

Inside the Module:

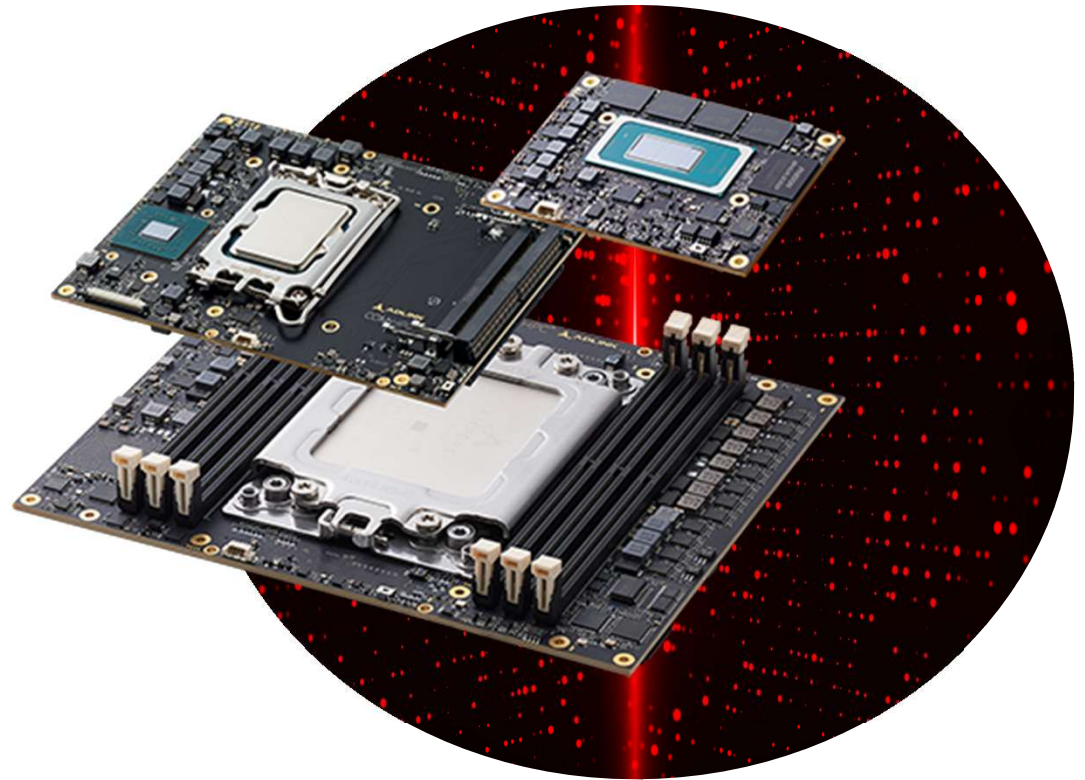
State-of-the-Art Advances in
Computer-on-Module Technology

Stone Shih
Nov 12, 2025



From Mezzanine to Miniature HPC

How **COM-HPC** and
Next-Gen **COM Express**
Redefined Embedded
Performance





Agenda

- Evolution of COM Platforms
- Technical Advances: COM-HPC & Next-Gen COM Express
- I/O Bandwidth Breakthroughs
- Compute Density & AI Integration
- High-Speed Networking & TSN
- Scalability & Serviceability
- Thermal & Power Design
- Key Takeaways

The Evolution of COM

COM Express (2005) → Compact-PCI → COM-HPC (2020+)

- Early COMs: “Processor mezzanines” designed for flexibility.
- 2010s: Widespread adoption of COM Express Type 6 and 7.
- 2020+: COM-HPC introduces server-class I/O and bandwidth



