SNIA DEVELOPER CONFERENCE
SDC 25
By Developers FOR Developers

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Why should we have yet another Enterprise and Datacenter Standard Form Factor for SSDs?

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Storage Form Factor History

- 1950s-1990: Form factor wild west
  - 24″->14″->8″->5.25″->3.5″
- 1990s: 2.5″, 3.5″ form factors specs
  - 3.5″ Desktop, server. 2.5″ laptop
- Early 2000's: Move to SATA/SAS signaling/Connectors
  - 1.8″, 1″ HDDs showed up
- Mid 2000's: 2.5″ SATA SSD
- Early 2010's: "Mini" SSD (mSATA/M.2)
  - Specialized for laptops
- Mid 2010's: U.2
  - Specialized for servers
- Late 2010's: EDSFF
  - Specialized for usages

Trends

- HDDs stabilized but it took a while
- The new form factor cadence increased
- Fragmentation based on usage
- EDSFF was a result of this fragmentation

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EDSFF Background

- Goal: Commonality across a set of form factors
  - Same pinout/functions = Same connector
  - Same connector = Same signal integrity
  - Same signal integrity = Same PCIe speeds

- 3 usages, 3 form factors:
  - Enterprise storage: E3
  - Datacenter compute: E1.S
  - Datacenter storage: E1.L

- So, we were done, right?

Flash Memory Summit

EDSFF SSD Key Goals

- Datacenter system-optimized design
  - Fits in common datacenter system chassis: 1U, 2U, etc.
  - Cost benefit to system designs with 12V only for main power
- Meets common customer needs for storage devices
  - Drive is easily accessible to the user
  - Supports Hot-plug insertion and removal
- Cost-optimized card edge drive interconnect
- High density, capacity and performance options
  - Family of form factors to meet key use cases
  - Compatible connector options to support x4 and x8 NVMe drives

Common capabilities across family of SSD form factors

Flash Memory Summit

Scalable Family for Different Usages

E1.L (SFF-TA-1007)
- 318.75 x 38.4 mm
- Supports > 40W
- Up to 48 Standard NAND sites

- Same Protocol: NVMe
- Same Interface: PCIe
- Same Connector: SFF-TA-1002
- Same Pinout and Functions (hot plug, serviceable)
- Different Usages, Same Expectations!

E1.S (SFF-TA-1006)
- 111.5 x 31.5 mm
- Supports >12W
- Up to 12 Standard NAND sites

E3 (SFF-TA-1008)
- (104.9/142.2) x 76mm
- Supports up to 70W
- Up to 48 Standard NAND sites

