Performance Benefits in Gaming Through the Use of a Solid-State Drive

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Executive Summary

The market penetration of solid-state drives (SSDs) into the PC game market will begin with the early adopters in the enthusiast segment. By 2012 over 50% of the enthusiast class game PCs will be equipped with SSDs making the CAGR for that segment over 200% between 2009 and 2012.

The Performance segment will grow a little less quickly but still show a CARG of almost 78%.

A solid state drive will improve overall system performance, run cooler, and quieter. Those are wonderful attributes within themselves. However, currently a solid state drive is over four times more expensive than the best hard disk drive. Therefore, other than the quiet operation, how would one justify the cost difference of the SSD?

Gamers and hobbyists seek to have the highest performance system possible and will manipulate the CPU's and GPU's clock speed to obtain a few percentage points of more of performance. They will add expensive exotic cooling systems, and specialized communications boards to get that extra edge, either for playing performance or just for bragging right.

Therefore, it's reasonable to assume that gamers will be attracted to a solid state drive if any advantage can be shown in its use.

Although it's intuitive that a solid state drive (SSD) would give higher performance we at Jon Peddie Research (JPR) undertook to prove it. We took a state of the art system and ran tests with a top of the line 10,000 RPM hard disk drive (HDD) and then swapped out the HDD with a Samsung SSD to see if any difference could be measured.

We used games and benchmarks to test the systems.

The results varied from game to game and so averages had to be used to arrive at any conclusions. (The methodology is covered at the end of this report.)

Conclusions

Gamers want the game to load instantly and play at maximum possible frames per second (FPS) with all features turned on. Using that as our measurement objective we found:

- 4.4% improvement in average game loading time was obtained.
- 6.4% improvement in frames per second was measured.
- 33.5% improvement on one test and 58.3% on another was realized in system benchmarks.

Using a solid state drive will give the gamer the extra edge he or she is seeking.

A final thought

Although not quantifiable, there was a definite feeling of smoothness while running the system with the SSD. The system was in general more responsive and although the latency of the HDD's initial seek is short, the absence of it tended to make the system feel faster.

The market for SSDs in gaming PCs

As has been pointed in other reports the PC gaming market is larger in unit volume than the much heralded console market. However, what may be confusing to the casual reader of this data is the segmentation of the PC gaming market, ranging from midrange systems costing as little as $500 to ultra enthusiast machines costing a much as $10,000. As might be expected, the population of users varies according to price.

