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## Interconnect Sustainability and Lifecycle Management in DoD Programs

### Summary

The Department of Defense (DoD) faces rising lifecycle costs across weapon systems and critical programs, where sustainment frequently accounts for the majority of total ownership cost. To reduce lifecycle costs while maximizing capability and readiness, DoD programs must integrate sustainability principles—particularly in **interconnect technologies**—through early design decisions that prioritize **long-life materials, maintainability, and supply-chain resilience**. These elements collectively reduce **Total Cost of Ownership (TCO)**, mitigate sustainment risks, and support strategic readiness objectives.

### Introduction

Lifecycle management in DoD acquisition has evolved to prioritize sustainment outcomes over short-term acquisition metrics. DoD policy emphasizes **Total Life Cycle Systems Management (TLCSM)** wherein program managers are accountable for sustainment performance from design through disposal. Early integration of sustainment planning, especially for critical subsystems like interconnects, directly impacts operational availability and sustainment costs.

Interconnect systems (electrical connectors, wiring harnesses, and high-reliability signal paths) are fundamental to defense platforms. Their reliability, material selection, and supply availability affect operational performance, maintenance burden, and long-term supportability.

### The Importance of Long-Life Materials in Defense Interconnects

#### Reliability and Durability

Choosing **long-life materials** for interconnects (e.g., corrosion-resistant alloys, advanced composites) extends **mean time between failures (MTBF)** and reduces unplanned maintenance. These materials deliver sustained performance in extreme environments, decreasing replacement frequency and logistics tail burdens.

#### Lifecycle Cost Reductions

Although high-performance materials may carry a higher initial unit cost, they significantly reduce lifecycle expenditures by limiting:

- **Corrective maintenance events**
- **Part replacements**
- **Logistic support overhead**



- This aligns with the broader sustainment principle that most life cycle costs occur outside initial acquisition. Early DoD leadership has acknowledged sustainment can consume more than two-thirds of total program cost.

### **Corrosion, Wear, and Failure Prevention**

DoD guidance mandates proactive corrosion planning in acquisition programs because corrosion prevention reduces sustainment costs and improves maintainability and system availability. Programs must identify corrosion risks, environments (marine, desert, humidity), and mitigation strategies early, not as an afterthought.

### **Environmental Severity Definition**

Explicitly defining exposure conditions (salt fog, fuel vapors, temperature cycling, UV, fungal growth) during requirements development to drive material and finish selection.

### **Use of Corrosion-Resistant Materials**

- Stainless steels, titanium alloys, aluminum-lithium alloys
- Nickel- or gold-plated contacts in connectors
- Fluoropolymers (PTFE, FEP), ETFE, and polyimide insulations for wiring

### **Examples of Corrosion-Resistant Alloys (CRAs)**

1. Stainless Steel –
  - Composition: Primarily iron, chromium (Cr), and nickel (Ni).
  - Corrosion Resistance: Excellent resistance to rust, oxidation, and corrosion, especially in chloride environments.
  - Applications: Pipelines, marine applications, and medical devices
2. Titanium Alloys –
  - Composition : Titanium with aluminum and vanadium.
  - Corrosion Resistance: Exceptional resistance to corrosion in seawater. Chlorine, and sulfuric acid.
  - Applications: Aerospace components, marine structures, and medical implants.
3. Monel –
  - Composition: Nickel-copper alloys.
  - Corrosion Resistance: Outstanding resistance to seawater and acidic environments.
4. Aluminum Alloys -



- Composition: Primarily aluminum with magnesium, copper, and silicon.
- Corrosion Resistance: Good resistance to general corrosion, especially in marine environments, though may be susceptible to pitting corrosion.
- Applications: Aircraft, marine vessels, and structural applications.

Each alloy offers unique benefits based on its composition. Its immunity to corrosion is often enhanced by the presence of specific elements that form protective oxide layers. Alloys can also provide resistance to explicit chemicals or environmental conditions.

**Galvanic Compatibility Analysis** – Avoiding dissimilar metal pairings or coatings, gaskets, or primers to prevent galvanic corrosion.

**Qualified Coating Systems** – specifying coatings qualified to standards such as:

- MIL-PRF-23377 / MIL-PRF-85582 primers
- MIL-DTL-5541 conversion coatings
- MIL-PRF-85285 Topcoats

### **Connector Sealing and Overmolding**

Environmental backshells, gaskets, and potting compounds to block moisture ingress in harsh environments.

