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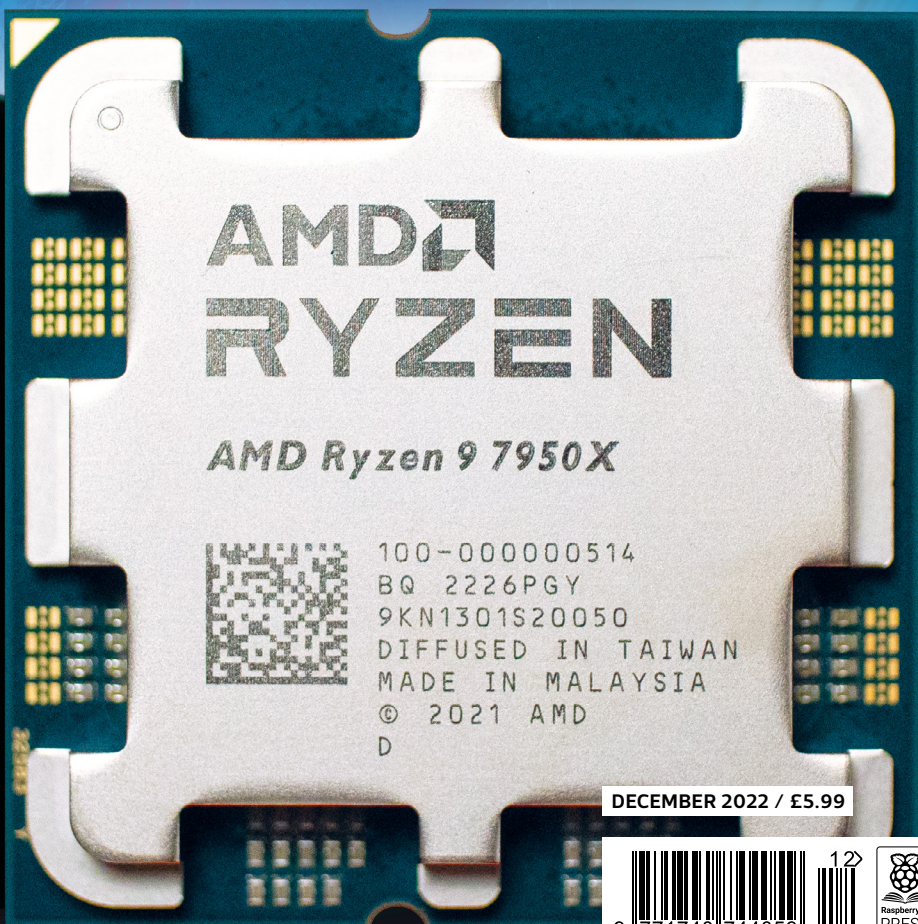
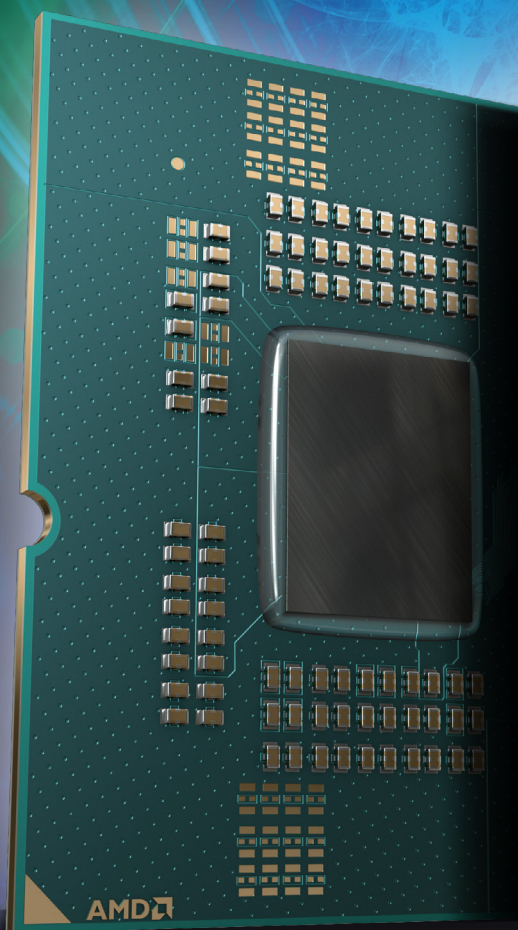
# CUSTOM PC

THE BEST-SELLING MAG FOR PC HARDWARE, OVERCLOCKING, GAMING & MODDING / **ISSUE 231**

# AMD ZEN 4

**THE FULL GUIDE TO AMD'S NEW SUPER-FAST PROCESSORS**

- ▶ DEEP DIVE INTO THE NEW ARCHITECTURE
- ▶ SOCKET AM5 MOTHERBOARD REVIEWS
- ▶ RYZEN 7000-SERIES CPUs REVIEWED
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# Welcome

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Custom PC Issue 231

/ FROM THE EDITOR

## Round one goes to AMD

**T**he first of 2022's autumnal flurry of hardware launches is upon us, and it's a bit good. AMD has once again pulled out a blinder of a CPU architecture with Zen 4 (see p64). The single-threaded performance is huge, and the multi-threaded performance is even bigger. Even the clock speed, which has previously been a weak point for AMD, is genuinely hitting 5.7GHz – there's no merely theoretical boost clock nonsense here.

Again, AMD's chiplet approach has paid off, with AMD able to make a highly scalable system using a single die design built on TSMC's 5nm process, while Intel is still languishing at 10nm. The new I/O chip (IOD) has also been overhauled, being built on a 6nm process and incorporating an integrated GPU.

What's more, as James Gorbould outlines on p98, stock is perfectly stable, especially compared with the shaky supply of Zen 3 CPUs at launch. While this is all good news, though, one factor has come as a bit of a smack in the face, which is the price.

Even the Ryzen 7 7700X (see p16) costs nearly £500, and the Ryzen 9 7950X (see p14) costs nearly £850. The cost of upgrading from an existing system won't be cheap either, as you'll need a new motherboard and DDR5 memory. Only ASRock was able to supply us with Socket AM5 motherboards in time for our print deadline, and the very cheapest option is £300.

We can sadly expect this to be a common theme for new PC hardware this year. Nvidia's latest announcement of its Ada Lovelace GPUs has prices starting at £949 for a card with 12GB of memory and a 192-bit memory interface, with the top-end RTX 4090 coming in at £1,679 inc VAT. With spiralling inflation, as well as a weakened pound against the dollar, it's fair to say that PC upgrades are going to be pricey for the moment.

On the plus side, there's a whole load of competition coming soon, with Intel's Raptor Lake and AMD's Radeon RX 7000-series GPUs on the horizon – let's hope that some fierce competition starts to push down prices. As such, while AMD's latest CPUs are undoubtedly brilliant, it's worth holding out for a month or two just to see how this all plays out. **GPC**



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When you have finished with this magazine please recycle it.





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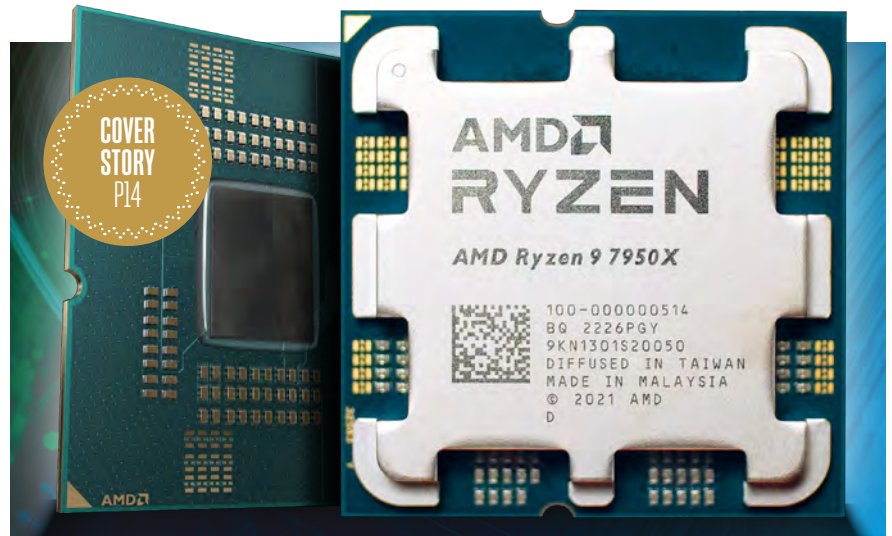
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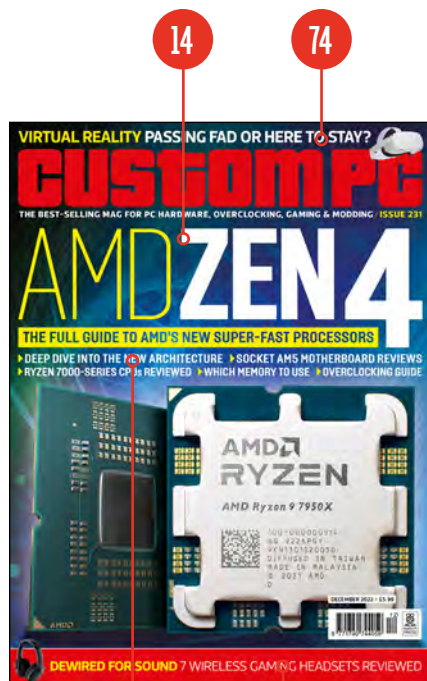
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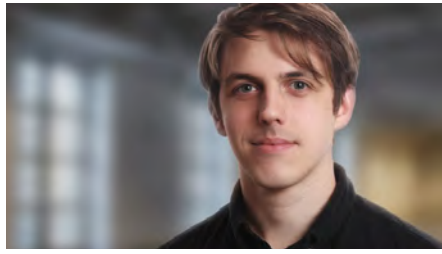
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**RICHARD SWINBURNE** / VIEW FROM TAIWAN

# WHAT ATX 3 CAN DO FOR YOU

With headroom for current spikes and 16-pin power connectors, Richard Swinburne recommends upgrading to a new PSU

**A** PSU may put in a decade of service before being replaced, but if you're looking at upgrading to a next-gen graphics card, or even a current-gen card as prices continue to fall, you need to be aware of the benefits of the ATX 3 standard. Otherwise, you might find yourself with a PC that shuts off unexpectedly, even if its wattage seems sufficient.

This is exactly what happened to me. Early in the summer, I jumped on a Radeon RX 6900 XT graphics card, as the prices had fallen below MSRP. The Seasonic website told me my old Focus PX 750W 80 Plus Platinum PSU was good to go. All great, I thought, but then my PC randomly switched off during games.

Even enabling Radeon Chill and limiting the frame rate didn't prevent the PSU from cutting the PC power entirely. I suspected it was hitting the overcurrent protection breaker, so I ran HWiNFO64 software to monitor the power draw. I fired up a game in windowed mode and watched the max power draw – 69A of peak current on just the graphics card! My 750W PSU is only capable of providing 62A via 12V for the whole system, so it's woefully insufficient to handle these peak loads.

After some digging around, I read about how high-end GPUs from both AMD and Nvidia produce transient peak loads that can be well in excess of their average current draw, and what their max TDP suggests. Certain high-power (or recently designed) PSUs are built with enough capacity to mitigate this problem, but there's no simple way to tell.

Thankfully, a new generation of ATX 3-spec PSUs are starting to appear, and they're designed to address this exact issue. ATX 3 marketing focuses on next-gen graphics cards, but it

will also benefit current-gen users. ATX 3 requires PSUs rated at 450W and above to support transient load spikes of up to 200 per cent of the rated power for a fraction of a second, eliminating overcurrent shutdown situations.

The new spec also replaces the multiple 8-pin PCI-E connectors with a new 16-pin high-power connector (12VHPWR) that supplies up to 600W. Introduced by Nvidia on its RTX 3000-series Founders Edition cards, the connector was only officially inked into the spec in February this year. It seems more next-gen graphics cards will use 12VHPWR, so if you're planning to buy one, you'll want to budget for a new ATX 3 PSU as well.

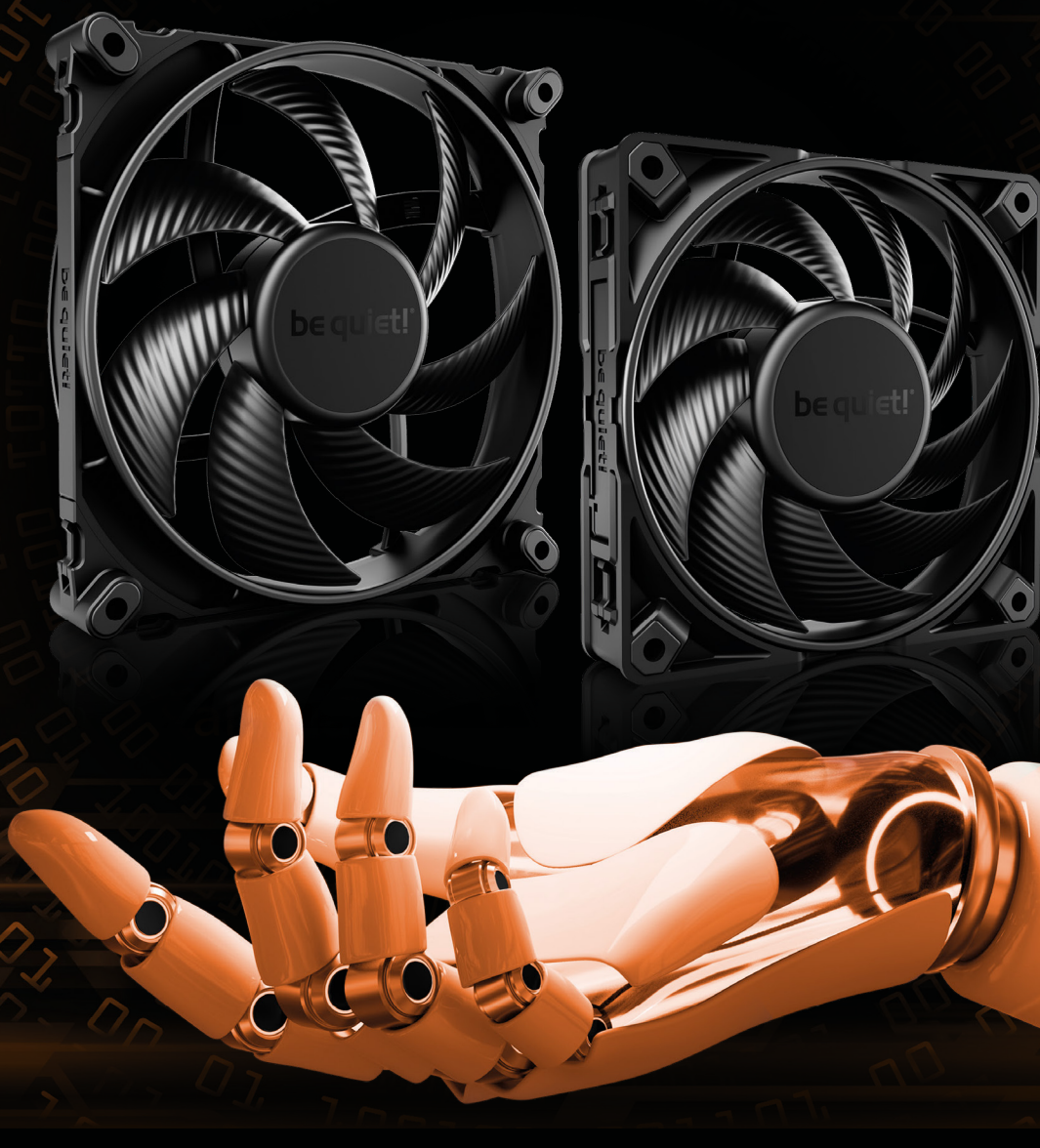
Should you have a mega-powerful ATX 2-era power supply that you still want to keep, the standards body, PCI-SIG, has warned NOT to use cable adaptors that convert multiple 8-pin PCI-E connectors to 12VHPWR, because it won't balance the current load across the 8-pin cables, risking excessive power draw on any one of the cables, which can melt and cause a fire.

Instead, you need to contact your PSU maker to get a 12VHPWR cable that replaces the 8-pin PCI-E cables entirely and plugs directly into the PSU itself. At the time of writing, no PSU maker has yet offered this upgrade path, however.

This is only one of the new specs for ATX 3, which includes single-to-multiple rail switching, better 12V voltage drop protection, superior idle efficiency (one model sports up to 40 per cent load in fanless mode), and a feedback signal between PCI-E devices and the PSU, allowing the PSU to become an active part of the system. It's certainly worth considering a jump to ATX 3 in your next upgrade. **GPC**

Then my PC  
randomly switched  
off during games

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan [@ricswi](#)



# LEAP IN INNOVATION

## SILENT WINGS 4

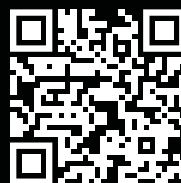
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# Letters

Please send us your feedback and correspondence to  
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## RG BARIJY

Thank you for the excellent Labs test on fans this month. I have just bought a Thermaltake P8 case, which is awesome, and needed to buy some more LED fans (the P8 can take 18 x 120mm fans!). I went with your recommendation of the Deepcool 120s, with five available for £35 from Amazon.

I had no idea what I was getting into though. I assumed that most fans and LEDs would follow a connection standard, rather than offering proprietary and incompatible systems – this is a PC and not an Apple system after all.

Anyway, these fans had all the cables and adaptors to connect them to my Corsair Commander Pro for the PWM control, and the RGB 12V header on my motherboard for the LEDs. So far so good, and if I had just bought some more of these fans, or more Corsair fans, all would have been well.

However, the story then takes a turn for the worse. I bought some Deepcool 140s for the air intake on the front of the case. Like the 120s, these use JST-SM connectors for the LED cables and a standard 5V PWM connector. Unfortunately, the 140s didn't come with the adaptors to connect to the motherboard or the Commander Pro lighting node, and after spending a couple of days buying and then sending back cables I'm now about to try making my own connector cable. This is all so I can use Corsair's iCUE software to control the LEDs.

My point is twofold. First, ideally you would have discussed the fan cables and connections in the

When's the next issue out?

**Custom PC**

Issue 232

On sale on Thursday, 3 November



article, and secondly perhaps this is a subject of interest for an in-depth look in a **Custom PC** article? Anyway, keep up the good work.

**JOHN MULCAHY**

**Ben:** The silly number of different 'standards' for RGB connections and controllers is a constant source of frustration for us, and many other system builders – I'm sorry to hear you've had such a nightmare with them. Corsair's iCUE software is excellent for lighting control, but sometimes you just have to end up using your motherboard as an RGB controller for some parts, or getting another third-party controller – it's all very irritating.

The fan reviews in that Labs test were only half-pagers, where we mainly focused on cooling performance and noise – we wouldn't have had space to try out every fan with various different lighting control systems. Also, there isn't a 140mm version of the Deepcool FC120s we reviewed – the nearest is the CF140, which is a different model. However, you're right that this is a minefield that could do with a proper look at some point – we'll see if we can do a more in-depth foray into the confusing world of RGB control and connectors in a future feature.

## Clean-up masterclass

A quick thanks for issue 229, where you provided a masterclass on constructing a computer. I've

James found a yeti  
inhabiting his radiator



languished with my old PC for years and decided it was time for a change.

Using your informative guide, I moved the motherboard into a be quiet! case, tidied up the wires, added some RAM and cleared out the yeti that inhabited my CPU radiator. I'm loving the new setup!

**JAMES ELLIOTT**

After reading through  
our PC building  
masterclass, James  
now has a neat and  
tidy PC interior

**Ben:** Glad to be of service, James. It's well worth cleaning the dust out of your PC from time to time, and I can't imagine that radiator was working very well! That's a tidy-looking setup now.



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# Incoming

## NVIDIA UNVEILS GEFORCE RTX 4000 SERIES

Nvidia has officially unveiled the first of its GeForce RTX 4000-series GPUs, the GeForce RTX 4090 and RTX 4080. Both will be powered by the company's new Ada Lovelace GPU architecture, which will be built using TSMC's N4 manufacturing process.

Among the new features is an improvement in ray-tracing acceleration, with Nvidia promising double the triangle intersection performance, and a new Shader Execution Reordering mode technology, which the company claims is as revolutionary as out-of-order execution for CPUs, enabling the GPU to process and reorder ray-tracing shader instructions no matter when they arrive in the pipeline.

In addition to the new GPUs, Nvidia also demonstrated its new DLSS 3 resolution scaling technology, which doesn't just insert new pixels into existing upscaled frames, but also inserts new frames altogether, using a new optical multi-frame generator and optical flow accelerator. If Nvidia's demo is to be believed, the result is a huge speed up in frame rates with minimal impact on image quality.

Starting with the RTX 4090, this top-end GPU will have 11 Graphics Processing Clusters (GPCs), nine of which feature 12 Streaming Multiprocessor (SM) blocks, and two of which have ten SMs. With each SM containing 128 CUDA cores, you get a total of 16,384 on the RTX 4090, compared to 10,752 on the RTX 3090 Ti. Each SM also contains one RT core for ray tracing, so you get 128 of them on the RTX 4090, along with 512 4th-gen Tensor cores, which Nvidia says can offer up to double the AI calculation performance of their predecessors.

Cards based on this flagship GPU will also feature 24GB of GDDR6X memory, accessed via a 384-bit wide memory interface. Meanwhile, the stock boost clock will be 2520MHz, and Nvidia claims the RTX 4090 will offer double the performance of the RTX 3090 Ti. Nvidia says prices will start at £1,679 inc VAT.

So far, so expected – GPUs are expensive now, particularly at the top end, but Nvidia has surprised a lot of people with the high prices and comparatively low specs of the next rung down, the RTX 4080.

Two flavours will be available, denoted by whether they have 16GB or 12GB of memory, but the differences extend well beyond the memory allocation. The 16GB version has 9,728 CUDA cores and a 256-bit wide memory interface, while the 12GB version has just 7,680 CUDA cores and a 192-bit-wide memory interface.

Compared with the Ampere range, you had to step down to an RTX 3070 Ti to get a 256-bit wide interface, and the RTX 3060 Ti to get a card with a 192-bit-wide memory interface. Using Ampere as a comparative example, the RTX 3060 Ti had 4,864 CUDA cores, compared to 10,496 on the RTX 3090 – a 115 per cent increase, and there's just a 113 per cent increase in the number of CUDA cores when you go from the RTX 4080 12GB and the RTX 4090.

In short, in terms of spec compared with the flagship, the RTX 4080 12GB appears to be more like the RTX 3060 Ti than the RTX 3080, and the RTX 4080 16GB more like the RTX 3070 Ti. That's not a problem if the pricing followed, but Nvidia states that the RTX 12GB and 16GB will cost at least £949 and £1,269 inc VAT respectively. That's a massive price bump compared with Ampere, so let's hope the benchmarks deliver.



## AMD RDNA3 TO BE UNVEILED IN NOVEMBER

AMD has taken the opportunity to thumb its nose at Nvidia's GeForce RTX 4090 announcement to tease a 3 November unveiling of its upcoming RDNA3 GPUs. 'Join us on November 3rd as we launch RDNA3 to the world! More details to come soon! #RDNA3 #AMD,' announced the company's SVP & GM for AMD Radeon, Scott Herkelman, via his Twitter account.

Beyond this announcement teaser, AMD has revealed no further details of the new GPUs – expected to be released as the Radeon RX 7000 series, but the company has previously confirmed it will be using a chiplet approach for some of its RDNA3 implementations, relying on multiple GPU dies to achieve full performance.



## EVGA SPLITS WITH NVIDIA

Previously one of Nvidia's key board partners, EVGA has announced that it's pulling out of the graphics card industry. YouTube channel Gamers Nexus ([custompc.co.uk/EVGASplit](https://custompc.co.uk/EVGASplit)) said that it was flown out to a 'closed doors meeting' at EVGA's HQ, during which EVGA CEO Andrew Han reportedly said, 'We are not

going to be on Jensen's lap on stage ... EVGA has decided to not carry the next gen.'

A statement on EVGA's forums has since confirmed that EVGA will indeed not be producing next-gen graphics cards, but that it will continue to produce current-gen cards and support their warranties.

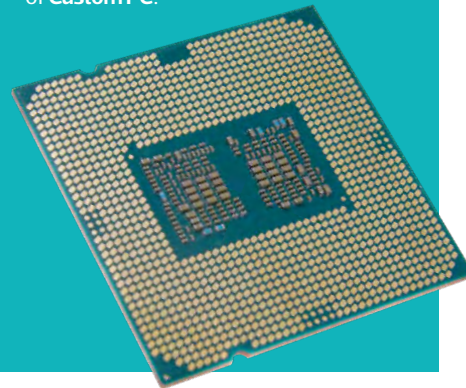


## INTEL RAPTOR LAKE INBOUND

As with AMD's Zen 4 announcement last month, the full details of Intel's new 13th-gen Raptor Lake CPUs are due to be announced four days after this issue goes to press, so we don't know the full skinny. However, Intel has revealed that its top-end CPUs are capable of boosting to 6GHz, with liquid nitrogen overclocking able to get them up to 8GHz.

Intel recently published a page detailing the CPU specs to its Canadian website, before hastily deleting it. Assuming the stats listed are correct, the flagship Core i9-13900K is rumoured to feature 24 cores in total, with eight P-Cores and 16 E-Cores, while the Core i7-13700K is rumoured to have 16 cores, comprising eight P-Cores and eight E-Cores.

If true, this would mark a step up of four E-Cores compared with Alder Lake, potentially also giving Intel the edge over AMD's Zen 4 CPUs in heavily multi-threaded software. We hope to have our first tests of Raptor Lake in the next issue of **Custom PC**.



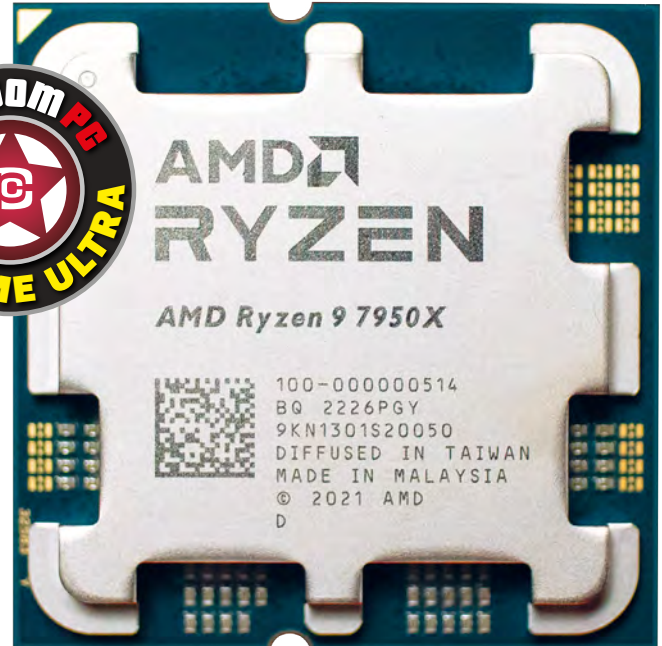


# Reviews

## SOCKET AM5 PROCESSOR

# AMD RYZEN 9 7950X / £849 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)



**T**his autumn is going to represent an interesting battle for the CPU performance crown, with AMD's new 5nm Zen 4 microarchitecture vying for pole position against the expected Core i9-13900K from Intel. However, while AMD has made huge performance gains from shrinking the manufacturing process and introducing a new microarchitecture, it hasn't increased the core count on its latest flagship compared with its predecessor.

The Ryzen 9 7950X still has the same 16 cores (and 32 threads via SMT) as the Ryzen 9 5950X,

and it's similarly based on two core complex dies (CCDs) with eight cores each. It also has a much higher TDP of 170W, compared to 105W for the Ryzen 9 5950X. Overclocking the latter offered huge gains in multi-threaded performance, so it looks as though AMD has increased the power available to it in order to clock up the boost frequencies.

Indeed, the Ryzen 9 5950X has a massive 5.7GHz peak boost frequency, compared to 4.9GHz for the older CPU. Even if both CPUs processed the same number of instructions per clock (IPC) at stock speed, that boost would offer a sizable jump in performance, but AMD is also claiming a 13 per cent uplift in IPC too.

We'll know more about Intel's plans by the time this magazine hits the shelves, but if rumours are to be believed, it looks set to increase the core counts for its flagship to a possible 24 cores, meaning AMD may have its work cut out if it wants to compete.

Back to the Ryzen 9 7950X, under the hood is an L2 cache that has doubled in

size to 16MB (1MB per core), which should cut latency as well as boost performance. There's also a new front end, plus improvements to branch prediction and the execution engine, which all improve performance further. You can read all about the architectural details in our deep dive feature on p64.

Also, don't forget that you get integrated Radeon RDNA2 graphics inside the chips too, although it's only powerful enough to drive displays rather than games according to AMD, plus there's now AVX-512 support, although AMD's 256-bit wide SIMD design means AVX-512 instructions will take two cycles to execute, as opposed to a single cycle on Intel's full 512-bit wide SIMD machine.

Those quoted clock speeds aren't just theoretical either. We saw peak all-core boost frequencies of up to 5.2GHz, which is a huge increase over its predecessor, with the single-core boost often hitting 5.7GHz. What's more, if you're concerned about heat and power draw, AMD has introduced a feature called Eco Mode. This allows you to drop the TDP from the standard 170W to either 105W or even 65W.

At the time of writing, you had to enter specific power limits into the EFI's Precision Boost settings in order to enable this, but AMD has told us that this feature should be a one-click affair soon after the launch, both in motherboard EFIs and in its Ryzen Master software.

That's just as well, as the Ryzen 9 7950X is a rather toasty CPU out of the box. Its core temperature regularly rose to

## SPEC

**Base frequency**  
4.5GHz

**Max boost frequency**  
5.7GHz

**Core**  
Zen 4

**Manufacturing process**  
5nm

**Number of cores**  
16 (32 threads)

**IGP**  
AMD Radeon Graphics

**Simultaneous Multithreading (SMT)**  
Yes

**Cache**  
64MB L3, 16MB L2

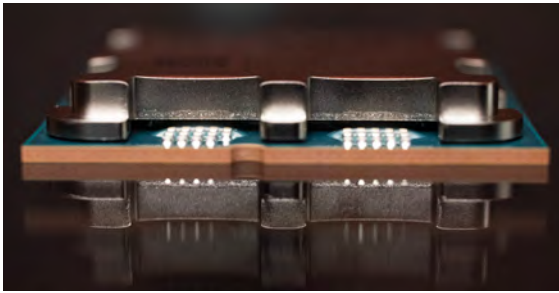
**Memory controller**  
Dual-channel DDR5, up to 5200MHz

**Packaging**  
AMD Socket AM5

**Thermal design power (TDP)**  
170W

### Features

Precision Boost 2, Precision Boost Overdrive 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE



90°C in multi-threaded workloads, even with our custom water-cooling loop hooked up to it, which means a manual overclock is best avoided – AMD’s automatic overclocking features are going to be better options.

However, this temperature fell dramatically when using Eco Mode, largely due to boosting frequencies being curtailed, falling to a 4.7–4.9GHz all-core boost at 105W and 3.6–3.8GHz at 65W.

Incredibly, though, even at 65W the 7950X’s Cinebench multi-threaded score of 29,821 was still faster than those of the Core i9-12900KS and Ryzen 9 5950X, with dramatically lower temperatures. When using the 105W profile, the score was well above 30,000 points at 31,165, but still a fair way from matching the monstrous 170W score of 38,422 that absolutely obliterated the competition.

The 7950X also recorded the fastest result we’ve seen in the image editing test of 93,724, which mostly stresses single-threaded performance, outstripping even the mighty Core i9-12900KS by over 7,000 points and achieving 1,397,365 in our heavily multi-threaded Handbrake video encoding test, which was nearly 40 per cent higher than the Ryzen 9 5950X. The system score of 495,461 is the best result we’ve ever seen, and by a long way, with only the Core i9-12900KS also being able to break the 400,000 point barrier with a score of 412,369.

The single-threaded Cinebench test was less impressive, with the Core i9-12900KS able to top the 2,050 scored



by the new AMD CPU – but only just – with the standard Core i9-12900K not able to crack the 2,000-point mark. The Ryzen 9 5950X, though, could only manage 1,653, which goes to show just how much AMD’s lightly threaded performance has increased with this new generation.

Games were faster too, although the Ryzen 9 7950X was a little behind the Ryzen 7 7700X in Watch Dogs: Legion and didn’t make many gains over Intel’s 12th-gen CPUs, even if it was noticeably faster than AMD’s older Zen 3 CPUs here. Far Cry 6 saw the flagship 7950X hit 101fps on the 99th percentile result, which matched the Core i9-12900KS and beat the Core i9-12900K by 10fps, but the Ryzen 7 5800X3D was still a little faster.

## Conclusion

As expected, AMD’s Ryzen 9 7950X is an absolute monster, and it comes with a price to match. While it’s not the killer gamer CPU that many had anticipated, it’s much faster than previous AMD CPUs, except for the Ryzen 7 5800X3D. However, when it comes to content creation, this is the most powerful mainstream desktop CPU we’ve ever tested by a long way – it absolutely annihilates the competition.

What’s particularly interesting is AMD’s Eco Mode, which could help to rein in temperatures so that even modest air coolers can cope with this beast of a CPU, yet still offer performance that outstrips any other option. If you want a CPU that’s ludicrously fast at every single job, then this is currently the one to get, at least until Intel launches its 13th-gen CPUs later this year.

ANTONY LEATHER

## VERDICT

It’s expensive, but this is hands down the most powerful mainstream desktop CPU we’ve ever tested.

## ZEN 4

- + Fantastic multi-threaded performance
- + Eco mode has huge potential
- + Massive boost in single-threaded speed

## SUPERMAN 4

- Gets hot in multi-threaded workloads
- Very expensive
- Could be faster in games

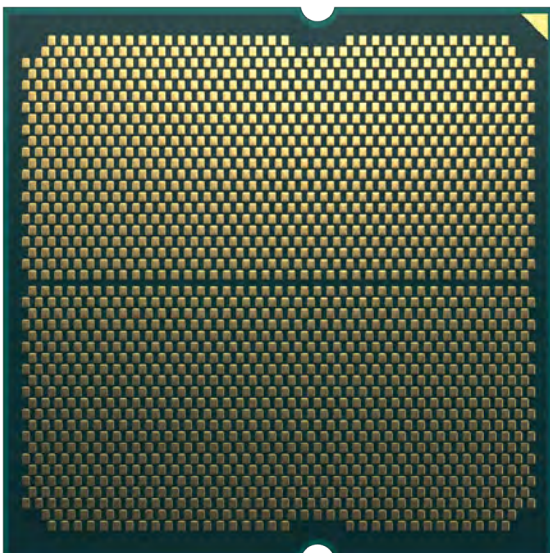
PERFORMANCE  
**49/50**

FEATURES  
**14/15**

VALUE  
**26/35**

OVERALL SCORE

**89%**





## SOCKET AM5 PROCESSOR

AMD RYZEN 7  
7700X / **£480** inc VATSUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

**T**he only CPU to receive a slight name tweak with AMD's Zen 4 range is the Ryzen 7700X, but despite the fact it's not called the 7800X, little else appears out of place with this processor. You get eight 5nm Zen 4 cores, which can execute 16 threads at the same time, thanks to AMD's Simultaneous Multithreading tech. It's very much the successor to the mighty Ryzen 7 5800X. At a price of £480 inc VAT, it's up against some stiff competition, though, seeing as the excellent Core i7-12700K retails for £60 less and has four more cores, even if they're not Intel's full-fat P-Cores.

If you don't already have an AM5-compatible CPU cooler, also bear in mind that there are no CPU coolers included with any of AMD's Ryzen 7000-series products, even the Ryzen 5 7600X that we'll be reviewing soon, so you'll need to purchase your own.

Not surprisingly, clock speeds are lofty, with the Ryzen 7700X hitting a peak boost frequency of 5.4GHz in lightly threaded workloads, making it the second fastest CPU we've ever tested in terms of actual megahertz. Incredibly, it was able to hit 5.2GHz across all cores in multi-threaded workloads too, while the Ryzen 7 5800X could only hit 4.5GHz.

That's a massive 700MHz increase and comes despite the fact that the two CPUs have the same TDP of 105W. Thankfully, the Ryzen 7700X also ran much cooler than the Ryzen 9 7950X, only hitting 87°C under sustained multi-threaded loads. As with the rest of the Zen 4 range, the L3 cache remains unchanged compared with its predecessor at 32MB, but the L2 cache has increased from 4MB to 8MB, as you now get a full 1MB of L2 cache per core, which should help to cut latency and improve tasks such as gaming performance.

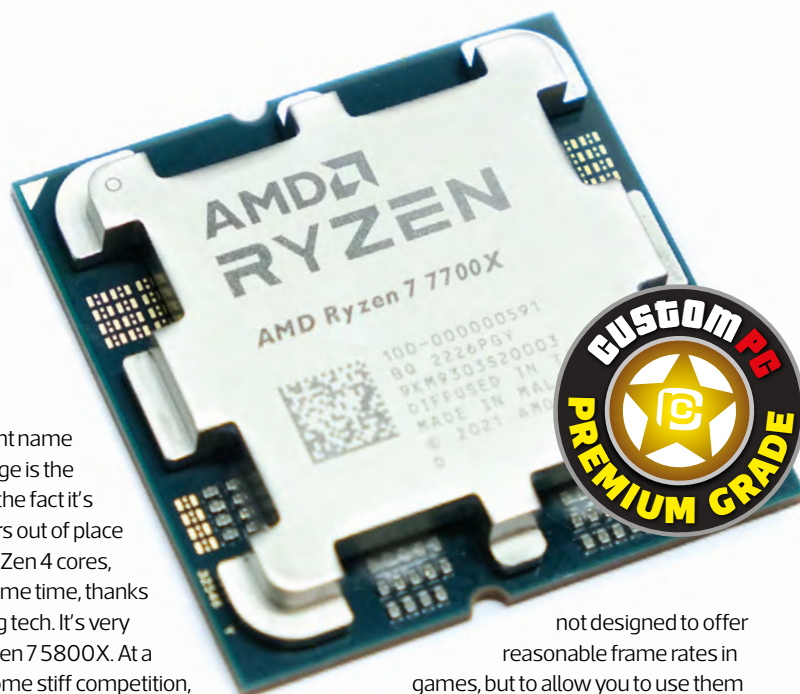
Also, like other CPUs in this generation, the Ryzen 7700X has integrated Radeon graphics. It's done this before, of course, with its so-called APUs, but here they're

not designed to offer reasonable frame rates in games, but to allow you to use them without a GPU and drive a couple of 4K monitors.

The IGP only has a dual compute unit, giving you a total of 128 stream processors, which is a long way from the spec of even a basic RDNA2 discrete GPU. As such, AMD is keen to stress that if you want to play games, you'll need a dedicated graphics card. Still, it's handy to have for troubleshooting, or for tasks that have limited GPU acceleration built in. Plus, it's an added cost saving if you're not interested in gaming.

## Performance

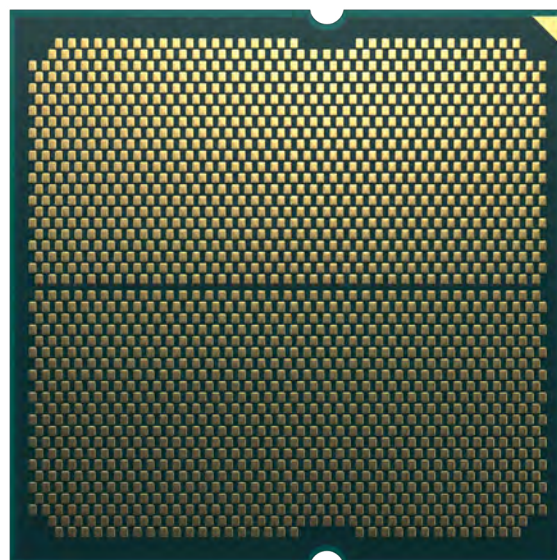
In our image editing test, which stresses single-threaded performance, the Ryzen 7700X's score of 387,941 beat all of its predecessors, even outpacing the Ryzen 9 5950X. It also matched the mighty Core i9-12900K, while sitting 14 per cent higher than the Core i7-12700K, which is almost exactly how much more it costs than the Intel CPU.



