Western Digital.

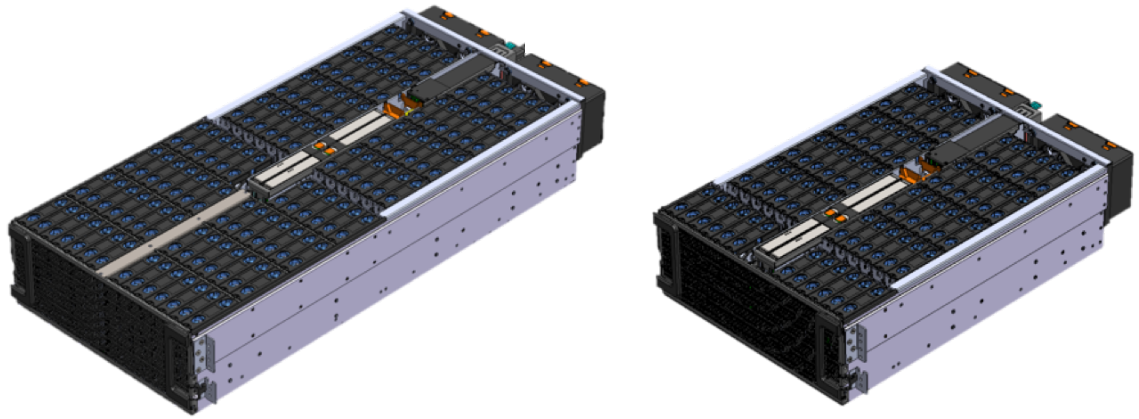
Mt. Madonna Hybrid Storage Platform

Product Overview

Introducing the Mt. Madonna Family

"Vertical Innovation" Continues …
Storage platform design through the lens of a disk drive designer

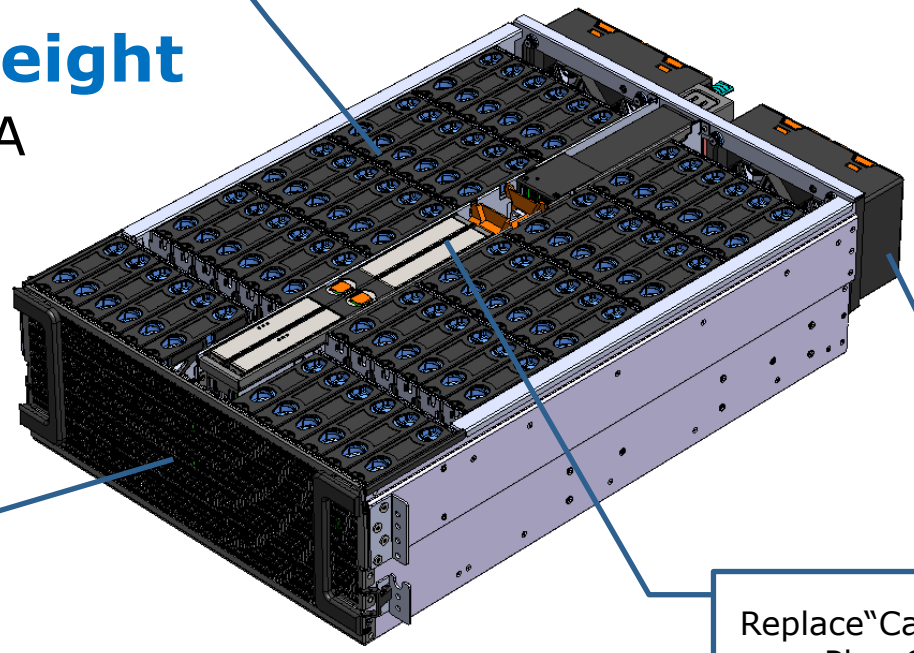
- Innovative design
  - Patented vibration isolation
  - Patented cooling scheme
  - Enhanced serviceability
- Two leading products from a common design
  - Mt. Madonna 4U60 Hybrid Storage Platform
  - Mt. Madonna 4U102 Hybrid Storage Platform
- Common elements
  - Basic chassis design
  - Drives/carriers
  - PSUs
  - IO Modules
  - Baseboard



Mt. Madonna 4U60 Mechanical Features

Up to 840TB in a 4U Enclosure to fit within a standard EIA 900mm rack

- **Best-in-class Depth/Weight**
  - Only 890mm depth with CMA
  - Only 175lbs fully loaded



Mt. Madonna Architectural Features

4U Enclosure to fit within standard racks

- Support for 102 or 60 dual ported drive paths
- Support for 6 x4 powered and managed mini-SAS HD connectors per IO Module
- Support BW of up to 235 MB/s/d
- Support 12G SAS-3 drives – dual ported
- Support 6G SATA-3 drives – single ported
- Support for up to 12W drives – 18W individual slots
- Support hot replacement of individual drives
- Support drive power off with drives that support T10 Power Disable Only
- Support hot replacement of individual FRUs
- Support full high availability, independent dual paths to all HDDs
- Support for enclosure management out of band via integrated microprocessor and in-band via SES-3
- Dual redundant Platinum rated CRPS PSUs

Mt. Madonna Family Basics

Leading I/O Capability

- Industry-leading cable-free IO Module – hot swap in cold aisle
- 12 x4 powered and managed mini-SAS HD – 6 ports per IO Module – up to 235 MB/s/d

Flexibility in Balancing Cost, Capacity, Performance and HA

- Dual-ported 12G SAS-3 drives for full High Availability and maximum performance
- Single-ported 6G SATA-3 drives for a lower cost option
- Optional flash performance tier with up to 24 SSDs

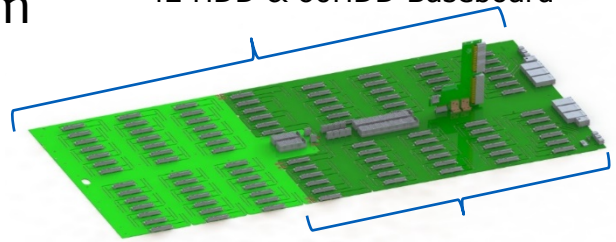
Management & Supportability

- In-band via SES-3 and out-of-band via Redfish enclosure management

Power

- Dual redundant 80+ Platinum rated 1600W PSUs
- Drive power off using T10 Power Disable
- Up to 12W per drive slot fully populated – up to 18W per drive slot for individual drives

