

Value Engineering in the Aerospace Industry: Balancing Performance, Cost, and Innovation

Introduction

The aerospace industry is defined by extreme demands: uncompromising safety standards, high performance requirements, long operational lifecycles, and massive capital investments. Whether for commercial aircraft, defense systems, or space exploration vehicles, every component and system must deliver maximum reliability while staying within strict budget and schedule constraints. This is where Value Engineering (VE) becomes indispensable.

Value Engineering is a systematic, organized approach to improve the "value" of products, systems, or processes by analyzing their functions - defined simply as:

Value = Function / Cost

In aerospace, value is not just about cutting costs; it means delivering the necessary performance, safety, and quality at the lowest possible total lifecycle cost. It transforms the traditional mindset of "design first, save money later" into "design for value from the start." This article explores how value engineering works in aerospace, its core principles, applications across the lifecycle, real-world examples, and future trends.

What is Value Engineering?

Originating in the 1940s during World War II to address material shortages and production challenges, VE evolved into a structured methodology used worldwide today. Unlike simple cost-cutting - which often reduces quality or capability - VE focuses on function: "What does this part/system do, and is there a better, cheaper way to do it without losing what matters?"

In aerospace, it is often called Value Analysis/Value Engineering (VA/VE) or Value Engineering and Value Management (VEVM), and it covers every stage: from initial concept and design to manufacturing, operation, maintenance, and disposal.

Core Principles

1. **Function-First Thinking:** Identify all required functions, separate "essential" from "nice-to-have," and eliminate anything unnecessary.
2. **Team Collaboration:** Brings together engineers, designers, manufacturing experts, procurement specialists, and customers to get diverse perspectives.
3. **Lifecycle Perspective:** Considers not just purchase cost, but total cost over the product's life - including fuel, maintenance, repairs, and retirement.
4. **Evidence-Based Decisions:** Uses data, testing, and analysis rather than assumptions to choose the best solutions.

5. Continuous Improvement: Applied repeatedly throughout development and operations to keep optimizing value.

Why Value Engineering Matters in Aerospace

The aerospace sector faces unique challenges that make VE critical:

1. High Costs: Developing a new aircraft or satellite costs billions of dollars. Even small savings per part multiply into huge amounts across thousands of components.
2. Strict Standards: Safety, reliability, and performance are non-negotiable. VE ensures cost reductions never compromise compliance or safety.
3. Long Lifecycles: Commercial planes operate for 25 - 30 years; satellites stay in space for 15+ years. Decisions made during design affect costs for decades.
4. Complex Supply Chains: Parts come from global suppliers. VE optimizes sourcing, standardization, and logistics to reduce waste and delays.
5. Competition & Sustainability: Airlines and governments demand better efficiency, lower emissions, and better value - pressuring manufacturers to innovate while controlling costs.

How Value Engineering Works: Step-by-Step

In aerospace projects, VE follows a structured process, typically divided into six phases:

1. Information Phase

Gather all data: design requirements, specifications, costs, performance targets, and operational needs. Understand exactly what the product must do and what it costs now.

2. Function Analysis Phase

Break down every part and system into its basic functions. Ask:

"What is it?"

"What does it do?"

"What is it worth?"

"What else could do the same job?"

For example: A landing gear's main function is "support weight and absorb impact" - not necessarily "be made of this exact metal or have this specific shape."

3. Creative Phase

Brainstorm alternative ways to achieve the same or better functions. No idea is too small or too bold here - focus on generating options without judging them yet.

4. Evaluation Phase

Test and compare all ideas against key criteria:

Does it meet safety/performance rules?

How much does it save or cost?

Is it easy to manufacture and maintain?

Does it fit with existing systems?

5. Development Phase

Turn the best ideas into detailed designs, perform simulations, build prototypes, and test to prove they work as intended.

6. Implementation Phase

Put the changes into production, update documentation, train teams, and monitor results to confirm expected savings and performance are achieved.

Key Applications in Aerospace

1. Design & Development

This is where VE has the biggest impact - changes made early cost much less than fixing problems later.

Material Selection: Replace expensive, hard-to-process materials with alternatives that offer similar performance at lower cost. For example, switching from specialized alloys to optimized composites or standard metals where possible.

Standardization: Use common parts across different models or systems to reduce design work, inventory, and production costs. Boeing reduced costs on the 787 by standardizing component sizes instead of using custom-made versions.