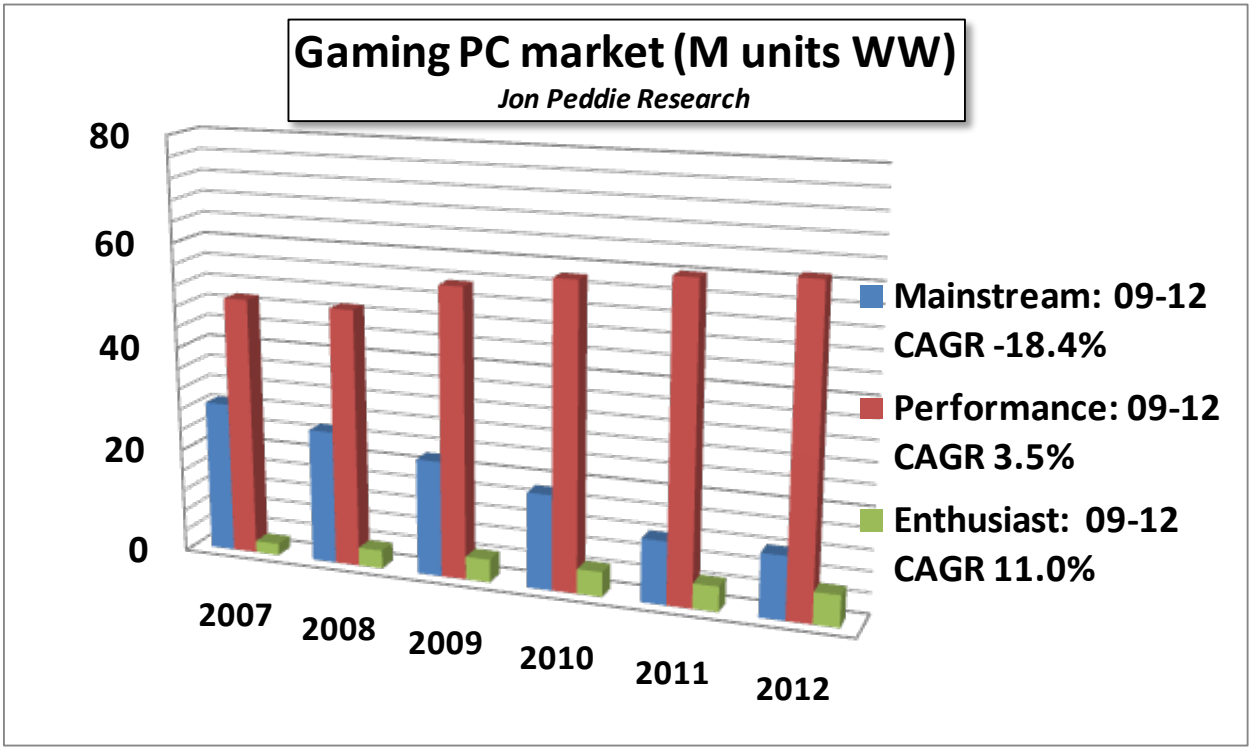


Figure 1: Market for gaming PCs

SSDs will be first used by the Enthusiast segment because they have the budget, and passion for maximum performance. However, the large price difference in SSDs to HDDs will limit the initial adoption. Assuming SSDs follow a similar price per Mbit curve as the popular USB thumb drives (aka memory sticks) we believe the adoption rate will increase exponentially reaching a penetration rate of 50% by 2012, and showing an initial introduction into the Performance segment. We don't anticipate any penetration of SSDs in the mainstream gaming PC market until after 2013 when the prices will be much lower and almost all PCs will be so equipped.

