

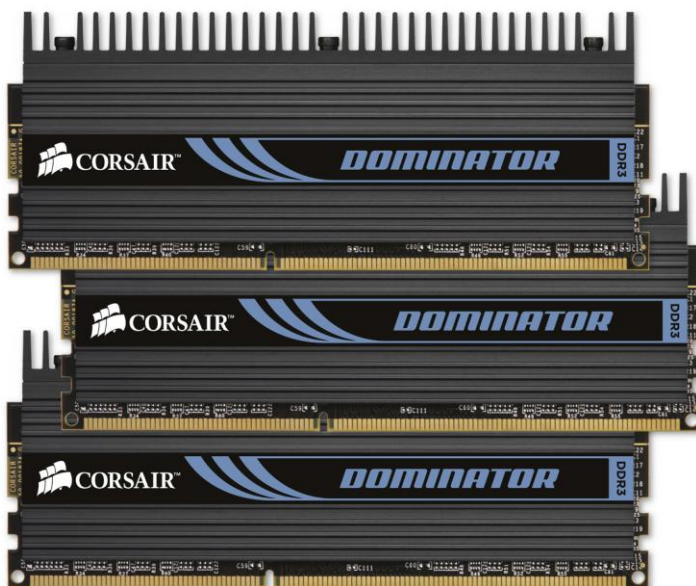


AN811: Gaming Performance Analysis– 6GB vs. 3GB

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Introduction

In Corsair Application Note [AN804](#) we examined the performance impact on modern games of using a 4GB memory array size compared to a 2GB memory array size. The results of this Application Note proved that upgrading to 4GB provided significant performance benefits, partly due to reduced Windows page file usage compared to an equivalent PC with only 2GB of system memory. The performance drop for the system with 2GB of system memory was due to frequent load stuttering, which reduced the in-game frame rates, particularly the minimum frame rates.



With the introduction of the Intel Core i7 processor series, which features an on-die, triple-channel memory controller, consumers now have a choice between 3GB (3 x 1GB) and 6GB (3 x 2GB) system memory densities. This Application Note aims to assess the potential gaming performance advantages of installing 6GB of system memory compared to 3GB of system memory, using the same testing methodology as described in AN804.

The results echo those of AN804 and show that 6GB of system memory is essential for gaming PCs based around Core i7 CPUs, with up to a 3x increase in performance compared to an identical PC with 3GB of RAM.

How we tested

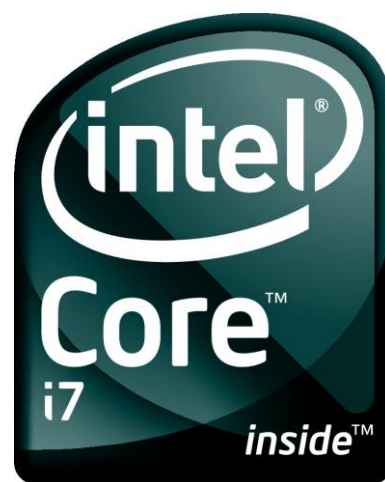
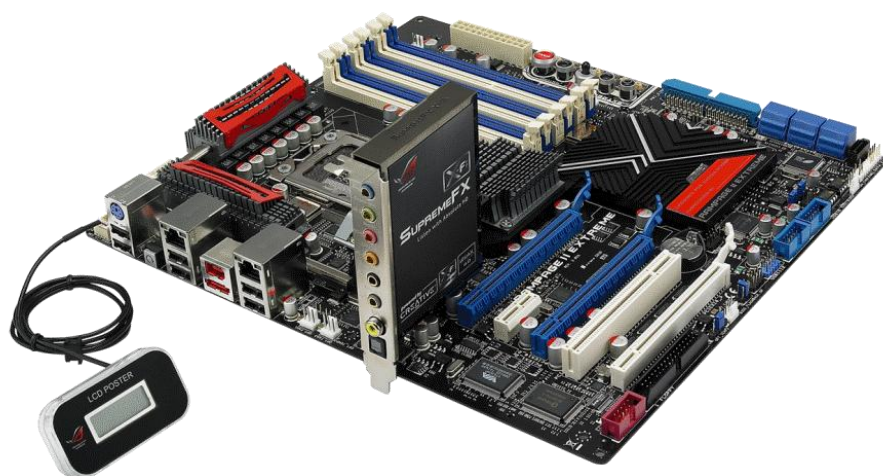
To conduct the testing we built a high-performance Core i7 test system that reflects the type of PC that a gaming enthusiast would buy. By using high-end components we also preclude the possibility of any single item of hardware causing performance bottlenecks, which allows us to accurately measure the effect of increasing the memory density.

Memory Configurations

- **3GB** – 1600MHz Corsair Dominator [TR3X3G1600C8D](#)
- **6GB** – 1600MHz Corsair Dominator [TR3X6G1600C8D](#)

Test Platform

- ASUS P6T Deluxe motherboard (BIOS version 0804)
- Intel Core i7-965 Extreme Edition CPU
- 2 x 1GB Nvidia GeForce 280 GTX in SLI
- 2 x Seagate Barracuda 7200.10 320GB in RAID 0
- 24in TFT monitor
- Windows Vista Ultimate 64-bit, SP1
- Nvidia 180.43 BETA drivers (required for SLI on ASUS P6T Deluxe)



The test system uses an Asus P6T Deluxe X58-chipset motherboard and Intel Core i7-965 Extreme Edition processor

Testing Methodology

Due to the various methods available for benchmarking different games, we used a variety of tools to assess the impact of using 3GB and 6GB memory array sizes. The specific testing methodology for each game is detailed below for each title. In each case we used a resolution of 1680 x 1050 and configured each game to run at the highest detail settings. We ran each test 3 times, rebooting between each test, and recorded the average of the 3 runs.