Mt. Madonna 4U102
42 HDD & 60HDD Baseboard



Mt. Madonna 4U60
60HDD Baseboard

Mt. Madonna Innovations Build on the Strengths of HelioSeal® Drives

Why everything in the data center gets better with Helium-filled HDDs

- **Mt. Madonna platforms are designed with these drives in mind** to further reduce vibration, improve cooling efficiency and reduce operating costs
- Helium has approximately 1/7th the density of air
  - Provides significantly lower resistance to the rotating disk pack and head/arm assembly
- Benefits of HelioSeal® HDDs
  - Less power required to spin the disks and move the arms
  - Reduced heat generation means less cooling required
  - Lower operating temperatures generally leads to higher long-term reliability
  - Less turbulence means tighter precision of read/write heads that enables higher capacity
  - Reduced noise from the drives and from lower speed fans

- At the disk shelf or rack level, these effects are multiplied to increase storage density, reduce power and cooling costs, and enhance performance and reliability
- Ultimate confidence in reliability is reflected in our **5-year warranty for the entire platform**

Mt. Madonna Hybrid Storage Platform at a Glance

	Mt. Madonna 4U60		Mt. Madonna 4U102	
Form Factor	4U / 60-bay (HA)		4U / 102-bay (HA)	
Max Capacity per Enclosure	840TB		1.4PB	
Max Configurations	Fully Populated SAS 60 x 14TB SAS	Fully Populated SATA 60 x 14TB SATA	Fully Populated SAS 60 x 14TB SAS	Fully Populated SATA 102 x 14TB SATA
Daisy Chain	Up to 4		Up to 4	
Host Ports (per IOM)	12Gb/s SAS, 6 x Mini-SAS (3 x mini-SAS to mini-SAS cables included)		12Gb/s SAS, 6 x Mini-SAS (12 ports total) (3 x mini-SAS to mini-SAS cables included)	
Cable Management Arm	Standard		Standard	
Drive Connectivity	12Gb/s SAS 6Gb/s SATA		12Gb/s SAS 6Gb/s SATA	
Zoning	Up to 6		Up to 6	
Power Supply Units (PSU)	1600W x 2		1600W x 2	
Dimensions	Height: 175mm (6.89”) Width: 447mm (17.61”) Depth: 712mm (28.05”) Depth in Rack: 890mm (35.06”) w/ CMA		Height: 175mm (6.89”) Width: 447mm (17.61”) Depth: 1047mm (41.25”) Depth in Rack: 1186mm (46.72”) w/ CMA	
Weight (Fully Populated)	175lbs		262lbs	
Availability	LVM – Nov 2017; Volume – Jan 2018		LVM – Nov 2017, Volume – Jan 2018	

Preliminary specifications - subject to change

Mt. Madonna 4U60 Hybrid Storage Platform

Product Specifications

Category	Specs
Max. Drives	60 x 3.5” HDD drive bays Up to 24 x 2.5” SSD (in 3.5” bay)
Drive Interface	12Gbps SAS, 6Gbps SATA
Available HDD Capacities	6TB, 8TB, 10TB, 12TB, 14TB 4Kn/512e, SE/ISE/TCG
Available SSD Capacities	SAS: 400/800/1600/3200/6400GB
Host Interface	1+1 I/O Modules (IOM), 6 HD Mini-SAS ports per IOM (12 ports total)
Management	• In-band management interface • Out of band management • Enclosure health monitor • Enclosure cooling control • System event log • On-line firmware update • Power management • Drive power control (pin 3)

Category	Specs
Physical Dimensions	• Height: 175mm (6.89”) • Width: 447mm (17.61”) • Depth: 712mm (28.05”) • Depth in Rack: 890mm (35.06”) w/ CMA
Weight	• Product w/ 60 HDDs: 79.4kg (175lbs)
Power	• 1+1 1600W, 80+ Platinum • 200-240 VAC (1600W max), 50/60Hz • C13 to C14 • Alternating Current (AC)
Cooling	• 4 hot swappable cooling fans • 1 fan module per power supply, air flow through PSU • Fan speed tuning via system management interface
Serviceability	• Hot-swappable IOMs, power supplies, fans and drives

Preliminary specifications - subject to change

Mt. Madonna 4U102 Hybrid Storage Platform

Product Specifications

Category	Specs
Max. Drives	102 x 3.5” HDD drive bays Up to 24 x 2.5” SSD (in 3.5” bay)
Drive Interface	12Gbps SAS, 6Gbps SATA
Available HDD Capacities	6TB, 8TB, 10TB, 12TB, 14TB 4Kn/512e, SE/ISE/TCG
Available SSD Capacities	SAS: 400/800/1600/3200/6400GB
Host Interface	1+1 I/O Modules (IOM), 6 HD Mini-SAS ports per IOM (12 ports total)
Management	• In-band management interface • Out of band management • Enclosure health monitor • Enclosure cooling control • System event log • On-line firmware update • Power management • Drive power control (pin 3)

Category	Specs
Physical Dimensions	• Height: 175mm (6.89”) • Width: 447mm (17.61”) • Depth: 1047mm (41.25”) • Depth in Rack: 1186mm (46.72”) w/ CMA
Weight	• Product w/ 102 HDDs: 118.8kg (262lbs)
Power	• 1+1 1600W, 80+ Platinum • 200-240 VAC (1600W max), 50/60Hz • C13 to C14 • Alternating Current (AC)
Cooling	• 4 hot swappable cooling fans • 1 fan module per power supply, air flow through PSU • Fan speed tuning via system management interface
Serviceability	• Hot-swappable IOMs, power supplies, fans and drives

Preliminary specifications - subject to change

Mt. Madonna Platform Leadership

Delivering Ongoing Family Innovation

	4U60 Q1 ’16	4U60G2 Q1 ’17	Mt. Madonna 4U60 Q4 ’17	Mt. Madonna 4U102 Q4 ’17
External Connectivity	2x QFSP+ per IOM	4x HD mini-SAS per IOM	6x HD mini-SAS per IOM	6x HD mini-SAS per IOM
Drive Slots	60	60	60	102
Storage Capacity	600TB[1]	720TB	840TB[2]	1.4PB[2]
Performance	19.2 GB/s	38.4 GB/s	48 GB/s	48 GB/s
Depth	983mm (38.7”) w/ CMA	1110mm (43.7”) w/ CMA	890mm (35.1”) w/ CMA	1186mm (46.7”) w/ CMA
SSD Support	Up to 12	Up to 12	Up to 24	Up to 24
HDD Capacity	4TB – 10TB[1]	6TB – 12TB	6TB – 14TB[2]	6TB – 14TB[2]
Serviceability	Traditional	Traditional	Hot Swappable Parts w/o Cable Removal	Hot Swappable Parts w/o Cable Removal
OOB Management	N/A	N/A	Yes	Yes
Common FRU	N/A	N/A	Across Family	Across Family

