



Education

Economics of Solid State Storage: Perception & Reality

Terry Yoshii, Intel
Neal Ekker, Texas Memory Systems

- The material contained in this tutorial is copyrighted by the SNIA.
- Member companies and individual members may use this material in presentations and literature under the following conditions:
 - ◆ Any slide or slides used must be reproduced in their entirety without modification
 - ◆ The SNIA must be acknowledged as the source of any material used in the body of any document containing material from these presentations.
- This presentation is a project of the SNIA Education Committee.
- Neither the author nor the presenter is an attorney and nothing in this presentation is intended to be, or should be construed as legal advice or an opinion of counsel. If you need legal advice or a legal opinion please contact your attorney.
- The information presented herein represents the author's personal opinion and current understanding of the relevant issues involved. The author, the presenter, and the SNIA do not assume any responsibility or liability for damages arising out of any reliance on or use of this information.

NO WARRANTIES, EXPRESS OR IMPLIED. USE AT YOUR OWN RISK.

➤ **Economics of Solid State Storage: Perception & Reality**

- ◆ This tutorial will explore how solid state storage (SSS) when appropriately deployed and configured offers cost benefits that will accelerate into the future. The presentation will introduce the application-based Return on Investment (ROI) formula that has driven SSS deployments until recently. Though this formula is still operative in many enterprise environments, the falling price of Flash SSS is driving ever increasing Total Cost of Ownership (TCO)-based SSS deployments. The tutorial will review SSS value vectors, overview server workloads and usage models where SSS can yield lower TCO, and introduce a user-oriented TCO model allowing enterprise assessment using end user specifications and input.

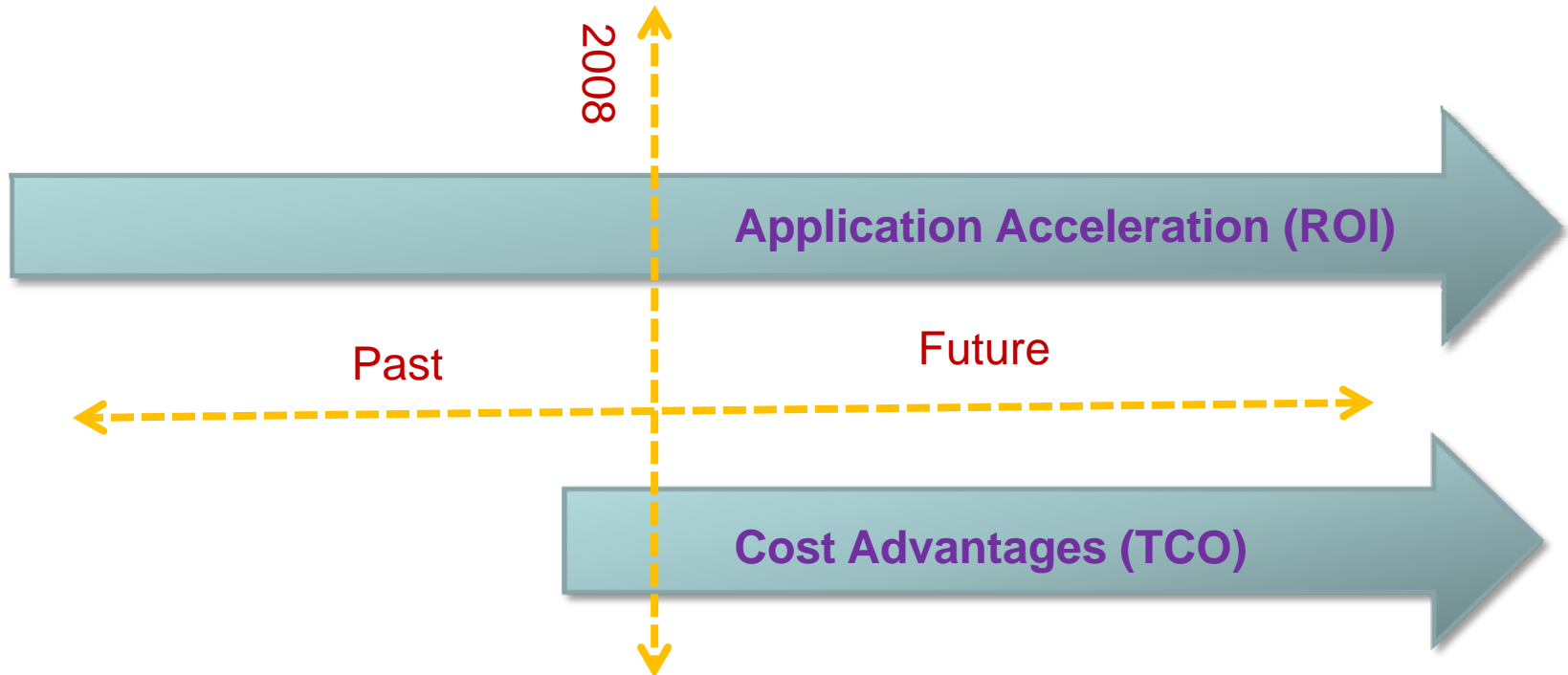
- Introduction and analysis of application acceleration / ROI model for SSS deployments
– Neal Ekker

- Introduction of TCO model for SSS deployments and TCO Calculator
– Terry Yoshii

Perceptions & Realities

- Perception: Solid state storage (SSS) is still too expensive.
- Reality: For many enterprises, SSS has been cost effective for years.
- Perception: SSS can't compete on cost per capacity.
- Reality: Evaluations and comparisons of SSS based on cost per capacity are "...misleading and frequently wrong...*"
- Perception: SSS is a relatively new technology.
- Reality: From a business / application perspective, SSS has offered ROI advantages for years.
- Perception: SSS is only cost effective in certain high performance environments / applications.
- Reality: SSS may already offer TCO advantages over equivalent hard disk drive-based solutions in a broad range of enterprise environments / applications.
- And the TCO advantages will accelerate into the future.

