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Reduced SWaP Pressure Forcing Connector Redesigns

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Most defense electronics programs don't fail because the processor is too slow or the sensor isn't accurate enough. They fail when the system can't be packaged, powered, cooled, routed, and serviced inside the real-world envelope it has to live in. When that happens, the interconnect and wireharness is often where the physics shows up first.

It's no secret that constraints on SwaP – size, weight, and power – keep tightening across soldier-worn gear, airborne payloads, autonomous platforms, and space systems. Designers are packing more capability into smaller volumes while demanding longer endurance and more data throughput. That pressure turns connectors from “commodity hardware” into an enabling technology – and sometimes into a hard constraint.



Why Connectors are Shrinking (and getting harder)

Miniaturization is being driven by two forces that move together: Electronics are operating at lower voltages and currents, while simultaneously running faster and moving more digital data. Smaller form factors become possible, but the margin for error shrinks. As assemblies compress, issues like crosstalk, interference, and grounding become more difficult to manage.

At the same time, more sensing and computing is moving closer to the edge, migrating into compact, mechanically dynamic environments. The connector can't just be small – it has to survive motion, shock, vibration, g-forces, thermal swings, and repeated handling without becoming a reliability risk.

Smaller Doesn't Mean Simpler

When teams chase lower-SWaP design, the limiting factor is rarely the connector outline alone. Cable design, insulation choice, contact spacing, shielding strategy, and sealing requirements all become part of the trade space.

In practice, engineers end up balancing three competing demands:

- **Power delivery in a small package:**
Miniature connectors still need low-resistance interfaces and sufficient current capacity, which is often constrained by wire diameter and thermal limits.
- **Signal integrity under tight packaging:**
As systems become denser, interconnects must reduce susceptibility to interference and prevent crosstalk, especially when high-speed signals share a path with power.
- **Environmental survivability:**
Harsh conditions don't disappear with miniaturization. Smaller components can actually raise the difficulty of sealing and moisture protection, because the protective features must scale down too.

One of the Biggest SWaP Levers: Fewer Interconnects

A straightforward way to reduce size and weight is not simply by using smaller connectors, but using fewer of them. A common approach is to combine power and signal contacts into a single connector footprint. Such a move reduces connector count, simplifies routing, and can cut harness complexity – often a hidden driver of packaging challenges.

This aspect is especially relevant when a platform needs both higher-speed data and meaningful power delivery. Carrying both through one compact interconnect can mean avoiding separate power connectors, extra cable runs, and additional sealing or strain-relief features.

Don't Underestimate EMI and Shielding

As systems shrink, electromagnetic interference (EMI) becomes less forgiving. Differential signaling helps, but it isn't always enough, especially when cables must remain flexible, lightweight, and compact.

Shielding choices then become system-level decisions. A designer might start with twisted pairs for balanced signals, then add shielding when the environment demands it. The goal is to manage interference without turning the cable assembly into a bulky, stiff constraint that undermines the original SWaP target.

Customization is a Schedule Tool, Not a Schedule Risk

"Custom connector" used to imply long lead times and program risk. That connotation is changing as more designs start from standard families and evolve through targeted changes – materials, layouts, or mixed-contact configurations – rather than from-scratch redesigns.

For SWaP-driven programs, this element matters because the interconnect is often discovered as a constraint late in packaging after sensors, compute, and batteries have already consumed the envelope. Faster iteration helps prevent connectors from becoming the last-minute redesign driver.

The Takeaway

SWaP pressure isn't only an electronics challenge – it's a packaging, integration, and life cycle challenge. The programs that handle it well treat interconnects as part of the architecture early, not as a final procurement detail. This approach means designing the connector-and-cable approach right alongside power budgets, data paths, mechanical packaging, EMI strategy, and environmental requirements.

Because when the envelope tightens, the connector doesn't just connect the system – it decides whether the system can exist at all.