[1]12TB is highest supported capacity for 4U60 at present
[2] Higher capacities supported when available

Mt. Madonna Family Innovations

IsoVibe™ Patented Vibration Isolation Technology

ArcticFlow™ Patented Thermal Zone Cooling technology

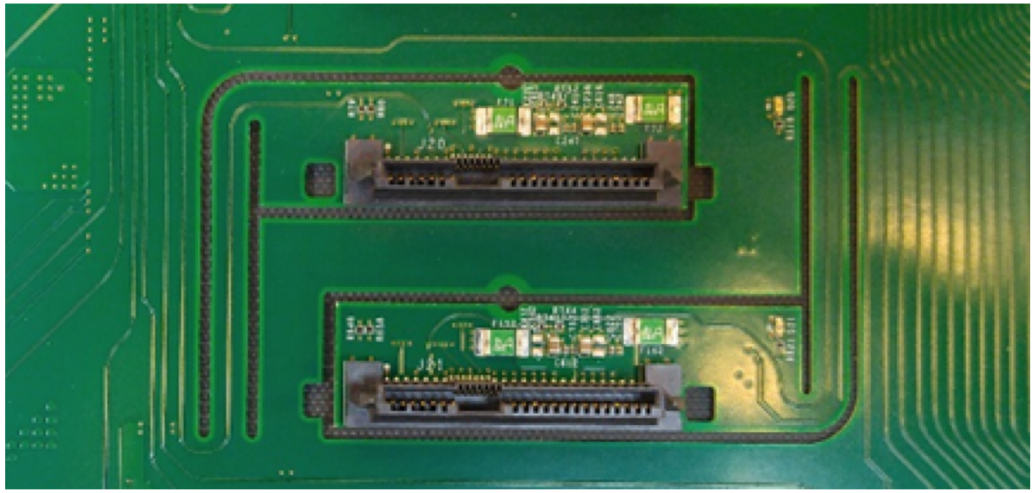
Serviceability – Maximizing “cold aisle” access

IsoVibe™ - What is it?

Isolating Vibration" of the Drive Sockets

IsoVibe™ Patented Vibration Isolation Technology

- **Vibration Isolated HDD Carrier/Slot**
  - Enables future drive technologies with even higher track density
  - Reduces externally induced vibration to the drives
  - Performance degradation < 5% across the platform
- **Vibration Isolated Fans**
  - Dampens vibration from fans into chassis improving drive performance at high temperatures

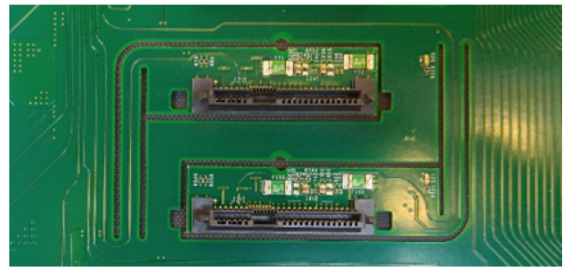


Drive Sockets & Baseboard of 4U60/102

IsoVibe™ - Why Vibration Control is Important

Why Your Customers Should Care

- **The high density of current HDDs comes from ever higher track density**
  - Extremely tight tolerances on positioning the read/write head correctly over the data track
- **External shock and vibration can cause the head to go off track**
  - The external shock and vibration is easily understood, but in a dense array of HDDs adjacent drives that are seeking at high speed can induce vibration into their neighbors
  - **The shock and vibration is detected by sensors on the drive**
    - For reads, the head has to resettle and wait for the correct sector to come around again so that reading can continue
    - For writes, the write gate is shut off so that adjacent tracks are not corrupted. Then the head has to resettle and wait for the correct sector to come around again so that the data can be written in the correct place
  - The overall effect is reduced application performance as additional disk latency is introduced to every operation
- **Shock and vibration control is a significant factor in platform design**
  - Should allow for future HDDs with even tighter track densities to operate at full performance



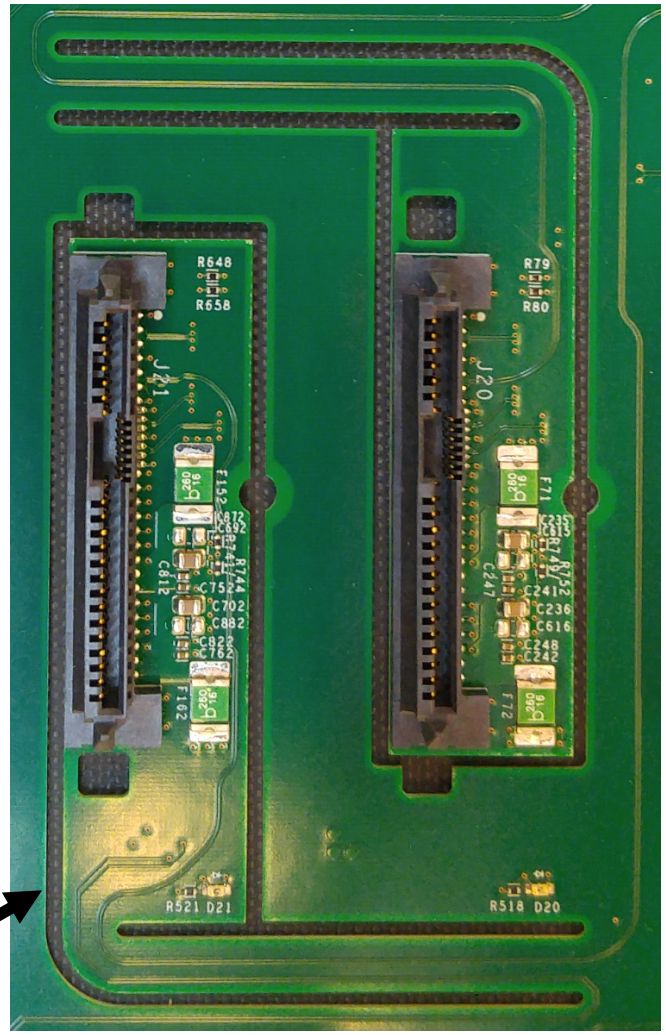
Drive Sockets & Baseboard of 4U60/102

IsoVibe™ at Work

We understand how our drives vibrate better than any other platform supplier!

