VNX+ Enables Small-Form-Factor Embedded Designs

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Abstract

This white paper explains the basics of the VNX+ family of standards, how they can be used, how VNX+ fits into the greater SOSA, MOSA, and VITA arenas, and the interconnect systems that enable them.

Integration leads to Innovation

Samtec is structured like no other company in the interconnect industry: we work in a fully integrated capacity that enables true collaboration. The result is innovative solutions and effective strategies supporting optimization of the entire signal channel.

For more information contact SIG@samtec.com

Introduction

VNX+ is a rugged, small-form-factor modular embedded computing standard that formalizes abstraction layers for control, data, expansion, and peripheral planes. Developed within the VITA 90 Technical Working Groups and ratified by ANSI in 2026, VNX+ (ANSI/VITA 90) builds on the ANSI/VITA 74 VNX standard to extend standards-based modular computing into new classes of space, weight, and power (SWaP)-constrained, mission-critical environments [1].

VNX+ advances the architecture with well-defined module profiles, significantly higher data throughput bandwidth, and improved power-dissipation capability. The hardware defined in the VNX+ family of standards enables smaller platforms than previous standard architectures (see Figure 1) such as OpenVPX or AMC (including MicroTCA and ATCA). It incorporates the highest-density rugged coaxial, optical, and high-speed copper interconnect technologies available.

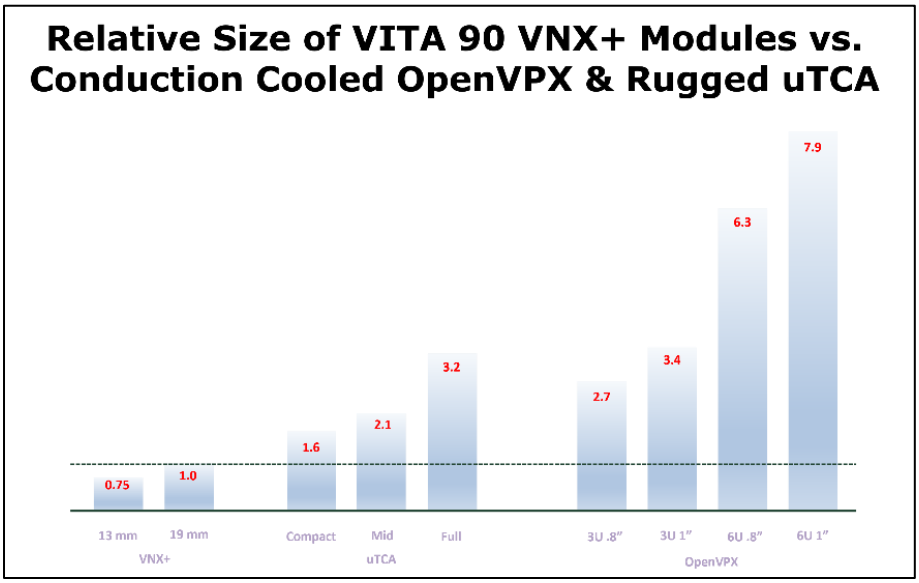


Figure 1: VNX+ embedded system modules offer significant size advantages compared to other rugged standards-based ones.

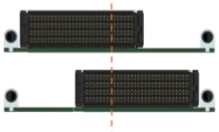
Samtec interconnect and alignment hardware was selected as the baseline connectivity solution for ANSI/VITA 90 VNX+ systems, supporting both plug-in module (PIM) and backplane (BP) implementations. This white paper provides an overview of the VNX+ family of standards, describes how the architecture can be applied in modern rugged embedded systems, and explains how VNX+ aligns with broader U.S. Department of Defense Modular Open Systems Approach (MOSA) initiatives [2], including SOSA® [3] and related open-architecture ecosystems. It also outlines the Samtec interconnect technologies which enable practical, standards-compliant VNX+ system deployment.

Why VNX+?

VNX+ addresses embedded computing applications where existing standards-based systems are too large or heavy, yet OpenVPX-class performance, modularity, and MOSA alignment remain essential. Target use cases include terrestrial platforms such as unmanned aerial vehicles (UAVs); unmanned underwater vehicles (UUVs); missiles; common launch tube surveillance pods; ground and naval vehicle electronics; man-wearable command, control, communications, computers, cyber, intelligence, surveillance, and reconnaissance (C5ISR) systems; as well as space-based small satellites and CubeSats. In these environments, weight directly affects range and speed, while physical volume is often the primary constraint preventing effective system integration.

