

Leil partners with AIC to deliver an HDD-Native high-density storage platform for HPC, AI Training, and Petabyte-Scale Workloads

Highlights

Petabyte-Scale SMR Density:

60× 3.5" hot-swap bays in a single 4U chassis – up to **1.92 PB** raw with the latest-generation 32 TB SMR drives¹. Benchmarked with WD Ultrastar HC690 30 TB UltraSMR. Rack-scale deployments of 10 nodes yield **19.2 PB** raw capacity per rack with the latest-generation 32 TB SMR drives¹ (18 PB with the 30 TB Seagate or WD drives).

SAS4 24G Performance:

2x 30-port EOB (expander on board) backplane delivers **15.3 GB/s** sequential reads and **14.05 GB/s** sequential writes³ – validated with 30 TB WD Ultrastar HC690 UltraSMR drives on 60-drive configuration paired with ATTO ESAH-240F HBA.

Universal Storage Building Block:

An affordable, high-performance foundation for HPC clusters, AI training pipelines, media production, backup, and active archive – a single platform that scales with every modern data-intensive workload.

Up to 70% Energy Savings:

Leil's Infinite Cold Engine (ICE) physically disconnects idle drives via Power Pin 3, achieving true zero-watt standby and dramatically reducing archive storage power consumption.

AI-Ready Infrastructure:

PCIe Gen 5 expansion and up to 4 TB DDR5 memory deliver the compute headroom needed for high-speed data ingestion, AI training pipelines, and HPC parallel file system workloads.

Non-Disruptive Scalability:

Near-linear performance scaling across nodes. Mix CMR and SMR drives, or drives of different capacities and generations, without service interruption.

Data Integrity and Immutability:

Copy-on-write snapshots, NFS/SMB/S3 protocol support, and POSIX-native semantics provide robust active archive protection at petabyte scale.

Solution

The AIC SB407-VA is the reference hardware platform for Leil OS – the industry's first HDD-Native™ storage operating system purpose-built for the SMR era. Together, they form an affordable, high-performance appliance for any modern storage infrastructure: HPC clusters, AI training pipelines, media production, backup, and active archive. Validated with WD Ultrastar HC690 30 TB UltraSMR drives, this joint solution brings hyperscale storage economics – maximum density, sequential throughput, and intelligent power management – on-premises, without cloud dependency.



Fig 1: AIC SB407-VA, Front view

The AIC SB407-VA provides a 4U chassis with 60 hot-swap 3.5" and 8 rear 2.5" bays, driven by 2x 30-port EOB backplanes with 40-PHY expanders. SAS connectivity is provided by the ATTO ESAH-240F, a 16-port PCIe 4.0 SAS4 24G host adapter delivering full-bandwidth access across all drive bays. Powered by dual Intel Xeon Gold 5515+ processors and up to 4 TB DDR5 memory, the platform handles demanding ingest, processing, and archival workloads in parallel. Leil OS extends this hardware with an HDD-Native file system that fully unlocks SMR drive capability – zone-aware sequential write optimization, CDL-based tail latency control, and ICE power-disable – delivering the storage efficiency historically exclusive to hyperscale cloud providers.

Large Scale Storage Challenges

AI and Analytics Workloads:

Raw data archives increasingly serve AI training, media processing, and analytics pipelines that demand high-throughput sequential access at petabyte scale.

Lack of Efficient Active Archive:

Tape is too slow for actionable data; flash is too costly. A high-density, sequential-optimized HDD tier is the essential middle layer.

Energy Costs at Scale:

Power demands grow proportionally with drive count. Traditional arrays waste energy keeping idle archive drives fully powered.

SMR Compatibility Gap:

Most storage software cannot manage HM-SMR drives natively, leaving **20–30%** of density and performance unrealized.

Costly, Disruptive Migrations:

Upgrades across drive generations, interfaces, or capacity points typically require downtime and reconfiguration, risking data availability.

Data Integrity and Immutability:

Long-term storage must guard against data corruption, bit rot, and unauthorized modification across multi-year retention periods.

Cost Management:

Maximizing usable capacity per rack unit while maintaining performance and resilience is essential to managing total cost at petabyte scale.



