Gaming CPU Performance: Athlon XP 3200+ Versus Pentium 4 C

By Johan De Gelas – May 2003

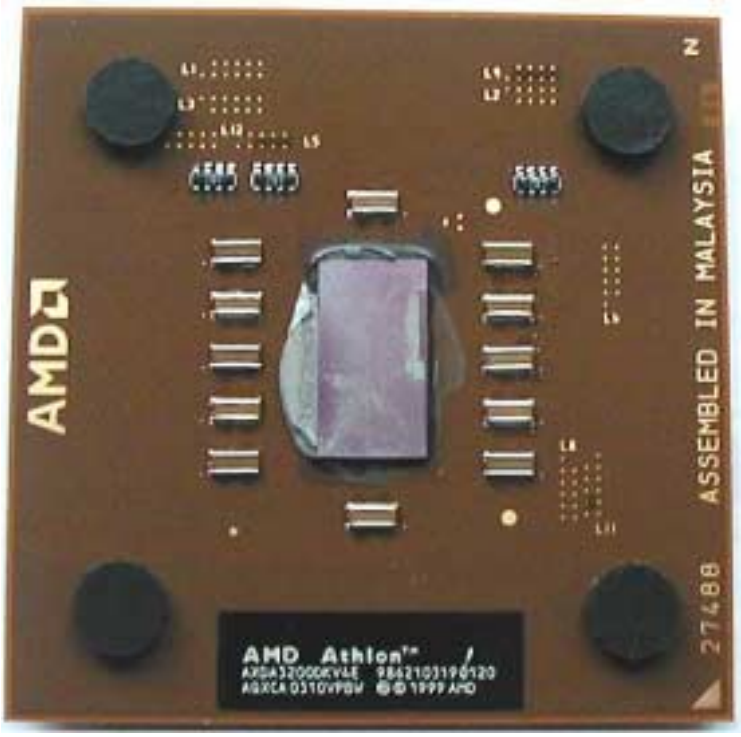
Athlon XP 3200+ Reviewed

As AMD feels that the Athlon 64 still isn't ready for prime time, the Athlon "Barton" core remains their flagship desktop processor that must face the fierce competition of Santa Clara. Today, AMD claims that a 2.2 GHz Athlon with 512 KB cache and a 400 MHz FSB should carry the 3200+ performance rating.

Clockspeeds higher than 2.2 GHz seem to be a hurdle too high for the current Athlon. In our humble opinion, the primary limiting factor is power dissipation. The Athlon faces two problems: it is not capable of reaching high clockspeeds without a core voltage of 1.65V and it is hard to get rid of the heat of the resulting power dissipation when you have to dissipate it through a very small die without a heat-spreader. The carefully mounted heat-spreader and the SOI circuits on the Opteron show, however, that AMD has solved this problem with its next generation processors.

But for now, eight months after the introduction of the 2.25 GHz AMD Athlon (2800+), the Athlon is still running at 2.2 GHz. Intel seems to face the same problem with the Pentium 4, as the 3 GHz P4 has been the fastest processor for 7 (!) months now. Nevertheless, when we knew that the new Athlon XP 3200+ was a 2.2 GHz part, we could not help but to be a bit disapointed. Our last review shows that while the Athlon XP 3000+ was quite a bit faster in typical office productivity benchmarks than the 3 GHz P4, the latter outperformed the Athlon XP 3000+ in most games and quite a few 3D Animation benchmarks. And these two categories are the most important reason why we need faster CPUs. So will 33 extra MHz and a 20% faster FSB make the 2.2 GHz Barton Athlon fast enough to perform like a 3.2 GHz Pentium 4?

Now as this review is slightly late thanks to several failing IBM hard-drives, you might already have a good idea how the Barton 3200+ performs. As it is very hard to evaluate a processor, **we decided to focus on gaming benchmarks and we tested no fewer than 10 different game engines**, so that we can be pretty sure that our comparison is fair and conclusive. This way we avoid the problem that we might pick a few game engines which prefer one architecture over the other.



Just like you we are still skeptical as to whether or not the 3200+ lives up to its QuantiSpeed performance rating. The reason is that in November 2002, Intel's engineers reported that they wouldn't wait for DDR-II to give the Pentium 4 memory subsystem a large boost. The result is that today the Pentium 4 is fed by a gigantic data highway, more specifically the 200 MHz quad-pumped Front Side Bus of the i875P chipset. This fine piece of Intel chipset engineering can - in theory - transfer 6.4 GB per second, or 1.33 DVDs per second.

The Chipset War

So while clockspeeds did not increase for seven months, performance of both the AMD and Intel platforms have been boosted by faster chipsets and memory subsystems. How do these memory subsystems compare? We did a little investigating with **Sciencemark 2.0** and PCMark 2002. The first bandwidth number is reported by Sciencemark 2.0 membench, the second to fifth are PCMark 2002 results.

Chipset	Bandwidth (best)	Bandwidth Read	Bandwidth Write	Bandwidth Modify	Bandwidth Random
"Canterwood" Dual DDR400	4068	3252	1427	1566	2826
"Canterwood" Single DDR400	2797	N/A	N/A	N/A	N/A
"Granite Bay" Dual DDR266	2887	2730	845	910	2369
Nforce 2 FSB400 DDR400	2614	1642	1050	997	1106
Nforce 2 FSB400 DDR333	2251	1419	917	891	994

The i875P chipset, codenamed "Canterwood," is a very impressive chipset capable of producing some impressive bandwidth numbers. Even with a single DDR DIMM, it is able to compete with every other chipset currently available. Please note that this doesn't mean that the Nforce 2 is not well designed: chipset efficiency can only be compared among chipsets on the same platform. With a 200 MHz DDR FSB, the Nforce 2 does very well.

Nevertheless, the numbers are clear, the Pentium 4's memory subsystem is capable of delivering 55% more bandwidth according to Membench and 40 to 255% more according to PCMark2002. The 200 MHz DDR FSB delivers generally 11 to 16% more bandwidth to the Athlon compared to the previous 166 MHz DDR FSB. But bandwidth is of course not the only relevant factor. What about Latency? The results in Sciencemark 2.0 (4 MB datasize) are summarized below.

Chipset	Latency - 128 bit	Latency - 256 bit	Latency - 512 bit
"Canterwood" Dual	209	214	253
"Canterwood" Single	226	227	269
"Granite Bay"	251	254	260
Nforce 2 FSB400	213	214	216
Nforce 2 FSB333	239	239	241

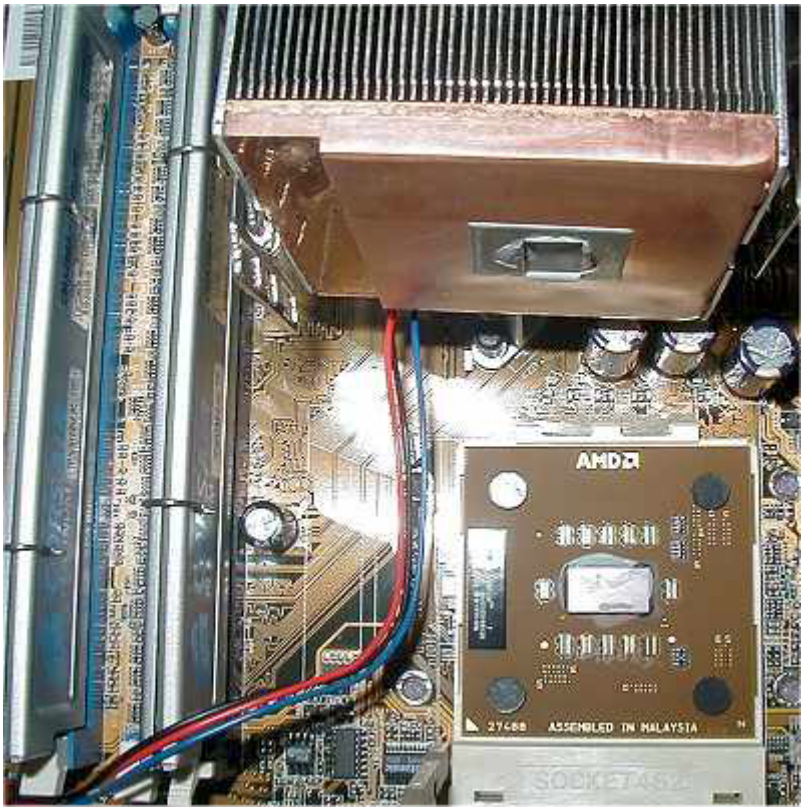
ScienceMark reports that both the Athlon and Pentium 4 wait more or less the same number of cycles (seen from the CPU) for data to arrive. Of course, in absolute time, the Pentium 4 is the winner here.