- Business advantages / application acceleration dominated SSS deployments in the past.



- IT infrastructure cost advantages / TCO will accelerate SSS deployments into the future.

Lessons from the Past

- Until recently, IT infrastructure TCO did not play a significant role in enterprise SSS deployments.
- Application acceleration / business advantages drove SSS deployments.
- Application owners / business managers drove SSS decisions more often than IT infrastructure managers.
- SSS deployed to increase profits, improve mission success, or gain competitive advantage.
- Why is this important now?
 - ◆ These points often overlooked in current focus on TCO
 - ◆ Valuable lessons for current / future market development
 - ◆ This type of ROI deployment will continue

Historical ROI Model

- Historical SSS purchases were based on an ROI formula for application acceleration.
- A conceptual way to represent application acceleration ROI might be:

$$(B * P) / C$$

- B = Incremental or quantifiable benefit an application currently supplies to enterprise mission.
- P = Application performance gain provided by SSS.
- C = Deployment cost of the SSS solution.
- When the results of the ratio are greater than 1, SSS ROI is positive.

Lesson from ROI

$(B * P) / C$ not a true formula, just a symbolic expression for SSS application acceleration ROI.

- Thousands of current SSS deployments worldwide using this basic model.
- The cost, “C,” is not restrictive as long as the overall benefit gain $(B * P)$ is greater.
- “...SSD [has been] application-specific storage, designed and purchased to enhance the performance of a specific application with a huge level of importance to the revenue generation of the organization.*”

ROI-based deployments depend on the value of “B.”

- You can't calculate ROI without some input for all 3 variables:
 - ◆ SSS performance gains can be verified with tests
 - ◆ SSS solution costs provided by vendor, but...
- How do enterprises discover the value of an application or its storage performance requirements?
- Without understanding application benefits and / or performance requirements, ROI evaluations aren't compelling.
- This means that SSS adoption rates have strongly correlated with “B” calculations in the marketplace, more than cost.
- It's not the size of the business that determines applicability of the ROI model, it's the type of application and its business importance.

Who Knows Their “B”?

Some enterprises, no matter their size, can more easily calculate and “institutionalize” application importance / benefits:

- Financial services institutions
- Telecommunications providers
- DOD organizations
- Other performance-sensitive public entities
- e-Commerce based companies
- Online gamers and gaming
- Media/entertainment groups, especially video streaming, rendering, and editing
- Science and technology research and development labs
- Energy exploration and management companies and utilities.

These enterprises are among those that evaluate SSS by mission success / ROI, not exclusively by cost savings / TCO.

Alternatively to mission value / business benefit, “B” can also be expressed / understood as an application’s performance requirements.

Ray Lucchesi of Silverton Consulting* investigated SSS and HDD performance trends and the performance requirements of one representative application: **MS Exchange Server**. Some conclusions:

For Flash SSS performance and representative SSS pricing information:

- If an application requires more than 6.2 IOPS/GB of performance it would be cheaper today to buy Flash SSS storage to sustain this performance.
- While it is clear that 6.2 IOPS/GB represents superior performance, **the data shows that multiple Exchange Server configurations already exceed this performance requirement.**
- SPC-I benchmark result trends indicate that the application performance gap is widening.

*Disc-application performance gap and the future of SSS; Silverton Consulting Storint Briefing

Why Do We Care About B?

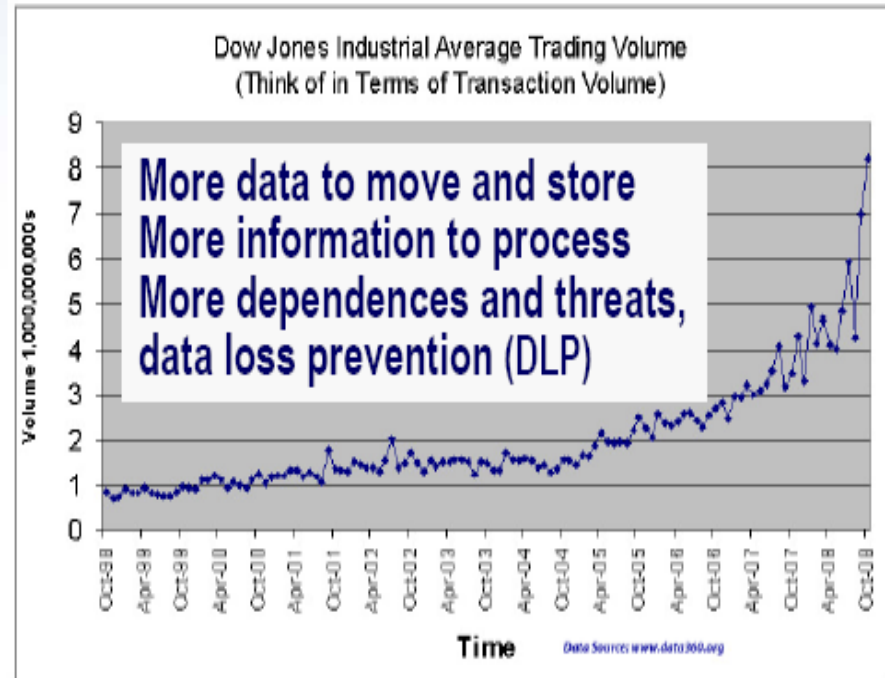
$$(B * P) / C$$

- SSS market stakeholders care about establishing “B” value because it leads to greater SSS adoption rates.
- The more enterprises that can calculate their “B,” the longer the list of SSS adopters.
- “B” discussions highlight that SSS market stakeholders should focus more attention on developing and disseminating “B” calculation strategies and tools to help more enterprises understand the potential value to them of SSS.
- Analysis of “B” value leads away from overly simplistic cost per capacity discussions and towards a more clear and functional perspective of the value of storage performance in mission success.

Will ROI Model Remain Operative?