During development of the VITA 90 VNX+ family of standards (Table 1), the technical working group established several core objectives: reduced SWaP, fully conduction-cooled operation, support for high-speed serial fabrics, accommodation of high-density coaxial and optical I/O, and alignment with MOSA design principles. With ANSI ratification of the published VITA 90 standards, these objectives have been fully realized. The VNX+ specifications define COTS components and hardware that give system designers the flexibility to modernize or upgrade their platforms rapidly and cost-effectively. This enables responsive adaptation to evolving mission requirements or emerging threats while maintaining interoperability and compliance within the constraints of the standard.

Table 1: Overview of VNX+ Family of Standards

STANDARD	TITLE	REFERENCE
VITA 90.0	VNX+ Base Standard: • SEARAY™ & Guidance System • 56 Gbps PAM4 & FMLB	
VITA 90.1	VNX+ Profile Tables: • Application signaling, slot profiles • Instructs users on creating unique slot names to ensure PIM & Backplane compatibility	Ethernet, PCIe®, SATA, USB, HDMI, General Purpose Serial Ports or Electrical, Signal over Coax, CVBS, STANAG 3350, SDI, CoaXPress, ADVB, DisplayPort, CANbus, GPIO, etc.
VITA 90.2	VNX+ Optical & Coaxial Connector Modules: • Coaxial Contacts (DC to 110 GHz), MT Ferrule Slot • Adjacent to SEARAY™	
VITA 90.3	VNX+ Power Subsystem Modules: • SEARAY™ placement, pin spacing	
VITA 90.4	VNX+ Cooling & Mounting Systems	Alternate retention and thermal management system features in VNX+ systems.
VITA 90.5	SpaceVNX+: Optimizing VNX+ for Space	Draft beginning Jan. 2026

Vita 90.0 Base Standard

The VITA 90.0 base standard defines a PIM measuring 89 mm X 78 mm, available in 13 mm and 19 mm single-height versions and 27 mm and 39 mm double-height variants (Figures 2 and 3). The VITA 90.0 base standard advances the original VNX mechanical architecture by:

- Incorporating precision alignment features
- Offering multiple module-mounting options that support integrated and federated system architectures
- Defining retention schemes that balance module replaceability with volumetric efficiency
- Enabling modern thermal-management approaches that support higher power density
- Integrating enhanced connectivity provisions that deliver world-class power-delivery and signal-integrity performance across high-speed copper, coaxial, and optical interfaces

Because VNX+ systems are deployed in environments where blind-mate insertion, field maintenance, and rapid module replacement are routine, the standard incorporates multiple layers of polarization and alignment features to prevent both immediate and latent damage to the BP or PIM.

To meet these requirements, Samtec provides alignment and protection features at every electromechanical interface, including the SureWare™ primary alignment feature (PAF) that incorporates a grounding contact to provide first-mate/last-break (FMLB) functionality. Establishing a chassis ground connection before, during, and after signal engagement, FMLB enhances operator safety and reduces system electrostatic discharge (ESD) susceptibility. (Additional module-retention, mounting, and thermal-management features are defined in VITA 90.4.)

The primary interconnect used across all VNX+ modules is a VITA 90-variant of the Samtec SEARAY™ high-density open-pin-field array. Proven in VITA-aligned architectures, including VITA 57.1 FMC, VITA 57.4 FMC+, VITA 74 VNX, VITA 88 XMC+, and VITA 90.3 power-system modules (Figures 2 and 3), SEARAY is a rugged, scalable connector family supporting 56-Gbps PAM4 signaling. Its high-reliability contact system and open-pin-field architecture enable routing flexibility, signal integrity, and high-reliability to support the unique signal and power definitions of VNX+ module profiles.

SEARAY connectors are available in multiple standard column counts to accommodate both the 4-row and 8-row configurations associated with the 13/27 mm and 19/39 mm module heights. For example, the 50-column version is used in standard VNX+ modules without coaxial or optical I/O requirements, while the 40-column and 30-column variants support the half- and full- connector module (CM) configurations, respectively.