## SPEC

**Base frequency**  
4.5GHz**Max boost frequency**  
5.4GHz**Core**  
Zen 4**Manufacturing process**  
5nm**Number of cores**  
8 (16 threads)**IGP**  
AMD Radeon Graphics**Simultaneous Multithreading (SMT)**  
Yes**Cache**  
32MB L3, 8MB L2**Memory controller**  
Dual-channel DDR5, up to 5200MHz**Packaging**  
AMD Socket AM5**Thermal design power (TDP)**  
105W

## Features

Precision Boost 2, Precision Boost  
Overdrive 2, FMA3, F16C, SHA, BMI  
/ BMI1 + BMI2, AVX-512, AVX2, AVX,  
AES, SSE4a, SSE4, SSSE3, SSE3,  
SSE2, SSE

## 5NM

- + 5.2GHz all-core boost
- + Excellent gaming performance
- + Brilliant tightly threaded performance

## 14NM+++

- Limited overclocking headroom
- Cheaper Core i7-12700K is faster in some tests
- Reasonably expensive

That massive all-core boost clock helped in multi-threaded applications too, with the Ryzen 7 7700X scoring 932,918 points in our heavily multi-threaded Handbrake video encoding test. That's enough for it to beat the 12-core Ryzen 9 5900X and Core i7-12700K, and it's a massive 30 per cent improvement over the score of the Ryzen 7 5800X. The overall RealBench system score of 360,350 sits just below that of the Ryzen 9 5950X at 373,168 – it's also reasonably higher than the score of the Core i7-12700K and miles higher than the 288,079 scored by the Ryzen 7 5800X.

Meanwhile, running Cinebench R23 resulted in a score of 20,030 in the multi-threaded test. This was beaten by the Core i7-12700K, which managed 22,802, but soundly thrashed the Ryzen 7 5800X with its lowly score of 15,608. The single-thread Cinebench score of 2,007 was enough to beat every Intel CPU except the Core i9-12900KS, though, and was again fast enough to annihilate even the best result achieved by the Ryzen 5000-series CPUs. For example, even the Ryzen 9 5950X scored just 1,653 here.

Finally, gaming performance was excellent too, with a 99th percentile result of 100fps in Far Cry 6 at 1,080p, closely matching the scores of the Ryzen 9 7950X, Core i9-12900KS and Ryzen 7 5800X3D, while offering near double-digit gains over the Core i9-12900K and Ryzen 7 5800X. Watch Dogs: Legion saw it offer the highest 99th percentile result we've seen of 82fps, gaining a few frames per second over the Ryzen 9 7950X, and pipping every other CPU to the post too.



We also managed to overclock the Ryzen 7 7700X, hitting an all-core frequency of 5.4GHz with a vcore of 1.25V, matching the peak single-core boost frequency. This didn't result in stellar benefits, though, only boosting the Cinebench R23 multi-threaded score by 5 per cent, although it did this without increasing the peak load power draw for the whole system.

AMD's new Eco Mode works with this CPU too, and limiting the Ryzen 7 7700X to a TDP of 65W saw the Cinebench score drop from 20,030 to just 19,207, but the peak total system power draw fell by a massive 70W, and the peak temperatures plummeted as well.

## Conclusion

It's clear that in many situations, the Ryzen 7 7700X is now the top dog in its sector of the market. In nearly every test, from games through image editing to multi-threaded workloads, it was more than a match for the best of the rest. It's not a clean sweep, though, with the cheaper Core i7-12700K keeping up in some games and also offering better multi-threaded performance in Cinebench.

There's also the question of the Ryzen 5 7600X and Intel's new 13th-gen Raptor Lake CPUs looming on the horizon, and we should have numbers for both next issue.

In terms of longevity, though, if you're building a new system, it makes more sense to go with Socket AM5 than Intel's current LGA1700 socket, as the latter might possibly be having its last outing with Raptor Lake.

The only main issue for the Ryzen 7 7700X is that its price is a tad higher than we'd have liked, but there's no doubting that it packs a huge punch if you can afford it.

ANTONY LEATHER

## VERDICT

Not as keenly priced as we'd hoped, but this is one seriously fast 8-core CPU.

PERFORMANCE  
**45/50**

FEATURES  
**14/15**

VALUE  
**28/35**

OVERALL SCORE

**87%**



# OVERCLOCKING ZEN 4 AND USING ECO MODE

**T**here are several aspects to tweaking Zen 4 CPUs, and this time we also have AMD's new Eco Mode, which allows you to limit your CPU's thermal design power (TDP) in order to rein in power consumption and temperatures without losing heaps of performance. Here, we'll be looking at this feature, as well as manual overclocking and AMD's automatic tools, while discussing where and when you should consider using each of them.

## Precision Boost Overdrive

This remains the easiest and safest way to overclock your Ryzen CPU and hit frequencies higher than you'll get at stock speed. The differences are often small, as the limiting factor is nearly always temperature, and even custom liquid cooling can't do much about temperatures inside the CPU. It's the same with manual overlocks, as we saw this month with the Ryzen 7 7700X gaining just 200MHz.

This in part comes from the fact that, while AMD CPUs can hit high frequencies with large voltages, it's not a good idea to use much above 1.25V on a 24/7 basis. Also, today's CPUs already run fairly close to their limits at stock speed.

Precision Boost Overdrive provides extra power to a CPU that, when combined with Automatic Overclocking, can allow a CPU to boost up to 200MHz higher than stock speed. However, this doesn't mean it will hit this figure all the time – it needs enough power and thermal headroom for this to occur. The benefit of using PBO is that, unlike using a manual overclock, your stock peak boost frequencies remain, even if they don't go higher than stock speed.

To enable PBO and automatic overclocking, head to your motherboard's EFI. The actual location can differ between manufacturers, but in general, you'll need to find the Advanced section, which is often outside the main overclocking or tweaking sections. Here, you should find an option for AMD



**Our PBO settings enable the CPU to add another 200MHz to its frequency if there's enough power and thermal headroom**

overclocking, and you'll probably be met with a prompt to continue. Accept this prompt, and on the next page you should see an option for Precision Boost Overdrive.

The wording will differ between motherboard manufacturers, but the principles and basic settings are the same. In the PBO section on our ASRock motherboard, we changed the mode to Advanced to reveal the rest of the options. We then changed the PBO Limits to Motherboard, changed the Scalar Control to Manual and set the Actual Scalar to 10x. Finally, we entered 200 into the Max CPU Boost Close Override box. This will allow the CPU to add 200MHz to its boosting frequencies if there's sufficient power and thermal headroom available. We saw a small improvement to both single and multi-threaded scores in Cinebench by doing this.

If you prefer to avoid delving into your motherboard's EFI, you can also use AMD's Ryzen Master software. Click on a profile in the left options pane, then head to Automatic Overclocking and enter 200 into the Boost Override CPU box.

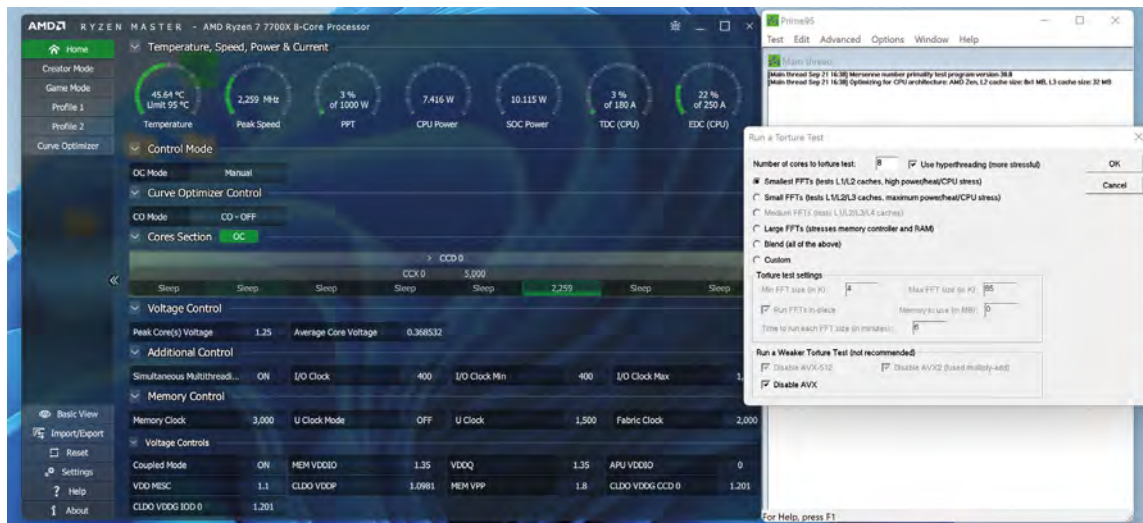
## Manual overclock

A manual overclock works well with some CPUs, but not with others. For example, you may get a higher frequency

**A good old-fashioned manual overclock can still be worth doing on CPUs that don't have huge core counts**

**You can also use Ryzen Master to enable PBO if you're not keen on fiddling in your motherboard's EFI**





**Stress-test your CPU with Prime95 and watch the temperature in Ryzen Master to make sure it doesn't overheat**

across all cores than you would at stock speed in all-core boost scenarios, but you may not be able to match the peak boost frequency a stock speed CPU could hit in lightly threaded workloads.

You'll need to make that call with your own CPU, especially as all chips overclock differently. In general, AMD's CPUs with high core counts see increased multi-threaded performance from a manual overclock, but may not match their single-core boost frequencies. Its 6-core or 8-core CPUs might be able to do both, though, as we saw this month with the Ryzen 7 7700X. It bettered its all-core boost by 200MHz and also managed to match its peak boost frequency.

Start by entering 1.25V into the CPU voltage section, and then enter a frequency value 200MHz below the usual all-core boost frequency. The latter is 5200MHz for our Ryzen 7 7700X, so we've entered 5000MHz.

Next, run Prime95's smallest FFT test (downloadable from [mersenne.org](https://mersenne.org)) and disable all AVX options at the bottom, then run Ryzen Master and focus on the CPU temperature it displays. If it remains below 90°C then your manual overclock is fine – leave the test running for five minutes before heading back to the EFI, then raise the frequency by 100MHz and repeat the process.

Keep doing this, and eventually Prime95 will crash, at which point you'll need to back off the frequency by 100MHz. We found a frequency of 5.4GHz was stable at 1.25V.

## Eco Mode

Eco Mode has existed before, but this time AMD is trumpeting it as a major feature. Its key benefit is being able to limit the TDP of a CPU to lower levels than stock settings, such as forcing a 170W chip to run with a TDP of 105W or even 65W.

This might sound like a recipe for drastically reducing performance, but you can significantly lower power consumption and thermals, and still sacrifice very little performance in most tasks. In fact, the Ryzen 9 7950X was still significantly faster than the Ryzen 9 5950X, even when it was capped at 65W compared to its usual 170W.



**While we wait for AMD to implement its one-click Eco Mode system, you can enable it yourself by setting the PPT, TDC and EDC in your EFI**

AMD will be implementing Eco Mode in a one-click feature in both motherboard EFIs and Ryzen Master soon, but for now, you can enable it manually by heading to the EFI and locating the Precision Boost Overdrive section; on our ASRock motherboard, this was in the AMD Overclocking part of the Advanced section.

As before, the wording will differ between motherboard makers, but the principles and settings remain the same. On our ASRock board, we selected Advanced in the first box to access detailed options, then set the PBO limits to Manual. You'll then see options to set the PPT, TDC and EDC, and we've outlined the necessary numbers you'll need to enter into these fields to hit various TDPs.

**65W** 88,000 PPT / 75,000 TDC / 150,000 EDC  
**105W** 142,000 PPT / 110,000 TDC / 170,000 EDC  
**170W** 230,000 PPT / 160,000 TDC / 225,000 EDC

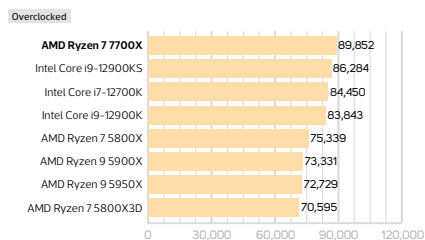
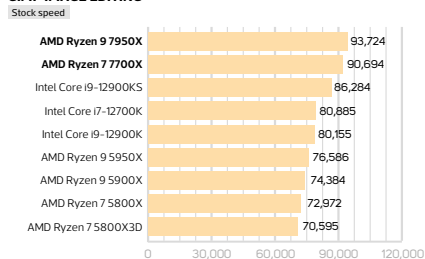
Entering one string of the above into these boxes will fix the CPU to that TDP limit, which will result in lower CPU temperatures and power draw – good news in these times of rocketing energy prices.

**ANTONY LEATHER**

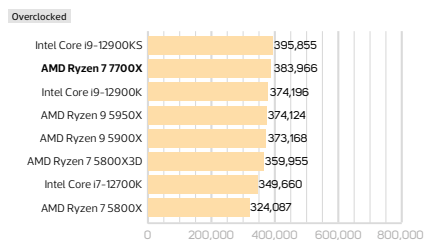
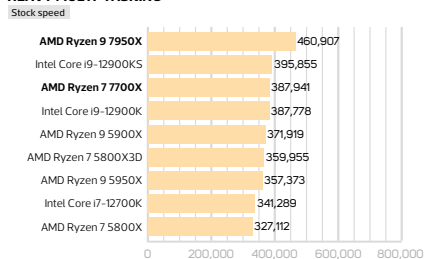


# AMD ZEN 4 CPU RESULTS

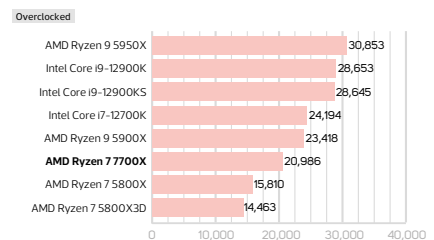
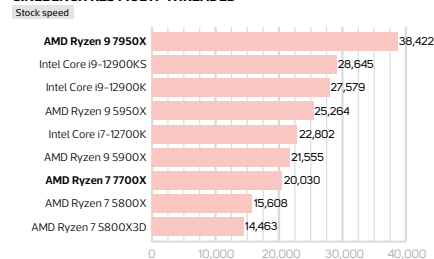
## GIMP IMAGE EDITING



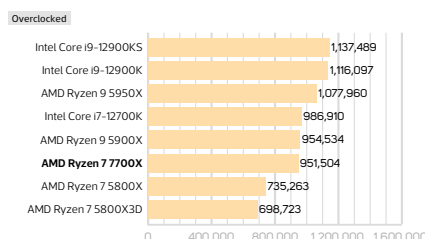
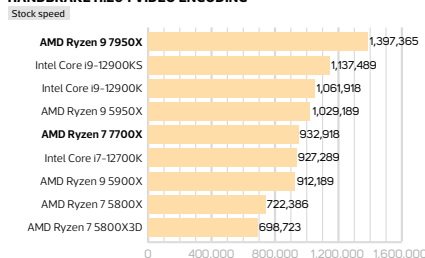
## HEAVY MULTI-TASKING



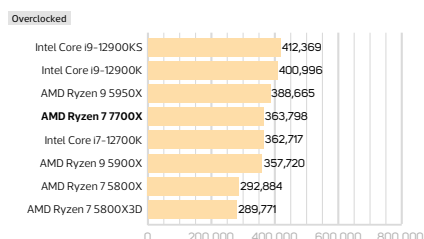
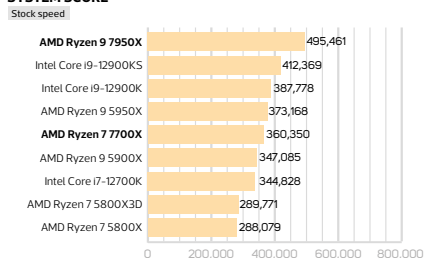
## CINEBENCH R23 MULTI-THREADED



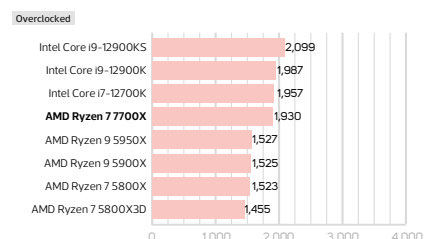
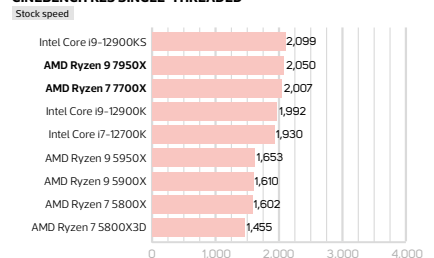
## HANDBRAKE H.264 VIDEO ENCODING



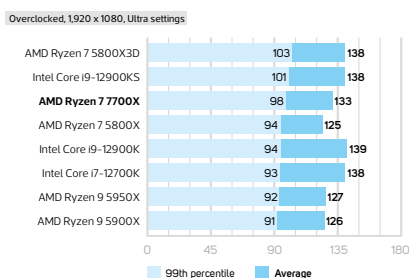
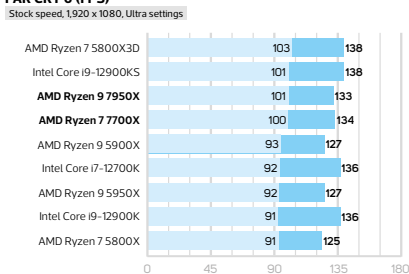
## SYSTEM SCORE



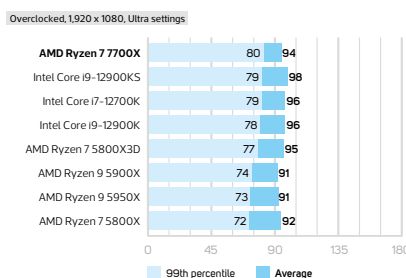
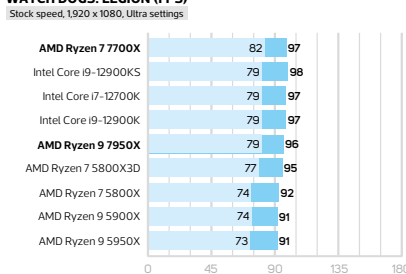
## CINEBENCH R23 SINGLE-THREADED



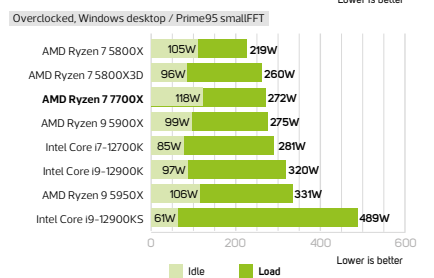
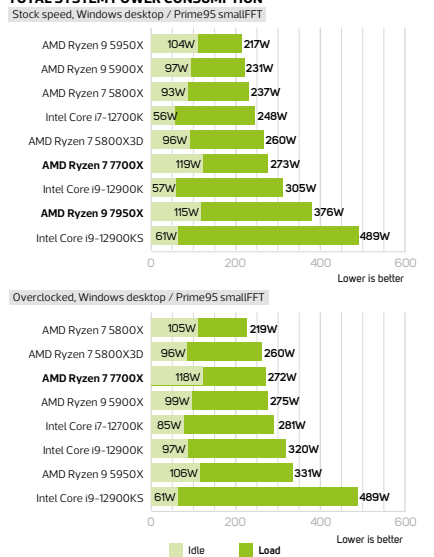
## FAR CRY 6 (FPS)



## WATCH DOGS: LEGION (FPS)



## TOTAL SYSTEM POWER CONSUMPTION



# WHICH RAM WORKS BEST WITH ZEN 4?

**T**he landscape has changed since we first looked at DDR5 alongside Intel's 12th-gen CPU launch, and you won't now need to wait weeks for your DDR5 kit to arrive. Frequencies are much higher too, with many kits offering speeds in excess of 6000MHz, which is the new sweet spot for Ryzen CPUs according to AMD's gurus. What's more, AMD has also introduced the EXPO standard. This is essentially like Intel's XMP, but for AMD systems, honing timings to offer the best performance.

We want to answer two questions here. Firstly, which speeds are best for an AMD system – will a cheap 5200MHz kit represent a false economy, and is using a faster kit going to net you more performance? Secondly, is there much difference between a typical DDR5 kit and an EXPO kit?

Our test system this month includes an ASRock X670E Taichi motherboard, Nvidia GeForce RTX 3070 GPU and 32GB of G.Skill Trident Z5 Neo EXPO memory adjusted to different speeds, plus a similar kit of non-EXPO memory. The Infinity Fabric clock was kept at auto, but the memory controller frequency was in sync with the RAM frequency.

The image editing score revealed small scaling when increasing the speed to 6400MHz from 6000MHz, but the gains over 5200MHz were minimal. Meanwhile, the non-EXPO kit performed roughly the same as the EXPO kit set to the same frequency.

The video encoding test, though, saw even the 6000MHz EXPO kit outperform the non-EXPO kit, despite its 400MHz advantage, and while it was a near tie for the top spot between 6400MHz kits, it was the 6000MHz and 6400MHz EXPO kits that prevailed.

Meanwhile, Cinebench saw slim margins between all kits in the multi-threaded test, with both 6400MHz tests within spitting distance, but again there wasn't much difference



between any of the results here. The single-threaded test, though, put the non-EXPO 6400MHz kit in a distant last place, where even our EXPO kit reduced to 5200MHz was noticeably better.

In Far Cry 6, the best result was from the EXPO kit set to 6400MHz, with the 6400MHz non-EXPO kit getting similar frame rates to the EXPO kit when it was reduced to 6000MHz. However, there was a slight drop when reducing the EXPO kit to 5200MHz.

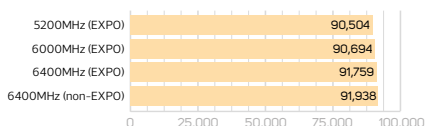
There are clear signs that the enhancements in timings of the EXPO memory kit offer advantages, with several tests showing our 6000MHz EXPO kit outperforming a 6400MHz non-EXPO kit. The latter was quicker in some tests, showing that frequency still counts and even boosting the EXPO kit to 6400MHz saw gains too.

However, a lot will come down to pricing and while EXPO offers tangible benefits in some situations, we'd suggest getting the cheapest 6000MHz kit you can find. If that happens to be an EXPO kit, that's great, but we wouldn't lose any sleep if it wasn't.

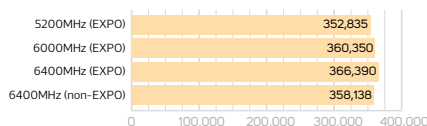
ANTONY LEATHER

## BENCHMARK RESULTS

### GIMP IMAGE EDITING

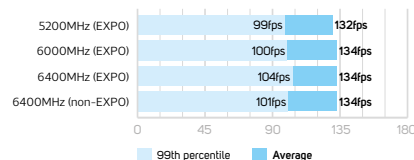


### SYSTEM SCORE

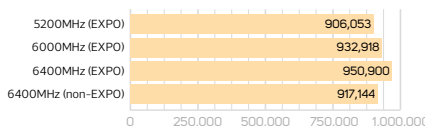


### FAR CRY 6

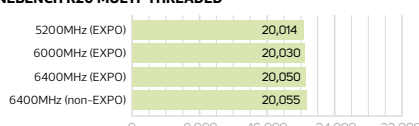
1,920 x 1,080, Ultra settings



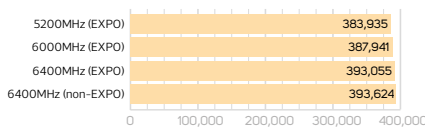
### HANDBRAKE H.264 VIDEO ENCODING



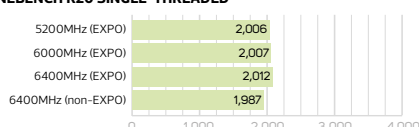
### CINEBENCH R20 MULTI-THREADED



### HEAVY MULTI-TASKING



### CINEBENCH R20 SINGLE-THREADED





## X670E MOTHERBOARD

# ASROCK X670E TAICHI

£600 inc VAT

SUPPLIER scan.co.uk

It's surprised us that many motherboard manufacturers are opting for AMD's flagship X670E chipset at the heart of the majority of their launch products, further putting strain on people's wallets when the prices of new CPUs and DDR5 memory are already a concern. However, it's the right fit for the ASRock X670E Taichi, with its whopping £600 asking price, which also buys you some decent hardware features.

In fact, based on some of the Intel Z790 motherboards we've seen, features such as Thunderbolt 4 could become more common on AMD motherboards this autumn than on Intel's equivalents, and you get a pair of them on the X670E Taichi that also offer USB 4 support. Sadly, there's no

10Gbps Ethernet, and while Thunderbolt-to-10Gbps adaptors do exist, at this price, it should have been included. Thankfully, you do get 802.11ax Wi-Fi and a 2.5 Gigabit Ethernet port too.

Meanwhile, the audio system is geared towards high-quality stereo listening, rather than analogue surround speaker sets. It's based on Realtek's ALC4082 audio codec, and only has two minijacks on the rear I/O panel, with the front panel header benefiting from an ESS SABRE9218 DAC. There's also an optical output.

You're sorted for USB ports too. There are eight Type-A USB ports, all of which are USB 3 or faster, and five of them support the high-speed USB 3.2 Gen 2 standard. Plus, if your case has a USB Type-C front panel connector, you can get a really high-speed USB 3.2 Gen 2x2 port up and running. If you want to ditch a discrete graphics card and use your CPU's integrated graphics, then there's a single HDMI port as well.

Overclocking and testing tools are usually one of ASRock's strong points, even on more

value-conscious motherboards, and here you get a USB BIOS flashback system, a clear-CMOS button, power and reset buttons, and an LED POST code display. The power circuitry is also positively monstrous, with a 24+2+1 phase 105A array that's clearly designed to stand up to AMD's new 170W CPUs.

As well as massive heatpipe-linked heatsinks, there's also a small fan that kicked in with the VRMs around 58°C. Thankfully, this fan was inaudible even from a few inches away, and with our Ryzen 9 7950X under load for ten minutes, the temperature failed to climb further. You can also adjust the fan speed profile in the EFI, or in ASRock's A-Tuning software; at stock settings, this showed that the fan would only speed up much more if the VRM temperature hit 95°C.

Elsewhere, all four M.2 slots are equipped with hefty heatsinks, including one set between the DIMM slots and



### SPEC

#### Chipset

AMD X670E

#### CPU socket

AMD Socket AM5

#### Memory support

4 slots: max 128GB DDR4 (up to 6600MHz)

#### Expansion slots

Two 16x PCI-E 5

#### Sound

6-channel Realtek ALC4080

#### Networking

1x Realtek 2.5Gbps LAN, 802.11ax Wi-Fi

#### Cooling

Eight 4-pin fan headers, VRM heatsinks, VRM fan, M.2 heatsinks, extra-large PCI-E 5 M.2 heatsink

#### Ports

8x SATA 6Gbps, 1x M.2 PCI-E 5, 3x M.2 PCI-E 4, 2x Type-C Thunderbolt 4/USB 4, 5x USB 3.2 Gen 2 Type-A, 3x USB 3, 1x USB 3.2 Gen 2x2 Type-C header, 1x audio out, 1x mic, 1x S/PDIF out

#### Dimensions (mm)

305 x 244



## HOME RUN

- + No stability issues despite new socket
- + Extensive power delivery
- + Good VRM cooling

## HOME SICK

- Expensive
- EFI is a little basic
- Lacks the pizzazz expected for £600

24-pin ATX connector, which will be easier to access than the others. For those foaming at the mouth to get hold of PCI-E 5 SSDs, the slot nearest the CPU is where you'll want to place them.

We're getting a bit concerned about the heat reportedly generated by those SSDs, though, and like a few other boards we've seen, the X670E Taichi includes both a low-profile heatsink and a much taller fan-equipped one to cool what we can only assume will be some very toasty drives in the near future.

The board caters particularly well for storage in other areas as well, with a massive tally of eight SATA 6Gbps ports, but then we are talking about a £600 motherboard. You also get eight 4-pin fan headers and four RGB headers, should the small splash of RGB lighting on and under the chipset heatsink area not be enough. On the downside, there are only two PCI-E slots, but that's generally enough for most people's needs now, and they also both have 16 PCI-E 5 lanes allocated to them.

## Performance

The standard heatsink did enough to keep our 2TB Kingston Fury Renegade PCI-E 4 SSD away from any thermal throttling, dishing out a read speed of 7,343MB/sec and write speed of 6,909MB/sec, with the temperature only peaking at 55°C in our extended load test. The audio performance was excellent, though, with a noise level of -110.7dBA and dynamic range of 110.5dBA.



Meanwhile, the RealBench system score of 495,461 was the fastest we've seen from a mainstream desktop CPU, as was the Cinebench R23 multi-threaded score of 38,422. However, ASRock was the only company able to send us Socket AM5 motherboard samples in time for our print deadline, and it remains to be seen how motherboards from other manufacturers handle this CPU at stock speed and if they can eke out enough thermal headroom with some tweaking to allow manual overclocking.

Delving into the EFI revealed a fairly basic BIOS compared with the likes of MSI or Asus, and the equally simplistic fan-control suite lacked the ability to fine-tune the VRM fan with a curve, yet it was listed and tweakable in the software, and in the basic text-only area of the EFI. For now, we've not overclocked out Ryzen 9 7950X, as it gets too toasty at stock speed, but we'll hopefully be tweaking it and other CPUs further over the next few weeks in time to review other motherboards.

## Conclusion

For one of its first motherboards on a new platform, the ASRock X670E Taichi is remarkably solid, with not a peep of any of the instability or other flakiness that occurred during AMD's last CPU socket launch. It dialled in our EXPO memory profile, coped easily with a Ryzen 9 7950X, has monstrous power circuitry and provides a beefy heatsink for future PCI-E 5 SSDs too.

There's no getting around the fact that £600 is a lot of cash to spend on a motherboard, though, and while there's plenty on offer here, it's not exactly a packed feature set. There's no 10Gbps Ethernet, all the M.2 ports are on the PCB rather than a breakout card, as we've seen from other premium boards in the past, and while there are some fancy aesthetic tweaks, it doesn't exactly leap out at you with enormous heatsinks or RGB lighting either.

We weren't privy to enough pricing information from other manufacturers at the time of writing to know if this is competitive with other boards with similar feature sets, but either way it costs a lot of money. Even so, it's a very solid motherboard that has numerous high-end features, as well as enough power to deal with any CPU AMD can throw at it.

ANTONY LEATHER

## VERDICT

Remarkably well made and stable for a first release, although it doesn't feel like it's worth £600.

PERFORMANCE  
**32/35**

FEATURES  
**31/35**

VALUE  
**16/30**

OVERALL SCORE

**79%**



## X670E MOTHERBOARD

# ASROCK X670E STEEL LEGEND / £385 inc VAT

SUPPLIER scan.co.uk



If you're after a more affordable Socket AM5 option than the £600 Taichi (see p22), ASRock also has the X670E Steel Legend, which will give you change from £400 and isn't as eye-wateringly expensive. In fact, in terms of appearance, we even think the Steel Legend looks a little sexier than the surprisingly dull-looking Taichi, with the Legend sporting S-shaped light-silver heatsinks and more extensive use of RGB lighting.

The £200 price drop from its more expensive sibling sees Thunderbolt 4 and USB 4 support vanish, but there's still a PCI-E 5 M.2 port that's equipped with a tall heatsink as standard. This kept our PCI-E 4 SSD at a peak of 61°C

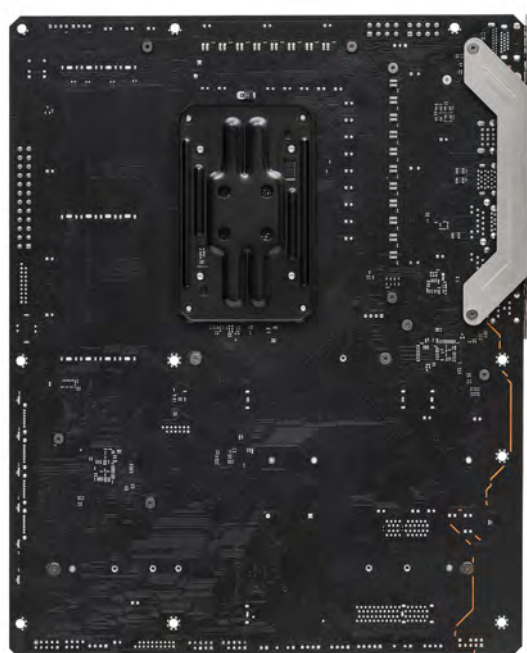
under load, which is a tad warmer than the X670E Taichi.

Weirdly, while the lower M.2 slot has a larger heatsink than the top one, the 7,349MB/sec read and 6,874MB/sec write speeds we saw in the top port fell by a few hundred megabytes a second with the same SSD in the bottom port, despite the SSD actually running a few degrees cooler. If you have a fast SSD, you'll want to use it in the top port, and attach the heatsink. You still get four M.2 ports in total too, with the other four being PCI-E 4-compatible and two of them being equipped with heatsinks.

Meanwhile, the power delivery is slightly dumbed down compared with the Taichi, but the Legend still boasts a total of 19 phases with some fairly beefy heatsinks. These certainly got toasty, but the VRMs were kept below 60°C according to our IR probe. Irritatingly, ASRock had removed a handy VRM readout in its software for this board, which was included with the X670E Taichi.

Unlike the Taichi, there's no fan to assist the VRM cooling, but you get a fairly

standard count of six 4-pin fan headers to power case fans. The rear I/O panel is very well equipped, though, and while there's no Thunderbolt or USB 4, you get a generous tally of 11 Type-A USB ports, seven of which are USB 3 or faster. One of these supports USB 3.2 Gen 2, and there's also a high-speed USB 3.2 Gen 2x2 Type-C port, with a corresponding front panel header on the PCB for compatible cases.



### SPEC

#### Chipset

AMD X670E

#### CPU socket

AMD Socket AM5

#### Memory support

4 slots: max 128GB DDR5 (up to 6600MHz)

#### Expansion slots

One 16x PCI-E 5, one 16x PCI-E 3, one 1x PCI-E 3

#### Sound

Realtek ALC1220

#### Networking

1x Realtek Gigabit LAN, 1x Realtek 2.5Gbps LAN, 802.11ax Wi-Fi

#### Cooling

Six 4-pin fan headers, VRM heatsinks, M.2 heatsinks

#### Ports

4 x SATA 6Gbps, 1x M.2 PCI-E 5, 3 x M.2 PCI-E 4, 1x USB 3.2 Gen 2x2 Type-C, 1x USB 3.2 Gen2 Type-A, 6 x USB 3 Type-A, 1x USB 3.2 Gen 2x2 Type-C header, 1x audio out, 1x mic, 1x S/PDIF out

#### Dimensions (mm)

305 x 244



The rear I/O panel also sports two LAN ports, the fastest of which supports 2.5Gbps Ethernet, and you get 802.11ax Wi-Fi as well. ASRock has again cut back on audio outputs here, with just microphone and stereo speaker jacks in addition to an optical output for the Realtek ALC1220 audio.

Sadly, this board lacks most overclocking and testing tools as well, but does at least have a BIOS flashback button, so if you pick the board up in a year or two and drop in a future CPU, you'll be able to update the BIOS even if the existing one doesn't support your new CPU.

The Legend offers an extra display output over the X670E Taichi as well, with both HDMI and DisplayPort outputs, although the latter could use its Thunderbolt ports for this purpose if need be.

Another cutback from the pricier board this month are the SATA 6Gbps ports, with four rather than eight being included, although four is enough for most people. The board is slightly more flexible with PCI-E slots too, with a single 16x PCI-E 5 slot, a 16x PCI-E 3 slot at the bottom of the PCB and a 1x PCI-E 3 slot between them.

## Performance

The Steel Legend's audio performance was fairly typical for the Realtek ALC1220 codec, with RightMark Audio Analyzer returning a noise level of -98.3dBA and dynamic range of 98.4dBA along with a total harmonic distortion (THD) of 0.228 per cent, which are perfectly adequate for music and gaming.

Heading into benchmarks, and the board actually added over 100 points to the Cinebench R23 multi-threaded test score of the X670E Taichi, scoring 38,550, while returning a near identical RealBench system score of 497,096 too, so it seems perfectly happy to deal with our mighty Ryzen 9 7950X test CPU.



The EFI was basic, as we've come to expect from ASRock, but all the necessary settings were there to take advantage of AMD's interesting Eco mode, as well as Precision Boost Overdrive. The CPU and memory frequencies, as well as voltage settings, are now all on the same page in the EFI too, which is handy for overclocking.

## Conclusion

If you want premium features such as top-notch VRM cooling, Thunderbolt 4 and USB 4, as well as massive heatsinks to cool PCI-E 5 SSDs, you'll need to reach deeper into your wallet than the £385 asking price of the X670E Steel Legend. However, the fact it coped fine with AMD's 16-core flagship and still boasts PCI-E 5 support for next-generation SSDs, and has practically every other feature most people could need, means the X670E Steel Legend is ultimately one of the most affordable premium X670E motherboards available.

It offers much better value for money than the X670E Taichi, it still has decent audio performance, there are plenty of USB ports and it has a decent design too. The only factors to consider are the lacklustre M.2 speeds in the lower ports, and a lack of on-board overclocking and testing tools. Apart from these small issues, it's a decent (if overpriced) buy.

ANTONY LEATHER

## VERDICT

Simple and effective, although the price of £400 is high for what's on offer.

## LEGEND

- + Copes fine with Ryzen 9 7950X
- + PCI-E 5 M.2 support
- + 11 Type-A USB ports

## FAKE NEWS

- No on-board overclocking and testing tools
- EFI is quite basic
- M.2 speeds a little slow in some slots

PERFORMANCE  
**30/35**

FEATURES  
**29/35**

VALUE  
**23/30**

OVERALL SCORE

**82%**



## X670E MOTHERBOARD

# ASROCK X670E PG LIGHTNING / £300 inc VAT

SUPPLIER scan.co.uk

If your hopes of owning a Ryzen 7000 system were dashed due to recent motherboard pricing leaks, the fact that some X670E-chipset models won't cost you more than £300 probably comes as moderately good news. The ASRock X670E PG Lightning still costs more than we'd have paid for a premium offering a few years ago, and even the £300 pricing was still very approximate when we wrote this review. The big question, though, is whether you lose anything major by opting for a cheaper board such as this one.

The heatsinks for the 14+2+1 phase power delivery are fairly beefy, but the one above the rear I/O panel fails to extend all the way to the integrated I/O shroud, meaning there's a bunch of unsightly shiny silver ports visible next to the black heatsink. The rest of the board looks very smart, though, with an attractive black and white patterned PCB, and black heatsinks. Thankfully, our IR probe revealed temperatures no higher than 57°C, so we're confident this board has what it takes to handle AMD's latest 16-core CPU.

Sitting near the bottom of ASRock's Socket AM5 motherboard stack, the ASRock X670E PG Lightning has shed a few features to get there, such as only sporting Realtek's ALC897 audio codec and a trio of audio outputs excluding an optical output, plus there's no Wi-Fi included either. There is 2.5Gbps Ethernet, though, and amazingly, ASRock has managed to shoehorn four M.2 ports into the equation, two of which have heatsinks, and the top M.2 port even offers PCI-E 5 support too.