All of the test components were run at stock speeds and all unused peripherals were disabled in the BIOS. In addition, the following BIOS settings were used:

- **Memory** – Manually configured to 1600MHz at 8-8-8-24 timings, 1T command rate, 1.65v VDIMM
- **QPI Frequency** – Manually configured to 6400MHz
- **BClock Frequency** – Manually configured to 133MHz
- **CPU Turbo Mode, C1E, EIST, SpeedStep** – Disabled
- **Intel Hyper Threading** – Enabled

Results

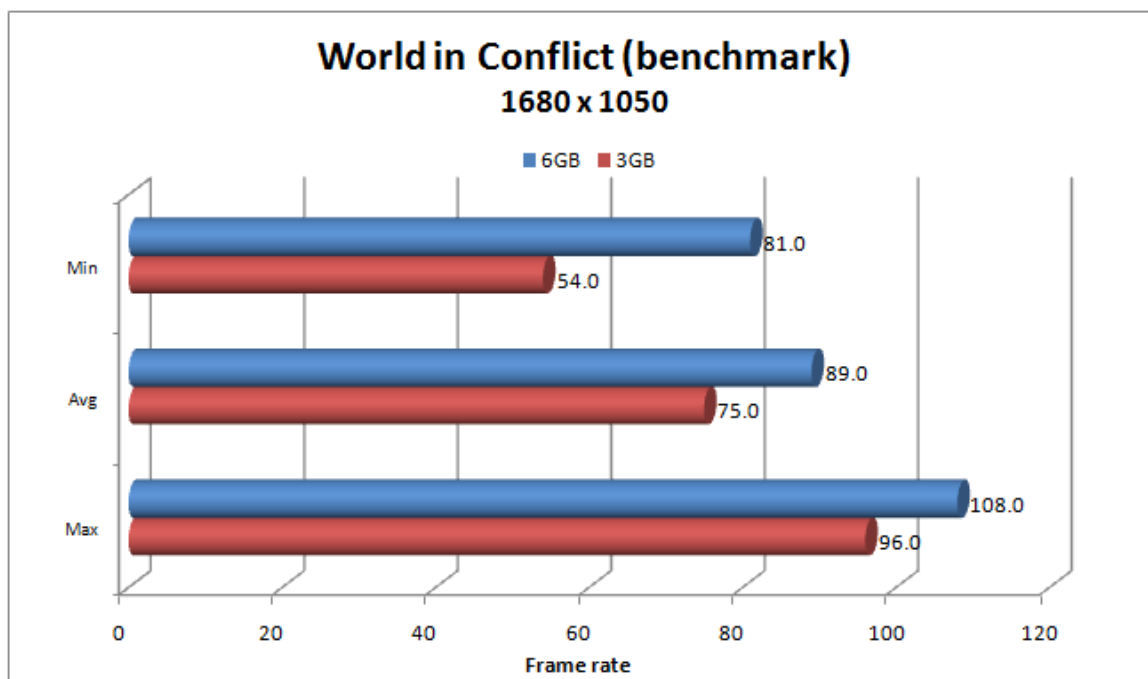
World in Conflict

World in Conflict is a modern, highly resource-intensive Real-Time Strategy (RTS) game, which was released in September 2007. World in Conflict supports DirectX 10 graphics cards and is a tough test of overall system performance. The game includes a built-in benchmarking tool, which we used to assess the performance of this game with 3GB and 6GB system memory sizes. Each test was run at 1680 x 1050 in DirectX 10 mode.



World in Conflict performance

The following results from World in Conflict's built-in benchmarking tool show that there are clear performance benefits from using 6GB of system memory compared to 3GB of system memory. The minimum, average and maximum frame rates all increase substantially when using 6GB of system memory. The average frame rates increases by 19%, from 75fps to 89fps while the minimum frame rate increases by 50% from 54fps to 84fps. The increase in minimum frame rate is most significant since the minimum frame rate determines the overall smoothness of the gameplay.



Crysis Warhead

Crysis Warhead is one of the most demanding games on the market, requiring high-end graphics processors, CPUs and plenty of memory. We used the latest Crysis title, Crysis Warhead, to examine the performance impact of using 3GB of memory compared to 6GB.



