



Weight Reduction Opportunities Through Cable Construction Choices

Introduction

In modern aerospace, defense, and industrial systems, every gram counts. Reducing weight without compromising reliability or performance is critical to improving system efficiency, payload capacity, and operational longevity. Electrical cabling, often overlooked, can constitute a significant portion of system weight, particularly in complex aircraft, unmanned platforms, and high-density vehicle harnesses.

Cable construction choices—including **conductor size**, **insulation type**, and **shielding design**—offer tangible opportunities for weight reduction. By evaluating these elements holistically, engineers can achieve measurable weight savings while maintaining electrical performance, environmental resilience, and ease of maintenance. This whitepaper explores practical strategies for weight optimization in cabling systems, highlighting materials, design approaches, and engineering trade-offs.

Conductor Material and Size Optimization

Conductor Material Selection

Copper is traditionally favored for its excellent electrical conductivity and mechanical durability. However, aluminum offers a substantial weight advantage, approximately 30–50% lighter for the same cross-sectional area. Advanced aluminum alloys and silver-coated aluminum can maintain conductivity and thermal performance comparable to copper in many applications.

Trade-offs:

- Aluminum is more prone to creep and requires specialized termination techniques.
- Voltage drop and current-carrying capacity must be carefully evaluated.

Right-Sizing Conductors

Reducing **conductor size** to match actual current requirements without excessive oversizing can significantly reduce harness weight. Engineers can achieve this through careful load analysis, voltage drop calculations, and safety margin optimization. Parallel conductor bundles and optimized stranding patterns further balance flexibility with weight reduction.



Insulation and Jacket Material Selection

Lightweight Insulation

The choice of **insulation type** directly impacts cable mass. High-performance polymers like FEP, ETFE, and thin-wall fluoropolymers allow for reduced wall thickness while maintaining dielectric strength, thermal tolerance, and mechanical protection. Thinner insulation reduces both conductor-to-conductor spacing and overall harness diameter.

Jacket Material Considerations

Advanced jackets, including composite and low-density polymers, provide environmental protection at a fraction of the weight of traditional PVC or thick rubber jackets. Lightweight LSZH (Low-Smoke Zero-Halogen) or specialized composite materials maintain fire safety and abrasion resistance without adding unnecessary mass.

Impact: Selecting the right insulation and jacket combination can reduce harness weight by up to 15–25%, particularly in long, multi-run cable assemblies.

Shielding Design

Shielding is essential for EMI/RFI protection, but traditional copper braids add significant weight. Optimizing **shielding design** provides substantial weight savings:

- Use of tinned aluminum or aluminum-polymer composite shields instead of copper.
- Reducing braid coverage or implementing spiral shields in areas of lower EMI risk.
- Combining functional shields with structural support elements to minimize redundancy.

Impact: Properly designed shielding can reduce harness weight by 20–30% while maintaining EMI performance, particularly in shielded bundles running across complex platforms.

Cable Geometry and Harness Design

Optimized Stranding and Bundling

Smaller gauge conductors in parallel bundles and optimized stranding reduce weight while maintaining flexibility and mechanical integrity.



Harness Architecture

- Minimizing redundant lengths and using straight, direct routing reduces both harness mass and bulk.
- Lightweight cable supports or integrated conduits allow reduction of jacket thickness or shielding where structural support is provided externally.

Advanced Weight Reduction Strategies

- **Micro-cabling:** Flat or ribbon-style cables consolidate multiple conductors into a compact, low-mass form.
- **Predictive Design:** Computational models identify where conductor, insulation, or shielding reductions are feasible without compromising performance.
- **Additive Manufacturing Supports:** 3D-printed lightweight guides and clamps replace traditional heavy metal supports.

Conclusion

Weight reduction in complex electrical harnesses is achieved through deliberate engineering choices in **conductor size**, **insulation type**, and **shielding design**. Selecting lighter conductor materials, optimizing conductor dimensions, using high-performance thin-wall insulation, and carefully designing shielding systems can dramatically reduce harness mass without compromising electrical performance or reliability.

These strategies provide measurable benefits in payload capacity, fuel efficiency, and overall system performance. By applying a holistic approach to cable construction choices, engineers can create lighter, more efficient, and more maintainable harnesses that meet the stringent demands of aerospace, defense, and industrial systems.

(See Information Table on Page 4)



Information Table on Cable Construction Choices affecting Weight Reduction

Design Element	Weight Reduction Strategy	Impact on Harness Weight	Vital Considerations
Conductor Size	Right-sizing conductors to match current requirements; using parallel bundles; advanced stranding	Up to 15–25% reduction in conductor mass depending on harness length	Must maintain electrical performance (voltage drop, ampacity); consider mechanical strength
Conductor Material	Substituting aluminum or copper-clad aluminum for copper	30–50% lighter than copper for same conductivity	Requires proper termination; creep resistance and thermal performance must be evaluated
Insulation Type	Thin-wall high-performance polymers (FEP, ETFE, fluoropolymers); lightweight jackets	10–25% reduction depending on insulation thickness and harness length	Ensure dielectric strength, flexibility, and abrasion resistance are sufficient
Shielding Design	Use of lightweight materials (aluminum/polymer shields), reduced braid coverage, spiral shields	20–30% reduction in shielded harness mass	EMI/RFI protection must meet system requirements; combine with structural support where feasible
Harness Architecture	Optimized routing, minimal redundant length, integrated supports	Reduces cumulative harness mass by minimizing unnecessary length	Requires detailed layout planning; must avoid stress points and maintain maintainability