

WHITE PAPER

Replacing HDDs with SSDs: The Business Case for Transition

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IN THIS WHITE PAPER

In this white paper, IDC explores the potential benefits of replacing hard disk drives (HDDs) with solid state drives (SSDs). The potential benefits are discussed in the context of a formal total cost of ownership (TCO) analysis that compares metrics from organizations deploying HDD-based laptop PCs with published specifications for the same SSD-related metrics. The metrics used in this analysis are associated with device performance, reliability, and environment as well as normal labor costs incurred by companies using systems that leverage these storage technologies. The result is a model-based three-year operational cost comparison of HDD-based and SSD-based PCs.

Methodology

To develop a complete operational cost analysis, IDC identified several cost variables associated with the deployment, management, use, and support of corporate laptop PCs. The metrics chosen are common to both HDDs and SSDs so that there are no inconsistencies within the TCO model.

The variables populated into the HDD-based part of the equation are culled from IDC's Business Value Database, which includes IT operational data from over 1,000 organizations. The comparable SSD variables are based on published specifications in some cases and vendor-supplied data resulting from controlled laboratory tests in other cases. IDC then modeled how these specifications would translate into the cost analysis. It should be noted that little real-world data is available for SSDs since SSD usage in PCs is a nascent market dynamic. As large vendors ship more SSD-based PCs into the hands of customers, better real-world data will become available and should be used to qualify and validate the results of this study.

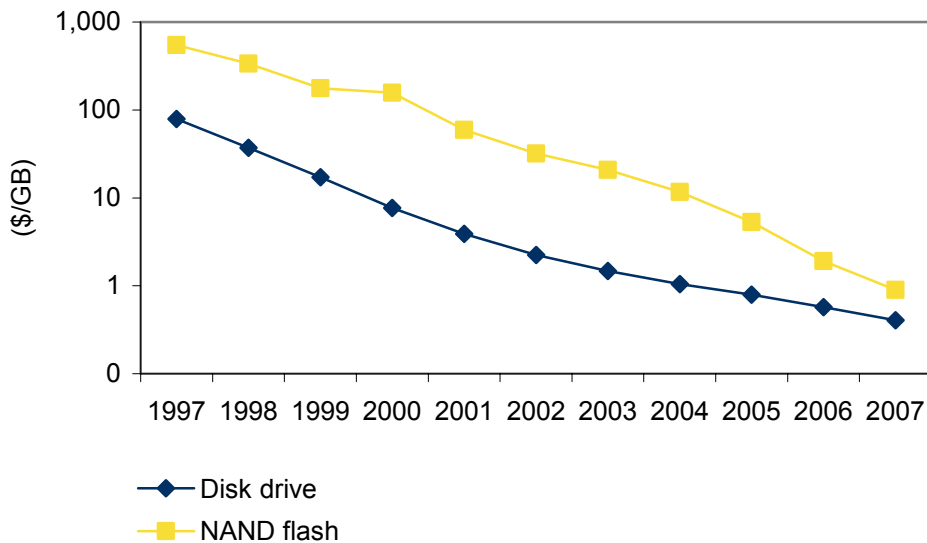
PC operations are subject to a myriad of factors that influence costs, including usage environments, workloads, and IT practices and policies. Because of these factors, the actual operational cost may differ significantly from the costs calculated within this analysis. The goal of this analysis is to model the reduction in operational costs that a company can expect to see when replacing HDDs with SSDs in laptop PCs that are used under normal everyday work environments.

SITUATION OVERVIEW

It used to be said that there were only two guarantees in life: death and taxes. A third dynamic is just as assured: the decreasing cost of storage (measured in terms of dollar per gigabyte [\$/GB]). Figure 1 illustrates the price erosion curves for HDDs and flash over history. Note the accelerated decline of flash over the past few years as well as the slower \$/GB erosion of HDDs since 2003.

FIGURE 1

HDD Versus Flash Price Erosion, 1997–2007



Source: IDC, 2007

It is this price erosion that has helped to advance the sophistication and capability of computing devices, especially mobile computing devices. Commensurate with these advances in storage technology are advances in other technologies, such as processing power, software, battery life, and wireless communication. Combined, these technology advancements have helped evolve mobile computing activities from performing simple calculations on calculators to today's portable PCs and mobile phones capable of connecting to a wireless network and running sophisticated applications or simply streaming video. One thing in common among all of these devices (from the calculator to the PC) is the presence of local storage.

