SECURING THE HMI SUPPLY CHAIN FOR NEXT-GEN DEFENSE MANUFACTURING

WHAT DOES THE NEW STANDARD FOR MANUFACTURING READINESS REQUIRE?

Military OEMs are now accountable for the entire genealogy of every component in their supply chain, including the sub-tier vendors their partners rely on. One documentation gap, one adversarial semiconductor, one undisclosed firmware dependency is all it takes to stall a platform that's otherwise ready to field.

This guide breaks down exactly what "mission-ready" looks like across the mandates, engineering disciplines, and lifecycle strategies that separate a tactical liability from a true HMI program partner.

Ready to evaluate your current supplier?

*The **Mission Readiness Checklist** at the end of this guide walks you through the 3 critical areas that separate a tactical liability from a true program partner: Manufacturing Readiness, Engineering Resilience, and Partnership Velocity.*

WHICH DEFENSE MANDATES DETERMINE YOUR PROGRAM ELIGIBILITY?

Before the manufacturing process begins, a qualified partner must provide documented evidence of compliance with the legal mandates governing defense electronics. For programs operating across U.S. and European defense ecosystems, these requirements run in parallel and both carry consequences that reach deeper into the supply chain than most procurement managers initially expect.

U.S. Mandates

NDAA Section 5949 (Effective December 2027): Prohibits procuring electronic equipment containing semiconductors from foreign entities designated as national security risks. Compliance depends on tracing the actual fabrication source of every semiconductor, not just its declared point of assembly.

NDAA Section 889: Prohibits federal contracting with companies that use telecommunications or video surveillance equipment from named Chinese entities and their subsidiaries. Suppliers must audit not just the components they ship, but covered technologies embedded in their own facilities.

European Mandates

Security Action for Europe (SAFE): Establishes adversarial content thresholds for EU-funded defense programs, prohibiting third-country control of prime contractors and subcontractors without specific mitigation measures.

NIS2 Directive: Mandates cybersecurity risk management, supply chain security protocols, and incident reporting.

Intra-EU Transfers Directive: Governs the movement of defense products between EU member states.

WHAT ARE THE KEY COUNTRY OF ORIGIN (COO) REQUIREMENTS?

COO requirements determine how much of what you buy must be domestically sourced—and those thresholds are actively rising on both sides of the Atlantic.

U.S. Requirements

Buy American Act (BAA): Requires end products be manufactured in the U.S. using domestically sourced components. Required domestic content is currently 65% for items delivered through 2028, and rising to 75% from 2029 onward.

Defense Federal Acquisition Regulation Supplement (DFARS) 252.225: Governs specialty metals and restricts non-domestic sources for items like housings and contacts in military-grade switches.

Berry Amendment: Mandates domestic sourcing for specific material categories, including certain electronic components.

European Requirements

SAFE: Sets a ceiling on third-country content at 35% in EU-funded defense programs, which applies to the entire program's bill of materials, not just individual line items.

European Defence Industry Programme (EDIP): Requires 65% EU-origin components in EDIP-funded projects. It sets a hard floor on domestic content to restrict dependency on adversarial or high-risk sources.

International Traffic in Arms Regulations (ITAR) Compliance

A supplier with an established ITAR licensing track record can mean the difference between a program that ships on schedule and one that stalls.

The Bottom Line: A qualified HMI supplier doesn't just verify COO at the finished-goods level. They trace it through every sub-component, raw material, and manufacturing process.

Questions to Ask When Evaluating HMI Partners

– *How many export licenses have they processed?*

– *Have they managed export license applications for parts sourced from foreign suppliers?*

– *Do they have a dedicated ITAR compliance team with a track record of managing technical data and hardware exports to allied nations?*

– *What does their average approval timeline look like?*

DOES YOUR SUPPLIER UNDERSTAND YOUR FLOW-DOWN REQUIREMENTS?