- Vibration Frequency, Harmonics
- Impact on heads, platters, etc.

- Precise cuts in the baseboard provide "suspension" for the HDDs
- Isolation of the drives reduces the vibration transmitted from one drive to another
- Performance is maintained across the platform, even when all the drives are working hard

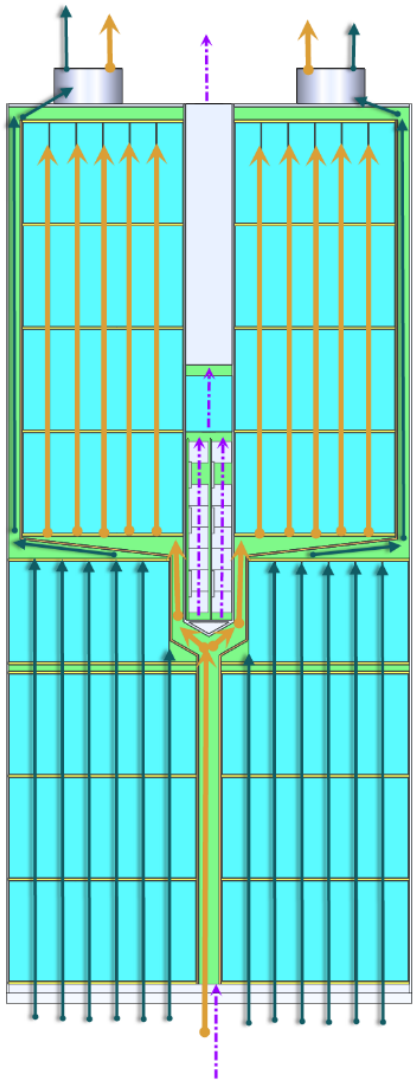


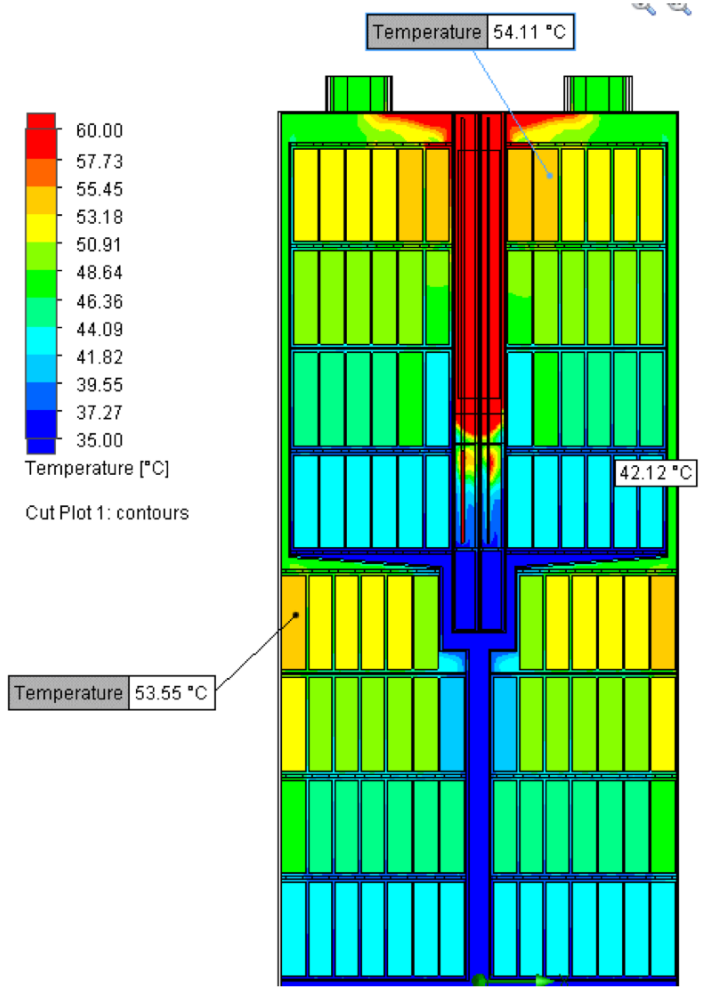
Drive Suspension Cuts

ArcticFlow™ - Patented Thermal Zoning

Design channels outside air directly into center of chassis

- **Thermal Zone Cooling**
  - Reduces internal temperatures and temperature variation across the drives
  - Reduces system fan PWM, reducing power and performance degradation due to fans
- **Zero Loss Backflow Prevention Fans**
  - Completely closes during fan failure to prevent hot air from being recirculated





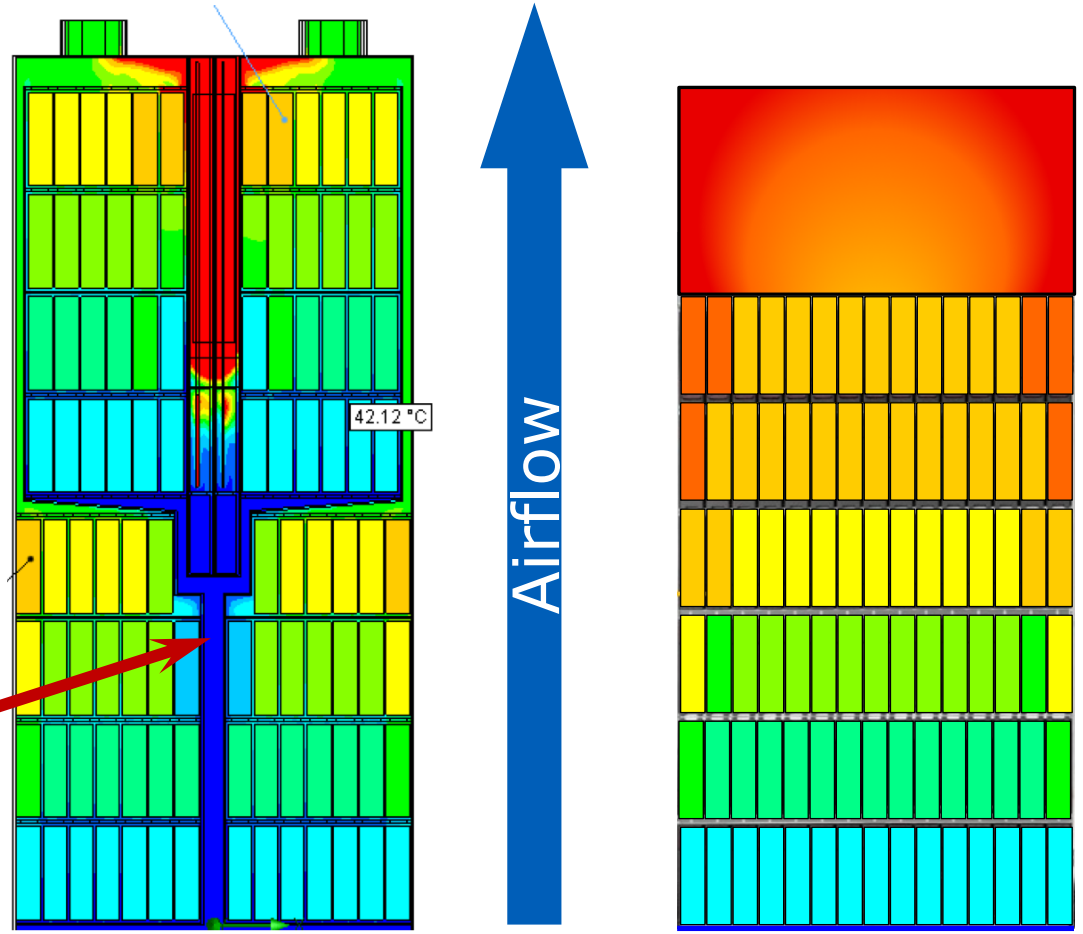
ArcticFlow™ Technology at Work – Thermal Images