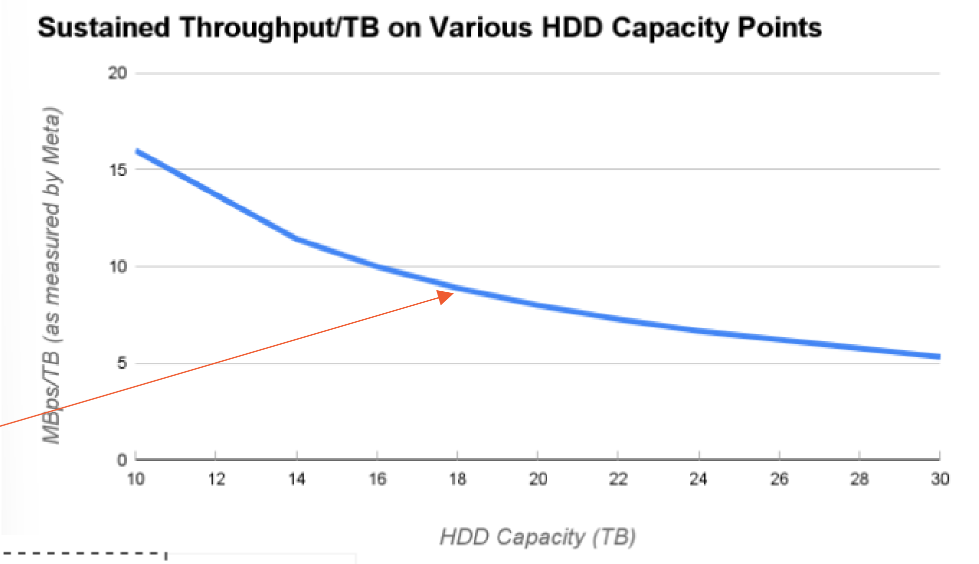
Santa Clara, CA
August 2018

5

New Opportunity

- QLC, NAND scaling continue lowering costs
- HDDs have difficulty scaling performance/TB
- QLC performance is lower than TLC but better than HDDs
- Hyperscalars have targets

Source: Meta blog: A case for QLC SSDs in the data center
https://engineering.fb.com/2025/03/04/data-center-engineering/a-case-for-qlc-ssds-in-the-data-center/



	HDD (Bulk Storage)	QLC SSD (Capacity Tier)	TLC SSD (Performance Tier)
Capacity (TB)	20-30	64-150	8-16
Acquisition Cost ($/TB)	Low	Med	High
Performance (BW/TB)	Low	Med	High
Power (W/TB)	High	Low	High

Source: OCP Storage Tech Talk (May 14, 2025)
https://www.youtube.com/watch?v=ppPGAngXX7c

More Context

- HDD Scaling
  - To continue their TCO curve HDDs need to keep growing capacity
  - Physics limits their maximum IOPs
  - IOPs per TB wall
- Data Lake Temperatures
  - A portion of the HDD tier is warming up
  - Guess is that AI is playing a role
  - Customers are paying to store the data and want a return on that
- TCO
  - Encompasses a lot more that just acquisition cost
    - Power, cooling, life span, replacement rate, etc.
  - Does not need to reach parity to start the ball rolling

Need to move to some form of HDD Displacement

Requirements

- Minimum of 64 NAND placements for high capacity at low die stacks
- Fit vertically in a 2U chassis for node density
- Large board area for low-cost componentry
- Symmetrical connector registration for component placement flexibility
- E1 LED placement for simplicity and cost
- Moderate performance (8-10 MBs/TB?) for low TCO (QLC)
- EDSFF connector and electricals (future proof for G7+)
- NVMe protocol (who would pick anything else in this day and age?)

Challenge: Acquisition Cost

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- How do you minimize this cost?
  - Increase the nominal capacity of the SSD
- Nominal Capacity is cost sweet spot.
- Higher Nominal capacity = Less SSDs to hit same rack capacity
  - Reduces number of non-NAND components per rack
  - Reduces number of SSDs per rack
  - Reduces number of control nodes per rack
- Note: This is all predicated on a BW/TB performance goal