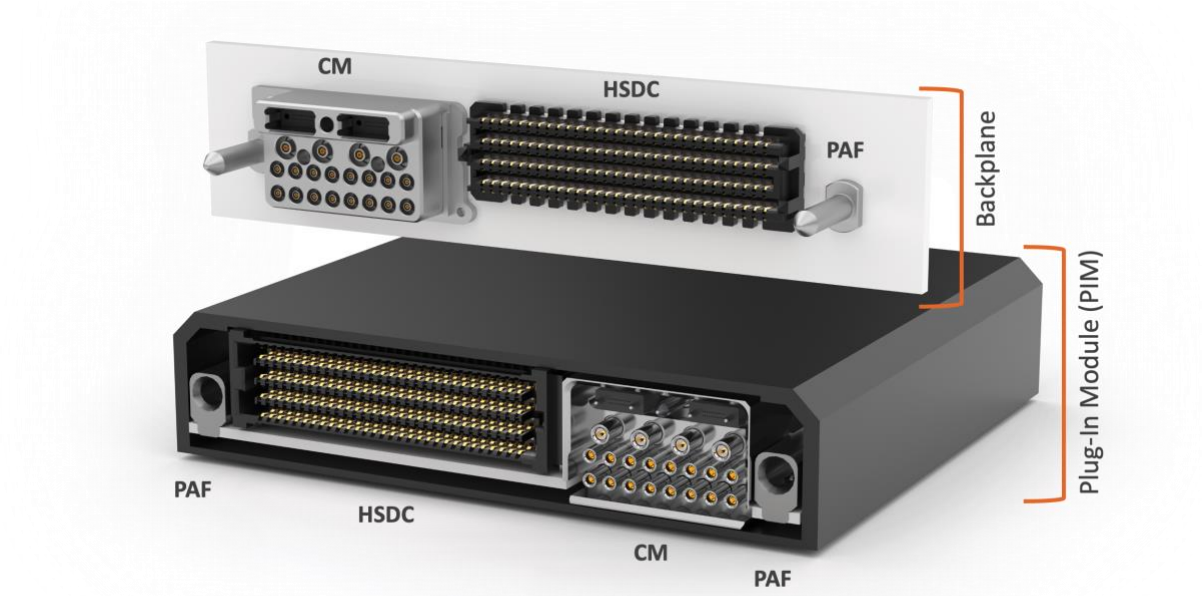


Figure 2: VNX+ Interconnects and Alignment Features: Connector Module (CM); High-Speed Digital Connector (HSDC); Precision Alignment Feature (PAF)