A fourth dynamic that is as certain as the other three is change and innovation. The declining cost of NAND flash memory has led to the development of flash-based SSDs as an alternative storage solution to hard disk drives.

Local storage within computing devices comes in all shapes and sizes but largely is monopolized by HDDs and solid state technology. For over 20 years, disk drives have served the IT industry and its users well, and they continue to do so today. There are times, however, when technologies face challengers. Disk drives have been

challenged numerous times and, for the most part, have remained victorious. Only on a few occasions have HDDs ceded share in a well-established market. The Apple iPod mini/nano battle is a lucid example of a sudden and somewhat surprising defeat for HDDs by a technology challenger, in this case solid state storage.

Some would say you need a good reason to ditch a hard disk drive for anything else. Most of the time, the choice of a storage medium within a device is a cost-based decision. However, in the case of the Apple iPod mini/nano, it wasn't cost based at all. In fact, the demise of the 1.0in. HDD-based iPod mini wasn't based on a lower-cost replacement technology (the nano was more expensive from a \$/GB perspective); instead, the swap-out occurred for a number of other reasons, not the least of which was an acceptable amount of capacity for the application commensurate with a compelling set of other features that included smaller form factor, longer battery life, and a more robust or shock-proof design. The key, however, was that there was *an acceptable amount of capacity to ensure a positive end-user experience*. Obviously, the absolute cost was held in check (that is, the nano didn't "cost" the end user more than the mini to purchase; the end user paid the same amount but got less storage capacity). This did not mean that all iPods forsook the disk drive. Instead, a bimodal distribution emerged between iPods with excellent form factor and acceptable capacity and iPods with excellent capacity and acceptable form factor.

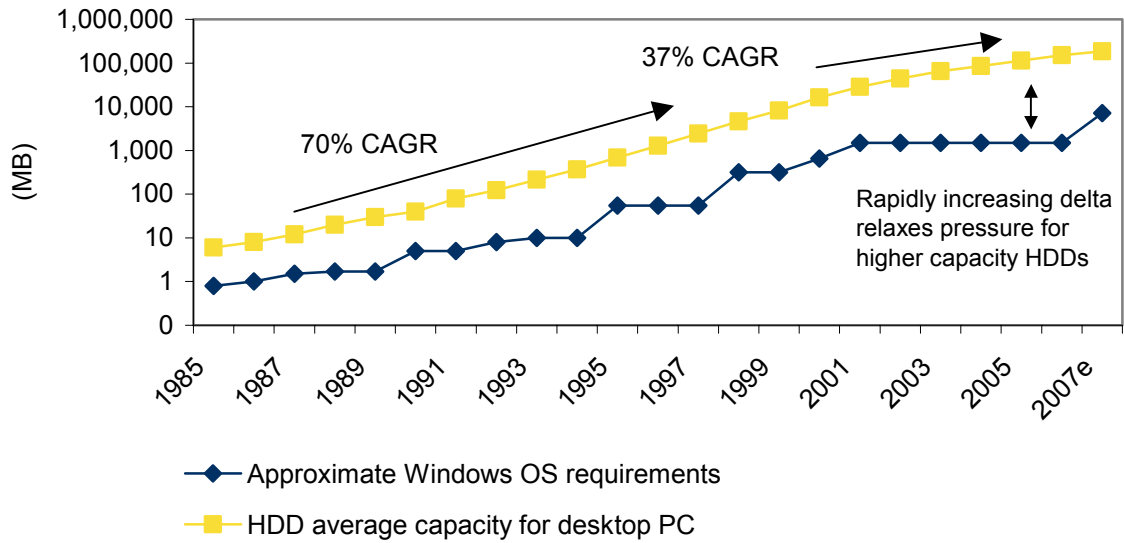
While the iPod mini/nano transition is an outstanding example, there are other less notable cases where one storage technology overtook another one's territory. The subject of this analysis is to put on paper the suggested justification for SSDs to overtake HDDs in laptop PCs from an efficiency perspective. Granted, we are not talking about an all-out swap of technologies but instead a measured approach in certain market segments where substituting an SSD for an HDD might make sense.