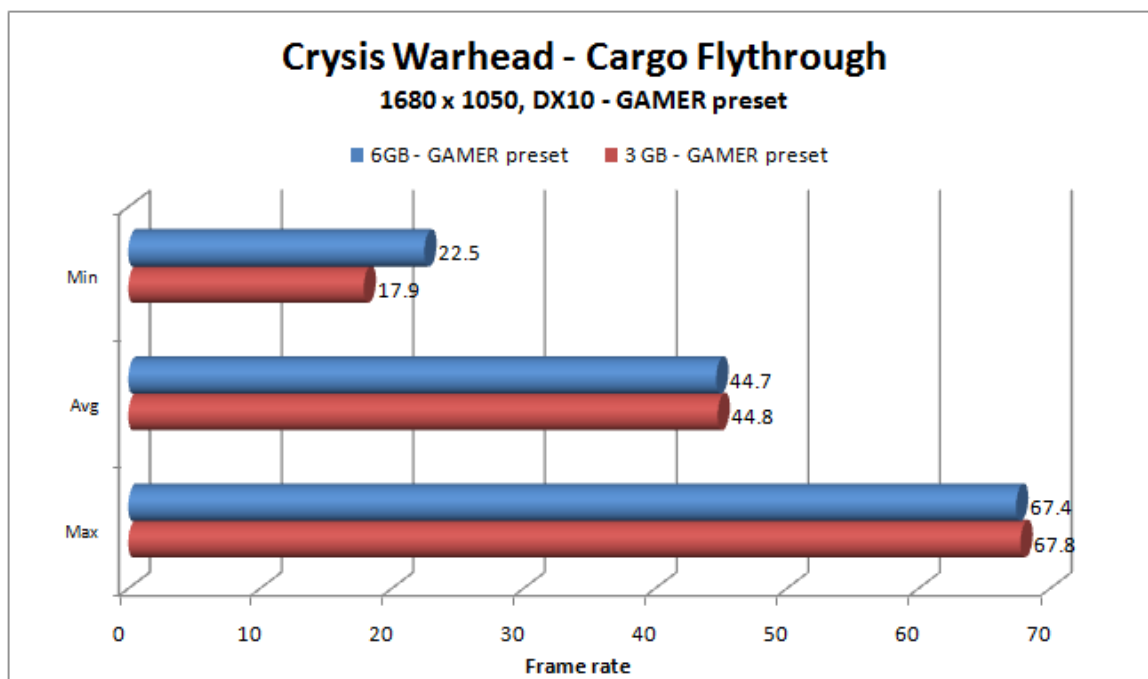
To assess the frame rates in this game we used **FBWH Tool**, which was developed by 'Mr.John' on the [InCrysis](#) forums. This allows for detailed adjustment of graphical and system settings, in addition to providing accurate benchmarking options. We used the latest version of FBWH Tool, Version 0.31, which you can download [here](#).

The following benchmarks were run at 1680 x 1050 in DirectX 10 mode.

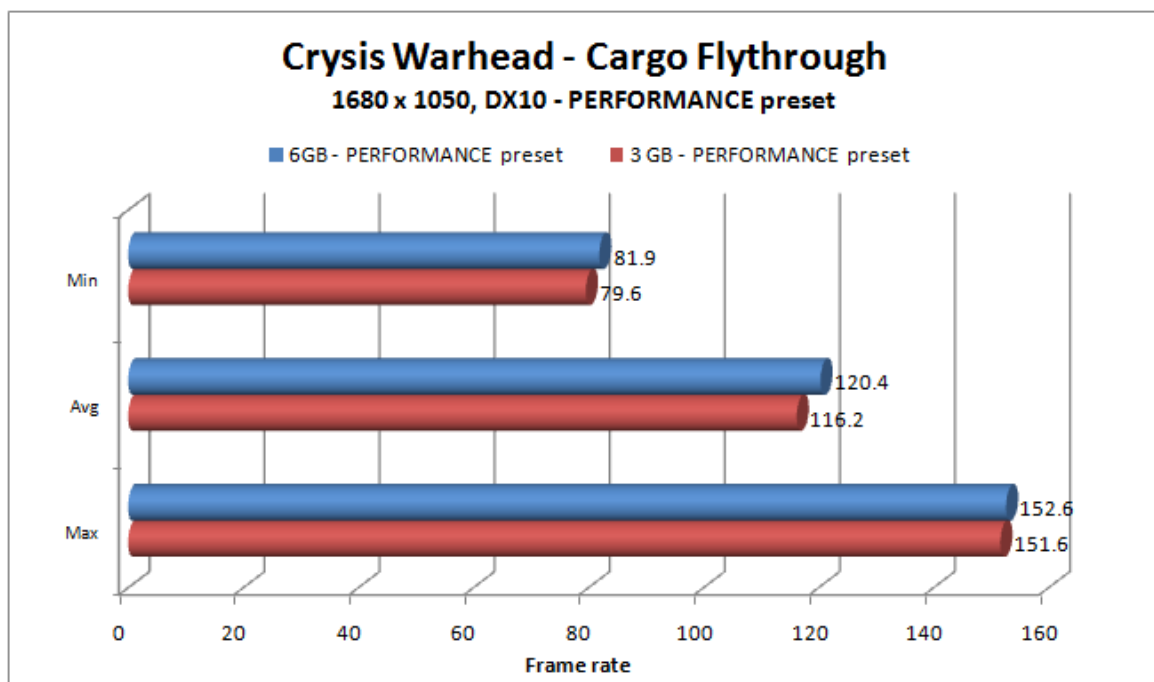
We used both the GAMER and PERFORMANCE presets and tested with the 'Cargo Flythrough' benchmark. The GAMER preset uses high graphical detail settings and is a more resource-intensive test.

Crysis Warhead performance

The results using the GAMER preset shows that, although the average and maximum frame rates are virtually identical for 3GB and 6GB memory array sizes, the minimum frame rate is increased by 26% when using 6GB of system memory.