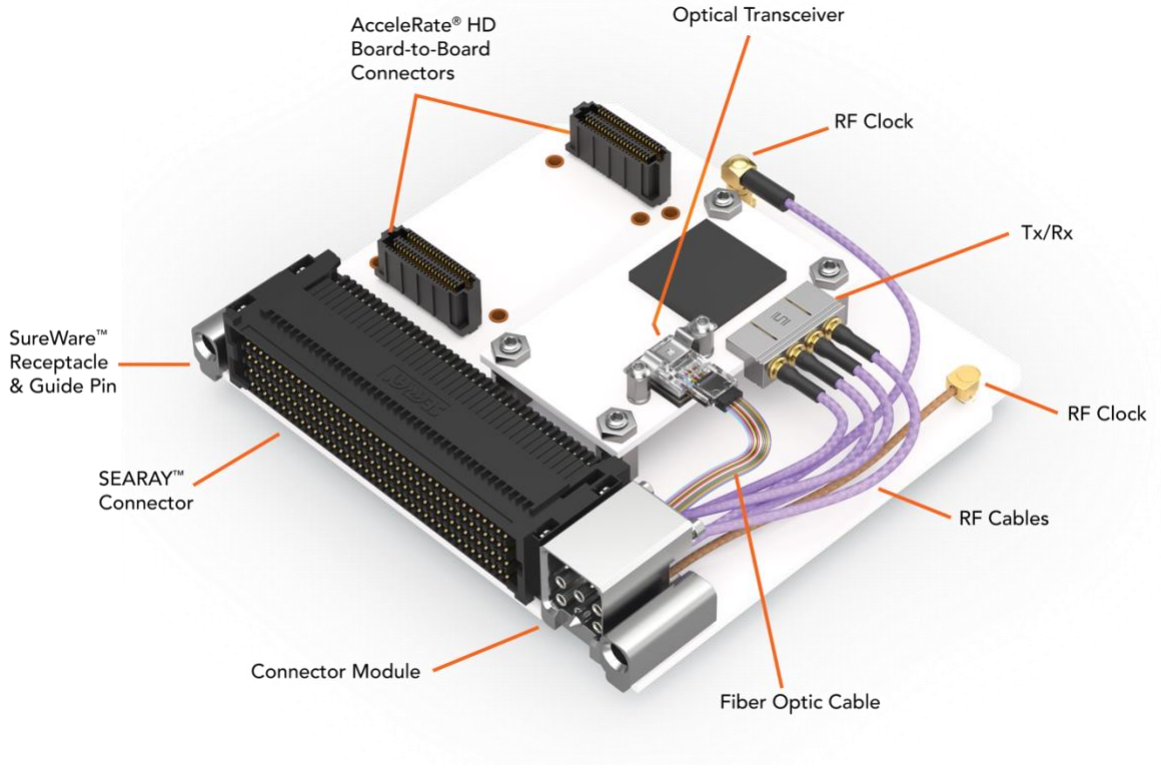


Figure 3: VNX+ mechanical envelope showing connector module and optional VITA 93 QMC Standard AcceleRate®HD board-to-board connectors.

VITA 90.2 Connector Modules

Standard coaxial and optical contacts housed in a VITA 90.2 connector module (CM) extend VNX+ beyond single-ended or differential electrical signaling. This new standard supports coaxial signaling for radio frequency (RF) signals, high-speed/high-definition video paths, and optical data links containing high-bandwidth digital I/O.

The half- or full-CM configurations defined in VITA 90.2 are used to accommodate Samtec GPCC-20 or GPCC-16 coaxial contacts and/or MT-style optical ferrules. The coaxial contacts are available in both 50 Ω and 75 Ω variants, with characteristic impedance (Z_0) optimized for RF feedlines and video-signal transport, respectively. The optical interfaces use standard 12-fiber or 24-fiber MT-style ferrules, consistent with those employed in Samtec's FireFly™ and FireHawk® electro-optical encoder/decoder modules.

All of these connections are made within the VNX+ footprint (see Figure 3), eliminating the need for external transition modules, proprietary mezzanines, or external power circuitry. The CM enables short, controlled signal paths from inside the system or the outside world, suitable for harsh military or rugged environments.

Specifying a VITA 90.2 Connector Module

Samtec offers a pre-defined set of CM options allowing a mixture of RF, video, and/or optical contacts as required to meet requirements (see Table 2). If there is not a pre-defined CM available to meet your needs, contact Samtec about your configuration (VNX@samtec.com). Below is some advice for specifying a VITA 90.2 CM.

Select the VITA 90.2 CM that best meets the PIM's connectivity requirements. Options include full- or half-sized CMs for PIM and BP applications. Backplane CMs float in BP apertures, while PIM CMs use precision machined fasteners and mounting holes. All VITA 90.2 CM types are compatible with VITA 47, DO-160, and MIL-STD-810 standards, and sustain 500 mating cycles with repeatable performance.

Consider coaxial cable and contact sizes. Contact choices determine if the CM will be coaxial-only, optical-only, or a hybrid configuration within the selected CM mechanical envelope. For coaxial contacts and cable, this will either be 110 GHz high-density 50 Ω size 20 contacts or 75 Ω size 16 contacts. Contact Samtec for coaxial cable assemblies terminated to satisfy specific system requirements.

Determine the need for optical connectivity. For VITA 90.2 rugged optical connections, CMs can include up to two MT-style optical ferrule sites, which are shrouded for protection against foreign object debris (FOD) and handling damage. The standard defines the interface requirements for optical connections without mandating specific interconnect products. Options include the Samtec FireFly mid-board transceivers which support up to 28 Gbps per lane in x4 and x12 configurations, or the Samtec FireHawk

ruggedized mid-board optical transceivers which support 10 Gbps per lane in a x4 configuration [4].