COM Express

Compact PCI

COM-HPC

AMD

AMPERE

NXP

intel

MEDIATEK

Qualcomm

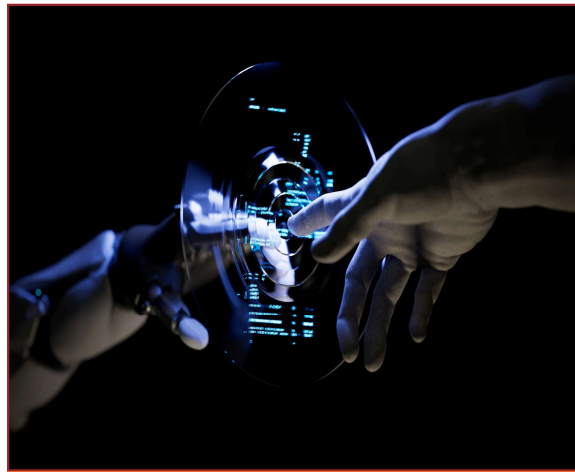
Why COMs Matter Today

Built for Speed, Designed for Growth



Fast CPU Refresh

Modular upgrade paths



Edge Scalability

Need for scalable compute
near data source

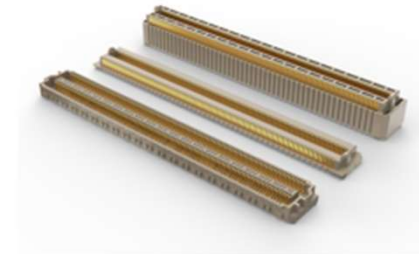


Regulatory Environments

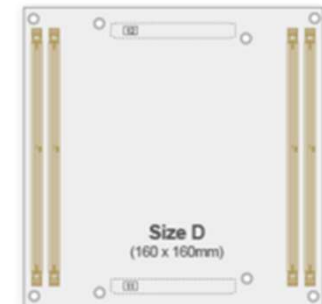
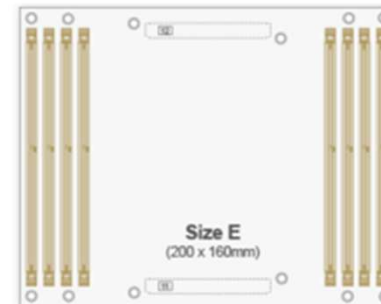
Easier recertification

Introducing COM-HPC

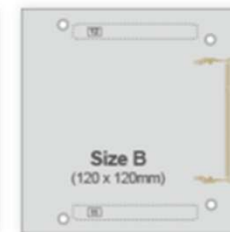
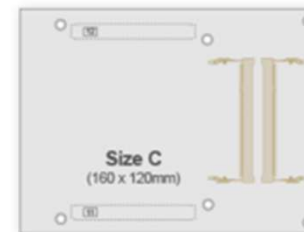
- Designed for high-performance edge and industrial servers.
- Supports PCIe Gen 5 and 100 GbE I/O.
- Five module sizes: Client A–E, Server A–E.
- 400-pin high-speed connectors rated for 32 GT/s.



Mini Type



Server Type



Client Type

I/O Bandwidth: The New Frontier

- PCIe Gen 5 = 32 GT/s; ready for Gen 6/7 in same footprint.
- Up to 64 PCIe lanes available on COM-HPC Server modules.
- Integrated 25/100 GbE KR and multiple USB 4.0/TBT4 ports.

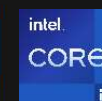


COM+HPC™

13th Gen Intel® Core™

Core i9 + PCIe Gen 5

- Up to 24 cores/32 threads
- PCIe Gen5 x16, PCIe Gen4 x8
- 128GB DDR5 up to 4000 MT/s
- Dual 2.5GbE Ethernet



Compute Density

- Up to 24 cores (Intel® hybrid architecture).
- Built-in AI acceleration (VNNI, Intel® Arc GPU options).
- Up to 128 GB DDR5 on-module.
- ECC and LPDDR5x variants for rugged use.

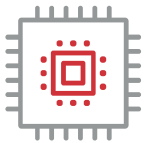
Maximum Performance and I/O



Up to 24 cores / 32 threads / 36MB cache

AI & Edge Intelligence

- On-module AI engines simplify real-time inference.
- Support for OpenVINO™, TensorRT, ONNX.
- Hardware-level security (TPM 2.0, TME, SGX).



TPM 2.0



TME



SGX



High-Speed Networking

- Native 10/25/100 GbE KR ports.
- Time-Sensitive Networking (TSN) for deterministic control.
- Ideal for robotics, autonomous machines, and industrial automation.



