

## IT@Intel Brief

Intel Information Technology

Computer Manufacturing

Data Storage

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# Enterprise-wide Deployment of Notebook PCs with Solid-State Drives

Intel IT has begun to deploy up to 10,000 notebooks with solid-state drives (SSDs) instead of hard disk drives (HDDs) this year, following an evaluation that showed significant benefits including reductions in IT support costs and improvements in user productivity.

Based on Intel IT and industry data, SSDs are expected to have a 90 percent lower failure rate than HDDs over a three-year refresh period. As a result, we estimate a 90 percent reduction in employee time lost due to drive failures and a 96 percent reduction in IT support time for PC rebuilds. SSDs also provide much faster data access, resulting in user productivity improvements; we estimate an average 44 percent time savings for common tasks such as reboots and loading software. Other benefits include a lower thermal footprint; our tests showed that notebooks with SSDs ran about 12 degrees cooler.

Because of these benefits, we plan to deploy notebooks with 160-GB Intel® X-25M and Intel X-18M Mainstream SATA Solid-State Drives to employees as we refresh our installed PCs.

### Profile: Solid State Drives

- Benefits to users include increased productivity, reduced data loss and drive-related errors, and lower thermal footprint for more comfortable use.
- Benefits to IT include faster malware scans, better performance with less RAM, and extended battery life cycle.

### Improvement with Solid-State Drives

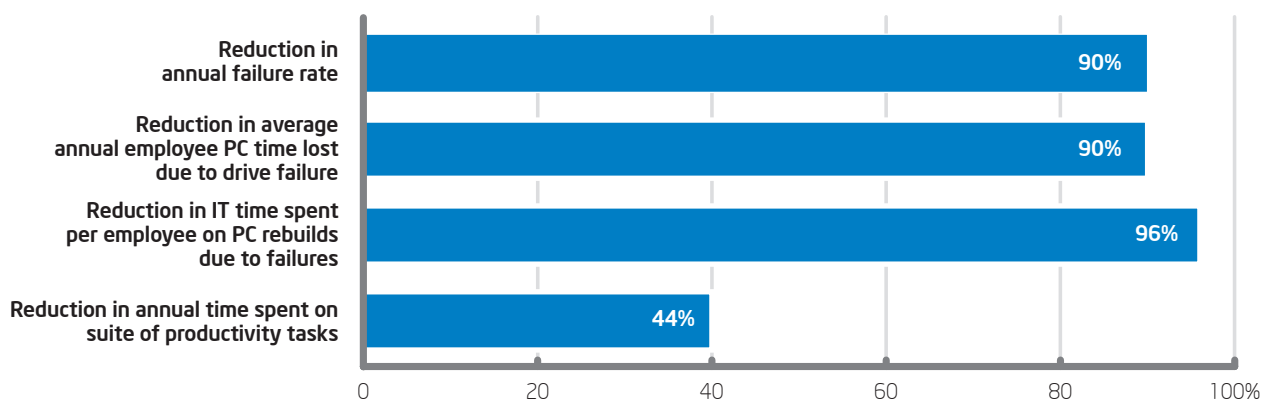


Figure 1. Solid-state drives (SSDs) provide many benefits to IT and users compared to hard disk drives (HDDs).

Intel IT estimates based on Intel internal data and industry estimates, July 2009.

**Table 1. Hard Disk Drives versus Solid State Drives**

<b>Hard Disk Drives</b>	<b>Solid State Drives</b>
More fragile due to rotating platters and mechanical arms	More durable because there are no moving parts
Reduced battery life due to high energy consumption	Longer battery life and cooler machines due to reduced energy consumption
Decreased performance as file fragmentation increases	Consistent performance because fragmentation is not an issue
Greater risk of data loss and hard drive failure when transported	More resistant to bumps and drops expected from mobile users
Slower responsiveness and performance due to drive spin-up time and mechanical arm movement	Faster responsiveness and performance due to no drive spin-up time, no mechanical arm movement and minimal latency

## Background

Intel's workforce is highly mobile: Our global computing environment includes more than 100,000 client PCs, of which 83 percent are notebooks. Because of the potential to provide increased performance, battery life, and reliability, Intel IT has been investigating the use of SSDs as replacements for the HDDs in these notebooks.

