Total Cost of Solid State Storage Ownership

An In-Depth Analysis of Many Important TCO Factors

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The Solid State Storage Initiative

The Solid State Storage Initiative (SSSI) was formed to foster the growth and success of the market for solid state storage in both enterprise and client environments. It consists of various subcommittees that are focused on developing technical standards and tools, in order to educate users about the advantages of SSS devices.

The goal of the TCO subcommittee of the SSSI is to educate end users on the true value of SSS devices in an enterprise environment. It has developed a Total Cost of Ownership Calculator to assist enterprise data storage users to assess and compare various storage deployments.

Introduction

When comparing Solid State Storage (SSS) devices with Hard Disk Drives (HDDs), many people stop after reviewing the initial acquisition cost of both storage media and conclude that SSS devices are still too expensive to be seriously considered. However, when comparing storage alternatives, acquisition cost is just one of the many parameters that need to be considered. A better tool for comparison is Total Cost of Ownership (TCO), where factors such as performance, power consumption, reliability, maintenance, repair, and many other factors are taken into account.

This white paper reviews the many aspects of TCO that should be considered when choosing a storage solution. It will show a TCO calculation for a random write intensive Microsoft Exchange email application, designed for 2,000 heavy Blackberry users. The calculation will compare the cost between the implementation of an SSS-based system and an HDD-based system. The TCO results indicate that SSS is a better choice than HDD for this application.

The TCO Calculator subcommittee of the Solid State Storage Initiative (SSSI, a program of the Storage Networking Industry Association) has developed a Total Cost of Ownership Calculator to assist enterprise data storage users in assessing and comparing various storage deployments. The goal of this committee is to educate end users on the true value of SSS devices.

The SNIA SSS TCO Calculator, in Microsoft Excel 2007 format, is available for download from the SNIA website at http://www.snia.org/forums/sssi/programs/TCOcalc. The TCO calculation example in this white paper utilizes the SNIA SSS TCO Calculator.

Defining Total Cost of Ownership

A TCO calculation is designed to assess both direct and indirect costs of owning a storage product or system over its life cycle. Direct costs are traditionally what organizations find easiest to measure. Typically, direct costs are made up of labor and capital costs. Indirect costs are more difficult to measure and rationalize. According to various industry studies, the costs incurred after the initial deployment can comprise up to 80% of the total IT cost. It costs more to operate

a storage device over three years than to buy it. When performing a TCO study, the following parameters should be considered:

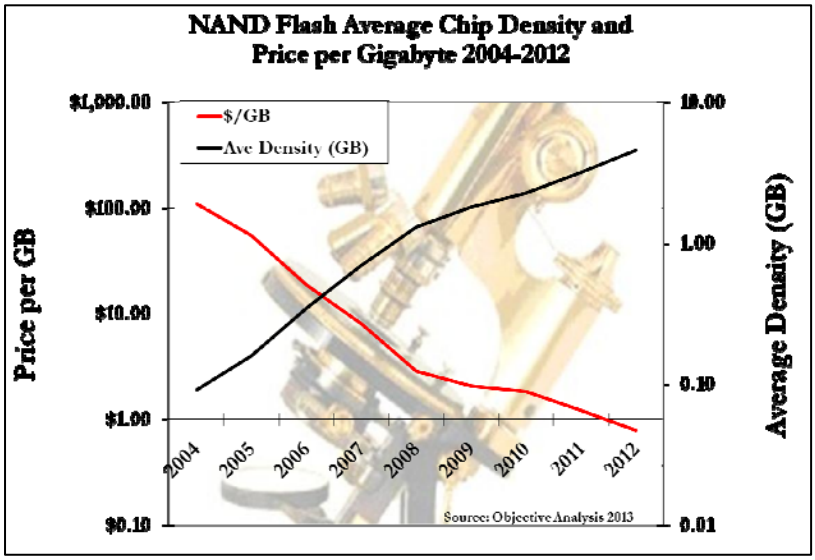
- Acquisition
- Maintenance and Repair
- Power and Cooling
- Performance
- Productivity
- Refresh Cycles
- Endurance

Storage is one of the main components in any mission-critical system and requires thorough scrutiny. Performance, failure rates, power consumption, and maintenance/repair are all cost factors that should be reviewed when choosing the appropriate storage technology. Total Cost of Ownership, once appropriately measured, analyzed and managed, is a critical means of controlling storage expenditures and measuring the effectiveness of a storage implementation.