Precise Measurements



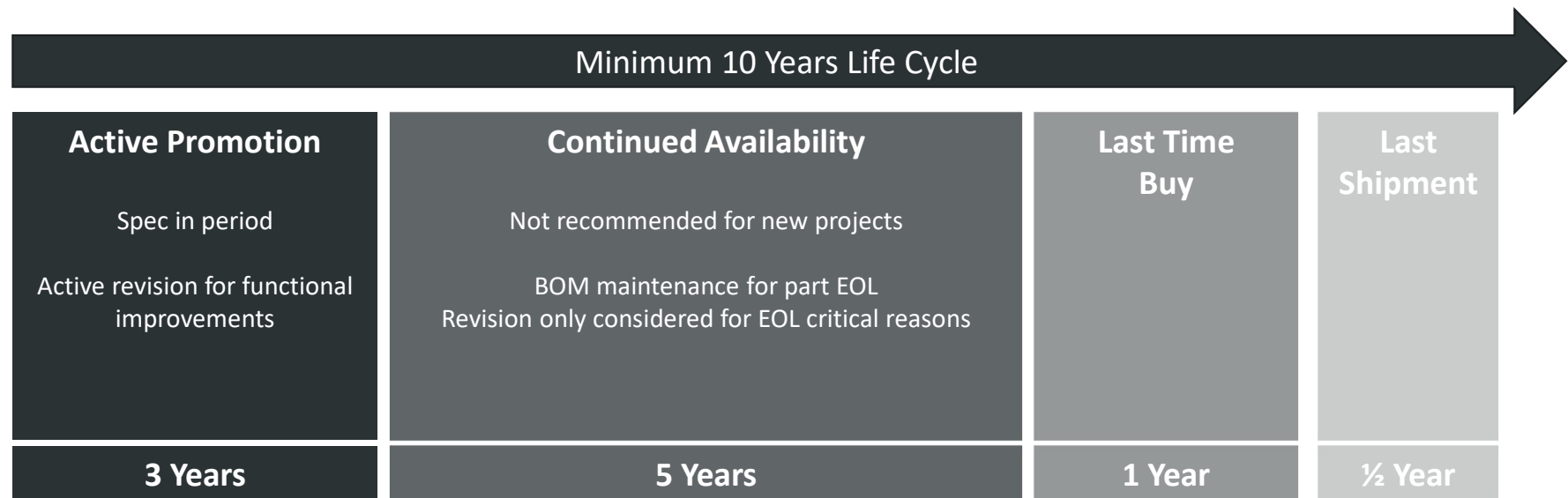
Humanoid Robots



Industrial Automation

Scalability & Serviceability

- **Module-carrier separation: refresh CPU, keep system.**
- **Simplifies maintenance, extends product life.**
- **Retain EMC, safety, FDA certifications on carrier.**



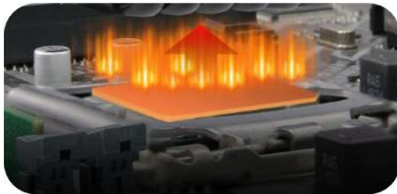
Thermal Design Challenge

- 45 W $\rightarrow$ 65 W+ processors are now common.
- Fanless cooling requires creative mechanical design.
- Heatsink, vapor chamber, and spreader comparison.



Cooling Solutions in Practice

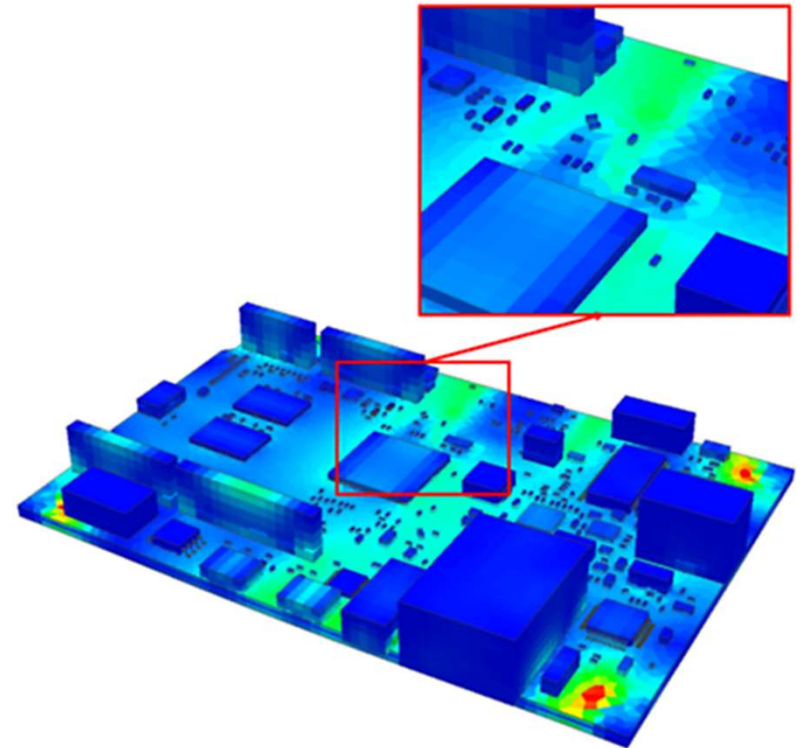
- Direct-touch heat spreaders for even dissipation.
- Vapor chambers for vertical orientation.
- Thermal simulation using SIM tools to optimize enclosure airflow