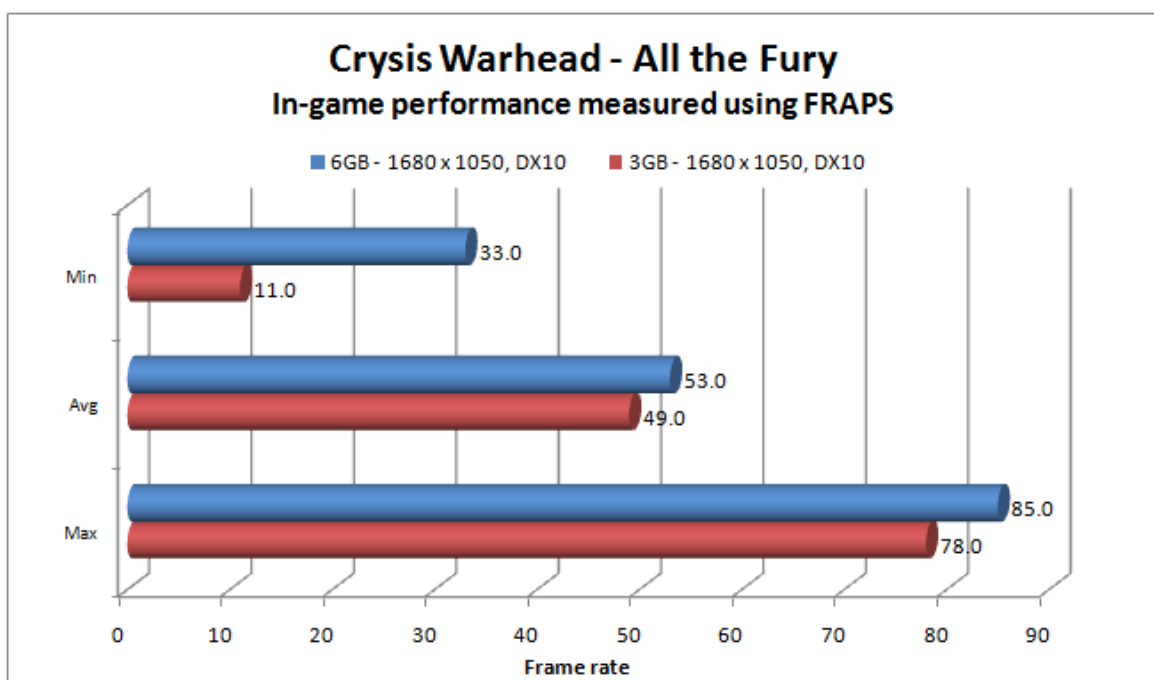
The PERFORMANCE preset reduces the graphical complexity of the game resulting in a less 'GPU-bound' scenario, whereby the video card is not the performance limiter. The results show that the average and minimum frames rates are higher with 6GB of memory, although the gap in minimum frame rate is smaller than when using the GAMER preset, most likely due to reduced memory requirements. The results indicate that using 6GB of memory is highly advisable to run Crysis Warhead at high graphical detail settings.



In addition to running pre-scripted benchmarks using FBWH Tool, we also analysed the in-game performance of Crysis Warhead using [FRAPS](#) (version 2.9.6, build 7637).

To assess actual gameplay performance we played through an easily repeatable scene in the 'All the Fury' chapter on the airfield. The results show that the in-game memory usage of Crysis Warhead is significantly higher than when running only the benchmark, which resulted in significant performance differences between 3GB and 6GB memory array sizes.

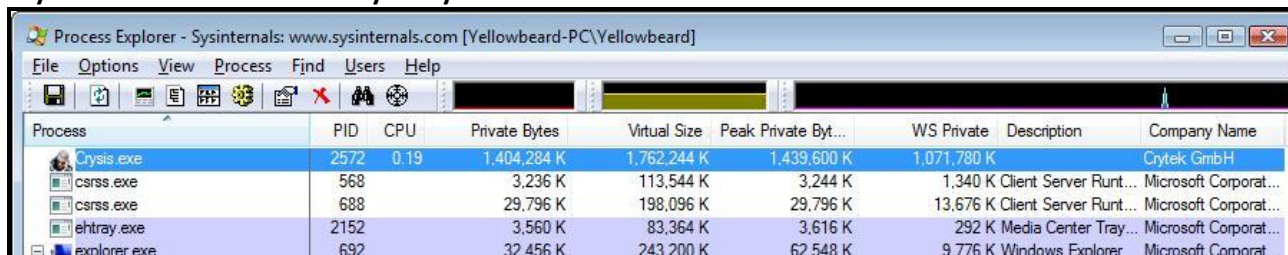
Once again the most significant difference was to the minimum frame rate, which dropped to an unplayable 11fps when using 3GB of memory, compared to 33fps with 6GB – a substantial difference of 3x.



Crysis Warhead memory usage analysis

The dramatic difference in minimum frame rate between 6GB and 3GB memory array sizes can be partly explained by analysing the memory usage of Crysis Warhead for the two configurations.

Crysis Warhead – 3GB memory array size

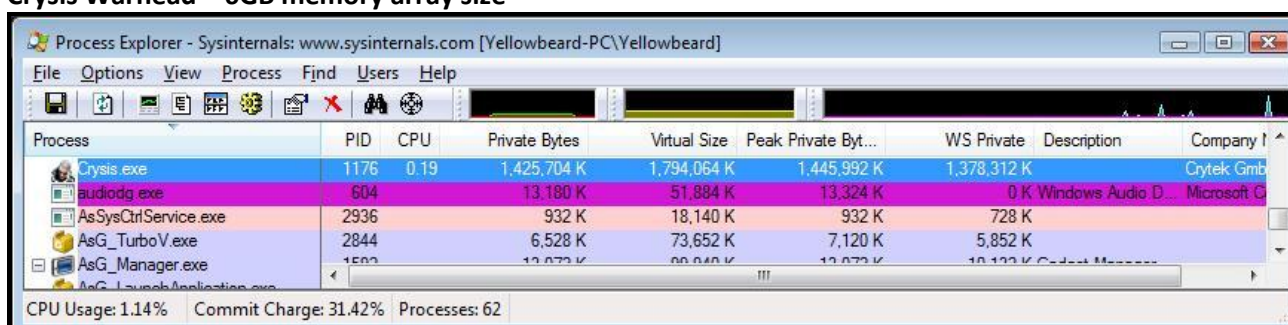


The screenshot shows the Process Explorer window with the following data for the Crysis process:

Process	PID	CPU	Private Bytes	Virtual Size	Peak Private Byt...	WS Private	Description	Company Name
Crysis.exe	2572	0.19	1,404,284 K	1,762,244 K	1,439,600 K	1,071,780 K		Crytek GmbH
csrss.exe	568		3,236 K	113,544 K	3,244 K	1,340 K	Client Server Runt...	Microsoft Corporat...
csrss.exe	688		29,796 K	198,096 K	29,796 K	13,676 K	Client Server Runt...	Microsoft Corporat...
ehtray.exe	2152		3,560 K	83,364 K	3,616 K	292 K	Media Center Tray...	Microsoft Corporat...
explorer.exe	692		32,456 K	243,200 K	62,548 K	9,776 K	Windows Explorer	Microsoft Corporat...

The above screenshot was taken during the 'All the Fury' level and shows the memory usage of the Crysis process when 3GB of system RAM was installed. The total amount of memory committed to the process (Private Bytes) is over 1.4GB, of which only 1GB is stored in physical memory. This difference leads to more regular hard disk access and stuttering in the game.

Crysis Warhead – 6GB memory array size



The screenshot shows the Process Explorer window with the following data for the Crysis process:

Process	PID	CPU	Private Bytes	Virtual Size	Peak Private Byt...	WS Private	Description	Company Name
Crysis.exe	1176	0.19	1,425,704 K	1,794,064 K	1,445,992 K	1,378,312 K		Crytek GmbH
audiodg.exe	604		13,180 K	51,884 K	13,324 K	0 K	Windows Audio D...	Microsoft Corp...
AsSysCtrlService.exe	2936		932 K	18,140 K	932 K	728 K		
AsG_TurboV.exe	2844		6,528 K	73,652 K	7,120 K	5,852 K		
AsG_Manager.exe	1592		12,072 K	60,040 K	12,072 K	10,132 K	Content Manager	

At the bottom of the window, the status bar shows: CPU Usage: 1.14% | Commit Charge: 31.42% | Processes: 62

With 6GB of system RAM installed in the PC, the Private Bytes figure has remained roughly the same as with 3GB installed, but the physical memory usage has increased to 1.4GB. Storing more game data in physical RAM reduces the need to load data from the hard disk drive, ensuring a consistently higher minimum frame rate.

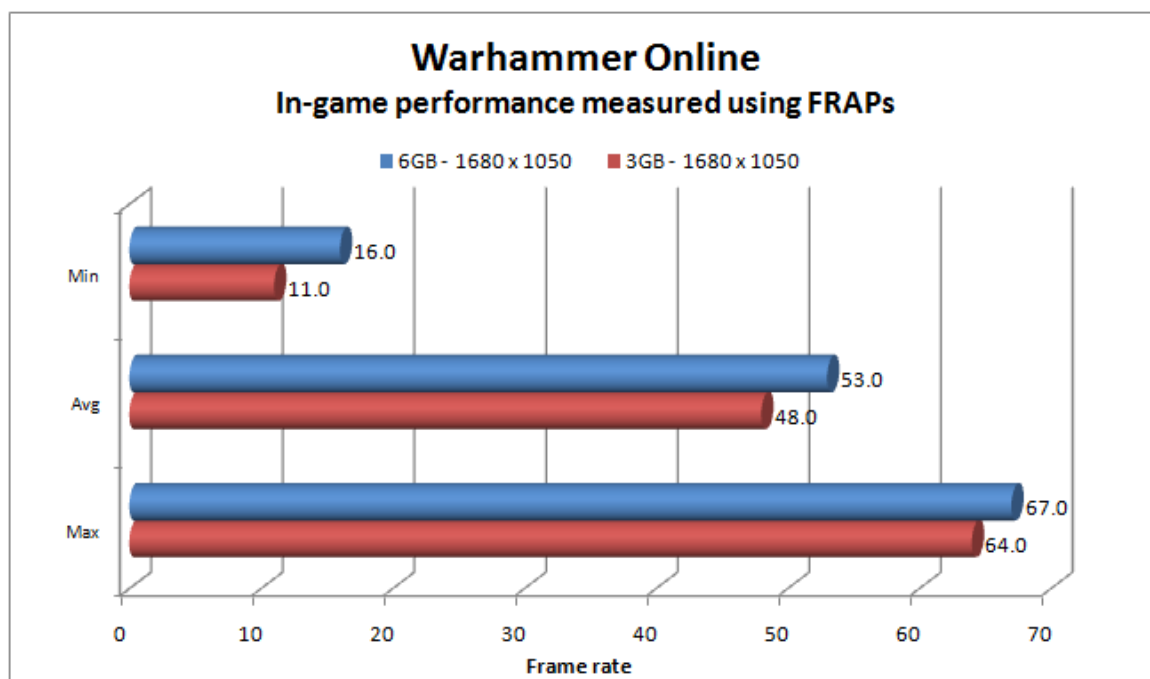
Warhammer Online

The Massively Multiplayer Online Role Playing Game (MMORPGs) genre is a hugely popular and influential area of PC gaming with titles such as World of Warcraft being played by 11 million people worldwide. Warhammer Online is one of the latest and most sophisticated games in this genre, and while not quite as graphically demanding as Crysis Warhead, it still requires significant amounts of system memory in order to run smoothly. We played through a repeatable section of the game and recorded the average, minimum and maximum frame rates using FRAPs.