An interesting dynamic related to storage capacity in iPods is storage capacity requirements in PCs. Figure 2 illustrates the average HDD capacity shipped into desktop PCs correlated with the capacity requirements of the Windows operating system. Obviously, the operating system itself consumes a very small percent of a disk drive's capacity. Nevertheless, the strong correlation in trend lines is unmistakable and suggests that storage requirements in PCs have been relaxing.

The inflection point in the average HDD capacity trend line in Figure 2 occurred around 40GB. In other words, at the 40GB capacity point, computing configurations had an acceptable amount of storage for most users. In fact, 40GB became the most popular capacity point three years after shipments started, and it became one of the longest-lasting sweet spots of all time. Figure 3 represents the capacity life cycles of laptop PC 2.5in. HDDs; it illustrates the elongating life cycles, supporting the slower growth rate of HDD capacities.

FIGURE 2

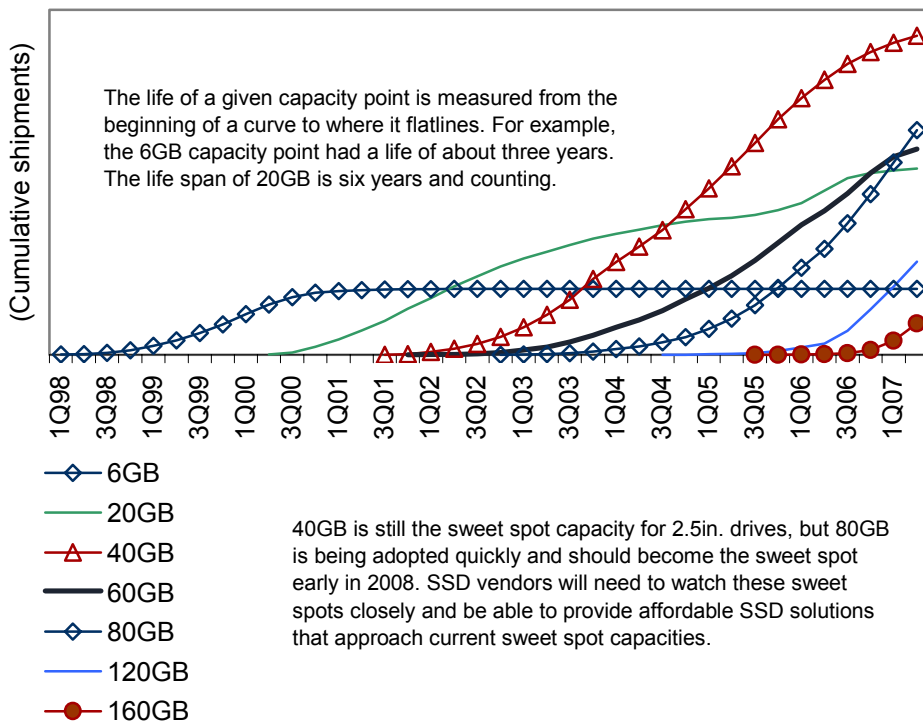
HDD Capacity Versus Windows OS, 1985–2007



Source: IDC, 2007

FIGURE 3

2.5in. Desktop HDD Capacity Life Cycles, 1Q98–1Q07



Source: IDC, 2007

This is not to say that higher-capacity HDDs are not needed or desired. There are a plethora of applications that require higher-capacity HDDs. However, from a mainstream perspective, some questions arise: How quickly will mainstream capacity points of laptop PCs increase? And is it possible for SSDs to satisfy economically this sweet spot capacity?

Capacity requirements of laptop PCs are one piece of the equation. However, to determine whether or not this technology swap-out is feasible, a usage model to capture the costs associated with the use of a technology, in this case a laptop PC, was developed so that the cost benefits of swapping out HDDs with SSDs in a corporate environment could be calculated.