Greg Schulz of
Storage IO says:

**“Application performance
requirements will
increase.”**



Issues, challenges and drivers

➤ **$(B * P) / C = \text{Future...}$**

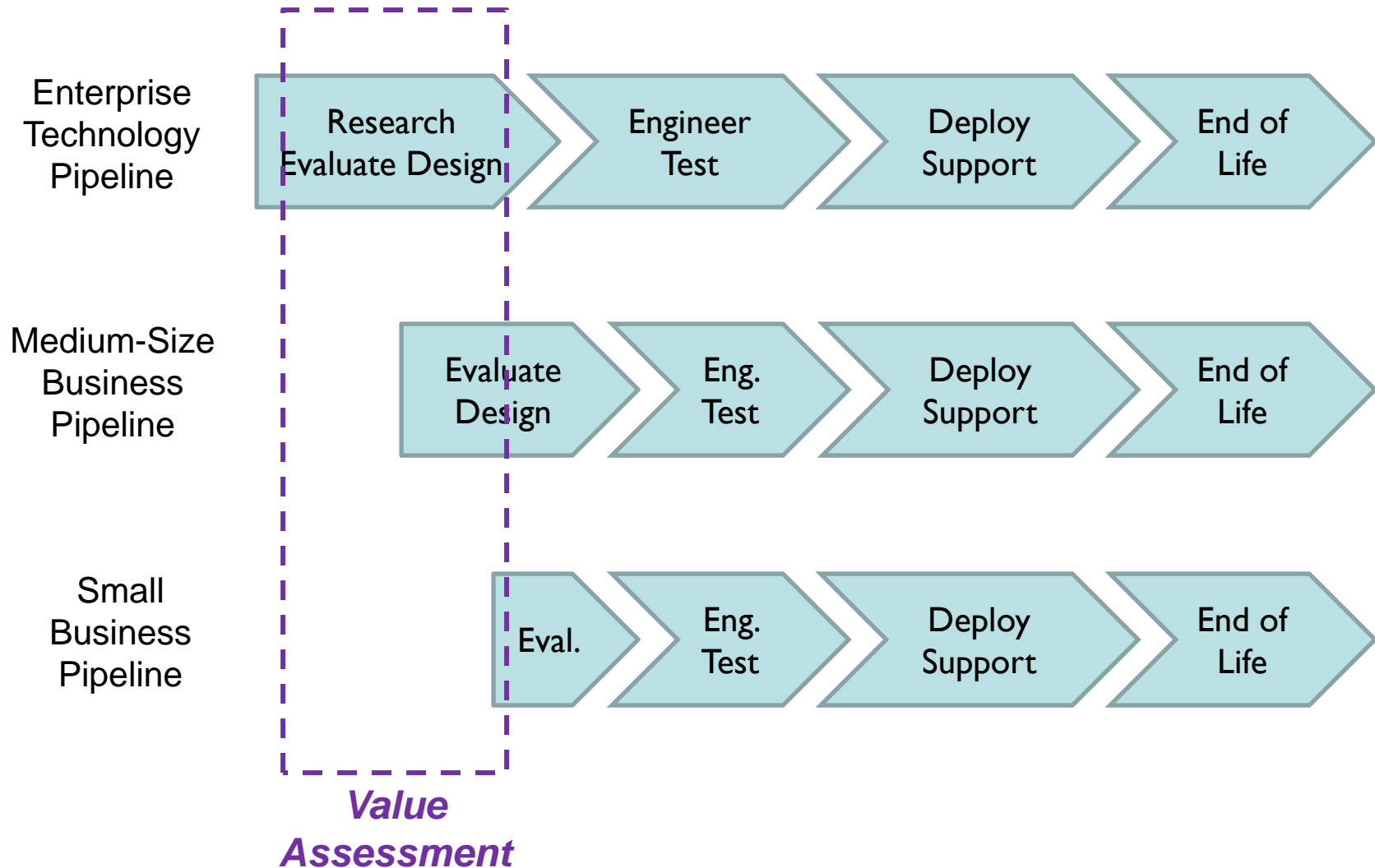
Application Acceleration (ROI)

But what if we don't know “B”?

- Most IT shops don't know or haven't quantified “B” for their applications
- The business value “B”, of application performance improvement, can be misleading and/or difficult to measure
- Most enterprise shops have 100s, if not 1,000s, of applications
- Need a starting place for estimating value of SSDs with what we know

- Question: What will Storage Devices cost over the term of its expected life?
- Used for comparative analysis of optional solutions from a cost/benefit perspective
- All costs need be considered
- Cost is offset by benefits expressed in dollars
 - ◆ Hard Value – Can be quantitatively measured in \$\$
 - ◆ Soft Value – Qualitative value to which \$\$ is assigned (e.g., user productivity, deferred sales, company brand, etc.)