### **Maintainability and Product Support Design**

- **Maintainability as a Design Parameter**

Maintainability, the ease with which a system can be retained in or restored to operable condition, must be specified early in requirements and systems engineering. Design features that support maintainability decrease downtime and enable rapid repairs, reducing operational and support costs.

- **Good maintainability practices include:**

- Modular interconnect designs
- Standardized connectors and cables
- Tool-free or minimal-tool replacement architectures

These design choices simplify training, reduce specialized spares needs, and limit field-level support complexity.

### **Integrated Logistics Support (ILS)**



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Integrated Logistics Support (ILS) is the systems engineering process that ensures supportability and maintenance considerations are baked into acquisition decisions. It explicitly links reliability and maintainability data to design choices to lower lifecycle costs.

Implementing ILS principles early in program development leads to:

- Better predictions of maintenance burden
- Optimized spare parts provisioning
- Clear sustainment strategies integrated into Program Management documentation

### **Supply-Chain Resilience and Its Impact on TCO**

- **Strategic Supply-Chain Transparency**

The DoD has emphasized the need for **supply chain resilience** through broader mapping and risk mitigation of defense industrial base dependencies. Enhanced understanding of supply tiers enables proactive management of risks that could otherwise drive costly sustainment delays and emergency procurement.

- **Reducing Risk Through Diversification and Onshoring**

Resilient supply chains, through supplier diversification, onshoring of critical capabilities, and development of domestic sources for strategic materials, limit disruptions and price volatility that inflate lifecycle costs.

- **Risk Mitigation and Proactive Resourcing**

Applying supply chain risk management (SCRM) frameworks and aligning investments toward resilient supply nodes reduce:

- Emergent logistics costs
- Delays due to single source or constrained supply
- Operational downtime resulting from unavailability of sustainment spares

### **Quantifying Lifecycle and Total Cost of Ownership Benefits**

**TCO and Sustainment Outcomes** – By incorporating sustainable interconnect design and resilient supply chains, programs benefit from:

- Lower corrective maintenance cost
- Reduced inventory holding costs



- Fewer emergency procurements
- Decreased obsolescence management burden

Performance-based logistics approaches illustrate how life cycle pricing informed by through-life models can align contractor incentives with reduced TCO.

### Recommendations for DoD Programs

- **Prioritize Sustainment in Early Requirements** – Incorporate long life and maintainability criteria explicitly in procurement requirements rather than treating sustainment as a downstream add-on.
- **Invest in Sustainable Materials and Technologies** – Support R&D in advanced interconnect materials that offer extended life and lower environmental impacts while meeting performance standards.
- **Strengthening Supply-Chain Visibility and Risk Management** – Apply robust SCRM processes that can anticipate disruptions and adapt sourcing strategies accordingly.
- **Establish Lifecycle Metrics** – Define sustainment KPIs (Key Performance Indicators) tied to lifecycle cost metrics to evaluate performance over time.

### Conclusion

Total cost of ownership is determined far less by initial acquisition price than by the durability, serviceability, and resilience of the systems that remain in operation over time. Long-life materials reduce the frequency of failure, replacement, and performance degradation, directly lowering maintenance labor, spare inventory requirements, and unplanned downtime. When systems are designed to endure harsh operational environments, they preserve performance margins and avoid costly mid-life redesigns or premature obsolescence.

Maintainability further compounds these savings by enabling faster diagnostics, simplified repair, and modular replacement. Designs that prioritize accessibility and standardized components shorten repair cycles, extend service life, and minimize operational disruption. This not only reduces direct maintenance costs but also stabilizes schedules and improves mission availability, critical factors in high-reliability and distributed systems.

Supply-chain resilience completes the TCO equation. Materials and components sourced from diversified, qualified suppliers mitigate the risks of shortages, single-point failures, and long lead times. Resilient supply chains reduce program delays, price volatility, and the need for costly last-minute



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substitutions or requalification efforts. Over the system lifecycle, this stability translates into predictable costs and sustains operational readiness.

Taken together, long-life materials, maintainable designs, and resilient supply chains shift cost from reactive spending to planned investment. Organizations that adopt this lifecycle-driven approach consistently realize lower total cost of ownership, reduced risk exposure, and greater long-term value; proving that durability and resilience are not premiums, but essential enablers of cost efficiency and mission success.