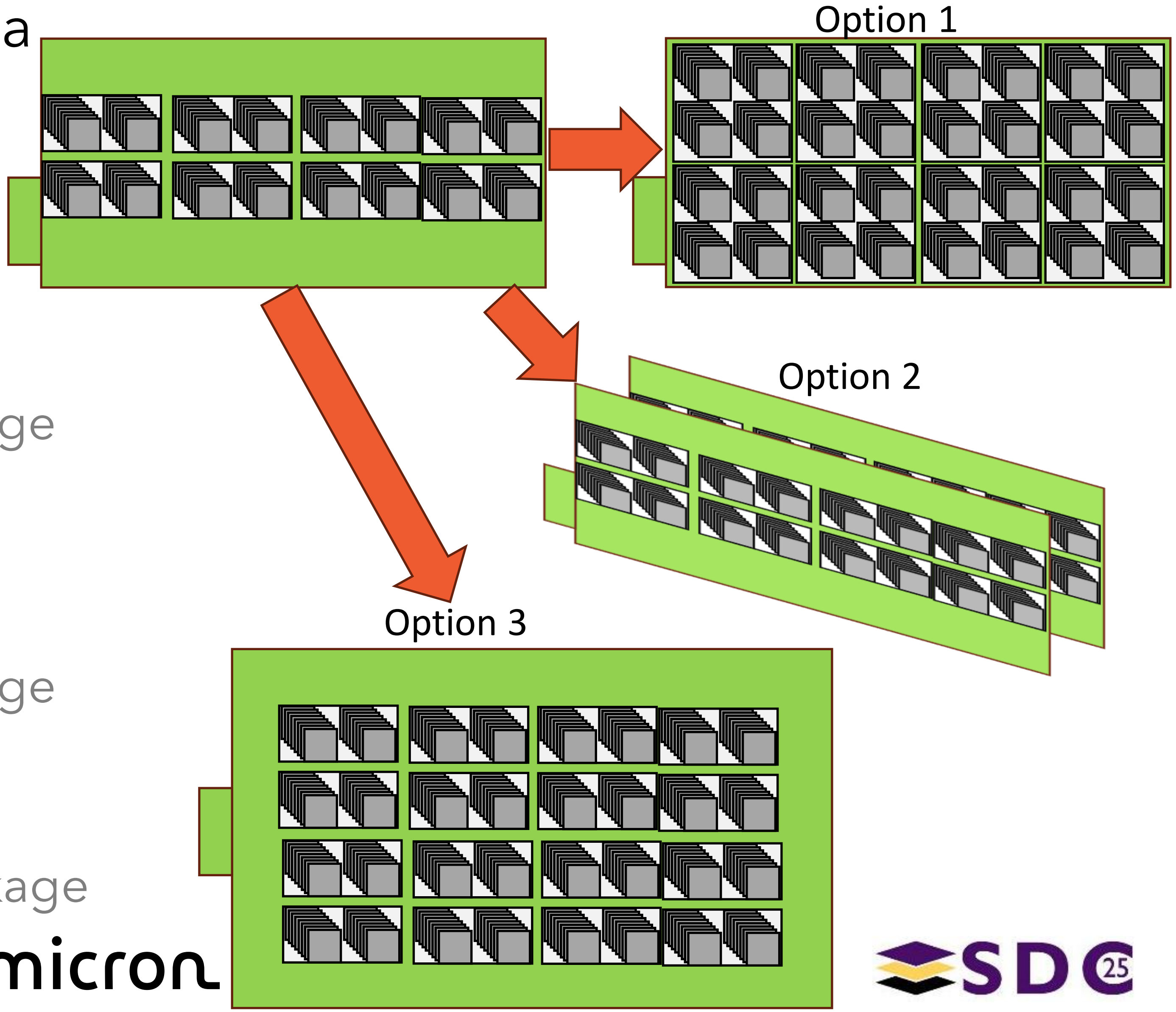
Solution: Capacity Tier SSDs

- SSD built for lower BW/TB goals
- Cloud Storage Optimized NAND
- Higher number of NAND dies/SSD
- Cost optimized BOM
- Another term is Near Line SSDs

SSD	Performance SSD	Capacity SSD	Near Line SSD
NAND Dies	16-128	128-512	1024-2048+

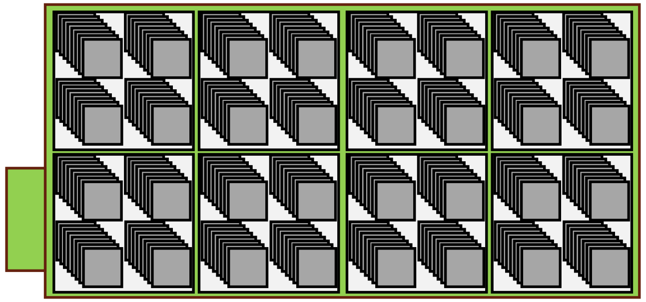
Challenge: Cost optimized capacity

- How do get 1024+ NAND dies in a single SSD?
- Option 1: Use current SSD form factors and Double the NAND dies/package
  - 32 NAND packages x 32 dies/package
- Option 2: Use current SSD form factors but make them thicker.
  - 64 NAND packages x 16 dies/package
- Option 3: New form factor
  - 64 NAND packages x 16+ dies/package