Acquisition Cost

Enterprise-grade SSS costs roughly 5x more than enterprise-class HDD in terms of cost per gigabyte (GB). When comparing the acquisition cost of SSS vs. HDDs in a high random I/O (input/output) transaction application (i.e. Exchange email, banking transaction, etc.), given a robust storage subsystem interconnect architecture, an SSS device can be used to replace an array of 10 or more HDDs, providing a much smaller footprint, higher performance, and lower hardware and software licensing costs.

Figure 1: SNIA SSS TCO Calculator Screenshot



In the past, the main barrier to the deployment of SSS devices has been their high cost per gigabyte. Figure 1 shows that the cost barrier is diminishing rapidly, with flash prices showing an average 30-40% yearly decline over the past decade. For example, analyst firm Gartner expects prices for enterprise server SSDs to decline from $1.90/GB in 2012 to $.28/GB in 2017 as the

industry moves to 1z nm flash. Similarly, enterprise storage SSD prices will decline from $4.45/GB to a mere $.54/GB in 2017, an 88% reduction over five years.

Flash manufacturers continue to push product roadmaps to increase density and reduce costs. Samsung recently announced that it is moving into mass production of its 3D V-NAND flash that reads and writes twice as fast, consumes 50% less power, and will last 10 times longer than current 2D flash technologies. Micron has announced a similar plan to move to 3D flash technology.

The net result of product advancements such as 3D flash will be increased reliability and downward pressure on prices to the point that all-flash storage arrays will be priced competitively with performance based enterprise HDD arrays.

Maintenance and Repair

HDDs are the number one failing component being replaced in storage systems worldwide, causing an overall increase in TCO. The overall failure rates in controlled environments show ranges from 2% to 8.6%, based on existing studies and industry data[1,2].

An annual failure rate of 2-8% indicates that as many as one out of every 12 HDDs deployed will fail every year. Replacement cost can be much higher than just the cost of the drive itself, when the costs of service personnel and system downtime are taken into consideration. In addition, factors such as liability related to service level guarantees, company reputation and customer satisfaction are important as well.

SSS device support and maintenance requirements are determined by multiple factors – product level quality, product life, and number of units deployed. Dependent on manufacturer and design, SSS devices can outperform HDDs in all of these areas, saving time, money and resources required for storage system maintenance.

Power and Cooling

Currently, Data centers consume 2% of all U.S electrical power output and between 1.1% and 1.7% of global power output[3]. A recent census indicated that global energy consumption by data centers increased 63% from 2011 to 2012 and is expected to increase an additional 17% in 2013. Cooling accounts for over 50% of data center power consumption while servers and storage account for an additional 25%[4]. Several studies indicate that in the coming years, energy costs will consume up to one-third of IT budgets.

Because SSS devices have no rotating media, read/write heads, actuators, or spinning motors, it is easy to understand why SSS power consumption numbers are substantially lower than those for HDDs. In some Tier 0 & 1 storage systems, SSS devices can save over 80% in total storage system energy requirements. Taking that one step further, iSuppli estimated that if SSS were used in place of high performance HDD-based storage systems, global data center power consumption could be reduced by more than 166 Megawatts Hours over a five-year period[5], more power than is used by some small countries in an entire year.

1 Failure Trends in a Large Disk Drive Population, Google Inc., 2007

2 Disk Failures in the Real World: What Does an MTTF of 1,000,000 Hours Mean to You? Carnegie Mellon University, 2007

3 Data Centers Use 2% of U.S. Energy

4 Info-tech Research Group, 2010

5 iSuppli Energy Savings Forecast

In data center applications that perform high random read/write transactions, hundreds of short-stroked HDDs must be deployed to offset the low I/O performance inherent to each HDD. A short-stroked HDD only uses a fraction of its capacity as a method to improve access time. For example, a well-known Tier-1 OEM storage system that offers 123,000 IOPS uses 512 HDDs to achieve this level of performance. Because all the HDDs are short-stroked and the data is mirrored for data redundancy, the system's 53TB of internal storage capacity pares down to only 9TB of usable space.