Bandwidth helps when the cacheline is send back from the memory controller, but only if you need the whole cacheline. In all other cases bandwidth is only important if you run out of it. (Critical Word) Latency is always important, and will have an impact every time a L2-cache miss occurs.

We can conclude that the Athlon has a serious handicap when it must stream information to the CPU, while the latency handicap compared to the Pentium 4 is small.

Power Dissipation & Overclocking

While we could not overclock the Athlon XP 3000+ beyond 2.3 GHz, the Athlon XP 3200+ proved to be a much better overclocker. The Ajigo MF035-032I heatsink proves that good cooling doesn't need to be noisy or very large. We definitely like the silent fan and the fact that it takes advantage of the six hold-down tabs on the socket.



We replaced the silent cooler with our good old "louder than a jetfighter" 6800 RPM Delta AFB-60HP fan and placed this screamer on top of the Ajigo heatsink. With 1.77 V, the processor was capable of booting up the BIOS screen **at 2.55 GHz**, but it wasn't stable in Windows XP. However, we did manage too boot up Windows XP with the FSB set to 228 MHz while the core voltage was at 1.74V. You can see the result below.

Vendor String	AuthenticAMD					
CPU Type	Original OEM Processor				0	
Family	6	Model	10	Stepping ID	0	(Standard)
	7		10		0	(Extended)
Name String	AMD Athlon(tm)					
Internal Clock	2515.07	MHz		System Clock	228.64	MHz
System Bus	457.29	MHz DDR		Multiplier	11.0	
L1 I-Cache	64 K	Byte		L2 Cache	512 K	Byte
L1 D-Cache	64 K	Byte		L2 Speed	Full	
					2515.07	MHz

The Ajigo heatsink in combination with the Delta fan was capable of keeping the core temperature between 40 and 42°C, which is extremely good, and a testimony to the fact that the Ajigo copper bottom made very good contact with the processor die. The Athlon 3200+ was (1.7V core voltage) completely stable with a 225 MHz FSB overclock, so we can conclude that it can reach **2.48 GHz** with forced-air cooling. Our 3 GHz Pentium 4 was capable of reaching **about 3.45 GHz** with forced aircooling and 1.65V core voltage. Let's take a look at how much power the processors dissipate.

Processor Model	Frequency (MHz)	Nominal Voltage	Typical Thermal Power	Maximum Thermal Power
Athlon 1400 (T-bird)	**1400**	1.75V	65 W	72 W
Athlon XP 1700+ (Palomino)	**1467**	1.75V	57.4 W	64 W
Athlon XP 2100+ (Palomino)	**1733**	1.75V	64.3 W	72 W
Athlon XP 1700+(T-bred)	**1467**	1.50V	44.9W	49.4W
Athlon XP 1800+	**1533**		46.3W	59.2 W
Athlon XP 1900+	**1600**		47.7W	60.7 W
Athlon XP 2000+	**1667**	1.60V	54.7W	60.3W
Athlon XP 2100+	**1733**		56.4W	64.3 W
Athlon XP 2200+	**1800**	1.65V	61.7W	67.9W
Athlon XP 2600+	**2133**	1.65V	62 W	68.3W
Athlon XP 2800+ (T-bred)	**2250**	1.65V	64 W	74.3 W
Athlon XP 2500+(Barton)	**1833**	1.65V	53.7 W	68.3 W
Athlon XP 3000+ (Barton)	**2167**	1.65V	58.4 W	74.3 W
Pentium 4 2.0 GHz (0.18 micron)	**2000**	1.7V	72 W	92 W
Pentium 4 2.0 GHz (0.13 micron)	**2000**	1.5V	52.4 W	66 W
Pentium 4 2.2 GHz	**2200**	1.5v	55.1 W	70 W
Pentium 4 2.8 GHz	**2800**	1.525V	68.4 W	85 W
Pentium 4 3.06 GHz	**3060**	1.55 V	81 W	+/- 105 W
Athlon XP 3200+ (Barton)	**2200**	1.65V	60.4 W	76.8 W

Considering that the Athlon XP 2100+ (1733 MHz - 0.18µ) was already hard to cool, we can conclude that the Athlon XP 3200+ is approaching the thermal limits again. Especially in light of our excellent overclocking results we are tempted to say that the Athlon could reach 2.4 GHz, but it is very hard to get rid of all the dissipated power with such a small die. It is a pity AMD's 0.13µ cores use a relatively high core voltage (1.65 V).

To conclude this section, a quick look at AMD's pricing:

AMD CPU	Price (official AMD Price 1K)	Intel CPU	Price (official Intel Price 1K)
Athlon 3200+	$464	Pentium 4 3.2 GHz Pentium 4 3 GHz C	$637 $417
Athlon 3000+	$325	Pentium 4 3.06 GHz	$401
Athlon 2800+	$225	Pentium 4 2.8 GHz	$262
Athlon 2700+	$180	Pentium 4 2.66 GHz	$241
Athlon 2600+	$151	Pentium 4 2.6 GHz	$241
Athlon 2500+	$124	Pentium 4 2.53 GHz	$193
Athlon 2400+	$103	Pentium 4 2.4 GHz	$163
Athlon 2200+	$81	Celeron 2.4 GHz	$103

While AMD's high-end CPU prices might be a bit ambitious, AMD's midrange CPUs are priced very competitively. You can get a 2600+ for less than a 2.4 GHz Pentium 4, and the Athlon XP 2400+ is sold at the same prices as a 2.4 GHz Celeron. In both cases, AMD is offering better performance for a lower price.

AMD seems to price the Athlon XP 3200+ slightly higher than the 3 GHz Pentium 4 C but well below the price of the upcoming 3.2 GHz Pentium. The 3.2 GHz Pentium 4 should launch by end of June 2003. This will be the last "**Northwood**" processor, as the new Prescott core should start at 3.4 GHz.

Benchmarked Configurations

All Pentium 4 systems used the **Gigabyte GA-8INXP ("Granite Bay chipset"),** except for the 3 GHz C which used AOPEN's AX4C MAX. The AX4C Max performs identical to Intel's own Canterwood board. All systems were tested with NVIDIA's Detonator 43.45 drivers. The desktop was set at a resolution of 1024x768x32bpp with an 85 Hz refresh rate. V-sync was off at all times.

We used **Corsair's XMS 3200 CAS 2 DDR** (DDR400) for maximum overclocking possibilities and stability.