There are four SATA 6Gbps ports as well, so you have plenty of storage options, and there's a fairly typical total of six 4-pin fan headers as well. Meanwhile, ASRock's software and EFI offer reasonable control over your fans, but it's not as granular or appealing as the fan control options from the competition, while the EFI in general feels less attractive and a bit dated, even if we approve of the simple layout.

There's also PCI-E 5 support to be found on the top 16x PCI-E slot, with two further 16x PCI-E 4 slots and a 1x PCI-E 4 slot as well, with these additional slots actually



### SPEC

#### Chipset

AMD X670E

#### CPU socket

AMD Socket AM5

#### Memory support

4 slots: max 128GB DDR5 (up to 6600MHz)

#### Expansion slots

One 16x PCI-E 5, two 16x PCI-E 4, one 1x PCI-E 4

#### Sound

Realtek ALC897

#### Networking

Realtek 2.5Gbps LAN

#### Cooling

Six 4-pin fan headers, VRM heatsinks, M.2 heatsinks

#### Ports

4 x SATA 6Gbps, 1x M.2 PCI-E 5, 2x M.2 PCI-E 4, 1x M.2 PCI-E 3, 1x USB 3.2 Gen2 2x2 Type-C, 1x USB 3.2 Gen2 Type-A, 6 x USB 3 Type-A, 4 x USB 2, 1x USB 3.2 Gen 2x2 Type-C header, 1x audio out, 1 x mic, 1x line-in

#### Dimensions (mm)

305 x 244



### LIGHTNING REFLEX

- + Copes fine with AMD's Ryzen 9 7950X
- + PCI-E 5 M.2 support
- + 11 Type-A USB ports
- + Non-ridiculous price

### LIGHTNING STRIKE

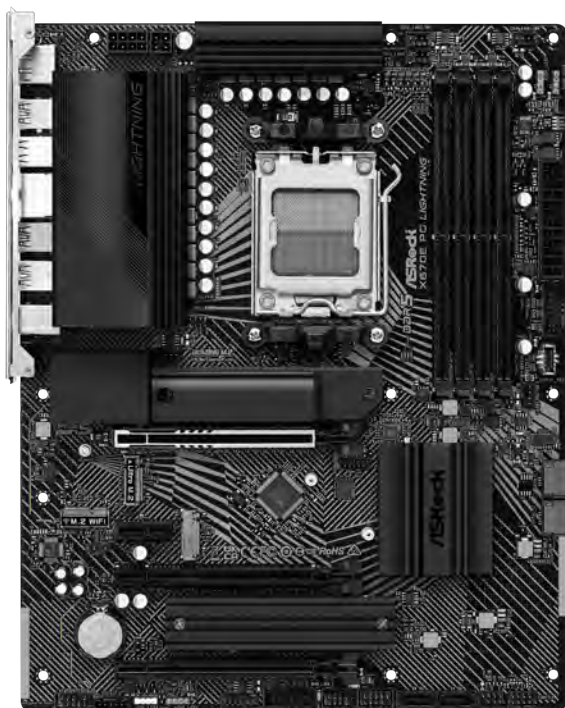
- No on-board overclocking and testing tools
- Basic EFI
- Mediocre M.2 temperatures
- Entry-level audio

offering more bandwidth overall than the slots on the more expensive X670E Steel Legend. The rear I/O panel hasn't been neglected either, and while there's no Wi-Fi, ASRock includes mounts here for aerials, and there's a dedicated M.2 port to add your own Wi-Fi module.

In addition, this panel offers an impressive tally of 11 Type-A USB ports, four of which are USB 2, one is USB 3.2 Gen 2 and the rest are USB 3. Not surprisingly, the lone Type-C port lacks Thunderbolt and USB 4 support, but both it and the Type-C header on the PCB are USB 3.2 Gen 2x2-capable. There's also a USB BIOS flashback button, plus both HDMI and DisplayPort graphics outputs.

### Performance

The X670E PG Lightning's top M.2 port was able to return read and write speeds of 7,322MB/sec and 6,842MB/sec respectively with our PCI-E 4 SSD, although the SSD temperature did peak at 68°C at the end of our load test, so you'd be well advised to have a case fan blowing across the motherboard, in order to keep temperatures in check under sustained loads.



Despite only having Realtek ALC897 audio, the PG Lightning returned some half-decent numbers in RightMark's Audio Analyzer software, with a dynamic range of 96dBA, noise level of 95.8dBA and THD of 0.0015 per cent – it's not outstanding audio quality, but it's fine for most people's needs.

Power consumption was noticeably lower than other boards we've tested as well, with the X670E Taichi drawing 376W under load compared to 336W for the X670E PG Lightning. However, this could be down to BIOS versions, as a new one had just landed for the latter just before we wrote this review.

Performance was fine though. The PG Lightning's multi-threaded Cinebench score of 38,502 was slightly ahead of the X670 Taichi, while the RealBench system score of 491,557 was just a fraction behind that of the other boards we tested this month. Overall, in terms of basic performance, there doesn't seem to be any benefit from spending more money on a Socket AM5 motherboard, even if you're using a Ryzen 9 7950X.

### Conclusion

It's clear that aside from overclocking, which we haven't had time to explore with AMD's 170W-TDP CPUs much yet, there isn't much benefit from spending upwards of £400 on a Socket AM5 motherboard. The ASRock X670E PG Lightning has some quirks, such as its strange-looking I/O shroud, mediocre M.2 temperatures and basic EFI, but it otherwise performed flawlessly with AMD's Ryzen 9 7950X at stock speed, offering performance that was on par with more expensive boards.

Its audio codec isn't the best, but it's still fine for most people's needs, and its PCI-E 5 M.2 and 16x slots add an element of futureproofing too. It's a shame there are no on-board overclocking and testing tools, or Wi-Fi, which we'd normally expect ASRock to include at this price, but all new computer hardware is increasing in price at the moment. Whatever Zen 4 CPU you buy, though, the ASRock X670E PG Lightning has what it takes to accommodate it.

ANTONY LEATHER

### VERDICT

Proof that you don't need to mug your wallet in order to afford a Socket AM5 motherboard.

PERFORMANCE  
29/35

FEATURES  
27/35

VALUE  
26/30

OVERALL SCORE

82%



## 45IN OLED GAMING MONITOR

## CORSAIR XENEON FLEX 45WQHD240



**C**orsair caused quite a stir when it announced the Xeneon Flex a few weeks ago. Not only is it one of the very few OLED PC monitors to ever be announced, but it's also a huge 45in ultrawide panel that can be bent so that it offers the option of both a curved or flat screen. Add in a 240Hz refresh rate and the inherently ultra-fast response time of an OLED display, and you have quite an alluring combination.

Although it's still several months away from being available, and it's yet to have an official price tag – expect it to be very pricey – we recently got some hands-on time with the display to get a feel for what it can do. Given that we were using pre-production samples, and features such as the on-screen display were locked down, our observations can't be considered final, but the models we saw were largely representative of the final product.

What first strikes you about the Xeneon Flex is its size. Even by modern standards – where 34in ultrawide panels are relatively commonplace – the Flex is a huge screen with panel dimensions of 1,048 x 441mm. Due to it using a 21:9 aspect ratio, it even has a 20 per cent larger total screen area than Samsung's colossal 49in super-wide panels that use a shorter, but wider, 32:9 ratio. It's also 81 per cent larger than a typical 34in, 21:9 screen.

The impact of such a large screen makes it fantastic for immersive gaming and watching video. However, this panel only has a resolution of 3,440 x 1,440; when stretched out over such a large screen, this does limit its sharpness. It's less a problem for gaming and video, but text looks a little blocky and you gain no extra desktop space over a 34in screen, despite the vastly bigger panel. This will certainly limit its appeal for general desktop use.

As for its bendability, the roughly 10mm-thick panel is mounted on a hinged arm system that supports the panel and limits the bending of the screen. On the sides of the screen are two slide-out handles that are used to manhandle the screen into its bent or flat states. The final version can be set to five bend levels, but the version we tested could only be flat or fully bent into a tight 800mm radius curve.

It takes quite an effort to bend the screen – it's bent by your brute force, with almost no mechanical assistance – and it's a little unnerving to do, but it worked well enough the half-dozen times we tried it. Corsair says the mechanism is rated for a few thousand bending cycles, but we suspect many users will largely set and forget the panel once they've decided if they prefer the curved or flat setup.

Although we only had a short time with the screen, we erred towards leaving the panel in a bent state. Unlike with some LCD panels, the benefit isn't about getting an optimal viewing angle across the whole width of the panel, but rather that you get a more consistent view of the panel – without a curve the edges of such big panels start to disappear off in the distance. It's also great to have a slightly more immersive view when gaming.

Any time you might sit back and watch the screen, though, having the option to set it flat again would be very useful

**The panel is mounted on a hinged arm system that supports the panel and limits the bending of the screen**



## SPEC

**Screen size**  
45in

**Resolution**  
3,440 x 1,440

**Panel technology**  
OLED

**Maximum refresh rate**  
240Hz

**Stated response time**  
0.03ms grey-to-grey

**Max brightness**  
1,000cd/m<sup>2</sup> SDR and HDR

**Stated contrast ratio**  
1,350,000:1

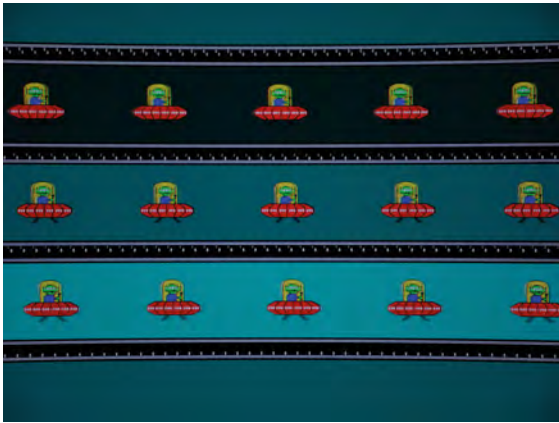
**Adaptive sync**  
FreeSync Premium, G-Sync compatible

**Display inputs**  
1x DisplayPort 1.4, 2x HDMI 2

**Audio**  
Headphone out

**Stand adjustment**  
Height, rotation, tilt

**Extras**  
5-port USB 3.2 hub, bendable screen



**The 0.03ms response time results in a very sharp image in fast motion**

– flat screens provide a better view if there are multiple people viewing them, and the curve is only beneficial when sat up close.

A downside of the curving mechanism is that the display doesn't have a VESA mount for using monitor arms. However, Corsair will be offering an extra desk clamp that can be swapped out for the feet of the included stand.

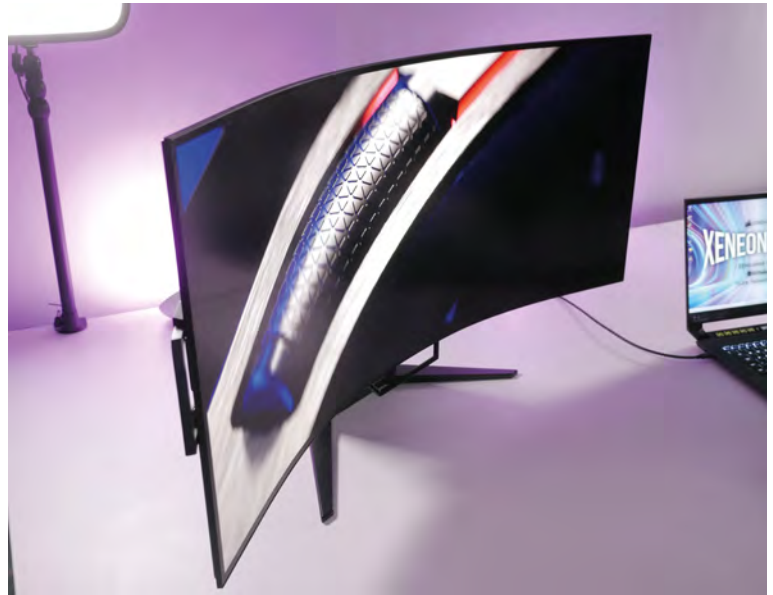
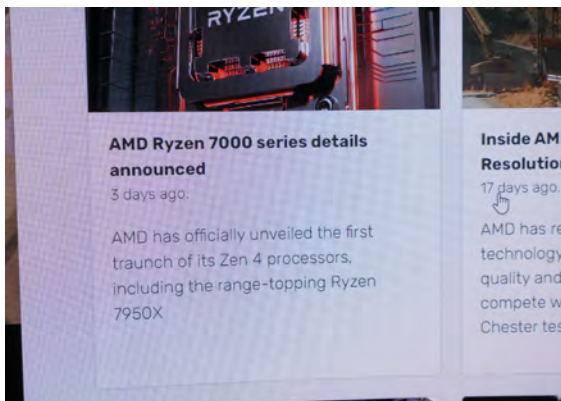
Connection options are contained in the stand, with a DisplayPort input and two HDMI video inputs, along with three USB ports on the back of the stand. Around the front are two more USB ports, alongside a headphone jack, input select button, power button and the OSD control.

## Performance

We jumped into some game tests to gauge its performance in action, and the 240Hz refresh rate and 0.03ms response time – that's roughly 100 times faster than a standard LCD panel – does feel incredibly snappy. The true status of it as a competitive gaming panel will need further testing – especially as we tend to find such large panels can actually be detrimental to your focus in first-person shooters, for instance – but we expect it to be very capable.

One feature this display doesn't include, though, is a black frame insertion mode, akin to the backlight-strobing blur

**The large screen size and modest resolution results in text that doesn't look particularly smooth**



reduction modes we see on some LCD monitors. Although these modes exist partly to mask the slow response time of LCD panels, the momentary flashing of a black screen also helps to trick the eye into seeing smoother motion, so it has a place on OLED panels too.

Finally, we come to the experience of using such a large OLED panel in general. The most obvious factor when it comes to using this monitor is the stunning 1,350,000:1 contrast ratio, thanks to the true black you get from OLEDs not using a backlight – any LCD looks grey and washed out in comparison. Also, when bright colours are needed, this panel delivers in spades thanks to a 1,000cd/m<sup>2</sup> peak brightness, resulting in dazzling HDR reproduction.

We'd need to use the panel for longer in order to assess how well it works for general use for long periods, as it can be more pleasant to work on screens that are less vivid and with lower contrast to help reduce eyestrain. Moreover, there's the ever-present concern of the effects of OLED burn-in to consider. That's where the pixels can be permanently affected by showing the same colour for long periods, resulting in ghostly images of on-screen elements, such as the Windows taskbar being visible in your games and videos.

**With its per-pixel OLED lighting, the Xeneon Flex provides a staggering 1,350,000:1 contrast ratio**

## Conclusion

Without a price, we can't yet recommend or advise you to steer clear of the Xeneon Flex based on any consideration of value. However, as a piece of technology, we can see it having wide appeal. For gaming and video, its amazing contrast, bright colours and large screen size make for a dazzling spectacle. We can also see the flexible screen trick being genuinely useful to some people. The relatively low resolution will be a limitation for desktop use, though, so it may not be the ultimate all-rounder for work, rest and play. We look forward to reviewing a final sample in the future.

EDWARD CHESTER



## ERGONOMIC MOUSE

# POSTURITE PENGUIN / £119 inc VAT

SUPPLIER [posturite.co.uk](http://posturite.co.uk)

### POSTURE

- + Best vertical mouse design yet
- + Relieves finger and wrist pain
- + Available in multiple sizes

### POSTURING

- Only two main buttons
- Mushy button feel
- Quite pricey for its basic features

Ideally, ergonomic mice allow your hand to sit in a natural, upright position, putting less twisting strain on your wrist and forearm than a normal mouse. The Posturite Penguin takes this idea to its ultimate conclusion. It's completely vertical, so your hand grips it much like it would grip a joystick. What's more, it's completely ambidextrous. The controls sit on the front edge of the upright section where they can be reached by either hand. However, the completely upright design isn't the most revelatory part of the design – and nor is the bowtie-like switch on the bottom that completes the Penguin look. Rather, it's the wide flat base that transforms this mouse's usability.

Most upright mice require your arm and hand to rest on the desk surface, as with normal mice. However, instead of the weight of your hand and arm resting on the fleshy underside of your forearm and base of your hand, these upright mice expose the less fleshy side of your hand and the relatively unprotected ulna bone of your forearm to the hardness of your desk.

Consequently, vertical mice can be a bit uncomfortable in a different way, relieving twisted forearm pain and replacing it with scraped-bone pain. Such a setup also makes movement feel quite restricted and you sometimes have to grip the mouse surprisingly firmly to move it.

The Penguin largely eliminates these issues thanks to its plastic skirt. You can rest the side of your hand on the base and easily lift your arm away from the desk surface to totally remove any forearm friction. What's more, the side of your hand's purchase on the Penguin's base means you don't have to grip the joystick part to move around, taking further strain off your hand.

The downside to relying almost exclusively on arm movement – rather than hand and wrist movement – is accuracy. We only felt comfortable using the lowest 400 DPI setting, which we normally find is too low, as it means picking up a mouse multiple times to move the cursor larger distances. However, because the Penguin relies on large arm movements, you don't have to worry about this issue, as long as you have a large enough mouse mat.



You get just three main controls – left-click on the top, right-click below and a large scroll wheel in between them. The bowtie switch tilts back and forth to switch the mouse between left or right-hand modes, which just amounts to it reversing the direction of the scroll wheel.

On the underside of the Penguin is a button for changing the DPI between its four fixed settings – 400, 600, 800 and 1,200, along with a power switch and a stowage area for the wireless dongle. We tested the large wireless version of the Penguin, but wired and wireless versions are available in small, medium and large variants. The wired versions are cheaper, at £86 inc VAT.

Overall build quality is a little underwhelming for the price. The main buttons are rather mushy and undefined, the glide pads on the underside are quite small, and the overall fit and finish is on the basic side. However, it's solid enough with no creaks or flex and certainly gets the job done.

### Conclusion

The Posturite Penguin is by far the most comfortable vertical mouse we've used, mainly thanks to its wide flat base. As well as relieving pain from twisting your forearm, it avoids the pain and awkwardness of using other vertical designs. It's not the flashiest device otherwise, and is pricey for its basic feature set, but if wrist pain is a major concern, it's the best antidote we've tested.

EDWARD CHESTER

### VERDICT

The best forearm pain-relieving vertical mouse we've tested, but it's quite basic for the money.

### SPEC

#### Weight

232g (large version)

#### Dimensions (mm)

121 x 154 x 98 (W x D x H)

#### Sensor

Optical

#### Buttons

3 (left, right, scroll wheel)

#### Stated battery life

Up to one month

#### Extras

RGB lighting, USB dongle extension

DESIGN  
19/20

FEATURES  
10/20

PERFORMANCE  
25/30

VALUE  
21/30

OVERALL SCORE

75%

# Wireframe

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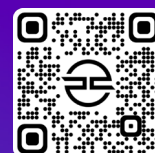
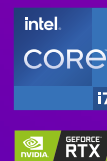
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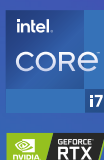
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## 55IN GAMING MONITOR

# SAMSUNG ODYSSEY ARK / £2,599 inc VAT

SUPPLIER [samsung.com](https://www.samsung.com)

### HOMER

- + Incredible, immersive design
- + Great image quality
- + Loads of adjustment
- + Powerful speakers

### SIMPSON

- HDR could be even better
- Some underwhelming features
- Hugely expensive

### SPEC

**Screen size**  
55in

**Resolution**  
3,840 x 2,160

**Panel technology**  
VA

**Maximum refresh rate**  
165Hz

**Stated response time**  
1ms (GTG)

**Stated contrast ratio**  
1,000,000:1

**Active sync**  
AMD FreeSync Premium Pro

**Display inputs**  
2 x HDMI 2.1

**Audio**  
Headphone out, 4 x speakers, 2 x subwoofers

**Stand adjustment**  
Height, pivot, tilt

**Extras**  
100 x 100mm VESA mount, 1x USB Type-C 3.2 Gen 1, 2 x USB 2, One Connect box, 100Mbps Ethernet, Wi-Fi 5, Bluetooth 5.2

**HDR standard**  
Quantum HDR 2000

**S**amsung's 55in Odyssey Ark is a behemoth, deploying a 1000R curve and 4K resolution to deliver incredible immersion. On the inside, the Ark uses 1,056 Quantum Mini LEDs for its backlight, and its VA panel also supports AMD FreeSync Premium Pro at 165Hz.

What's more, the panel runs in 21:9 or 32:9 aspect ratios, as well as its default 16:9, and you can shrink the display area if you want to sit closer to it. It also has every notable smart TV app, alongside Nvidia GeForce Now and Xbox game streaming, while the remote control and wheel-based Ark Dial make navigation simple.

That's great versatility, although Samsung's Multi View mode is inconsistent. It lets gamers deploy four sources in landscape orientation and three in portrait view. It's easy to configure and useful for gaming with streams or comms tools. Sadly, though, it only supports single HDMI inputs, its windows run at 120Hz and most mainstream apps aren't supported.

The windows aren't sharp either. In landscape mode, they run at 1080p, but in portrait mode, they struggle at 1,280 x 720. At least you'll get good audio – the four speakers and two subwoofers deliver well-balanced sound with loads of volume and thumping bass.

This 41.5kg unit also needs two people to manoeuvre, and at 379mm deep, it's far larger than most screens and TVs. Build quality is impeccable, though, and there are loads of stand adjustment options. You don't have to fumble around the back for ports either, because Samsung's One Connect box includes four HDMI 2.1 sockets and transmits signals to the Ark via one cable. It's intuitive, but its 100Mbps Ethernet, Wi-Fi 5 and USB 2 connections all disappoint.

Image quality is better. The Ark's black point of 0.02 nits pairs with a factory brightness of 90 nits for an incredible contrast ratio of 4,500:1, and that level was retained at the screen's SDR peak brightness of 742 nits. The delta E of 2.29 and colour temperature of 6,536K are good, and the Ark



rendered 99.5 per cent and 91.6 per cent of the sRGB and DCI-P3 gamuts respectively.

Those results mean games look bright, bold and deep. Switch to HDR mode and the Samsung's peak brightness level goes up to 1,226 nits with a contrast level of 61,300:1. Combine those figures with the Quantum Mini LEDs and you get fantastic HDR performance. Proper OLED TVs are still better in this regard, but the Ark is still great at reproducing HDR content.

Meanwhile, the 165Hz refresh rate is ideal for single-player games and mainstream esports, and performance is good – games are crisp and smooth with minor ghosting. Samsung claims a 1ms grey-to-grey response time, but the Ark's VA panel doesn't match that – in the display's Standard mode, its average hit 7.97ms, and that figure only improved to 7.57ms in the Faster setting. That's fine for mainstream gaming, but not for fast-paced, twitchy esports.

### Conclusion

Nevertheless, this screen's colours, contrast and form factor make games look incredible. Samsung's panel impresses with its speakers, smart TV options and adjustment, but it suffers due to its size, misfiring options and cost. At this price you could get better quality from a flagship OLED TV at the expense of refresh rate and the curve. If you want a huge display for all your entertainment needs, though, the Ark succeeds in most key departments, but for a huge price.

MIKE JENNINGS

### VERDICT

Incredible design and performance, but with a few frustrating shortcomings and a vast price.

IMAGE QUALITY  
**28/30**

GAMING  
**26/30**

FEATURES  
**17/20**

VALUE  
**10/20**

OVERALL SCORE

**81%**

## STEREO GAMING SPEAKERS

# EDIFIER G5000 / £350 inc VAT

SUPPLIER [overclockers.co.uk](http://overclockers.co.uk)

### SONIC BLISS

- + Powerful sound
- + Lots of connections
- + Fantastic build quality

### AUDIO ASSAULT

- Cheesy gamer styling
- Very large for desktop speakers
- Expensive

**E**difier is one of the few companies still making dedicated PC speakers, and we've been consistently impressed by the great sound and fantastic value of its products. With the G5000 series, though, Edifier has abandoned the classic look of its previous products and gone full gamer mode.

Out is the simple cuboid shape and faux wooden or black vinyl finishes of the R1280DB, and in is an aluminium-clad, multi-faceted, RGB lighting-adorned design. The main body of each speaker is a very hefty wooden box that's painted in a wonderfully smooth matt black finish. However, thick aluminium plates are slapped on the sides and extend beyond the back of the speaker like a spoiler.

The RGB lighting sits between the body and the metal plate, shining from a plastic strip running round the edge of the plate. The lighting also shines through a 'GAMING' logo in the centre of each side of the speaker.

As a competitor to the likes of the Razer Nommo speakers – with their RGB illuminated bases – the G5000 delivers the lighting goods, but the design is a little over the top. If Edifier did away with the 'GAMING' and 'LED TECHNOLOGY' labels on the sides, the whole design would look classier.

Moreover, the lighting isn't compatible with any of the usual RGB lighting-control apps, so you can't sync it with the rest of your system. Instead, you can choose from 11 different lighting effects, selected by double-tapping a button on the top of the right speaker.

That same button cycles through three different audio modes with a single press, while holding it down turns off the lighting. Greeting each change in audio mode is a strongly

accented voice alert to tell you the current mode, or 'mood' thanks to that accent. That same voice tells you which input you've selected too, and frankly, it's irritating, especially as its volume doesn't change along with the volume control.

Powering on (accompanied by a revving engine noise) is controlled by a second button (when held down) on the top of the right speaker, and that button also cycles through the input options when tapped. In between the two buttons is a volume switch that you tap or hold up and down to adjust. The volume up control was a little finicky on our review sample as well.



Around the back of the right speaker is a USB Type-B input for connection to your PC, along with coaxial and optical digital inputs and a 3.5mm analogue input, although there sadly isn't a headphone output. Meanwhile, the left speaker is attached via a proprietary 9-pin cable, which provides power for the RGB lighting as well as the audio signal.

Given these speakers' large size, it's no surprise they deliver masses of volume and power, but they work well at low volumes too. They also deliver excellent clarity, with a strong but not overly forced bass presence. Huge, pounding sub bass isn't quite there, but these are desktop speakers after all.

The movie and game audio modes do a reasonable job of enhancing dialogue and bombast for the former, and bringing out detailed treble noises, such as footsteps, for the game mode. However, we generally left the speakers in music mode for a flatter sound that we found suited most needs.

### Conclusion

The Edifier G5000's 'gamer' design additions aren't subtle and not genuinely useful for gaming, plus it's a shame the lighting can't be software-controlled, and the various sound effects and voice queues are pure cheese too. On the plus side, this is an excellent set of PC speakers when it comes to audio quality and connections – it just struggles to justify its £350 asking price.

EDWARD CHESTER

### VERDICT

Big, powerful and feature-rich but pricey and unsuited.

### SPEC

#### Weight

4.3kg (right speaker),  
3.9kg (left speaker)

#### Dimensions (mm)

190 x 230 x 270 (W x D x H) per speaker

#### Drivers

1 x 34mm tweeter and 1 x  
94mm woofer per speaker

#### Connections

Bluetooth 5, 3.5mm aux,  
USB, optical, coaxial

#### Frequency range

70-40,000Hz

#### Extras

Optical, USB and power  
cables; RGB lighting

DESIGN  
12/20

FEATURES  
17/20

SOUND QUALITY  
24/30

VALUE  
20/30

OVERALL SCORE

73%



## AMD B550 GAMING PC

# PC SPECIALIST FUSION-RX / £1,499 inc VAT

SUPPLIER [custompc.co.uk/FusionRX](http://custompc.co.uk/FusionRX)

**T**his Fusion-RX system might share magazine space with AMD's new Zen 4 processors, but PC Specialist's rig aims to prove that there's still life in Zen 3 silicon yet, especially in mid-range systems. The familiar Ryzen 5 5600X deploys six SMT-enabled cores with a top speed of 4.6GHz, and the CPU underpins a Gigabyte GeForce RTX 3070 card, which overclocks the GPU boost clock from 1725MHz to 1815MHz.

You also get 16GB of dual-channel memory, along with a 2TB SSD. Corsair's TX750M PSU is reliable thanks to a semi-modular design and 80 Plus Gold certification. Those components don't set the world alight, but they're good for the price, and they'll handle mainstream games fine.

The motherboard isn't bad either. The Gigabyte B550 Aorus Elite AX V2 looks good and offers 2.5Gbps Ethernet and dual-band 802.11ax Wi-Fi. It has some other limitations though – only one of its two M.2 socket supports PCI-E 4, and the rear I/O panel doesn't have a USB Type-C port.

Despite the relatively modest components, the Fusion does a decent job of competing with pricier rivals. The £1,799 Gladiator Nocturnal, for example, has the same GPU, along with an Intel Core i5-12600K processor and an Asus motherboard with PCI-E 5 support and USB Type-C, but it has slower memory, a smaller SSD and a weaker PSU.

PC Specialist's own-brand Spectrum enclosure holds all that hardware. The chassis has all the essentials, including a tempered glass side panel, a PSU shroud, a magnetic dust filter on top and a fetching, removable front panel with RGB LED intake fans. More lighting comes from an internal strip, the graphics card support bracket, PC Specialist's FrostFlow cooler and Corsair's memory – it's an eye-catching design.



Build quality is consistently good, and the chassis is neat. If you want to upgrade, there are two free memory slots and one M.2 connector easily accessible, but the graphics card support bracket makes the bottom half of the board trickier to reach. At the rear, you'll find pairs of 2.5in and 3.5in drive bays – the latter are tool-free – but no fan controller.

Finally, PC Specialist's standard warranty covers the basics, with a year of parts and labour cover, including a month of collect and return service, plus an extra two years of return to base labour cover. However, that's only the bare minimum of parts cover, and it's worth considering paying the extra £69 to upgrade to the Gold warranty, which includes two years of parts cover, including collect and return service.

## PERFORMANCE

The overclocked RTX 3070 might be getting long in the tooth, but it remains viable for mainstream gameplay. If you play at 1080p, you'll be fine – its Assassin's Creed Valhalla and Cyberpunk 2077 99th percentile results easily stayed

## SPEC

### CPU

3.7GHz AMD Ryzen 5 5600X

### Motherboard

Gigabyte B550 Aorus Elite AX V2

### Memory

16GB Corsair Vengeance RGB Pro 3600MHz DDR4

### Graphics

Gigabyte GeForce RTX 3070

### Storage

2TB PC Specialist M.2 SSD

### Networking

2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5

### Case

PC Specialist Spectrum G

### Cooling

CPU: PC Specialist FrostFlow 240 with 2 x 120mm fans; GPU: 3 x 90mm fans; front: 3 x 120mm fans; rear: 1 x 120mm fan

### Ports

Front: 2 x USB 3.2 Gen 1, 2 x audio; rear: 2 x USB 3.2 Gen 2, 3 x USB 3.2 Gen 1, 2 x USB 2, 5 x audio, 1 x optical S/PDIF

### Operating system

Windows 11 Home 64-bit

### Warranty

One year parts and labour with first month collect and return, then two years labour only return to base

## FUSION

- + Solid gaming performance
- + Good-looking, tidy case
- + Large SSD
- + Cheaper than rivals

## CONFUSION

- Modest motherboard
- Aging CPU
- Disappointing SSD speed



above 60fps, so single-player games will run smoothly, and the triple-figure results in Doom Eternal shows that undemanding games can be played on screens with high refresh rates.

Games remained perfectly playable at the trickier 2,560 x 1,440 resolution as well, although you'll need to reduce the settings slightly to achieve 60fps 99th percentile results in tougher titles. This card can handle ray tracing too, with no noticeable performance hit if it's set to Medium in Cyberpunk 2077 with DLSS enabled. It coped fine with Metro Exodus with High ray tracing at 1,920 x 1,080 in our tests too.

This machine didn't quite keep up with the aforementioned Gladiator system in games, with the Intel CPU giving it an advantage, but the differences are small. Likewise, in our RealBench application tests, the Ryzen 5 chip returned a benchmark score of 227,415, which was 25 per cent slower than the Core i5-12600K in the Gladiator. AMD's silicon was 11 per cent behind in our image editing test, which stresses single-threaded performance, and a whopping 36 per cent behind in the Handbrake benchmark, where the Intel chip benefited from its extra E-Cores.

The PC Specialist's SSD could be quicker too, delivering comparatively mediocre read and write speeds of 2,665MB/sec and 1,015MB/sec, although this is still fine for most people's needs and it's good to get 2TB of capacity for game storage.

The Ryzen 5 5600X remains fast enough for gaming, multi-tasking and light content creation, but Intel's Core i5 processors and AMD's Zen 4 chips are much quicker. When it comes to thermal performance, the PC Specialist is good though. Fan noise is moderate and manageable (although

## BENCHMARK RESULTS

### DOOM ETERNAL

1,920 x 1,080, Vulkan, Ultra Nightmare settings



2,560 x 1,440, Vulkan, Ultra Nightmare settings



### ASSASSIN'S CREED VALHALLA

1,920 x 1,080, Ultra High settings, High AA



2,560 x 1,440, Ultra High settings, High AA

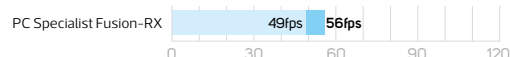


### CYBERPUNK 2077

1,920 x 1,080, Ultra preset, no ray tracing

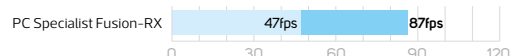


2,560 x 1,440, Ultra preset, no ray tracing

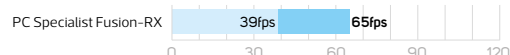


### METRO EXODUS

1,920 x 1,080, Ultra, HairWorks off, Advanced PhysX off, High RT



2,560 x 1,440, Ultra, HairWorks off, Advanced PhysX off, High RT



99th percentile Average

67,570

GIMP IMAGE EDITING

545,529

HANDBRAKE H.264 VIDEO ENCODING

279,836

HEAVY MULTI-TASKING

227,415

SYSTEM SCORE

the Nocturnal is quieter, thanks to its all-Noctua cooling), the CPU and GPU delta Ts of 40°C and 45°C are fine, and the processor achieved its proper turbo speeds.

## CONCLUSION

When taken at face value, there are many areas where the PC Specialist misses the mark – its CPU is getting on a bit and its SSD lags behind the latest drives. Neither of those issues impede the Fusion's ability to handle everyday gaming and computing, though, and this PC fights back with a large amount of storage space, a sturdy, good-looking case and a much lower price.

If you're happy to spend more, you'll get a better balance of components and a quieter build from the Nocturnal, or more pace from an RTX 3070 Ti-based Alder Lake PC. However, if you're on a tight budget, the Fusion-RX still gives you great gaming power for under £1,500.

MIKE JENNINGS

## VERDICT

It may not have the very latest tech, but the Fusion-RX still offers solid gaming pace at a fair price.

PERFORMANCE  
17/25

DESIGN  
21/25

HARDWARE  
19/25

VALUE  
22/25

OVERALL SCORE

79%



# Custom kit

Phil Hartup checks out the latest gadgets, gizmos and geek toys

## BLACK SHARK LUCIFER T2 / £34.99 inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

The Lucifer T2 earbuds from Black Shark bring the angular illuminated aesthetic of gaming peripherals directly into your ears. It's a bold design choice, but the Lucifer T2 keeps it practical, using the LEDs to indicate charge levels. The earbuds themselves are comfortable and just about stable enough, but they fall short of a good fit. The sound quality is respectable, being very clear for audiobooks or podcasts, while slightly weaker in the mid and lower tones.

Battery life is solid – the earbuds last for five hours when fully charged and the on-board



battery in the case is good for another 15 hours. Meanwhile, the controls rely on double-tapping a concealed button, rather than using a single press for pausing or playing, which reduces the chances of accidentally hitting pause, but does make for a slightly clumsy interface and a lot of tapping your ear like a confused bodyguard in a Hitman game. These aren't bad earphones for the money, but you can get a better sound and fit elsewhere.

Button mashing ●●●●○ Double tapping

## KENSINGTON UH1400P /

£184.99 inc VAT (plus £25.91 for optional power adaptor)

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

The Kensington UH1400P is a USB Type-C-based laptop dock that adds an array of connection options in a relatively tiny package. It's a very small, sleek device, which makes it a practical carrying companion for a laptop when out and about. The loadout includes four USB 3 ports, 4K at 60Hz HDMI video, Gigabit Ethernet and both SD and microSD readers – essentially, all the sockets a practical working laptop might need.

Meanwhile, an optional power adaptor not only provides power to the connected devices, but can also recharge your laptop. The power adaptor does add a chunk to the overall bulk and the price tag, but it can be handy depending on how you use your laptop setup. It's not cheap, but this is a small, sleek and very handy dock for today's often USB Type-C-only laptops.



Weak ●●●●○ Sleek

## ORB CASE-X / £34.99 inc VAT

SUPPLIER [thumbsup.com](https://www.thumbsup.com)

The Orb Case-X is so wildly ostentatious that it's impossible not to be in awe of it. It's a gamepad case that contains a 5,200mAh power bank to recharge your pad when it's not in use. The Case-X allows you to carry your gamepad around like you might do a snooker cue or a fishing tackle box. Then, when you get to the place where you want to play games, you pop the clasps, lift the lid and remove the pad to the wonder of any onlookers.

There's not a lot of practicality here, but there's utility – the padding keeps your pad safe, and you can charge devices inside or outside of the box. There's even a carrying handle, giving it the appearance of a tiny nuclear football. It's silly but the good kind of silly.



Serious gamer ●●●●○ Absurdly serious gamer

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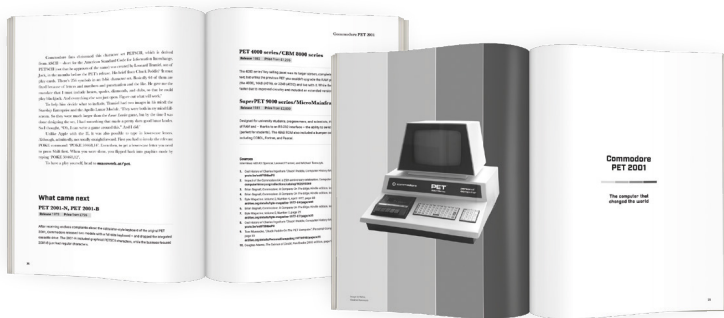
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- **Stuart Turton**, bestselling author  
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# How we test

## MOTHERBOARDS

### TEST PROCESSORS

- **AMD AM5** AMD Ryzen 9 7950X
- **Intel LGA1700** Intel Core i5-12600K
- **Intel LGA1700 mini-ITX** Intel Core i7-12700K

We use a GeForce RTX 3070, plus a WD Black SN850 SSD (LGA1700) or Kingston Renegade SSD (AM5) to test the speed of M.2 ports and heatsink performance. For memory, we use 16GB of Corsair 3466MHz Vengeance RGB Pro DDR4 RAM, 32GB of Corsair 5200MHz Dominator Platinum DDR5 RAM (LGA1700) or 32GB of G.Skill Trident Z Neo EXPO RAM (AM5).

All CPUs are cooled by a Corsair Hydro-X water-cooling loop with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock. We test with our RealBench suite and Far Cry 6 on Windows 11. We test each board's M.2 ports with CrystalDiskMark, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer.



## PROCESSORS

### TEST MOTHERBOARDS

- **AMD AM5** ASRock X670E Taichi
- **Intel LGA1700** Asus ROG Maximus Z690 Apex

We use a GeForce RTX 3070, plus a Samsung 970 Evo SSD (LGA1700) or Kingston Renegade SSD (AM5). We use 32GB of Kingston Fury 5200MHz DDR5 RAM (LGA1700) or 32GB of G.Skill Trident Z Neo EXPO RAM (AM5). The CPU is cooled by a Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock.

We use the latest version of Windows 11 with security updates, plus the latest BIOS versions and drivers. We record results at stock and overclocked speeds, and tests include our RealBench suite, Cinebench, Far Cry 6 and Watch Dogs: Legion.