In mixed read/write applications, such as a Microsoft Exchange Server, the data is presented in small block I/O (4 - 8Kbyte file size). These small random block transfers require more disk seek operations, each suffering from the average read/write latency for standard HDDs. Enterprise-grade SSS devices are designed to handle an extremely high volume of small block random I/O transfer operations and are a good fit for these applications.

Today's enterprise and server-class data center applications that require more than 100,000 IOPS, such as social network services and multi-million record databases, are becoming very common. A number of companies have introduced PCIe SSS solutions to satisfy the operational requirements of these applications.

RAID Configuration

RAID configurations can greatly improve performance and reliability, offering many advantages over the use of individual HDDs. The current RAID configurations and vendor implementations are tuned to mask I/O latency that is inherent in HDDs. Therefore, the performance advantage of SSS versus HDD may not be as pronounced in a RAID configuration.

RAID controller vendors are beginning to implement numbers of new features such as Native Command Queuing (NCQ), TRIM and SSS auto detection in an effort to further enhance the performance and reliability of the SSS devices. Different levels of RAID provide different tradeoffs in terms of performance, capacity, cost and reliability. RAID 1 (disk mirroring) is used in the TCO calculation for critical email data storage.

Productivity

When analyzing TCO it is important to consider the intangible costs and benefits that result from technology transitions. One such benefit is improved worker productivity. This often results from improved application performance whereby users process more transactions in a given amount of time. Consider a travel reservation system; reduced wait times lead to higher bookings and increased sales.

Productivity, however, is not measured strictly in terms of worker efficiency. In the world of automated financial trading, companies make money in two ways - on each transaction and the speed at which transactions are completed. Microseconds can often mean the difference between making and losing money. Yet another source of productivity gains is improved IT efficiency. Any change that impacts existing IT staff and their ability to manage assets should be considered as part of a TCO analysis.

Worker and system productivity are different for every organization, and they can be difficult to capture and quantify. Moreover, they are beyond the scope of the SNIA SSS TCO Calculator. Still, basic productivity can be measured even if the *Before* and *After* transaction times and

quantity are the only variables known. A vendor sponsored study conducted by IDC found that productivity gains achieved by study participants represented 42% of the total project ROI, equivalent to an additional 2-3% of worker productivity.

Refresh Cycles

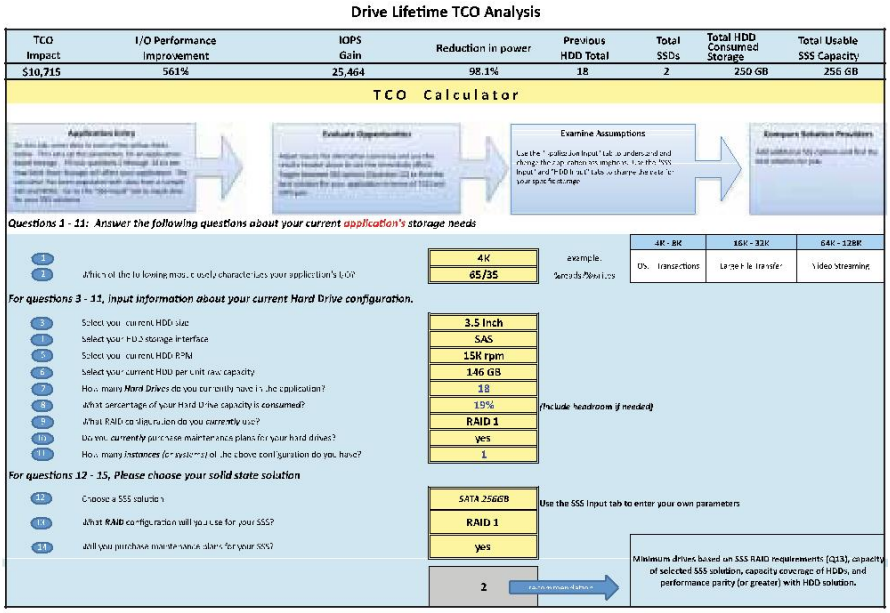
Historically, IT infrastructure gets refreshed regularly to take advantage of advancements in technology and to scale with user needs. Refresh cycles are often aligned with accounting-based asset depreciation schedules, ranging from 3-5 years. However, mobile device, cloud, and big data are forces driving businesses to upgrade their IT capabilities at an ever increasing rate. This vicious and costly cycle is both resource intensive and fraught with risk.