Pentium 4 2.8 GHz, 3.06 GHz (Hyperthreading enabled) - 533 MHz FSB

- **Gigabyte GA-8INXP (E7205/ "Granite bay" Chipset) - Dual DDR266**
- **2x256 MB Corsair PC3200 XMS (DDR-SDRAM) running at 266 MHz CAS 2 (2-2-2-6)**
- **Sound Blaster Live!**

Pentium 4 3 GHz C (Hyperthreading enabled) - 800 MHz FSB

- **AOPEN AX4C-MAX (i875P/ "Canterwood" Chipset) - Dual DDR400**
- **2x256 MB Corsair PC3200 XMS (DDR-SDRAM) running at 400 MHz CAS 2 (2-3-3-6)**
- **Sound Blaster Live!**

Athlon 1400 (T-bird), Athlon XP 2700+ (T-bred) and Athlon 3000+/ 3200+ (Barton)

- **ASUS A7N8x Deluxe nForce 2 rev. 2.0, BIOS version 1.04**
- **2x256 MB Corsair PC3200 XMS (DDR-SDRAM) running at 333 MHz CAS 2 (2-3-3-6)**
- **Barton 3200+: 2x256 MB Corsair PC3200 XMS (DDR-SDRAM) running at 400 MHz CAS 2 (2-3-3-6)**
- **Build-in APU**

Shared Components

- **Maxtor 80 GB DiamondMax 740X (7200 rpm, ATA-100/133)**
- **MSI Geforce Ti4600 (AGP 4x) 128 MB**

Software

- **Intel chipset inf update 5.09.1012**
- **NVIDIA 43.45 drivers**
- **NVIDIA nForce 2 2.03 drivers**
- **Windows XP Service Pack 1**
- **DirectX 9**

We'd like to thank the following helpful people for their support and important contributions to this review:

- Damon Muzny (**AMD**)
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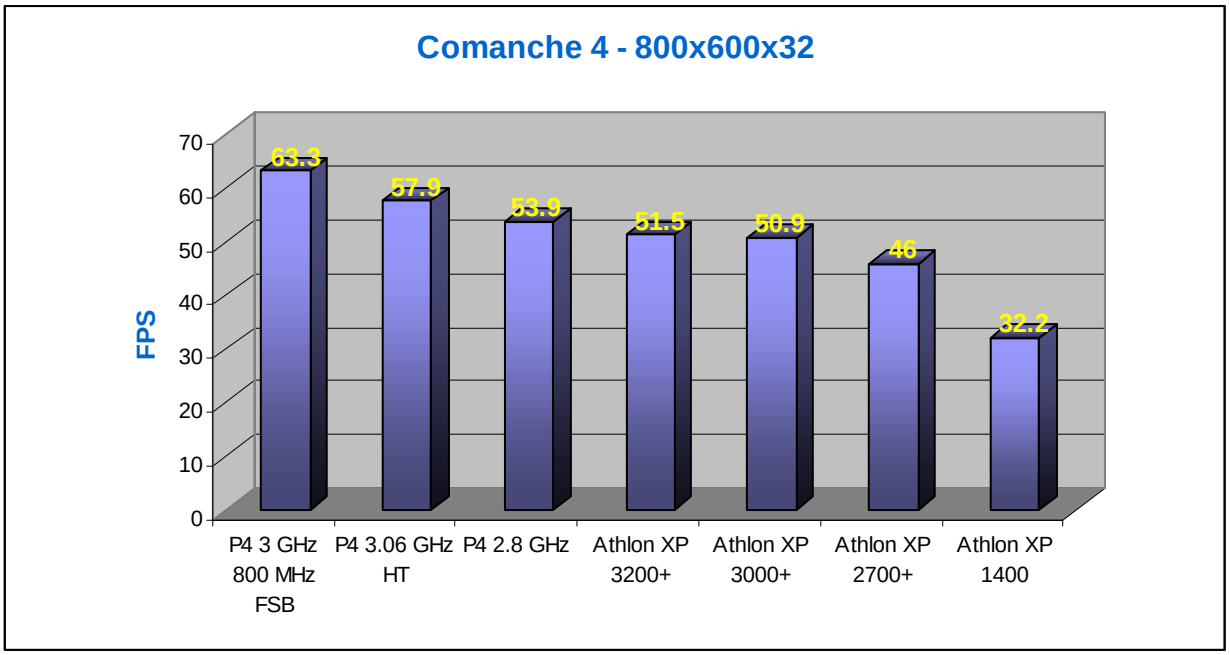
- Angelique Berden (**MSI**)
- Robert Pearce (**Corsair**)
- Will Teng and Carol Chang (**ASUS**)
- Sharon Tan (**BAS computers Netherlands**)

Let's see some benchmarks!

Gaming Benchmarks

We start with the Comanche results, the military helicopter simulator, which is one of the few games that uses DirectX 8's pixelshader effects.



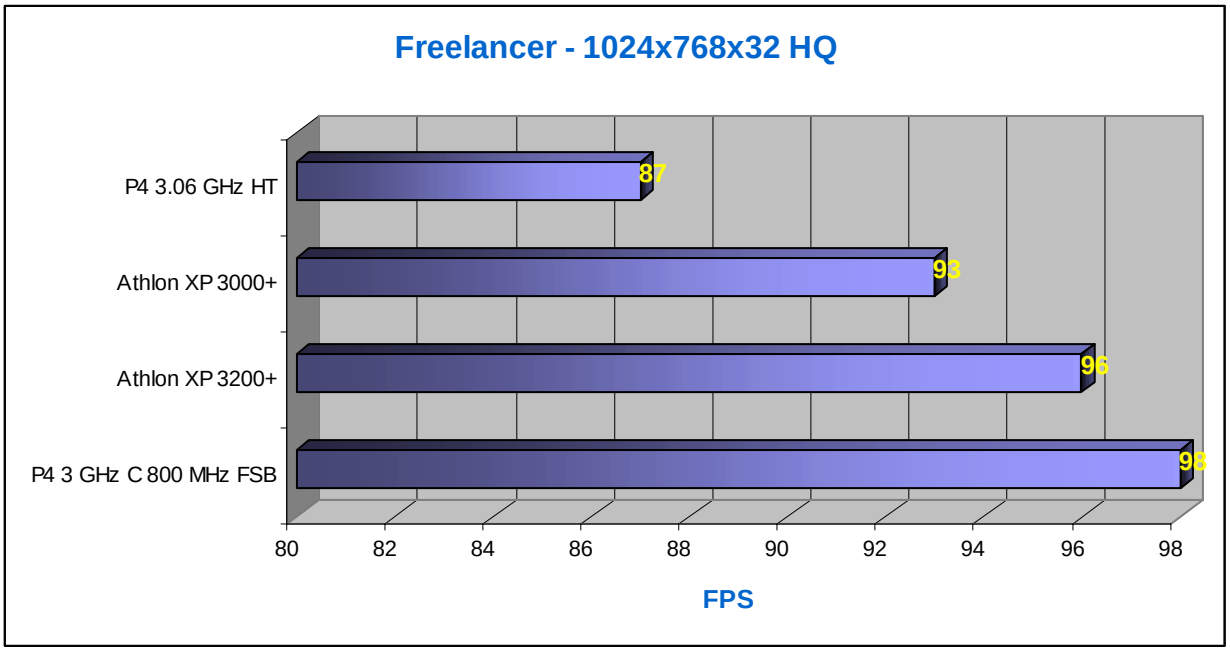
From our review of the Athlon 3000+ you might remember that the extra 256 KB L2-cache of the Athlon 3000+ (512 KB, 2.17 GHz) boosts performance by 10% compared to the Athlon 2700+ (256 KB, 2.17 GHz). Looking at the Athlon 3200+'s score, it seems that Comanche does not depend on the memory subsystem anymore. Even with 33 MHz more and a faster FSB, the Athlon 3200+ doesn't come close to a P4 3 GHz.

Freelancer

While Comanche is a very accurate game benchmark, we wanted to include a very popular Space Simulator too. Freelancer reminds of the time I enjoyed myself a lot while I was shooting Kilrathi in Wing Commander II, one of the best Space Simulators ever. Freelancer is somewhat similar to Privateer, but comes of course with a state-of-the-art graphics engine. I didn't find much information on the engine, but it is must be said that this space simulator features very impressive lighting effects, lens and spotlight glares.