For games, we record the 99th percentile and average frame rates using either the game's built-in benchmark or Nvidia FrameView. Finally, we note the idle and load power draw of the whole system, using Prime95's smallfft test with AVX disabled.



## MONITORS

We test image quality with an X-Rite iDisplay Pro colorimeter and DisplayCal software to check colour accuracy, contrast and gamma, while assessing more subjective details such as pixel density and viewing angles by eye. For gaming, we test a monitor's response time with an Open Source Response Time Tester, and use Blur Busters' ghosting UFO test to check the sharpness of a display in high-speed motion.



## CPU COOLERS

We use CoreTemp to measure the CPU temperature, before subtracting the ambient air temperature from this figure to give us a delta T result, which enables us to test in a lab that isn't temperature controlled. We use Prime95's smallest FFT test with AVX instructions disabled to load the CPU and take the temperature reading after ten minutes.

For the Intel LGA1200 system, we take an average reading across all eight cores, and for the LGA1700 system, we take an average reading across both the P-Cores and E-Cores. AMD's CPUs only report a single temperature reading, rather than per-core readings, so we list what's reported in Core Temp.

### TEST KIT

Fractal Design Meshify C case, 16GB of Corsair Vengeance RGB Pro memory, 256GB Samsung 960 Evo SSD, Corsair CM550 PSU.

### INTEL LGA1700

Intel Core i9-12900K at stock speed, Asus ROG Maximus Z690 Apex motherboard.

### INTEL LGA1200

Intel Core i9-11900K at stock speed with Adaptive Boost enabled, MSI MEG Z590 Ace motherboard.

### AMD AM4

Ryzen 7 5800X overclocked to 4.6GHz with 1.25V vcore, or Ryzen 5 5600X overclocked to 4.6GHz with 1.25V vcore on low-profile coolers, MSI MEG X570 Unify motherboard.



## GRAPHICS CARDS

We mainly evaluate graphics cards on the performance they offer for the price. However, we also consider the efficacy and noise of the cooler, as well as the GPU's support for new gaming features, such as ray tracing. Every graphics card is tested in the same PC, so the results are directly comparable. Each test is run three times, and we report the average of those results. We test at 1,920 x 1,080, 2,560 x 1,440 and 3,840 x 2,160, using an AOC U28G2XU monitor.



### TEST KIT

AMD Ryzen 9 5900X, 16GB (2 x 8GB) of Corsair Vengeance RGB Pro SL 3600MHz DDR4 memory, Asus ROG Strix B550-E Gaming motherboard, Thermaltake Floe Riing 240 CPU cooler, Corsair RM850 PSU, Cooler Master MasterCase H500M case, AOC U28G2XU monitor, Windows 10 Professional 64-bit.

### GAME TESTS

**Cyberpunk 2077** Tested at the Ultra quality preset and Medium ray tracing preset if the GPU supports it. We run a custom benchmark involving a 60-minute repeatable drive around Night City, and record the 99th percentile and average frame rates from Nvidia FrameView.

**Assassin's Creed Valhalla** Tested at Ultra High settings with resolution scaling set to 100 per cent. We run the game's built-in benchmark, and record the 99th percentile and average frame rates with Nvidia FrameView.

**Doom Eternal** Tested at Ultra Nightmare settings, with resolution scaling disabled. We run a custom benchmark in the opening level of the campaign, and record the 99th percentile and average frame rates with Nvidia FrameView. This test requires a minimum of 8GB of graphics card memory to run, so it can't be run on 6GB cards.

**Metro Exodus** Tested at Ultra settings with no ray tracing and both Advanced PhysX and HairWorks disabled. We then test it again with High ray tracing if the GPU supports it. We run the game's built-in benchmark, and report the 99th percentile and average frame rates.

### POWER CONSUMPTION

We run Metro Exodus at Ultra settings with High ray tracing at 2,560 x 1,440, and measure the power consumption of our whole graphics test rig at the mains, recording the peak power draw.



## CUSTOM PC AWARDS



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### CUSTOM KIT

For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.

## CUSTOM PC REALBENCH

Our own benchmark suite, co-developed with Asus, is designed to gauge a PC's performance in several key areas, using open source software.

### GIMP IMAGE EDITING

We use GIMP to open and edit large images, heavily stressing one CPU core to gauge single-threaded performance. This test responds well to increases in CPU clock speed.

### HANDBRAKE H.264 VIDEO ENCODING

Our heavily multi-threaded Handbrake H.264 video encoding test takes full advantage of many CPU cores, pushing them to 100 per cent load.

### LUXMARK OPENCL

This LuxRender-based test shows a GPU's compute performance. As this is a niche area, the result from this test has just a quarter of the weighting of the other tests in the final system score.

### HEAVY MULTI-TASKING

This test plays a full-screen 1080p video, while running a Handbrake H.264 video encode in the background.

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## LABS TEST

# Head space

Wireless gaming headsets are moving up in the world, with Bluetooth now readily included and several including internal microphones. Edward Chester tests seven of the latest models

## How we test

**T**here's a distinct sense of a step-change in wireless gaming headsets of late. Not long ago, many still used micro-USB charging sockets, only offered stereo sound and had few connection options. However, nearly all the major players in the gaming headset space have new headsets that now include USB Type-C charging (sometimes with USB-C audio too) along with Bluetooth, so you can conveniently connect them to your phone, laptop or other portable device.

RGB lighting still abounds, but it tends to be more subtly integrated than before, while overall designs have matured into sleeker forms that you might actually consider using in place of normal headphones when you're out and about. Good-quality virtual surround sound is now commonplace too, bringing excellent in-game directional audio without the expense and bulk of multi-driver headphones.

In testing this latest raft of headsets, we looked at the designs in terms of ease of use, comfort, ease and range of adjustment, and styling. Some headsets are comfortable but look naff, while others

look amazing but fall off your head. Comfort, in particular, is tricky to get right, with the wrong choice or thickness of foam padding, or a badly contoured headband, making all the difference.

We also assessed the range and ease of use of any extra features. Some headsets only use a 2.4GHz USB dongle-based wireless connection, while some include Bluetooth, USB audio and analogue audio inputs. Others include retractable or fold-down microphones, while others have removable or internal mics. Extra controls for all those features can certainly help, but too many controls can make the headset tricky to use.

To test the microphone, we recorded a voice sample and recorded a section of music to check for overall sound quality, breath pickup, noise cancelling and more. Meanwhile, the headphones were tested using a range of music and games, to assess the audio range, level of detail and the balance of bass, mid-range and treble frequencies. We also engaged the virtual surround sound modes to see how they performed in games.

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# ASUS ROG DELTA S WIRELESS / £173 inc VAT

SUPPLIER amazon.co.uk

**T**he Delta S Wireless is the only headset on test to maintain more of a traditional gamer aesthetic and bulky desktop-centric design. It has very deep and wide earcups, but it only weighs 310g. That's not the lightest weight on test but it's not the heaviest either.

The large earcups provide loads of room for your ears, ensuring they don't get squashed. Having so much earcup space can result in a headset sloshing around on your head but the Asus' headband maintains a firm grip, plus the pleather finish on the earcup padding helps them not to slip. They're not the most breathable pads, but a set of replacement fabric pads are included in the box that allow more air through them.

Although the triangle design of the earcups is a little outlandish, the Delta S Wireless is far from being outright garish. Most of the headset is black, with just a silver logo on the outside of each earcup and silver earcup-holding forks. The use of internal microphones also means there's no gangly boom mic breaking up the clean lines of the earcups.

For features, the Delta S Wireless includes 2.4GHz wireless and Bluetooth connections, with the former using a USB Type-C dongle. A USB Type-C (charging only) port sits on the left earcup, behind which sits a 2.4GHz/

Bluetooth/Off slider switch, a multi-purpose Bluetooth button (play/pause, skip track and pairing), and a volume wheel that can be pressed to mute the microphone.

The internal microphones pick up sound through two tiny pinholes in the front of each earcup. They combine their efforts to actively cancel out background noise, as opposed to the boom arm microphones on most headsets that just rely on the analogue pickup pattern of the microphone – and its proximity to your mouth.

The noise cancelling does work, but there's no substitute for a better mic held closer to your mouth – the audio quality is rather thin and not overly clear. It's good enough for voice comms and taking a call when you're out, but there's a definite compromise of convenience over audio quality here.

As for the Delta S Wireless' headphone quality, thanks to the drivers being slightly set back into the deep earcups, the soundstage is quite wide with an open, airy quality. It's initially quite a pleasing change from the very closed-in sound of some other headsets. However, there's a lack of clarity at times, with the mid-range feeling compressed. The result is a slightly muddy sound that ultimately can lack the detail needed to pick out fine in-game audio cues, without some EQ tweaking.

Asus' Armoury Crate software provides plenty of EQ and virtual surround options, along with bit-rate control, a microphone noise gate, a 'perfect voice' mic setting and the AI-driven mic noise cancellation. It's not the slickest software – it's a little slow to load and not quite as intuitive as the likes of Razer's software, for instance, but it gets the job done.

## Conclusion

The Asus Delta S Wireless is an intriguing prospect, with good comfort and reasonable headphone sound quality. Meanwhile, the



## DELTA FORCE

- + Comfortable
- + Convenient internal microphones
- + Bluetooth and 2.4GHz connections

## SUICIDE SQUAD

- Microphone not as good as boom mics
- Quite bulky design
- Sound quality lacks clarity

internal microphones don't sound as good as conventional boom mics, but they're certainly more convenient.

However, in terms of aesthetics, while its design is relatively muted in terms of garish colours, it's still rather bulky and angular, plus it lacks active noise cancelling to reduce train and plane noise. This isn't a bad headset, but its mic and headphone sound quality need to be better for the asking price, and it's up against some stiff competition.

## VERDICT

Convenient internal microphones and decent comfort, but you can get better sound quality elsewhere.

DESIGN/COMFORT

14/20

FEATURES

14/20

SOUND QUALITY

28/40

VALUE

14/20

OVERALL SCORE

70%

## SPEC

**Connections** 2.4GHz wireless, Bluetooth, USB Type-C charging

**Frequency range** 20-40,000Hz

**Sensitivity / sound pressure level** 116dB

**Mic frequency response** 100-10,000Hz

**Mic sensitivity** -37dB

**Weight** 310g

**Stated battery life** 25 hours

**Extras** Internal mics, USB Type-C dongle, USB Type-A to Type-C extension cable, spare fabric earpads



# CORSAIR HS80 RGB WIRELESS / £109 inc VAT

SUPPLIER johnlewis.com

**C**orsair's HS80 is among the cheapest headsets in this test, at just under £110 inc VAT. The design is on the chunkier side, with a wide headband and large, slightly angular earcups. However, the styling is quite subtle, with just plain black or white finishes available, and small illuminated Corsair sail logos on each earcup being the only addition.

The sail logos can be set to show various lighting effects, or a custom colour to match your system's other lighting, via Corsair's iCUE software. Meanwhile, a thin ring of light around the tip of the microphone indicates when it's muted (red) or live (white).

The HS80 uses a fixed headband with an adjustable elastic strap for both cushioning the top of your head and adjusting the fit of the headset. It works well, taking the strain off the earcups while distributing the weight across the length of the elastic strap. The downside is that adjustment requires removing the headset to reach the strap. Once adjusted, though, there's no reason for the headset to ever lose its perfect fit, unlike models with adjustable arms.

The earcups are mounted on arms that pivot from a point in the top rear corner of each earcup, then again where the arm meets the headband. This allows for the earcups to be

folded flat and lets them adjust easily to most head shapes. The headset is tight enough to fit smaller heads without clamping too hard onto larger heads.

Earcup padding is ample, both in terms of cushioning and ensuring there's room for your ears to not get squashed. There's a fair amount of space around your ears as well, but the headset remains secure.

For physical features, the HS80 is quite basic. While you get an auto-muting, flip-down microphone, it can't be removed and you don't get an extra analogue audio socket, there's no Bluetooth and controls are limited to just power and volume. However, the USB Type-C port offers both charging and a direct USB connection to your PC, with the wired connection upping the sample rate from 24-bit/48kHz to 24-bit/96kHz.

While simple, the HS80's controls and features are very easy to use. Both the power button and volume wheel are easy to find, and volume adjustment is quick. Likewise, the microphone is simple to deploy and stow.

Overall audio quality from the mic is adequate but nothing special. It gets the point across with in-game voice comms but lacks the depth and clarity of the EPOS H3Pro Hybrid. Headphone sound quality is very good though. There's bass and warmth without it feeling too forced, while clarity is decent. There's a touch less sparkle in the top end than with pricier headsets, but that's to be expected. Interestingly, we noticed a marked improvement in audio quality when using



the wired mode, despite not opting to up the sample rate. There was less background noise, a stronger bass response and better clarity, suggesting the internal amps benefit from the extra power.

The headset also comes with a licence for Dolby Atmos to provide excellent virtual surround sound. The headset's EQ can also be changed in software, with the FPS preset proving useful for picking out subtle in-game cues.

## Conclusion

The HS80 RGB Wireless looks great, it's comfortable, sounds decent and has enough core features to do the job. The inclusion of USB charging and audio makes it convenient for modern systems, and its virtual surround works well. It's not packed with extra features but it does a lot for the price.

## VERDICT

With a smart design, decent sound quality and a basic but easy-to-use feature set, this is a decent wireless headset if you have a tighter budget.

## SPEC

**Connections** 2.4GHz wireless, USB Type-C charging and audio

**Frequency range** 20-40,000Hz

**Sensitivity / sound pressure level** 116dB

**Mic frequency response** 100-10,000Hz

**Mic sensitivity** -40dB

**Weight** 367g

**Stated battery life** 20 hours

**Extras** Dolby Atmos, fold-down auto-mute mic, RGB lighting

## SET SAIL

- + Smart design
- + Easy-to-use features
- + Decent mic and headphone sound quality
- + Good value

## SHIPWRECK

- Paying more gets you better sound
- Non-removable microphone
- No Bluetooth

DESIGN/COMFORT

16/20

SOUND QUALITY

30/40

FEATURES

11/20

VALUE

19/20

OVERALL SCORE

76%

# EPOS H3PRO HYBRID / £220 inc VAT

SUPPLIER [currys.co.uk](https://www.currys.co.uk)

**W**e've generally been impressed with EPOS' (previously Sennheiser) gaming headsets, with the GSP 300 still topping our Elite list for budget wired headsets. The new H3Pro Hybrid is at the other end of the scale, though, with a premium price and lots of features.

The H3Pro Hybrid is a smarter, sleeker looking unit than previous GSP models. The three colour options – black and dark blue, white and light grey, and dark green and gold – are relatively subtle. Previously, the GSP range used a wide, split headband design that was less elegant than the single-piece design here. We expected this to compromise comfort, as the split design was excellent at distributing the headset's weight, but the H3Pro Hybrid's memory foam padding proved very comfortable.

## RACING GREEN

- + Superb sound quality
- + Comfortable
- + Loads of useful features
- + Includes ANC

## BOWLING GREEN

- Expensive
- Unresponsive volume wheel
- Slightly awkward headband adjustment

## SPEC

**Connections** 2.4GHz wireless, Bluetooth, USB Type-C charging and audio, 2.5mm analogue jack

**Frequency range** 20-40,000Hz

**Sensitivity / sound pressure level** 116dB

**Mic frequency response** 100-7,500Hz

**Mic sensitivity** -20dB

**Weight** 308g (288g without boom mic)

**Stated battery life** 30 hours wireless (19 hours with ANC), 38 hours Bluetooth (22 hours with ANC), 29 hours with 3.5mm cable (19 hours with ANC)

**Extras** Detachable fold-down mic arm, mic arm joint cover plate, secondary internal mic, smart button, USB Type-A extension cable, USB Type-C cable, active noise cancelling (ANC)

The same goes for the contoured earcup design that closes round your ears for a secure fit without putting pressure on them. The earcup padding is deep and soft, with a lovely plush finish on the surface that touches your head, while the padded sides have an easy-to-clean pleather finish.

You can adjust the fit via the notched sliding earcup arms. We found them difficult to adjust while on your head, and too easy to knock

otherwise, so you can't just set and forget the headband. We ended up memorising how many notches per side we liked in order to dial in the right fit before donning the headset.

For features, the H3Pro Hybrid is packed to the gunnels. Along with USB dongle-based wireless audio, you get Bluetooth, direct USB Type-C audio and a 2.5mm analogue jack input. Annoyingly, though, the analogue input only works when the headset has power.

Otherwise, audio quality is fantastic and easily tops the charts in this group test. Detail levels are well ahead of the pack, and there's a spaciousness and width to the stereo image that far surpasses the other headsets on test. Music feels alive, and your sense of direction and place when gaming is superb, even without engaging the excellent virtual 7.1 surround mode (via EPOS' software). Tapping the Smart button switches between stereo and 7.1 modes, or between the preset EQ modes.

Back to those features, and as well as having EPOS' signature large, excellent quality fold-down microphone, the H3Pro Hybrid has a secondary built-in microphone for mic noise cancelling, as well as powering the headphones' active noise cancelling (ANC). The ANC isn't the most accomplished we've used, but it takes the edge off the worst transport noise. What's more, the primary microphone can be removed (it's magnetically attached), and you can rely entirely on the

built-in mic, making for a cleaner, more portable arrangement.

There's a pleasingly large and easy to feel for volume wheel on the right earcup too, but it's disappointingly unresponsive, taking a quarter turn to respond then changing the volume in large increments. Meanwhile, battery life ratings are middling for a gaming headset, with a rating of 30 hours for wireless use without ANC, but we found it easily lasted us a week of regular use, unlike some longer-rated units.

## Conclusion

Despite its slightly unresponsive volume wheel, the EPOS H3Pro Hybrid is a superb gaming headset. Its sound quality is class-leading, plus it's comfortable and packed with useful, easy-to-use features. Its ability to morph into an ANC-enabled, travel headset by removing its boom mic is also a huge boon for regular travellers.

## VERDICT

Expensive, but this is a great-sounding, comfortable and versatile gaming headset.

DESIGN/COMFORT

18/20

SOUND QUALITY

36/40

FEATURES

18/20

VALUE

14/20

OVERALL SCORE

86%



# LOGITECH G735 / £199 inc VAT

SUPPLIER logitech.com

**L**ogitech's G735 is a sleek, stylish affair aimed just as much at travelling as PC gaming. It's also only currently available in white. You can customise the headset with lime green or pink earpads and mic arm (£17 inc VAT for a set) but there's no black version.

Opting for white only is a risky choice, but the G735's design is otherwise rather special. Even compared with the EPOS H3Pro Hybrid and Razer Barracuda, which have similar street-ready aspects to their design, the G735 is seriously sleek. The headband is effortlessly elegant as it broadens gently towards its middle, then slims down to a single polished steel pivot point upon which the earcups spin. The addition of braille markings on the headband, to indicate left and right, is also a nice touch and the earcups themselves are compact, as well as wonderfully smooth and lozenge-like.

Logitech has also managed to cleverly squeeze some RGB lighting into the design. Between the earcup padding and the rest of the earcup is a rubber skirt, which covers a tilt mechanism that allows the padding to tilt up and down to adjust to your head. Behind that skirt, and shining through it, is a ring of RGB lighting. It's prominent when powered on but

disappears completely into the design when it's turned off.

This simple headset also only weighs 260g – 100g lighter than some other headsets on test. Combine that weight with the really soft, deep earcup padding and the equally soft – though not all that deep – headband padding and you have a headset that's deceptively comfortable. It stays secure too, despite the arm length adjustment just using a friction fit around the steel pivot poles.

Despite all this impressive compactness, the G735 still includes plenty of features. The left earcup houses the removable mic arm, along with the USB Type-C charging port, mic mute button, 3.5mm analogue jack, volume wheel and power button.

The right earcup has a Bluetooth button (that also switches between wireless and analogue inputs) and an A/B switch, which lets you adjust the mix between Bluetooth and either the wireless or analogue inputs, so you can take a call while still hearing your game, for instance. It's a great set of controls that feels intuitive, easy-to-use and precise, although there's a bit of a learning curve with so many small buttons spread around the headset.

Our least favourite aspect of this headset is its microphone. Its audio quality is fine for voice comms, but its mostly fixed position (it's flexible but doesn't stay where you bend it) and lack of stowage makes it less convenient than fold-down options when sat at your desk, and it leaves an unsightly hole when removed – the white finish makes it particularly obvious.

Back to the good stuff, and the G735 has great overall sound quality. It's not up with the EPOS H3Pro Hybrid for stereo image, spaciousness and detail but it provides a bassy, warm yet detailed sound. With a rating of 16 hours of battery life with its RGB lighting



## PURE BRILLIANT WHITE

- + Effortlessly stylish design
- + Comfortable and light
- + Loads of features
- + Decent sound quality

## OFF WHITE

- Quite expensive
- Clunky microphone arm
- Only available in white

turned on, the G735 is seemingly down on its rivals, but turning the lighting off more than triples battery life.

## Conclusion

Assuming you don't mind its white colour, the Logitech G735 is excellent. It's stylish, compact, light, easy to use, comfortable, has great battery life when the lighting is turned off and it sounds decent too. You don't get quite the sound quality or active noise cancelling of the EPOS, but otherwise this headset largely lives up to its premium price.

## VERDICT

A fantastic premium headset, as long as you don't want it in black.

## SPEC

**Connections** 2.4GHz wireless, Bluetooth, 3.5mm jack input, USB Type-C charging

**Frequency range** 20-20,000Hz

**Sensitivity / sound pressure level** Not stated

**Mic frequency response** 100-10,000Hz

**Mic sensitivity** Not stated

**Weight** 260g

**Stated battery life** 16 hours gaming with lighting, 56 hours gaming without lighting

**Extras** RGB lighting, Detachable mic, swappable ear pads and mic

DESIGN/COMFORT

18/20

SOUND QUALITY

32/40

FEATURES

18/20

VALUE

14/20

OVERALL SCORE

82%



# RAZER BARRACUDA / £150 inc VAT

SUPPLIER ebuyer.com

**R**azer's Barracuda misses out on the ANC and THX AAA amplifier of its Pro-branded range sibling, but still has Bluetooth and internal microphones, plus it adds an extra feature in the form of an analogue 3.5mm input. It's aimed squarely at the emerging market for premium, multi-purpose headsets, with a tag line of 'home gaming, street living'.

It's only available in black, and there's not even a hint of a coloured highlight – unlike the Logitech G735, you can't even accessorise the Barracuda with colourful extras. It's a neat look of which we approve.

The clean lines of the earcups' outer surfaces – adorned only by a shiny black Razer logo hidden among the otherwise matt black finish – and the simple headband look effortlessly cool, and the lack of sticky-out mic

arms makes the Razer Barracuda practical for travel as well.

The headset's fit is secure, thanks to a reasonably strong clamping force and a grippy pleather surface to the headband. The notched arm adjustment works about as well as usual too, and allows for heads small and large to be accommodated.

Comfort is middling, with the headband not as cushioning as headsets with elasticated bands, and the foam not quite as squishy as that of the EPOS. It's about on par with the Logitech G735, and ahead of the Corsair and Roccat in this respect. Meanwhile, the earcups have sufficiently deep and soft padding, with a fabric cover that provides breathability without the slightly scratchy feel of the Roccat headset.

Two holes on the front edges of the earcups show where the internal mics pick up their sound, while further back on the left earcup is the USB Type-C charging port, 3.5mm analogue input, power button, volume wheel and mic mute button. On the back of the right earcup is the Bluetooth button that will play/pause music and connect to devices. The headset supports connecting to two devices at once but can't mix the two audio sources.

Sadly, audio from the internal microphones is, along with the Asus, the worst on test, with a tinny, inconsistent sound – there's only so much that the headset can make up for the microphones being so far from your voice. It's sufficient for voice comms, and there's noise cancelling that works well for drowning out background annoyances, such as keyboard taps, but there's an inherent compromise of convenience over sound quality.

Thankfully, the headphones sound better. Overall clarity is very good with a strong but not overblown bass response, pleasingly warm mid-tones and plenty of top-end sparkle. The EPOS H3Pro Hybrid beats it for detail and stereo image, but the Barracuda easily justifies its premium over the likes of the Corsair HS80.



The Barracuda also supports THX Spatial Audio for virtual surround sound, and it works well. We particularly like how you can assign the software to automatically enable or disable the spatial audio on a per-game or per-app basis. Razer's software also supports ample tweaking of the EQ and spatial audio calibration. Thanks in part to its lack of RGB lighting, battery life is also decent, with a 40-hour rating.

## Conclusion

With its compact, stylish design and internal microphones, the Razer Barracuda does an excellent job of bridging the gap between home gaming headset and portable 'street' headset, although its lack of ANC dents its appeal for use on planes and trains. Sound quality is solid and the feature list is strong, but microphone quality is poor compared with headsets with mic arms.

## VERDICT

A well-designed crossover headset for home and away use, but the internal mics don't sound great.

### OCEAN PREDATOR

- + Stylish design
- + Practical, compact design
- + Lots of features for its price
- + Good headphone sound quality

### BAIT FISH

- Poor microphone sound quality
- Lack of ANC limits use on noisy transport

## SPEC

**Connections** 2.4GHz wireless, Bluetooth, 3.5mm analogue, USB Type-C charging

**Frequency range** 20–40,000Hz

**Sensitivity / sound pressure level** 96dB

**Mic frequency response** 100–10,000Hz

**Mic sensitivity** –38dB

**Weight** 300g

**Stated battery life** 40 hours

**Controls** Power button, volume wheel, mic mute button

**Extras** Internal mics, analogue cable, USB Type-C wireless dongle, USB Type-A to Type-C charging cable, USB Type-A to Type-C extension cable

DESIGN/COMFORT

16/20

FEATURES

16/20

SOUND QUALITY

32/40

VALUE

16/20

OVERALL SCORE

80%

# ROCCAT SYN PRO AIR / £100 inc VAT

SUPPLIER box.co.uk

**P**erhaps the most obvious aspect of the Roccat Syn Pro Air is its surprisingly low price. Widely available for £100 inc VAT, it still offers several extras. There's the prominent RGB lighting, the detachable, rotating, auto-muting microphone, a dedicated game/chat mix dial and more.

The overall design is quite conventional, with a traditional padded headband, sliding side arms for fit adjustment, and earcups that rotate left and right to fold flat. However, the arm adjustments aren't notched but move smoothly. This makes them easy to adjust when the Syn Pro Air is on your head, but they're not the most secure and they'll need adjusting each time you wear them.

Overall comfort levels are middling. The headband is quite narrow and the padding, while reasonably soft, isn't on the same pillow memory foam level of softness as that of the EPOS H3Pro Hybrid. Likewise, the earcup padding is amply deep but not the softest, and the rather coarse woven fabric feels a bit rough and scratchy.

Meanwhile, the earcups have a reasonably large opening that, when combined with the

modest clamping force and not particularly grippy earcup covering, means the headset slides around a little on your head. It's not terrible for people with larger heads, but it feels quite loose on smaller heads, plus the headband adjustment doesn't go small enough for such users.

In terms of styling, the Syn Pro Air takes on Roccat's current signature look of a having a semi-translucent black housing with a hexagonal pattern through which RGB lighting shines. The lighting only comes from the bottom rear quarter of the earcups, creating a firefly-like effect. It's a bold move, as we can see it being a divisive look when the lighting is on, although otherwise the headset is quite plain.

For physical features, the microphone is on the left earcup, along with the power button, USB Type-C charging port and volume wheel. The mic rotates down and auto activates when lowered, or you can just pull it out completely, so you can use the headset as a set of headphones instead. The hole can be covered with an included plastic piece that we suspect most users will lose almost straightaway.

You can hear your voice piped back through the headset from the microphone, but its level can be changed via a second volume wheel on the back of the right earcup. That's the only extra physical feature, but it's a particularly handy one – it lets you control one of the most useful features for gaming chat right on the headset. Audio quality from the microphone is clear enough for voice comms, but won't stretch beyond those duties.

## FIREFLY

- + Decent sound quality
- + Easy-to-use features
- + Useful fold-down, removable mic

## BLAKE'S7

- Fit is a bit loose
- Slightly scratchy earcup fabric



Sound quality from the headphones is solid enough, with plenty of clarity on offer. Bass is a little less prominent than on some rivals but this only serves to make for a better experience when gaming, as powerful bass can drown out finer details. It's less fun for music listening though. Finally, in terms of audio connections, the Syn Pro Air only supports its wireless USB transmitter, with no Bluetooth, analogue or direct USB connection support.

## Conclusion

While Corsair's HS80 is our low-cost pick of the bunch, if you can't quite stretch your budget that far, the Roccat Syn Pro Air is a good-value wireless gaming headset that provides decent sound quality and an easy-to-use feature set, while the removable mic means it can double as a portable set of headphones. Its fit is a bit loose, and the earcup padding is a little scratchy, but it otherwise does the job.

## VERDICT

It's not perfect, but this is a decent-quality wireless headset for its modest asking price.

## SPEC

**Connections** 2.4GHz wireless, USB Type-C charging

**Frequency range** 20-20,000Hz

**Sensitivity / sound pressure level** 116dB

**Mic frequency response** 100-10,000Hz

**Mic sensitivity** -40dB

**Weight** 390g

**Stated battery life** 24 hours

**Controls** Power button, volume wheel, mic mute button, mic monitor wheel

**Extras** Flip-down removable mic, USB Type-C charging cable, USB Type-C adaptor, USB Type-A transmitter, RGB lighting

## DESIGN/COMFORT

12/20

## SOUND QUALITY

30/40

## FEATURES

12/20

## VALUE

19/20

## OVERALL SCORE

73%

# STEELSERIES ARCTIS NOVA 7 WIRELESS / £170 inc VAT

SUPPLIER currys.co.uk

**S**teelSeries has recently refreshed the acclaimed design of its Arctis headsets, and the result is more cluttered. The main culprit is the addition of a secondary circular bump to the earcup, on top of the main lozenge shape. The controls are clustered on the sides of these bumps, making them convenient to find, but more visible than on the old Arctis design.

Magnetically attached discs cap the earcups, and removing them reveals nothing. There's no hole to store the USB dongle or a replaceable battery, for instance. Instead, the caps can be used to stylise your headset, with replacement packs of caps and elastic headbands (red, green, purple and pink) available for £30 inc VAT.

Although build quality is solid enough, the look and feel of the earcups, arms and much of the headband is a little plasticky, with several mould seams visible – it broadly feels like a step down from the build quality of the older Arctis line, although no worse than the likes of the Corsair HS80 or Roccat Syn Pro Air.

The fit is also a step down. The Arctis range was on the slightly looser-fitting end of the spectrum and the Nova is worse. The fit is

loose enough that the headset slides off when you're leaning forwards or backwards, and the earcups don't tuck under your ears very well, hampering the natural noise reduction of wearing closed-back headphones. Sound quality is also affected, with the poor seal robbing the headset of bass – gently pressing in the bottom edges of the earcups provides a marked bass boost.

The Velcro-adjusted elasticated headband of the Arctis has also been dropped in favour of one that's adjusted via three holes on each end of the band, which clip onto bumps on the inside of the outer headband. It's a more awkward and less versatile system than before, but it's comfortable and once it's set, you shouldn't need to touch it again; plus it doesn't hang down, getting in the way, like the old design. The earcup padding is pleasantly soft but a little shallower than some, so our ears just touched the driver cover.

For features, the Nova 7 Wireless wants for very little. You get a retractable microphone, volume wheel and microphone mute button on the left earcup, as well as a Bluetooth button, power button, game/chat mix volume wheel and 3.5mm analogue jack input on the right earcup. All the controls fall comfortably to hand, making for an easy control system. The analogue volume wheel is particularly welcome, as it makes for a more immediate response than digital dials.

Overall sound quality is good in terms of having a smooth, detailed presentation without an overly forced bass or treble response. However, because of the loose fit of the earcups, the headset can sound a little tinny, depending on how well you can get it to sit.

Battery life is also among the highest of the headsets on test, thanks to the headset having no lighting. A USB Type-C dongle and Type-A to Type-C extension cable is included, plus you get an analogue audio cable and a USB



## NEWLY FORMED

- + Useful combination of features
- + Easy-to-use controls
- + Decent sound quality

## FADING AWAY

- Dull plasticky design
- Step down in build quality
- Loose earcup fit

Type-C charging cable, along with a funky little Minecraft-esque 3D cardboard character for you to build.

## Conclusion

The SteelSeries Arctis Nova 7 Wireless is a decent gaming headset with good sound quality and plenty of convenient and easy-to-use features. However, its styling and build quality feels like a step back from the older Arctis headsets and its fit is a little loose, potentially compromising sound quality. **CPC**

## VERDICT

A decent enough gaming headset, but it could do with a better fit.

### DESIGN/COMFORT

10/20

### SOUND QUALITY

28/40

### FEATURES

16/20

### VALUE

14/20

### OVERALL SCORE

68%

## SPEC

**Connections** 2.4GHz wireless, Bluetooth, 3.5mm analogue jack, USB Type-C charging

**Frequency range** 20-22,000Hz

**Sensitivity / sound pressure level** 93dB

**Mic frequency response** 100-6,500Hz

**Mic sensitivity** -38dB

**Weight** 390g

**Stated battery life** 38 hours

**Controls** Power button, Bluetooth button, volume wheel, mic mute button, game/chat mix wheel

**Extras** Retractable mic, USB Type-C charging cable, USB Type-A to Type-C extension cable, USB Type-C transmitter



## Core component bundles

The fundamental specifications we recommend for various types of PC. Just add your preferred case and power supply, and double-check there's room in your case for your chosen components, especially the GPU cooler and graphics card. We've largely stopped reviewing power supplies, as the 80 Plus certification scheme has now effectively eliminated unstable PSUs. Instead, we've recommended the wattage and minimum 80 Plus certification you should consider for each component bundle. You can then choose whether you want a PSU with modular or captive cables.

### 8-core system with integrated graphics

#### 8-core CPU, basic gaming

Needs a micro-ATX or ATX case. We recommend a 450W 80 Plus Bronze power supply. See Issue 218, p76 for an example build guide.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 5700G	awd-it.co.uk	#218 p20	£280
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	#218 p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 8 integrated into CPU	N/A	#218 p20	£0
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2B3200C16)	scan.co.uk	#218 p78	£59
MOTHERBOARD	Asus TUF B450M-PLUS II (micro-ATX) with BIOS flash	awd-it.co.uk	#218 p78	£99
STORAGE	500GB WD Blue SN570 (M.2 NVMe)	scan.co.uk	#222 p20	£46
Total £454				

### 1,920 x 1,080 gaming

#### 6-core CPU, 1080p gaming

Needs an ATX case. We recommend a 500W 80 Plus power supply. See Issue 224, p76 for an example build guide.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12400F	cclonline.com	#227 p51	£173
CPU COOLER	ARCTIC Freezer i13X	scan.co.uk	#224 p76	£20
GRAPHICS CARD	AMD Radeon RX 6600 XT	scan.co.uk	#228 p90	£360
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX DDR4 3200MHz (CMK16GX4M2B3200C16)	scan.co.uk	#224 p76	£59
MOTHERBOARD	Gigabyte B660 Gaming X DDR4 (ATX)	scan.co.uk	#224 p50	£155
STORAGE	1TB WD Blue SN570 (M.2 NVMe)	scan.co.uk	#222 p20	£80
Total £847				
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	scan.co.uk	#228 p90	£420
SWAP STORAGE	1TB WD Black SN850	scan.co.uk	#225 p27	£120

## 2,560 x 1,440 gaming system

### 10-core CPU, 2,560 x 1,440 gaming and ray tracing

Needs an ATX case. We recommend a 550-600W 80 Plus Bronze power supply.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12600K	scan.co.uk	#227 p56	£300
CPU COOLER	ARCTIC Liquid Freezer II 240 RGB (240mm AIO liquid cooler)	scan.co.uk	#226 p49	£80
GRAPHICS CARD	Nvidia GeForce RTX 3070	overclockers.co.uk	#228 p90	£530
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz DDR4 (CMW16GX4 M2D3600C18)	scan.co.uk	#230 p47	£73
MOTHERBOARD	Gigabyte Z690 Gaming X DDR4	scan.co.uk	#222 p46	£220
STORAGE	1TB WD Black SN850	scan.co.uk	#225 p27	£120

**Total £1,323**

#### UPGRADES

ADD SECONDARY STORAGE	Western Digital Blue 4TB	ebuyer.com	#166 p54	£85
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## Mid-range gaming system



### 10-core CPU, smooth 2,560 x 1,440 gaming and ray tracing, some 4K gaming

Needs an ATX case with room for a 240mm all-in-one liquid cooler. We recommend a 750W 80 Plus Bronze power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12600K	scan.co.uk	#227 p56	£300
CPU COOLER	ARCTIC Liquid Freezer II 240 RGB (240mm AIO liquid cooler)	scan.co.uk	#226 p49	£80
GRAPHICS CARD	Nvidia GeForce RTX 3080 10GB	overclockers.co.uk	#228 p90	£690
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz DDR4 (CMW16GX4M 2D3600C18)	scan.co.uk	#230 p47	£73
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	scan.co.uk	#222 p48	£260
STORAGE	1TB WD Black SN850	scan.co.uk	#225 p27	£120

**Total £1,523**

#### UPGRADES

ADD SECONDARY STORAGE	Western Digital Blue 4TB	ebuyer.com	#166 p54	£85
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# Core component bundles cont ...

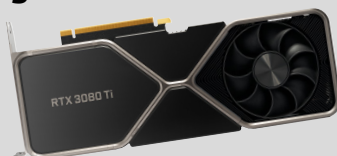
## 4K gaming system

### 8-core CPU, 4K gaming and ray tracing

Needs an ATX case with room for a 360mm all-in-one liquid cooler.

We recommend an 850W 80

Plus Gold power supply.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 7700X	overclockers.co.uk	#231 p16	£480
CPU COOLER	Corsair iCUE H150i Elite LCD (360mm AIO liquid cooler)	scan.co.uk	#226 p78	£220
GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	nvidia.com	#226 p78	£929
MEMORY	32GB (2 x 8GB) G.Skill Trident Z5 Neo DDR5 6000MHz EXPO (F5-6000J3636 F16GX2-TZ5N)	memoryc.co.uk	#231 p21	£280
MOTHERBOARD	ASRock X670E PG Lightning	scan.co.uk	#231 p26	£300
STORAGE	2TB WD Black SN850	ebuyer.com	#215 p49	£200

**Total £2,409**

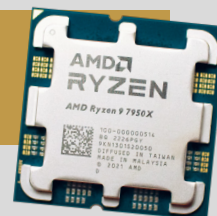
#### UPGRADES

ADD SECONDARY STORAGE	4TB Western Digital Blue	ebuyer.com	#166 p54	£85
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## Content creation system

### 16-core CPU, 1,920 x 1,080 gaming

Needs an E-ATX case with room for a 360mm all-in-one liquid cooler. We recommend a 750W 80 Plus Gold power supply.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 9 7950X	overclockers.co.uk	#231 p14	£849
CPU COOLER	Corsair iCUE H150i Elite LCD (360mm AIO liquid cooler)	scan.co.uk	#226 p78	£220
GRAPHICS CARD	AMD Radeon RX 6600 XT	scan.co.uk	#220 p53	£360
MEMORY	32GB (2 x 8GB) G.Skill Trident Z5 Neo DDR5 6000MHz EXPO (F5-6000J3636 F16GX2-TZ5N)	memoryc.co.uk	#230 p54	£280
MOTHERBOARD	ASRock X670E Steel Legend	scan.co.uk	#222 p50	£385
STORAGE	2TB WD Black SN850	scan.co.uk	#215 p49	£200

**Total £2,294**

#### UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	nvidia.com	#221 p48	£929
ADD SECONDARY STORAGE	4TB Western Digital Blue	ebuyer.com	#166 p54	£85



# Mini PCs

Our favourite components for building a micro-ATX or mini-ITX PC. Always double-check how much room is available in your chosen case before buying your components. Some mini-ITX cases don't have room for large all-in-one liquid coolers, for example, or tall heatsinks. You'll also need to check that there's room for your chosen graphics card.