Beyond statutory mandates, defense suppliers must also comply with a set of Federal Acquisition Regulation (FAR) clauses that prime contractors flow down through purchase orders. A qualified HMI partner should be prepared to demonstrate compliance with these key requirements:

Sensitive Country Notification: Under Title 22, Code of Federal Regulations 126.1, suppliers must notify customers in writing if any shipment originates from a politically sensitive country regardless of whether the component is ITAR-controlled. This places affirmative disclosure obligations on the supplier before a purchase order is fulfilled.

Defense Priorities & Allocation System (DPAS, 15 CFR 700/FAR 52.211-15): Rated defense orders carry DO (high) or DX (highest) priority designations that require suppliers to prioritize them over commercial work. A supplier unfamiliar with DPAS can inadvertently delay a rated program by treating it as a standard commercial order.

Supplier Responsibility & Debarment (FAR 52.209-6): Prohibits subcontracting with contractors that are debarred, suspended, or proposed for debarment. A qualified partner actively screens their own sub-tier supply base against the SAM.gov exclusions list.

Subcontracting & Small Business Reporting (FAR 52.244-2): Requires quarterly reporting on subcontract awards, including small business status and spending.

Quality & Conformance (FAR 52.246-15): Requires suppliers to provide a Certificate of Conformance attesting that delivered items meet all contract requirements.

What to Ask Your HMI Supplier

1. *Do they have a formal process for reviewing, accepting, and operationalizing prime contractor flow-down clauses?*

2. *Do they maintain an active SAM.gov screening process for their sub-tier suppliers?*

3. *Do they have a documented process for identifying and disclosing country of origin?*
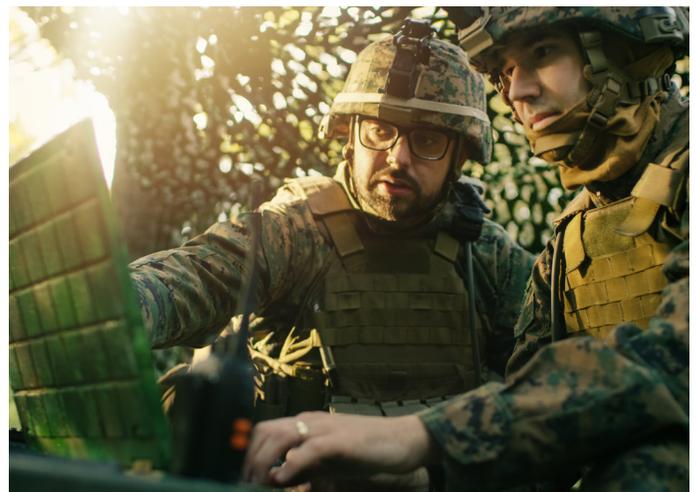
HOW DO YOU ESTABLISH PROOF OF ORIGIN ACROSS YOUR HMI SUPPLY CHAIN?

During a DCMA audit, incomplete records can ground a mission-critical platform as effectively as a hardware defect. A qualified partner ensures that every HMI node, from tactical radio keypads to navigation encoders, carries a verifiable Digital Birth Certificate: a complete, unbroken trail satisfying the following mandates.

International Traffic in Arms Regulations: Partners must strictly regulate controlled files within CAD systems and protect manufacturing records, such as nonconformance logs for a custom joystick assembly, with the same rigor as design specifications.

AS9100 Quality Documentation: Mandates comprehensive records tracing of every manufacturing decision back to customer requirements. For example, any change (paint, hardware, materials, connectors, etc.) must be documented and approved.

National Institute of Standards & Technology (NIST) SP 800-171: Governs how defense contractors protect Controlled Unclassified Information (CUI)—including design files, manufacturing records, and program data—on their internal systems. Compliance requires implementing 110 security practices across 14 domains.

What Does a First Article Inspection for HMI Panels Actually Look Like?