Note that CMs, contacts, full cable assemblies with pre-terminated contacts, and optical connectors for both the PIM and backplane must be purchased separately. For reference, visuals of fully populated VNX+ CM mating solutions are in Table 2, with mated sets identified by “Type.” For example, “Type A” PIM Connector and “Type A” Mating Backplane Connector are mated sets. Part numbers listed in the “Type A” column identify required components for final assembly.

Table 2: Options in Connector Modules for VNX+

Part Numbers	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Plug-In Module Connector							
Block	RSP-239120-01	ASP-223034-01	RSP-224882-01	RSP-233089-01	RSP-233410-01	RSP-233193-01	RSP-244881-01
Mating Backplane Connector							
Block	RSP-222466-01	ASP-223035-01	RSP-224881-01	RSP-233088-01	RSP-233409-01	RSP-233192-01	RSP-244880-01
Contacts	(4) GPCC-16, (16) GPCC-20	N/A	(6) GPCC-20	(8) GPCC-16	(6) GPCC-16	(10) GPCC-20	(24) GPCC-20
Optics Slot	(2) MT Ferrules**	(2) MT Ferrules**	(1) MT Ferrule**	N/A	(1) MT Ferrule**	N/A	N/A

*Fully Assembled Blocks Shown. Mated Sets indicated by "Type" grouping.
**Pluggable with Samtec's FireFly™ or FireHawk™ assemblies using an MT ferrule on End 2

VITA 90.3 Power Supply Modules

240-pin and 320-pin SEARAY connectors are part of the VITA 90.3 power supply module, with the connector’s physical placement on the PCB serving as a hardware key. This positional keying prescribes allowable power or I/O configurations and enables automatic system-level configuration and protection.

VITA 90.3 defines the following standardized power supply subsystem modules:

- Power Supply Unit (PSU)
  - Converts vehicle power to the voltages required to power VNX+ PIMs. Produces multiple output voltages from a single input voltage and provides system management interfaces as well as a host of optional serial and discrete buses for control and monitoring
- Power Conversion Unit (PCU)
  - Converts high voltage AC or DC voltages to lower voltages that are more easily managed by a PSU in a VNX+ system
- Power Filter Unit (PFU)
  - Provides EMI Filtering in accordance with MIL-STD-461 or other similarly appropriate standard
- Energy Storage Unit (ESU)
  - Accumulates energy from the platform during normal operations and provides that energy to the VNX+ system during short-duration abnormal power interruptions

The modules defined in VITA 90.3 use the same SEARAY connector specified in all VITA 90 standards. Of specific interest to VITA 90.3, the SEARAY connector contacts have been tested, derated, and qualified for typical large pin adjacencies found in power delivery applications. For example, individual contacts that have been qualified to more than 2 amps/pin were derated to 1 amp/pin for differential and single-ended signaling. That same pin would be further derated to 0.6 amps/pin if used with large groups of power pins, such as in a power bus with local heating caused by high-current loads. These derations give high confidence that the connectors will overperform not only for payload and compute modules but also for power system modules over the entire -40 °C to +85 °C temperature range.

VITA 90.4 Cooling, Mounting, & Retention

VITA 90.4 defines system-level approaches and module-specific adaptations for module and system cooling, module bulkhead mounting, module retention using wedge-locks, and other electromechanical adaptations such as module-by-module keying.

Specific mechanical strategies discussed in VITA 90.4 complement the alignment and guide features defined in VITA 90.0. The most common feature adaptations described in VITA 90.4 are the mechanical definitions of the wedge-lock retention mechanisms used to facilitate frequent module insertion and removal, as well as to provide enhanced thermal transfer in certain circumstances. The second most common feature adaptations described in VITA 90.4 are the mechanical adaptations for bulkhead-mounting of individual VNX+ modules for use in small volume platforms or when only one or two modules are necessary to build a system. These definitions can be used for cabled backplanes or federated system architectures.