Fig 2: AIC SB407-VA, Top and rear views

The following graphs show sequential read and write performance of Leil OS running on the AIC SB407-VA reference appliance, configured with 60 WD Ultrastar HC690 30 TB UltraSMR drives. SAS connectivity was provided by the ATTO ESAH-240F 16-port PCIe 4.0 SAS4 24G host adapter. Tests were conducted using FIO at increasing job counts to characterize throughput efficiency across the full drive sweep. Utilization rises as job count increases, approaching the platform's throughput ceiling at roughly one FIO job per drive. All values represent MB/s throughput, with Erasure Coding EC62 applied. Raw figures were captured locally on the platform, while the Leil OS™ file-system figures were measured over a dual 100GbE network from a single client.

SMR Drives: 30 TB WD Ultrastar HC690 UltraSMR, ePMR recording technology (SATA)

Platform: AIC SB407-VA, 60-drive configuration, dual Intel Xeon Gold 5515+ processors

Host Adapter: ATTO ESAH-240F, 16-port internal PCIe 4.0 to 24Gb SAS

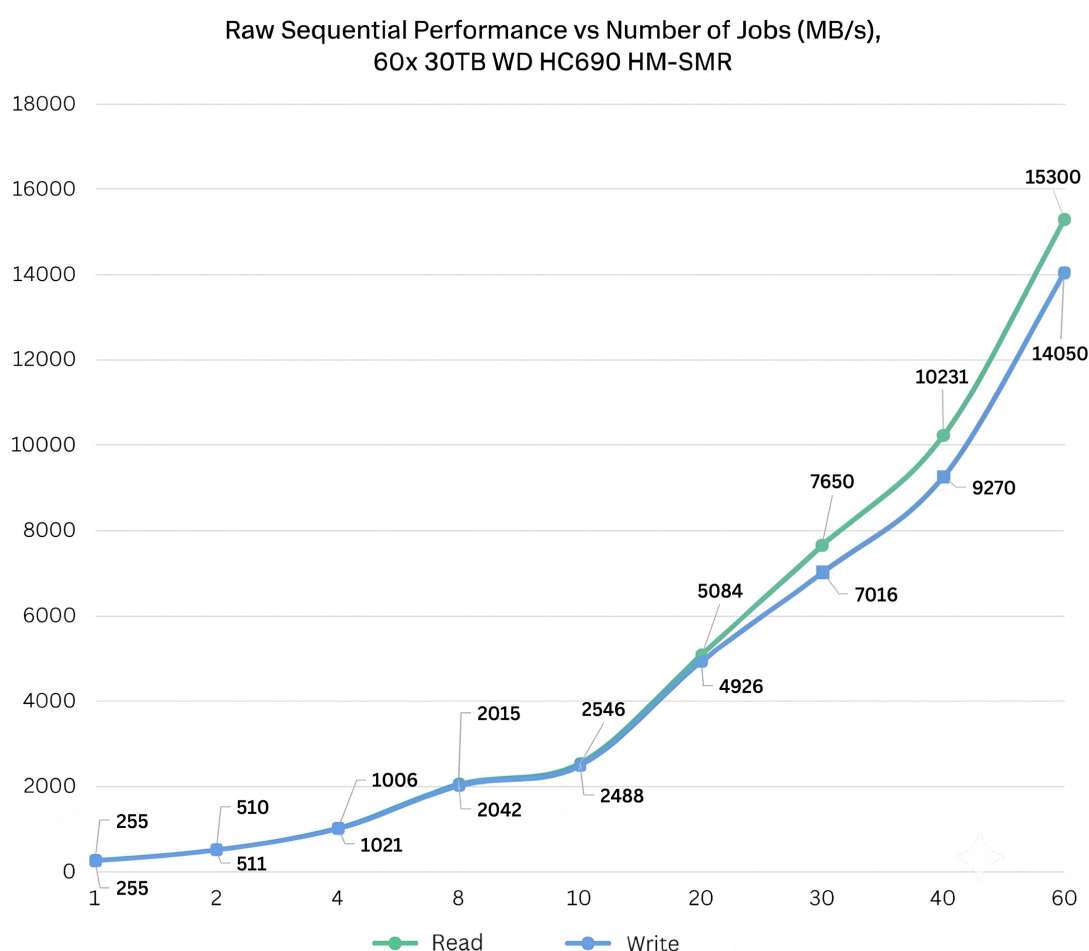


Fig 3

At 60 FIO jobs – one per drive – the AIC SB407-VA achieves **15.3 GB/s** sequential read and **14.05 GB/s** sequential write raw throughput³. The 2x 30-port EOB backplane architecture removes the bandwidth ceiling of prior-generation 12G SAS3 interfaces, providing ample headroom to sustain full sequential read and write throughput across all 60 drives. Throughput scales near-linearly with job count from a single job through the full 60-drive sweep, confirming that the platform sustains bandwidth headroom for large-scale AI training ingest, media workflows, and data pipelines without hotspot bottlenecks. Notably, these SMR drives sustain sequential read and write throughput on par with conventional CMR drives, with no significant practical performance delta – dispelling the misconception that SMR's zoned structure makes it slow or unable to sustain writes efficiently.