The First Article Inspection (FAI) report provides evidence that manufacturing processes consistently produce parts that meet all design requirements. In practice, an FAI package for a defense HMI component includes:

– Actual measurements of a part, such as a rotary switch, against specified tolerances.

– Material certifications for compatible metals and platings, non-metallic resins, potting compounds, and other polymer materials against design callouts.

– Process parameters for automated assembly against approved procedures.

– Documented review of all engineering drawing notes and records of special processes, including heat treating, welding, and soldering.

> **Did You Know?**
>
> *If a design is modified, a process changes, or if production lapses for more than two years, many prime contractor quality flow-downs require a new FAI.*

ARE YOUR HMI CONTROLS TRULY ENGINEERED FOR CONTESTED ENVIRONMENTS?

Every gram matters when trying to extend the mission range for battery-powered or fuel-critical assets. Integrating multi-function controls, such as a single-deck rotary switch, reduces footprint and weight without taxing the battery.

Engineering for Environmental Extremes
True military-grade hardware must survive conditions that would instantly compromise commercial electronics. A sophisticated manufacturing partner engineers for these specific stressors:

Altitude and Rapid Decompression
(MIL-STD-810H, Method 500.6)

Tests external pressure drops and simulates a sudden loss of cabin pressure in avionics applications to ensure the component maintains integrity and does not fail.

Submersion
(MIL-STD-810H, Method 512.6)

Validates that a component is waterproof beyond just rain, ensuring no ingress when fully submerged. This is often paired with ingress protection ratings IP67/68 for equipment deployed in aquatic or wet environments.

Salt Fog & Corrosion
(MIL-STD-810H, Method 509.7)

This is the primary test for naval or coastal hardware. It subjects controls to a concentrated salt-laden atmosphere to ensure that materials do not corrode or that salt deposits do not seize rotary and pushbutton mechanisms.

High-G Shock & Gunfire Vibration
(MIL-STD-810H, Method 519.8)

Subjects components to sustained high-frequency vibration profiles induced by weapons fire to verify they maintain electrical continuity and mechanical integrity, conditions that cause commercial contacts to bounce, arc, and fail.

Temperature Extremes
## (MIL-STD-810H, Method 501 and 502)

Materials, lubricants, and electronic components must be selected and qualified to perform across the full temperature spectrum—from Arctic cold-start conditions to extreme heat in desert vehicle interiors.

Mechanical Shock
(MIL-STD-810H, Method 516.8)

Mechanical shock tests simulate abrupt, single-event impacts, such as hard vehicle landings, ballistic events, or equipment drops.

Electromagnetic Compatibility/Electrostatic Discharge (MIL-STD-461G)
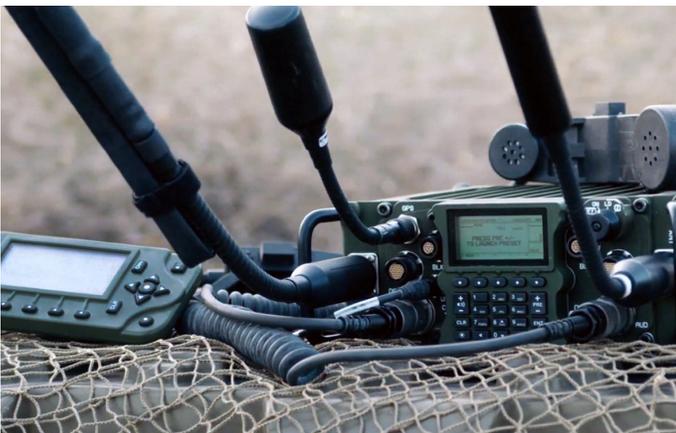
Governs radiated and conducted emissions, ensuring HMI controls do not interfere with adjacent mission-critical electronics and can survive electromagnetic threats.

Night Vision Goggle (NVG) Compatibility
(MIL-STD-3009)

Governs spectral output, luminance, and uniformity to prevent NVG interference and preserve operator night vision.