MODELING THE LAPTOP PC ENVIRONMENT

Defining the Cost Variables and Relationships

Total cost analysis evaluates the complete life cycle of the technology:

- ☒ **Acquisition.** The cost to acquire the laptop PC (The acquisition cost is *not* considered in this analysis since it is a moving target, varies greatly among companies, and will be demand driven. In IDC's opinion, the cost of any new technology, such as the SSD-based PC, that seeks to replace legacy technology should be a "result" of the cost-benefit analysis versus an "input." In other words, device suppliers and system OEMs should use TCO analysis to help determine the premium threshold users are willing to tolerate based on the expected TCO.)
- ☒ **Deployment.** The IT labor costs to deploy PCs to users including acquisition, staging, setup, distribution, and initial support for 30 days
- ☒ **Maintenance.** The cost to troubleshoot, repair, and maintain the device, including both IT labor and outsourced labor costs
- ☒ **Performance.** The costs associated with using the device (PC user productivity is a measure of user salary lost when users do not have access to applications due to boot/shutdown times, application launches, data transfers, and other related variables, as well as lost time due to PC incidents or failures. In addition, power and extended battery life variables influence this part of the TCO model.)
- ☒ **Retirement.** The IT labor and hardware/software costs associated with replacing a device at the end of a cycle (Generally, this is related to the refresh cycle of the device. Early replacement [or lengthened refresh cycle] is a key variable within this cost bucket. Because we did not use acquisition costs in this analysis, we excluded hardware and software replacement, as well.)

No single cost variable alone provides justification for substituting SSDs with HDDs in corporate laptop PCs. However, certain relationships among the variables can multiply the benefits (or detriments) associated with a given variable. Hence a formal model must be defined using the appropriate variables and relationships to ascertain the most realistic cost-benefit picture.

Populating the Variables

Hard disk drives have been around for multiple decades and are the most economical way to store digital content that needs to be accessed quickly and efficiently. HDDs have been used in and throughout the IT infrastructure and have significant roles in the entire digital universe, corporate and consumer. Much is known about the integrity and life of an HDD. This industry knowledge is readily available and leveraged to populate the many variables listed above.

Solid state drives, on the other hand, are quite new to the digital storage scene. Granted, SSDs have been around for many years; however, there is far less industry knowledge and experience on how SSDs will perform under the same workload environments as HDDs have performed marvelously over the past decade. SSD vendors are quick to offer up data resulting from intense laboratory tests. However, as most know, laboratory tests can simulate many real-world scenarios, but not all.

Nevertheless, to complete the operational cost analysis, vendor-supplied SSD data was leveraged to populate the correct fields within the cost model.

The result is a number of key findings that point toward a reduced TCO for replacing laptop HDDs with SSDs. However, as stated previously, real-world scenarios and environments differ widely, as do end-user preferences and behaviors.

Given the newness of flash-based SSDs in real-world usage scenarios, IDC believes our cost analysis does warrant a disclaimer similar to disclaimers associated with most weight-loss and hair treatment commercials: Actual results will vary.

Key Findings

SSDs can provide a tangible benefit in the context of a TCO analysis that compares metrics from an organization deploying HDD-based laptop PCs with published specifications for the same SSD-related metrics. These benefits can be summarized by improvements in device performance that translate to increased user productivity, the reduction of costs associated with maintenance and products refreshes, and power savings benefits.

Performance/Productivity Improvement

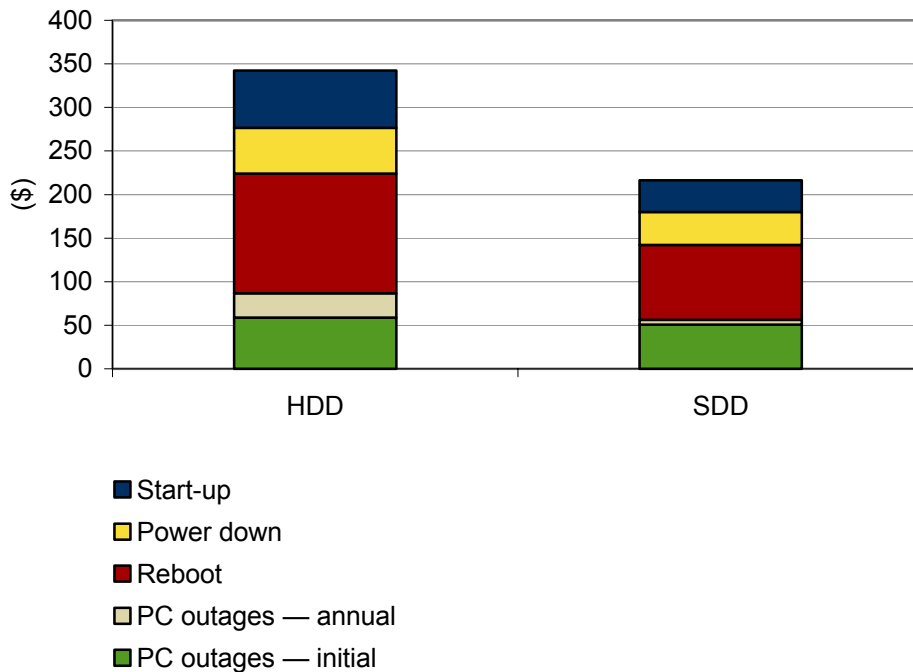
SSDs provide a higher productivity due to their increased reliability, higher performance, and lower power consumption when relying on battery power. The published reliability improvement in terms of mean time between failure (MTBF) of SSDs over HDDs is about sixfold, increasing productivity by reducing repairs and replacement. By utilizing solid state memory, SSDs can provide increased performance by offering quick data accessibility and fast data reads. Our model suggests the following benefits of using SSDs (see Figure 4):