SSDs are data storage devices that use solid-state memory to store persistent data. Because they emulate HDDs, they can easily replace HDDs in many applications. SSDs have no moving parts, so they are much more reliable than HDDs. They also offer much faster data access, with the potential to accelerate user and IT tasks. A comparison of SSDs and HDDs is shown in Table 1.

We previously conducted a series of performance and usability tests, as well as a proof-of-concept deployment to a limited number of users, with promising results.<sup>1</sup>

However, because SSDs cost more than HDDs, we needed further total cost of ownership (TCO) analysis to quantify the potential benefits of notebooks with SSDs before proceeding with more widespread deployment. Accordingly, we performed an evaluation of the benefits to Intel IT and to employees.

## Evaluation

Our analysis was based on Intel IT and industry data. It included an assessment of the time required for typical IT and user tasks on notebooks equipped with SSDs compared with notebooks with HDDs. We estimated the duration and frequency of each task. Then we used this information to estimate and compare the total impact over the useful life of a notebook PC.

## Assumptions

Our assumptions were based on a combination of Intel IT data and widely accepted industry data.

**Refresh period.** We assumed a three-year refresh period.

**User time lost per drive failure.** Based on industry estimates, we assumed that when a hard drive fails, employees lose access to their PCs for an average of 12 working hours. Internally, we have found that the impact can often continue for longer than this, depending on an employee's location and proximity to an on-site PC service center.

**Annual drive failure rate.** Because of their moving parts, HDDs are one of the most failure-prone PC components—particularly as they near the end of the PC refresh period. An analysis of 12 months of recent Intel IT data showed an average HDD failure rate of about 4.9 percent. SSDs are assumed to be much more reliable because they have no moving parts. However, we have not yet had time to accumulate similar internal data about SSD failure rates; we therefore used an industry estimate of 0.5 percent—about a tenth of the HDD failure rate.

**Time to rebuild PCs.** Based on our experience and industry estimates, we assumed an average 1.25 hours of IT support time to rebuild a PC after a HDD failure—one hour for the basic build installation and 0.25 hours for additional work such as joining the PC to the corporate directory. Because of the additional performance SSDs provide we assumed that the rebuild can be completed in less than half the time—about 0.5 hours.

## Annual Impact

Based on these assumptions and other factors, we analyzed the annual impact of using PCs with SSDs instead of HDDs.

**Employee time lost.** When averaged across all Intel employees, the expected SSD failure rate results in an annual loss of about 0.06 hours per employee—less than four minutes—compared with more than 0.6 hours per employee with HDDs.

**IT time spent per employee on PC rebuilds.** With SSDs, we expect a reduced number of rebuilds due to drive failures, and we expect that each rebuild will be faster. This results in a huge potential reduction—estimated at 96 percent—in the average IT time spent on rebuilds.

**Employee productivity.** We analyzed the impact on employee productivity using two sources of data:

- Intel IT tests comparing the time taken to complete common daily tasks, such as booting systems and loading applications, with SSDs and HDDs.
- An online survey to determine how frequently employees performed each task.

Based on 488 responses and assuming a 225-day work year, we calculated a user's average annual time savings. Details are shown in Table 2.

Summary results of our evaluation are shown in Table 3.

## Other Benefits

We have also identified a series of potential additional benefits. These include:

**Lower thermal footprint.** With many HDD-equipped notebooks, users complain of the heat when trying to rest the notebook directly on their laps. To quantify the effect of switching to SSDs, we conducted a study to measure and compare the temperature of notebooks containing Intel SSDs and 7200-RPM HDDs, using an infrared camera to capture the heat signature of the top and bottom of each notebook in the area of the drive.