Warhammer Online performance

The results show a clear performance gain from using 6GB of system memory compared to 3GB of system memory. With 6GB of RAM the minimum frame rate was 16fps, 45% higher than when using 3GB of RAM.



Warhammer Online memory usage analysis

Examining the memory usage of Warhammer Online during actual gameplay helps to understand the reason for the increased performance when using 6GB of memory compared to 3GB.

Warhammer Online – 3GB memory array size

Process Explorer - Sysinternals: www.sysinternals.com [Yellowbeard-PC\Yellowbeard]									
Process	PID	CPU	Private Bytes	Virtual Size	Peak Private Byt...	WS Private	Description	Company Name	
zboard.exe	1912		54,264 K	296,564 K	54,320 K	9,824 K	Ideazon Z Engine	Ideazon, Inc.	
winlogon.exe	1188		3,900 K	64,732 K	5,072 K	3,304 K	Windows Logon A...	Microsoft Corporat	
wininit.exe	668		2,348 K	61,164 K	2,656 K	1,912 K	Windows Start-Up...	Microsoft Corporat	
WAR.exe	2796	0.38	1,310,908 K	1,563,584 K	1,358,428 K	1,228,292 K		Electronic Arts, Inc.	
taskmgr.exe	2256	0.19	5,072 K	98,448 K	8,928 K	4,476 K	Windows Task M...	Microsoft Corporat	

With 3GB of system memory the physical memory usage of the Warhammer Online process during an intense battle scene with 60 combatants reached 1.2GB. Private Bytes peaked at 1.35GB.

Warhammer Online – 6GB memory array size

Process Explorer - Sysinternals: www.sysinternals.com [Yellowbeard-PC\Yellowbeard]									
Process	PID	CPU	Private Bytes	Virtual Size	Peak Private Byt...	WS Private	Description	Company Name	
WAR.exe	3484	0.57	1,443,248 K	1,690,860 K	1,476,660 K	1,361,316 K		Electronic Arts, Inc.	
taskeng.exe	1948		11,780 K	117,268 K	13,828 K	5,476 K	Task Scheduler E...	Microsoft Corporation	
taskeng.exe	2716		3,508 K	65,204 K	3,592 K	2,852 K	Task Scheduler E...	Microsoft Corporation	
System Idle Process	0	97.50	0 K	0 K	0 K	0 K		Microsoft Corporation	
System	4		0 K	16,328 K	0 K	0 K		Microsoft Corporation	

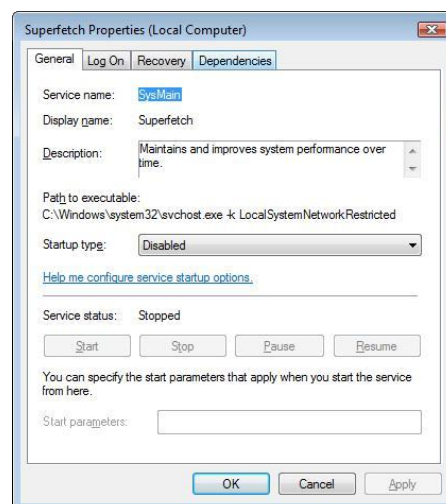
With 6GB of RAM the Private Bytes figure rises to just over 1.4GB and 1.35GB is stored in physical memory. The extra memory headroom of the 6GB configuration leads to smoother performance in the game.



Game loading times

To assess whether installing 6GB of system memory improved game loading times, we ran two different tests using Crysis Warhead and World in Conflict. For Crysis Warhead we loaded a saved game from the 'Call me Ishmael' chapter, recording the time taken from clicking on the load button until 'Press Any Key To Continue' was displayed. We repeated the test three times, rebooting between each test. For World in Conflict we used a section from the 'Behind the Iron Curtain' campaign. We recorded the time taken from clicking on the 'Continue Campaign' button until 'Press Any Key To Continue' was displayed. The test was repeated three times, rebooting between each test.