- Increases user productive time by improving access times to applications and overall PC functionality by 37% (\$96 per user per year)

- ☒ Improved reliability reduces user productivity costs due to time without a PC by 35% (\$30 per user per year)
- ☒ The extended battery life of SSDs (not included in Figure 4) means that users will add 10 hours of work time per year when traveling

FIGURE 4

Annual Productivity Costs per User



Source: IDC, 2007

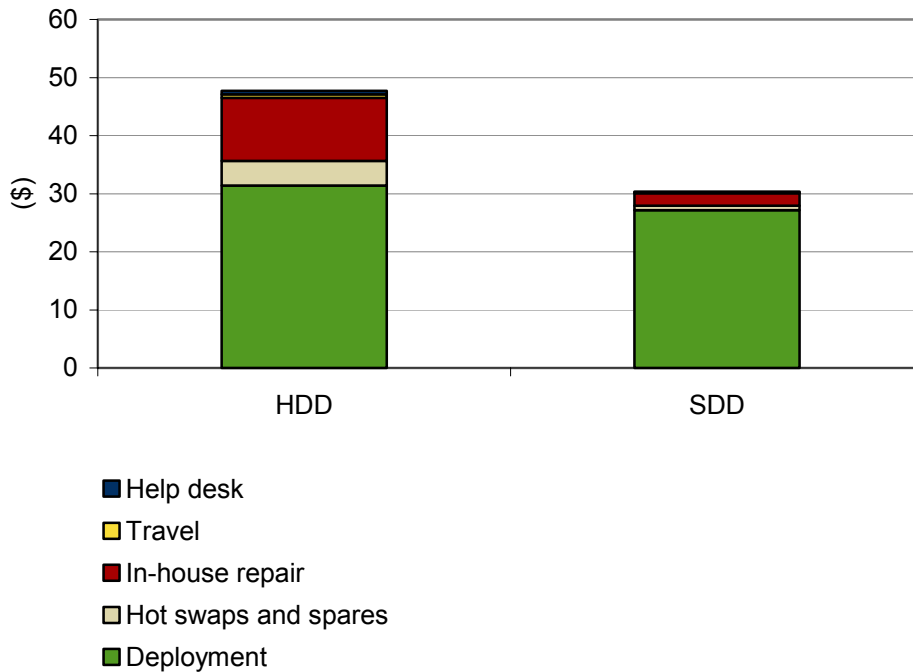
Maintenance/Refresh Cycles

The cost to maintain, repair, and replace is a large percentage of the costs associated with corporate laptop PCs (see Figure 5). With the 6x published reliability improvement in terms of MTBF of SSDs over HDDs, the benefits were bound to favor SSDs. IDC translated this 83% improvement to a 50% improvement to account for variations of best practices among IT organizations, understanding that not all laptop PC HDD-related incidents are MTBF related. This dynamic results in the following reduction in costs:

- ☒ Reduces annual IT labor costs to evaluate, fix, and repair crashed or improperly working disks and recover lost data by 81% (\$13 per user per year)
- ☒ Reduces outsourced repair costs by 80% (\$2.40 per user per year)
- ☒ Extends life cycle of PC by 14% (\$4.25 per user per year)

FIGURE 5

Annual IT Labor Cost per PC



Source: IDC, 2007

Power Savings

Power costs continue to increase and there is no end in sight, at least for the next 10 years. Companies are looking to decrease energy costs in any way possible. Although the SSD-based PC power conservation is small, the savings do add up. IDC estimates that the total energy-related savings is almost \$1.50 per user per year.

