WOLF Advanced Technology

SMALLER, SMARTER, SHARPER, STRONGER: VNX+ FOR MODERN EMBEDDED SYSTEMS

– WHITEPAPER

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WOLF ADVANCED TECHNOLOGY

INTRODUCTION

In defense and aerospace computing, one constant remains: everything is getting smaller, lighter, and expected to do more with less. The holy trinity of SWaP — size, weight, and power — has become the gatekeeper of what flies, rolls, or orbits. Every extra gram, every cubic centimeter, and every watt matters.

For years, VPX boards have been the backbone of modular open systems. The 3U and 6U VPX modules have shouldered the load for high-performance embedded computing, while mezzanine cards have provided flexible, feature-level upgrades. But as platforms shrink and mission profiles demand greater agility, even the smallest VPX cards can feel like bringing a sledgehammer to tighten a watch.

Enter VNX+ — the VITA 90 standard. Think of it not as a challenger to VPX, but as its nimble younger sibling. One-third the size of a 3U VPX, VNX+ extends modular open standards into domains where VPX simply can't fit: small UAVs, satellites, smart munitions, and handheld systems. It is rugged, open, and built for the edge cases where "just a little smaller" can make or break the mission.

This whitepaper explores how VNX+ reshapes the conversation. It'll examine the SWaP constraints pushing system engineers to rethink integration, compare VNX+ directly with VPX and other form factors, and show how WOLF Advanced Technology is leading the charge to bring this small form factor from concept to deployed capability. Most importantly, this whitepaper will illustrate why VNX+ isn't just another standard — it's the missing puzzle piece in the modular ecosystem that makes tomorrow's missions possible.

THE SWAP-C CHALLENGE IN EMBEDDED SYSTEMS

In defense and aerospace, SWaP-C — size, weight, power, and cost — is not merely an engineering metric; it is the terrain itself. Every watt consumed, every gram carried, and every cubic millimeter occupied ripples outward, affecting range, endurance, and mission success. VPX-based modules have long been the champions of high-performance embedded computing, but the highest power isn't always the best answer for every application.

For small platforms, size and weight are immediate hurdles. A 3U VPX chassis can easily overwhelm the internal volume of a Group 1 UAV or occupy precious real estate inside a missile body — space that could otherwise be devoted to sensors, fuel, or payload. Weight compounds the issue, directly affecting speed, range, and maneuverability.

Power consumption further complicates matters. High-end VPX modules can handle tasks as demanding as AI training or multi-sensor data fusion at the edge, but the hundreds of watts they consume are not always necessary for more focused applications. Moreover, the thermal load these systems generate often exceeds what compact, passively cooled enclosures can dissipate. When platforms are forced to carry oversized boards and chassis, the financial cost extends beyond initial procurement — it affects sustainment and lifecycle expenses, especially when much of the available performance goes unused.

THE EXISTING STANDARDS LANDSCAPE

For years, the embedded defense computing ecosystem has revolved around a series of open-standard building blocks, each optimized for specific roles. The 6U VPX form factor has set the pace for raw compute density, serving as the backbone for electronic warfare, RADAR processing, and server-class applications that demand extreme performance and scalability. The smaller 3U VPX strikes a balance between performance and footprint, becoming a staple for C4 and C5 ISR processing nodes and mission computers used across airborne platforms, ground vehicles, and tactical edge servers. XMC mezzanine cards have added modularity by enabling FPGA acceleration, specialty I/O, and storage expansion.

This family of standards has enabled modularity and interoperability across a wide range of systems, but none have been tailored to meet the extreme constraints of the smallest platforms. VNX+ emerges as the missing piece in this lineage — a rugged, defense-ready standard purpose-built for scenarios where neither 3U nor 6U VPX can fit.

THE VNX+ FORM FACTOR

The draft VITA 90 standard introduces VNX+, a form factor designed to extend modular open standards downward in size and weight. At roughly one-third the size of a 3U VPX card, VNX+ is suited for platforms where traditional VPX modules and chassis simply cannot fit: small UAVs, handheld devices, satellites, and smart munitions. Unlike commercial GPU modules such as MXM, VNX+ was conceived with ruggedization in mind. It is engineered to withstand vibration, shock, EMI, and thermal extremes typical of defense environments.

The strength of VNX+ lies in how it delivers many of the same modularity and interoperability benefits as VPX, while reimagining them to thrive in environments where compactness and efficiency are paramount. It does not compete with VPX — it complements it — filling the crucial gap that allows modular open standards to flourish where VPX exceeds physical or thermal limits.

The promise of the VNX+ standard becomes tangible only through implementation. In this respect, WOLF Advanced Technology has emerged as both an innovator and a proving ground. With its N4XP and N180 modules, WOLF has transformed the theoretical benefits of VNX+ into field-ready, ruggedized computing solutions that embody the principles of SWaP-C optimization, modularity, and reliability.