Typical IT Process



Storage Device Value Vectors

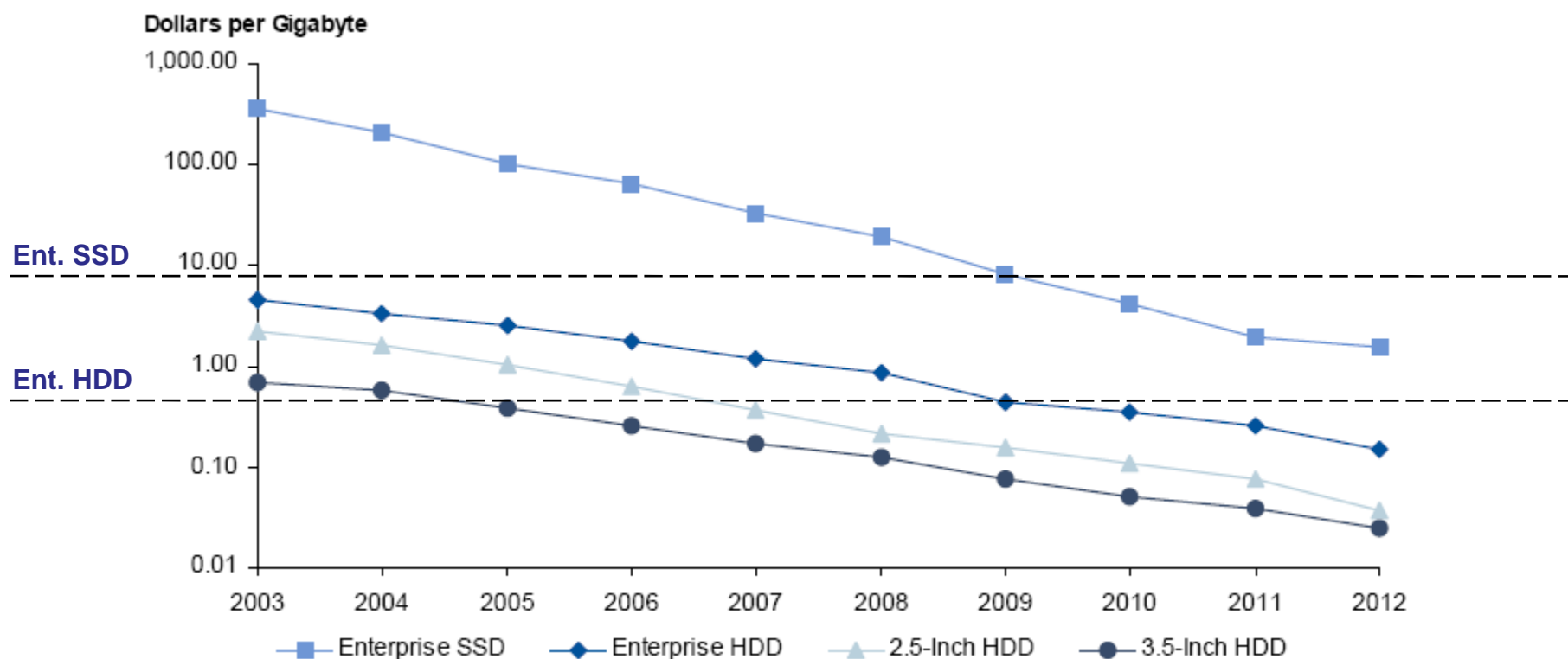
Quantifiable Value Vectors ...

- Capacity (\$\$/GB)
- Performance (\$\$/IOps)
- Power (\$\$ for operation/cooling)
- Reliability (\$\$ in operational support costs)
- Space (\$\$ per sq. ft. of DC space)

Is it the same or different for SSD?

Capacity Value

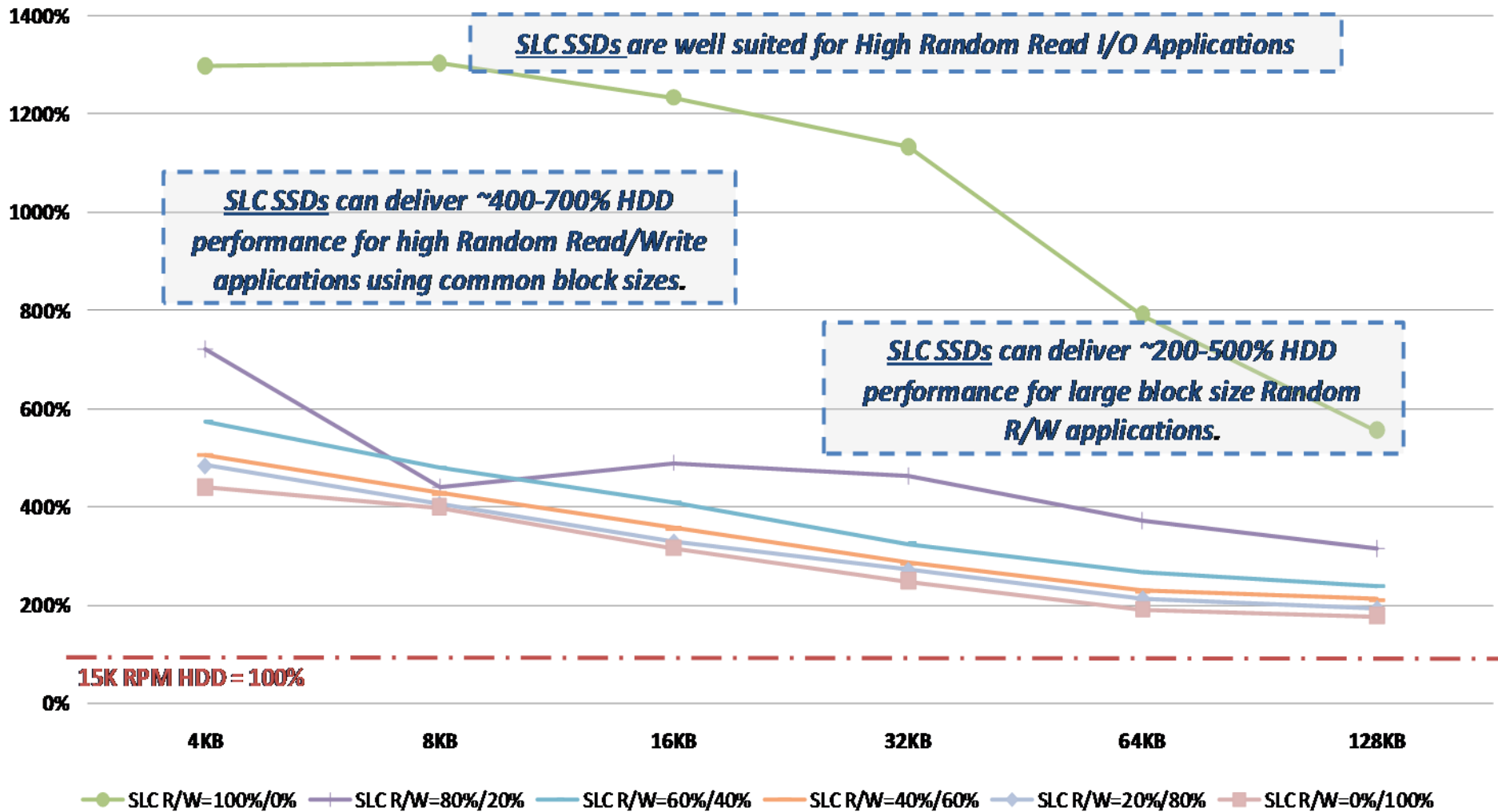
- SSD \$\$/GB is ~10x of Enterprise HDDs
- SSD \$\$/GB is ~4-5x of **15K RPM** Enterprise HDDs