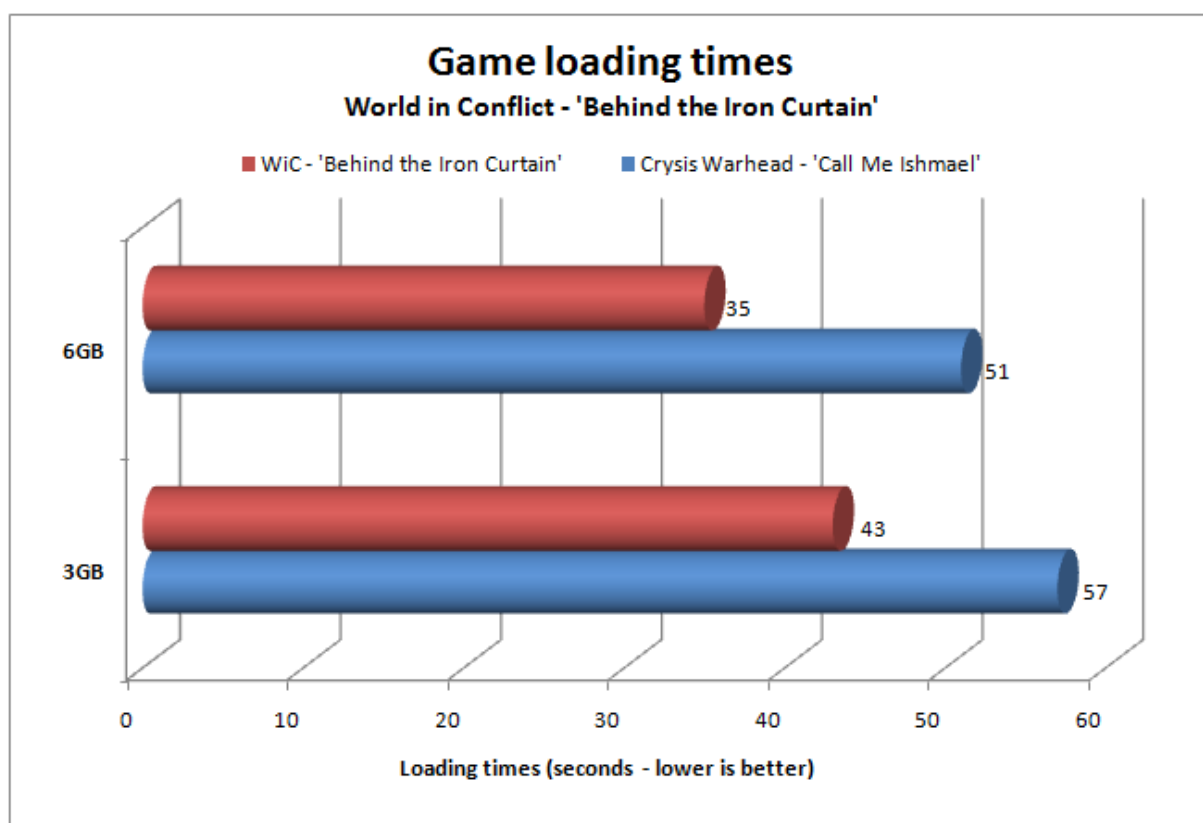
Windows Vista's SuperFetch process was disabled to ensure that the caching function of this process did not affect loading times.



The Windows SuperFetch feature was disabled to ensure repeatable loading time results were achieved

Game loading time results

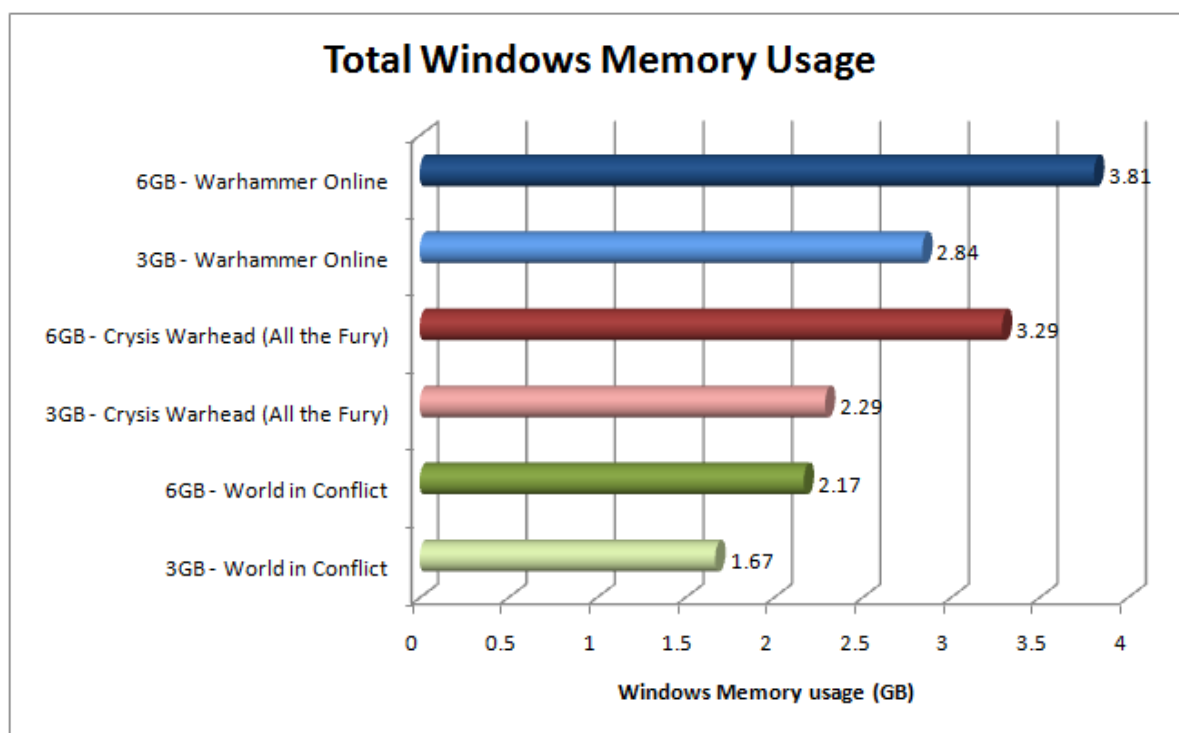
The results show that using 6GB of system memory significantly improved the game loading times of these two titles. The Crysis Warhead saved game loaded 12% faster with 6GB compared to 3GB, while the campaign in World in Conflict loaded 23% faster with 6GB of system memory compared to 3GB of system memory.



Average Game Loading Times	3GB	6GB
Crysis Warhead - 'Call Me Ishmael'	57 seconds	51 seconds
WiC - 'Behind the Iron Curtain'	43 seconds	35 seconds

Total Windows Vista x64 memory usage

In addition to analyzing the memory usage of each individual game process, we also recorded the total memory usage of the whole system, with no other applications running other than the specified game. The chart below shows that Warhammer Online and Crysis Warhead both clearly require more than 3GB of total system memory in order to run smoothly. World in Conflict uses less memory in total, but the extra headroom that 6GB of system memory provides still resulted in higher performance.