N4XP

The WOLF N4XP (VNXP-ORIN-NX) represents a deliberate convergence of intelligence, performance, and security in a compact computing node. Designed as an autonomous, trusted edge processor, it brings advanced AI and high-performance computing (HPC) to environments where every gram and watt matter.

At its foundation lies the NVIDIA® Jetson Orin™ NX 16 GB system-on-module, integrating an embedded Ampere GPU with 1,024 CUDA® cores and 32 Tensor Cores, coupled with an eight-core NVIDIA Cortex® ARM64 CPU operating at 2 GHz. Together, these architectures deliver up to 100 TOPS (INT8, Sparse) of inference performance — computational density once reserved for far larger VPX-class systems.

The N4XP incorporates 1 TB of NVMe storage, PCIe Gen4, 1000BASE-T Ethernet, USB 3.2/2.0, and MIPI CSI-2 camera interfaces with D-PHY 2.1 signaling (10 Gbps bandwidth). A dedicated Platform Security Controller (PSC) and Security Engine (SE) form a resilient cybersecurity foundation, while the integrated IPMI controller enables complete system observability and management. WOLF's Board Support Package (BSP), built on Jetson Linux and JetPack SDK, provides a stable software environment for rapid deployment and long-term maintainability.

For visual intelligence workloads, the module combines dual HEVC/AVC NVENC and NVDEC engines supporting 4K-UHD encode, a Programmable Vision Accelerator v2 (PVA) with dual Vector Processing Units, two Deep Learning Accelerator v2 engines, and a dedicated programmable audio processor — forming a balanced architecture for perception, decision, and response at the edge.

Mechanically, the N4XP is engineered for endurance. Within the ANSI/VITA 90 VNX+ form factor, it measures 101.6 × 78.1 × 19 mm (with PIM retainers), weighs 220 g, and sustains operation from –25 °C to +85 °C under 12 grms random vibration, 10 g sine vibration, and 40 G shock. Configurable between 20 W and 35 W, it provides a quiet assurance of performance within

N180

The WOLF N180 (VNXP-FGX2-VIO) exemplifies precision engineering in high-density video capture and transmission. Built around WOLF's second-generation Frame Grabber eXtreme 2 (FGX2) technology, it provides a reliable foundation for mission systems where clarity, speed, and resilience are non-negotiable.

At its core, the Xilinx® Kintex® UltraScale+™ FPGA enables 4K-capable digital frame grabbing, format conversion, and transmission. Supporting up to two 12G-SDI or four 6G/3G/HD-SDI SerDes inputs and outputs, the N180 delivers deterministic, low-latency video performance essential for real-time decision-making.

Designed for machine vision, synthetic vision, and advanced video-processing environments, the module operates efficiently within a 12 W – 25 W power range, ensuring exceptional performance per watt. A PCIe Gen3 ×4 interface provides high-speed data transfer, while an optional 8 GB DDR4 RAM buffer supports demanding processing tasks and extended application workloads.

When integrated with a WOLF GPU module or SBC, the N180 enables direct peer-to-peer communication—bypassing the CPU to achieve near-instantaneous processing and encoding. This architecture minimizes latency and maximizes throughput, aligning perfectly with applications where every microsecond matters.

Engineered for endurance, the N180 is rugged conduction-cooled, qualified for –40 °C to +85 °C operation, and proven against 10 G vibration and 40 G shock. It adheres to the ANSI/VITA 90 VNX+ mechanical standard, with dimensions of 101.6 mm × 78.1 mm × 19 mm (with PIM retainers) or 89 mm × 78.1 mm × 19 mm (without), and weighs approximately 280 g.

With its modular interfaces, MCOTS configuration options, and long product lifespan, the N180 embodies the principles of technical wisdom and adaptability—a solution built not just to perform, but to endure and evolve with mission demands.

SYNERGY IN THE MODULAR ECOSYSTEM

Together, the N4XP and N180 embody WOLF's philosophy of distributed intelligence — pairing edge AI inference with high-fidelity data acquisition in a unified, rugged computing framework. Whether deployed within a single VNX+ chassis or distributed across a networked system, these modules enable efficient division of labor between data capture, pre-processing, inference, and system communication.

This synergy underscores WOLF's role not merely as a hardware supplier, but as a systems enabler — proving that the VNX+ form factor can deliver fully functional, secure, and high-performance computing at the extreme edge. By engineering solutions that are functionally rich, thermally stable, and physically resilient, WOLF Advanced Technology continues to define the operational frontier of compact, high-reliability embedded computing.