## Mini-ITX



### Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>Intel Z690</b> (LGA1700)	Gigabyte Z690I Aorus Ultra Plus	amazon.co.uk	#228 p46	£330
<b>Intel B660</b> (LGA1700)	Gigabyte B660I Aorus Pro DDR4	scan.co.uk	#228 p47	£220
<b>AMD X570</b> (AM4)	Asus ROG Strix X570-I Gaming	cclonline.com	#228 p40	£309
<b>AMD B550</b> (AM4)	Asus ROG Strix B550-I Gaming	cclonline.com	#228 p39	£224

### Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>ALL-PURPOSE</b>	Cooler Master MasterBox NR200P	scan.co.uk	#206 p18	£100
<b>TOWER</b>	Ssupd Meshlicious	overclockers.co.uk	#225 p51	£105
<b>HIGH AIRFLOW</b>	Fractal Design Torrent Nano	scan.co.uk	#225 p45	£120
<b>PREMIUM</b>	Streacom DA2 V2	quietpc.com	#214 p51	£199

### Other components

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>LOW-PROFILE CPU COOLER</b>	Noctua NH-L12S	scan.co.uk	#219 p54	£59
<b>SFX POWER SUPPLY</b>	Phanteks Revolt SFX 750W	overclockers.co.uk	#228 p74	£130

## ATX cases



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>BUDGET RGB</b>	Antec DF700 Flux	cclonline.com	#214 p26	£87
<b>SUB-£100 AIRFLOW</b>	Corsair 4000D Airflow	scan.co.uk	#222 p56	£80
<b>COMPACT</b>	Fractal Design Meshify 2 Compact	scan.co.uk	#215 p20	£125
<b>HIGH AIRFLOW</b>	Fractal Design Meshify 2	scan.co.uk	#212 p45	£155
<b>PREMIUM HIGH AIRFLOW</b>	Fractal Design Torrent RGB TG	scan.co.uk	#225 p20	£250
<b>LUXURY</b>	Corsair iCUE 5000T RGB	scan.co.uk	#224 p22	£350

## Micro-ATX



### Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>AMD B450</b> (AM4)	Asus TUF B450M-PLUS II	awd-it.co.uk	#218 p76	£89
<b>AMD B550</b> (AM4)	MSI MAG B550M Mortar	scan.co.uk	#204 p42	£145

### Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>BUDGET</b>	Kolink Citadel Mesh RGB	overclockers.co.uk	#218 p26	£63

## Networking



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>BUDGET ROUTER</b>	Belkin RT3200-UK	amazon.co.uk	#216 p52	£88
<b>ROUTER</b>	Asus RT-AX68U	scan.co.uk	#216 p51	£177
<b>MESH ROUTER</b>	Asus ZenWiFi AX Hybrid XP4	amazon.co.uk	#226 p59	£260
<b>WI-FI ADAPTOR</b>	TP-Link Archer TX3000E	overclockers.co.uk	#196 p58	£60
<b>DUAL-BAY NAS BOX</b>	Synology DS220j	box.co.uk	#200 p22	£159
<b>DUAL-BAY MEDIA NAS BOX</b>	Synology DS218play	box.co.uk	#174 p34	£207
<b>2.5 GIGABIT DUAL-BAY NAS BOX</b>	QNAP TS-231P3	ebuyer.com	#212 p25	£372

F - FREESYNC, G - G-SYNC, W - ULTRAWIDE

## Monitors



## Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144Hz, IPS, 1,920 X 1,080, F, G	AOC 24G2U	cclonline.com	#214 p28	£149
25IN, 240Hz, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	box.co.uk	#209 p57	£230
25IN, 360Hz, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	box.co.uk	#212 p20	£639

## Up to 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 144Hz, IPS, 1,920 X 1,080, F, G	AOC 27G2U	overclockers.co.uk	#201 p53	£170
27IN, 165Hz, IPS, 2,560 X 1,440, F, G	LG UltraGear 27GP850	currys.co.uk	#229 p48	£379
27IN, 165Hz, VA, 2,560 X 1,440, F, G	AOC CQ27G3SU	overclockers.co.uk	#223 p45	£320
27IN, 240Hz, TN, 2,560 X 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£590
27IN, 240Hz, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£669
28IN, 144Hz, IPS, 3,840 X 2,160, F, G	AOC U28G2XU	overclockers.co.uk	#221 p29	£569

## Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60Hz, VA, 3,840 X 2,160, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£370
32IN, 144Hz, VA, 2,560 X 1,440, F, G	iiyama G-Master GB3266QSU	scan.co.uk	#224 p30	£320
32IN, 165Hz, IPS, 2,560 X 1,440, F, G	LG UltraGear 32GP850	currys.co.uk	#220 p38	£449
34IN, 144Hz, IPS, 3,440 X 1,440, W, F	iiyama G-Master GB3461WQSU	overclockers.co.uk	#206 p53	£430
38IN, 144Hz, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	currys.co.uk	#208 p30	£1,099
32IN, 240Hz, VA, 3,840 X 2,160, F, G, HDR	Samsung Odyssey Neo G8	scan.co.uk	#229 p17	£1,299
55IN, 165Hz, VA, 3,840 X 2,160, F, G, HDR	Samsung Odyssey Ark	samsung.com	#231 p34	£2,599

## Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 75Hz, IPS, 2,560 X 1,440, F	LG 27QN880	amazon.co.uk	#210 p26	£395

## Peripherals and audio

## Gaming keyboards



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET TKL	SteelSeries Apex 3 TKL	currys.co.uk	#221 p59	£40
MECHANICAL 65 PER CENT	Ducky One 3 SF	overclockers.co.uk	#230 p26	£120
MECHANICAL TKL	NZXT Function MiniTKL	cclonline.com	#226 p32	£100
PREMIUM TKL MECHANICAL	Corsair K70 RGB TKL	scan.co.uk	#214 p31	£150
PREMIUM MECHANICAL	Corsair K70 RGB Pro	overclockers.co.uk	#225 p30	£150
PREMIUM WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	overclockers.co.uk	#208 p60	£230

## Gaming mice



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	NZXT Lift	scan.co.uk	#226 p32	£40
FIRST-PERSON SHOOTER	Glorious Model O	overclockers.co.uk	#215 p57	£50
AMBIDEXTROUS	Razer Viper 8K	currys.co.uk	#215 p59	£70
MULTI-BUTTON	Roccat Kone XP	roccat.com	#225 p60	£80
WIRELESS	Razer Viper Ultimate	currys.co.uk	#217 p54	£100
PREMIUM WIRELESS	Razer DeathAdder V2 Pro	scan.co.uk	#210 p28	£80
ULTRA LIGHTWEIGHT	Asus TUF Gaming M4 Air	overclockers.co.uk	#227 p36	£48
PREMIUM LIGHTWEIGHT WIRELESS	Logitech G Pro X Superlight	amazon.co.uk	#217 p52	£116

# Peripherals and audio cont ...



## Game controllers



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>RACING WHEEL</b>	Logitech G29 Driving Force	currys.co.uk	#202 p50	£269
<b>BUDGET GAMEPAD</b>	PowerA Spectra Infinity Xbox Series X	amazon.co.uk	#228 p55	£32
<b>MID-RANGE GAMEPAD</b>	Sony DualSense	scan.co.uk	#228 p58	£60
<b>PREMIUM GAMEPAD</b>	Scuf Instinct Pro	scufgaming.com	#228 p57	£200
<b>BUDGET FLIGHT STICK</b>	Logitech Extreme 3D Pro Joystick	currys.co.uk	#207 p52	£36
<b>FLIGHT STICK</b>	Thrustmaster T.16000M FCS HOTAS	scan.co.uk	#207 p56	£130

## Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>BUDGET STEREO</b>	Roccat Elo X Stereo	scan.co.uk	#210 p56	£40
<b>STEREO</b>	EPOS GSP 300	amazon.co.uk	#210 p54	£40
<b>WIRELESS</b>	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£146
<b>PREMIUM WIRELESS</b>	EPOS H3Pro Hybrid	currys.co.uk	#231 p47	£220

## Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>STEREO</b>	Edifier R1280DB	overclockers.co.uk	#224 p59	£110

## Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>WIRELESS 84-KEY ELECTRO-CAPACITIVE</b>	Niz Mini 84 Pro	keyboardco.com	#220 p29	£132
<b>BUCKLING SPRING MECHANICAL</b>	Unicomp New Model M	keyboardco.com	#219 p26	£129

# PCs and laptops



## Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>BUDGET GAMING</b>	PC Specialist Prism Nova	Intel Core i5-12400F	Nvidia GeForce RTX 3060	custompc.co.uk/PrismNova	#229 p30	£1,199
<b>4K GAMING</b>	PC Specialist Magnus Pro K500	Intel Core i7-12700K	Nvidia GeForce RTX 3080 Ti	custompc.co.uk/MagnusPro	#225 p34	£2,499
<b>WATER-COOLED ULTIMATE PERFORMANCE</b>	CyberPower Hydro-X Infinity RTX	Intel Core i9-12900KS	Nvidia GeForce RTX 3090 Ti	custompc.co.uk/CPHX	#228 p26	£4,369

## Laptops



CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
<b>MID-RANGE GAMING</b>	Asus ROG Strix Scar15 G533ZW	Intel Core i9-12900H	Nvidia GeForce RTX 3070 Ti Laptop	15.6in 2,560 x 1,440 IPS 240Hz	custompc.co.uk/AsusScar15	#227 p40	£2,400
<b>HIGH-SPEED GAMING</b>	Alienware x17 R2	Intel Core i7-12700H	Nvidia GeForce RTX 3080 Ti Laptop	17.3in 1,920 x 1,080 IPS 360Hz G-Sync	custompc.co.uk/AlienwareX17	#227 p38	£3,449



# Games



RICK LANE / INVERSE LOOK

## CRUSHING CROSSOVERS

The IP crossover trend is shifting from fun 'what if' scenarios to turgid licensing bombardments, argues Rick Lane

**H**ey you there, with the face! Want to play a game where Superman fights Shaggy from Scooby Doo? Such is the rallying cry of MultiVersus, a fighting game in the vein of Nintendo's Smash Bros series that takes every licensed character in Warner Bros' Raiders of the Lost Ark-style vault and pits them against one another in colourful, chaotic brawls. See Batman battle the Iron Giant, Arya Stark fight the Tasmanian Devil, Tom & Jerry punch it out against ... LeBron James? Oh, he was in the terrible Space Jam sequel. Now I understand.

MultiVersus has been an enormous hit, which isn't entirely surprising. 'What if x fought Y?' scenarios have made for fine entertainment for years. It isn't hard to imagine Roman soldiers hunched over a campfire arguing who would win in a fight between Hannibal and Alexander the Great. Heck, there are people who are probably still having that argument today.

While the idea predates games, it's also a natural fit for them, letting you take those hypothetical grudge matches out of your brain and play them out directly. We've seen numerous games that ask what would happen if Alien fought Predator, or Marvel superheroes battled Capcom's fighting roster. It's an ideal premise for games and a harmless bit of fun.

But here's the twist – MultiVersus isn't really doing that. These fantasy contests thrive on the assumption that the skills of the two combatants would result in a fair fight.

Whatever argument you may have for or against Bruce Lee and Muhammad Ali in a sparring match between the two, there's ultimately some uncertainty over who would emerge victorious.

Whereas if you ask, 'Who would win in a fight between Shaggy and Superman?' The answer is, always, 'Superman'. In fact, there's a question over whether there would be a fight at all, given that Shaggy would immediately run away.

The point here is not to quibble over MultiVersus' representation of individual characters. The point is that

**It's just an intellectual property bomb**

MultiVersus as a whole doesn't really care about your fantasy face-offs. It's just an intellectual property bomb, designed to lure you with an explosion of familiar faces from your childhood. It's the cheap trick pulled by fiction such as Ready Player One, and increasingly by Fortnite, which

has gone from survival shooter to Battle Royale to a gigantic, playable licensing repository.

Crossover fiction can be fun, but if you mix up every single colour, you always end up with brown. The first Avengers film is fantastic, for example. The ending of the Ready Player One film, meanwhile, is like licensing diarrhoea.

The point of these crossovers is to create an interesting story out of that scenario. If you keep adding stuff with no thought about whether it actually fits, there comes a point where it stops being interesting, and if big games continue down this crossover railroad, it won't be long until they run out of steam. **GPG**

Rick Lane is Custom PC's games editor [@Rick\\_Lane](#)

# Stray / £23.99 inc VAT

DEVELOPER BlueTwelve Studio / PUBLISHER Annapurna Interactive

**B**lueTwelve studios' Stray has a powerful hook, with you playing a ginger tabby cat searching for its missing family in a sprawling cyberpunk city. It features astonishing visual design, some gently entertaining puzzle-platforming and a button dedicated specifically to meowing.

The game begins promisingly, with a brief introductory sequence where you follow your cat family through the overgrown outskirts of an abandoned metropolis, before a mistimed jump separates your kitty from its feline friends. Plunged into the ancient city's drainage canals, your cat must navigate along the abandoned streets and rooftops, searching for a way to the surface.

Stray is at its best when it quietly allows you to explore its environments from a cat's perspective. The engrossing city is a dense, layered jumble of concrete, neon and corrugated iron. The game is very simple, as jumps are always predetermined in such a way that your cat never misses the mark. However, the intermingled puzzling elements, such as using empty barrels as platforms by hamster-wheeling them into new positions, and casually pawing objects off ledges to smash windows and other breakable obstacles, add just enough meat to the experience to keep it engaging.

Unfortunately, Stray loses its way in a less endearing sense when the robots show up. The game's underground city is populated by screen-faced automatons, which became trapped when the city's human residents died out and have since taken on the mannerisms of their creators. At this point, the story becomes increasingly dialogue driven, with your cat taking on a heroic role in a quest to help the robots find a way out of their subterranean incarceration.



## CAT'S PYJAMAS

- + Stunning cyberpunk cityscapes
- + Cat is fun to control

## DOG'S LIFE

- Annoying robots
- Misguided narrative emphasis
- Cat behaves more like a dog



That's a problem, because the narrative-heavy conversations are a less natural fit for Stray than the visual storytelling of the game's opening hour, an issue compounded by framing the cat as a heroic saviour.

The central appeal of Stray is that its cat is realistically depicted, and this is true in terms of its abilities and appearance. However, Stray gets the behaviours completely wrong. Cats are independent and mischievous, and they like to murder small animals. Stray's cat, by comparison, is loyal, obedient and compliant with instruction. In other words, it behaves like a dog.

There's not much depth to Stray. Outside of platforming, which the game mostly does for you, the only notable mechanic involves evading 'Zurks' – scuttling spider-like creatures that will mob your cat unless you run away from them. These sections are designed to add a little action to Stray's otherwise placid pacing, but the Zurks quickly wear thin as opponents and there's nothing else to replace them.

As a short, gentle action-adventure, Stray is moderately enjoyable, and certainly a visual treat, but its portrayal of cat life is ultimately fur-deep.

RICK LANE

## / VERDICT

Stray offers a decent adventure with some stunning visual design, but its cat protagonist doesn't really deliver.

## OVERALL SCORE

63%



# Marvel's Spider-Man Remastered / £49.99 inc VAT

DEVELOPER Insomniac Games / PUBLISHER Sony

**M**arvel's Spider-Man isn't the greatest superhero game, but Insomniac's Spider-Man is the greatest game superhero. The studio's adaptation of Peter Parker and his wall crawling alter ego is mechanically and narratively one of the best video game protagonists ever committed to code. Even as the game around him pinballs between fantastic and frustrating, Spidey is never less than a joy to inhabit.

Nowhere is this more evident than in the game's traversal system. Web swinging is arguably the most crucial part of realising the Spider-Man fantasy, giving players the ability to travel across New York in soaring, sweeping arcs. Many Spider-Man games have tried to replicate this in interactive form, but nobody has done it better than Insomniac.

The secret to Insomniac's web swinging is keeping it simple. The basic action of moving above the streets

of New York is condensed into a single button. Pressing left-Shift will shoot a web to the nearest, ah, sticking point, while holding the button will continue the swing until it's released. At any point during a swing, Spidey's trajectory can be adjusted with the mouse, which incidentally provides considerably more precision in movement than analogue gamepad sticks.

Insomniac doesn't want the simple act of getting around to feel like an obstacle – it wants it to be liberating and fun, and it absolutely succeeds here. The game's sense of freedom is breathtaking, letting you explore every nook and cranny of New York from the start. It also accompanies your traversal with a rousing soundtrack that makes you feel like a superhero every time you launch yourself from a rooftop.

Moreover, while you can get around fine with the straightforward taps of left-Shift, there are also optional mechanics that turn web swinging into a game of its own. Releasing a swing as it reaches its apex will give Spidey an extra boost in height. Letting him then fall until the last moment, meanwhile, provides a huge injection of speed. Pressing the spacebar between swings lets Spidey do a web-powered double-jump, while hitting the C key performs a 'web-zip' that instantly propels him towards a targeted surface.

Combined with incredibly detailed animations and a city that buzzes with activity, the web swinging of Marvel's Spider-Man is comfortably the strongest part of the game. However, Spidey is almost as fun when he stops to confront the thugs and hoodlums that prowl New York.

Combat is broadly inspired by Rocksteady's work on the Batman: Arkham games, with Spidey able to pummel enemies with the left mouse button and dodge incoming attacks with the right. But Spidey is much more acrobatic than Batman, able to rebound off walls for extra damage and







punch enemies into the air to get them away from a crowd. You can also use Spidey's web shooters to entrap foes, alongside a wider range of gadgets, such as electrified webs and web 'bombs' that splatter whole areas in sticky goo.

Insomniac also does fantastic work with Spidey from a narrative perspective, using the extra breathing room provided by a video game over a movie to create a more rounded portrayal of Peter Parker. In the game, Peter has been Spidey for several years, making him an experienced superhero, but one struggling to balance his nights of crime fighting with the increasing demands of normal adult life. We see him grappling with a recent breakup with Mary Jane, helping Aunt May to run a homeless shelter, and becoming a proto father figure to future Spider-Man Miles Morales.

The most effective of Spider-Man's various character dramas, though, is Peter's working relationship with Otto Octavius, soon to become Doctor Octopus.

The game takes considerable time to establish their relationship as friends and colleagues, which makes the gradual unravelling of Otto's psyche gripping and tragic. None of which is to say that Spider-Man is a miserable game, merely that it balances quippy one-liners and knockabout action with characters worth caring about and drama that makes the stakes feel authentic.

Yet while Spidey himself is a great character to inhabit, the wider game can struggle to give you interesting tasks to do with him. Many of the game's open-world activities, such as collecting backpacks, chasing pigeons and solving visual puzzles left behind by professional thief Black Cat, become highly repetitive.

Other activities include solving small-scale crimes and clearing out more substantial enemy bases, which are more involved and entertaining, but don't really evolve in a meaningful way.

The game's biggest problem, though, is that it fails to capitalise upon Spider-Man's incredible roster of villains. While the game features many classic Spidey opponents, such as Doc Ock, Scorpion, Rhino and Electro, most of them don't appear until towards the end of the game. When they do, it's in highly restrictive story missions that make little use of New York or the game's wider systems. The inability to track, chase and fight these villains across New York is a major oversight.

Instead, most of your time is spent fighting three different factions of increasingly powerful thugs. Some are regular thugs, some are magical thugs and some are thugs with high-tech military equipment. But they're all ultimately thugs, and although the combat system has a respectable level of depth, it nonetheless wears thin due to the incessant, increasingly protracted fights in which Spider-Man gets embroiled.

On the plus side, developer Nixxes has done a respectable job with the PC port. The game plays impressively well on keyboard and mouse. Not only is the complex combat system well adapted to the keyboard, as mentioned earlier, but web-swinging is in some ways superior to the console version thanks to added mouse control. The PC version also benefits from unlocked frame rates, support for ray-traced reflections and several performance-enhancing technologies, including AMD FSR 2.0 and Insomniac's homebrew Temporal Injection, alongside Nvidia's DLSS.

In the end, Insomniac's Spider-Man is a less well-rounded superhero game than Arkham City and Arkham Knight, which better balanced their portrayal of Batman with a fun world in which he can interact. That said, even if the open world is a little undercooked, Spidey himself is never less than wonderful in this game.

RICK LANE

## SPIDER-MAN

- + Incredible central character
- + Great story
- + Good combat system

## GREEN GOBLIN

- Unremarkable open world
- Neglected villains

## / VERDICT

Insomniac's Spider-Man is a perfect superhero in an imperfect open world.

## OVERALL SCORE

75%

# HARD WEST 2 / £23.99 inc VAT

DEVELOPER Ice Code Games / PUBLISHER Good Shepherd Entertainment

## HARD WEST

- + Novel take on turn-based tactics
- + Bravado system works well
- + Expansive, well-designed missions

## DUE SOUTH

- Game logic can be inconsistent

## / VERDICT

Tough yet rewarding, Hard West 2's distinctive spin on turn-based tactics is a hard-fought victory.

## OVERALL SCORE

# 78%

**H**ard West 2 tells the story of charismatic cowboy Gin Carter and his colourful gang of outlaws, who get on the wrong side of the devil himself when an ambitious train heist goes horribly awry. It transpires the locomotive they've chosen to loot is a bona fide ghost train driven by a demon called Mammon, who helps himself to Gin's soul before tossing the trespassers off the tracks.

The rest of the game is about Gin getting his soul back, with the game seeing him and his crew trek across half the Old West, robbing banks, dealing with forest spirits and getting into more gunfights than Jesse James. These gunfights are the meat of Hard West 2's core play, and they revolve largely around a mechanic called Bravado.

This system completely refills a character's action points whenever they kill an enemy, essentially giving them a bonus action. There's no limit on the number of times you can trigger Bravado, which means that, in theory, you can wipe out an entire screen of enemies in a single turn.

It's an extremely powerful system, although in practice, using Bravado effectively is much more complicated. Your

units are always limited to three action points at once, and most attacks use either two or all three action points, not to mention moving around or using any of your character's special abilities.

Moreover, your posse is nearly always outnumbered by the enemy, so you must think carefully about how to combine Bravado with other mechanics. For example, pistol shots can be ricocheted off in-game objects in order to hit enemies squatting behind cover, letting you take down enemies without having to waste action points on moving.

Grappling with Hard West 2's unusual interpretation of turn-based tactics can be tricky, though, not least because the game's logic doesn't always seem consistent. In certain situations, such as shooting someone holed up in a building, or using the ricochet system from a distance, the game's basis for deciding whether or not these actions are viable seems entirely arbitrary.

Once you've unlocked a few character skills, however, the game becomes more flexible, blossoming into an enjoyably chewy tactical experience. Each level is large and lavishly designed, with some missions taking a couple of hours to complete. Between missions, you explore a top-down overworld that takes the form of a light narrative-based RPG, visiting towns to purchase new weapons and gear, chatting with your posse to reveal their backstories, and embarking on short (but well-written) side-quests.

Like Clint Eastwood's Man With No Name, Hard West 2 can be a tricky character to fathom, but don't let that fool you into underestimating it. It's a formidable gunslinging experience.

RICK LANE





# TWO POINT CAMPUS / £34.99 inc VAT

DEVELOPER Two Point Studios / PUBLISHER SEGA

**R**eleased in 2018, Two Point Hospital was a delightful modernisation of the distinctly British style of management sim pioneered by Bullfrog in the 1990s. For the sequel, Two Point Studios has applied this template to an entirely different type of institution – universities.

Two Point Campus puts you in charge of a network of higher-education facilities across its fictional Two Point County. You need to construct the university's facilities, laying out lecture theatres, tuition rooms, student dormitories and so on, while also managing the college's everyday affairs, such as hiring and firing staff, organising annual courses and arranging events.

The visual style is virtually identical to that of Two Point Hospital, and the game sports a similarly goofy humour and eye for detail.

Almost every object you place in a room, from advanced laboratory equipment to library bookshelves, has bespoke animations with which your students can interact, which makes watching the cogs of your university turn fascinating.

Campus also has a slightly different structure from Hospital, which is designed to reflect how universities operate. The game's core loop is heavily based around the academic year. At the start of the year, you choose which courses to run from a limited selection that gradually unlocks as you progress, and each course can only take a set number of students. Unlike Two Point Hospital, where the challenge revolves around catering for an endless influx of patients, Two Point Campus is more about working within the budget provided by that annual matriculation.



This structure is less immediately engaging than the more pressurised environment of a hospital, but Two Point Campus compensates for it through its mission design. Each university has a specific theme, ranging from culinary colleges and robotics institutes, to more eccentric institutions such as a wizard's academy. These all come with unique room types and objects, but also with specific challenges, such as dealing with a curse epidemic at the Wizard's Academy. These level-specific problems add the granularity missing from the broader management challenge.

Two Point Campus also introduces inter-character relationships, although you'd be forgiven for not noticing. Students can become friends and even have relationships. However, it's all fairly abstract, mostly impacting student grades, which are important for completing missions, but not interesting to watch in action. In its attempt to be genial and inoffensive, Two Point Campus misses an opportunity to represent both the domestic drama of student life, and the friction that comes with a wealthy institution overseeing a body of young people with emerging ideologies.

Still, this doesn't prevent Two Point Campus from being a highly enjoyable management sim. It succeeds in giving players a completely new type of organisation to manage, without losing the essence of Two Point Hospital.

RICK LANE

## DISTINCTION

- + Totally new setting for a management game
- + Same great presentation
- + Colourful, creative courses

## EXPULSION

- Takes a while to reveal its best qualities
- Undercooked relationship system

## / VERDICT

Two Point Campus is a perfectly pleasurable university builder, although it doesn't quite reach PhD level.

## OVERALL SCORE

80%





# ZEN 4: THE INNER CORE

**AMD'S RYZEN 7000-SERIES CPUs BRING A BRAND-NEW ZEN 4 MICROARCHITECTURE, ALONG WITH A HOST OF OTHER KEY CHANGES. EDWARD CHESTER EXPLAINS EVERYTHING YOU NEED TO KNOW ABOUT THE NEW CHIPS**

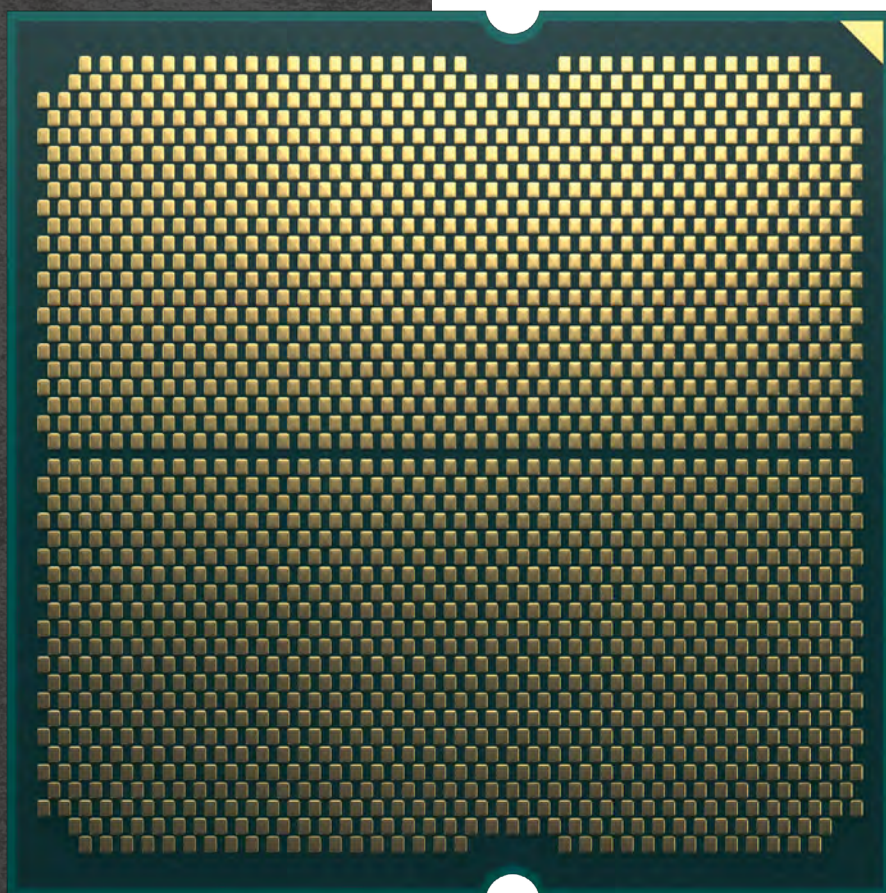
**W**ith Intel having wrestled back the CPU performance crown (in some applications) from AMD with its 12th-gen Core processors, there's a lot riding on AMD's new Ryzen 7000-series chips and their Zen 4 architecture.

While AMD has garnered a significant amount of good will from the PC-buying public, thanks to its previous Ryzen processors pushing forward progress on CPU performance, pricing and platform

longevity, when it comes to putting your money where your mouth is, most buyers will go where they can get the best bang for their buck.

It's good for AMD, then, that as Antony Leather shows in his in-depth reviews of the AMD Ryzen 9 7950X (see p14) and Ryzen 7 7770X (see p16) that the new chips well and truly deliver on their performance promise. But what makes them tick and what other features are hidden away inside AMD's latest CPUs? Let take a closer look.





Socket AM5 sees AMD moving to an LGA socket, with each chip sporting 1,718 contacts

## THE PLATFORM AND LINE-UP

Before we delve too deep into the architecture of Zen 4 itself, let's quickly recap which processors are launching now, which features the chips include and the other key products that are launching alongside them.

There are four Ryzen 7000-series CPUs in the initial launch roster – the 16-core Ryzen 9 7950X, the 12-core Ryzen 9 7900X, the 8-core Ryzen 7 7770X and the 6-core Ryzen 5 7600X. All support Simultaneous

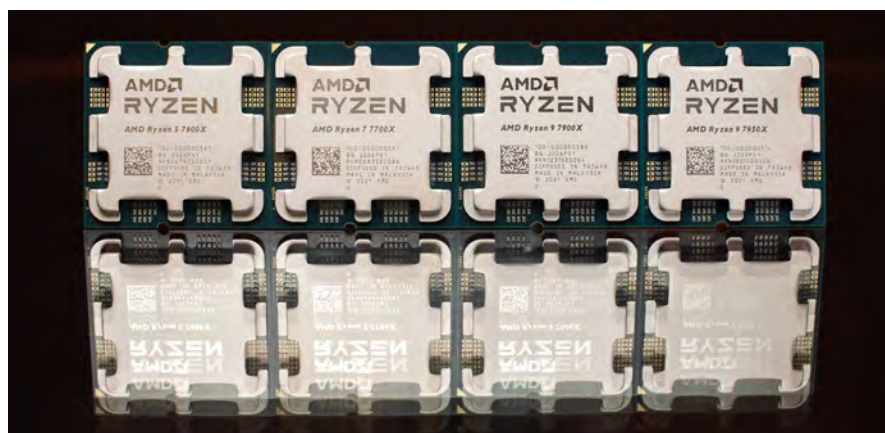
Multithreading (SMT), so can have twice as many application threads in flight as they have cores.

The 16-core 7950X tops out at a whopping peak single-core clock of 5.7GHz, which makes for a 0.9GHz or 18 per cent maximum clock speed increase over the Ryzen 9 5950X. All the other launch CPUs also have decent boost clocks, ranging from 5.3GHz on the Ryzen 5 7600X to 5.6GHz on the Ryzen 9 7900X. Considering that raw clock speed has for a long time been the one area where AMD hasn't been able to compete with Intel, for it to now surpass the best from Intel is a significant moment.

However, Intel did just hint that its upcoming Raptor Lake CPUs, launching later this year, will top out at over 6GHz, and that they've hit 8GHz with extreme overclocking, so it may be a short-lived victory for AMD. For now, though, AMD can at least revel in having taken a big leap forward in this area.

One negative consequence of the general uptick in clock speed and processing power of the 7000 series is an increase in heat and power draw – ideal timing for an energy crisis. The thermal design power (TDP) for the 5000 series topped out at 105W, but the 7950X and 7900X both have TDPs of 170W. You probably won't need to upgrade your power supply to accommodate these changes, unless your current one is right on the limit already, but as we found in our testing, good-quality cooling will be essential, as these chips run hot.

Rather countering this increase in maximum TDP, AMD is also introducing an Eco Mode that can be used to limit the CPUs TDP to 105W or even 65W, although obviously this impacts peak performance, with boosted clock speeds dropping to below 5GHz at 105W and to under 4GHz at 65W in our testing.



There are four Ryzen 7000 CPUs at launch, ranging from 16 to six cores





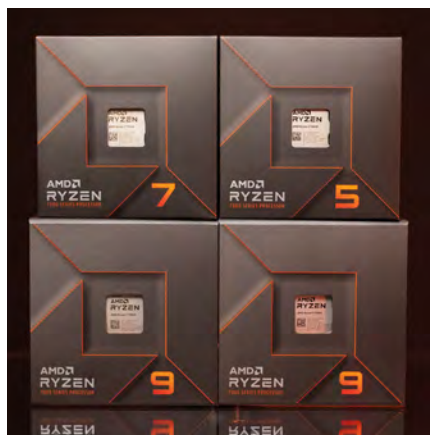
Each Ryzen 7000-series chip will include one IOD die (centre) and one or two CCDs (top left and right)

What will need an upgrade if you want to buy one of these CPUs is your motherboard, as the new chips use a new socket. Out is the pin grid array (PGA) socket of AM4 – where the pins are on the CPU – and in is a land grid array (LGA) layout where the motherboard plays host to the pins and the CPU has flat gold contact points.

Essentially, it's shifting the burden of busted pins from the CPU to the motherboard manufacturer, but also allows for a denser grid of pins, with AM5 supporting 1,718 contacts, up from the 1,331 contacts of AM4.

Making your Ryzen 7000-series upgrade even more pricey is the need to invest in DDR5 memory, as Ryzen 7000-series CPUs and AM5 motherboards won't have support for DDR4 memory at all. DDR5 comes with clock speed and power consumption benefits, but still demands a premium over DDR4.

Finally, one other interesting feature bonus with Ryzen 7000-series processors is that they all include integrated Radeon graphics, which is a first for standard Ryzen chips.



Assuming you're not into gaming, so don't require the extra grunt of a dedicated graphics card, the integrated graphics here will easily be sufficient for desktop work, saving you on the cost of an extra card.

## UNDER THE HOOD

Prise off the integrated heatspreader (IHS) of a Ryzen 7000-series chip and you'll see two or three main chips, consisting of one or two Zen 4 core complex (CCX) dies (CCD) and the input/output die (IOD).

The IOD controls communication between the core dies, and between the whole CPU and the rest of your system. It includes features such as the Infinity Fabric interconnect, DDR5 DRAM controller, PCI-E 5 interface, USB 3.2 interface and more. It's also where the new RDNA 2 integrated GPU is housed.

Meanwhile, the CCDs each house eight Zen 4 cores, although only some may be enabled, and you'll get one or two CCDs depending on the core count of the chip. So, for instance, a Ryzen 7 7770X will have two CCDs with each of those CCDs having two of its cores disabled. Alongside the cores, each CCD is also home to

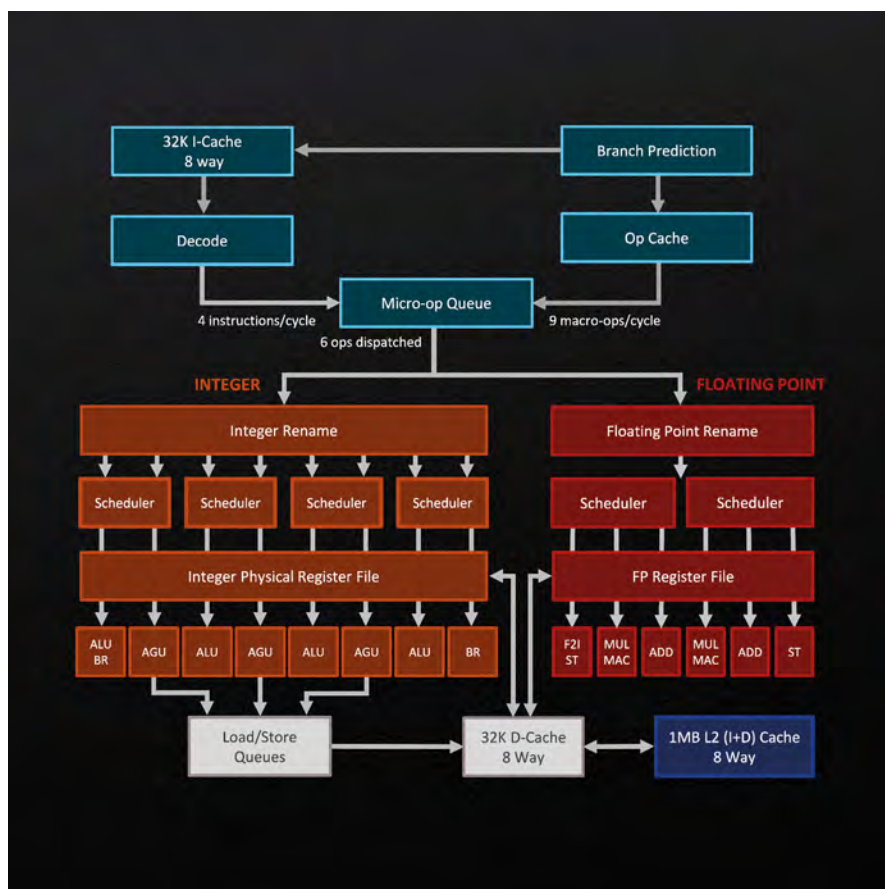
32 1MB chunks of L3 cache that are combined – along with the cache from the second CCD – to form a single shared L3 cache for the whole CPU. When cores of a CCD are disabled, the neighbouring two 1MB chunks of L3 cache are disabled too.

Aside from an area for the Infinity Fabric interconnect, and a few extra system management units, that's all that makes up a CCD – all the rest of the CPU's features are offloaded to the IOD.

This approach of using multiple dies for different functions – known as chiplet design – comes with a multitude of advantages and one main disadvantage. The advantages include improving manufacturing efficiency and cost, as you can fit more smaller CCD dies in a silicon wafer than a larger single die that incorporates everything in the CPU.

You can also do what AMD has done here and use a cheaper, older process for some parts of the CPU, saving the most advanced and expensive processes for just the cores. The impact of any defects is reduced as well,

From a block diagram perspective, Zen 4 is remarkably similar to Zen 3





# "Zen 3" to "Zen 4" Evolution

	"Zen 3"	"Zen 4"		"Zen 3"	"Zen 4"
LDQ	72	88	Issue width (Int + FP/SIMD)	10+6	10+6
STQ	64	64	Int reg	192	224
Micro-op cache	4k ops	6.75k ops	Int scheduler	96	96
L1 I/D-cache	32/32k	32/32k	FP reg	160	192
L2 cache	512k	1M	ROB	256	320
L3 cache/core	4M	4M	FADD/FMUL/FMA latency	3/3/4 cycles	3/3/4 cycles
L2 TLB	2k	3k	L1 BTB*	2 x 1k	2 x 1.5k
L2 latency	12 cycles	14 cycles	L2 BTB*	2 x 6.5k	2 x 7k
L3 latency	46 cycles	50 cycles			

as one ruined CCD uses much less silicon than a whole ruined CPU die.

Other advantages include the ability to create a wide array of CPU designs using the same core building blocks. With the same components, AMD can in theory offer any design from a 2-core to a 16-core desktop processor, and while AMD no longer produces Threadripper high-end desktop processors, which used up to four CCDs per CPU, it does still produce EPYC server processors that use up to 12 CCDs per CPU.

