NVIDIA SLI IS IT STILL WORTH USING TWO GPUs FOR GAMING?

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Welcome

Custom PC Issue 201

/ FROM THE EDITOR

Uncompromising specs

It feels very strange to be finishing off an issue of **Custom PC** in the midst of the chaos surrounding COVID-19, and it hasn't always been easy, but we're still immensely pleased with this issue.

In particular, the PC in our cover feature (see p76) has an amazing specification for the budget – we've never managed to assemble a sub-£1,000 PC with such an uncompromising spec before.

It's not just that there's a 6-core 3rd-gen Ryzen CPU beating at its heart, but it also has a GeForce RTX 2060 Super GPU, a cracking case, 16GB of very fancy Corsair RGB memory and a 500GB NVMe PCI-E SSD. It even looks good. There isn't a single part of this PC that made us rub our chins and think, 'Hmm, well, that's a bit rubbish, but I suppose you have to compromise somewhere'.

If you want to play games at 1,920 x 1,080 at high settings, including ray tracing, then this PC can handle it with no problem. In fact, it can even handle gaming at 2,560 x 1,440 with decent settings.

If you want to go all out with the gaming eye candy at much higher resolutions, and you have plenty of money (not to mention patience), then we also thoroughly recommend checking out our Nvidia SLI test on p86.

Many of us are going to be spending a lot of time indoors over the next few months, so now is a good time to be fiddling with our PCs, playing games and taking our minds off the horror outside when possible. If you turn to p13, you'll also find details about how you can use your PC's spare CPU and GPU cycles to conduct research that could be used in COVID-19 therapies, via Folding@home.

If you're not spending a lot of time indoors, and you're carrying on as an essential worker, then I also want to say an enormous thank you. For everyone else, stay home, stay safe and, if possible, enjoy fiddling with your PC. GPC

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CUSTOM PC

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ISSUE 201

ISSUE 201
SUBSCRIBERS EDITION

This magazine is printed on paper sourced from sustainable forests. The printer operates an environmental management system which has been assessed as conforming to ISO 14001.

Custom PC magazine is published by Raspberry Pi (Trading) Ltd., Maurice Wilkes Building, St. John's Innovation Park, Cowley Road, Cambridge, CB4 0DS. The publisher, editor, and contributors accept no responsibility in respect of any omissions or errors relating to goods, products or services referred to or advertised. ISSN: 1740-7443.

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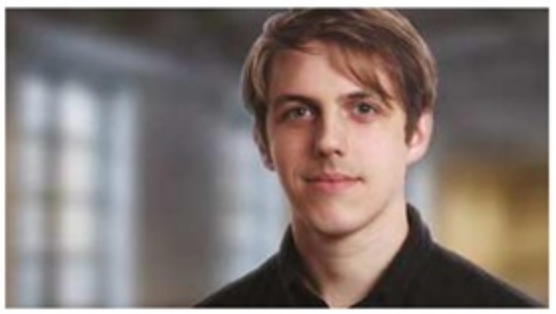

RICHARD SWINBURNE / VIEW FROM TAIWAN

GET READY FOR WI-FI 7

Richard Swinburne looks at the latest Wi-Fi tech developments, from 30Gbps speeds to superior mesh networks

The folks at the IEEE and Wi-Fi Alliance aren't sitting still. After just launching Wi-Fi 6E, which is Wi-Fi 6 (802.11ax) extended into the '6GHz band' (5.71–7.13GHz actual), engineers are already knee-deep in 802.11be development, which is likely to adopt the Wi-Fi 7 name.

Called 'Extremely High Throughput' (EHT), it features impressive headline speeds of 30Gbps. However, the better features, in my opinion, are some of the improvements elsewhere. Firstly, though, don't worry if you've just upgraded your home router, as this new standard isn't expected to launch for a few years yet.

Just as Wi-Fi 5 (802.11ac) and Wi-Fi 6 borrowed heavily from 4G LTE mobile tech, such as MU-MIMO and OFDMA respectively, Wi-Fi 7 is borrowing from tech that's now being proven in 5G. That's clever, because it means research and development costs are being adsorbed by smartphone chip/modem makers and mobile network operators, with engineers being able to reuse their knowledge when it comes to creating future Wi-Fi chips.

> Working together, these three technologies will make large mesh networks feel seamless

However, even though Wi-Fi is influenced by mobile tech, these two areas are also competing against each other in some respects. 5G has enjoyed taking a lot of wireless spectrum under its paid-for banner, which locks it out from public use. Mobile lobbyists are also pushing to use the same 6GHz spectrum that's in the process of being allocated in the US, UK, and Europe. Wi-Fi 6E effectively beat them to it, though. By launching products into the market that use the full 5.71–7.13GHz range, Wi-Fi 6E has made a spectrum landgrab that can't be undone.

Wi-Fi 7 builds on this approach by allowing each compatible device to aggregate multiple smaller bands among the 2.4GHz, 5GHz, and 6GHz ranges, boosting performance. Termed 'non-contiguous uplink' it's analogous to the carrier aggregation system used in 4G and 5G, and it will really help to increase average throughput for upload heavy tasks, such as streaming. Why it's not also being used for downlink is unclear, although it's possible that non-contiguous downlink could be added later during the standard's development.

Mesh networks will get a big boost from non-contiguous connections, while also benefitting from 'Multi-Access Point (AP) Coordination' and 'Cooperative Multi-User MIMO' (CMU-MIMO). These technologies mean that data isn't just split between various bands across the 2.4GHz, 5GHz, and 6GHz frequency ranges, but also across different access points. Working together, these three technologies will make large mesh networks feel seamless. That's not just great for the home, but in particular, it will result in a significant boost for public Wi-Fi spaces that are shared by many users.