I used the demo and saved just before one of the most intensive space fights. I did not move my own spaceship but I just let it move forward from a well determined amount of time (until the frigate of the general blows up). This way I could benchmark the scene with fraps, and get repeatable results. Typically, the results were repeatable with a difference of 1-3 frames (1-3 % error margin).

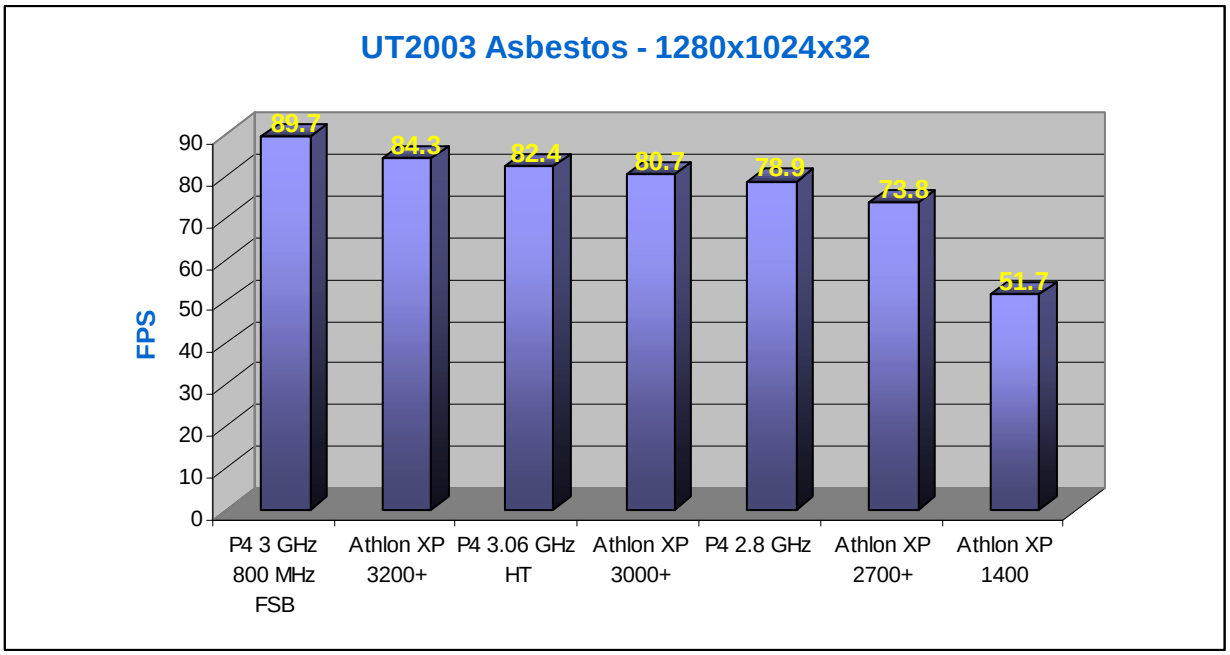
The picture above shows the battle scene we benchmarked. All graphical options were set to maximum quality.



The Athlon does rather well here and outperforms the P4 3.06 Ghz with a measurable margin. However, the new i875P chipset makes the P4 3 GHz the fastest space simulator CPU.

Unreal Tournament

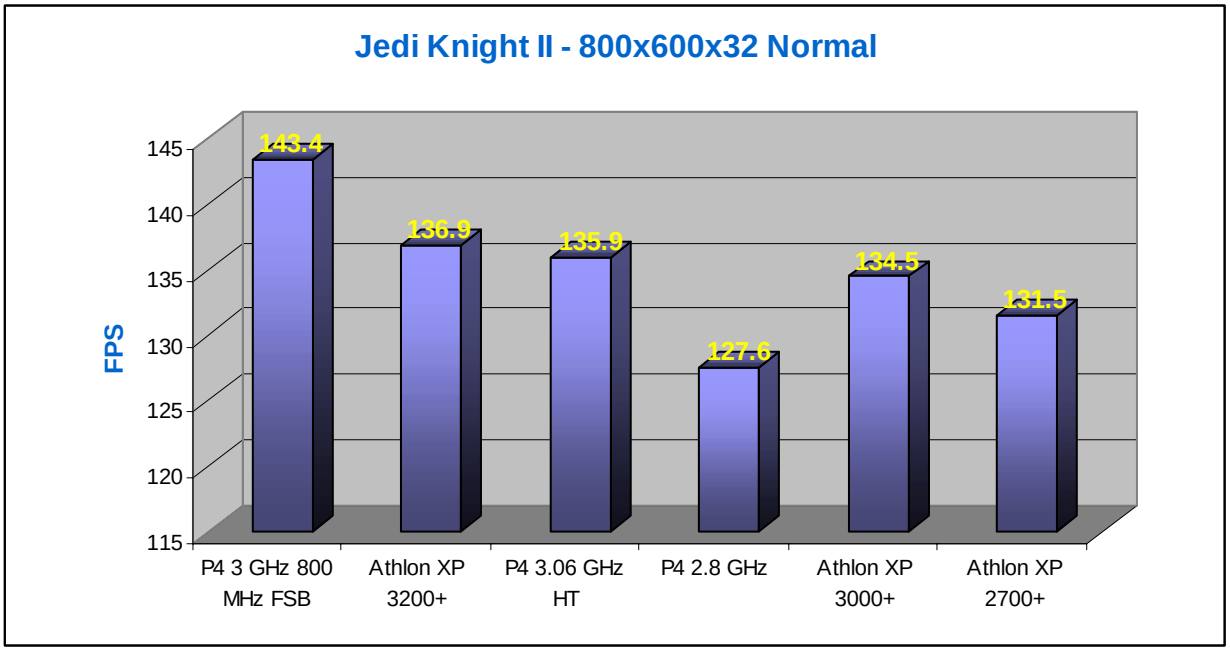
No review can be complete without some Unreal Tournament 2003 benchmarks, as the latest Unreal game is definitely one of the most popular first person shooters around. We chose the Asbestos Botmatch benchmark, as it is one of the most intensive UT2003 benchmarks available.



Barton is 9% faster than a similar Thoroughbred, which is what justifies the 300 points higher QS rating. However, the Athlon is beaten again by the Pentium 4, which holds a slight edge thanks to Hyperthreading.

Jedi Knight II

Jedi Knight II is based on a vastly improved Quake 3 engine. This is the only game where we tested with sound off.

