-400 (no equivalent)
Weapons Load Cost	$8-10M (8 missiles)	$35-60M (32 missiles)	F-22 (per missile cost)
Engagement Opportunities	8 targets per loadout	32+ targets per loadout	S-400

Cost Per Engagement	$1-1.5M per shot	$0.5-3M per shot	Comparable
Personnel Required	100+ per squadron	20-30 per battery	S-400
Infrastructure Required	Specialized hangars, runways	Roads/mobile positions	S-400

Table 4: Direct Cost Comparison - F-22 vs. S-400

3.1 The Fleet Comparison: 187 F-22s vs. Equivalent S-400 Investment

To provide a meaningful comparison, consider what equivalent investment in S-400 systems would provide. The F-22 program's total cost of approximately $67 billion (plus ongoing operating costs) could purchase approximately 55-130 S-400 batteries at export prices (or 130+ at domestic Russian prices). Each S-400 battery provides air defense coverage over approximately 400 km radius, with 32-48 missiles ready for engagement. This comparison reveals the fundamental cost asymmetry between offensive air power and defensive systems.

However, this comparison has important limitations. The F-22 provides capabilities that the S-400 cannot: global power projection, air superiority over enemy territory, deep strike capability, and the ability to seize and hold aerial dominance. The S-400, conversely, provides area denial over a fixed geographic region. These are fundamentally different military capabilities, and a nation's specific security requirements determine which represents better value.

Investment	F-22 Fleet (187 aircraft)	Equivalent S-400 Investment
Total Acquisition	$67 billion	55-130 batteries
Engagement Capacity	~1,500 missile shots	1,760-4,160 missiles ready
Geographic Coverage	Global (with basing)	Fixed air defense zones
Annual Operating Cost	$5-7 billion	$275M - $2 billion
Operational Flexibility	High (mobile, offensive)	Moderate (mobile, defensive)
Offensive Capability	Excellent	None (defensive only)

Table 5: Fleet-Level Cost Comparison

4. COST-EFFECTIVENESS ANALYSIS

4.1 Cost Per Kill Estimate

From a pure cost-per-engagement perspective, the S-400 offers superior economics. Against a conventional aircraft target, the S-400 can engage at ranges up to 400 km using missiles costing $0.5-3 million each. Against a stealth target like the F-22, the effective engagement range decreases dramatically, and multiple missiles may be required to achieve a probability of kill. However, even accounting for reduced effectiveness against stealth, the cost exchange ratio favors the SAM system.

Consider a scenario where an S-400 fires 4 missiles (at $1-2 million each) to achieve a 50% probability of kill against a penetrating stealth aircraft. The total cost per engagement is $4-8 million. The target aircraft (if it's an F-22) represents an investment of $350 million. This creates a cost exchange ratio of 40:1 to 90:1 in favor of the SAM system. Even if the SAM requires 10 missiles to achieve a kill, the cost ratio remains heavily favorable to the defender.

4.2 The Survivability Factor

However, cost-per-engagement analysis must account for survivability. The F-22, with its stealth and offensive capability, can actively hunt and destroy SAM batteries before they engage. In a contested environment, the F-22's probability of survival in each engagement is relatively high, while the S-400 battery, once detected, faces high probability of destruction. This

creates a dynamic where the F-22's higher cost may be justified by its ability to complete multiple missions and return, while each S-400 battery may be a single-use asset in a high-intensity conflict.

This survivability consideration somewhat balances the cost equation, but remains highly scenario-dependent. In a defensive posture where the S-400 operates within an integrated air defense network with fighter cover, its survivability increases significantly. In an offensive scenario where the F-22 penetrates hostile airspace alone, its survivability depends on maintaining stealth and successfully engaging threats before detection.

5. VERDICT: WHICH IS LOWER COST?

LOWEST COST: S-400 TRIUMF SURFACE-TO-AIR MISSILE SYSTEM

By the Numbers: The S-400 offers dramatically lower acquisition costs per engagement opportunity, significantly lower operating costs, and a much more favorable cost-per-kill ratio against aerial targets. A $500 million S-400 battery provides 32 immediate engagement opportunities with missiles costing $0.5-3 million each. An F-22 at $350 million provides only 8 engagement opportunities with missiles costing $1-1.5 million each. The 20-year lifecycle cost of a 5-battery S-400 deployment ($3.7-9.2 billion) is roughly 10% of the F-22 fleet's lifecycle cost ($100-115 billion).

Important Caveat: The F-22 and S-400 are not directly comparable systems. The F-22 provides offensive capability and air superiority that the S-400 cannot replicate. Nations requiring power projection must invest in air forces. Nations focused on territorial defense can achieve cost-effective deterrence with SAM systems. The 'better value' depends entirely on strategic requirements. But purely on cost metrics, the SAM system wins decisively.

Metric	F-22 Raptor	S-400 Battery	Lower Cost
Acquisition (per engagement)	$43M per missile slot	$15M per missile slot	S-400
Annual Operating Cost	$30-40M per aircraft	$5-15M per battery	S-400
20-Year Lifecycle	$550M per aircraft	$750M-1.8B per battery	F-22 (per unit)
Personnel Cost	High (100+ per unit)	Low (20-30 per battery)	S-400
Infrastructure Cost	Very High	Low	S-400
OVERALL VERDICT	Higher cost	Lower cost	S-400 WINS

Table 6: Final Cost Comparison Summary