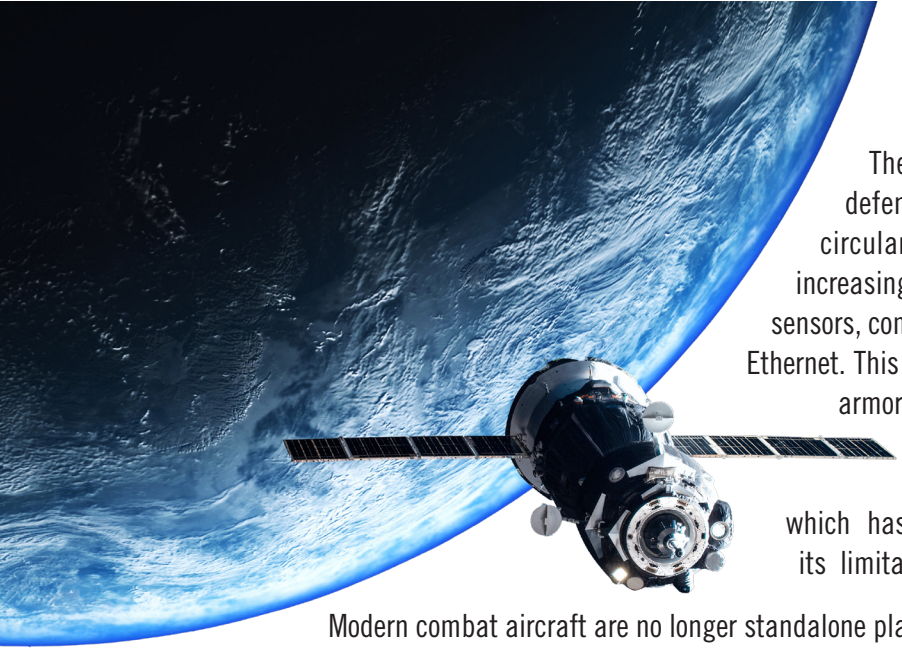
THE INTERCONNECTED BATTLEFIELD

OPTIMIZING SYSTEMS BEYOND STANDARD D38999

Modern defense platforms are no longer isolated systems. They are high-bandwidth nodes in a joint network spanning air, land, sea, space, and cyber domains - and the connectors holding it all together are being pushed to their limits.

PIC® WIRE & CABLE

JUNE 2026



The increasing prevalence of high-speed Ethernet in defense is pushing the boundaries of the tried & true circular D38999 connector. Military jets are becoming increasingly interconnected with edge computing devices, sensors, communication equipment and cameras via high-speed Ethernet. This is being replicated in other military assets, such as armored ground vehicles, artillery and command as we move closer to the envisioned "interconnected" battlefield. The industry standard D38999, which has been around for decades, is starting to show its limitations when it comes to high-speed data signals.

Modern combat aircraft are no longer standalone platforms; they're high-bandwidth network nodes inside a larger joint "system of systems" that span air, land, sea, space and cyber domains. This shift towards network-centric warfare, sensor fusion and manned/unmanned teaming is driving widespread adoption of 1Gbps and 10Gbps Ethernet and other high-speed interfaces inside not only aircraft and ground vehicles, but across the broader battlespace. This in turn exposes the limitations of traditional D38999 connectors and creates a need for optimized high-speed solutions.

NETWORK-CENTRIC WARFARE AND HIGH-SPEED DATA

Current generation fighters and ISR aircraft are designed to function as nodes in a distributed combat cloud, fusing onboard and offboard data to build and share a common operational picture. High-end platforms like the F35 exemplify this model: they combine AESA radar, EO/IR sensors, electronic warfare suites and multiple data links with external sources such as satellites, ISR aircraft and UAVs. They then perform intensive onboard processing to deliver integrated sensor fusion to the crew and to other nodes on the network.