It is important to consider the impact of an investment on the refresh cycle. Will it extend the useful life of an asset thus slow the pace of investment? Does it improve application or performance scalability? Virtualization is a perfect example. Its use has had a dramatic affect on overall server demand. Fewer physical servers means reduced capital investment; however, it also means increased operating expenses, increased system complexity and the need for new tools and administrator skills. This shift in cost must be considered.

SNIA SSS TCO Calculator

The SNIA SSS TCO Calculator will ask users to answer a number of questions about the configurations of their storage system, including specifications and cost of both SSS devices and HDDs. The TCO Calculator is populated with sample data from SSS devices and HDDs for the user's reference.

Figure 2: SNIA SSS TCO Calculator Screenshot



User input fields are marked in yellow in the various tabs. Figure 2 shows a screenshot of the main page of the TCO Calculator.

The TCO Calculator guides users through a 5-step approach in order to calculate accurate TCO results:

Step 1: The *README Tab* contains details on how to use the TCO Calculator.

Step 2: The *TCO Calculator Tab* asks users to enter data describing the technical setup of their storage system.

Step 3: The SSS Input Tab allows users to enter SSS information, such as capacity, cost per drive, power consumption, and random read/write performance data of proposed SSS devices.

Step 4: The HDD Input Tab allows users to either change the HDD specification, such as power consumption, cost per drive, random read/write performance, or leave the values at default settings.

Step 5: The *System Environment Tab* allows the user to input parameters on cost of maintenance, power consumption, disk enclosures, etc.

TCO Calculation Example

Transaction oriented applications, such as Microsoft Exchange Server, require significant data throughput, typically measured by I/O transactions. To meet the high I/O performance requirements, conventional HDD-based servers have to increase the number of short-stroked HDDs.

The following example shows a Microsoft Exchange Email Server, configured for 2,000 Blackberry heavy email users, with 100MB storage per mail box and 3 IOPS per user. The SNIA SSS TCO Calculator (rev 1.2) is used in this example to compare the Total Cost of Ownership for HDD and SSS storage alternatives.

Assumptions are:

- *Workload Read/Write ratio: 65% Read / 35% Write*
- *Block Size: 4Kbyte random small block I/O*
- *A short stroked 3.5 inch 146GB 15K SAS HDD can sustain 479.7 IOPS (4Kbyte block size)*
- *An enterprise-grade 2.5 inch 256GB SATA SSS can sustain 30,000 IOPS (4Kbyte block size)*

The formula below is used to calculate the required number of HDD drives:

$$\frac{(IOPS \times \%R) + WP(IOPS \times \%W)}{Drive\ IOPS}$$

With:

- *IOPS: expected I/O operations per second*
- *%R: percentage of IOPS that are reads*
- *%W: percentage of IOPS that are writes*
- *WP: RAID Write Penalty (RAID 1 or RAID 10 = 2)*
- *2,000 users x 3 IOPS per user = 6,000 IOPS*

Number of 15K 146GB SAS HDDs required:
[(6,000 x 0.65) +2(6,000 x 0.35)]/479.7 = 17 (or 18 HDDs for RAID 1 configuration)

The SNIA SSS TCO Calculator can determine and recommend the number of required SSS based on the following four key inputs from the user:

- *Minimum consumed HDD capacity (19% for this example)*
- *IOPS for HDD (4Kbyte block size)*
- *IOPS for SSS (4Kbyte block size)*
- *Minimum RAID requirements*

When using the above data, the SNIA SSS TCO Calculator recommends the user to replace the 18 HDDs with 2 SSS drives in this Microsoft Exchange Email Server example.

Table 1 and Figure 3 below show the results of the SNIA SSS TCO Calculator for a 5-year TCO calculation.