Direct-touch heat spreaders



Heat Pipes and Vapor chambers



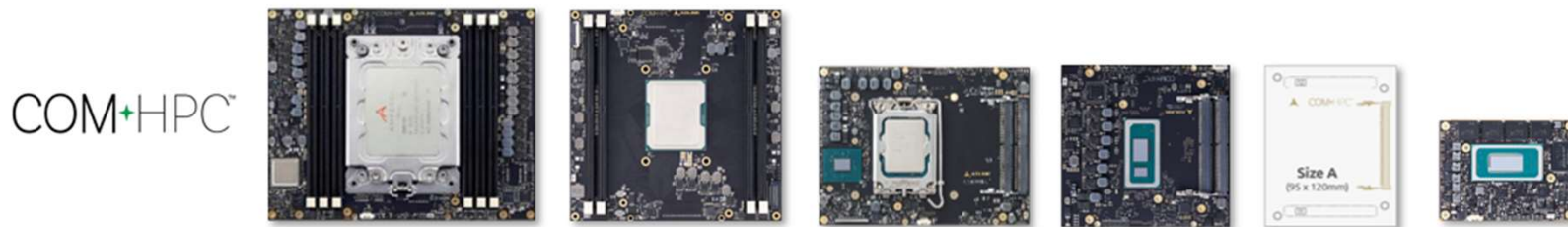
Real-World Lessons

- Validate thermal models early with real data.
- Balance module power budget vs. carrier capability.
- Collaboration between electrical, mechanical, and thermal teams.



Key Takeaway

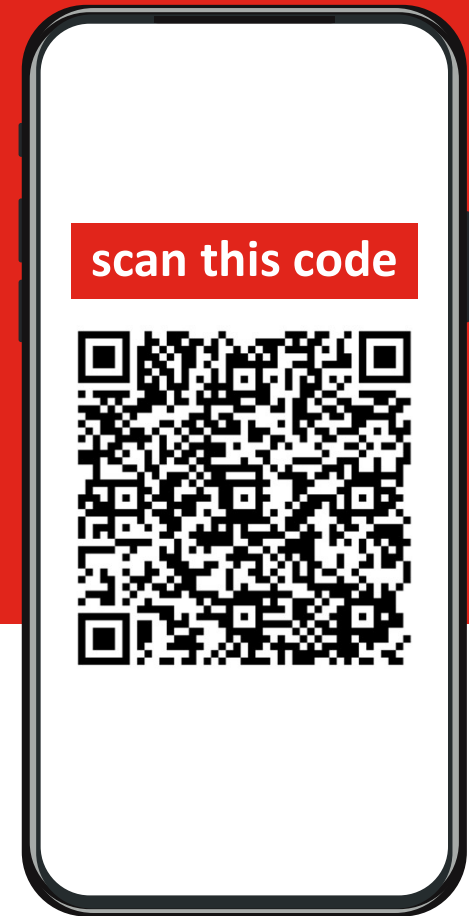
- COMs have evolved into edge-class HPC nodes.
- COM-HPC unlocks PCIe Gen 5/6, 100 GbE, and AI acceleration.
- Scalability and reusability lower total cost of ownership.
- Smart thermal design makes 65 W+ feasible.



Q&A

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