The main disadvantage of chiplet design is managing the data flow between the CCDs and the IOD. Traditionally, resorting to off-silicon interconnects results in significant reductions in speed, but AMD has managed to make its Infinity Fabric interconnect work well enough for its chiplet design to keep up so far.

Intel hasn't used a chiplet design for its CPUs yet. Instead, it currently uses a single slab of silicon for its 12th-gen processors and will do the same for its upcoming 13th-gen processors. However, it's set to adopt a chiplet design for its 14th-gen Core CPUs arriving next year.

AMD is also set to use a variant of a chiplet design for its upcoming RDNA3 GPUs, with multiple GPU dies being used to make up the total processing power of the card. This would see the company out on its own for now, with

neither Intel nor Nvidia set to adopt the same approach for their next generation of chips.

AMD's CCDs are built on the latest 5nm process from Taiwan Semiconductor (TSMC) but the new IOD is built on the slightly older 6nm TSMC process. Both are upgrades over the Ryzen 5000 series, which used 6nm or 7nm processes for the core dies and 14nm for the IOD.

As ever, a move to a smaller manufacturing process means a lower power draw and, in this instance, a fairly significant uptick in clock speed too. AMD is claiming Ryzen

## AMD CLAIMS ZEN 4 WILL PROVIDE A 49 PER CENT PERFORMANCE UPTICK FOR THE SAME POWER DRAW

7000-series CPUs will provide a 62 per cent drop in power consumption for the same performance level as Ryzen 5000-series chips, or a 49 per cent uptick in performance for the same power draw.

While a lot of that improvement is just down to the new manufacturing process, a significant chunk comes from the new Zen 4 architecture, with AMD boasting a 13 per cent uptick in instructions per clock (IPC) over Zen 3. That's actually the lowest generational change we've yet seen from a new Ryzen processor, but a double-digit uptick is still impressive and, when combined with the

**When added up, there are actually many small differences between Zen 3 and Zen 4**

significant clock speed gains, AMD expects a step up in single-core performance over Zen 3 of 29 per cent.

## ZEN 4 OVERVIEW

Taking a closer look at the core design of Zen 4, from a block diagram perspective, the overall setup of the new core looks very similar to that of Zen 3, with the same front-end layout, the same execution engine layout and largely the same load/store and cache

setup. In comparison, the move from Zen 2 to Zen 3 incorporated several more obvious macro-level changes.

However, on a deeper level, there have been tweaks throughout the design of

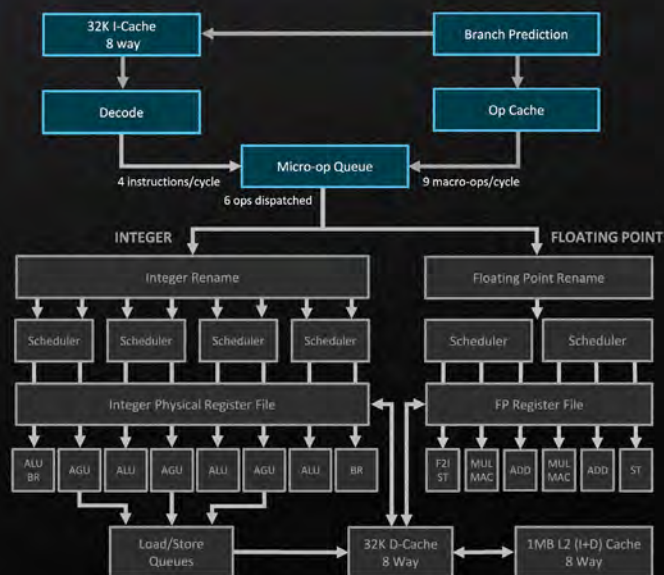
Zen 4, along with some more obvious changes, such as added support for AVX-512 instructions, a larger L2 cache and a larger micro-op cache. As ever with chip design, it can be the combination of many smaller tweaks that add up to big changes in performance and efficiency, rather than a total redesign being required.

## FRONT END CHANGES

The front end of a processor core design is where larger instructions that have been sent to the CPU are decoded into smaller micro-operations (micro-ops), which are passed on

## Front End Advances

- Branch Prediction Improvements
  - Predict 2 taken branches per cycle
  - 50% Larger L1 BTB
  - Larger L2 BTB
- ~68% Larger Op Cache
- 9 macro-ops per cycle out of OpCache
- Baseline from “Zen 3”:
  - 6 ops dispatched between INT and FP



Improvements to branch prediction and a larger op cache provide large performance boosts

to the execution engine portion of the chip. These micro-ops are stored in a micro-op queue and then scheduled for execution by the separate integer and floating point portions of the execution engine. Some operations can also be directly passed on to the micro-op queue without needing further decoding, and these macro-ops are stored in the op cache before joining the micro-op queue.

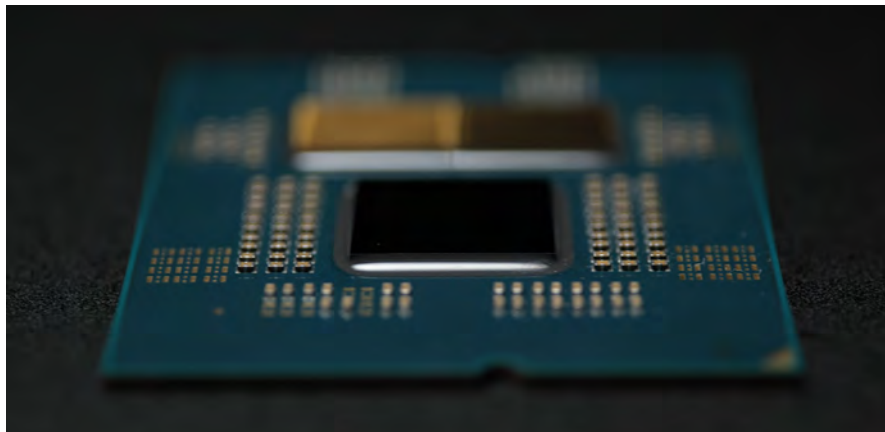
The design of Zen 4's front end is largely very similar to that of Zen 3, with a 32KB instruction cache that can commit four instructions per clock cycle from its decoder to the micro-op queue, while the macro-op

cache can commit up to nine macro-ops per cycle. Zen 4 also retains the six micro-ops per clock cycle dispatch rate of Zen 3 – it can pass six operations per cycle to the integer or floating point engines.

The first big front end improvement with Zen 4 is a 68 per cent larger op cache. This allows the core to handle and prioritise more potential work for the execution engine at once, to ensure it's passing on work to the execution engine in the most efficient manner.

The branch prediction engine has also been improved. Branching is where a program is waiting on the result of a calculation with

**THE FIRST BIG FRONT  
END IMPROVEMENT  
WITH ZEN 4 IS A 68  
PER CENT LARGER  
OP CACHE**





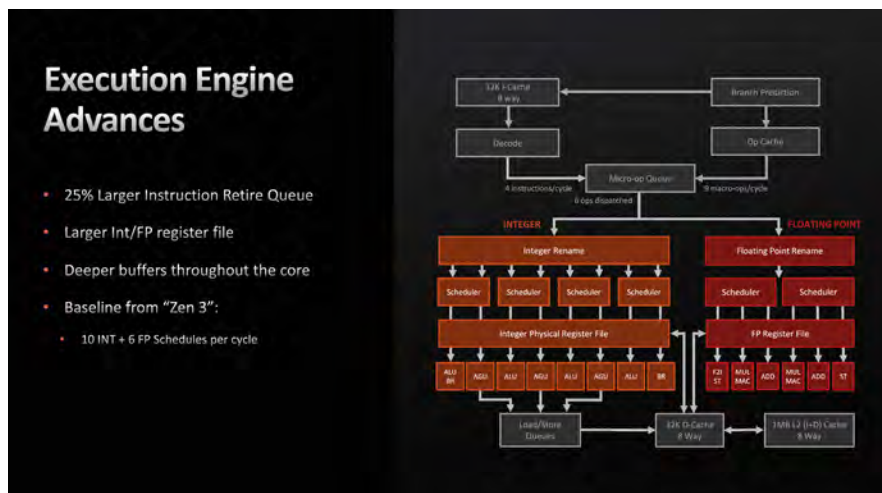
## Zen 4's execution engine sees a few tweaks compared with Zen 3 but looks much the same

multiple outcomes – an if/then/else type of statement. Waiting for branch outcomes to be resolved before proceeding to the next stage can leave the CPU starved of work. As such, CPUs employ branch prediction to guess the outcome of the branch and set up the data and operations for that branch outcome.

Branch prediction is one of the very first stages through which an instruction goes when it's received by a CPU, as guessing right as early as possible can save a lot of time and wasted resources. With Zen 4, the branch predictor has seen several improvements, including a larger L1 branch target buffer (BTB) and larger L2 BTB.

While AMD has provided a 13 per cent IPC improvement figure for the architecture improvements with Zen 4, it doesn't break down how much each individual change to the architecture contributes to the total improvement. Its visual representation of these proportions (below), shows the branch prediction changes alone account for the third largest contribution to that IPC increase.

Meanwhile, the other combined front end changes account for the biggest portion of the total IPC increase. In essence, this shows the importance for performance of efficiently



managing the workload of the CPU before that workload is passed onto the number-crunching execution engine portion of the chip.

## EXECUTION ENGINEERING

The block diagrams of Zen 3 and Zen 4 show no change between the two when it comes to the execution engine portion of the core – on a macro level, Zen 4's execution engine is the same as Zen 3. It still has an issue width (the number of operations that can be performed per cycle) of ten for the integer engine and a 6-wide issue for the floating point engine.

The scheduler arrangement also remains the same 4x2 setup for integer and 2x3 for floating point as before.

As a side note, a notable difference between Intel's current core design and AMD's latest is that Intel uses a combined integer and floating point scheduler, not the separate paths used here.

However, there are changes hidden inside the execution engine that combine to provide

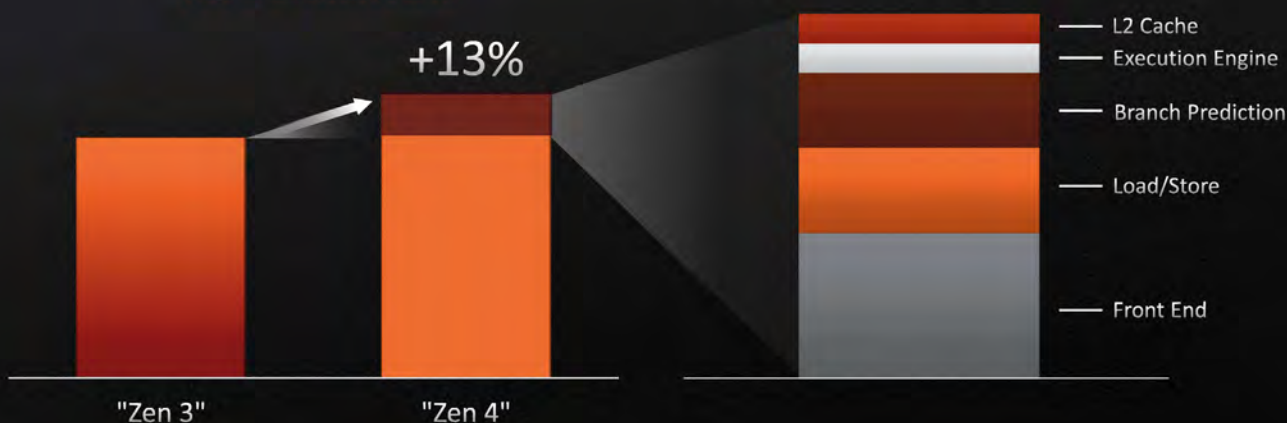
**AMD has provided only a visual representation of how each change to the Zen 4 core contributes to the total 13 per cent IPC improvement**

## Industry Leadership "Zen 4" 13% IPC Uplift for PCs<sup>1</sup>

Geomean of 22 Workloads  
(Fixed 4GHz Frequency, 8 Cores)

+13%

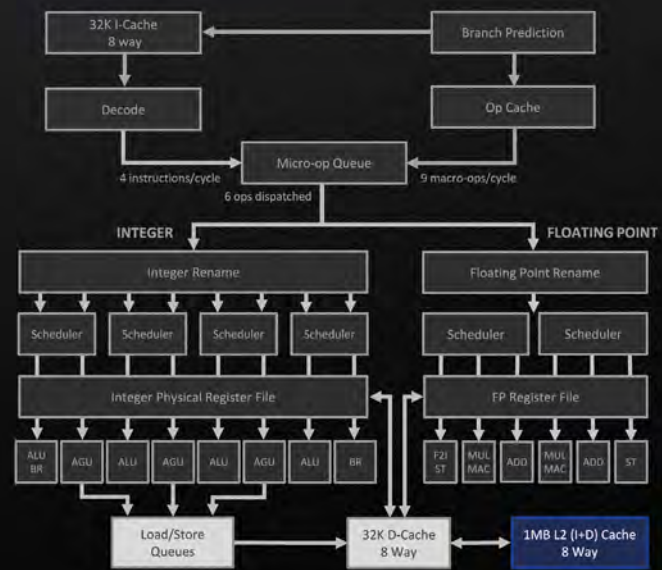
"Zen 4" Performance Contributors





## Load/Store Advances

- 22% Larger Load Queue
- Fewer Data cache port conflicts
- 50% Larger L2 DTLB
- Baseline from "Zen 3":
  - 3 memory operations a cycle
  - Max 3 Loads, 2 Stores
  - 6 Table Walkers



### A larger load queue and L2 cache provide a significant performance uplift for Zen 4

a modest uptick in performance. These include a 25 per cent larger instruction retire queue, a larger main register file for both integer and floating point engines, and deeper buffers throughout the core. We don't have any details beyond that, but essentially this adds up to the engine as a whole having slightly larger data stores than Zen 3 throughout.

### LOAD/STORE AND CACHE CHANGES

AMD has attributed more of a significant performance uplift to changes to the load and store portions of the Zen 4 core. These deal with moving data back and forth between the core and system memory or internal caches.

Again, the overall setup is largely the same as with Zen 3, with a maximum of three memory operations per clock cycle – three memory loads or two memory stores – and

six table walkers (used to automatically manage entries in the translation lookaside buffers). However, the L2 data cache size has been increased by 50 per cent, while the load queue has increased by 22 per cent as well.

These larger data stores allow more data to be in flight at the same time, increasing the chance that the right data will be available for other operations down the line. The downsides to larger caches are an increase in die space and potential difficulty in ensuring the store can be accessed efficiently, but clearly AMD felt the larger stores would provide a net benefit.

Other changes to the data access structures include support for more outstanding misses from the L2 to L3 caches, and from L3 cache to memory. A cache miss is where the data

required isn't stored in that cache, so the CPU has to move to a higher-level cache, or even to system memory, to retrieve that data.

While those data retrieval processes are being undertaken, the information pertaining to that cache miss is held in what's known as an outstanding miss store. Increasing the size of these stores ensures that any more cache misses – and the processes associated with them – can be kept on standby, ready to be executed again as quickly as possible when the miss is resolved.

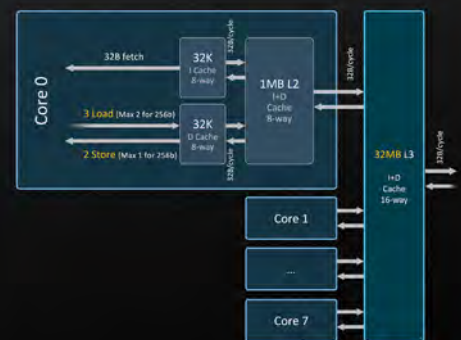
Again, looking at AMD's visual breakdown of the contribution towards IPC increase provided by each of the changes to the Zen 4 architecture, while the L2 cache change

### Greater support for cache misses allows Zen 4 to keep more micro-ops in flight



## Cache Hierarchy

- Fast private 1MB L2 cache
- More outstanding misses supported from L2 to L3 per core
- More outstanding misses supported from L3 to memory
- Baseline from "Zen 3":
  - L3 shared among all 8 cores in the complex
  - L3 is filled from L2 victims
  - L2 tags duplicated in L3 for probe filtering and fast cache transfer



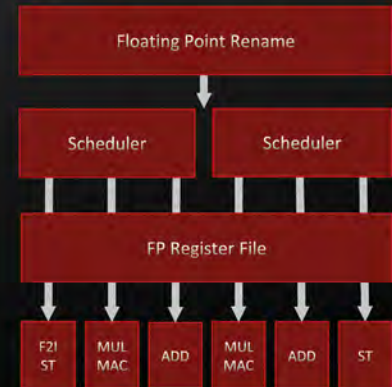


Zen 4 brings  
hardware AVX-512  
instruction support

**THE L2 DATA CACHE  
SIZE HAS INCREASED  
BY 50 PER CENT,  
WHILE THE LOAD  
QUEUE SIZE HAS  
INCREASED BY 22  
PER CENT**

## New AVX-512 Instructions

- Adds per lane masking capabilities
- Adds new Scatter/Gather instructions
- Implemented with 256b operations:
  - Area-efficient implementation
  - No frequency impact to using AVX-512 instructions
  - Throughput equivalent with reduced instruction fetch and control overhead, higher efficiency vs. AVX-256
- BFloat16 instruction support
- VNNI instruction support



is the smallest block shown, the load/store changes contribute the second largest proportion of improvement. This again shows the importance to processor performance of efficiently managing data in and out of the execution engine.

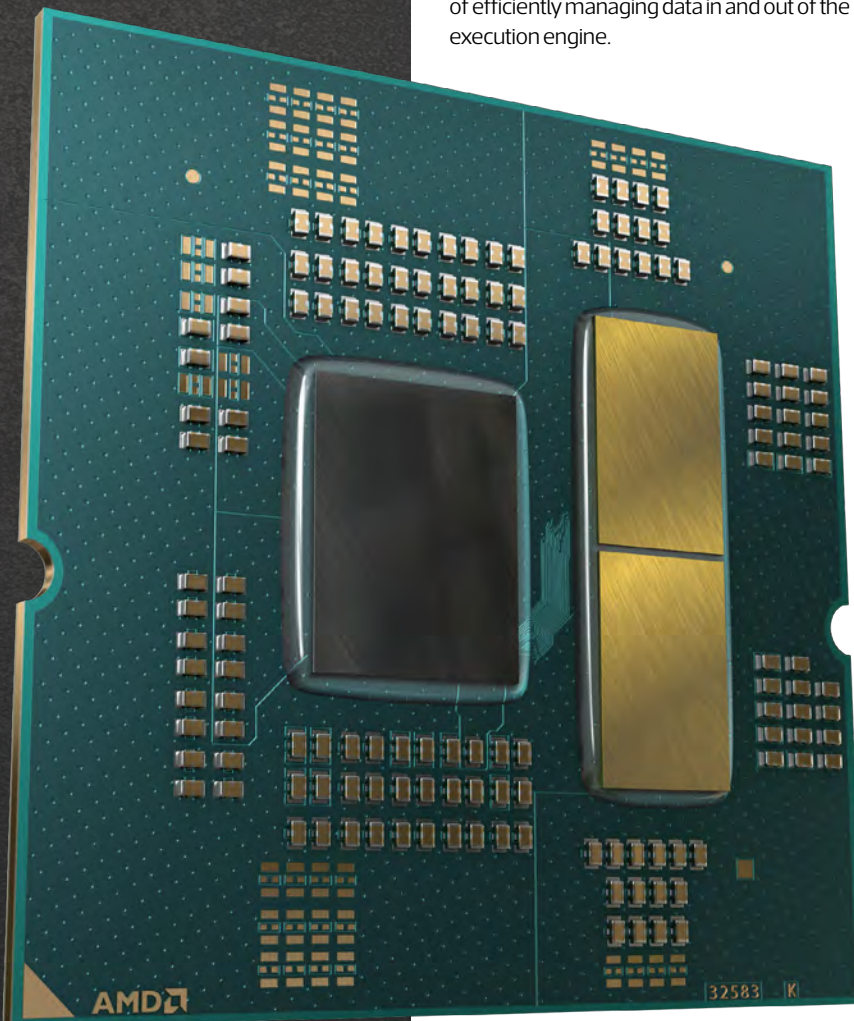
## AVX-512

One of the more intriguing additions to Zen 4 is proper hardware support for 512-bit vector instructions (instructions that perform the same calculation on multiple bits of data at once), known as AVX-512. Pioneered by Intel, these are generally only used in scientific, AI and other such specialist applications, but have seen growing support and are a feature that Intel has long highlighted as important.

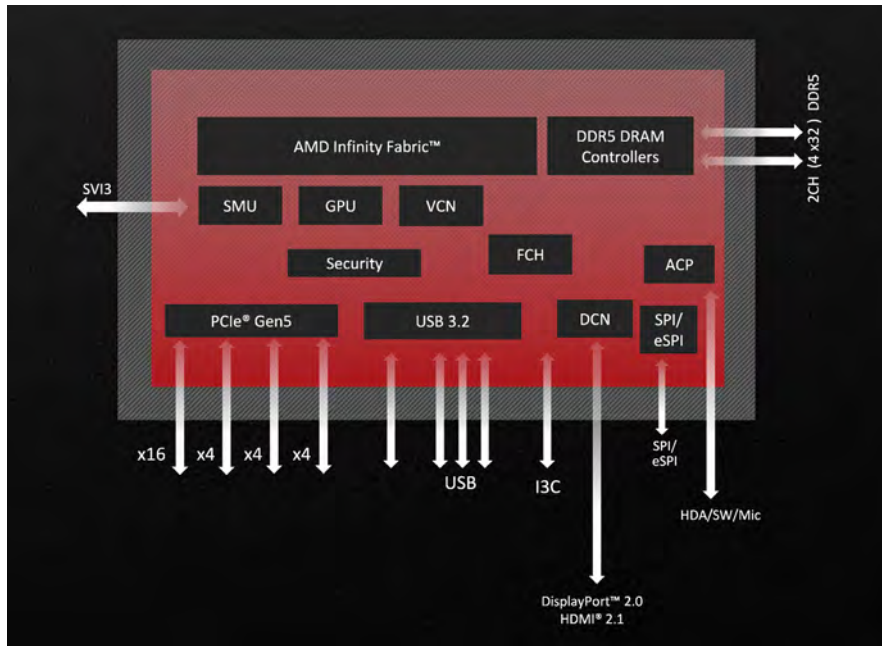
It's ironic, then, that with its 12th-gen Core processors, Intel actually removed AVX-512 support. Its removal was in part because of that architecture's use of different P-Cores (that support AVX-512) and E-Cores (that don't support AVX-512), which raised complications about managing instructions, but it also pointed to this being a niche instruction set for regular desktop processor users. As such, for AMD to now bring support is particularly notable.

Intel's AVX-512 implementation was also infamously power-hungry, causing huge power spikes that pushed well beyond the rated power output of the chips. Meanwhile, AMD is claiming power-efficient operation of its AVX-512 hardware. However, AMD's design uses a 256-bit wide single instruction multiple data (SIMD) design, so it takes two clock cycles to perform a full 512-bit wide instruction, compared with Intel's full 512-bit wide, single-cycle design, so it's no wonder AMD can claim its design is more power-efficient.

AMD claims an increase of 1.31x for FP32 inferencing calculations compared with Zen 3, and an increase of 2.47x for Int8 inferencing, thanks to this new AVX-512 hardware.







**Ryzen 7000's new IOD adds DDR5 and PCI-E 5 support, includes integrated graphics and uses a new 6nm manufacturing process**

2 and HDMI 2.1), USB Type-C with DisplayPort Alt Mode, and AV1 and H.264 video decoding and encoding. This is largely irrelevant for gamers, but for the wider PC market, it opens up AMD's CPUs to a far greater range of low-cost and compact systems.

What's more, while AMD says it's not for gaming as such, the integrated graphics system does still incorporate a single RDNA2 dual compute unit, so it can technically support all the latest processing requirements to run the latest games, but the emphasis here is on 'technically'.

RDNA2 GPUs have 64 stream processors per compute unit, so you'll get 128 in a Zen 4 CPU's integrated GPU. Comparatively, a Radeon RX 6600 has 28 compute units (1,792 stream processors), so there's a huge performance gulf between this integrated GPU and even a modest discrete GPU.

## A NEW IOD

Several of the biggest changes to Zen 4 over Zen 3 pertain to its IOD, as not only does it now incorporate integrated graphics, but it's also where support for new features such as DDR5 and PCI-E 5 come into play. Plus, the whole chip has seen a large change in manufacturing technology, from a relatively ancient 14nm process to a 6nm process.

**The addition of integrated graphics makes building full systems cheaper and easier, but it doesn't provide gaming-level performance**

The net result of this change in silicon manufacturing technology will be significantly lower power draw per on-die component, although with the Zen 4 die being so much denser and feature-packed than the Zen 3 die, it won't necessarily draw less power overall – it certainly won't if you're using the integrated RDNA2 graphics.

AMD is making it clear that the integrated GPU isn't meant for gaming, but instead it's just meant to support desktop usage, with support for high-resolution display output (DisplayPort

## AM5 AND NEW CHIPSETS

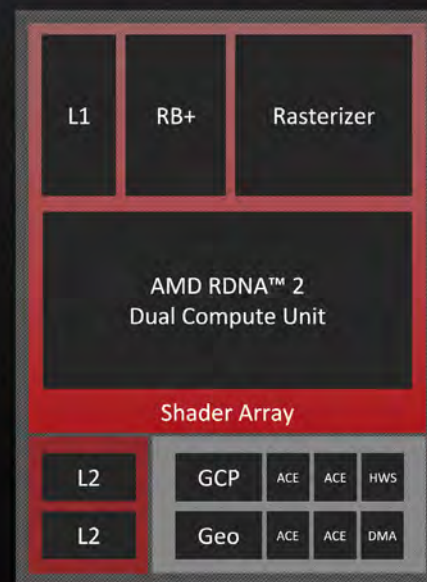
The final piece of the Ryzen 7000-series platform puzzle is the launch of AMD's accompanying new AM5 socket and a raft of new motherboard chipsets, as well as all the related motherboards, to support the new processors.

Along with its higher pin count and flipped pin arrangement, Socket AM5 also includes several power-related enhancements,

## New 6nm Ryzen™ 7000 Series IOD

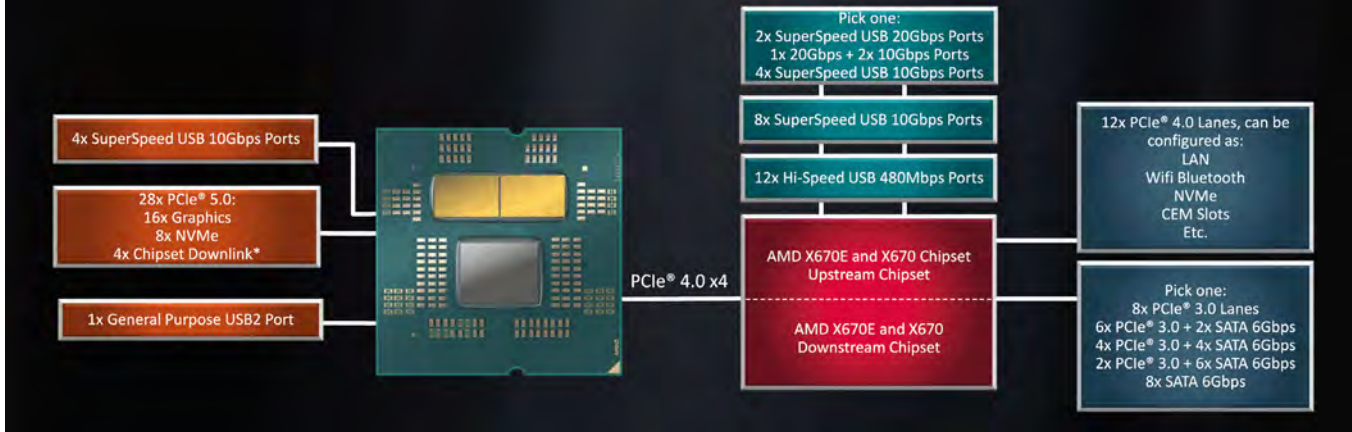
### INTEGRATED RDNA™ 2 GRAPHICS

- AV1 Decode
- H.264 & HEVC Decode/Encode
- DisplayPort™ 2.0 UHBR10
- HDMI® 2.1 with Fixed-Rate Link (FRL)
- USB Type-C™ with DisplayPort™ Alt Mode
- 4K60 Display Capabilities
- Hybrid Graphics Support





## AMD X670E AND X670 CHIPSET



AMD has created a single-chipset die that will be available in four chipset configurations, with X670/X670E boards using two dies per board

including two-way communication to motherboard voltage regulators and voltage regulator health monitoring. The result should be better system stability and potentially more overclocking headroom.

## X670-SERIES BOARDS WILL ESSENTIALLY PROVIDE DOUBLE THE FEATURES AND CONNECTION OPTIONS OF B650-SERIES BOARDS

As for those chipsets, AMD will be offering four of them: the X670E, X670, B650E and B650. Boards based on the X670-series chipsets will be available from September (by the time you read this), but the B650-series boards won't start arriving until October.

However, while AMD talks about chipsets, in reality, the company has only created one chipset die that will be implemented in different configurations for each chipset type.

As such, for X670 and X670E motherboards, two dies will be used in an uplink and downlink configuration, while the B650 variants will use a single die for both.

USB 20Gbps port and six USB 480Mbps ports for B650, unless the motherboard maker adds third-party controllers.

Other differences between the chipsets include X670E configurations supporting PCI-E 5 across all PCI-E slots and M.2 slots, whereas X670 only supports it for one PCI-E slot – the rest will be PCI-E 4. As for B650, as well as having fewer connection options than on the other chipsets, you'll also miss out on overclocking support.

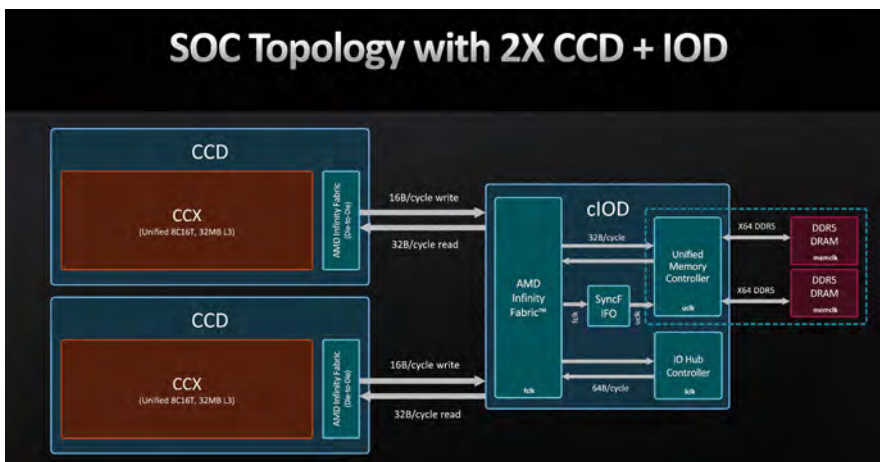
## AMD EXPO MEMORY

Launching alongside Zen 4 is AMD's new EXPO memory technology. Fundamentally a rival to Intel's eXtreme Memory Profiles (XMP), EXPO is AMD's one-click technology for overclocking DDR5 RAM.

Like XMP, EXPO-certified memory will guarantee stable performance of a memory kit for the EXPO rated clock speed, voltage and timings. Also, like XMP, it doesn't necessarily guarantee that the kit will play ball with your chosen CPU at its rated speed – just that the memory kit can reach those speeds in isolation. However, given the kits will have been tested with AMD CPUs – rather than with Intel CPUs, as is the case for XMP – you stand a greater chance of it working with your new AMD chip than a non-certified memory kit.

A total of 15 EXPO-certified memory kits are set to be available at launch, with speeds of up to DDR5-6400 available, but we're sure more will arrive in the near future. **GPC**

The IOD is integral to managing communication between the CCDs and system memory





# VIRTUAL REALITY HERE TO STAY OR GONE TOMORROW?

VR REMAINS AT THE CUTTING EDGE OF GAMING AND INTERACTIVE EXPERIENCES, BUT DOES THE SECTOR HAVE A VIABLE LONG-TERM FUTURE? **RICK LANE** INVESTIGATES

**T**wo years ago, virtual reality was riding high. In March 2020, Valve had just released *Half-Life: Alyx*, by far the most prestigious and exciting title to release on VR devices. Meanwhile, Facebook was selling huge numbers of its Oculus Quest headset, and was gearing up to release the Oculus Quest 2, which would quickly outperform its older sibling to become the biggest-selling VR headset to date. It seemed like the sector was brimming with potential, on the verge of bursting into the mainstream.

Today, you'd be forgiven for wondering where all that potential went. Neither Valve nor any other developer has followed up *Alyx* with anything close to its ambition, while Facebook, having recently rebranded as Meta, has jacked up the price of the Quest 2

while it piles vast amounts of money into its highly speculative Metaverse project. From an outsider's perspective, the path ahead seems far less clear than in 2020, to the point where it isn't unreasonable to wonder whether VR has already seen the peak of its popularity, and is now in a decline.

## THE SALES STORY

But the reality of virtual reality currently sits somewhere between these two extremes. 'VR is definitely here to stay. We are still selling significant numbers of VR headsets every month,' says James Gorbald, director of content at Scan Computers. 'It's not one of those things like 3D displays, which in terms of gaming, as opposed to cinema, were around for the better part of a year and a half.'

There are numerous reasons for this stability in VR sales, not least the simple fact that the technology properly works, unlike the first wave of VR devices that appeared in the 1990s. One of the key factors that separates VR from 3D displays is that, whereas 3D displays were purely a luxury product, VR has far greater practical uses to go alongside its potential as a gaming device.

'They're really popular in organisations doing training, because it allows people to be trained much more cheaply and much more safely than in the real world,' Gorbald explains. 'Surgery, fire and rescue, oil rig training – a lot of things that are dangerous and expensive to do for real.' Other areas outside gaming where VR has high demand include engineering, research and development, and





When Half-Life: Alyx launched in March 2020, Scan saw a spike in sales of VR headsets

the entrepreneurial sector, where VR devices are used for events, presentations and so on.

Much like PCs in general, there's a stable market for VR devices independent of the game industry, and they aren't reliant on sales of games to sustain them, unlike 3D monitors or bespoke game consoles. However, this isn't to say that the typical outsider perspective on VR is entirely wrong. VR sales *have* declined over the past couple of years, with Gorbold stating Scan is currently selling 'roughly half

Most notably, while the Meta Quest 2 is by far the most popular consumer VR headset, substantially outselling HTC's various Vive headsets, in terms of business-to-business (B2B) sales of VR devices, the two companies are 'more equally split'.

Given that B2B represents a substantial chunk of the VR market, this may explain why Meta's next headset, codenamed Cambria, is rumoured to be a more powerful, premium headset.

## IT ISN'T UNREASONABLE TO WONDER WHETHER VR HAS ALREADY SEEN THE PEAK OF ITS POPULARITY, AND IS NOW IN A DECLINE

the number of units per month' that they were selling around the same time in 2020.

However, there are mitigating factors at play. First, the pandemic and the resulting lockdown caused significant increases in hardware sales, with Scan's sales increasing by around 300 per cent across the board. Furthermore, when Half-Life: Alyx launched in March 2020, Scan saw a spike in sales of VR headsets that not only massively exceeded the sales bump caused by the pandemic, but was bigger than the spikes triggered by the Black Friday sales of both 2019 and 2020. 'Alyx must have had an effect, because it's too much of a coincidence,' Gorbold observes.

The drop in sales Scan has experienced is less of a decline and more of a return to normality. Within this general trend are more specific stories told by the sales data.

This leads to another point. If VR manufacturers aren't reliant on consumer sales to support their business then the health of the VR sector and the health of VR gaming are two different areas. Headset sales only provide part of the story, and to understand the future of VR gaming, we need to speak to the developers themselves.

### PC vs QUEST

One UK VR developer is nDreams, which has specialised in VR development for around a decade. In 2020, the studio released Phantom: Covert Ops, a stealth shooter that saw players infiltrating a secret paramilitary base via the unusual medium of a kayak.

'Unexpected or unnatural movement in VR can be really uncomfortable for the player,' says Glenn Brace, studio head at nDreams

Elevation. 'In a kayak, you don't expect to move off suddenly; it takes time to build momentum or come to a stop. And that's great because that gives us one-to-one, intuitive, analogue control, with none of the usual abstractions that come with button mapping on controllers and so on. It's more natural and therefore broader and more accessible.'

Brace states that nDreams was initially targeting high-end PC VR, namely the Vive and the Rift, but then Facebook revealed the first Oculus Quest. 'We were lucky enough to get our hands on some of the first prototypes built,' Brace says. 'There were so many positives about the Quest headset that really excited us, but the real challenge was that the chipset still very much had a mobile level of performance.'

At this point, development of Phantom became 'mega complex', as the studio looked for ways to optimise the game for Quest without compromising on the experience it had planned. 'We pushed the hardware harder than anyone in the world at that point,' Brace says. 'Phantom had a significant influence on where nDreams is now and what we have become.'

Phantom was both a critical and commercial success, to the point that nDreams is now working on multiple new projects. This includes the upcoming Ghostbusters VR game, which is being published by Sony, but also an entirely new, unannounced project developed by the company's new second studio, nDreams Orbital. 'The market is certainly in a growth phase right now,' says Steve Bristow, head of nDreams Orbital. 'VR isn't really a niche anymore. We're looking at audiences of tens of millions in the next few years.'

Indeed, while there are no official figures, it's estimated by some market research firms, including IDC, that Meta alone has sold between ten and 20 million Quest 2 headsets. This is substantially fewer units than the



Market research firms estimate that Meta has sold between ten and 20 million Quest 2 headsets



hundreds of millions of PlayStation 4 consoles sold by Sony, but if these figures are in the right ballpark, it's not far off sales of the latest generation of consoles, with Sony having sold around 20 million PlayStation 5 consoles, and Microsoft having sold around 15 million Xbox series X/S devices.

'The audience size has got to the point now where we can begin to apply some of the knowledge that we've gained from conventional game dev to our VR development strategies,' Bristow explains. 'Our titles will receive regular updates, incorporate live events, and players can team up with friends as a core component.'

### THE INDIE INFLUENCE

What's interesting about the VR market right now is that it's large enough to support dedicated VR developers such as nDreams, but still new enough that it isn't dominated by a handful of large corporations. This is resulting in some interesting transitions. Incuvo Games is a Polish VR developer that has worked on titles such as *Blair Witch VR*, and the recently released *Green Hell VR*. Incuvo originally started out developing mobile games, but quickly found it impossible to compete in that market.

'Basically, small independent companies were squeezed out by huge players,' says Radomir Kucharski, CEO of Incuvo, about what happened in the mobile market.

The company then moved into developing more traditional games for the Nintendo Switch, but was again crowded out by larger studios swamping the console's storefront. With VR, however, Incuvo has established

itself as a developer of note. This is partly due to the smaller market size, but also because designing for VR requires a specific set of skills with which not all developers are equipped.

'Some people think it's pretty easy to port a flat version of a game into VR – you just need to put the VR camera in the game, but unless the game is specifically designed for VR, it will not succeed,' Kucharski says. 'When you have the same game on flat platforms and VR, it will be more comfortable and easier to play on flat platforms than VR. So players need to get some fun and added value that's special to the VR experience, to make it enough to endure the additional [physical] cost of playing VR.'

we redesigned all the interactions into physical VR interactions.' With Quest, however, the device couldn't render *Green Hell*'s massive open world, so Incuvo had to restructure the game, then add new features to give the Quest version its own appeal.