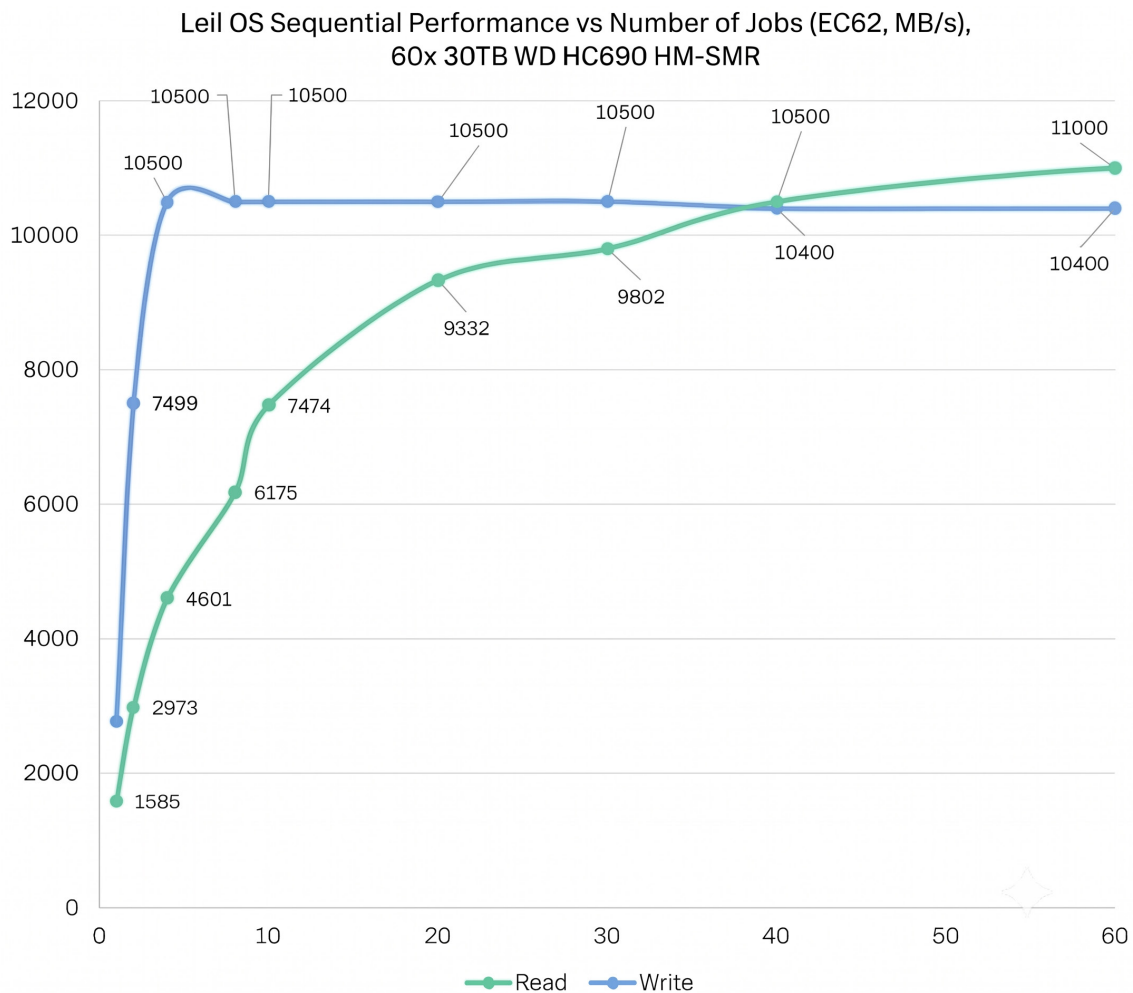


Fig 4

LeilOS file system benchmarks reflect actual usable performance rather than raw interface metrics, delivering **11 GB/s** sequential read and **10.4 GB/s** sequential write throughput utilizing Erasure Coding 6+2 (EC62). Notably, Leil OS™ reaches near-peak performance with significantly fewer concurrent threads than raw configurations, fully saturating available bandwidth at lower FIO job counts. This provides the sustained, high-speed ingest required for large-scale AI training, high-bitrate media production, and intensive data pipelines while preventing localized bottleneck hotspots.