Table 1: 5-year TCO Calculation

	SAS 15K 146GB HDD	SATA 256 GB SSS
Power		
Power Cost ($0.158/kwh)	$1,794	$34
Cooling Cost	$2,153	$41
Disk Array		
Cost of Enclosures	$6,500	$3,250
Enclosure Energy Draw	$1,365	$683
Drives and Maintenance		
Drive Cost	$4,489	$2,000
Maintenance/Warranty Cost	$763	$340
Total Cost of Ownership		
Upfront Cost	$13,177	$6,273
Per Year Cost	$987	$19
5 Year TCO	**$17,063**	**$6,348**

Figure 3: TCO Calculator - Cost Breakdown

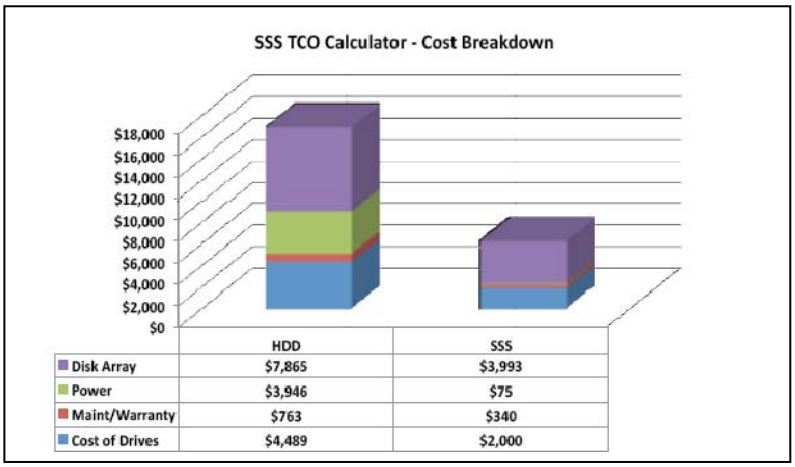
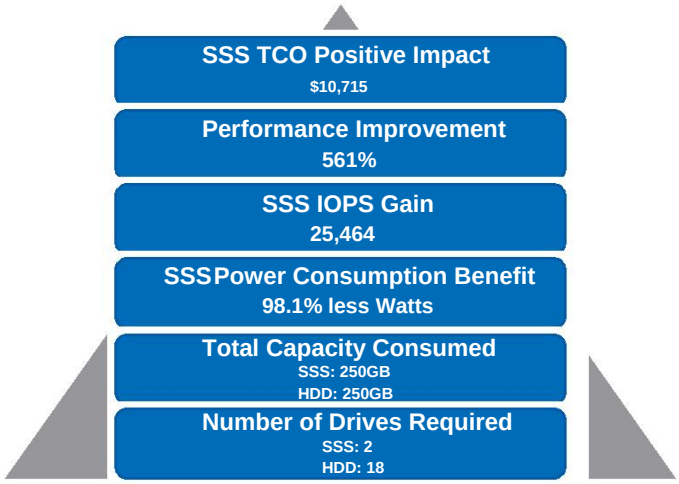


Figure 4 below shows the benefits of using an SSS-based storage deployment over HDDs in the Microsoft Exchange server example.

Figure 4: SSS Benefit in TCO Calculation



Summary

SSS devices are emerging as viable alternatives to HDDs in enterprise storage applications. Significant improvements in random I/O performance, reliability, and power consumption are clear and direct benefits of SSS devices.

While the initial acquisition cost per gigabyte for storage favors traditional HDDs, many other factors must be considered when choosing a storage technology for implementation. Power consumption, I/O performance, maintenance, and failure rates are all part of the equation when assessing the Total Cost of Ownership. With rising energy consumption costs, power, cooling, and space should become integral parts of the Total Cost of Ownership analysis for each IT organization purchase.

Equally important are the intangible costs such as the impact of investments on product refresh cycles, worker skills and productivity. The effects of these intangible costs vary widely from business to business; consequently, their measurement and valuation are outside the scope of the SNIA SSSI TCO Calculator.

The SNIA SSSI TCO Calculator is a tool meant to assist users in the industry to develop appropriate TCO calculations and comparisons of common costs associated with various storage deployments. For further information about SNIA and all of its programs please visit: www.snia.org/.