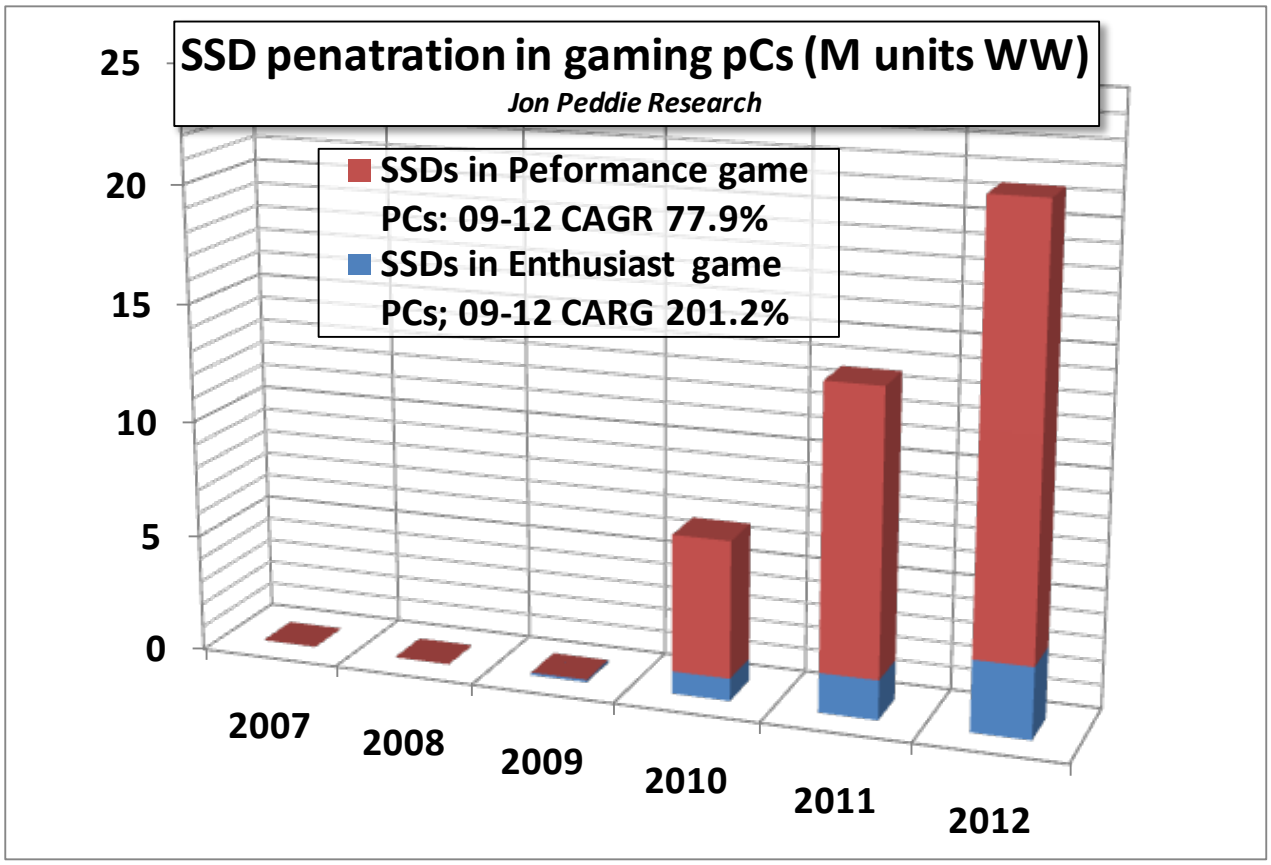


Figure 2: SSDs used in gaming PCs

The game enthusiast who are the early adopters will be the proof point for the advantages of SDD of HDD. They will use the larges versions of SDD. The performance segment game PC users will be mixed, as might be expected, the segment is not homogeneous but rather graduated from the mainstream to the enthusiast class.

SSD vs. HDD – is there a difference?

We recently tested a Samsung MMDOE56G5MXP 256GB solid-state drive (SSD against a WD1500HLFS 150 GB with 16MB buffer, 10,000 RPM hard disk drive (HDD.) Our tests were graphics-centric and not designed to be universal quality of performance analysis.

Our goal was to see if a SSD could contribute to gamer performance. Other have reported that a SSD will open basic applications ten times faster than the quickest 10,000RPM drive.

The SATA2 transfer rate is 3G Hz. It translates to 300 MB/sec bus transfer rate.

All SATA2 drives (SSD or HDD) supports 300MB/sec bus transfer rate. This does not mean too much in drive performance rating. The sustained transfer rate is more meaningful for drive performance measurement.

Spec/Device	SSD	HDD
Buffer to host (Gb/s)	3	3
Host to/from drive-sustained (MB/s)	220 read	126
	185 write	
Price	$799	$169

Table 1: Comparison of SDD to HDD specifications

The tests

We ran several tests using game and benchmarks and the results are summarized in the following sections. (The test data is in the associated spreadsheet.)

The gamer's edge

Game enthusiasts want every tenth of a second advantage they can get and don't want to wait for anything – no such thing as postponed gratification n in game land.

They want to game to load instantly and play (run) as fast as possible. They want high resolution screens, full textures, shading, lighting, and special effects – instantly.

Modern game, especially the new 3D advanced first-person shooters (FPS) and role-playing games (RPG) offer stunning scenes and scenery. To make those pictures the game developer has to create hundreds of texture maps. To see those images the game (the application) has to pull the textures off the disk and store them in local (system) memory. They have to get pulled out of local memory and put in the graphics board's frame buffer memory. All that takes time and impact the gamer's enjoyment. Anything that can speed up that process is desirable. Of the pipeline just mentioned, the disk is the slowest element

System tests

PCMark Vantage

We ran a full suite of tests using FutureMark's Vista test suite PCMark Vantage at 1600x1200 resolutions, and as might be expected in the raw disk test the SSD showed a remarkable difference.