'There's fewer mechanics in the Quest version, but they are even more VR-orientated,' Kucharski points out. 'In the PC VR version, we've got the table to craft stuff in a similar fashion as the original flat version, but in the Quest version, it's all physical. If you want to craft an axe, you need to have a stick and a sharpened stone, and put all these things together.'

**TO MAKE THE MOST OF PC VR, BUT ALSO PUT YOUR GAME ON THE MOST POPULAR VR PLATFORM, YOU ESSENTIALLY HAVE TO MAKE TWO GAMES**

In addition to this is the complexity brought by Oculus Quest; as pointed out by Glenn Brace, this has much less processing power than a VR device connected to a PC. If you want to make the most of PC VR, but also put your game on the most popular VR platform available, you essentially have to make two different games. This is what Incuvo did with *Green Hell VR*.

'We actually started with a PC VR version, and it's very close to the original flat version in terms of the environment, and the story is almost the same. The only difference is that

### PC COMPLICATIONS

Incuvo has the experience and resources to be able to develop two very different versions of the same game. However, the divide Meta has created between its own headsets and high-end PC VR is forcing other developers to pick their battles. Chris Youles is the Creative Director of Foggy Box Games, which earlier this year launched a sci-fi bartending simulator called *Startenders* on Oculus Quest.

The game is yet to release on PC VR, though, and getting it onto high-end devices is a low priority for Foggy Box, compared with getting it onto other devices, such as PlayStation VR (PSVR). 'One of the biggest differences in terms of Quest vs something like Steam, is that with Quest you have a closed store. There is at least some quality control,' Youles says.

'If you go into the Steam store right now, and go to VR, most of the games in the top sellers, trending or even the carousel areas, are all games that have a VR mode, but aren't [full] VR. And I think that's such a hindrance. If I go on there, and I see *F12022*, I think, great, it has a VR mode, but I'm looking for VR specific games, and all those great games are way down the list, because they're not flat traditional games that have sold well.'

This isn't the only issue encountered when developing for PC VR. With both the Quest and PlayStation VR, developers are building their game to work on a single, universal device.



**Phantom: Covert Ops, from nDreams, sees you infiltrating a paramilitary base in a kayak**



**Startenders on Oculus Quest, by Foggy Box Games, has yet to get a release on PC VR**



**One big challenge when developing for the Quest was its limited performance compared with PC VR**

With PC VR, developers not only need to account for different headsets (whether it's one of several Vives, Valve Index or more niche headset brands such as Pimax), but also for the wide range of hardware that those users might be running.

'The problem with something like Steam is everyone has a different computer,' Youles says. He points out that if your PC can only just run a PC VR title, and the frame rate is lower than optimal, the problem is exacerbated because it can have physical consequences, such as inducing nausea. 'That could ruin someone's experience with VR and put them off forever.'

For VR developers, then, the consistency, curation and market stability offered by Meta and Sony currently makes these platforms

more viable than the untamed wilderness of PC VR. That doesn't necessarily mean PC VR is doomed though.

For one, it would be foolish to rule out any project with which Valve is involved. We don't know exactly how many Indexes have shipped, but there are some rumours circulating about Valve's future with VR.

One is that Half-Life: Alyx will come to Sony's upcoming PSVR2 ('I think Sony and Valve have a very good relationship,' Youles says), and another is that Valve's next headset will essentially be a frame into which the Steam Deck can be slotted. While there's no hard evidence for any of this speculation, as the industry saw with Alyx, Valve can have a massive effect on the VR scene at a moment's notice.

More broadly, as with VR headsets in general, there is a market for PC VR experiences outside direct consumer purchases. Sam Watts is the Immersive Partnerships Director of Make Real Ltd, a developer that works in both the commercial sector and in traditional game development.

In 2017, Make Real released Loco Dojo, a multiplayer VR party game. Loco Dojo sold modestly until last year, when Make Real released it on the Quest platform. 'It took three weeks to sell as many copies on Quest as it had done on PC in five years,' Watts says. 'That should give you an idea of the sort of current marketplace opportunities.'

However, Make Real has also found success with PC VR in the form of dedicated VR arcades, or 'location-based entertainment' (LBE). Here, customers can book out a space and play VR with their friends, colleagues

and so on. 'It's actually worked out well for us, because these locations use proper dedicated LBE licensing systems,' Watts explains. 'We get paid so many cents per minute that the game has run. Plus, because they're playing four-player games, we get paid four times.'

## A BRIGHT FUTURE?

In short, VR is now an established part of the game industry, and it looks set to remain that way for the foreseeable future. The Quest has given VR developers access to a substantial and dedicated audience, and although PC VR is less predictable, elements such as the LBE scene and the presence of Valve make it worth many developers' while to be a part of it.

The question now is whether VR has what it takes to fully break into the mainstream, to become a regular part of our gaming diet. It's not impossible that this will happen, but for it to do so will require several changes. First, the sector needs more games such as Half-Life: Alyx, killer apps that can tip players into purchasing a headset.

According to Watts, there are 'several titles' currently in development that 'will have a similar impact on sales', although he admits these titles aren't on the same development scale as the estimated \$50-150 million US that Valve allegedly spent making Alyx. Youles, meanwhile, sees Sony's flagship PSVR2 title Horizon: Call of the Mountain as a potential new Alyx.

This may also eventually come to PC VR, given Sony's more recent policy of releasing its premium titles on the platform.

Sony has 'such a quality roster of studios under them,' says Youles, 'that I think the more they put out, the more they're going to convince other third-party, high-end AAA studios to go, okay. This is something that we definitely can do.'



**'The problem with something like Steam is everyone has a different computer,' says Chris Youles, Creative Director of Foggy Box Games**





**Make Real has a found success with PC VR in the form of dedicated VR arcades, or 'location-based entertainment', seen here in Loco Dojo**

The other crucial requirement is better hardware. One of the main barriers to VR becoming mainstream is the inconvenience and discomfort of wearing headsets compared with sitting in front of a flat display, an issue that isn't going to disappear any time soon.

That said, VR has come a long way in the past decade, from low-res boxes that required external sensors and a cable link to your PC, to the high-res, wireless, easily set-up hardware of the Meta Quest 2, complete with internal tracking. Much like the evolution of mobile phones, the next decade of VR will probably see devices become both more comfortable and more powerful, although progress won't be straightforward.

'There are always new technologies and features that get added, which initially add

bulk, such as eye tracking, mouth tracking, facial tracking and so on,' Watts says. 'The next five years are still going to be having this situation where headsets are going to get smaller, and when new things get added they might get more bulky again.'

And new headsets are coming, most immediately in the form of Meta's Cambria (which is likely to be announced in October as the Quest Pro) and Sony's PSVR2. However, Kucharski also states there are other 'Facebook-sized' companies currently working on headsets of their own.

Kucharski doesn't specify which companies, but two notable absentees from the VR market at present are Microsoft and Apple. Watts suggests Apple has something substantial in the works. 'Whenever Apple does reveal its hand, it's probably going to turn everything on its head,' he says.

One final consideration is the spectre of the metaverse. Meta's lofty goal of a real-life cyberspace that integrates VR, AR and a host of other technologies. It's difficult to speculate about the impact of Meta's plan.

Gorbold notes that the whole concept is 'incredibly nebulous', while Watts observes that the term has been co-opted more broadly by people 'looking to make a quick buck'. The most important consideration at this stage

is that, beyond unscrupulous companies seeking to capitalise on a buzzword, the metaverse won't be a major factor of daily life anytime soon.

'The metaverse means the underlying networks and protocols that will enable the next generation of the Internet to exist,' Watts explains. 'It needs to be built first, but it requires more explanation and education, because it's causing more confusion among people currently.'

Wherever the future of VR ends up heading, the main takeaway is that VR has a future. It's hard to gauge where exactly the sector is sitting in terms of its evolution right now. Youles compares it with the 'indie golden age' between 2006 and 2014, when Steam and Xbox Live Arcade pushed indie developers to the fore for the first time.

But in practice, VR is probably closer in form to the game development scene of the 1980s, where the hardware was built by huge companies such as IBM, but the games were mostly made by small-scale developers, with a few medium to large studios thrown into the mix. Either way, Youles sums up the situation well: 'It's definitely around that point where you can really capitalise on being there before other people,' he says. 'It is a nice place to be at the moment.' **GPG**



**Valve's presence in the PC VR market makes it worth many developers' while to be a part of it**

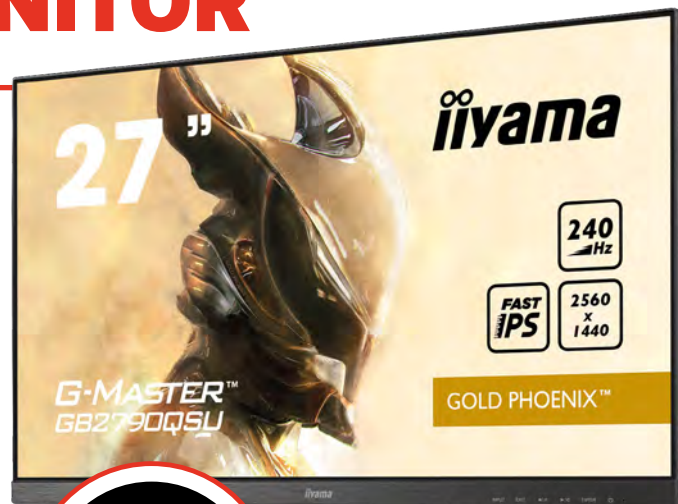


# WIN

## A 240Hz IIYAMA GAMING MONITOR

Fans of super-fast frame rates will love this fantastic prize from the generous folks at iiyama this month. Control the game with the 240Hz G-Master GB2790QSU Gold. Packed with the latest technologies, including FreeSync Premium, the 27in Gold Phoenix features a 240Hz refresh rate and a stunning 1ms MPRT response time, making sure your equipment will never hold you back.

Its fast IPS panel technology guarantees superb image quality, and the ability to adjust brightness and the dark shades with the Black Tuner delivers greater viewing performance in shadowed areas. To ensure comfort during marathon gaming sessions, you can also easily adjust the screen position to your preferences thanks to the height-adjustable stand.



WORTH  
**£430!**



- 27in IPS panel
- 240Hz refresh rate
- FreeSync Premium
- 1ms response time (MPRT)
- 2,560 x 1,440 resolution
- HDMI 2 and DisplayPort 1.4 inputs
- Height-adjustable stand



SUBMIT YOUR ENTRY AT **CUSTOMPC.CO.UK/WIN**

Competition closes on Friday, 4 November 2022. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation and Raspberry Pi Ltd, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. If you choose to enter by subscribing to our newsletter, be assured that we don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked.



GARETH HALFACREE'S

# Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino, and Android to retro computing

## REVIEW

### Keychron Q8 Alice Layout

**T**here was a time when split-layout keyboards were all the rage, with even Microsoft launching its own range of 'Natural' designs. Designed to keep the user's wrists in a neutral position, rather than requiring them to be turned outwards to accommodate a keyboard with horizontally laid-out keys, split layouts are less common today. What's more, those that do exist often take the concept to the extreme, physically splitting the keyboard into two sections with a cable between the two.

Keychron's latest mechanical keyboard doesn't go quite that far, using a single PCB



A near-bulletproof block of aluminium, the Keychron Q8 definitely doesn't lack heft

to create a unibody split keyboard. It adopts a modified Alice layout – 65 per cent, up from the 60 per cent of Yuk Tsi's original design, offering a dedicated cursor-key block and separate Insert, Delete and Home keys.

For anyone wondering if the resulting compact footprint would make this a good portable for taking to and from the office, the answer is a resounding no. Keychron has positioned the Q8 at the premium end of the market, using a CNC-machined aluminium body, which gives the device a near-2kg assembled weight – not the sort of device you want to be cramming into a backpack morning and evening.

As a desktop device, though, the weight provides a stability most keyboards can't match. While it lacks adjustable feet to change

the rake angle (although spare rubber feet are included in the pack), it's absolutely rock-solid. Both the board and plate inside are also mounted on gaskets above and below, vastly lowering the noise level, even when the clicky tactile Gateron Blue switch option is chosen.

The gasket mount isn't the only premium feature hiding inside the thick aluminium body. Keychron has also performed what's commonly called a 'tape mod', installing sound-absorbing tape underneath the PCB before the bottom half of the case to further reduce noise. Just as with aftermarket tape mods, it's reversible – if you'd prefer a little more noise, just unscrew the case and remove the tape layer. All switches are also pre-lubricated, with a choice of Gateron G Pro Blue clicky, Brown tactile or Red linear.



The keyboard is positioned as a premium product, complete with holographic-finish box labelling

## NEWS IN BRIEF

### Arduino seeks input on multi-tasking plans

The Arduino team has asked for community input on a plan to bring true multi-tasking capabilities to the microcontroller platform, finally putting an end to wasteful do-loop coding.

'The goal is to define a standardised API that can be ported across all architectures and that, in line with the Arduino philosophy, will make complex things easy for anyone,' explains Arduino's Alessandro Ranellucci. 'Multitasking is a hard concept, so here we have plenty of margin to bring the Arduino approach to make this available to everyone.' See [github.com/arduino/language/discussions/2](https://github.com/arduino/language/discussions/2) for more details.



The switches, meanwhile, are installed south-facing for clearer visibility of the programmable RGB lighting installed on the keyboard when using the stock double-shot PBT keycaps. Hot-swap sockets are used throughout, providing solder-free compatibility with Cherry MX-style switches with three or five pins, but there's no way to convert the board to north-facing LEDs for those installing shine-through keycaps.

The biggest feature of the board, though, is its programmability. The Q8 is built around an Arm microcontroller with the open-source QMK firmware installed, and Keychron provides a design file – not, at the time of writing, yet accepted into the upstream project – for the cross-platform VIA utility.

**A switch at the rear flicks between the macOS and Windows/Linux default layers**



### The keys and lighting can be customised using the cross-platform VIA utility



VIA provides access to the keyboard's five layers – two for standard and multimedia keys under macOS, two for the same under Windows or Linux and a final layer that turns the number keys into their Function key equivalents. Two layer-shift keys are positioned either side of the split spacebar, in another modification to the original Alice layout.

In VIA, the function of any key on the keyboard can be altered, including the ability to save and execute macros or emulate a mouse. There's also reasonably fine-grained control over the RGB backlighting, but only through solid colours, or a short list of preconfigured animations, none of which react to the user's typing nor allow host-based triggers to, for example, light up when an email arrives.

Keychron provides two main variants of the Q8, both available in three colours – Carbon Black, Silver Grey and the Navy Blue as reviewed. The first is an American-style ANSI layout, available fully assembled or as a barebones kit without keycaps or switches; the second is a UK-style ISO layout, available in kit-only form. Those buying either kit should be advised, however, that Keychron's OSA-profile keycaps use differing heights – and that not all third-party keycaps will provide a satisfying typing experience.

There's one final configurable option in the mix. The Insert key, located at the top right of the board, can be swapped for a continuous-rotation knob input. This is configurable in



**Three Gateron switch colours are offered, with hot-swap sockets if you want to fit your own ones instead**

software for any task from zooming in an image editing application or scrubbing through video, to simply adjusting the volume.

Regardless of which model you pick up, Keychron includes a few bonus items in the box. There's a sleeved USB Type-C cable with Type-A adaptor, four spare rubber gaskets, a switch puller, a keycap puller, a screwdriver and an Allen key. There are also Windows and Alt keys, to swap for the macOS Option and Command keys pre-installed.

At \$175 US for a barebones set, or \$195 US fully assembled (around £148 and £165 ex VAT respectively) for the knobless versions, or an extra \$10 US (around £8.50 ex VAT) for the knob, the Keychron Q8 isn't cheap, but that's still great value for the build quality on offer – it will last you a lifetime. The Keychron Q8 is available to buy from [keychron.com](https://keychron.com) now.





## REVIEW

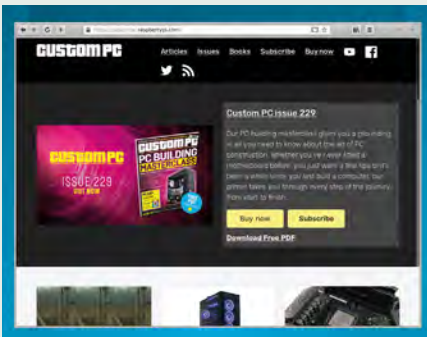
## Ubuntu 22.04 for the VisionFive

**T**he free and open-source RISC-V instruction set architecture is pretty mainstream these days, at least in some sectors. It's proven a smash hit with the microcontroller crowd, with Espressif going so far as to declare every chip it designs from here on out will be RISC-V. It's also displacing proprietary Arm cores in storage devices and graphics cards. Plus, as last month's review of the StarFive VisionFive showed, it's now even making an appearance in near desktop-class single-board computers that cost less than a second mortgage.

It's not quite there yet though. As in the early days of Arm-based single-board computers (SBCs) – and, it could be argued, even today – there's the thorny issue of software compatibility. When a company releases an SBC into the market, they all too often create a single operating system image and consider the job done – leaving it quickly outdated and riddled with security issues.

Even the VisionFive, a relatively new board, suffers from the problem. As our review noted, its Fedora-based Linux image is based on a version that was already end-of-life when the boards started shipping, and StarFive had provided no replacement at the time of writing.

Enter Canonical, which has already been investigating RISC-V support in its Ubuntu Linux distribution. Ubuntu 22.04 launched with official support for SiFive's HiFive Unmatched, for example – an expensive but high-performance desktop-class board, which has sadly been discontinued in the face of component shortages.



Tweaks speed up the desktop, but performance for graphical workloads is still weak

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-+SSSSSSSSSSSSSSSSSSSSyySSSS+-
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.-/+00SSSS00+/.-.