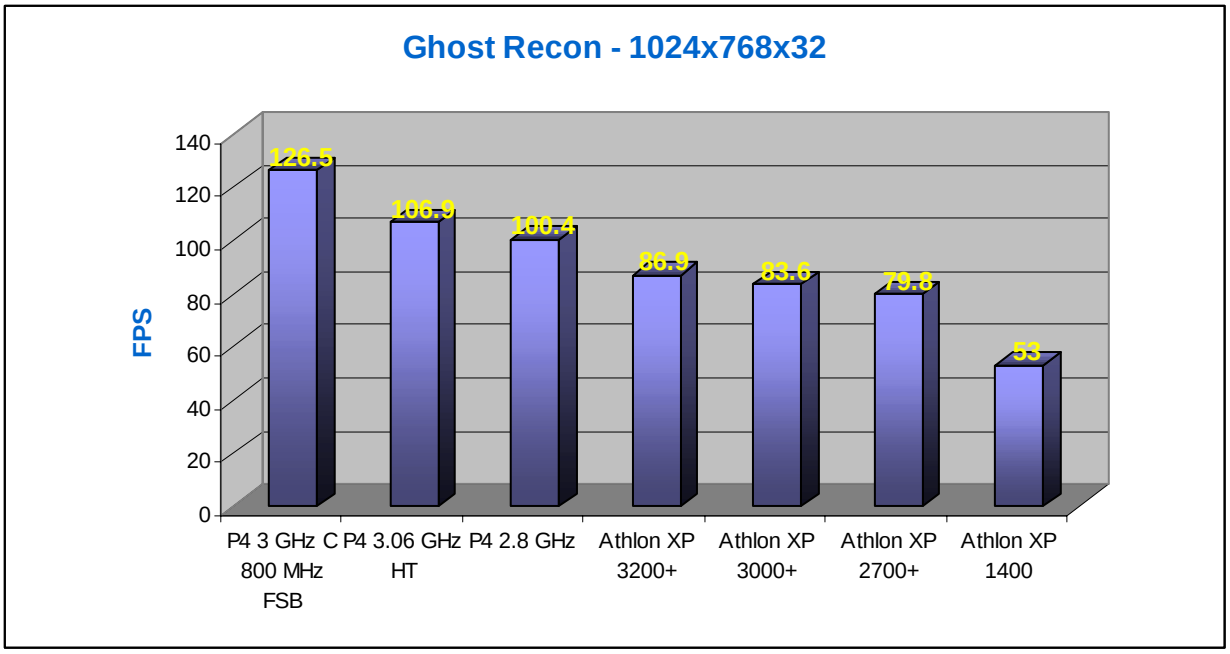


The Athlon XP 3200+ is once again passed by the 3 GHz Pentium 4 with the fast 800 MHz FSB.

Ghost Recon: Desert Siege

In our **last Upgrade Guide**, many people where happy to see **Ghost Recon** among the gaming benchmarks. The "Realistic Combat" First person shooter is the favorite game genre of no less than 17 to 18% of our readers! Just like in previous articles, we set all graphics settings to the highest quality.

Ghost Recon excels in detailed shadows and enemy AI, which are both very processor intensive. The error margin of our Ghost Recon benchmark is very low (1%), with very repeatable benchmark scores.

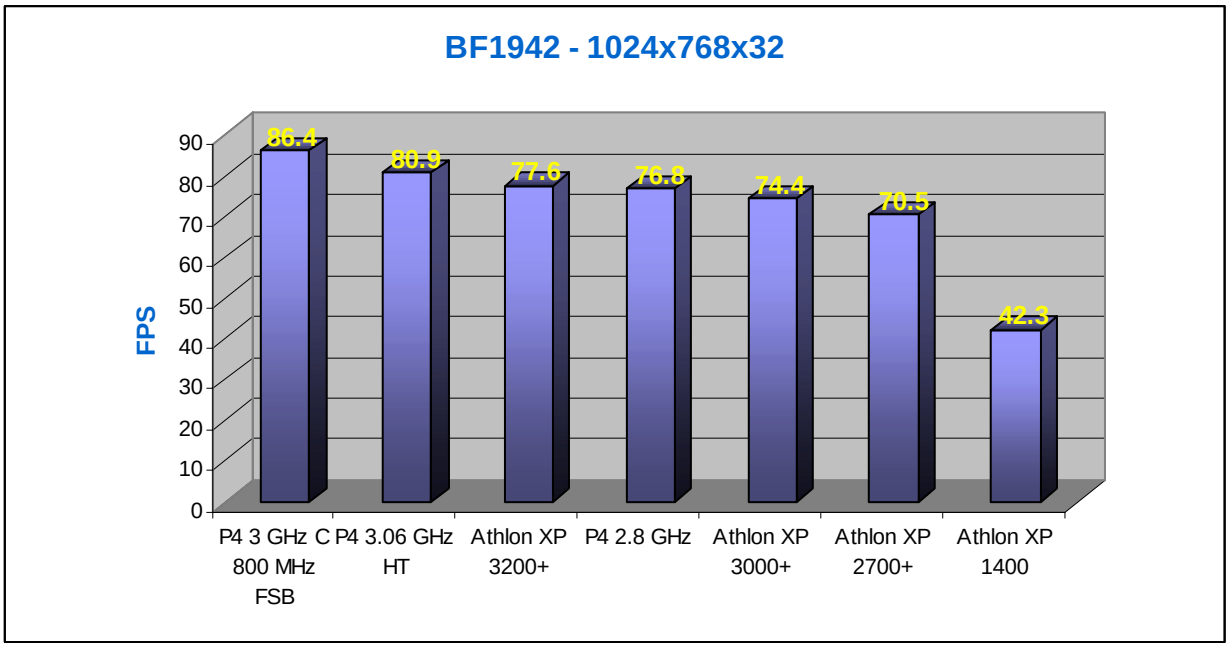


I assure that we have checked the result of the P4 3 GHz C at least 5 times. Ghost Recon seems to love a faster memory subsystem, as the 3 GHz 800 MHz FSB is no less than 18% than it's older brother. As the Pentium 4 already outperformed the Athlon by a decent margin, the difference between the Athlon and the Pentium 4 is rather dramatic.

Battlefield 1942

This first person, team-based action game places you in the midst of one of the WWII battles and you can drive tanks and jeeps and fly Spitfires and Stukas. While it is not as realistic as Ghost Recon, enemy and ally AI is very important. In fact, AI takes up at default 20% of the CPU power, and we raised it manually to its maximum of 25%. You can find **the other settings and more benchmarks here**.

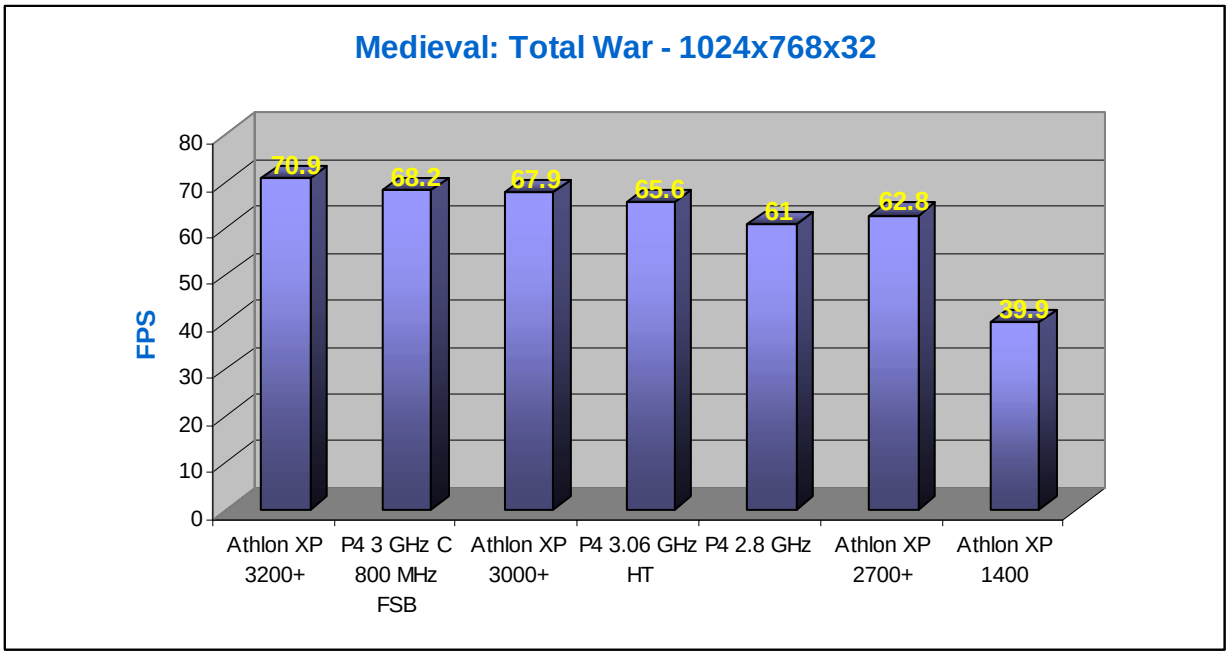
Artificial intelligence is very advanced and not scripted just like Ghost Recon. Shadows are calculated by the video card, and if a DirectX 8 compliant video card is available, it takes over the calculations of hardware skinning on animated meshes (what makes the soldiers look more life-like). Be careful with this benchmark, because we are still not getting very accurate numbers. The error margin between repeated tests is rather high (5%). We repeated our benchmarking with fraps several times to make sure we got a decent result. This benchmark has been run in the "Stalingrad" episode.