The minor variance between read and write performance stems from distinct architectural factors. At **10.4GB/s**, write throughput operates at roughly **99%** of its theoretical maximum once EC62 overhead is factored in. Because EC62 writes two parity blocks for every six data blocks, the physical drives commit substantially more data than the usable figures show, leaving virtually no headroom for further write gains. Read speeds, by contrast, are primarily limited by per-drive contention. Each FIO job issues at least six concurrent read streams per drive – one for each EC62 data block – and because drives deliver lower throughput when managing multiple simultaneous streams compared to a single sequential stream, Leil OS™ read speeds remain slightly below the maximum raw, single-stream baseline. To ensure high availability, EC62 automatically distributes parity blocks across the cluster. Additionally, Leil Storage features a configurable EC code rate, empowering administrators to dynamically balance storage efficiency against specific fault-tolerance requirements.

Because performance and capacity scale near-linearly, single-node benchmarks translate directly to multi-node clusters. This predictable scaling allows organizations to accurately project infrastructure requirements for petabyte-scale deployments. Thanks to a modular architecture, storage infrastructure can expand incrementally to meet growing demands, completely eliminating the need for system reconfigurations, planned downtime, or costly forklift upgrades.

Leil OS Capabilities

Leil OS™ – the Enterprise Edition – is purpose-built for HDD-Native workloads and is the operating system of record for the AIC SB407-VA appliance. It enables large HM-SMR configurations, allowing the platform to operate at near-theoretical interface maximum from a single compute node. This is key to realizing the full cost-per-TB and capacity advantage of SMR drives versus CMR alternatives. Leil OS and the AIC SB407-VA appliance are fully qualified for both Seagate and WD HDDs, helping organizations avoid vendor lock-in while allowing them to mix and match any capacity of HM-SMR and CMR drives – even in hybrid clusters – for zero-downtime storage refreshes.

Leil OS incorporates instant copy-on-write snapshots for data immutability and integrity, optimizing space by only storing incremental changes. Protocol support includes NFS, SMB, and an S3-compatible object storage interface, with a native Windows® and Linux® client. Command Duration Limits (CDL) are enforced at the filesystem layer: if a drive misses its execution window, Leil OS reconstructs data on-the-fly from parity, eliminating tail-latency spikes that would otherwise disrupt AI training or analytics runs.

Capacity	Performance	Resiliency
1.92 PB per node (32 TB drives) 19.2 PB per rack (10 nodes) +20% SMR desnsity gain Benchmarked: 30 TB HC690	11 GB/s reads 10.4 GB/s writes SAS4 24G interface Near-linear scaling	EC62 erasure coding CDL tail-latency control Head Depopulation Instant snapshots

Fig 5

AIC SB407-VA Platform Features

AIC SB407-VA – Leil OS Reference Platform	WD Ultrastar HC690 UltraSMR²	Seagate Exos® Xz³
• 60× 3.5” hot-swap HDD bays + 8× 2.5” rear bays • Up to 1.92 PB raw with 32 TB SMR drives¹ (1.8 PB in 30 TB HC690 benchmark config²) • 4U chassis – 10 nodes per rack = 19.2 PB raw per rack • Dual Intel Xeon Gold 5515+ processors • ATTO ESAH-240F: 16-port internal PCIe 4.0 to 24Gb SAS host adapter • 100GbE dual port Ethernet NIC	• 30 TB capacity per drive (benchmark configuration) • ePMR + UltraSMR recording technology • SATA drives	• 30 TB capacity per drive (benchmark configuration) • SMR + HAMR recording technology • SATA drives

Rack-Scale Density

A standard rack accommodates 10 × AIC SB407-VA 4U nodes, delivering **19.2 PB** raw capacity per rack with the latest-generation 32 TB SMR drives¹. With 30 TB WD Ultrastar HC690 UltraSMR drives – the benchmark configuration – that figure is 18 PB per rack. Leil supports seamless cluster expansion: additional nodes join live, and capacity is available immediately without data migration, downtime, or re-architecture.

High-Throughput AIC SB407-VA and Host Connectivity

2x 30-port EOB backplanes with 40-PHY expanders ensure that SMR sequential write streams are never backplane-limited. Host connectivity is delivered by the ATTO ESAH-240F – a 16-port internal PCIe 4.0 to 24Gb SAS host adapter that provides full-bandwidth access across all 60 drive bays simultaneously. The SAS4 interface doubles per-port bandwidth versus SAS3 12G, enabling the **15+ GB/s** read and **14+ GB/s** write throughput⁴ validated in testing on dual Intel Xeon Gold 5515+ processors. This architecture supports any workload demanding sustained high-throughput sequential I/O: HPC data storage, AI training, media ingest, backup, and active archive.