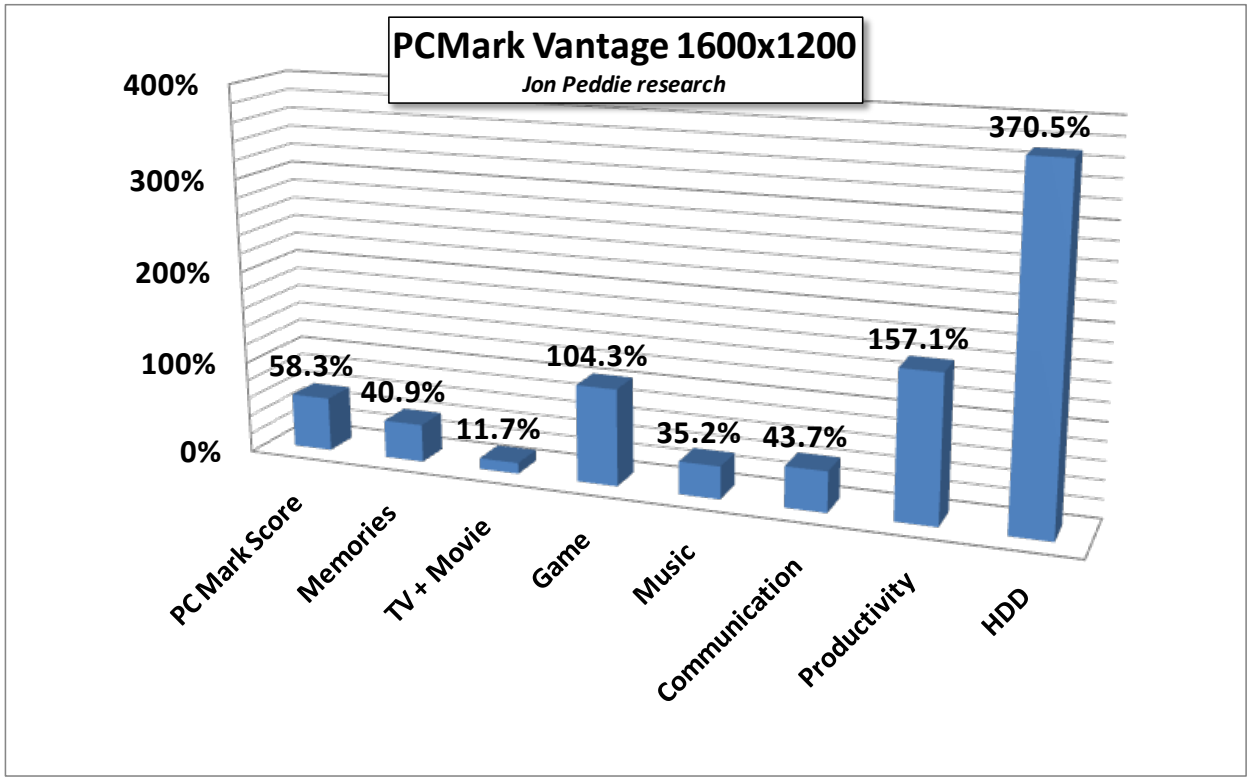


Figure 3: PCMark Vantage improvement with SDD

Referring back to the pipeline discussion (disk to memory to graphic board) PCMark shows the improvement in performance of that pipeline with the Memories score and the Hard Disc Drive (HDD) score.

A description of the PCMark Vantage test suite can be found at: http://www.futuremark.com/benchmarks/pcmarkvantage/features/

PassMark

PassMark is a respected system test that exercises all the components in a PC. We ran it on the system with the SSD and then with HDD and the results were quite impressive.