Conclusion

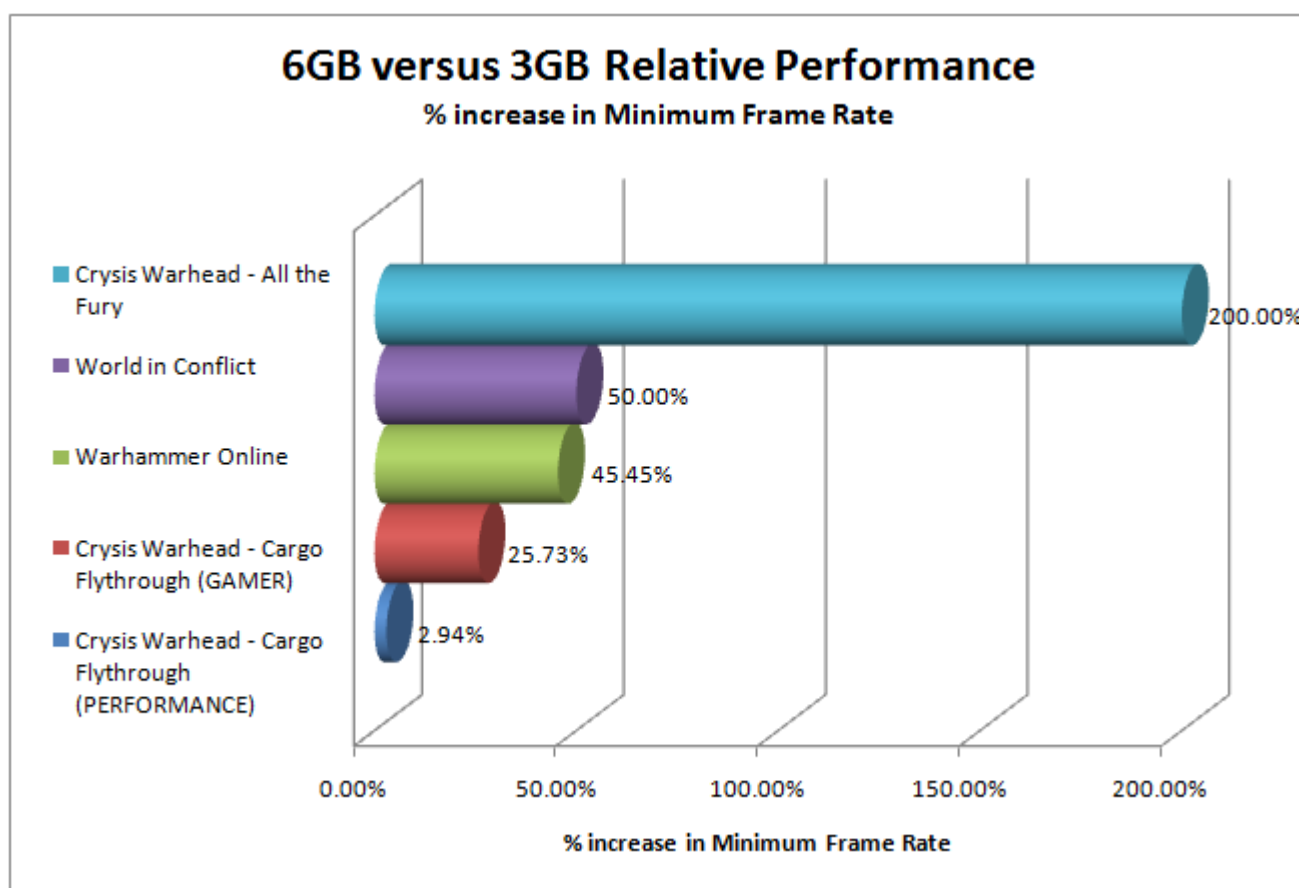
These results show that using 6GB of system memory provides significant performance benefits in today's games when using the Intel Core i7 platform.

The analysis shows that 3GB of system memory is insufficient to run modern games, such as Warhammer Online and Crysis Warhead, resulting in poor performance. The lack of memory when using 3GB of RAM results in increased hard disk drive access, sometimes called thrashing. This causes in-game stuttering, which reduces the minimum frame rate. The minimum frame rate is crucial for fluid gameplay since this determines the overall 'smoothness' of a game.

In our tests the minimum frame rate in World in Conflict rose by 50% when we upgraded from 3GB of system memory to 6GB of system memory. In Crysis Warhead the jump was far more significant, with the minimum frame rate increasing by a factor of 3x when upgrading from 3GB to 6GB of memory. The Crysis Warhead results also highlight the need for large amounts of system memory when using high graphical detail settings. The results from Warhammer Online are similar to World in Conflict and Crysis Warhead and show a minimum frame rate increase of 45% when upgrading from 3GB to 6GB of memory.

The message to enthusiasts who are looking to build a Core i7 system for gaming is clear – installing 6GB of memory will provide significantly higher frame rates and a considerably smoother gaming experience.

Summary of results



Additional Resources

Corsair Memory website: <http://www.corsairmemory.com/>

Corsair Application Notes: <http://www.corsairmemory.com/appnotes/default.aspx>

Corsair Core i7 memory kits: <http://www.corsairmemory.com/corei7/default.aspx>