While the error margin is high, there is little doubt that the Pentium 4's are a bit faster than the similar Athlons.

Medieval: Total War

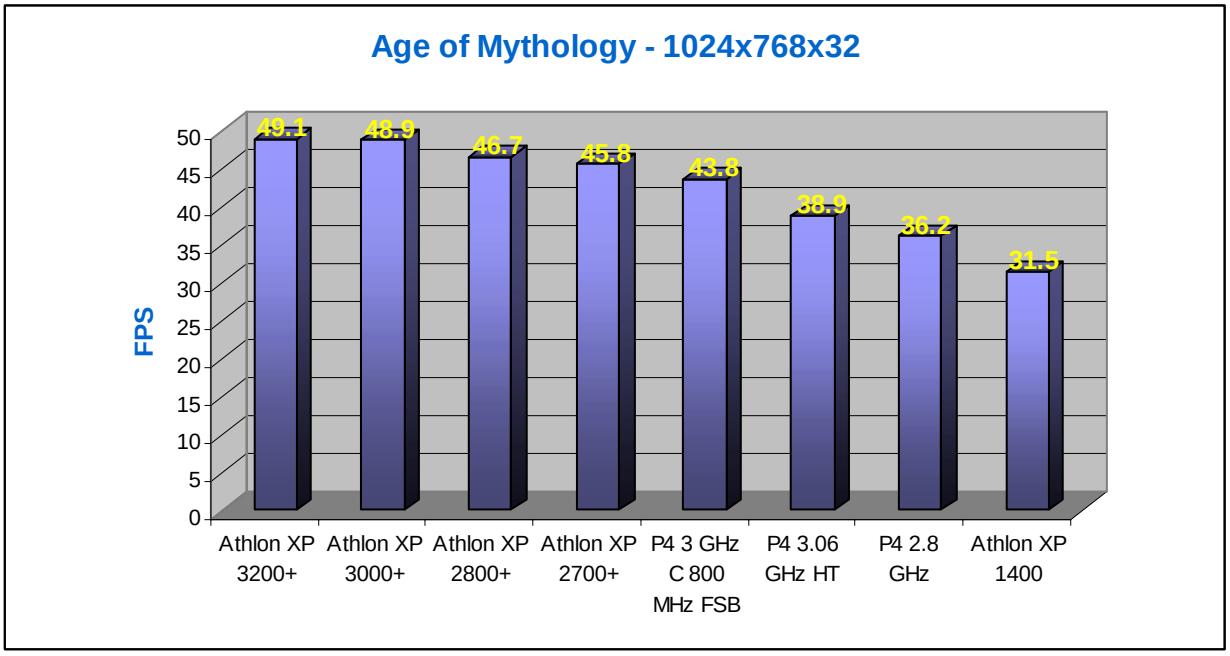
Medieval: Total War is based on the an improved version of the game engine that powered "Shogun: Total War." It contains a strategy "boardgame" element and a tactical, stunning "Real Time Strategy" battlefield element. Our fraps benchmarking is, thanks to the replay feature, very repeatable and error margins are low.



Contrary to previous reviews, we used NVIDIA's 43.45 drivers. While most of our results remained the same, Medieval: Total War seems to like what NVIDIA has changed in this new version. Performance was up to 20% better for all types of CPUs. After a bitter defeat in Ghost Recon, the Athlon XP 3200+ finally outperforms the fastest Pentium 4s.

Age of Mythology

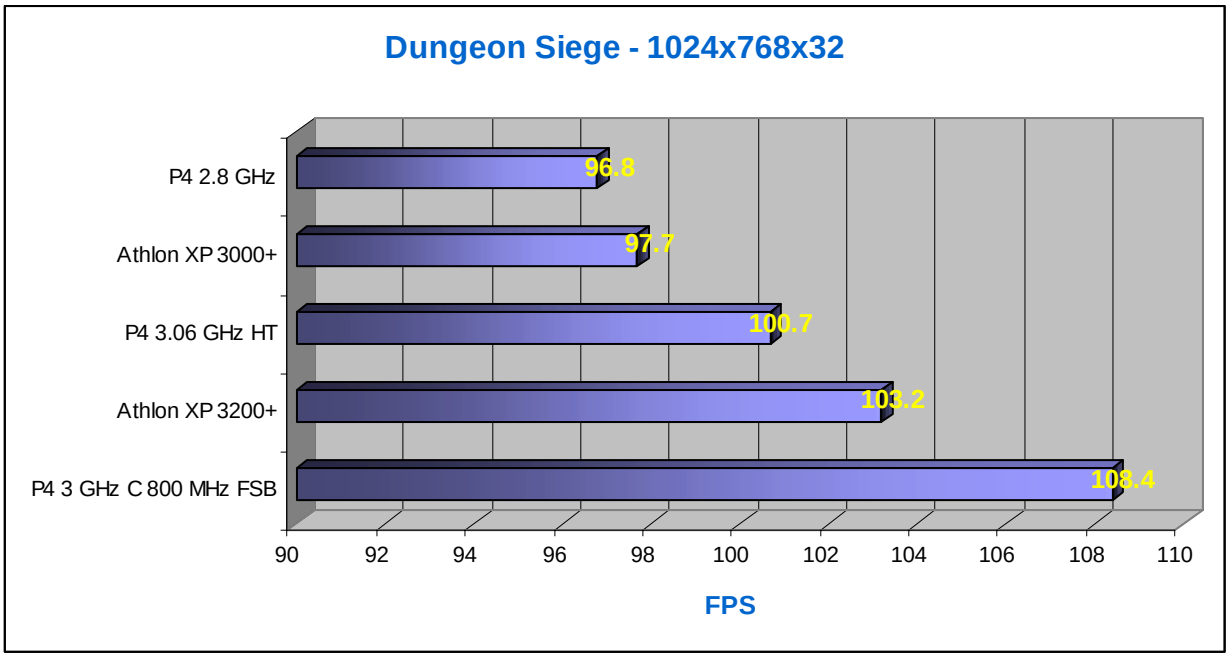
Age of Mythology is the third incarnation of Microsoft's and Ensemble Studio's very popular Age of Empires series. The 2D genie engine of Age of Empires has been replaced with a new 3D engine. Age of Mythology **is a mostly CPU limited game**, which makes it very interesting for this review. We tested the framerate of a battle with a few tens of units.



The Pentium 4 gets a very nice boost from the faster FSB, but this RTS game definitely prefers the Athlon.