Source: Gartner (January 2009)

Performance Value – Lower \$\$/IO

SLC SSD RAID 5 Relative Perf. - 100% Random I/O (15k RPM HDD = 100%)



- Reduced time for maintenance functions (\$\$)
 - ◆ Boot time
 - ◆ Patch times
 - ◆ Defrag time
 - ◆ RAID Rebuild time
 - ◆ Virus Scan time

- Application performance improvements
 - ◆ “B” - Business value varies by application

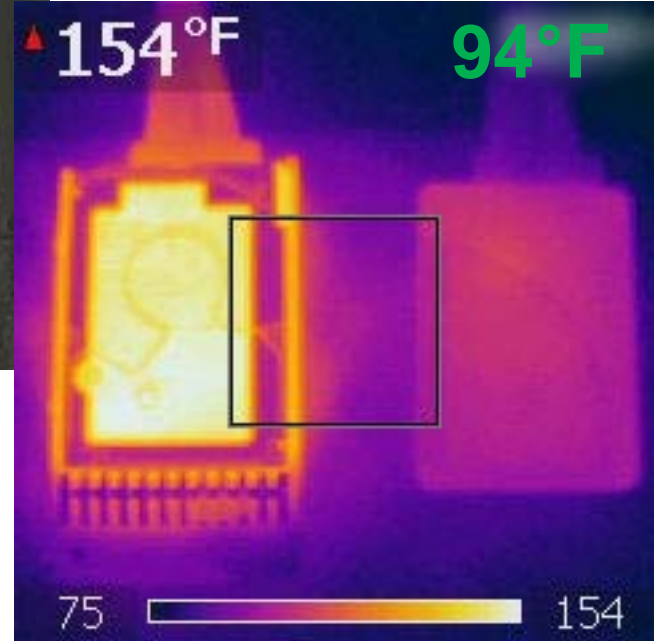
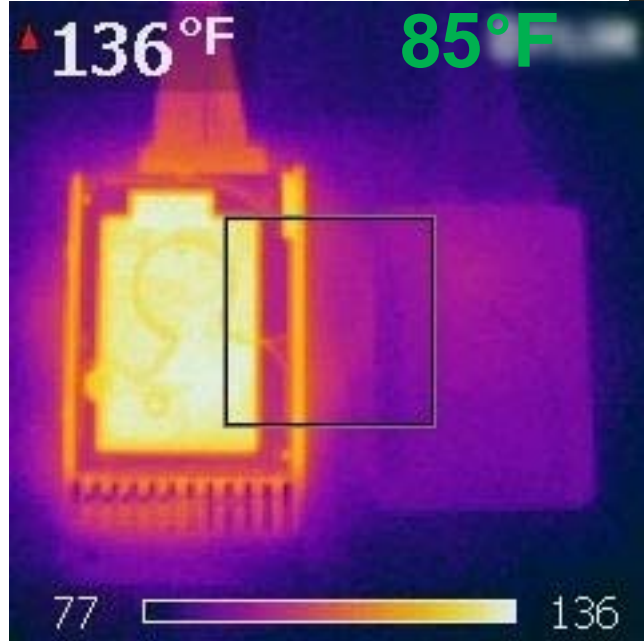
Power Value - Significant Power Savings

15k RPM
HDD

Enterprise
SSD

Idle Temp

Load Temp



SSDs reduce energy cost to operate and cool the data center

6.8W 0.5W

10.1W 0.9W

Idle Power

Load Power

~38% Less Heat, ~90% Less Power

Reliability Value

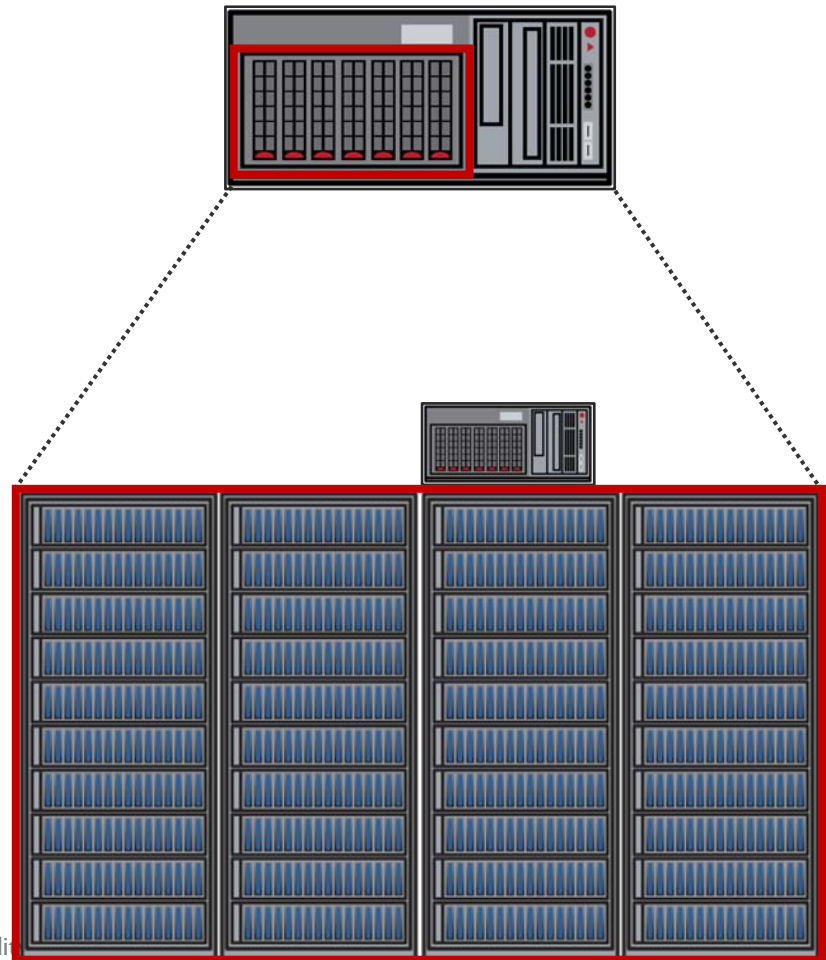
- **HDD MTBF: ~1M hours**
 - ◆ ~4% annual failure rate
- **SSD MTBF: ~ 2M hours**
 - ◆ Lower annual failure rate
- **Cost of disk failures (\$\$)**
 - ◆ Labor for replacement
 - ◆ Restoration of data
 - ◆ Downtime or degraded performance
 - ◆ Scrubbing or Crushing