Simplification: Reduce the number of parts, fasteners, and connections. Fewer parts mean less assembly time, fewer failure points, and lower maintenance needs. One manufacturer cut fasteners by 30% in landing gear designs, saving 25% in assembly time.

Weight Optimization: Every kilogram saved reduces fuel use, increases range, or allows more payload. VE balances weight reduction against material and production costs to find the optimal trade-off.

2. Manufacturing & Production

Process Improvement: Redesign parts to be easier to make, assemble, and inspect. Loosening unnecessary tight tolerances (where they don't affect function) can cut production costs by 10-15%.

Supplier Collaboration: Work with suppliers to improve designs together, find cheaper materials, or adjust production methods. This often leads to shared savings and stronger partnerships.

Waste Reduction: Minimize material scrap, energy use, and rework - critical in aerospace where materials are expensive and precision is high.

3. Operations & Maintenance

VE doesn't stop once the product is delivered. It helps reduce running costs:

Design for easier inspection, repair, and part replacement to cut downtime and maintenance expenses.

Improve fuel efficiency through aerodynamic tweaks or system upgrades, delivering huge savings over the aircraft's life.

4. Space Systems

In space, every gram and every dollar count even more. VE is used to:

Optimize satellite structures, propulsion systems, and electronics to meet strict mass limits while keeping costs down.

Design reusable rockets (like SpaceX's Falcon or Blue Origin's New Shepard) by focusing on "reusability" as a core function - completely changing the cost model of space travel.

Real-World Case Studies

1. Boeing 787 Dreamliner

Early in development, engineers chose advanced alloys for some fuselage parts to save weight, assuming costs would be similar to aluminum. However, VE analysis showed these materials were far more expensive and harder to source due to limited supply. The team switched back to

optimized aluminum designs, keeping most of the weight benefit while cutting material costs significantly.

Another example: lead screws used across systems were originally made in many different lengths, each with low production volumes and high prices. VE grouped requirements into standard sizes, increasing volume per type and reducing total cost without affecting performance.

2. Landing Gear Optimization

A major aerospace manufacturer applied VE to landing gear assemblies:

Switched from high-cost steel alloys to lower-cost alternatives for non-critical parts → 20% material savings.

Adjusted tolerances on non-essential features → 10% lower manufacturing costs.

Reduced part count and simplified assembly → 25% faster production.

Total result: 15% overall cost reduction, with no impact on safety or quality.

3. Defense Aircraft Upgrades

When upgrading existing military planes, VE helps extend service life and improve capabilities at a fraction of the cost of building new aircraft. By analyzing functions, teams identify which systems need modernization and which can stay as-is, delivering maximum value within tight defense budgets.

Challenges & How to Overcome Them

Challenge 1: "We've always done it this way"

Resistance to change is common.

→ Solution: Use data and clear evidence to show benefits, and involve teams early so they feel part of the process.

Challenge 2: Balancing Safety & Cost

There is no room for compromise on safety.

→ Solution: Make safety and compliance the first criteria in all evaluations - never trade essential functions for savings.

Challenge 3: Late Application

VE done too late in development has limited impact and can even cause delays.

→ Solution: Integrate VE from the very first concept phase, and repeat it at every major milestone.

Challenge 4: Measuring Full Lifecycle Value
Hard to calculate costs over 20+ years.

→ Solution: Use lifecycle cost models that include fuel, maintenance, and operational expenses in calculations.

Future Trends

1. Digital Transformation: Using AI, simulation, and digital twins to analyze thousands of design options quickly, finding optimal value combinations faster than ever before.
2. Sustainability Focus: VE now includes environmental impact as part of "value"- reducing emissions, improving recyclability, and lowering carbon footprints alongside cost savings.
3. Circular Economy: Designing parts to be reused, repaired, or recycled, reducing waste and long-term costs.
4. Global Collaboration: Digital tools make it easier to work with international teams and suppliers, optimizing value across the entire supply chain.

Conclusion

Value Engineering is more than a cost-cutting tool - it is a strategic approach that shapes how aerospace products are designed, built, and operated. By focusing on function rather than just form or cost, it enables the industry to meet the highest standards of safety and performance while making advanced technology more affordable and sustainable.

As the sector moves toward greener aircraft, reusable space systems, and smarter manufacturing, VE will remain central - ensuring every investment delivers maximum value for customers, operators, and society.