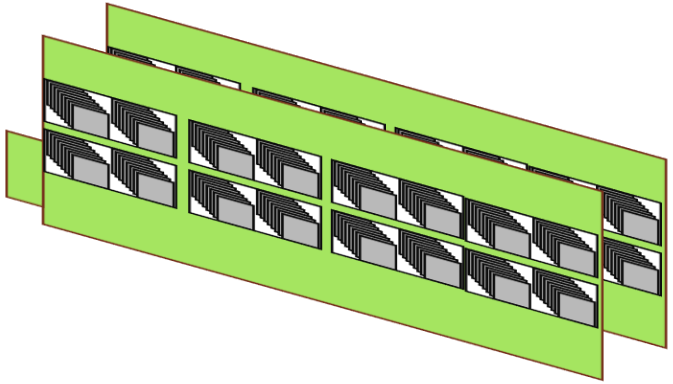
Doubling NAND dies/package

- Can likely use U.2, E3, E1.L
- Cost challenges
  - Package size
  - Package height
  - Compounding yields
- Thermals
  - 2x die density => 2x power



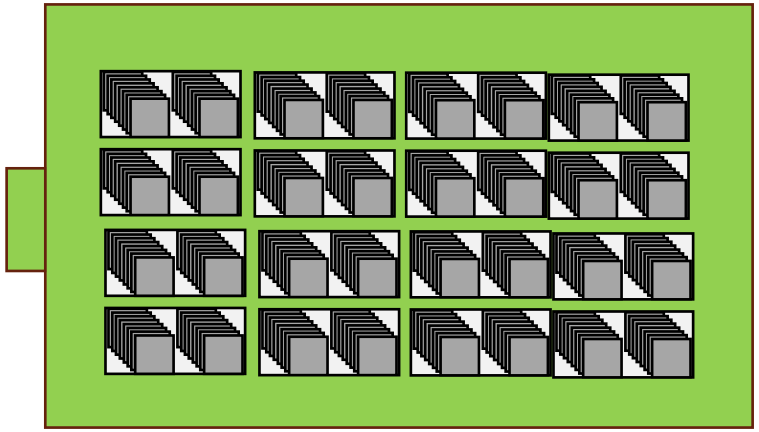
Thicker form factor

- Can likely use U.2, E3
- Front Panel challenge
  - Wider SSD = less SSDs per sled
  - 1 SSD 2X or 2 SSDs 1X?
- Cost challenges
  - 2 PCBs connected to each other
- Thermal challenges
  - Where does the heat go?



New form factor

- Larger single PCB provides several benefits
  - 1 PCB so no extra connectors
  - More space for larger packages and separation between packages.
  - More space for additional components
  - Can define thickness to allow for better thermals or taller components.



- This leads to better cost and thermals

- Downside: “Yet another form factor”

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Options

Option	Pros/Cons
Option 1: Use existing form factors and double NAND dies/package to stay at ~32 packages	+Use existing form factors -Higher cost -Thermals
Option 2: Use existing form factors and make the form factor thicker to support 64+ packages(multiple PCBs)	+Use existing form factors -Front panel area -Higher cost -Thermals
Option 3: New form factor supporting 64+ packages	+Cheaper +Thermals -New Form Factor

A new form factor is the best path forward to address the capacity problem

New Form Factor: E2

Fundamental goals:

- 64 NAND packages
- NVMe, PCIe, EDSFF (don’t invent something drastically new)
- Leverage what has already been done when possible

Comparing form factors

Form Factor	E2	E3.S/L 1T	E1.L 9.5	E1.S 9.5
Protocol	NVMe	NVMe	NVMe	NVMe
Transport	PCIe	PCIe	PCIe	PCIe
Connector	SFF-TA-1002	SFF-TA-1002	SFF-TA-1002	SFF-TA-1002
Pinout/electricals	SFF-TA-1009	SFF-TA-1009	SFF-TA-1009	SFF-TA-1009
Number of packages	64+	16-48	32-48	8-16
Enclosure Length	200mm	112.75/142.2mm	318.75mm	118.75mm
Enclosure width	76mm	76mm	38.4mm	33.75mm
Enclosure thickness	9.5mm	7.5mm	9.5mm	9.5mm
Connector alignment	E3 Aligned	E3 Aligned	E1 aligned	E1 aligned
Latch/Carrier	E1 Style	E3 Style	E1 Style	E1 Style
EMI/ESD	E1 style	E3 Style	E1 style	E1 style