Mt. Madonna™ 4U102 versus Competitor's 4U 90-bay Chassis

Mt. Madonna 4U102

- Front Half 14 x 4 rows deep (54 drives)
- Rear Half 12 x 4 rows deep (48x)
- Cold air tunneled directly into center of platform to cool last 4 rows of drives
- **Benefit: Enables lower fan speed to maintain cooling**
  - **Lower power required**
  - **Lower noise levels**
  - **Lower fan vibration**
- **Higher reliability over time due to reduced drive temperatures**

Cold air tunnel in center of Chassis

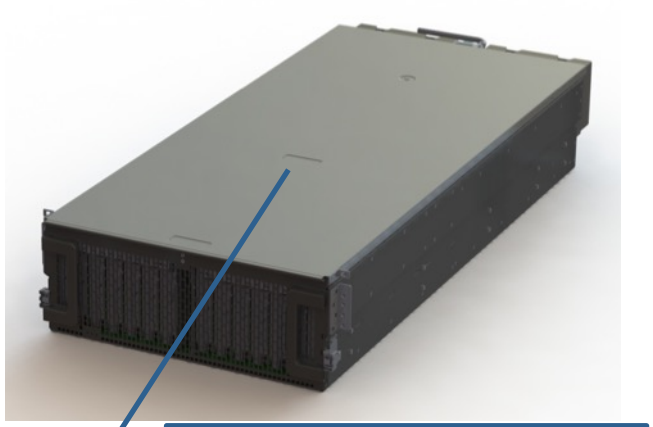


Typical 4U 90-Bay

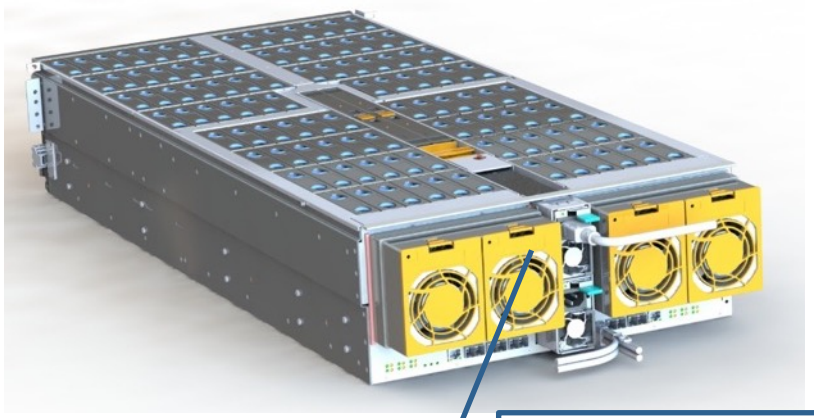
- 6 rows, 15 drives per row
- Warmed air flows over successive rows
- Higher fan speed required to cool rear drives
  - Higher power required
  - Higher energy cost
  - Higher noise levels
  - Higher vibration leading to performance degradation
- Lower reliability over time due to elevated operating temperatures