Image I. WOLF's N180 VNX+

Image II. WOLF's N4XP VNX+

COMPARING VPX AND VNX+

Attribute	6U VPX	3U VPX	VNX+
Dimensions	~ 233 × 160 mm	~ 100 × 160 mm	~ 101 × 78 mm
Weight	High	Medium	Low
Typical Power Draw	50-250 W+	30-120 W+	5-35 W
Processing Density	Very high	High	Medium-high
Ruggedization	MIL-grade	MIL-grade	MIL-grade
Target Use Cases	Servers, ISR	Edge compute	UAVs, handheld, smart munitions

For two decades, VPX has been the backbone of modular open systems, offering unmatched compute density and a flexible ecosystem of interoperable modules. The 6U variant has long been the powerhouse, enabling server-class performance for ISR processing nodes, mission computers, and central command applications. The smaller 3U VPX struck an elegant balance between size and processing capability, making it the workhorse for ground vehicles, airborne systems, and tactical edge servers. Both form factors align strongly with MOSA principles — and both remain indispensable.

Yet as designers push into ever-smaller platforms, they need equally compact compute solutions. The physical dimensions and weight of 3U VPX systems, while modest by traditional standards, still consume critical volume in a small UAV fuselage or impose payload penalties on a missile body. Their thermal and electrical demands, though manageable in larger enclosures, can easily overwhelm the limited cooling and power budgets of ultra-constrained environments.

This is where VNX+ changes the conversation. At roughly one-third the size of a 3U VPX card, it establishes a new tier in the modular open standards hierarchy. Operating in the 5–35 watt power envelope, VNX+ modules consume a fraction of the energy required by even modest VPX boards — and their reduced footprint allows them to occupy spaces no VPX card could fit. Despite this shrinkage, VNX+ retains defense-grade ruggedization and interoperability, ensuring compatibility with demanding environments.

The contrast isn't a matter of better versus worse — it's about scale and fit. VPX excels when maximum performance and flexibility are essential; VNX+ thrives when space, weight, and power are the limiting factors. Together, they form a continuum of modularity. A large airborne platform might employ 6U VPX for centralized sensor fusion or 3U VPX for edge servers, while smaller Group 2 and 3 drones could use VNX+ modules embedded at the sensor level for pre-processing or AI inferencing. In this way, VNX+ doesn't replace VPX — it extends its reach, ensuring that modular open standards apply across every echelon of the battlespace.

ALL THINGS CHASSIS

VNX+ is not just about the module itself — it's also about how that module is deployed. At WOLF, we have taken a deliberate approach to chassis design, ensuring that VNX+ can be integrated seamlessly into platforms of all shapes and sizes. Unlike most small-form-factor solutions, which are often constrained to a single enclosure style, our chassis come in a variety of configurations — from traditional box-shaped housings to our distinctive cylindrical enclosures.

These chassis range from four inches in diameter and up, a spectrum that makes them exceptionally adaptable in SWaP-constrained environments. Their compact dimensions allow them to be mounted in tight vestibules, pods, or fuselage cavities where every cubic inch must be justified. By tailoring chassis to both the standard and the platform, we enable VNX+ modules to inhabit spaces that would otherwise go unused — maximizing both design efficiency and mission capability.

In practice, this means VNX+ isn't limited to the obvious use cases of handheld or small UAV systems. With the right chassis, it becomes a versatile building block that can be embedded wherever designers need rugged, open-standard computing power — whether tucked into a sensor pod, integrated into a satellite payload bay, or hidden inside the narrow confines of a missile body.

Image III. Cylinder chassis

Image IV. Rectangular chassis

USE CASE SCENARIOS

The most compelling evidence of VNX+'s value lies in its real-world applications. In small unmanned aerial systems (sUAS), its reduced size and weight allow edge computing to be embedded directly within sensor pods. This local processing capability enables functions such as image recognition, target tracking, and data compression to occur before information ever reaches the main mission computer. The result is a reduction in bandwidth requirements and system latency, improving both responsiveness and overall mission efficiency.

In space systems such as CubeSats and small satellites, VNX+ provides onboard intelligence without exceeding limited thermal and power budgets. Tasks like anomaly detection, adaptive communication management, and image pre-processing can be handled locally, granting these compact platforms a degree of autonomy that was once the exclusive domain of larger spacecraft. This localized processing not only enhances resilience but also minimizes the dependency on continuous ground communication links.

For handheld or soldier-borne equipment, the same attributes translate into powerful advantages in mobility and situational awareness. VNX+ enables the creation of wearable or portable systems capable of fusing sensor data and delivering real-time insights without adding significant bulk or weight. This combination of ruggedness, modularity, and efficiency makes it possible to deploy open-standard computing solutions in environments where it was previously impractical.

Together, these examples illustrate how VNX+ extends modular open standards into every corner of the battlespace — from the skies to orbit to the individual operator — enabling smarter, faster, and more efficient mission execution.