VITA 90.5 SpaceVNX+

Unlike the rest of the VITA 90 family of standards, VITA 90.5 is still under development at the time of publication. Its aim is to adapt the VNX+ architecture for space and radiation-tolerant environments. SpaceVNX+ builds on the same SEARAY, RF, and optical connector architectures defined across the VITA 90 family, supporting radiation-hardened, space-appropriate interconnect strategies within the VNX+ ecosystem. It is anticipated that VITA 90.5 will include two main strategies:

1) Adaptations to the current terrestrial VNX+ standards to make VNX+ useful for LEO, low-cost, or short-lifetime space applications

2) Adaptations of the current VNX+ mechanical and electrical architecture to build-in redundancy, enhance system resiliency, facilitate cooling and thermal transfer from only one side of the system, allow connector interfaces from multiple surfaces, and generally make mechanical allowances to use the larger components often required for rad-tolerant space applications

Relationship to SOSA and OpenVNX

The Open Group SOSA Consortium is a US government and industry collaboration focused on sensor systems and C5ISR payloads. SOSA has adopted some VITA standards, including VNX+, which is referenced by the SOSA Consortium as the small-form-factor option for SWaP-constrained sensor processing in the SOSA Technical Standard (Edition 2.x).

VNX+ uses similar data, control, and expansion plane concepts to OpenVPX, and Samtec interconnect technologies provide a common physical foundation across OpenVPX, VNX+, and SOSA-aligned designs, supporting interoperability and design reuse [5].

Implementing VNX+ Using QMC

One way to implement VNX+ quickly and add board-to-board connections is to use the quarter-size mezzanine card (QMC™) established in VITA 93. This card is equipped with Samtec AcceleRate® HD slim array connectors [6] and supports 32 Gbps NRZ or 64 Gbps PAM4 performance. QMC was designed to fit within the low-profile space constraints of VNX+ small-form-factor solutions (Figure 4).

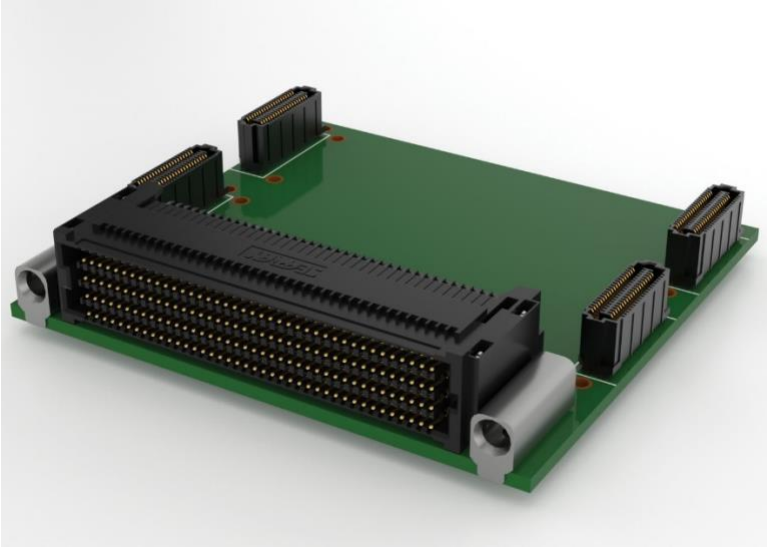


Figure 4: VNX+ QMC Carrier Card featuring the SEARAY connector and AcceleRate HD connectors.

VNX+ Applications

In summary, VITA 90 VNX+ adheres to a modular open-system design approach that provides system architects with a high-performance embedded computing platform specifically designed for space-constrained, harsh environments (Figure 5).

Figure 5: Trident infosol small-form-factor computers using VNX+ to meet the demands of harsh environments [7] (image courtesy Trident infosol).

Typical applications include UAVs, UUVs, missiles, satellites, CubeSats, and other systems in industrial, military, and aerospace environments. The modular nature of VNX+ provides flexibility to quickly upgrade or modernize hardware to satisfy evolving needs. And, the commonality of VITA 90 VNX+ designs encourages interoperability, replaceability, and design reuse [8].

More Information

[1] VITA - VPX
[2] MOSA
[3] Sensor Open Systems Architecture™ / SOSA® Consortium
[4] Samtec Optics Product Information
[5] Samtec SOSA products
[6] QMC
[7] Trident infosol Small Form Factor Computers
[8] Samtec VITA 90 VNX+ Standard Products and Support