Mt. Madonna 4U102 Major Mechanical Features

Up to 1.4PB in a 4U Enclosure to fit within a standard EIA 1200mm rack

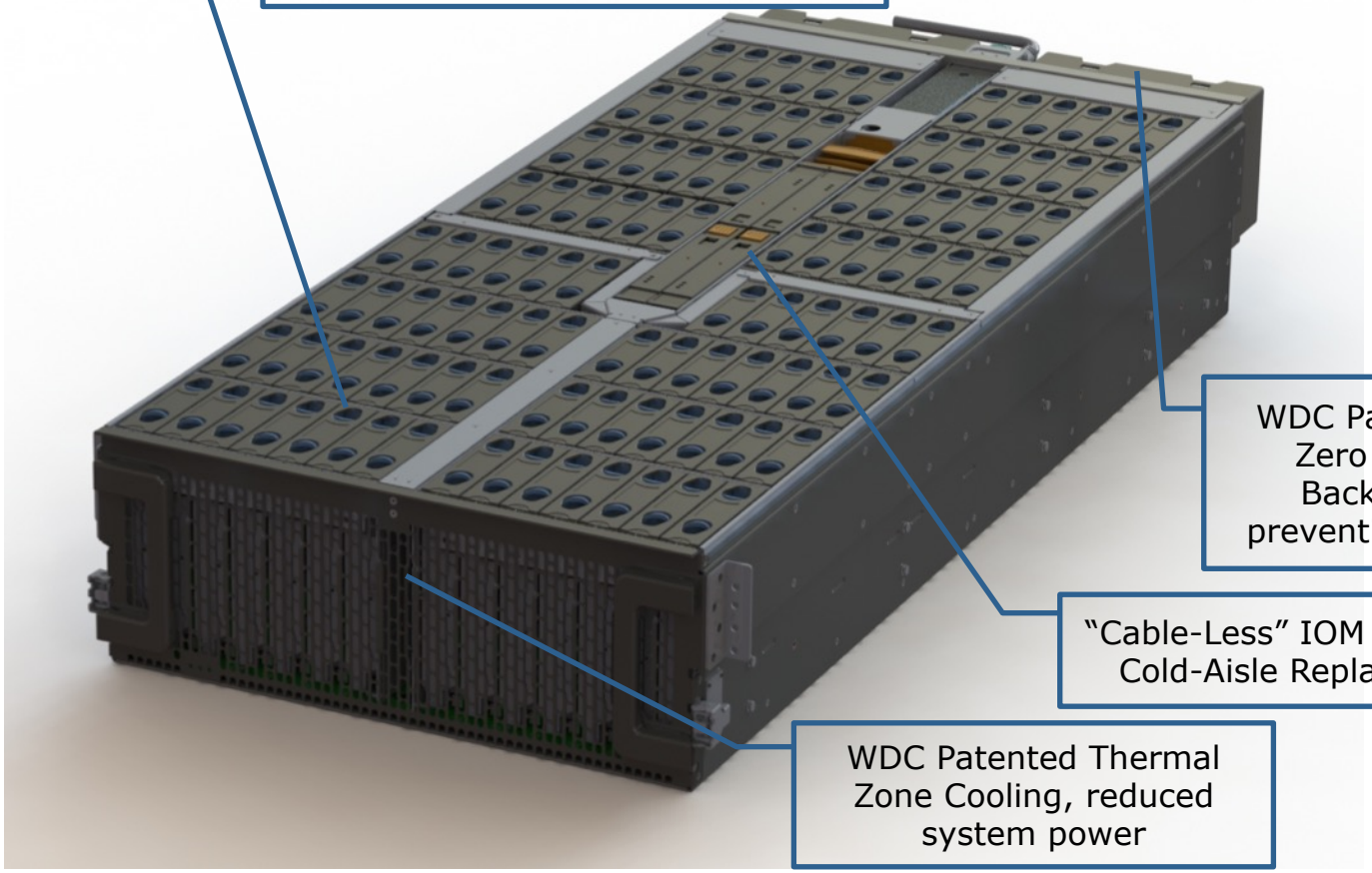


Rack Mounted Top Cover For Quick & Easy Service



Vibration Isolated Fans

WDC Patented Vibration Isolated HDD Carrier/Slot – Designed to enable future SMR HDD tight TPI



WDC Patented Zero Loss Backflow prevention fans

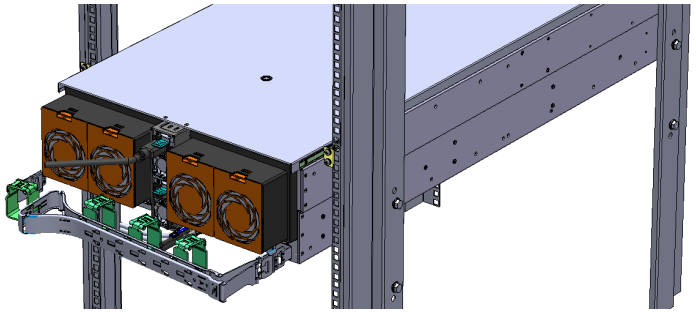
"Cable-Less" IOM Hot-Plug Cold-Aisle Replaceable

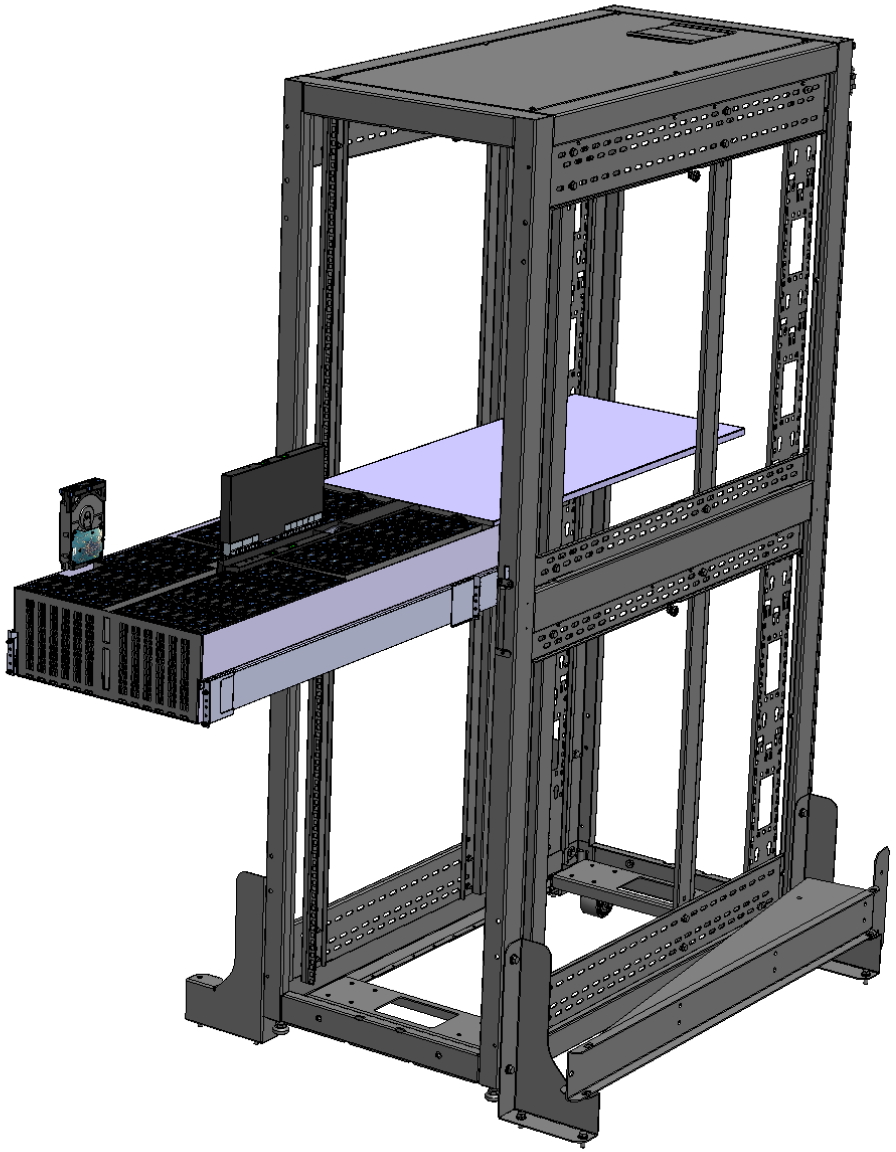
WDC Patented Thermal Zone Cooling, reduced system power

