Emerging Form Factors: EDSFF Overview

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Meet the Presenters

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PCI-SIG® Snapshot

Organization that defines the PCI Express® (PCIe®) I/O bus specifications and related form factors.

800+ member companies located worldwide. Creating specifications and mechanisms to support compliance and interoperability.

PCI-SIG member companies support the following industries
- Virtual reality
- Automotive
- Artificial intelligence
- Enterprise servers
PCIe® Technology:
One Interconnect, Infinite Applications

- Storage
- Enterprise Servers
- Aerospace
- Automotive
- AI/ML
- IoT
- Mobile
- Cloud
- Industrial
- PC
PCI-SIG® Roadmap

I/O BANDWIDTH DOUBLES EVERY 3 YEARS

Time

Bandwidth (GB/s)

20 40 60 80 100 120 140 160 180 200 220 240 260

0.13 (PCI) 0.53 (PCI 2.0) 1.06 (PCI-X) 2.13 (PCI-X 2.0) 8 (x16) (PCIe 1.0) 16 (x16) (PCIe 2.0) 32 (x16) (PCIe 3.0) 64 (x16) (PCIe 4.0) 128 (x16) (PCIe 5.0) 256 (x16) (PCIe 6.0)


Actual Bandwidth (GB/S) I/O Bandwidth Doubles Every Three Years
Data Center / Enterprise SSD Units Trend

Source: Forward Insights, Q1'20
PCI Express® Form Factors

**M.2**
- 42, 80, and 110mm lengths, smallest footprint of PCIe connector form factors, use for boot, for max storage density, for PXI/AXIe ecosystem

**U.2**
- 2.5in makes up the majority of SSDs sold today because of ease of deployment, hotplug, serviceability, and small form factor Single-Port x4 or Dual-Port x2

**CEM Add-in-card**
- Add-in-card (AIC) has maximum system compatibility with existing servers and most reliable compliance program. Higher power envelope, and options for height and length
# Data Center SSDs: Previous and Current Options

<table>
<thead>
<tr>
<th>AIC / CEM - Generic</th>
<th>M.2 – Consumer</th>
<th>2.5in Form Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="AIC / CEM - Generic" /></td>
<td><img src="image2.png" alt="M.2 – Consumer" /></td>
<td><img src="image3.png" alt="2.5in Form Factor" /></td>
</tr>
<tr>
<td><strong>Good</strong>: High-performance, general compatibility</td>
<td><strong>Good</strong>: Small and Modular</td>
<td><strong>Good</strong>: Hot-plug, Storage features</td>
</tr>
<tr>
<td><strong>Bad</strong>: need PCIe® AIC slots for other devices, limited hot-plug</td>
<td><strong>Bad</strong>: Low capacity, no hot-plug</td>
<td><strong>Bad</strong>: Mechanical design descended from HDD</td>
</tr>
<tr>
<td><strong>Ugly</strong>: consumes lots of space</td>
<td><strong>Ugly</strong>: limited power and thermal scaling for data center use</td>
<td><strong>Ugly</strong>: Blocks airflow to the hottest components in server</td>
</tr>
</tbody>
</table>
Today’s Challenges

Capacity Scaling ➔ Density: Drive ease of expansion and optimize costs
Performance Scaling ➔ Scale low latency bandwidth to the media
Thermally Efficient ➔ Optimized for airflow to maximize cooling
Future Proofing ➔ Support current and future interfaces, memory and devices
Solution Range ➔ Flexibility: Drive consistency across family of devices
What is EDSFF?

- Enterprise and Data Center SSD Form Factor
- Improved thermals, power, and scalability
- High-speed common connector, pinout – scalable to faster speed PCIe
- Integrated serviceability, hot-plug support
- Built in LEDs, carrier-less design
- Customizable latch for toolless serviceability
The ESDFF WG/SNIA Form Factors

- Family of form factors and standards for data center devices
- E1.S for scalable & flexible performance
- E1.L for high capacity storage
- E3 for 2U higher power/performance or 1U horizontal
## How To Make an EDSFF Device