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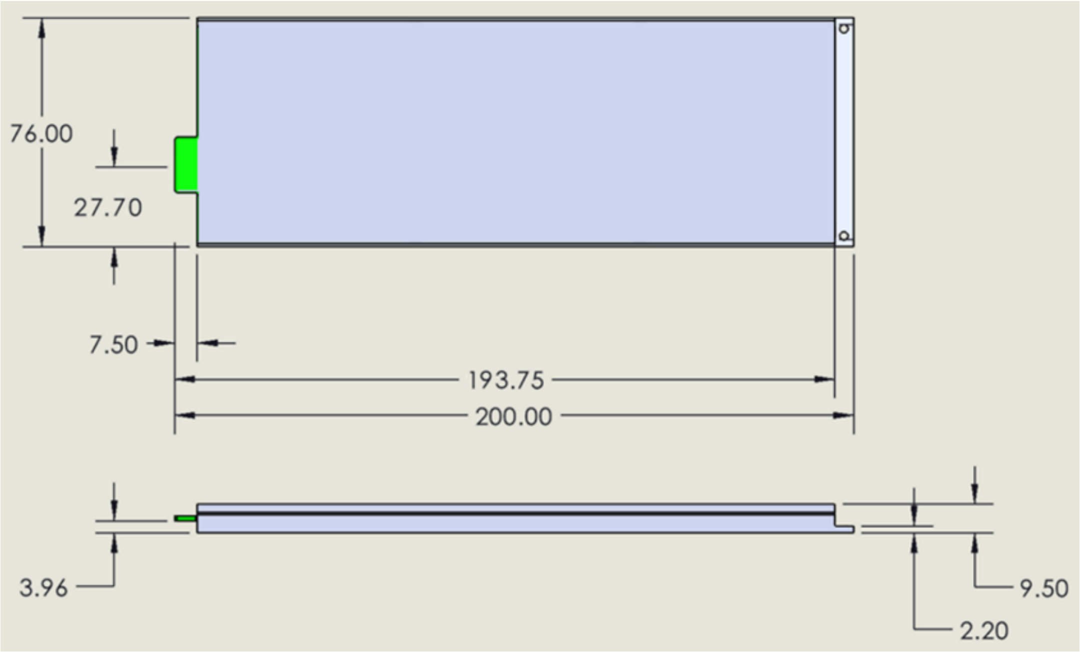
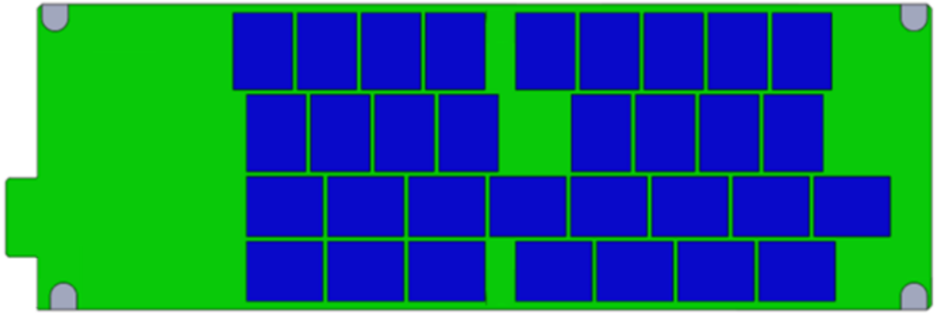
Dimensional Q&A