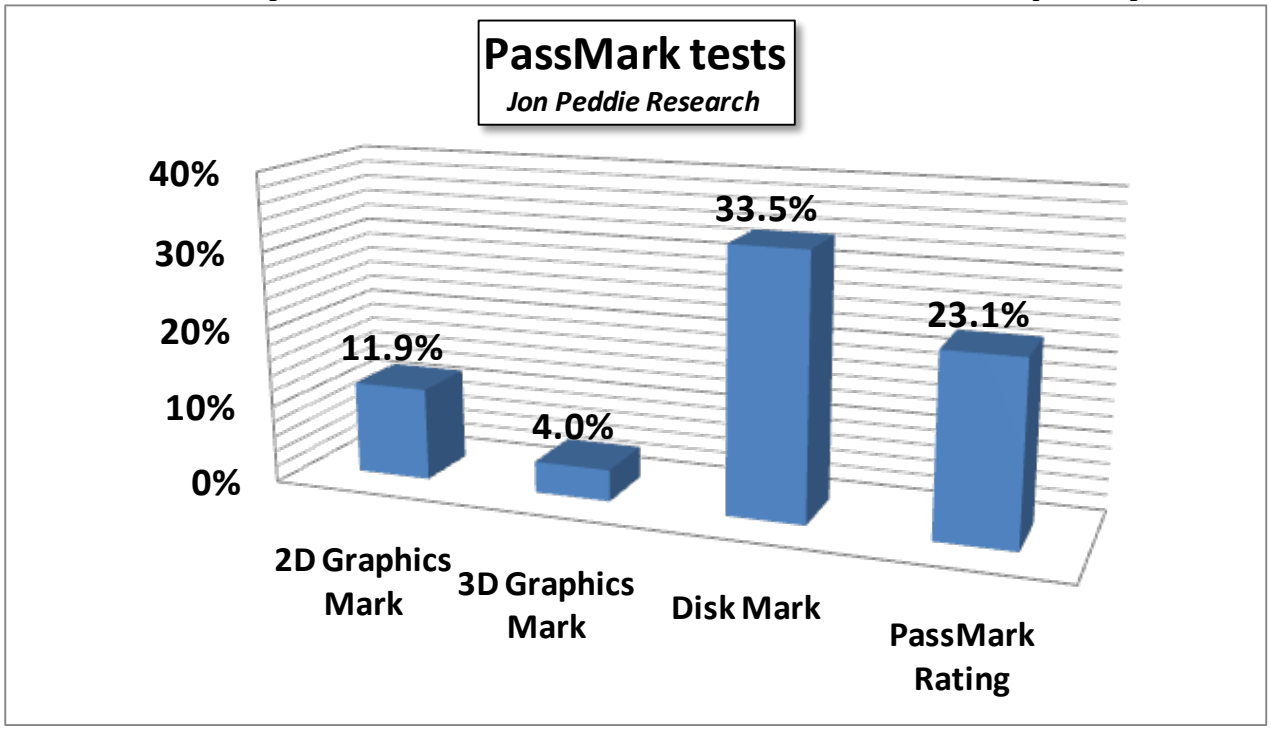


Figure 4: PassMrk test results

PassMark ques up as many of the textures and other graphics elements as possible when doing a 3D test so the differences don't look so dramatic in the chart. However, it should be pointed out that whereas the 3D test is designed to show the difference in graphics board operation with as little impact as possible form system overhead, the faster SSD still makes a significant contribution.

We ran the Passmark benchmarking program. The "PassMark rating" is a weighted average of all the other test results and gives a single overall indication of the computers performance. The bigger the number, the faster the computer. For example, a typical old Intel Pentium 4 3.20GHz, has a rating of about 700, while a Core2 Duo E8500 with 3GB of Memory may have a rating around 1250.

The "PassMark rating" can only be calculated if the results from all other tests are available (with the exception of the CD test, which may be omitted as some systems do not have them). The value is calculated using a series of weighted averages where some components are considered to be more important than others. For example the CPU performance has an larger overall importance than the CD result. On a typical desktop computer the overall result will be weighted as follows.

Test Suite	Weighting
Disk	21%
CD / DVD	5%
Memory	19%
3D Graphics	12%
2D Graphics	14%
CPU	29%
Total	100%

Table 2: Passmark summary results

A full description of the Passmark test methodology can be found at: http://www.passmark.com/products/pt.htm

Game tests

Game start up time

The average start up time improvement for the games we evaluated was 2.32 seconds for an average improvement of 4.4%.

A 4 or 5% improvement may not seem like much. However, it has to be put in context. During the game playing process the flow of data, texture maps and other elements takes place every second. So it's not a onetime static 4 or 5% improvement, it's an improvement through the game for as long as the gamer is playing.

We tested that with a stop watch (using the average of five app loads) The timing was from the time we hit the Enter key to the time we say a cursor in the opening screen where you can select load game, new game, etc.

Summary load time	Gain	time	SSD	HDD
Call of Duty 4	2.1%	12.5	117.27	119.8
Crysis Warhead	4.2%	-2.6	58.76	61.36
Fallout3	7.5%	-4.30	52.94	57.24
Left 4 Dead	12.0%	-0.90	6.58	7.48
Spore	5.3%	-1.72	30.44	32.16
Stalker Clear Sky	5.0%	-1.90	35.80	37.70