Dungeon Siege

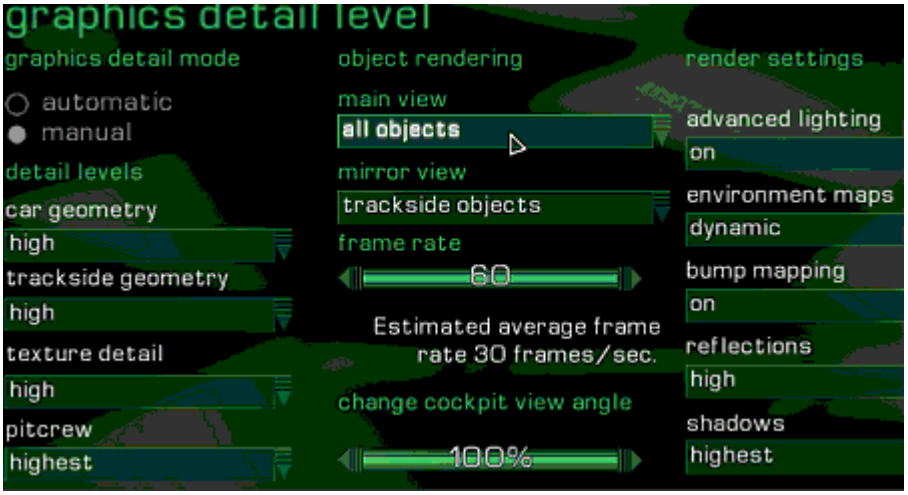
Dungeon Siege was not very innovative from the point of gameplay, but it is sure one of best looking PC RPGs out there. Let us try out Chris Taylor's Dungeon Siege:

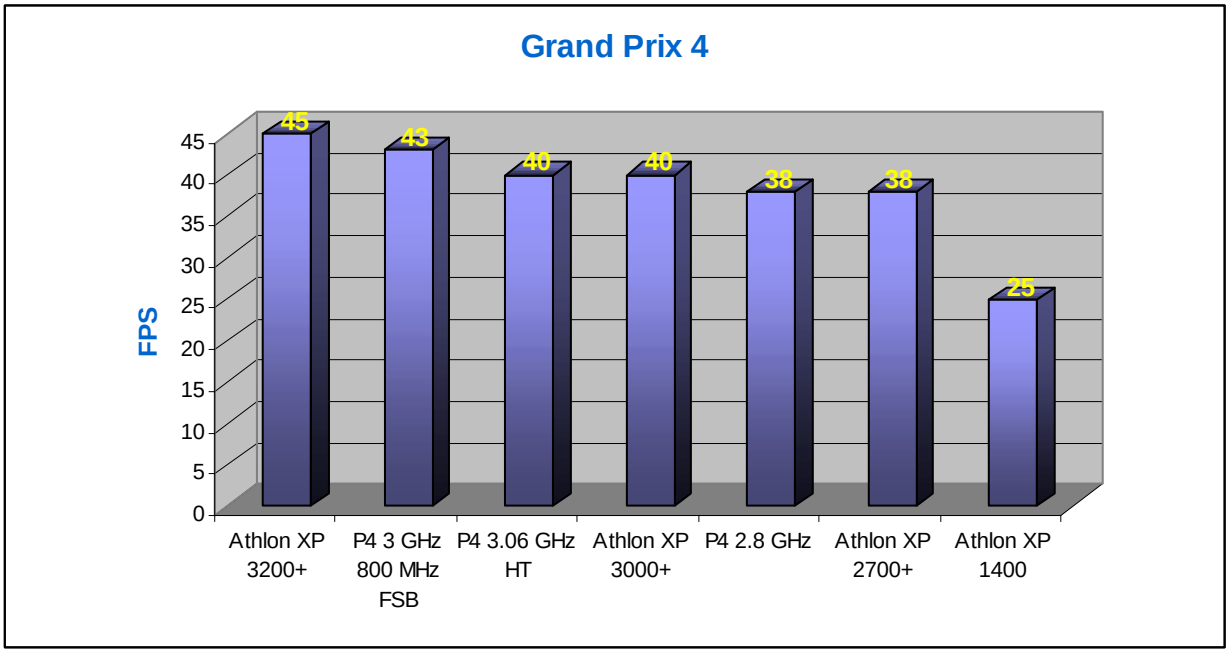


Dungeon Siege confirms that most games do like a faster memory subsystem. Again, the Athlon XP 3200+ loses to the 800 MHz FSB Pentium 4 despite pulling ahead of the 533 MHz FSB P4s.

Simulator: Grand Prix 4

We finish with one of the more popular Formula One simulators: Grand Prix 4. This engine is a typical directX 7 engine that takes advantage of hardware transform and lighting, environment mapping (cars, reflections in wet surfaces) and bump mapping (heat haze from engine heat).





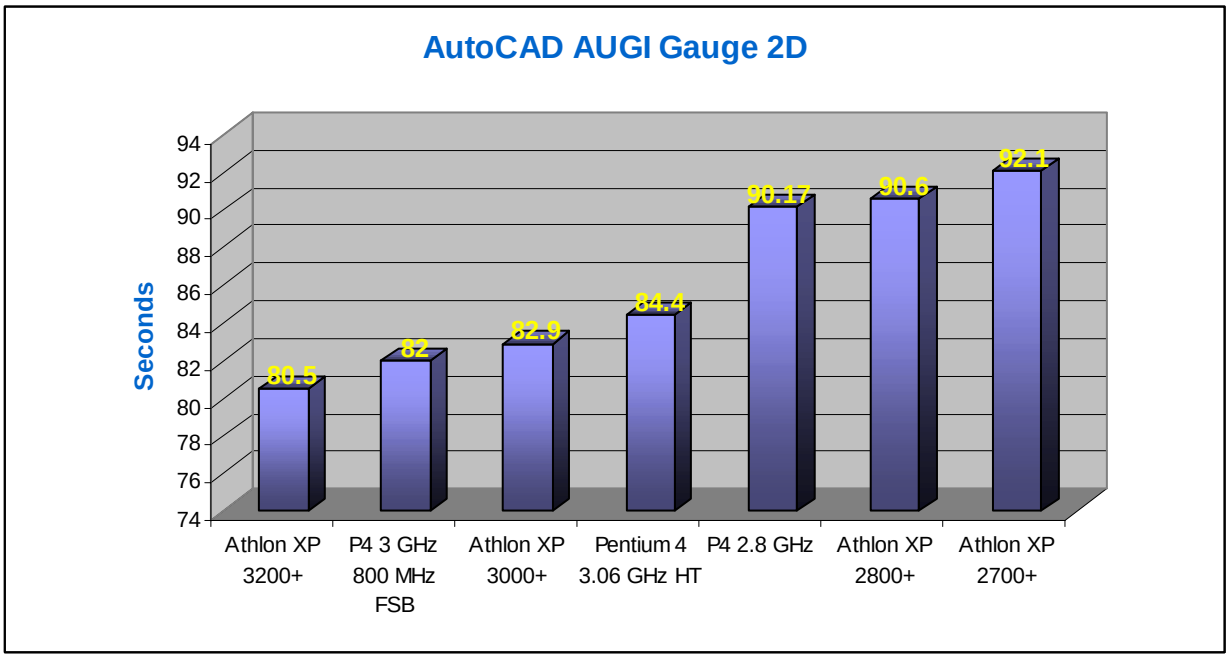
Grand Prix 4 is a bit of surprise, as the Athlon XP 3200+ definitely takes the lead and outperforms the Athlon XP 3000+ by 10%. We used the builtin benchmark in Grand Prix 4 which is rather "coarse-grained."

AutoCAD

We used the AUGI Gauge benchmark from Autodesk Users Group International. From the AUGI Gauge site:

> The AUGI Gauge is a performance-testing tool that can be used to develop benchmark scripts for testing different operations and different drawings. The testing tool comprises a Visual Basic front end and an AutoLISP testing engine. The AUGI Gauge prints completion times for each test operation to a text file, which can be imported into a spreadsheet for data manipulation. The original AUGI Gauge testing tool was designed to work with AutoCAD Release 12 (DOS), Release 13 (Windows) and Release 14. The current version works with AutoCAD Release 14 and AutoCAD 2000.

The benchmark itself consists of two sections, and we have used the real-world test that performs various file, edit, and display operations (totaling 30) on a series of 15 drawings that each average 2 MB in size.