Rack Mounting & Serviceability

- Cold Aisle Service
  - Industry-leading, cable-free, hot-swap IOM
  - Easy-swap, high-availability HDDs
- Hot Aisle Service
  - Fans and PSUs
  - CMA pivots away for easy access
- Lid remains in rack
  - Ease of use, prevents loss/damage

Rear View:
In rack with CMA



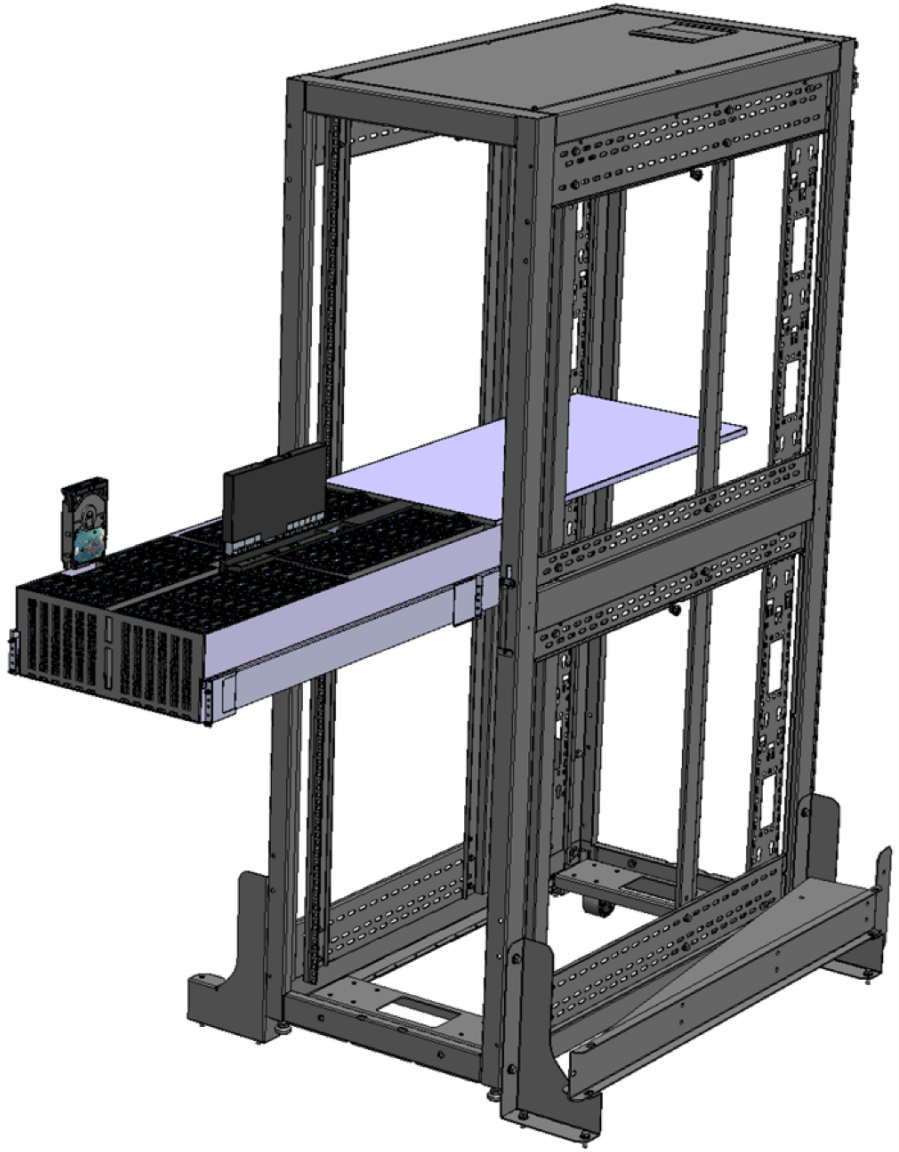


Serviceability – Enabling Maintenance from the "cold aisle"

Maximizing what can be done from the front-side

Serviceability

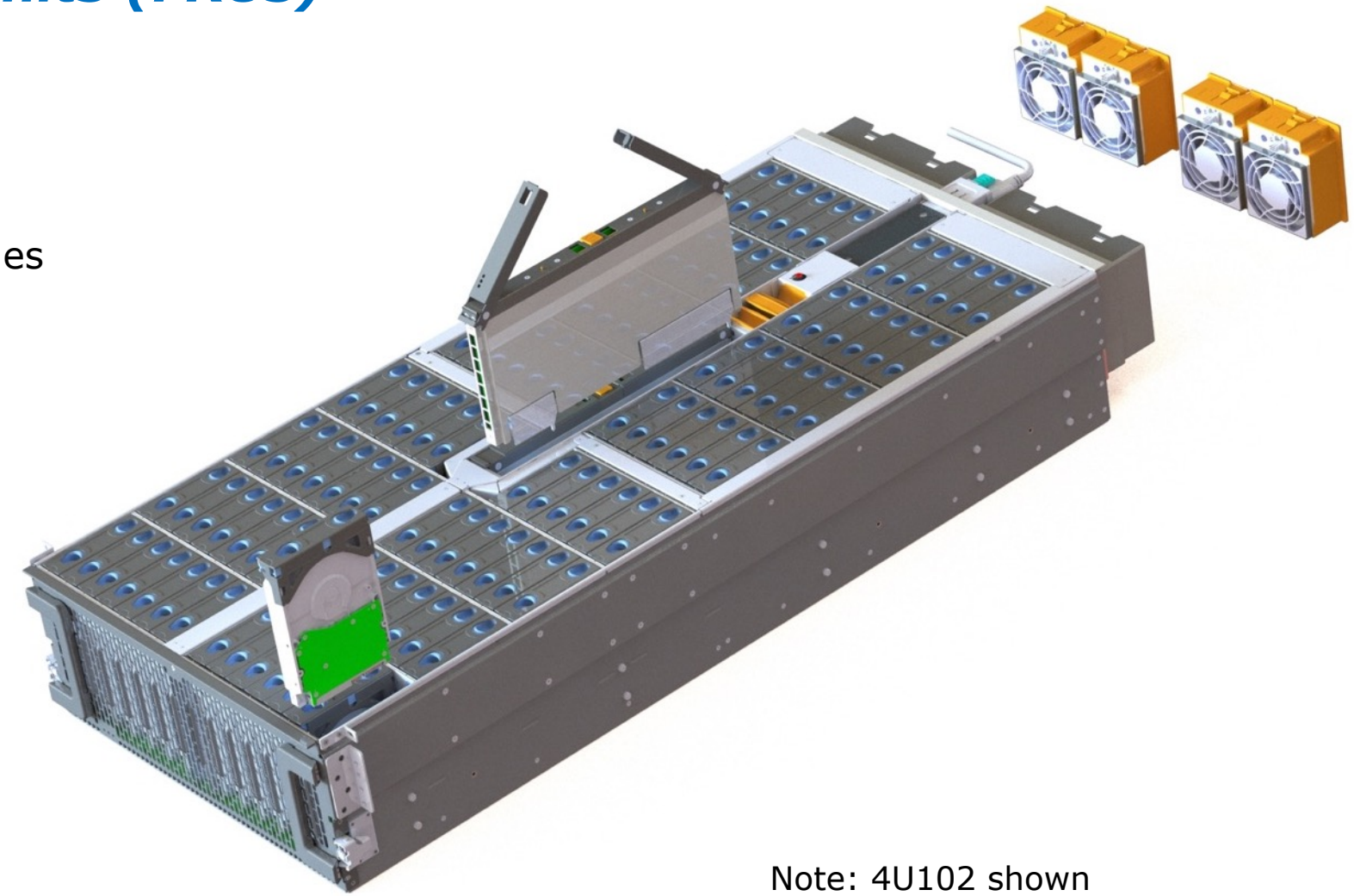
- **Rack Mounted Top cover for Quick and Easy Service**
  - No need to remove or open lid after sliding enclosure out on rails
- **"Cable-Less" IOM Hot-Plug Cold-Aisle Replacement**
  - Cables plug into the chassis baseboard, replacing IOM doesn't require cables to be disconnected