The difference between a commercial-grade vendor and a true defense partner isn't a datasheet claim. It's the documented test data, in-house lab capability, and engineering discipline to prove compliance against every one of these specifications.

DOES REPLACING A LEGACY COMPONENT HAVE TO MEAN A GROUND-UP REDESIGN?

Many active defense programs are currently hindered by legacy components that represent significant regulatory or obsolescence risks.

A sophisticated partner uses equivalence engineering to perform "Rip and Replace" upgrades, swapping out non-compliant or obsolete HMI nodes with modern equivalents that maintain exact mechanical and electrical continuity.

The Value of Form-Fit-Function (FFF) Engineering
While replacing these units will almost certainly trigger a requalification event, the goal of form-fit-function engineering is to minimize the scope, cost, and duration of that process.

For example, to minimize requalification costs and delays, a replacement CAN bus keypad or optical encoder must:

→ Match existing mounting points and tactile "feel" for operator ergonomics. **(Form)**

→ Utilize identical electrical connectors for "plug-and-play" installation. **(Fit)**

→ Mimic legacy communication protocols so the system computer requires no software logic changes. **(Function)**

HOW DOES VERTICAL INTEGRATION PROTECT YOUR PROGRAM VELOCITY?

Relying on a fragmented network of overseas toolmakers and sub-tier suppliers leaves a program at the mercy of geopolitical shifts and factory closures. The most effective shield against these external shocks is a domestic supplier with vertical integration.

A reliable vertically integrated supplier consolidates engineering, toolmaking, molding, PCB assembly, and testing into a single streamlined point of contact and possesses these capabilities:

Automated pick and place lines and selective soldering for precise, repeatable assembly of complex multi-layer boards.

100% In-Circuit Test (ICT) of all boards to verify electrical integrity at the component level before integration.

In-process vibration and burn-in testing to screen out early-life failures.

In-house optical tuning and 100% NVG compliance inspection to verify the spectrum, radiance, and uniformity of display icons/symbols using calibrated spot photometers and spectral radiometers.

The Strategic Advantage of Vertical Integration
Vertical integration pays dividends at three phases of a program's life:

1. **Joint Urgent Operational Needs (JUONs):** In-house soft-tooling delivers physical prototypes for MIL-STD-810H testing before final hard-tooling is cut—compressing the timeline from requirement to fieldable hardware.

2. **Low-Rate Initial Production (LRIP):** By owning molding presses and assembly assets, a partner can provide low-volume runs to keep the assembly line moving while long-term production assets are finalized.

3. **Long-Term Support:** Defense platforms require a 30-year operational life. 20-year lifecycle commitments and engineering drop-in replacements protect programs when sub-components go End-of-Life (EOL).

IS YOUR HMI PARTNER PREPARED FOR FUTURE OBSOLESCENCE?

Defense platforms are unique in their requirement for a 30-year operational life, a timeframe that commercial component cycles struggle to support. An unplanned Last Time Buy can force a program to purchase many years of inventory at once, which ties up capital and creates its own storage and shelf-life challenges.

A "defense-first" mindset should manage this gap through four specific pillars:

1. **30-Year Design Thinking:** The best defense suppliers don't just react to obsolescence, they engineer against it. From material selection to interface architecture, every design decision is made with supply continuity in mind, anticipating component turns before they become program emergencies.

2. **The "Bridge" Strategy:** When a sub-component nears EOL, a proactive partner secures strategic reserves or identifies an alternative that maintains form, fit, and function.

3. **Engineered Equivalents:** In cases where a component becomes truly unavailable, the partner should possess the engineering depth to design a drop-in replacement that requires zero modification to the OEM's existing panel or software.

4. **Cybersecurity Compliance:** As defense programs increasingly extend cybersecurity requirements to hardware suppliers, a partner actively pursuing NIST SP 800-171 certification demonstrates the organizational discipline to protect Controlled Unclassified Information (CUI) across design files, manufacturing records, and program data.