Space Value Proposition

Fewer Solid State Disks needed to meet IO requirements

Results in:

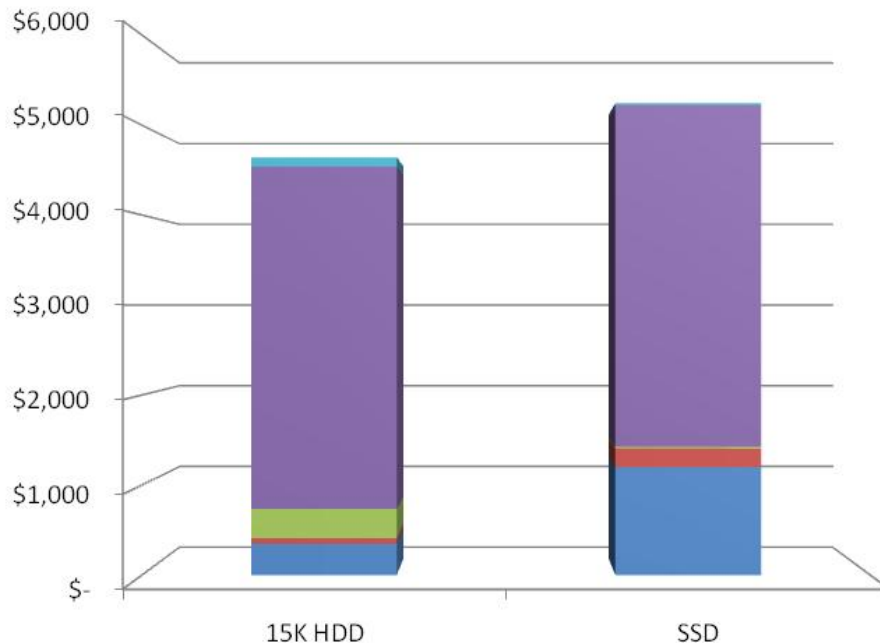
- **Lower Power Consumption**
- **Fewer Frames**
- **Fewer Controllers**
- **Fewer Switch Ports**
- **Fewer Cables**
- **Fewer Power Supplies**
- **Less Data Center Space**
- **Higher System Reliability**



- Input needed to perform a TCO comparison between HDDs and SSDs
 - ◆ # HDDs currently in use
 - ◆ HDD capacity/RPM/interface
 - ◆ Power consumed per drive/array
 - ◆ Total capacity used/required by an application
 - ◆ Application I/O characterization
 - > read/write data access percentage
 - > random/sequential access pattern
 - > average i/o block size
 - ◆ RAID configuration being used
 - ◆ Cost of disks, arrays, maintenance and repairs

Use Case #1

- Description: O/S disk replacement (4 year TCO)
- HDD Assumptions:
 - ◆ Using 2 x 73GB 10k RPM SAS drives – RAID-10
 - ◆ Total usable capacity needed 50GB
 - ◆ Access: 80% read / 20% write, random, 4KB block i/o
- SSD Replacement – 3 x 32GB SSD - RAID 5



- Reliability
- Disk Array
- Power
- Maint/Warranty
- Cost

TCO Increase ~\$624

Performance Increase >1,100%

Power Consumption Reduced >95%



Use Case #1 - Details

HDD Power Cost

Lifetime Cost

HDD Power Cost	\$ 149
HDD Cooling Cost	\$ 179
Total HDD Energy Cost	\$ 328

SSD Power Cost

Lifetime Cost

SSD Power Cost	\$ 20
SSD Cooling Cost	\$ 20
	\$ 40
	\$ 288 <i>Power Savings</i>

Reliability

Lifetime Cost

HDD failure drive replacement cost	\$ -
IT labor costs due to failure	\$ 102
Total Reliability Cost	\$ 102

Reliability

Lifetime Cost

SSD Failure drive replacement cost	\$ -
IT labor costs due to failure	\$ 19
	\$ 19
	\$ 83 <i>Reliability Savings</i>