INTEGRATION AND MIGRATION CONSIDERATIONS

Integrating VNX+ into existing architectures does not require abandoning VPX. In fact, the most effective designs often use them side by side. A common approach is to treat VNX+ as a distributed extension of a VPX-based system. Lightweight VNX+ modules positioned near sensors or effectors handle pre-processing, while centralized VPX boards perform heavier computation. This division of labor reduces latency and optimizes overall system efficiency.

From a software standpoint, VNX+'s alignment with a modular approach ensures that middleware and applications developed for VPX can often be ported with minimal changes. This continuity lowers integration costs and shortens development timelines.

While the VNX+ vendor ecosystem is still maturing, its growth is inevitable. As the standard gains adoption, designers will gain access to a diverse range of interoperable modules — across compute, I/O, and acceleration functions — ensuring long-term sustainability and avoiding vendor lock-in.

COMPLEMENTARY ROLES IN THE ECOSYSTEM

The genius of VNX+ is that it extends modular open standards without displacing what already works. In a UAV, a 3U VPX mission computer might still provide centralized sensor fusion and communications, while VNX+ modules embedded near the sensors handle AI inferencing or pre-processing. In missile systems, where size and weight are at a premium, VNX+ enables onboard computing that was once impractical — supporting adaptive guidance or real-time target recognition.

By carrying modularity into the smallest mission-critical systems, VNX+ ensures that the same benefits of interoperability, upgradability, and sustainability that have transformed larger platforms can now be realized at the tactical edge.

FUTURE OUTLOOK

The trajectory of VNX+ depends on two factors: the ratification of the VITA 90 standard and the continued expansion of its vendor ecosystem. As adoption grows, the ecosystem will broaden, offering interoperable modules ranging from processors and accelerators to specialized I/O. System designers will then be able to tailor architectures with the same flexibility they enjoy with VPX — but at a fraction of the size and power budget.

In an era when AI, autonomy, and edge computing are moving from novelty to necessity, VNX+ is poised to become a cornerstone of next-generation mission capability. It doesn't compete with VPX — it completes the ecosystem, ensuring that every platform, from the largest ISR node to the smallest munition, has access to modular, interoperable computing.

VNX+ TAKES ORBIT

Space is the ultimate SWaP-C laboratory — a place where constraints on mass, volume, and power are magnified by the unforgiving realities of orbital mechanics. Every additional gram drives up launch costs. Every watt consumed strains a solar budget. Every bit of waste heat must be dissipated through conduction or radiation, without the benefit of convection. These conditions make space the ideal proving ground for VNX+.

Compact VNX+ modules are a natural fit for CubeSats, hosted payloads, and other small satellite systems where traditional VPX boards are too large or power-hungry. Their rugged design ensures survivability under launch vibration, radiation, and extreme temperature swings, while their open-standard nature allows payloads to be upgraded or reconfigured without a complete redesign.

WOLF's extensive experience in ruggedized, conduction-cooled designs and high-reliability standards translates directly into space-ready VNX+ solutions. By scaling down our heritage in VPX-based GPU and FPGA modules, we can deliver orbit-ready capabilities such as AI inferencing, real-time video encoding, and image compression. These are essential for missions that demand autonomous decision-making in orbit — from anomaly detection and satellite maneuvering to responsive ISR.

CONCLUSION

In the evolution of defense and aerospace computing, every generation of technology has been defined by its ability to achieve more within less space, weight, and power. The pursuit of efficiency has become not simply an engineering goal, but a strategic imperative that shapes the very architecture of modern missions. Within this context, VNX+ represents more than a reduction in form factor; it is the logical continuation of modular open systems thinking — refined, focused, and adapted to the realities of emerging operational environments.

VPX has established itself as the cornerstone of rugged, high-performance embedded computing, enabling interoperability, scalability, and mission flexibility across a vast range of defense platforms. Yet as platforms themselves become smaller and more distributed, the boundaries of what can be achieved with existing standards have come into sharper relief. VNX+ does not seek to replace VPX, but to complement it — extending the reach of modular open standards into domains where size, weight, and power constraints once rendered such architectures impractical.

By adhering to the same principles of openness and interoperability embodied in MOSA, VNX+ ensures continuity across system generations and mission profiles. Its compact form factor and low-power profile make it a catalyst for a new era of distributed computing at the tactical edge — one in which intelligence is not centralized but embedded throughout the system, closer to the data and the decision.

As the VITA 90 standard advances toward ratification and the vendor ecosystem expands, VNX+ is positioned to become a foundational element in the next generation of defense-grade architectures. It enables designers to integrate compute capability where it is most effective, rather than where it merely fits. In doing so, VNX+ transforms SWaP-C from a constraint into an opportunity — one that drives innovation, resilience, and readiness across every echelon of the battlespace.

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