ubuntu@ubuntu:~$

```

```

ubuntu@ubuntu:~$
-----
05: Ubuntu 22.04.1 LTS riscv64
Host: StarFive VisionFive V1
Kernel: 5.17.0-1006-starfive
Uptime: 5 mins
Packages: 1207 (dpkg), 4 (snap)
Shell: bash 5.1.16
Resolution: 1920x1080
Terminal: /dev/pts/1
CPU: (2)
Memory: 190MiB / 7172MiB

```

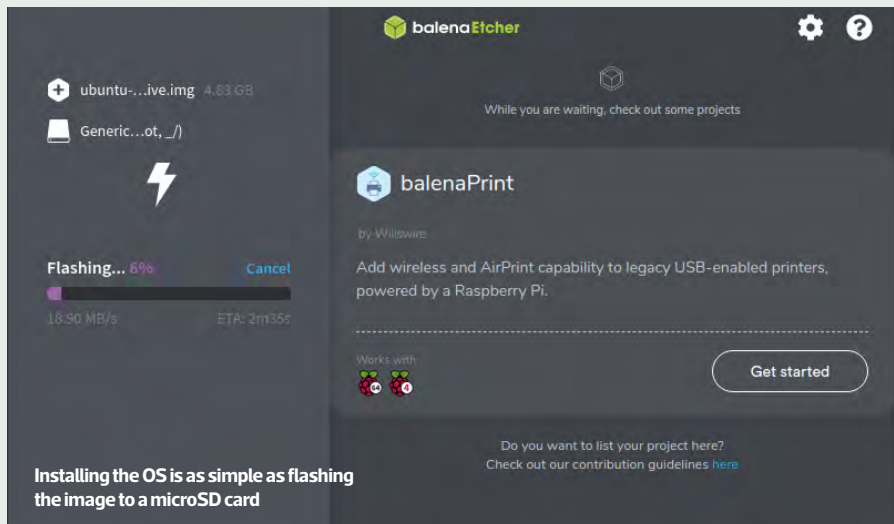
An official Ubuntu Server 22.04.1 image is now available for the VisionFive

Now, though, it has redoubled its efforts. Ubuntu 22.04.1, the latest point release, brings with it official images for the StarFive VisionFive and, surprisingly, the less capable but more affordable Sipeed Nezha D1 (reviewed in Issue 221).

Unlike the official StarFive Fedora remix, the image from Canonical for the VisionFive is based on Ubuntu Server, meaning there's no desktop environment as standard, booting instead into the text-based console. Adding Xfce is a quick command away, though, and

Canonical has even provided a tip for boosting performance sapped by the lack of a GPU on the VisionFive – deleting a kernel mode-setting library and replacing the running window manager with Openbox.

The result is a measurable boost – the Speedometer 2.0 browser benchmark jumped from 1.32 runs per minute on the stock StarFive Fedora image to 2.54rpm on the tweaked Ubuntu image. However, using it is still a rather painful experience. Canonical's work also does nothing for the board's



Installing the OS is as simple as flashing the image to a microSD card

## NEWS IN BRIEF

### StarFive formally unveils VisionFive 2

Even as Canonical launches its first Ubuntu images for the VisionFive, StarFive is working on its successor. Launching in 2GB, 4GB and 8GB variants, the VisionFive 2 uses a faster quad-core SiFive U74 cluster running at 1.5GHz. It features an Imagination BXE-4-32 GPU and two Gigabit Ethernet ports, but drops the Wi-Fi and Bluetooth radios in favour of M.2 M-key expansion.

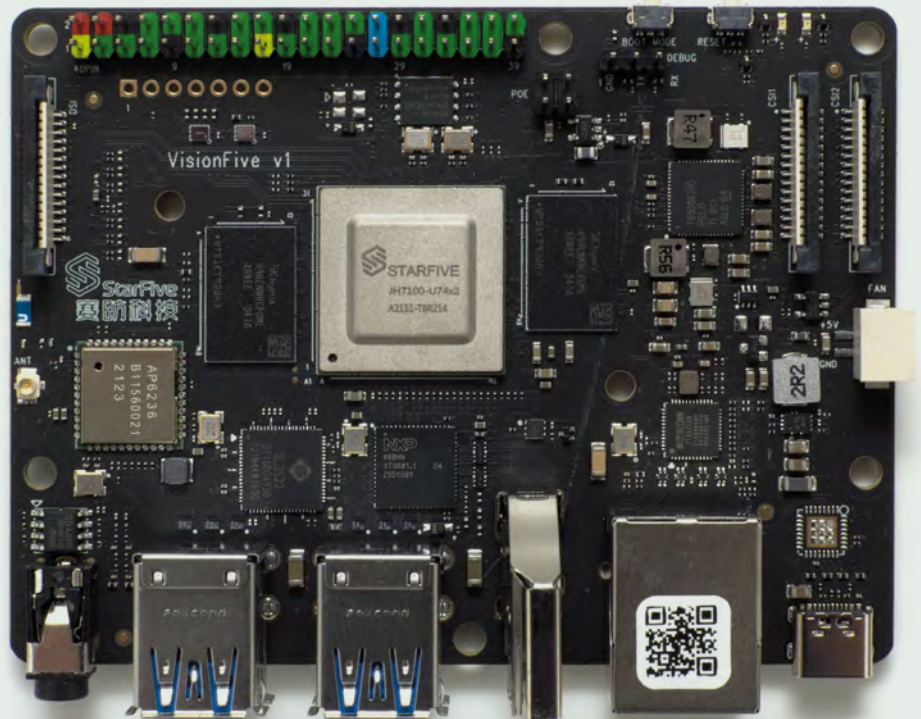
At the time of writing, the company was crowdfunding on [kickstarter.com](https://www.kickstarter.com), with options starting at \$46 US (around £39 ex VAT) with delivery in February 2023. An early model with one Gigabit port and one 10/100Mbps Ethernet port will ship in November 2022.



hardware shortcomings. The same display compatibility issues are present in Ubuntu as they were in Fedora, and the board still won't shut down properly without someone physically pulling the power out.

But moving to Ubuntu from the end-of-life Fedora image brings some major advantages. The first is, of course, security.

**The experience is more polished than StarFive's stock Fedora spin, but still feels beta-level**



**Ubuntu takes full advantage of all the features of the board, though it needs a PPA installing for Bluetooth**

Ubuntu 22.04 'Jammy Jellyfish' is a Long-Term Support (LTS) release, meaning Canonical will provide hardware and maintenance updates through to 2027, and an 'Extended Security Maintenance' period to 2032.

The software, meanwhile, comes from Canonical's own RISC-V repositories. There's almost every feature you would expect to find on a modern Linux system, ready to install at a moment's notice and largely fully compatible, with just a few exceptions. The biggest of these exceptions is in the web browsing category – there are no pre-built Firefox or Chromium packages available in Canonical's repositories, leaving Epiphany as the sole graphical browser option, unless you're willing to build your own one from source.

More important than what it offers now, though, is what it promises for the future. A partnership with a single company, SiFive, to support a single board could be a passing flight of fancy. However, tripling the support burden with another two boards suggests Canonical is serious about supporting Ubuntu on RISC-V – making it more likely that we'll have a future where chips based on the architecture are powering not only embedded and hobbyist-

level devices, but also desktop and server-class machines.

It's not going to happen overnight, sadly. While those looking to install Ubuntu on an x86 or AMD64 system can download a single ISO image, installing it on one of the three currently supported RISC-V SBCs means downloading a hand-crafted image specific to the board. While there's talk afoot regarding marrying RISC-V with the UEFI standard, which would make it easier to build a single operating system image compatible with a range of devices from different vendors, it's a work in progress with no firm dates attached for wide deployment.

But it's a start, and one that provides enough hope to even overlook some of the rougher edges. These include the reliance on an optional Personal Package Archive (PPA) to install the drivers required by the Bluetooth radio, owing to Canonical failing to get its hands on the source code for proper inclusion in the repositories, or the handful of non-critical errors seen on boot.

Those with a VisionFive or Nezha D1 board can try the Ubuntu Server 22.04.1 images now, by following the download links and instructions from [custompc.co.uk/](https://custompc.co.uk/) **VisionFiveUbuntu GPG**





ANTONY LEATHER'S

# Customised PC

Case mods, tools, techniques, water-cooling gear  
and everything to do with PC modding

## Small Socket AM5 boards

**O**ne of the companies I saw at the Gamescom show last month was Asus, which had a huge array of Socket AM5 motherboards on show. This was the first time I'd seen any AM5 boards in the flesh, so it was a good opportunity to familiarise myself with some of the models that would be landing on the test bench soon.

Firstly, I was surprised to see that all of the examples on show, from high-end ROG and Strix models all the way down to TUF and ProArt, were based on AMD's X670E chipset. I can understand flagship models donning AMD's premium chipset, but I'm slightly concerned that even TUF boards are

using it, when there will presumably be cheaper versions based on the X670 and B-series chipsets in October.

Normally, I wouldn't care too much, but I worry that the majority of its motherboards will be out of reach for many people. Anyway, that's not why I'm here. What really interested me were two ROG Strix motherboards – the ROG Crosshair X670E Gene and ROG Strix X670E-I Gaming.

The former is the first Gene-branded micro-ATX motherboard for an AMD chipset, and it clearly shows that Asus is fully on board with AMD's new platform in terms of appealing to enthusiasts. The new Gene has a single 16x PCI-E 5 slot, but it also has a smaller 1x PCI-E

**A large DIMM.2 module on the Gene has massive heatsinks to cool the pair of PCI-E 5 M.2 ports**



5 slot, giving it an advantage over a mini-ITX board. In addition, the Gene also has three M.2 ports, two of which support PCI-E 5 devices.

Another funky feature on the Gene is a large DIMM.2 module update, which has massive heatsinks to cool the pair of PCI-E 5 M.2 ports. Perhaps Asus has some advance knowledge here, and knows that these new SSDs are going to run rather hot. It certainly seems that way.

Meanwhile, the mini-ITX ROG Strix X670E-I Gaming has the dual USB Type-C daughterboard we've seen before, which offers SATA ports and other gubbins, freeing up PCB space.



**There isn't a single audio socket on the mini-ITX board's I/O panel, with audio instead coming from an external DAC**



The massive stacked heatsinks on the south end of the board seem to have changed a bit as well, again with huge heatsinks to deal with one PCI-E 5 M.2 port, and a second PCI-E 4 M.2 port in the mix too. The really big change, though, comes from the audio.

**Asus has introduced its first Gene-branded micro-ATX board for AMD CPUs in the form of the ROG Crosshair X670E Gene**

Asus has ditched on-board audio entirely and is instead including an external USB DAC. There are no audio ports on the rear I/O panel at all.

To be fair, Asus does generally make decent audio products when it comes to PC hardware, so I'm confident in it pulling this off, but opinion is definitely divided in the comments section on my YouTube channel.

**The ROG Strix X670E-I Gaming's dual USB Type-C daughterboard offers SATA ports and other gubbins, freeing up PCB space**

It does seem that mini-ITX has gained a following of enthusiasts who prefer a clean, tidy build, and that's not going to be easy if you have to have an external USB device. However, you'll always have at least some cables coming out the back of your PC, so adding one more isn't going to be a big issue, and you can probably just have the device sat under your desk or behind a speaker anyway.

The benefit of doing this wasn't clear at the show, though, and Asus wasn't forthcoming with information. I can only guess that there was increased need for space in order to include the option for a PCI-E 5 SSD in that heatsink stack. Hopefully, we won't have to wait long for more details on both these and even more Socket AM5 motherboards, and we'll hopefully have reviews for them soon – watch this space.



## Hands on with Alphacool's Rise Flat reservoir

**C**ompact reservoirs are all the rage at the moment, and EK has not only produced a 120mm version of its FLT reservoir, but a tiny 80mm version too. This time it's Alphacool's turn to get in on the action, though, with its Rise Flat reservoir. Available in both DDC and D5 pump mount variations, the reservoir features Alphacool's zero-height port plugs to save space in small builds.

Plus, while EK's similar models have

**The Rise Flat has ports on its flat-edged corners, a top-mounted fill port instead of a side-mounted one, and even a rear port**



annoyingly placed ports, the Rise Flat reservoir is more flexible. It has ports on its flat-edged corners, a top-mounted fill port instead of a side-mounted one, and it even has a rear port. If you've seen my orange Raijintek Ophion Evo water-cooled PC mod, you'll probably know I had to modify the EK FLT reservoir I used in there, as I needed a port on the rear side of the reservoir, so had to add one myself.

It's good to see a few more options here that will enable the reservoir to suit more situations than previous designs. It has RGB lighting as well, but sadly there's no PWM control for the pump. Alphacool's thinking here is probably that its power DDC310 pump has less grunt than a usual DDC pump, and is therefore quieter, but it would be much better to have full PWM control if you want to tune down your pump to very low RPMs.

Mounting can take place in 120mm fan mounts using the included



**There's sadly no PWM control for the DDC310 pump on the Rise Flat**

brackets, which can be mounted on the left or right side of the reservoir. Also, as the sides are flat, you can use mounting tape there.

Price-wise, the Rise Flat reservoir costs around £20 less than the EK FLT 120 DDC, but the latter is thinner and includes PWM control. The Rise Flat reservoir is still worth considering, though, especially if the port placement on EK's reservoir is a dealbreaker. **GPC**

# How to Fit a fan to a PSU cover

**Antony Leather** shows you how to use your case's PSU shroud as an extra fan mount

**TOTAL PROJECT TIME / 2 HOURS**

**T**here's a good reason why high-airflow cases point their front fans at your graphics card, as any extra airflow in its direction can improve cooling. It's little wonder, then, that some cases have added fan mounts to the PSU cover in order to point airflow directly at your graphics card's cooling fans, as any extra help here can often yield noticeable GPU cooling and clock speed improvements.

If your case has a PSU cover, and you're up for some case modding, then adding a PSU cover fan to blow at your GPU can shave several degrees off its load temperature. In this guide, we'll show you how to create your own PSU cover fan mount using basic tools, and take you through where to position it for the best effect.

## TOOLS YOU'LL NEED



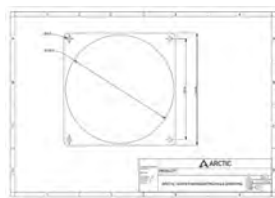
Glue stick  
Most hardware stores



Metal file  
Most hardware stores



120mm fan  
overclockers.co.uk



Fan template  
support.arctic.de



Hole saw  
Wickes.co.uk



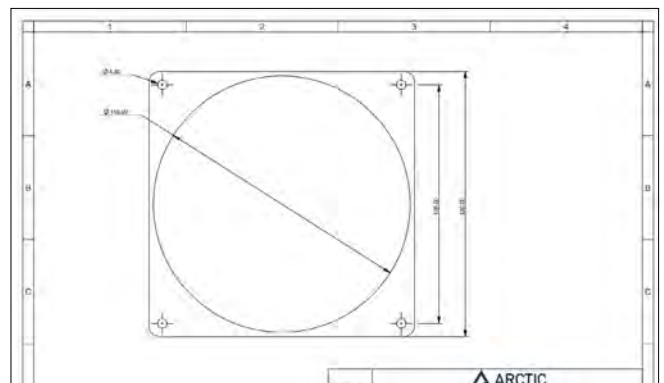
## 1 / CHECK FOR EXISTING FAN MOUNT

You might not have noticed it, but some cases include fan mounts in their PSU covers already, so it's worth checking to see if there is one. If there's not a complete fan mount then there might at least be some vents that will reduce the amount of modification you need to perform.



## 2 / IDENTIFY FAN VENT LOCATION

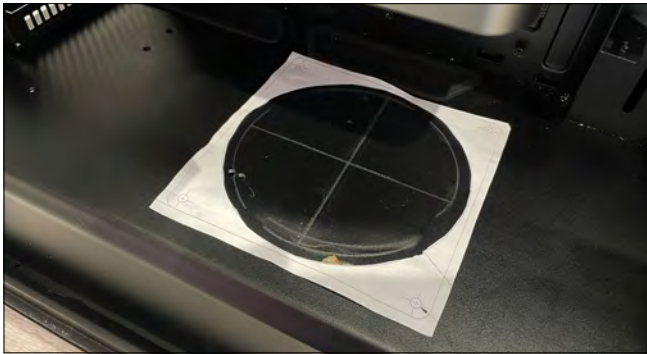
There are two key considerations with the location of the fan mount. It needs to sit so that the fan can exhaust straight into your graphics card's cooler, and it also needs to have a clear space underneath it, in front of your PSU. You'll want your graphics card installed in your case in order to work out the best location.



## 3 / DOWNLOAD TEMPLATE

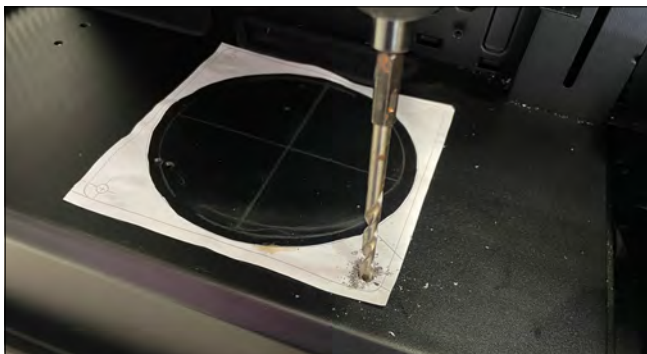
To accurately drill and cut the required holes, it's a good idea to use a template. These can be downloaded from ARCTIC's website at [support.arctic.de](http://support.arctic.de), although you'll need to resize the print so that it matches the hole distances on your actual fan.





#### 4 / MARK UP AREA

Remove any components from your case, if you haven't already, then cut out the template and stick it in the centre of the location in which you need the fan to sit, using Pritt Stick or a similar glue stick. We marked a cross for the centre on the PSU cover where we wanted the fan vent to sit.



#### 5 / DRILL FAN MOUNTING HOLES

Cutting the fan vent hole will probably tear up the template, so start by drilling the mounting holes first. You need to use a drill bit 1mm smaller than the thread of your fan mounting screws, so the screws will bite into the PSU cover and secure the fan in place.



#### 6 / CUT THE HOLE

Some drills are too big to sit inside a case. If the roof of your case can't be removed as standard, or by drilling out a few rivets, you can also use a Dremel and reinforced cutting disc to cut the fan hole. Measure the internal diameter of the fan ring and use a hole saw the same size as the diameter in order to cut the vent hole.



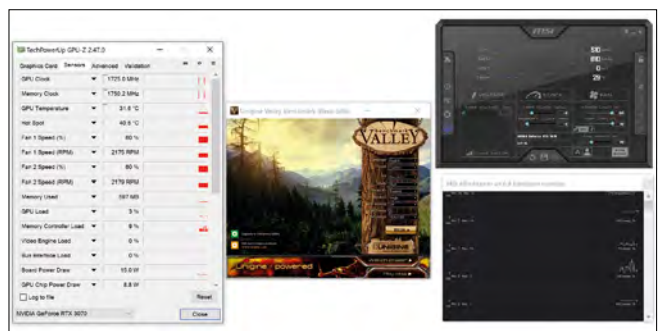
#### 7 / FILE THE EDGES

With the hole cut, use a metal file to sand the edges, as they will be rough in places. You can also use 100-200-grit sandpaper, but only use it on the inside of the hole, as it can easily mark exposed areas of the PSU cover.



#### 8 / INSTALL THE FAN

We've used Thermaltake's reversible SWAFAN 120, as it still looks good when exhausting, but any fan will do. Fit your fan using the mounting screws in the lower part of the fan, using a small screwdriver to pass through the upper hole to reach it. The screw will bite into the PSU cover and secure the fan.



#### 9 / COMPARE TEMPERATURES

Install and run GPU-Z ([techpowerup.com](http://techpowerup.com)) and MSI Afterburner ([guru3d.com](http://guru3d.com)), setting GPU-Z to show the highest GPU core frequency and temperature. Use a 3D graphics benchmark such as Unigine Valley ([benchmark.unigine.com](http://benchmark.unigine.com)) to record the peak values after ten minutes, both with and without the fan on the PSU cover. We saw a 4°C drop in GPU temperature and a 15MHz increase in peak boost frequency after our fan was added.





# How to Install and use a fill port

**Antony Leather** shows you how to make refilling your water-cooling loop easier and less hazardous, thanks to the magic of a fill port

**TOTAL PROJECT TIME / 2 HOURS**

**W**hile it's usually easy enough to fill up a reservoir these days, doing this in close proximity to your hardware, or with your PC powered on, can be hazardous, as well as inconvenient. Even after you've filled the reservoir and primed your loop, air bubbles can take hours or even days to work their way to the reservoir where they're trapped, eventually seeing its coolant level drop.

A far easier way to fill or top up your reservoir is to use a fill port. Any spills will then happen away from your components, and you won't even need to open your case's side panel. Installing one is a simple job, plus the port itself will only cost you a few quid. In this guide, we'll show you how to install and use one.

## TOOLS YOU'LL NEED



**Fill port**  
overclockers.co.uk



**Masking tape**  
Most hardware stores



**Step drill**  
Most hardware stores



**Rounded metal file**  
Most hardware stores



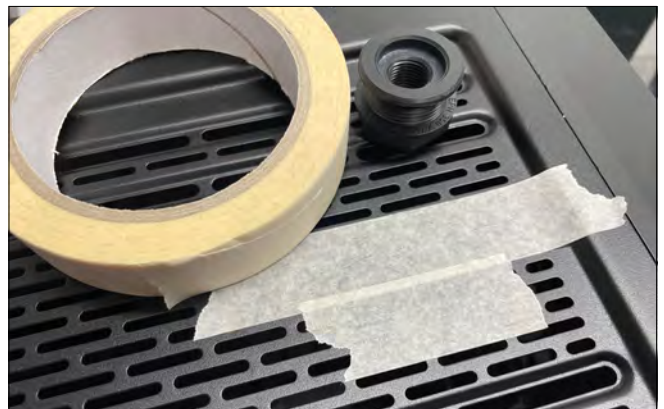
### 1 / CHECK FOR EXISTING FILL PORT HOLE

Some cases, especially high-end models from the likes of Phanteks and Fractal Design, already include the hole necessary to fit a fill port, usually in the top fan mount panel. It's worth checking your case's manual or product page first to see if it has one.



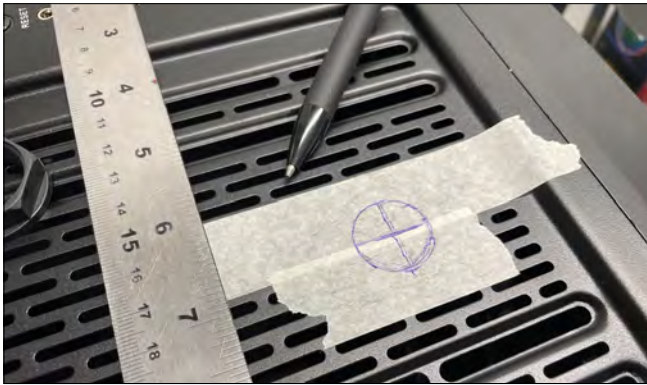
### 2 / IDENTIFY FILL PORT LOCATION

If you need to make your own fill port hole, it should be positioned above your reservoir, ideally in the roof of your case. You could add it next to the front panel ports, or even underneath a mesh panel, but you'll need to check there's clearance for it.



### 3 / MASK UP FILL PORT AREA

You'll be using a drill to cut the hole, and drill bits can easily slip and scratch your case's paint. For this reason it's essential to cover the area in masking tape, which will prevent damage to your case if this happens.



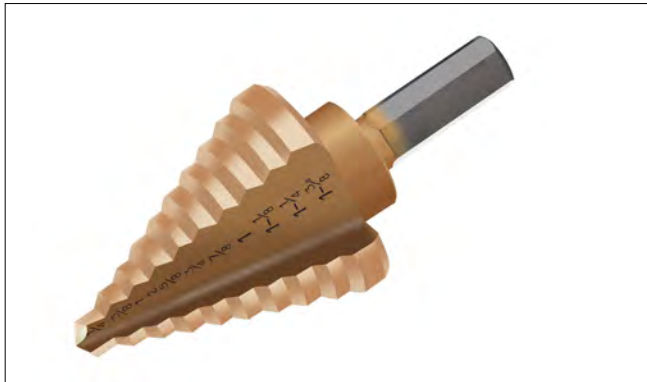
#### 4 / MARK FILL PORT LOCATION

The fill port will have a specific size of shaft, and you need to use a step drill of this size, or a millimetre wider, but no more or you risk the port cover not hiding the hole. Mark the centre position of the hole where you need it.



#### 7 / FILE THE EDGES

Once the hole for your fill port has been created with the step drill, use a rounded metal file to smooth down the hole, as it will very probably be sharp and have a serrated edge.



#### 5 / USE STEP DRILL

A step drill can gradually open a hole with its graduated cutting sections, starting with a small one as an anchor point. A step drill will also enable you to cut into mesh areas, as in our example. A hole saw shouldn't be used here, as it will tend to tear up the slim mesh sections.



#### 8 / TEST-FIT FILL PORT

Next, place the fill port into the hole. It should slot freely into place. Don't force it or screw it into the hole, as the metal case can damage the plastic threads on the fill port. If this happens, file away more of the edge or open the hole another millimetre.



#### 6 / DRILL THE HOLE

Remove all the hardware from your case, if you haven't done so already. Then, when you're ready to start drilling, use the weight of the drill to cut into the case using your step drill. Do this at a slow speed.

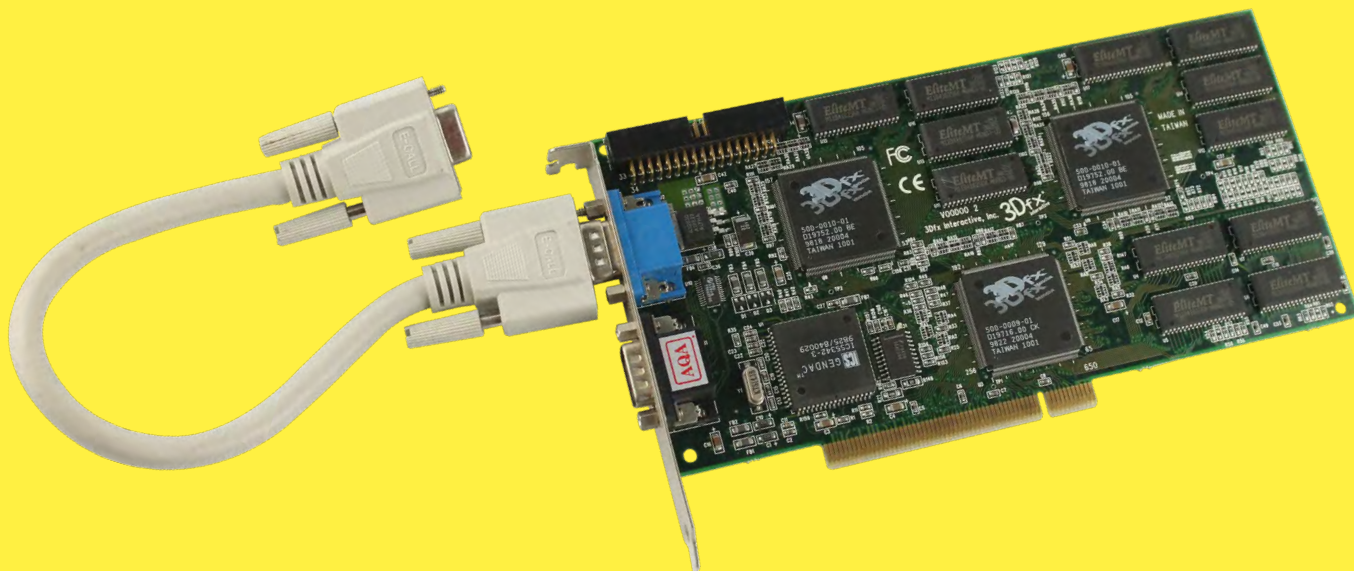


#### 9 / CONNECT FITTINGS AND TUBING

The fill port secures using a nut from underneath, leaving just a couple of millimetres on top. Both ends have a G/14in threaded hole, with a port plug going in the top and your tube fitting in the base. This needs to connect to a port on the main reservoir chamber, ideally its main fill port. **GPC**



# Retro tech



## 3DFX VOOODOO2

PCBs packed with chips, the first taste of SLI and 'high-res' 800 x 600 gaming. **Ben Hardwidge** takes a look at 3dfx's final dedicated 3D gaming card

**J**ust how do you follow up a card as beloved, groundbreaking and just plain damn awesome as 3dfx's original Voodoo Graphics chipset? There was, after all, no way to repeat that gargantuan leap from the grainy, low-resolution horror of CPU-bound 3D rendering to the smoothness of hardware-accelerated rendering all over again, but 3dfx knew it had to maintain its momentum, and the Voodoo2 promised an awful lot.

Not only did the Voodoo2 give you the ability to upgrade your 3D gaming resolution from 640 x 480 to 800 x 600, but if you paired two of them together with a ribbon cable in the new SLI mode, you could even play games at 1,024 x 768 (cue sarcastic jaw drop).

While it's difficult to think of this as high resolution in an age where people are sincerely discussing gaming at 7,680 x 4,320, back in 1998 most people were using 14-15in CRT screens, some of which couldn't even go above 800 x 600 in non-interlaced mode. The idea that you could actually run 3D-accelerated games at 1,024 x 768 (786,432 pixels), when the first Voodoo cards could only run at 640 x 480 (307,200 pixels), seemed astonishing.

### VOODOO MAGIC

We'll come to SLI in a minute, though, as the Voodoo2 was already taking advantage of parallel processing on its own, without the need for a second card.

Part of the reason why I loved the Voodoo2 so much at the time isn't just because it was immensely powerful, but also because the cards themselves really looked like they were packed to the rafters with silicon. Like early sound cards, the PCBs were covered in chips.

There was either 8MB or 12MB of EDO memory, made up of 256KB chips, often on either side of the circuitboard, and there were also three big chips with fancy 3dfx logos on them, which is where the magic happened. Why three? Well, the Voodoo2 took the idea of the original two-chip Voodoo Graphics chipset and parallelised some of the work.

Let's step back and look at that first Voodoo Graphics chipset, called SST1 and built by TSMC on a 500nm process. It had two main chips – a frame buffer interface (FBI) and a texture mapping unit (TMU), each of which were usually allocated 2MB of memory, giving you 4MB in total, although some cards gave you more memory.



The job of the FBI was to take the polygon data from your CPU, and do the basic pre-texturing work – Z-buffering, Gouraud shading, tracking the polygons and filling the visible ones with basic shading.

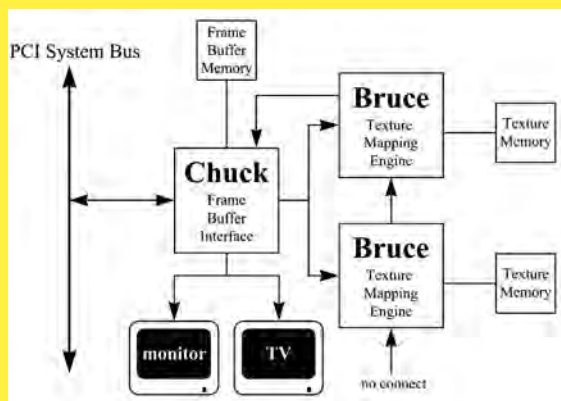
Each frame would then be split into scan lines and sent to the TMU (or T-Rex as 3dfx called it), which would apply perspective-correct textures, including mipmapping (using smaller, less-detailed textures as an object becomes more distant) and bilinear or trilinear filtering (smoothing out blocky textures when displayed at their largest size close to the viewpoint). For more background, it's worth reading Stuart Andrews' full piece on it, which is available in our Retrograde free PDF book download ([custompc.co.uk/retro](http://custompc.co.uk/retro)).

### THREE CHEERS FOR THREE CHIPS

The Voodoo2 then took this same approach and ran with it. For starters, it accelerated a bit more of the 3D graphics pipeline in hardware, taking the triangle setup process away from the CPU. Secondly, the architecture officially had the ability to scale with more texture units being added. The original Voodoo Graphics standard also had this ability to scale with extra TMUs (it's detailed in the whitepapers from the time), but it was never used in the gaming cards available in the shops.

## Trilinear filtering could now be performed in one pass rather than two

Like SST1, the new SST2 chipset (fabricated on a 350nm process by TSMC) also contained an FBI chip codenamed Chuck (denoted by 'CK' on the chip) and a texture unit codenamed Bruce (denoted by 'BE' on the chip). A standard Voodoo2 card would sport one Chuck chip, which did all the communication with the CPU, performed the aforementioned triangle setup, and also applied Gouraud shading, alpha blending, fogging, depth-buffering and dithering. Chuck also had its own 2-4MB allocated chunk of 90MHz EDO memory, addressed through a 64-bit interface, and handled display controller duties as well.



A close-up of one of the texture mapping units found on Voodoo2 cards – the 'BE' shows that it's a 'Bruce' chip. Photo credit: Stonda, licensed under CC BY SA 3.0

The frame buffer interface, codenamed Chuck, was joined by two texture mapping units, codenamed Bruce, with each chip getting its own allocation of memory

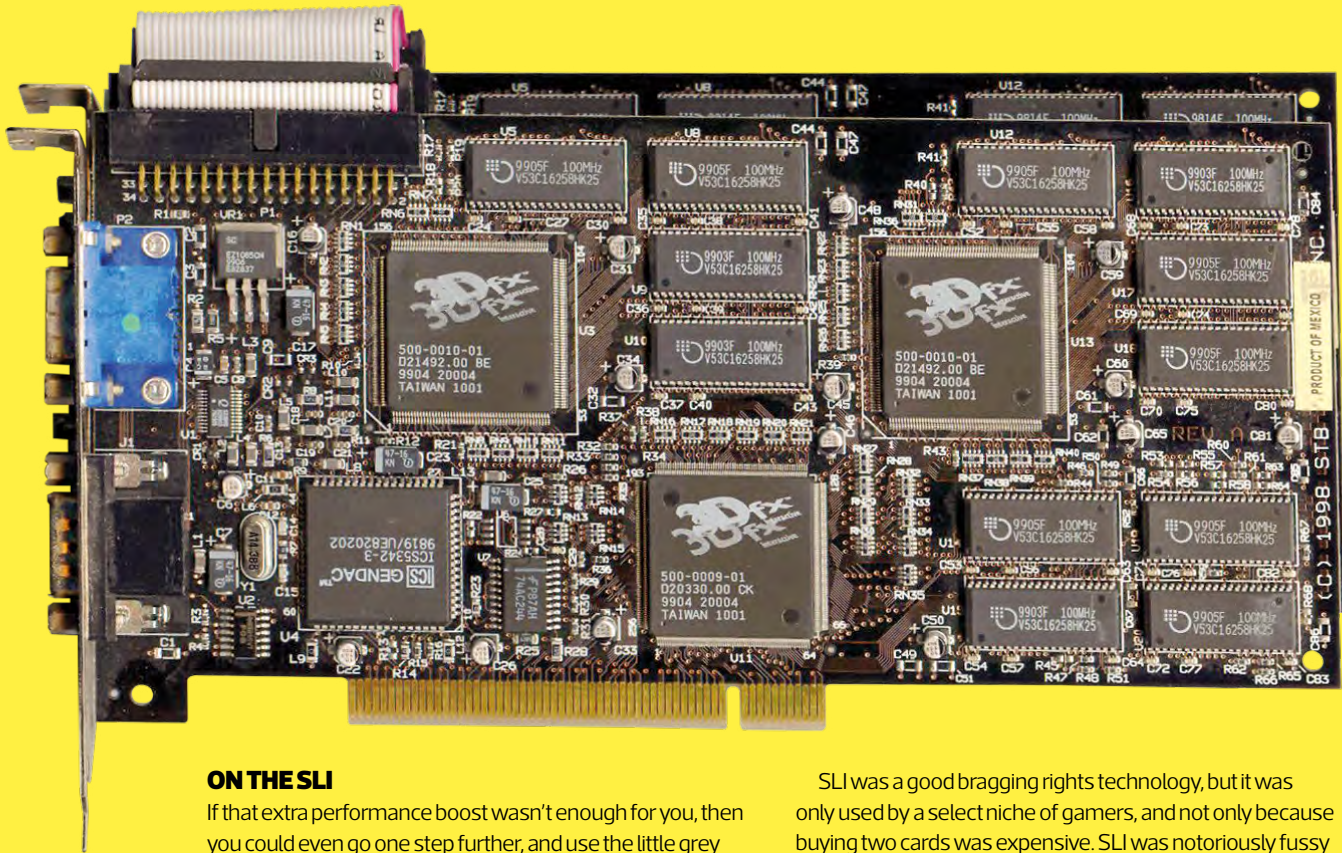
Two Bruce chips would then be hooked up to Chuck, and as with the T-Rex chip on the original Voodoo Graphics chipset, these would map the textures to the correct perspective, and process level-of-detail (LOD) mipmapping, as well as applying bilinear or trilinear filtering.

By having two of these chips on one card, you could effectively perform double the texturing work in a single pass, as long as the game supported more than one texture layer. Both Unreal and Quake II supported dual texturing per pixel in a single pipeline pass, for example, resulting in gains from the Voodoo2 compared with the original Voodoo Graphics cards.

If the game didn't support dual texturing then you'd still get a decent uplift from the clock speed increase, going from 50MHz on the first Voodoo to 90MHz on the Voodoo2, but the difference wasn't so pronounced. Having that extra chip on hand also effectively gave you the ability to enable other features that would otherwise take too much of a performance hit due to the number of passes required.

A prime example is trilinear filtering, which could now be performed in one pass rather than two. There was also then more headroom for simulated bump mapping, reflection maps, shadow maps, more detailed textures and lighting maps. Some games really took advantage of this, such as the 1998 game Battlezone, for which you could download a Voodoo2 patch that gave you some graphical enhanced effects, including more detailed explosions.

As with Chuck, each Bruce chip had a 64-bit memory interface and its own allocation of EDO memory. The minimum spec was 2MB per Bruce chip, which would give you an 8MB card with a 4MB frame buffer. There were also cards with more memory – 12MB cards, where each chip had 4MB allocated to it, were a very common option.



A pair of STB Voodoo2 cards connected by an SLI ribbon cable. Photo credit: Swaaye at the English-language Wikipedia, licensed under CC BY SA 3.0

## ON THE SLI

If that extra performance boost wasn't enough for you, then you could even go one step further, and use the little grey ribbon cable that came in every Voodoo2 card's box. This cable enabled you to chain two Voodoo2 cards together using the pin headers at the tops of the cards.

The two cards could then share synchronisation information with each other over the cable, giving you the headroom needed to run games at 1,024 x 768, and enabling even more work to be done in one pass, as you now had four Bruce chips working together.

Although SLI is the same initialism used by Nvidia, which bought out 3dfx and its assets in December 2000, for its (now largely defunct) multi-GPU gaming technology, the original 3dfx implementation worked quite differently. For Nvidia, it stood for 'scalable link interface', where cards worked together either on alternate frames or in a split screen mode.

For 3dfx, it stood for 'scan line interleave', and it took advantage of the part of 3dfx's pipeline in between the Chuck and Bruce chips. Chuck would do the job of splitting each frame into scan lines (horizontal chunks of pixels from the left edge of the scene to the right), and then the Voodoo2's pair of Bruce chips would get to work on the texturing work. With two cards, however, they could work in tandem – with one card texturing the even-numbered scan lines, and one card texturing the odd-numbered ones.

Again, the benefit here wasn't just the performance boost, but the ability to process even more work in a single pass. For example, a single Voodoo2 could do trilinear filtering with mipmapping in a single pass, but would require two passes if you then added detail textures to the mix. Adding a second card meant this could all be done in one pass.

SLI was a good bragging rights technology, but it was only used by a select niche of gamers, and not only because buying two cards was expensive. SLI was notoriously fussy when it came to cards working together, and the only safe way to ensure compatibility was to buy two identical cards from the same manufacturer at the same time.

This cut down your options for upgrading. If you bought a single Voodoo2 card at first, upgrading to SLI later would require you to look for an identical card. There were some exceptions, where cards from different manufacturers would cooperate with each other, but there was risk involved.

## The all-in-one Banshee was significantly slower in games that supported dual-texturing

Plus, as we mentioned earlier, not every game supported multi-texturing in this way, which meant your two expensive cards were sometimes no faster than a single one. What's more, having two cards put a lot of extra work on the CPU, which still handled a fair amount of the 3D graphics pipeline at this time, including transform and lighting.

Previously, you only needed a 1st-gen Pentium CPU to get a 3dfx Voodoo Graphics card working well at 640 x 480 in most games, and officially, the Voodoo2 had the same requirements. However, SLI upped the pressure on the CPU. In 3dfx's own tests, a 200MHz Pentium would run Quake II at 36fps in SLI mode, but this went all the way up to 67fps if you had a 300MHz Pentium II – you really needed to remove the CPU bottleneck if you wanted to run two Voodoo2 cards.



And there were more problems still, even if you bought two identical cards. For example, Creative's website detailed a problem using two Creative cards with a 75Hz monitor refresh rate using the bundled cable. Its advice was to either use a single cable or run your monitor at 60Hz instead.

The Voodoo2 was also still only a 3D accelerator, meaning you also needed a dedicated 2D graphics card, which you'd connect to the Voodoo2 with a VGA loop-back cable round the back. You still only needed one loop-back cable for SLI, but once you had two Voodoo2 cards, you were then using three of your PCI slots for graphics alone.

That's a problem when most motherboards had few integrated components, and people often had at least a PCI modem and sound card as well. Not only did an SLI system mean potentially running out of PCI slots, but every expansion card also needed its own system resources, and resolving IRQ conflicts with SLI systems was a right pain.

## WAILING BANSHEE

3dfx did have an answer to the multiple card problem, with a Voodoo2-based card that could handle both 2D and 3D duties, much like the previous Voodoo Rush cards had done with the first Voodoo Graphics, but with just one main chip. Called the Banshee (denoted by 'BAN' on the chip), it was available with the new Accelerated Graphics Port (AGP) interface, which had started appearing on motherboards.

The Banshee effectively combined the resources of a Chuck chip and a single Bruce chip in one piece of silicon. It also upped the chip clock speed slightly to 100MHz, and used 100MHz SDRAM, rather than the 90MHz EDO memory on the standard Voodoo2 cards.

The lack of a second texture unit meant the Banshee was significantly slower than the Voodoo2 in games that supported dual texturing, but its small clock speed advantage meant the Banshee was very slightly quicker in other games.

However, concentrating all that processing power (4 million 350nm transistors) into a single 137mm<sup>2</sup> chip made the Banshee a toasty customer. It came with a heatsink on the chip as standard (some Voodoo2 cards also had heatsinks on their chips), but that small heatsink still became seriously hot to the touch – it was well worth jerry-rigging a small fan to it if you wanted to keep it in check.

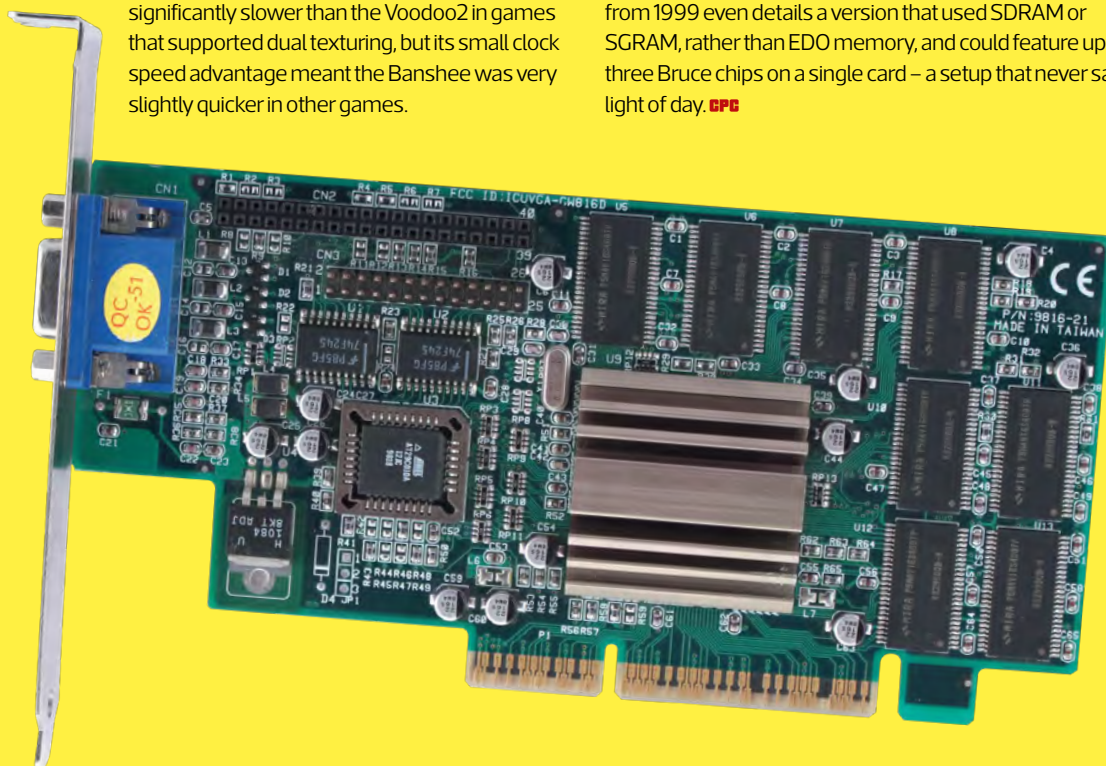
With largely disappointing performance, as well as thermal issues, the Banshee struggled to compete with other all-in-one cards, such as Nvidia's Riva TNT, as well as ATI's Xpert cards, but it did lay the foundation for the single-chip Voodoo3 that appeared later in 1999.

## THE LAST DEDICATED 3D CARD

The Voodoo2 was a success for 3dfx, with the ability to run games at 800 x 600, and its improved performance, making it highly popular with gamers. At this time, going down the 3dfx route was the only way to ensure compatibility with the company's GLide API, which was required by some games, and also sometimes looked better than Direct3D and OpenGL at the time – you could only get reflective floor surfaces in Unreal using GLide, for example.

But the Voodoo2 was the last of its era – the competition was busy making 2D/3D combo cards, such as Nvidia's Riva TNT, and 3dfx later fully joined the club with its Voodoo3. The age of the dedicated 3D gaming accelerator was over, but the Voodoo2 laid a large part of the foundation for parallelising the 3D graphics pipeline with multiple processors.

Its last gasp came when 3dfx pulled all of its card manufacturing in house, and rebranded it as the V2-1000, a budget 3D card for people who couldn't afford the Voodoo3, and later Voodoo4 and 5 cards. The final Voodoo2 whitepaper from 1999 even details a version that used SDRAM or SGRAM, rather than EDO memory, and could feature up to three Bruce chips on a single card – a setup that never saw the light of day. **CPC**



The Banshee didn't look anywhere near as exciting as the Voodoo2, and it only had one texture mapping unit. Photo credit: Slaventus, [vgamuseum.ru](http://vgamuseum.ru), licensed under CC BY SA 3.0



# Readers' drives

## Operation Don't Electrocute Yourself

For his 50th birthday, Steve Higgins decided to splash out on a top-end new system packed with RGB lighting, and have his first stab at making a custom water-cooling loop



### /MEET THY MAKER

**Name** Steve Higgins

**Age** 50

**Occupation** Self-employed community development specialist

**Location** Flixton, Manchester

**Main uses for PC** Gaming, video production, photo editing, office work and web development

**Likes** Horror movies, cycling, playing the ukulele (badly), the occasional glass of port

**Dislikes** Getting a mouthful of purple coolant

**GPC:** Let's start at the beginning. What inspired you to build this PC?

**Steve:** I've been building PCs for 30 years for myself, family, friends and so on, but I'd never actually got round to building a custom loop. I'd looked at some of the creations featured in *Custom PC* and thought 'I wish I could do that'. I'd messed around with a series of AIO coolers in the preceding years, but with my 50th birthday approaching, I decided I was going to take the plunge.

I'm self-employed and do a lot of my work via online conferencing – the aesthetics angle might be considered secondary to performance, but my PC is in the background when I'm conferencing. My previous builds have been a good talking point when speaking

with potential customers, so I also wanted to up the ante a little.

**GPC:** Why did you choose the Lian Li PC-O11D Asus ROG case?

**Steve:** I love the look of the O11D – it's a nice roomy case for building, it shows off your components nicely, and the second chamber for the PSU and drives makes tidying the cables a lot easier. When you're dealing with a lot of RGB components, you really need extra room for the additional cabling and control hubs.

I had the regular-sized PC-O11 in white and silver previously, but I upgraded to a black PC-O11 XL just for a change. I found that I loved the look of white components against a black case, as the components seem to glow against the dark backdrop.

**GPC:** Tell us about those light-up RGB triangles.

**Steve:** They're Corsair LC100 lighting panels. They're magnetic, so it's relatively easy to just put them where you want inside a typical



PC chassis. The PC sits next to some Nanoleaf panels on my office wall, so there's some attractive symmetry between them, although I haven't synchronised them with each other yet. They're controlled by iCUE, along with all of the other RGB elements, so synchronising them is very simple.

**GPC:** That's a lot of lighting! Take us through all the parts that light up.

**Steve:** My theme was essentially 'RGB all the things', which I know enrages some people (certainly my World of Warcraft guild mates!) but I love it. A guiding principle was



that every light had to be controlled using a single piece of software. I've previously used a wide range of RGB lighting, but it can be very hit and miss when it comes to how well the different parts work with each other, and the software is often awful, particularly from motherboard manufacturers.

I wanted a wide range of RGB products that would play nicely together, and for it to be relatively straightforward to change the lighting quickly. Corsair's iCUE is probably the best software I've used for this (though the bar is quite low!).

The case fans at the top and bottom of the case have the brightest RGB elements. They're

**GPG:** That's a really tidy build. How did you plan the tubing and cable routing?

**Steve:** I'd put together most of the hardware around three months ago using an AIO cooler, so I'd had time to get all the cables tidied away to a reasonable degree in the second chamber of the case.

I usually stick fan hubs, RGB hubs and so on to the back side of the motherboard tray and roof of the second chamber, to avoid cables piling up at the bottom of the case, and then route cabling up to them, making heavy use of cable ties to spread out surplus cabling. It's amazing how quickly a rat's nest forms in your case if you don't keep

The PC sits next to some Nanoleaf panels on my office wall, so there's some attractive symmetry between them

Corsair QL120 fans – they're okay in terms of performance and they look great. The CPU block, pump/reservoir unit and the RAM are also Corsair and controlled through iCUE. The GPU block is made by Barrow and was a little difficult to find, as my card (a Gigabyte RTX 3080 Vision OC) uses non-standard power connectors, so many manufacturers didn't release a block for it. It uses a 3-pin 5V connector for RGB duties, but I use an adaptor to plug it into a Corsair Hub and control it through iCUE.

The Asus motherboard has an RGB panel over the IO shield, but thankfully it plays well with iCUE without requiring any additional cables or adaptors. When I'm video conferencing for work (with the PC in the background), I tend to keep the larger RGB elements, such as the fans and the lighting panels, white and leave the RAM, waterblocks and pump/reservoir to slowly cycle through colours. If I put it in full rainbow-unicorn mode, it continually messes with the white balance on my camera!

on top of it. It helps that the second chamber of the case isn't visible – it's possible to get the interior looking in a 'good enough' state without having to be obsessive about it.

For the water-cooling loop, I spent some time placing the water-cooling components in various positions within the case to see what would give me the simplest tubing runs while still looking balanced – I didn't want to cram

## SYSTEM SPECS

**CPU** Intel Core i9-12900K

**GPU** Gigabyte Nvidia GeForce RTX 3080 Vision OC

**Storage** 4 x 2TB NVMe SSDs

**Memory** 32GB Corsair Vengeance RGB Pro 3200MHz

**Motherboard** Asus ROG Strix Z690-A

**PSU** Cooler Master V850 v2 Gold 850W

**Cooling** Corsair Hydro X iCUE XH303i water-cooling kit





all the gear into one corner of the case in order to keep tubing lengths shorter, and then have big empty spaces around the rest of the case.

I learned that understanding which ports are inlets and outlets on the waterblocks and pump/reservoir unit is paramount here – I almost got it wrong with the GPU block thanks to a dodgy translation in the instructions

**GPB:** What tubing did you use, and how did you cut and bend it to shape?

**Steve:** The Corsair Hydro X iCUE XH303i kit I bought was supplied with 14/10in PETG hardline tubing. I did use the little hacksaw that came with the kit, but soon binned it in favour of a Dremel, which was much faster and gave me a cleaner, more accurate cut. A cheap hot air gun did the business with bending the tubes, along with a silicon insert to keep the shape of the tubing as it was bent. I did have a bending tool available to create specific angles but ended up not using it.

**GPB:** Take us through the water-cooling loop?

**Steve:** I've always been put off custom loops because of my lack of understanding of (and fear of mismatching) fittings and tubing. I went with a Corsair complete kit, because it meant those decisions were already made for me, and I could be sure all the kit would match properly (plus I was already using iCUE).

Now that I've had a bit of experience, though, I'm a lot more comfortable buying other manufacturers' kit. Within a couple of days of setting up the CPU loop, I decided to add my graphics card to the loop, sourced a waterblock for it and merrily dismantled my card. Several days after that I added a second radiator. I was well and truly bitten by the water-cooling bug – I'm already planning what parts I'm going to use for my wife and son's PCs.



**GPB:** How did you find working with hard tubing?

**Steve:** This is the part that made me most nervous – I'd initially planned to use soft tubing due to the relative ease of cutting and manipulating it into place, but after looking at other people's systems, I decided that hardline tubing looked better, plus if other people can do it, so can I!

I watched hours of video, asked for advice on online forums, bought all the tools and so on. My wife actually did the first couple of tubes because she's far better at that sort of thing than me, before I gave it a whirl. It wasn't nearly as hard as I'd feared it might be though. Patience is the key – let it heat up slowly and evenly, and you can manipulate it quite easily.

**GPB:** What spec did you choose and why?

**Steve:** It's a Core i9-12900K with 32GB of RAM and an Nvidia GeForce RTX 3080 graphics card. I've been a PC gamer since I built my first PC in



1992, but I also use my PC for a wide range of activities, such as making videos, editing photos, conferencing and so on, so a good, versatile spec is important to me.

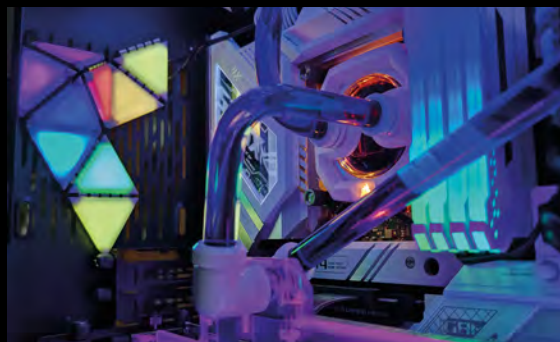
Over the years I've always gone for the best price/performance CPU but with my 50th approaching, I felt like splurging a little. That said, I didn't want to pay outrageous prices for DDR5 RAM, so I went with DDR4 motherboard and reused the RAM from my previous system.

**GPB:** What PSU cables are those?

**Steve:** They're Antec sleeved cable extensions. I'm using a white Cooler Master 850W PSU, and I find the sleeved cables look a little more respectable than the stock cables. I did previously use Lian Li Strimer RGB cables, which looked great but just wouldn't fit around the water-cooling tubing.

**GPB:** What temperatures do you get with those six fans and the custom loop?

**Steve:** I've been really impressed with both the temperature drops and the quietness of the system. The Core i9-12900K is a hot boy, and I hadn't expected much of an improvement from the AIO cooler I'd been using, but my system went from most cores idling in the mid-30°Cs to the mid-to-high-20°Cs, with significantly less noise from the fans.





Once I'd added the GPU to the loop, the CPU temperatures increased a little but the GPU temperature dropped by around 15°C. The fans often drop to zero rpm and the PC is almost silent, which is a pleasant change from what I'm used to.

**GPC:** Did you come across any difficulties?

**Steve:** Getting the air out of the loop. I now have arms like Popeye after rotating the case to move the air bubbles.

**GPC:** Do you have any tips for readers thinking about creating their first custom water-cooling loop?

**Steve:** Don't leave it as long as me to give it a try. There's a lot of information available online, and plenty of knowledgeable and helpful people to support you, plus the end result is incredibly satisfying.

Also, on a more practical note, I'd advise anyone building a custom loop to include a means of draining the system—I didn't and ended up getting a mouthful of coolant after trying to siphon it out when I added the GPU block. To be fair, it tastes better than you'd think, but it probably isn't good for you!

**GPC:** Are you completely happy with the end result?

**Steve:** I set out to familiarise myself with the process and the parts, so from that perspective, I'm happy with the end result. If I knew two weeks ago what I know now, I'd have included the GPU block and second radiator from the start, but I didn't think I'd find the whole experience so enjoyable. Now I've done it once, though, I'm keen to try out other components, other types of coolant and to see how creative I can get with the tubing. I suspect this build will never truly be finished! **GPC**

## WIN CORSAIR HYDRO X WATER-COOLING GEAR



To enter your rig for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (@CustomPCMag) or Facebook (CPCMagazine), or email low-res ones to [ben.hardwidge@raspberrypi.com](mailto:ben.hardwidge@raspberrypi.com). Fame isn't the only prize; you'll also get your hands on some fabulous prizes, courtesy of Corsair.

### Corsair Hydro X Series XD3 RGB Pump/Reservoir C

The Corsair Hydro X Series XD3 RGB Pump/Reservoir Combo features a high-performance DDC PWM pump, integrated RGB lighting and in-loop temperature sensor to drive even the most compact custom cooling systems. It has a high-performance Xylem DDC PWM pump controlled via PWM to deliver the perfect flow balance for your loop. There are also 16 individually addressable RGB LEDs, which light up the pump head to produce stunning, customisable lighting effects to match your build.



WORTH  
£151

### Corsair Hydro X Series XC7 RGB CPU Water Block

The Corsair Hydro X Series XC7 RGB CPU Water Block combines premium construction, vivid RGB lighting and extreme cooling performance to become the centrepiece of your water-cooling loop. It has a nickel-plated copper cold plate and more than 60 high-efficiency micro-cooling fins, which efficiently draw heat away from your CPU, lowering operating temperatures and allowing for maximum overlocks. You can choose a version for Intel or AMD CPU sockets.



WORTH  
£70

### Corsair Hydro X Series XR5 240mm Radiator

The Corsair Hydro X Series XR5 240mm Water Cooling Radiator delivers extreme custom cooling performance, with a 30mm radiator thickness and premium copper core. Its dual 120mm fan mounts on each side are ready for your most ambitious custom cooling build, and its 25 micron-thick cooling fins offer a high thermal transfer rate.



WORTH  
£55





JAMES GORBOLD / HARDWARE ACCELERATED

# ON THE RISE

With a decent amount of stock, and great performance, James Gorbald is impressed by AMD's latest CPU launch

**T**his issue marks the start of Q4, a time when tech companies positively fall over themselves to launch new products in time for the peak shopping season to come. The first company off the blocks this year is AMD, with its Ryzen 7000-series processors, but there are plenty more new products to follow.

By the time you read this, Intel will have announced its 13th-gen Core processors and Nvidia will have announced its next-gen GeForce graphics cards. AMD's next-gen Radeon graphics cards aren't all that far off either.

With such extensive editorial coverage in this issue, there's little value in recounting the specs and capabilities of AMD's new Zen 4 microarchitecture in my column. However, in case you've not read everything yet, let me give my own personal summary. AMD has done a fantastic job of increasing both single and multi-threaded performance with these new processors. In our own testing in the 3XS Lab, we measured up to a 30 per cent increase in the former and 50 per cent in the latter, when compared with the equivalent Zen 3 CPUs.

These sorts of speeds would be remarkable alone with an architectural shift, going from Zen 3 to Zen 4, but AMD has also accompanied them with a massive improvement in power efficiency, at least when performing heavily multi-threaded tasks such as rendering.

It's not all roses. We found that the Ryzen 9 7950X overheats and throttles at its default settings, even with a high-quality 360mm all-in-one liquid cooler attached, but this is easily fixed by undervolting the IMC, a task that takes a few clicks in the BIOS. That's a small blot in an otherwise unblemished record.

But enough about the architecture – the big question for both retailers and buyers is whether there will be enough

stock to meet demand, and if prices will remain stable. After all, AMD's Ryzen 5000-series CPUs, Intel's 12th-gen Core chips, Nvidia's GeForce RTX 30-series GPUs and AMD's Radeon RX 6000-series GPUs were plagued with purchasing problems. Unexpected high demand, limited and erratic supply, soaring costs and disrupted supply chains all contributed to many PC enthusiasts and gamers being unable to buy the products they wanted at the price originally intended.

While I don't have a crystal ball, I think it's a fair assumption that these launches won't see the unprecedented demand from which the first three of those launches suffered. Firstly because, outside of mainland China, most of the world's population is no longer in lockdown.

Secondly, at a time of impending recession, demand has already started to soften. Global supply chains and logistics are generally speaking in a much better position too, although there are still issues with the supply of some specific semi-conductor components, such as substrates.

While it's too early to see how the other launches will go, looking at the AMD Ryzen 7000-series launch in particular, I think AMD is definitely worthy of a 'most improved over last year' award.

For instance, while I can't reveal specific numbers, I'm really pleased that Scan has managed to secure over 110 per cent more Ryzen 7000-series CPUs for this launch day than Ryzen 5000-series chips at launch.

We'll have to see how long those CPUs last, and I may well be eating my words if demand is anything like that of 2021, but I really don't see that happening. Hopefully, this time, many PC enthusiasts will be able to freely buy a new CPU when they're ready for it. **GPC**

Scan has managed to secure over 110 per cent more Ryzen 7000-series CPUs

James Gorbald has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.





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