Mt. Madonna 4U60 and 4U102 – Serviceability

Field Replaceable Units (FRUs)

- Cold Aisle FRUs
  - HDDs and SSDs
  - IOMs
    - No need to remove cables
  - IOM Fan
- Hot Aisle FRUs
  - Main Enclosure Fans
  - PSUs



Note: 4U102 shown

Warranty and Support

Warranty	
HDD	5 Years
SSD	Earlier of 5 Years or 1% Endurance
Enclosure	5 Years
Support	
FRU/CRU RMA Replacement on Receipt	Yes
M-F Business Hours	Yes
Fee-based Services	
Advance Replacement Option	Coming Soon
No Return Option	Coming Soon
StorChoice Silver	Coming Soon – 1yr, 3yr, 5yr
StorChoice Gold	Coming Soon – 1yr, 3yr, 5yr
StorChoice Platinum	No

What's in the Box?

Enclosures include everything needed to function

- Mt. Madonna 4U60 Hybrid Storage Platform
  - Up to 60x 3.5" SAS or SATA HDDs
    - Up to 24 of the total 60 can be SAS SSDs
  - Power supplies, power cords
  - Rail kit, CMA
- Customer choices
  - HDD capacity
  - HDD sector size
  - HDD security
  - SSD capacity
  - SSD security

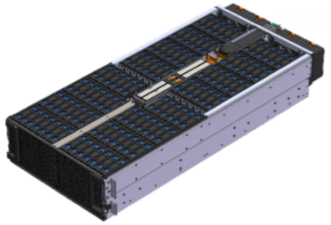
- Mt. Madonna 4U102 Hybrid Storage Platform
  - Up to 102x 3.5" SAS or SATA HDDs
    - Up to 24 of the total 102 can be SAS SSDs
  - Power supplies, power cords
  - Rail kit, CMA
- Customer choices
  - HDD capacity
  - HDD sector size
  - HDD security
  - SSD capacity
  - SSD security

Available Parts

- Base enclosure chassis (L6)
- HDD (installed in drive carrier)
- SSD (installed in drive carrier)
- 3.5” drive carrier with screws
- 2.5” drive carrier with screws
- I/O module
- Power supply
- Fan module
- Rail kit
- CMA
- SAS cable

Mt. Madonna Family Value Proposition

Superior Value Across All Capacities & Drive Types



- 4U102 Hybrid Storage Platform ➔ Density & Availability
  - Custom Designed for Extreme Density – over 1.2PB in 4U of rack space, 11PB in a single rack
  - Enterprise Grade – Designed for High Availability with hot-swappable I/O modules, power supplies, fans
- 4U60 Hybrid Storage Platform ➔ Availability & High Performance in a compact package
  - "Extra Small" – Custom Designed for APAC & space-constrained environments (900mm rack depth)
  - High Performance workloads – will support up to 24 SSDs for larger flash tier
  - Up to 12 server connections – 12 SAS ports (6 x 12Gbps SAS ports per I/O Module)
  - Lightweight – 23lbs (10kg) lighter than prior generations

- Common to both Platforms – Western Digital's 40 years of storage design experienc
  - Ease of Serviceability - Cables plug into the chassis baseboard, servicing IOM doesn't require cables to be disconnected
  - New WDC patents issues for:
    - Vibration isolated HDD carrier/slot Zero loss backflow prevention to maintain cooling
    - Thermal zone cooling for maximum efficiency & reduced system power consumption
    - Vibration isolated fans to reduce performance degradation
      - **Results in performance degradation under 5% across the array**
- Quality & Reliability – 5 year warranty for both enclosure and drives

Mt. Madonna Hybrid Storage Platform Summary

Why Platforms from WDC – 60 years of designing storage is reflected in our Platforms

- Our design excellence and patent portfolio stretches all the way back to the very first disk drive
  - We invented the disk drive and this expertise has made us the largest storage company in the industry
  - Our patent portfolio demonstrates that we understand better than anyone how drives are affected when they are packed into shelves and racks
  - *Our vertical integration – Disks & NAND through Platforms – enables us to deliver these innovations simply better than any other vendor in the industry*
- Patents in our Platforms build on our patents in our Drives
  - **IsoVibe™** vibration isolation technology enables higher capacities without performance degradation
  - **ArcticFlow™** thermal zone cooling technology allows higher density, reduced power and lower costs
- Exploiting the benefits of HelioSeal® HDDs
  - **Delivers up to 1.4PB in a single 4U enclosure**
  - We'll always have the latest technology available to give you a competitive advantage
- Ultrastar HDDs were the first in the industry to offer a 5-year warranty
  - Now we extend that to a **5-Year Warranty on the entire enclosure**


Western Digital.
ThankYou