<table>
<thead>
<tr>
<th>Features</th>
<th>Related Org. or Standard</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical, PHY, Channel, Link, Retimers, Transaction, Config</td>
<td>PCI-SIG®</td>
<td>PCIe® Base Specification</td>
</tr>
<tr>
<td>Command Set</td>
<td>NVMe, CXL</td>
<td>NVMe Specification</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CXL Specification</td>
</tr>
<tr>
<td>Pinout, Power</td>
<td>SNIA SFF-TA</td>
<td>SFF-TA 1009 Pin/Signal Spec</td>
</tr>
<tr>
<td>Connector</td>
<td>SNIA SFF-TA</td>
<td>SFF-TA 1002 Connector Spec</td>
</tr>
<tr>
<td>Form Factor</td>
<td>SNIA SFF-TA</td>
<td>SFF-TA 1006 E1.S Mechanical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SFF-TA 1007 E1.L Mechanical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SFF-TA 1008 E3 Mechanical</td>
</tr>
</tbody>
</table>
SFF-TA-1002 Connector versions: Vertical, Right-Angle, Orthogonal, Straddle, Cable. High speed up to 112 GT/s PAM4
SFF-TA-1012 shows pinout differences between EDSFF, OCP, etc.
Ecosystem Work

Storage is driving the new form factor

- Every major SSD vendor supporting EDSFF (all have E1.S designs)
- Volume being generated from multiple system manufacturers
- SSD & system and thermal level collaboration happening at OCP
- EDSFF WG disbanded, all working being done in SNIA SFF
Scalable, thermally efficient, and dense, E1.L is designed for high capacity storage with superior serviceability.
System Designs for E1.L

E1.L optimized for TB/rack unit & performance. High capacity per drive and system.

E1.L optimized for lowest TCO on QLC NVMe technology.


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System Designs for E1.L

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E1.L optimized for lowest TCO on QLC NVMe technology.

Vision:
Create a smaller, high density solid state drive standard that is optimized for the data center

E1.S (EDSFF 1U Short):
• Mainstream NVMe™ drive
• Compact, modular form factor
  • Vertical fit in 1U height (44.45mm)
  • Fits in depth of 2.5” drive
• High Performance and Capacity
• Supports hot-plug and enterprise feature set
• +12V main power for reduced system cost
• LEDs on-drive for lower cost and easier integration

Optimized for the NVMe drive design and use across all data center and edge systems to scale as mainstream storage.
Industry Standard datacenter-optimized NVMe™ drive that provides significant new system benefits

- Much **smaller** enabling high **density** storage
- Significantly improved **system airflow** and thermal solution
- Most **efficient** modular **scaling** of NVMe capacity and performance
- Enhanced feature set in **space-constrained** servers
- **Lower** base system infrastructure and drive **costs** (high volume, common building block)
## E1.S Options: Dimensions and Power

<table>
<thead>
<tr>
<th>Enclosure Parameter</th>
<th>5.9mm Device</th>
<th>Device with Heat Spreader (8.01mm)</th>
<th>Device with Symmetric Enclosure (9.5mm)</th>
<th>Device with Asymmetric Enclosure (15mm)</th>
<th>Device with Asymmetric Enclosure (25mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended sustained power (W)</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Enclosure Max Inlet air temperature, 950 m to 3050 m (°C)</td>
<td>35 - (1° C for 175 m of elevation gain)</td>
<td>35 - (1° C for 175 m of elevation gain)</td>
<td>35 - (1° C for 175 m of elevation gain)</td>
<td>35 - (1° C for 175 m of elevation gain)</td>
<td>35 - (1° C for 175 m of elevation gain)</td>
</tr>
<tr>
<td>Add in card to add in card pitch (mm)</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td>Recommended Fan Pressure loss across device (Pascal)</td>
<td>83</td>
<td>52</td>
<td>64</td>
<td>40</td>
<td>21</td>
</tr>
<tr>
<td>Airflow, average min per device (CFM), 1 CFM = 1.7 m3/h</td>
<td>1.41 - (0.01 CFM for every 1° C below 35° C inlet temp)</td>
<td>1.71 – (0.06 CFM for every 1° C below 35° C inlet temp)</td>
<td>2.02 - (0.02 CFM for every 1° C below 35° C inlet temp)</td>
<td>1.5 - (0.02 CFM for every 1° C below 35° C inlet temp)</td>
<td>4.10 - (0.04 CFM for every 1° C below 35° C inlet)</td>
</tr>
</tbody>
</table>
E1.S Future Use Cases

- E1.S is ideal with its versatility as a common, high volume building block FF across systems and use cases.