**Table 2. Estimated Annual Productivity Benefits (in Hours)**

Task	Hard Disk Drive	Solid-State Drive	Annual Time Savings
Boot up	5	2	3
Put into standby	3	0	3
Awaken from standby	0	0	0
Shutdown system	4	3	0
Start system and meeting task	20	12	9
Open an e-mail with three files	13	6	7
Awake from standby mode in wireless and meeting task	7	4	3
Put system in standby mode task (closing PC)	0.4	0	0
Open e-mail program, connect to collaboration software, and initiate an instant message	5	4	1
Awake from standby mode and send an e-mail	4	3	1
<b>Total Hours</b>	<b>62</b>	<b>35</b>	<b>27</b>

Intel internal measurements, May 2009.<sup>2</sup>

**Table 3. Benefits of Notebooks with SSDs**

	Hard Disk Drive	Solid-State Drive	Improvement
Annual failure rate	4.90%	0.50%	90%
Build time (hours)	1.25	0.5	60%
Average annual employee PC lost due to drive failures (hours)	0.61	0.06	90%
Annual IT time spent per employee PC on rebuilds due to drive failures (hours)	0.07	0.003	96%
<b>Annual time spent on suite of tasks (hours)</b>	<b>62</b>	<b>35</b>	<b>44%</b>

We tested four notebooks from two manufacturers. In each test, we ran industry-standard CPU and drive benchmarks concurrently. Each benchmark cycled three times; we measured temperature during the third cycle. We found that with SSDs, notebooks ran an average 12.2 degrees cooler. In addition, the notebooks completed CPU tasks more quickly with SSDs, allowing the processor and chipset to step down sooner; this resulted in a lower overall thermal footprint.

Our results suggest that notebooks with SSDs could be more comfortable for users, enabling them to work more easily in situations where they do not have access to desks or other places to rest the notebook while in use.

**Better performance with less RAM.** In Intel internal tests using several industry-standard benchmarks, a PC with an SSD and 1 GB of RAM outperformed a PC with an HDD and 4 GB of RAM. This suggests that moving to SSDs can produce more significant performance improvements than increasing the amount of RAM.

**Avoiding drive-related data errors.** Even when HDDs do not fail, they can cause errors such as corrupted and unreadable files. It can take considerable time to recover the data, resulting in IT cost and lost user productivity. With SSDs, we can avoid this problem.

**Faster malware scans.** Regular malware scans are essential to protect Intel's security; however they are resource-intensive and can impact the user's experience and productivity. With SSDs, these scans may complete faster, reducing the impact on users.

**Longer battery life cycle.** SSDs use less power than HDDs, so each battery charge lasts longer. This means batteries need to be recharged less frequently, which could extend the battery's useful life. As a result, we might need fewer costly battery replacements during the refresh period, though we have not yet been able to verify this.

## Conclusion

Our evaluation quantified substantial benefits that notebooks with SSDs can provide to Intel. Together with our previous testing and analysis, the results present a compelling case for deployment. Accordingly, we are moving ahead with enterprise-wide deployment as part of our refresh process. We expect to deploy about 10,000 notebooks with 160-GB Intel X-25M and X-18M Mainstream SATA Solid State Drives this year.

**Learn more about Intel IT's best practices at [www.intel.com/IT](http://www.intel.com/IT).**

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<sup>1</sup> "Improving the Mobile Experience with Solid-State Drives." Intel Corporation, January 2009. [www.intel.com/IT](http://www.intel.com/IT)

<sup>2</sup> Based on tests using a notebook PC with Intel® Core™2 Duo processor T9400 (2.53 GHz, 6-MB L2 cache, 1 066 MHz FSB), Mobile Intel® GM45 Express chipset ICH9M-Enhanced, 4-GB 800 MHz DDR2 SDRAM, Microsoft Windows XP\* SP3, 160-GB 7200-RPM SATA II hard disk drive, and 160-GB Intel® X-25M Mainstream SATA Solid-State Drive.

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