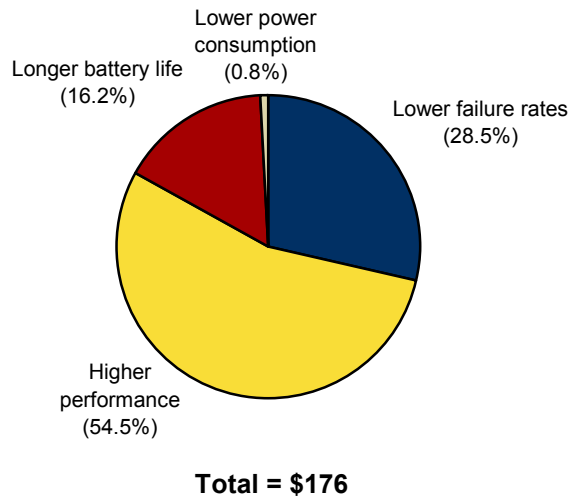
Closely related to power is the increased productivity in a mobile environment. Based on the SSD specifications, we estimate that the mobile user will gain up to 10% more hours to work. For the average mobile user, this totals about 10 hours per year. Productivity for each laptop user will realize \$28 annually, on average, due to increased battery life.

Total Cost Benefits and Potential ROI

The increased performance, reliability, and power savings all translate to a positive cost benefit for SSDs. Adding all of these cost benefits together results in a calculated annual cost reduction of up to \$176 per user (see Figure 6).

FIGURE 6

Annual Savings per PC with an SSD



Source: IDC, 2007

The clear indication from this analysis is that the greatest benefit in migrating to SSD-based laptop PCs is the increased productivity related to the higher performance of the SSD. In the context of Figure 6, this benefit is revealed in the costs associated with lower productivity when using an HDD-based laptop PC versus an SSD-based PC.

The next highest cost savings with SSD-based laptop PCs comes from higher reliability, or lower failure rates. The savings comes from lower support/replacement costs, resulting in more user productivity — a dual benefit.

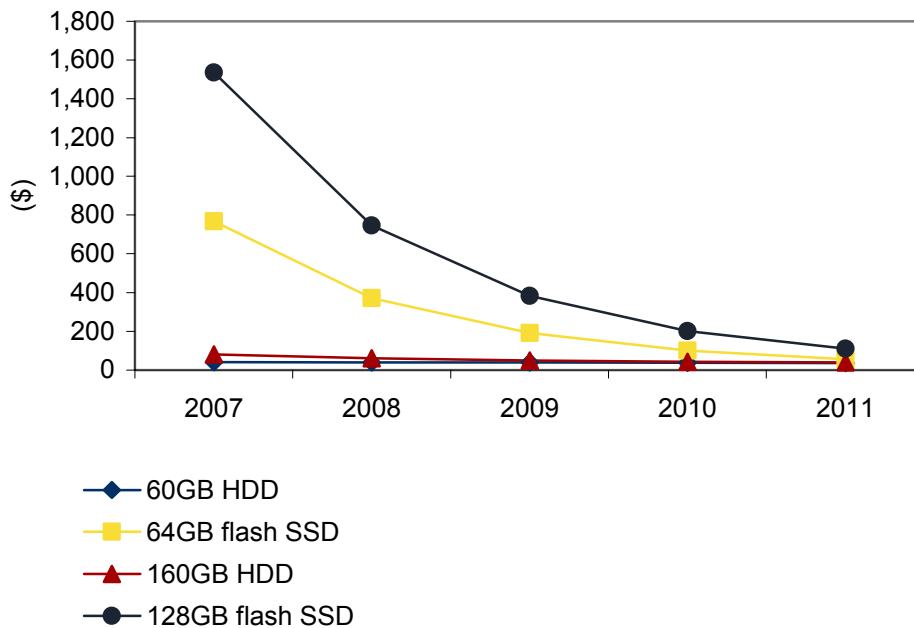
The longer battery life benefit varies with the number of travelers within any given company. However, increased productivity due to increased battery life is the essence of this metric. Again, in the context of Figure 6, the savings is related back to recouping the lower productivity of users using HDD-based laptops on battery power due to shorter battery life.