Legacy aircraft are being upgraded along the same lines, with high-speed data backbones added to support new sensors and mission systems. The F16V, for example, incorporates a high-volume, high-speed data bus to handle the increased data rates of its AESA radar and modern COTS avionics architecture, demanding faster, more robust internal connectivity between processing elements such as displays and radios. Tactical transports such as the C130 and MC130 are being fitted with Airborne Mission Networking (AbMN) suites and Tactical Targeting Network Technology (TTNT), transforming them from simple lift platforms into fully networked nodes that move large volumes of mission data in real time. Across this fleet, the common denominator is an explosion in the number and speed of data links that need to be routed through harsh environment interconnects.

THE BATTLEFIELD'S CROSS-DOMAIN DEMAND

At the operational level, the U.S. Air Force's transition from platform-centric command and control to concepts like the Advanced Battle Management System (ABMS) depends on resilient, high-speed connectivity between distributed sensors, shooters and decision makers. ABMS is conceived as a networked "system of systems" that replaces single, monolithic platforms such as JSTARS (Joint Surveillance Target Attack Radar System) with a mesh of manned aircraft, UAVs, ground nodes and space-based assets, all sharing data over secure IP-based networks. In Intelligence, Surveillance and Reconnaissance (ISR), this has driven a shift away from platform-centric thinking towards architectures where data must flow freely between assets, not remain siloed on one aircraft.

Future programs can take this even further with Manned/Unmanned Teaming (MUMT), in which a crewed aircraft coordinates multiple autonomous or semiautonomous wingmen. MUMT requires low latency, high-bandwidth links to manage command and control, sensor and weapons-related data streams across the formation, increasing both the number of high-speed ports and the need for reliable, low skew, or vibration-stable connections in contested environments. Similar trends are visible on the ground with Army vehicle modernization efforts and alignment through Modular Open Systems Approach (MOSA) framework. An open standards approach provides agility and speed in upgrading aging or legacy platforms that need more 1Gbps and 10Gbps class connections, more disconnects, and more modularity all in rugged form factors.

WHERE CLASSIC D38999 CONNECTORS REACH THEIR LIMITS

JOSEPH ADAMSON
GLOBAL PRODUCT MANAGER

> **Our industry is seeing that as systems move toward dense 10Gbps Ethernet backbones, the standard D38999 configurations become increasingly challenged.**

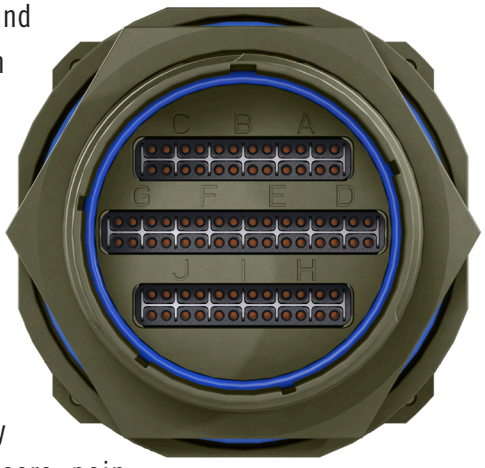
MIL-DTL-38999 circular connectors have long been the workhorse of aerospace and defense, proven in power distribution, low-speed signaling and early generation data links under vibration, temperature extremes, and exposure to fluids. As Ethernet penetrated avionics, integrators began using specialized contacts such as quadrax, twinax, and other differential pairs within D38999 shells to support 100Mbps and 1Gbps Ethernet, typically with acceptable performance over short distances and with a limited number of disconnects.

Industry testing has indicated that some D38999-based solutions, while able to pass basic Gigabit Ethernet requirements in simple, single connector channels, can struggle with 10GBASE-T performance due to insertion loss, return loss and crosstalk when link lengths or the number of connector pairs increase. In real systems, this can manifest as video or audio artifacts, reduced noise margins, bit errors and intermittent link drops, especially when multiple D38999 disconnects are chained between source and sink. For engineers trying to scale from a few 1Gbps links to multiple 10Gbps links in network-centric aviation and SOSA-aligned ground systems, these limitations drive difficult tradeoffs in channel length, connector count, routing and repairability.