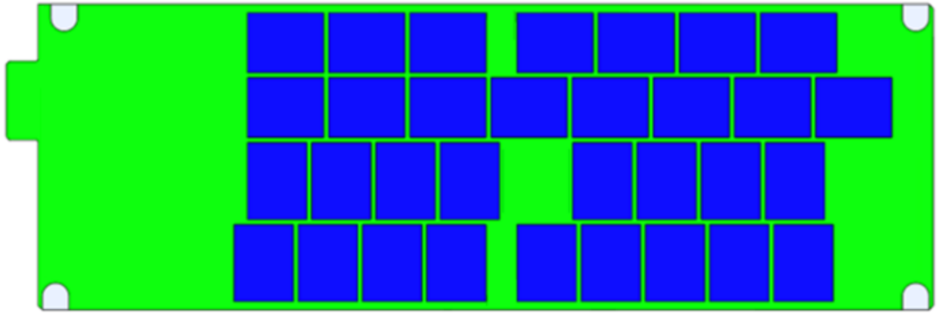
- Why 200mm?
  - Balance between host depth and NAND size.
  - Allows spacing for thermals
  - Allows for growth of NAND dies if needed.

- Why 76mm?
  - Fits in a 2U sled (proven with E3)

- Why 9.5mm?
  - Up to 32 SSDs in 2U 19″ sled (up to 40 SSDs in 2U 21″ sled)
  - Allows taller components on both sides
  - More volume for thermal dissipation.







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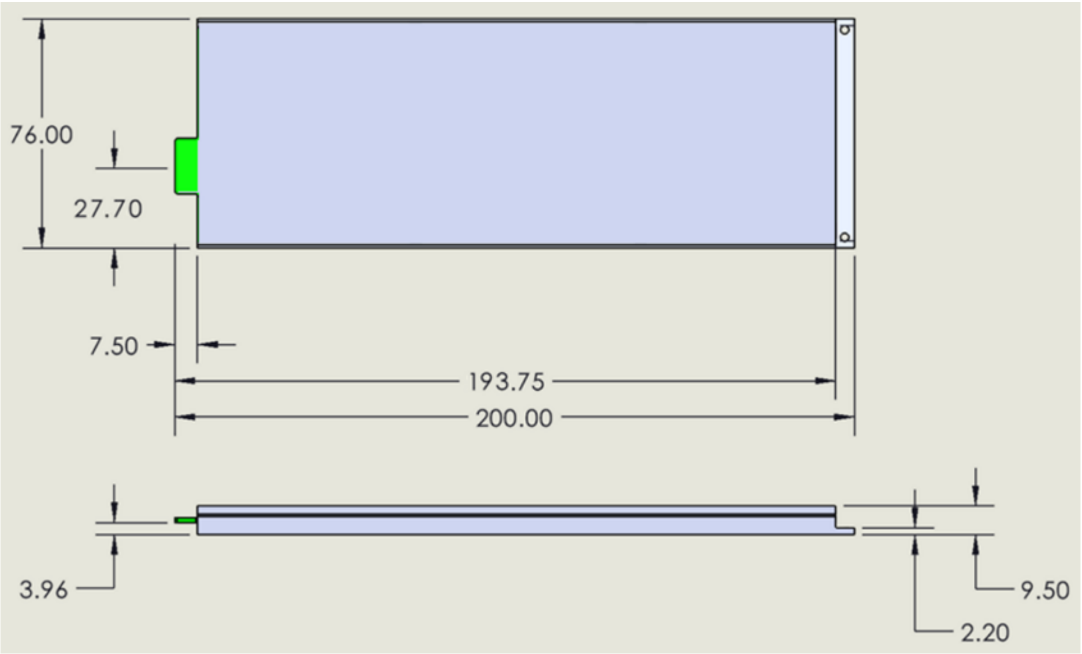
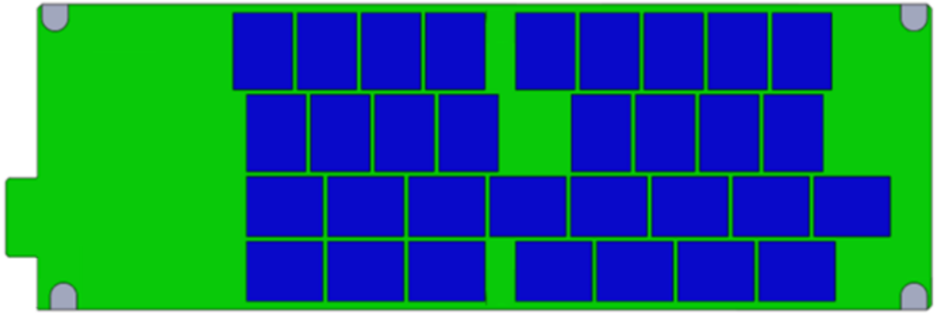
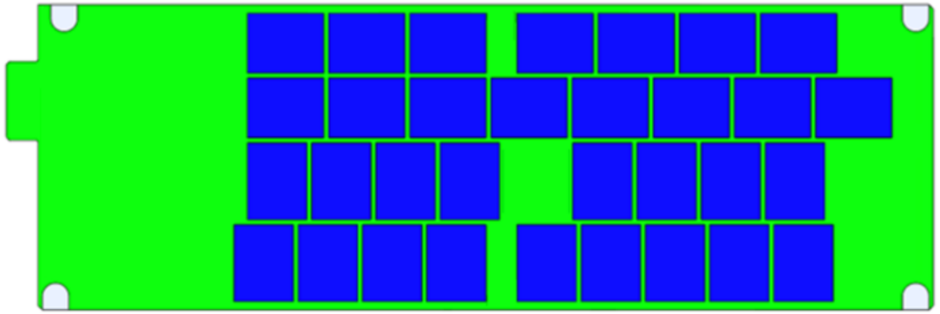
Dimensional Q&A - 2