Energy Efficiency – Leil Infinite Cold Engine (ICE)

Leil's Infinite Cold Engine (ICE) integrates directly with SATA/SAS Power Pin 3 to physically remove power from idle drives – true zero-watt standby at the drive level, not merely spin-down. ICE manages power transitions at the filesystem layer, keeping up to 90% of drives powered off simultaneously, with transparent, fast wake-up when data is required. Combined with the AIC platform's 80+ Platinum/Titanium-rated 800W 2+2 redundant PSUs and optimized front-to-back airflow, the result is up to **70% reduction** in storage-tier energy consumption on cold archive workloads. Reduced thermal cycling also extends drive longevity, lowering total cost of ownership.

AI-Ready Compute Platform

Six PCIe Gen 5.0 expansion slots and support for up to 4 TB DDR5 memory provide the infrastructure headroom for GPU accelerators, high-speed network adapters, and in-memory processing alongside the storage stack. Organizations running Leil OS™ can co-locate compute and storage on a single, dense platform, reducing network hops and enabling direct-attached AI training pipelines at petabyte scale.

Enterprise Reliability and Serviceability

- **Redundant Power:** 800W 2+2 hot-swap PSUs rated 80+ Platinum/Titanium
- **Cooling:** Hot-swap fans with front-to-back airflow; optimized thermal design for 24/7 operation
- **Management:** IPMI 2.0 and Redfish for out-of-band monitoring and control
- **Drive Serviceability:** All drive bays are hot-swappable; Leil's Head Depopulation feature allows drives with localized failures to continue operating at ~95% capacity rather than requiring immediate replacement

A Future-Proof Leil OS Appliance

The AIC SB407-VA is designed as a long-lived, future-proof appliance for Leil OS. Performance and compatibility testing has been conducted across multiple drive generations and recording technologies – including ePMR UltraSMR drives (WD Ultrastar HC690, used in these benchmarks) and future HAMR-based SMR drives. As drive capacity scales with each new generation, the platform's EOB backplane, PCIe Gen 5 architecture, and Leil OS's HDD-Native™ software layer ensure that new drives are supported without hardware changes. Organizations

investing in this appliance today are positioned to absorb next-generation 32 TB+ SMR drives and beyond as they become available, protecting capital investment while continuously increasing storage density.

Innovations to Deliver Performance, Flexibility, and Protection

The Leil OS + AIC SB407-VA appliance is an affordable, high-performance building block for any modern storage infrastructure – HPC, AI/ML, media, backup, or active archive. Validated with WD Ultrastar HC690 30 TB UltraSMR drives and powered by Leil's HDD-Native™ operating system, it enables scale, growth, and long-term management of your most valued asset: your data.

¹One terabyte (TB) = one trillion bytes; one petabyte (PB) = 1,000 TB. 1.92 PB = 60 × 32 TB; 19.2 PB = 10 nodes × 60 × 32 TB. Actual usable capacity may be lower due to operating environment.

²30 TB WD Ultrastar HC690 UltraSMR (ePMR, SATA) drives were qualified with AIC SB407-VA platform and used as the benchmark configuration. Tests performed on dual Intel Xeon Gold 5515+ processors with ATTO ESAH-240F host adapter.

³Seagate Exos® Xz ST30000NM011F SMR (HAMR, SATA) drives were qualified with AIC SB407-VA platform.

⁴Tests performed using SAS4 24G host connections on AIC SB407-VA with 60-drive configuration.



About Leil

Leil is an Estonian data storage company developing HDD-native software for large-scale, on-premise infrastructure. Its platform delivers energy-efficient, cost-effective, and scalable storage with hyperscale-grade efficiency. Available in commercial and open-source editions, Leil enables data-intensive organizations to manage rapidly growing data volumes without added complexity. Founded in 2022 by storage experts, Leil aims to make hyperscale storage economics accessible to the enterprise market.

leil.io

About AIC

AIC is a global leader in server and storage solutions with 30 years of expertise in high-density storage servers, storage server barebones, and high-performance computers/servers. The company's in-house design, manufacturing, and validation capabilities ensure products are highly flexible and configurable. Headquartered in Taiwan, AIC operates offices and facilities across the United States, Asia, and Europe.

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