Drive and Maintenance

Lifetime Cost

HDD Cost	\$ 349
Maintenance/Warranty Cost	\$ 59
	\$ 408

Drive and Maintenance

Lifetime Cost

SSD Cost	\$ 1,200
Maintenance/Warranty Cost	\$ 204
	\$ 1,404

HDD Total Cost of Ownership

\$ 4,641
\$ 4,210
\$ 108
64

Upfront Cost
Per Year Cost
Total usable capacity

SSD Total Cost of Ownership

\$ 5,265
\$ 5,206
\$ 15
64

Upfront Cost
Per Year Cost
Total usable capacity

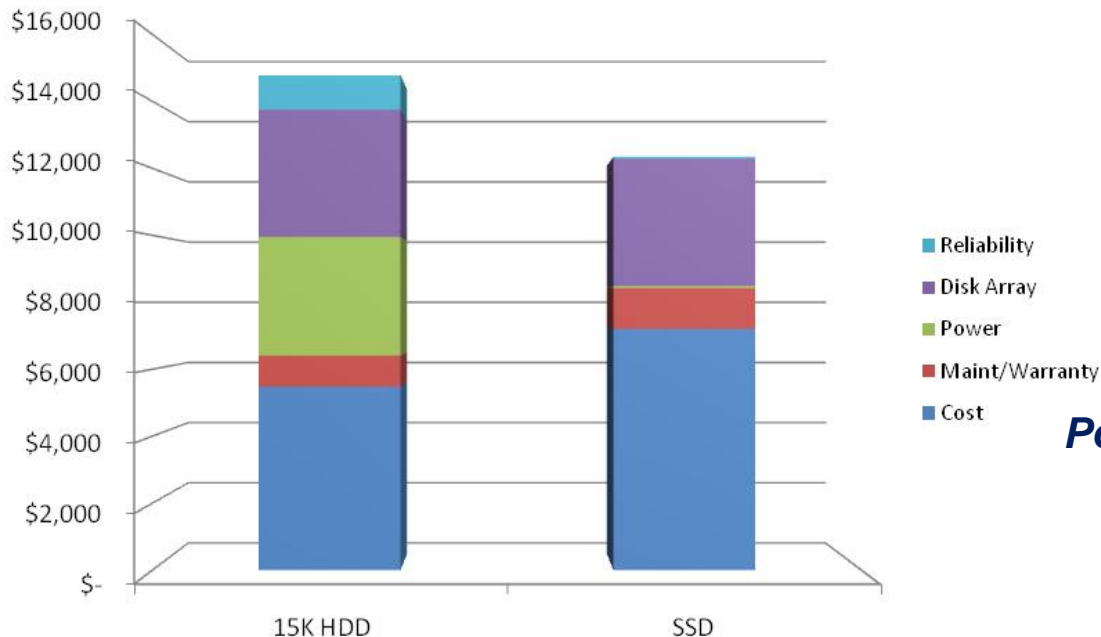
SSD Value for Application

(\$624)

Disk I/O Improvement	1128.65%
Total capacity	64 GB
"Green" drive improvement	95.6%

Use Case #2

- Description: DAS Array Disk Replacement (4 year TCO)
- HDD Assumptions:
 - ◆ Using **20** x 73GB 15k RPM SAS drives – RAID-10
 - ◆ Total usable capacity needed 500GB
 - ◆ Access: 80% read / 20% write, random, 4KB block i/o
- SSD Replacement – **9** x 64GB SSD - RAID 5



TCO Decrease ~\$2,375

Performance Increase >264%

Power Consumption Reduced >98%

Drive Space Reduced ~55%

Use Case #2 - Details

HDD Power Cost

	Lifetime Cost
HDD Power Cost	\$ 1,612
HDD Cooling Cost	\$ 1,934
Total HDD Energy Cost	\$ 3,546

Disk Array

	Lifetime Cost
HDD Cost of Enclosures	\$ 3,250
HDD Enclosure Energy Draw	\$ 552
Total HDD Enclosure Cost	\$ 3,802

Reliability

	Lifetime Cost
HDD failure drive replacement cost	\$ -
IT labor costs due to failure	\$ 1,024
Total Reliability Cost	\$ 1,024

Drive and Maintenance

	Lifetime Cost
HDD Cost	\$ 5,475
Maintenance/Warranty Cost	\$ 931
	\$ 6,406

HDD Total Cost of Ownership

Upfront Cost	\$ 10,208
Per Year Cost	\$ 1,143
Total usable capacity	1,095

SSD Power Cost

	Lifetime Cost
SSD Power Cost	\$ 60
SSD Cooling Cost	\$ 60
	\$ 119
	\$ 3,427

Disk Array

	Lifetime Cost
SSD Cost of Enclosures	\$ 3,250
SSD Enclosure Energy Draw	\$ 552
Total SSD Enclosure Cost	\$ 3,802
	\$ -

Reliability

	Lifetime Cost
SSD Failure drive replacement cost	\$ -
IT labor costs due to failure	\$ 58
Total Reliability Cost	\$ 58
	\$ 966