Mechanically and logistically, D38999 remains deeply entrenched: it is standardized, widely qualified, and supported by extensive supply chains. This has led industry down two complementary paths: evolving D38999-style offerings to better support high-speed performance and introducing new connector systems that retain D38999-like form and ruggedness but are electrically optimized for multigigabit differential signaling.

MACHFORCE® D38999-STYLE SOLUTION

Here's where our MACHFORCE Connectors come in – they solve not only increased bandwidth requirements, but two other critical concerns of standard D38999 connectors: port density limitations and complex field repairability. MACHFORCE occupies the space between mechanical familiarity and electrical optimization: it is a D38999 Series III-style circular connector system specifically engineered to support up to ten 10Gbps Ethernet ports per connector using four-pair cable per port. Internally, MACHFORCE uses a high-speed module (HSM) design with linear pair arrangements that maintain pair geometry and controlled impedance. The HSM fins and troughs minimize near- and far-end crosstalk, enabling Cat6A-grade 10GBASE-T performance over longer link lengths and through multiple disconnects than traditional D38999 implementations.

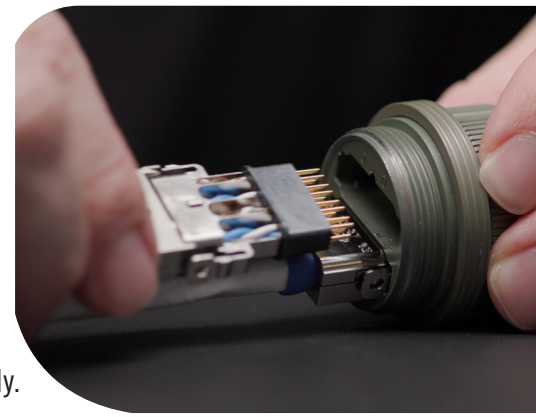


For platform designers facing ever-increasing interconnected realities of needing more sensors, more offboard links and more bandwidth-hungry applications on each aircraft or vehicle, MACHFORCE addresses three core pain points: bandwidth, port density, and maintainability. Each size 25 MACHFORCE connector can accommodate up to ten 10Gbps ports, dramatically increasing data density in a single circular interface, allowing engineers to reduce the number of bulkhead penetrations, umbilicals, and panel cutouts needed for mission networks. This is particularly valuable in crowded avionics bays, turret-to-hull interfaces on armored vehicles and antenna-to-hull runs where space and weight are at a premium.

The MACHFORCE Connector system offers familiar shell-type plug, jam nut and flange receptacles, and cable to PCB adapters in key sizes 17 and 25, with aluminum bodies and stainless-steel accessory rings to meet ruggedness and environmental requirements. Plating options include standard olive drab cadmium and new RoHS-compliant electroless nickel and black zinc nickel, meeting existing aerospace and defense standards for corrosion resistance, EMI performance and wear. This alignment makes MACHFORCE easier to qualify and integrate into existing platform standards that use D38999-style hardware.

FIELD REPAIRABILITY

One of the operational realities highlighted by network-centric upgrades is that connectors and harnesses will see more mate/unmate cycles, and more reconfiguration and field exposure as systems evolve over a platform's lifetime. In traditional high-speed multi-pair connectors, damage to a single contact can drive replacement of an entire connector or harness, often requiring depot level rework and lengthy downtime. MACHFORCE's specially designed HSM architecture addresses this by providing straightforward access to each terminated pair, allowing maintainers to troubleshoot and replace individual 22D pins and sockets with standard crimp tools instead of rebuilding the entire assembly.



PIC emphasizes that this contact-level serviceability is key for mission critical platforms "where downtime isn't an option," because it enables rapid turnarounds in field environments rather than waiting for depot repairs. In a notional ISR aircraft upgrade where multiple gimballed EO/IR sensors, high resolution mission displays and backbone links must be routed through

limited bulkhead real estate, legacy D38999-based quadrax solutions may hit channel length and crosstalk limits as data rates climb. Replacing those interfaces with MACHFORCE connectors and qualified Cat6A cable allows integrators to consolidate multiple 10Gbps video and data channels through fewer feedthroughs while maintaining field repairability at the pin level.