Table 3: Game loading time summary

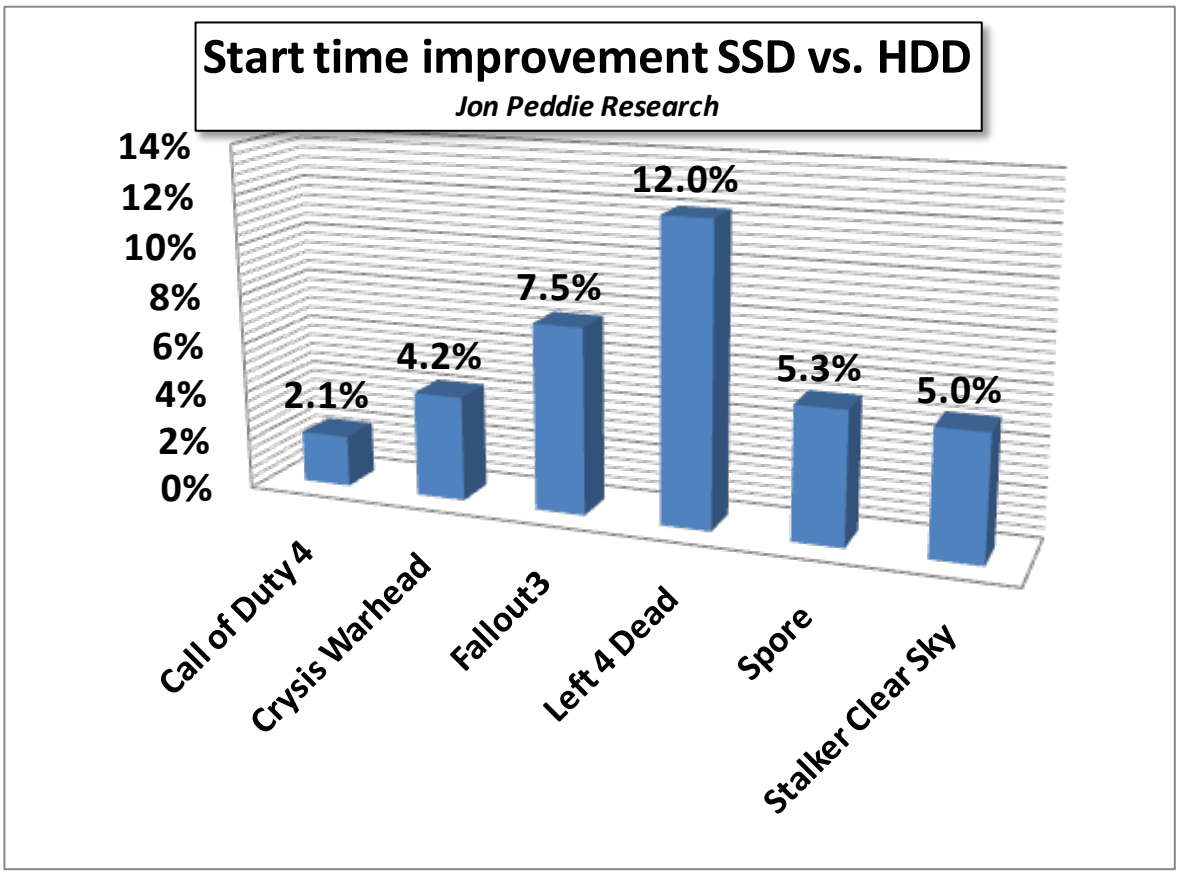


Figure 5: Startup time improvement using a SDD

The startup time effect will be felt throughout the game as new geometry, textures and images are loaded

FRAPS

Game play is measured in general in terms of frames per second. Anything less than 25 is considered jerky and destroys the quick interaction gamers want to have with the game. FRAPS is a benchmark that runs in the background and counts the frames per second. We used that test to see if there was any difference in game play due to the SDD and found that in general there was.