- In addition to scaling resources in datacenter use, **edge** and **IoT** use cases are also ideal to leverage its small, modular form factor.

- Optimal future use focuses on system scaling of devices with low to moderate power (6-25W).

- Future uses beyond NVMe storage include DRAM memory, Persistent Memory, computational storage, PCIe® accelerators and Ethernet NICs.
E3
# E3 Options: Dimensions and Power

<table>
<thead>
<tr>
<th></th>
<th>Short/Thin</th>
<th>Short/Thick</th>
<th>Long/Thin</th>
<th>Long/Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>76mm x 104.9mm x 7.5mm</td>
<td>76mm x 104.9mm x 16.8mm</td>
<td>76 x 142.2mm x 7.5mm</td>
<td>76 x 142.2mm x 16.8mm</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>20W</td>
<td>40W</td>
<td>35W</td>
<td>70W</td>
</tr>
<tr>
<td><strong>Recommended drive Pitch</strong></td>
<td>9.3mm</td>
<td>18.6mm</td>
<td>9.3mm</td>
<td>18.6mm</td>
</tr>
<tr>
<td><strong>Airflow (min per device) CFM</strong></td>
<td>1.8 CFM</td>
<td>2.8 CFM</td>
<td>2.7 CFM</td>
<td>4.2 CFM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>These dimensions are expected to change with pending spec updates</em></td>
</tr>
</tbody>
</table>

*Inlet temp – x for every 1° C below 35° C*
E3 Use Cases

- NVMe™ SSD devices with very high capacity and performance are possible due to larger package size, 16 lanes and increased power.
- Persistent memory devices using E3 will appear with the coming PCIe® 5.0 platforms.
- GPUs up to 70W are possible.
- 400GB NICs
# E3 Opportunity in Servers

## Potential Reasons to Move Away From U.2

<table>
<thead>
<tr>
<th>Reason</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal Integrity for PCIe® 5.0 spec @ 32GT/s</td>
<td>Multi PCIe device (beyond SSD) support</td>
<td>Decreased server infrastructure cost</td>
</tr>
<tr>
<td>Improved thermals &amp; cooling</td>
<td>Higher power &amp; perf modes</td>
<td>Improved capacity</td>
</tr>
</tbody>
</table>

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Real Performance

- Once NVMe controllers with 16 lanes of PCIe® technology are available, they will have superior burst transfer rates.

- PM (Persistent Memory) cards in E3 would replace PM in DDR slots.

- PCIe 5.0 architecture is essential for 400G NICs.
## EDSFF Device Solutions

<table>
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<tr>
<th>Feature</th>
<th>Description</th>
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<tr>
<td>Capacity Scaling</td>
<td>E1.L: 3x more capacity than U.2, 4x the drives in system of U.2</td>
</tr>
<tr>
<td></td>
<td>E1.S: 2x more capacity than M.2, 3-4x the drives in system of U.2</td>
</tr>
<tr>
<td>Performance Scaling</td>
<td>EDSFF Connector Support for x4, x8, x16. Up to 112Gbps signaling</td>
</tr>
<tr>
<td></td>
<td>E3: 2x+ higher power support and performance than U.2</td>
</tr>
<tr>
<td>Thermally Efficient</td>
<td>E1.L: Up to 2x less airflow required per drive vs. U.2 15mm</td>
</tr>
<tr>
<td></td>
<td>E1.S: Up to 3x less that U.2 7mm</td>
</tr>
<tr>
<td>Future Proofed</td>
<td>PCIe 4.0® and 5.0 specification ready - enabling scalability &amp; Interoperability to be the innovation form factor for the next 20 years</td>
</tr>
<tr>
<td>Solution Range</td>
<td>E1 and E3; low, med, and high power; case and caseless designs</td>
</tr>
</tbody>
</table>
PCI-SIG members have access to the PCIe® specification library. If you would like to learn more about joining, please visit the PCI-SIG website:

https://pcisig.com/membership/become-member
Questions?
Thank You For Attending