WHY DEFENSE MANUFACTURERS CHOOSE GRAYHILL FOR CUSTOM HMI CONTROLS

The mandates and disciplines outlined in this guide aren't aspirational. They're the baseline Grayhill was built around.

When we say **Everything Clicks™**, it is more than a tagline. Every discipline of our organization is synchronized with the success of your program.

The Core Disciplines of the Grayhill Advantage:

U.S.-Based Vertical Integration:
We don't just assemble parts; we own the process. By controlling the machine shop, molding presses, and automated assembly lines in our domestic facilities, we eliminate the long lag of overseas logistics and provide a physical shield against adversarial supply chain content.

Engineering-Led Problem Solving:
We act as an extension of your design team. Our philosophy means we don't just say "yes" to change notices; we provide the technical impact analysis and value-added feedback necessary to navigate shifting program scopes without missing a milestone.

The "Pre-Qualified" Edge:
We eliminate the anxiety of the test lab by maintaining full in-house qualification capabilities. Our components are pre-vetted for MIL-STD-810H environments, such as high-G gunfire vibration and salt fog, ensuring that by the time they reach your system-level tests, the outcome is already a certainty.

Proactive Lifecycle Management:
We defeat obsolescence paralysis by designing with a 30-year mindset. We manage the genealogy of every part to ensure 2027 NDAA compliance and provide engineered "bridge" solutions that protect your cash flow from the disruption of Last Time Buys.

MOSA & Smart Node Expertise:
We are aligned with the U.S. Department of War's Modular Open Systems Approach, which is the framework driving the future of defense platform integration. Our deep expertise in Serial Peripheral Interface, Universal Serial Bus, Pulse Width Modulation, and Inter-Integrated Circuit protocols gives our team an advantage with communication architecture already matched to MOSA's open-interface requirements.

MISSION READINESS CHECKLIST: EVALUATING YOUR HMI PARTNER

Use this checklist during your next Critical Design Review (CDR) or vendor qualification phase to determine if your HMI supplier is a tactical liability or a mission partner. A qualified partner should be able to answer 'yes' to every item below and provide documentation to back it up.

I. Manufacturing & Compliance Readiness

☐ **2027 Roadmapped:** Can the supplier provide a written genealogy of components (semiconductors, resins, firmware) to ensure "No Adversarial Content" by the 2027 deadline?

☐ **Export Fluidity:** Does the supplier have a dedicated team for ITAR/Export licensing with a track record of quick approvals for allied countries?

☐ **Domestic Control:** Is the majority of the value-add (tooling, molding, firmware, assembly) performed in the USA to mitigate geopolitical supply shocks?

II. Engineering & Lifecycle Resilience

☐ **True Mil-SPEC vs. "Industrial Plus":** Can they provide raw test data for rapid decompression, salt fog, and high-G gunfire vibration (MIL-STD-810H)?

☐ **Obsolescence Mitigation:** Do they offer a proactive lifecycle strategy that avoids "Last Time Buy" budget spikes? Can they provide engineered equivalents if a commercial sub-component goes EOL?

☐ **Fielded Reliability:** Can the supplier cite performance data from millions of fielded units in similar combat environments?

III. Partnership & Program Velocity

☐ **Flexible and Analytical:** When you issue a change notice, does the supplier provide a detailed impact analysis (lead time, NRE, technical trade-offs) rather than a blind confirmation?

☐ **In-House Qualification:** Does the supplier own their test labs? Waiting on 3rd party lab schedules is a primary cause of program delays.

☐ **Shared Urgency:** Can you reach a decision-maker when a program milestone is at risk?

☐ **Turnkey Capability:** Can they deliver a fully integrated, tested, and firmware-loaded HMI node (e.g., CAN bus/MOSA compliant) to reduce your integration "Frankenstein" risk?

Grayhill is a U.S.-based manufacturer of human–machine interface solutions for defense, aerospace, industrial, and medical markets. Learn more at *grayhill.com*.