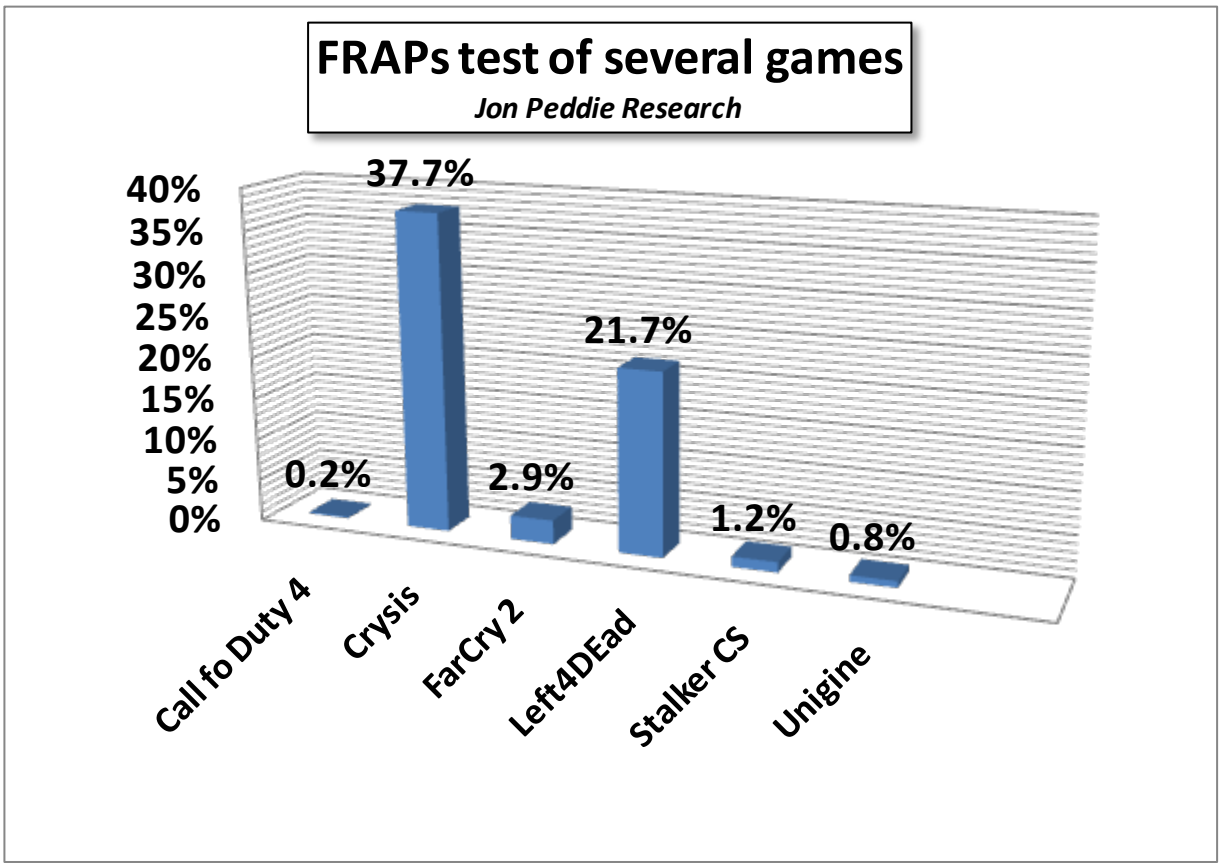


Figure 6: FRAPS scores for various games with SSD

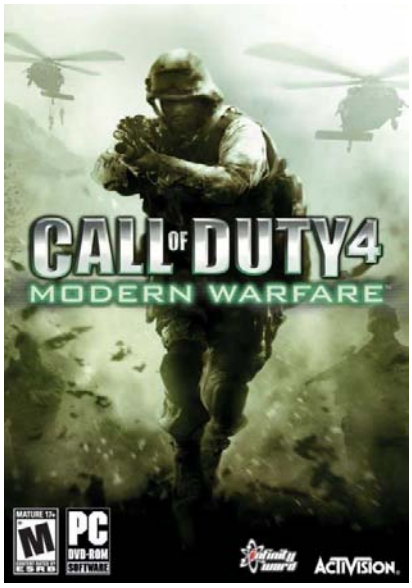
We can say that for the suit of games we tested, the average improvement of game play due to the SSD was 6.4%. The FRAPS score with regard to the SSD has to be judged on a per game basis. Some games make more use of the disk than others.

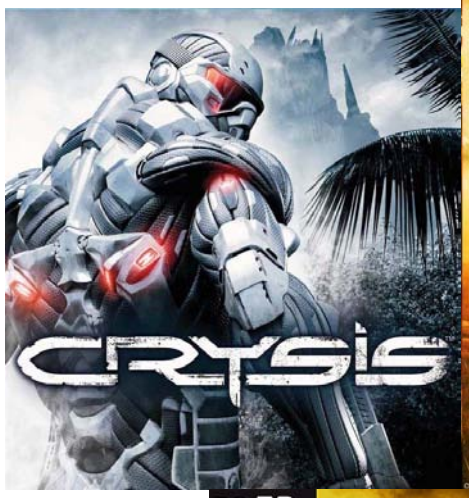
Unigine

We used the open source Unigine benchmark which is a cross-platform real-time 3D engine. It contains photorealistic 3D render, a physics module, object-oriented scripting system with a very rich library, full-featured GUI module, sound subsystem, and a set of flexible tools.