As mentioned previously, price is not the only metric companies will consider when weighing their options (granted, it is a major input) — the decision matrix can be quite complex. Yet when IDC evaluates storage requirements over time, we see them rising in general, but not as aggressively as in the past. This is notable in corporate environments where storage capacity requirements are not subject to the growing needs of consumer data, and thus lower capacity points, such as 64GB, can be quite acceptable. Corporations have motivations for limiting the amount of local storage within a laptop PC, not the least of which is limiting the amount of data that can be carried outside the security of the corporate walls. In addition, limiting local storage capacity can limit a corporate PC's usage for noncorporate data/activity. Given minimal operating system storage requirements, 64GB likely satisfies a large majority of corporate laptop PC users' needs.

In the 2011 time frame, IDC expects sweet spot capacities to be around 160GB for 2.5in. HDDs in laptop PC applications. A 160GB HDD should be priced at roughly \$40 in 2011, while a comparable SSD is expected to be about 2.7 times the cost. Again, prices are difficult to predict and numerous variables are involved. Nevertheless, IDC offers a comparison of its average selling price (ASP) forecast of a 60GB HDD, 64GB SSD, 160GB HDD, and 128GB SSD in Figure 7.

FIGURE 7

ASP Comparisons of HDD Versus Flash-Based SSD, 2007–2011



Source: IDC, 2007

In addition to the performance, reliability, and power savings benefits of an SSD, there were a number of other factors that could not be quantified due to wide variation in user case scenarios, lack of data, or an inability to quantify. When IDC analyzed TCO, the benefits of increased productivity due to quicker application launches and file opens were not included as individual user cases vary widely. However, the performance benefit from SSDs should increase users' satisfaction, performance, and productivity from a faster running system. As such, these examples from SanDisk show how SSDs provide increased performance and enhance the user experience using the Vista OS, a SanDisk 32GB SSD, and a representative 2.5in. 80GB 7,200rpm HDD:

- A user opening a 2MB Adobe PDF file can see a 59% decrease in the time it takes to open the file.
- Using Microsoft's PowerPoint, a user opening a 4MB PowerPoint file can see a 92% increase in the time it takes to open the file.
- A user opening a 2MB Word document file can see a 90% increase in the time it takes to open the file with HDD versus SSD.

Another variable not factored into IDC's analysis was the high cost to retrieve data from a failed disk drive. In certain instances, companies have to pay thousands of dollars to retrieve data from a failed disk drive because of the importance of the data. While this cost is high, IDC believes that the frequency of this event is few. Businesses are forced to retrieve data from failed drives however — hence there is an associated cost benefit for SSDs.

CHALLENGES

Technology swaps can be obvious but not necessarily automatic. The transition from VHS to DVD was an obvious one, and one that happened naturally over time based on the benefits offered by DVD technology as well as the cost declines in DVD technology. That said, DVD technology has not replaced tape in datacenters because of a completely different usage model.

Flash-based storage has a number of well-entrenched market segments (e.g., digital cameras and mobile phones) and has been able to hold its own as well as increase its presence in the compressed audio and personal media player markets. The success factors can be complex, even if the benefits seem obvious. On paper, the benefits of SSD-based laptop PCs seem obvious; in reality, there are a number of challenges to adoption that must be addressed:

- ☒ **Cost.** There is no question that the premium associated with SSD ASPs will be an immediate turnoff for many buyers. More savvy companies that take the time to understand their usage models and end-user preferences may find that the SSD premium is tolerable based on a cost-based analysis. In addition, PC OEMs will largely drive the premiums associated with PCs that integrate SSDs. These premiums can dwarf the premiums associated with the SSD device itself and can be an inhibitor to adoption.
- ☒ **Reliability.** Most would agree that from a robustness perspective (i.e., the ability to perform in adverse conditions) SSDs are superior to 2.5in. HDDs. However, SSDs suffer from a different reliability issue: a limited number of write cycles for any given cell. SSD vendors use a number of techniques to show that SSD still outlasts the normal PC life. Nevertheless, the SSD still falls short when compared with HDDs, which have virtually unlimited write cycles per bit.
- ☒ **Performance.** Most industry testing would point toward SSDs having superior performance over HDDs in all areas except write applications. Hence applications that have significant write cycles will favor HDDs and see limited SSD adoption.
- ☒ **Capacity.** SSDs will always lag behind HDDs in capacity and cost per capacity. Applications that have large capacity requirements will favor HDDs. Applications where capacity requirements are minimal will consider SSDs as an alternative storage strategy.