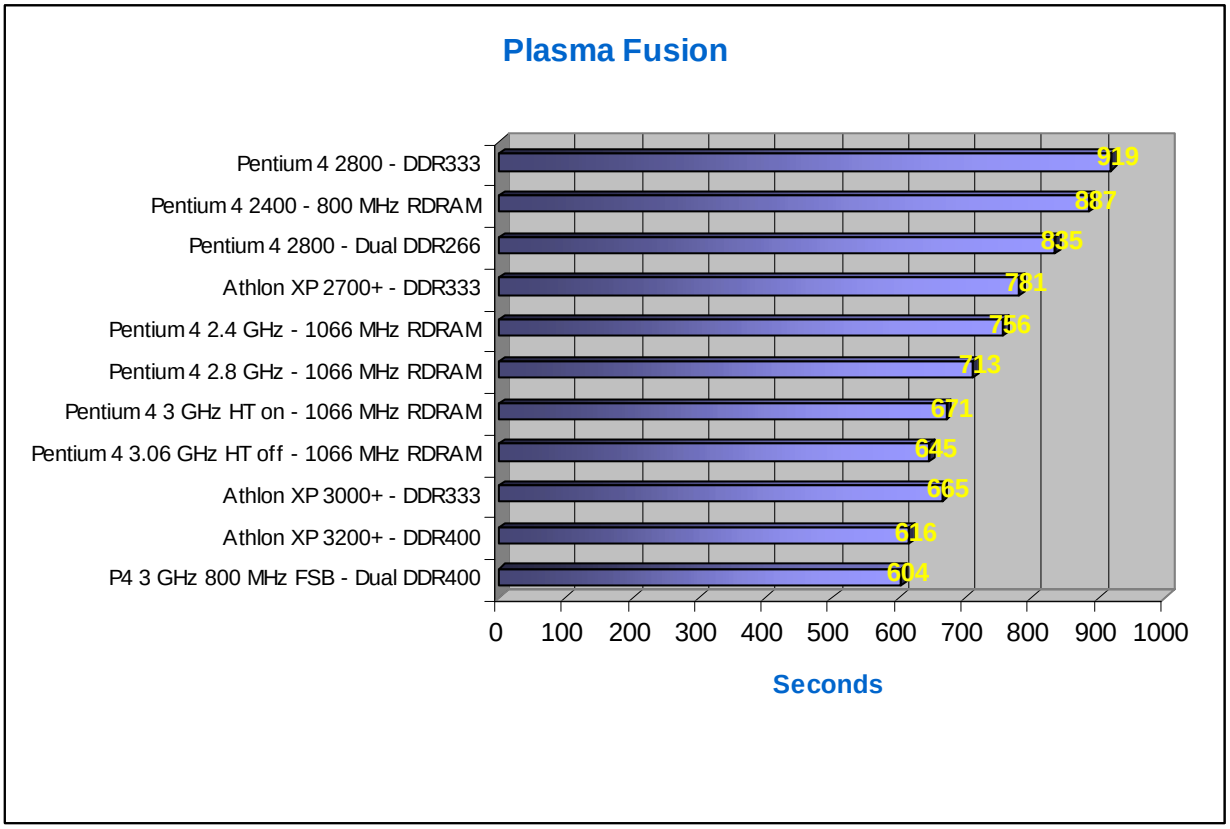
The Athlon 3200+ is slightly faster than the both the 3 GHz P4 C and the Athlon XP 3000+ in AutoCAD 2D.

Plasma Fusion Benchmark

The Plasma benchmark is one of our more recent additions, you can read **all about it here**. Dr. Simon Bland gave us some new information:

> "The MHD code is speed limited by the matrix inversion. The matrix consists of 2.1 million rows by 2.1 million columns, all values to double precision. It is, however, very sparsely populated... there are 29 non-zero diagonals. The current matrix solving method is an iterative solving method (bi-conjugate gradient solutions method). It uses 100 iteractions to solve the matrix, each iteraction consisting of ~5 matrix multipliers. As mentioned we are actively looking for better solving methods both for single and parallel."

Essentially, performance of this scientific simulation depends heavily on memory latency and somewhat on the memory bandwidth and FPU power.



The excellent memory subsystem of the nForce 2 in combination with low latency DDR400 boosts the Athlon past the RDRAM systems and right behind the Canterwood-based Pentium 4. In our previous article, the Athlon XP 3000+ was not much faster than the rest of the Athlons. That seems to have been an error, as our new test reveals that the Plasma simulation does benefit from the extra L2-cache.

With these kinds of huge, and more importantly, sparsely populated matrices, FPU power does not matter that much unless the memory subsystem can deliver the data in a timely matter. The Athlon XP 2700+ is able to beat the Pentium 4 2.8 GHz with DDR333, but a 2.4 GHz Pentium 4 equipped with fast PC1066 RDRAM races past both systems.

Conclusion: A QS Rating too far

So, how do you evaluate CPU performance? You benchmark as much relevant software as possible. But right now, we don't have the tools to evaluate Content Creation or Office Productivity. The creators of content creation benchmarks, such as Bapco (Sysmark 2003) and eTesting Labs (ZD Content Creation 2003) all felt the sudden urge to include Lightwave 7.5 or Windows Media Encoder. Never mind that 3DSMax is by far the most popular 3D Animation package, never mind that there are few people who buy a computer for running WME.

Worse is the fact that you cannot test the applications in these benchmarks suites separately.

The result is that a review which includes Sysmark 2003 or Content Creation 2003 and separate Lightwave or Media Encoder tests is penalizing the AMD processor twice for being slow in the same piece of software. We all know by now that the Intel Pentium 4 is quite a bit faster in both Lightwave and Windows Media Encoder, so that makes both Sysmark 2002 and Content Creation 2003 totally useless as they gives us no idea whatsoever how both CPUs compare in the other applications. At least back in the days of SysMark 2000 we could compare individual application performance. In Content Creation 2002 for example, where Lightwave and WME are not included, the Athlon XP 3200+ scored about 53, while the Pentium 4 was stuck at 47.5. So we don't know whether the Pentium 4 outperforms the Athlon in Content Creation 2003 because it includes newer software or because it includes Lightwave and WME, the "best case" benchmarks for the Pentium 4. Let us call a cat a cat: these kinds of benchmarks are useless and are only marketing tools.

We need to develop our own content creation benchmarks, but for now we have stuck to gaming benchmarks to evaluate the Athlon XP 3200+ and Pentium 4 3 GHz C. Below you find a table summarizing the game benchmarks:

Gaming Benchmarks	AMD 3200+ (400 MHz FSB) versus Pentium 4 3 GHz C (800 MHz FSB)
Age of Mythology 1024x768	**12 % faster**
BF1942 1024x768	**10 % slower**
Comanche 800x600	**19 % slower**
Dungeon Siege 1024x768	**5 % slower**
Freelancer 1024x768 High Quality	**2 % slower**
Ghost Recon 1024x768	**32 % slower**
Grand Prix 4 1024x768	**5 % faster**
Jedi Knight 800x600	**4 % slower**
Medivial War 1024x768	**4 % faster**
Unreal Tournament 2003 Asbestos	**6 % slower**

As we tested about 10 different games, we should have a good idea how the different CPUs compare. As you can see the 3 GHz Pentium 4 is faster than the Athlon XP 3200+ in 7 out of 10 games. You could argue that the 3 GHz 800 MHz FSB Pentium 4 will not find a home on a "Canterwood" board, but on a Springdale board. The I865P chipset is 2-4% slower than its sibling the i875P.

Nevertheless, the 3200+ rating is a clearly too optimistic for the gamer. The 3.2 GHz Pentium 4 will arrive at the end of June and probably outperform the Athlon XP 3200+ in almost every game benchmark (except AOM) out there. Athlon XP 3000+ should have been a 2.24 GHz (13.5 x 166 MHz DDR FSB) processor and the Athlon XP 2.2 GHz (11x 200 MHz DDR FSB) should have been just another 3000+ processor.

Of course one may argue that this all depends on the benchmarks you pick, but these kinds of fast desktop CPUs are largely bought by gamers, especially AMD CPUs, as there are still few OEMs that sell business-oriented desktops with AMD CPUs.