3Dmark Vantage

We also looked at the Futuremark benchmarks. However, they don't make much use of the disk drive and concentrate on the graphics board (and do that on purpose so as to not distort the measurement of graphics board performance.) The average difference between the SSD and HDD over four tests was only 0.8% in favor of the SDD.





Methodology

The test configuration and methodology is listed here.

Hardware

The tests were run on a an Intel Nehalem system with an Austek Rampage II Extreme motherboard with an Intel X58 (rev12) chipset. The CPU an Intel Xeon W3570 and it was run at 3.2 GHz. There was 2GB of DDR3 RAM running at 667MHz.

The graphics board was an ATI Radeon HD4870 with 1 GB GDDR5 running at 900 MHz, the GPU was running at 750 MHz, and ATI's latest driver, 9.7 (23 July 2009) was installed.

The display was a 30-inch Dell LCD with 2560 x 1600 resolution.

For the solid state drive tests a 256 GB Samsung MMDOE56G5MXP-0VB drive was used.

For the hard disk drive tests a 150 GB Western Digital WD1500HLFS running at 10,000 RPM with 16MB buffer.

Software

Microsoft Vista 64 Bit with all the latest upgrades was the operating system used.

All background operations that could be turned off were turned off. No virus checker software was running.

Benchmarks

The benchmark programs that were used were:

- 3DMark Vantage, version 1.0.1
- FRAPS, version 2.9.8
- Passmark, version 1007
- PCMark Vantage, 64-bit edition 1.0
- Unigine, Tropics benchmark, version 1.2

Games

The games that were used in the testing were:

- Call fo Duty 4
- Crysis
- FarCry 2
- Left4DEad
- Stalker Clear Sky

We tried to use Fallout 3 but it is a console game that has been modified to run on a PC. As a console game it is locked into vertical synch (so it will synch up with the TV's refresh rate) and since we couldn't change it we could get a frames per second measure measurement of than 60. We also tried to use Spore but there was no repeatable opening sequence in it.

Testing methodology

Each drive was clean (new), or cleaned (i.e., reformatted.) The same copy of Vista 64 was installed on each drive. All up dates were installed on each drive. All the same programs were installed on each drive. Every effort possible was made to make the two drives as identical as possible.

All of the benchmarks, with the exception of FRAPS, run independently and provide results afterwards. FRAPS is run inside a game while it is run and its results are stored in a log file.

The benchmarks were run three times and the average taken.

The games were run five times and the average taken.

Two tests were run using the games: Start up or load time, and opening story time.

Start up time was measured with an online stop watch (http://www.online-stopwatch.com/) The procedure was to start the program (game) and as closely as possible start the stop watch, and as soon as the game became useable, as determined by the presence of a menu, stop the stop watch. Two hands were used for the starting time, one on the mouse for the game and one on the mouse for the stop watch. The stop watch was run on a separate computer. Loading time average for these tests was 50 second. The average human reaction time is about 215 mS (http://en.wikipedia.org/wiki/Reaction_time) making the margin of error 0.43%. Five start up runs were made for each program on each drive and the average taken.

Story time was measured by starting the game and as soon as the game engine kicked in (as indicated by the scene on the screen) FRAPS was started. FRAPS was set to run for 100 seconds and report the average frames per second for that period. Five runs were made for each program on each drive and the average taken.

In all games the resolution was set at 2560 x 1600 with no anti-aliasing and no vertical synch. No AA was chosen because this was not meant to be a stress test of the graphics. Max resolution was chosen so that the largest texture maps would be loaded.

The opening story was chosen because it uses the game engine and texture maps, and because it is consistent and repeatable. Taking measurements within the game by actually playing the game is not a reliable or repeatable process. The path the payer takes, the AI reactions will vary each and every time and there is no way to control it. Also, the opening story generally employs all the special effects of the game (in a show off manner) and uses all of the features in the game.