CONCLUSION

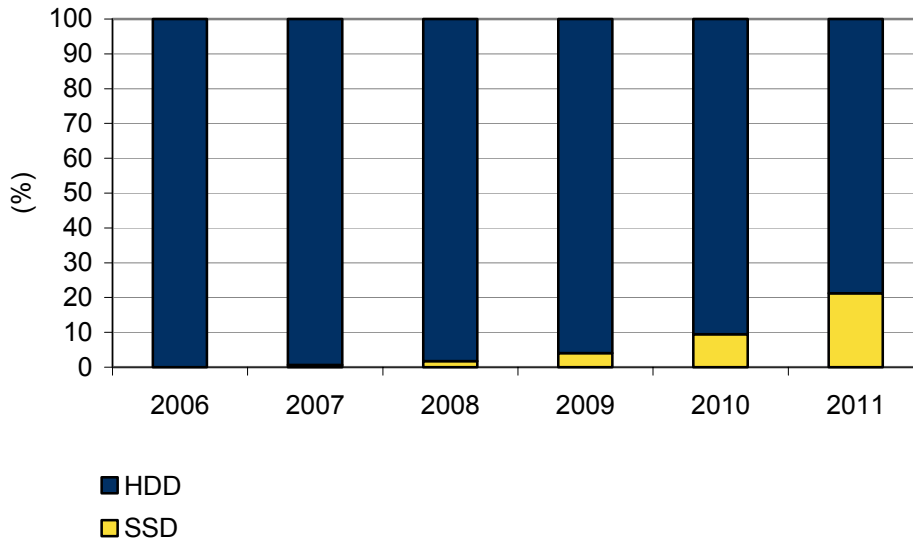
The debates surrounding SSDs versus HDDs are not likely to disappear any time soon. Instead, the industry will continue to see new and innovative devices that integrate SSDs or HDDs — or both — or even hybrid solutions depending on the application requirements. In a simplistic view, read-intensive applications with minimal storage requirements are a no-brainer for SSDs, while applications with large capacity requirements and applications that have heavy write loads will favor HDDs.

IDC has created this industry cost-based analysis to aid companies in identifying the important variables impacting decisions around using SSD-based and HDD-based laptop PCs. In addition, we've modeled the interaction of these variables to give the commodity purchasing manager a tool to aid in this decision.

On paper, the SSD possesses a number of benefits that justify its use in certain corporate laptop PC scenarios, especially those that have lower storage requirements. These segments are likely to find SSD solutions increasingly attractive as prices fall over time. Moreover, consistent with today's usage of solid state storage, applications or use scenarios that experience harsh operating environments favor SSDs. Figure 8 represents IDC's latest forecast for SSD adoption within the worldwide portable PC market.

FIGURE 8

Worldwide Portable PC HDD and SSD Penetration, 2006–2011



Source: IDC, 2007

There is no doubt that SSDs offer improvements in metrics important to various organizations worldwide. Some benefits will be more impactful than others, as one might suspect. As well, end users will favor certain SSD characteristics, thereby increasing the popularity of and satisfaction with SSD-based PCs. In conjunction with this cost-based analysis model, companies will need to evaluate their own usage models and end-user preferences to determine if SSD integration makes business sense.

In the end, SSDs will continue to identify applications appropriate for SSDs and displace HDDs in these applications. Significant premiums and margins garnered from servicing these applications will help to fund additional research that will address many of the SSD challenges discussed earlier. Successful SSD deployments will increase industry interest and lessen concerns regarding SSDs as a technology. Larger volumes will allow SSD manufacturers to benefit from economies of scale, thereby lowering the premium and cost to system OEMs and increasing adoption.

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