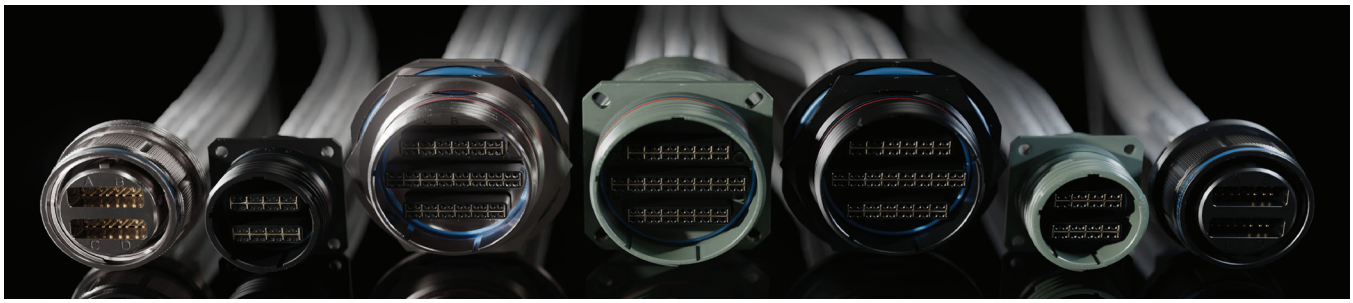
On ground vehicles modernized under SOSA-aligned open architecture principles, MACHFORCE connectors can be used in turret slip rings, hull penetrations and external payload interfaces where designers need to aggregate cameras, fire control data, situational awareness feeds and network backbones into compact, rugged interfaces that can be quickly reworked or expanded as payload suites evolve. The same characteristics of port density, high-speed performance and maintainability fit well with the frequent technology insertions and reconfigurations that SOSA-aligned architectures are designed to support.

BEYOND ETHERNET: FUTURE-FORWARD PROTOCOLS

Although MACHFORCE's headline capability is 10Gbps Ethernet, its controlled impedance and low crosstalk architecture makes it suitable for other high-speed differential protocols that are increasingly common in aerospace and defense applications. Market trends reflect high resolution displays, advanced pilot vehicle interfaces and complex sensor payloads, pointing to an increased use of interfaces like DisplayPort and USB in cockpit and mission systems.

The demand for combinations of 10Gbps Ethernet, high-speed USB and video standards, illustrate the feasibility of mixed protocol payloads in rugged circular connectors. Within that ecosystem, MACHFORCE can be positioned as a forward-looking interconnect solution. Today it delivers Cat6A class 10GBASE-T performance for mission and backbone networks and tomorrow it can be leveraged for DisplayPort class video or high-speed USB links as program requirements develop*.

"For engineers tasked with future-proofing architectures in line with JADC2, ABMS, NGAD and SOSA-aligned open systems standards," Adamson adds, "the combination of D38999-style mechanics, high port density and high-speed performance offers a practical way to keep the interconnect layer from becoming the bottleneck in an increasingly interconnected battlefield."



TO LEARN MORE ABOUT THE MACHFORCE SOLUTION, VISIT PICWIRE.COM/MACHFORCE

** Supported protocols and product capabilities are subject to change; contact your PIC representative for current availability.*

PIC WIRE & CABLE
W220 N1051 Springdale Rd.
Waukesha, WI 53186
Tel: (262) 246-0500
www.PICWire.com
sales@theangeluscorp.com

ABOUT PIC WIRE & CABLE

PIC Wire & Cable is your premier aerospace and defense connectivity expert, delivering comprehensive, innovative interconnect solutions engineered to enhance the performance of mission-critical avionics systems. For over 50 years, we've worked side-by-side with clients to solve challenging problems and integrate those engineered solutions into aircraft worldwide. This is what we do—we're here to make our customers' jobs easier. We are committed to providing high-quality service, premium products and superior solutions to the aerospace and defense industries. Make PIC your go-to for aerospace cabling solutions and you'll see why we've been trusted with some of the toughest jobs in the industry

PIC® WIRE & CABLE