- Why locate the card edge at 27.7mm?
  - Same as E3
  - Allows for other form factors to be used inside this enclosure.
  - Similar concept to E1.S in E3.S or E1.S in E1.L.
- Why use the E1 latch mounts?
  - No threaded holes
- How many sizes of E2?
  - 1







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Specification Development

- Specification Published!
  - https://www.snia.org/technology-communities/sff/specifications
  - Direct link: https://members.snia.org/document/dl/55771

- Work began Mid March, completed in Mid June

- Specification is part of EDSFF
  - Changes planned to add E2 to other specification.

Feature	EDSFF Recipe
Electricals, PHY	**PCIe Base Spec**
Command Set	**NVMe Spec**
Pinout, Power	**SFF-TA-1009** Pin/Signal Spec
Connector	**SFF-TA-1002** Connector Spec
Form Factor	**SFF-TA-1006** E1.S Mechanical; **SFF-TA-1007** E1.L Mechanical; **SFF-TA-1008** E3 Mechanical; **SFF-TA-1042** E2 Mechanical
Other	**SFF-TA-1023** Thermal spec

Date	ID	Title	Status
2025-06-16	SFF-TA-1042	Enterprise and Datacenter 2U Form Factor (E2)	Published 1.0, 2025-06-16

Prototype Development

- Goal to show that its manufacturable
- Functional prototype completed of SSD
- Prototype completed of a chassis

Micron E2 SSD Prototype

E2 Prototype chassis

Possible Future Improvements

- Liquid cooling support
- Expanded optional support for desired features
- x8, x16 lane card edge
- Minor changes for usages outside Storage

Closing thoughts

- There is a push for a “good enough” consistent BW/TB
- High-Capacity (Near Line) SSDs are working to solve this problem
- E2 provides benefits and flexibility to meet this need

Last note: The SFF TWG published EDSFF E2

- The SFF TWG and Community are always looking for new members
  - For more information https://www.snia.org/snia-new-member-entitlements
- Resources:
  - How to Join: https://www.snia.org/member_com
  - Public Site: https://www.snia.org/sff
  - Specifications: https://www.snia.org/technology-communities/sff/specifications
  - Questions about membership? Please send mail to membership@snia.org
  - Additional questions? Please send mail to sff-chair@snia.org

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Questions?

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