Drive and Maintenance

	Lifetime Cost
SSD Cost	\$ 7,200
Maintenance/Warranty Cost	\$ 1,224
	\$ 8,424

SSD Total Cost of Ownership

Upfront Cost	\$ 12,226
Per Year Cost	\$ 44
Total usable capacity	512

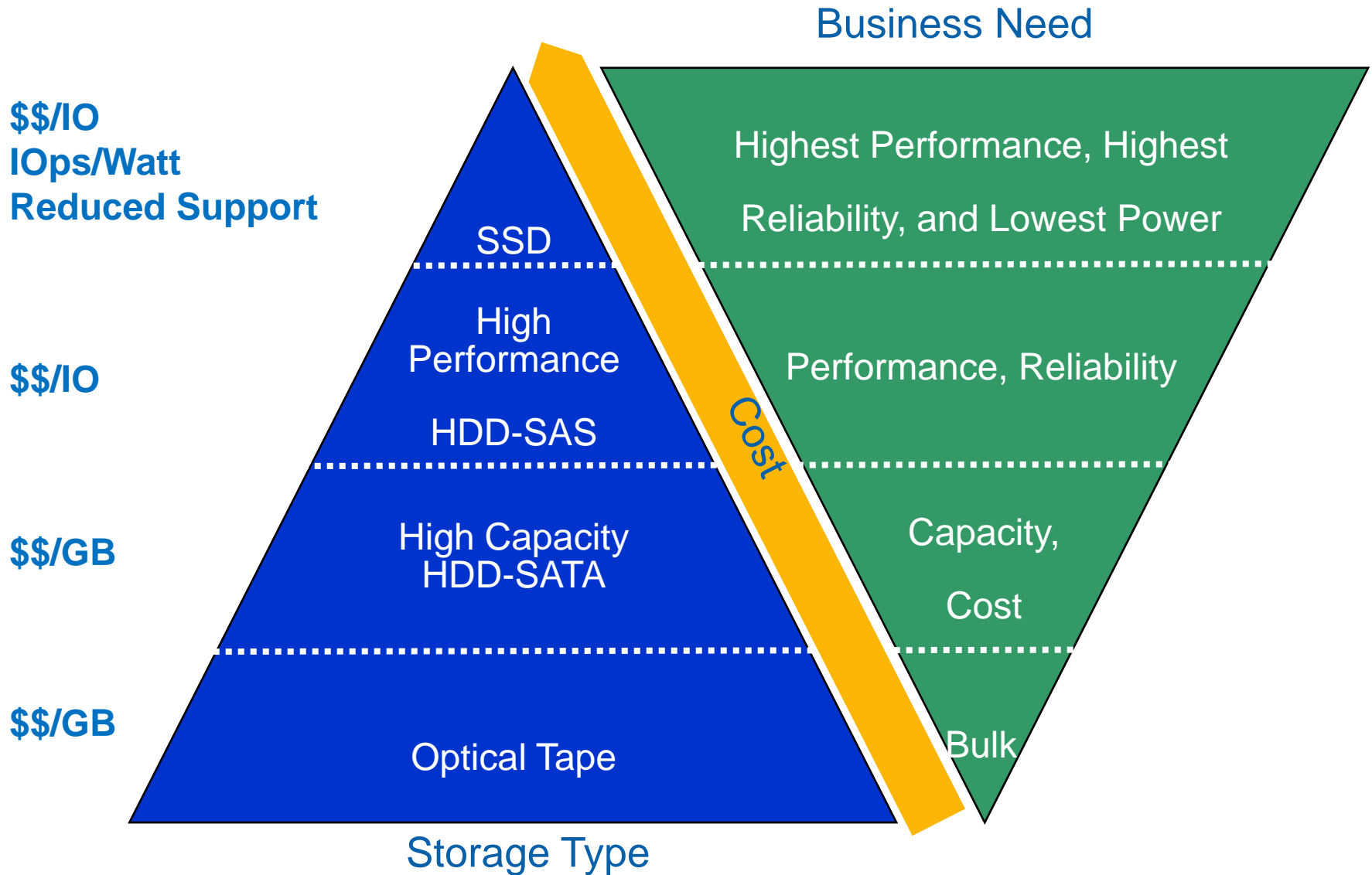
SSD Value for Application

Disk I/O Improvement	264.47%
Total capacity	512
"Green" drive improvement	98.8%
	29

So Where Might SSDs Fit?

Vertical	Platform Requirements	Storage Type	HDD Drive Interface	Target Apps (IO intensive/BW Intensive/Memory Intensive)
Portals (IPDC)	<ul style="list-style-type: none"> • Low Latency • Longer Lifetime • Efficient Space/Power 	DAS	SAS	<ul style="list-style-type: none"> • Portal search, Search video, large search index, Social networking, CDN, Web caching
Cloud (IPDC)	<ul style="list-style-type: none"> • Efficient Space/Power • Higher Throughput 	DAS	SAS/SATA	<ul style="list-style-type: none"> • High Performance Database, Virtualization
FSI	<ul style="list-style-type: none"> • Low Latency • Efficient Space/Power 	NAS	SAS/SATA	<ul style="list-style-type: none"> • Transaction processing/OLTP, FSI Analytics
HPC	<ul style="list-style-type: none"> • Higher Throughput 	DAS	SAS/SATA	<ul style="list-style-type: none"> • CAE/CAD, CT Scans, DCC, Energy Seismic, Reservoir, Visualization, DC clusters (hdd rep), DCC (Digital Content Creation), Bio Simulation, Weather Forecast, Climate Research, Reservoir Modeling, FEA
Telco (IPTV)	<ul style="list-style-type: none"> • Longer Lifetime • Higher Throughput 	DAS, NAS	SAS/SATA	<ul style="list-style-type: none"> • IPTV, IPDC, HLR/HSS, video delivery, video editing (creation), VOD, webcasting
Ext Storage	<ul style="list-style-type: none"> • Higher Throughput/Bandwidth • Efficient Space/Power • Longer Lifetime 	NAS/ SAN	SAS, FC (Perf) SATA (HC)	<ul style="list-style-type: none"> • OLTP • Database (indexes, logs, journals) Messaging (MSFT, IBM), • ERP • CRM
IT (Ent)	<ul style="list-style-type: none"> • Higher Throughput • Longer Lifetime • Efficient Space/Power 	DAS, NAS & SAN	FC/SAS/ SATA	<ul style="list-style-type: none"> • Virtualization • B2B-Extranet portals, SAAS Delivery, Product Lifecycle Management, Sales force Automation, eCommerce
IT (SME)	<ul style="list-style-type: none"> • Higher Throughput • Longer Lifetime • Efficient Space/Power 	DAS, NAS, SAN	SATA	<ul style="list-style-type: none"> • Data Warehousing • Business Intelligence • Business Analytics/Data Mining • Decision Support

Summary



Economics of SSS: Perception & Reality

© 2009 Storage Networking Industry Association. All Rights Reserved.

Call to Action

- Stop using \$\$/GB as the only metric for HDD/SSD value
- Assess full TCO based on your own costs and data
- Identify appropriate use of SSDs in your environment
- Add application/business benefit to overall TCO
- Look for additional value (encryption, compression, secure erase, etc.)
- Keep an eye on pricing and capacity
- Be aware of next generation SSD technologies
- Help develop an Industry Standard SSD TCO Calculator ...
visit www.StorTOC.org

Questions?

- Please send any questions or comments on this presentation to SNIA: tracksolidstate@snia.org

**Many thanks to the following individuals
for their contributions to this tutorial.**

- SNIA Education Committee

**George Crump
Ray Lucchesi
Greg Schulz**