Beyond these new additions, Wi-Fi 7 also multiplies the core numbers of Wi-Fi 6. It doubles total channel bandwidth from 160MHz to 320MHz, doubles the number of MIMO streams from 8 to 16, and quadruples the data squeezed into the signal with 4096-QAM.

This all sounds great, but the downside will be increased cost. Even with some of the principal research and development costs offloaded, all this tech needs really high-performance network processors, plus twice the number of antennas and all their associated radio front-end filter chips, which increases costs. Backward compatibility means Wi-Fi will remain ubiquitous to all devices, but the best speeds and most reliable connections won't come cheap. A main benefit of Wi-Fi is that it's accessible in places where you can't get a mobile signal – let's hope the 802.11be development committee doesn't forget this. CPC

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

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TRACY KING / SCEPTICAL ANALYSIS

CANCELLED

With big gaming shows being cancelled in the wake of COVID19, Tracy King asks if we even really need big gaming showcase events now

Our time is now. All of the hours we've spent indoors, in isolation, online and entertaining ourselves, have turned out to be ideal practice for a pandemic quarantine. Of course, by the time this column goes to print things may have changed completely, but at the time of writing, the year ahead in gaming looks like one of physical solitude. So, gaming as usual for us, but goodbye to showcase events.

Most people who have been to a games event, or a convention of any sort, will be familiar with 'con crud', the cold or mild flu everyone seems to get from being in close proximity to others indoors. The spread of viruses is exacerbated by everyone touching the same stuff – from controllers to VR headsets to door handles – with nary a sanitising handwipe in sight. For this year, all events are cancelled, but that doesn't mean doom for the game industry.

The first major event to announce cancellation was E3, but even then there were already rumours of difficulties, with big names such as Sony bailing in 2019 to avoid competing for press coverage with Nintendo and Microsoft. While huge conventions are an industry staple for networking, and they foster a sense of excitement through big crowds, they're increasingly cost-ineffective, particularly when online gaming influencers can do so much for a brand from home.

Instead, PR events will shift to online. Gaming showcases can be streamed in different ways. Instead of a huge stage of presentations to a live audience, there will be smaller, more intimate presentations with the at-home viewer feeling as much a part of the 'show' as industry professionals. That's the model I'd prefer anyway. Too much money is spent on showboating and splashy PR, and losing the 'champagne gaming' events will contribute to a more grassroots and authentic gaming culture. Ubisoft and others have already announced digital E3 alternatives.

> Losing the 'champagne gaming' events will contribute to a more grassroots and authentic gaming culture

At the time of writing, all scheduled games events are cancelled, but console online subscriptions are up and Twitch streaming has doubled. The BAFTA Games Awards will now be a streaming event instead. Esports events are either cancelled or postponed in parallel with physical sports such as football. Watford Football Club tweeted a simulated game against Leicester City in Football Manager 20 – it's had a million views.

This situation might be scary, weird and new, but some of the cultural changes will be good. Empathy could rise, and those of us who already live online are well equipped to support friends, strangers, industry and even science. If you can, sign up for **foldingathome.org/start-folding** and use your gaming rig to help simulate potentially druggable protein targets from SARS-CoV-2 (the virus that causes COVID-19) – the **Custom PC** team number is 35947 if you want to join us. Not least, that could help to tackle some of the weird helplessness that kicks in after reading the news.

I have no idea what 2021 will look like, for the gaming and tech industries, or for society in general, but I'm determined to make the best of it. Gaming is essential for my mental health, so I'll continue to buy as many games as I can afford, to do my part to keep the industry going and to keep me sane during quarantine. There will be other ways to make up for the loss of physical events, and if the gaming industry can weather the financial storm of the next 18 months, then it will realise that those huge expensive conventions aren't needed. CPC

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdot

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Incoming

AMD CONFIRMS 'ENTHUSIAST-CLASS' RAY-TRACING GPUs FOR 2020

AMD has revealed that its next-gen gaming GPUs are scheduled to be released in late 2020. Unlike the company's first RDNA Navi products, such as the Radeon RX 5700 XT, the new RDNA 2-based GPUs will also support hardware-accelerated ray tracing.

AMD unveiled these details about its new GPUs at its Financial Analyst Day on 5 March, while also revealing that RDNA 3 is in development, with products expected before the end of 2022.

The company describes its forthcoming RDNA 2 GPUs as 'enthusiast-class', with 'uncompromising 4K gaming', meaning they could potentially take on Nvidia's top-end GPUs, rather than competing in the mid-range like AMD's current Navi chips.

In addition to hardware-accelerated ray tracing, AMD also promises up to a 50 per cent improvement in performance per watt for RDNA 2 chips over their 1st-gen RDNA predecessors.

The company puts the improvements down to logic enhancements and optimisations to the new microarchitecture, enabling it to reduce the complexity and switching power of the new chips, as well as improve the performance per clock and increase the clock speed.

According to AMD, the new GPUs will also fully support Microsoft's recently announced DirectX 12 Ultimate API.

RDNA 2 will also support variable rate shading (VRS), another feature that was previously only supported by Nvidia's Turing GPUs. Meanwhile, Scott Herkelman, vice president and general manager for Radeon, has also confirmed on a Reddit thread that there will be no blower coolers on the reference models of the new GPUs. That's a great move, although we're still surprised it's taken AMD so long to get around to it.

AMD's first Navi products showed enormous improvements in both performance and power consumption over AMD's previous Graphics Core Next chips, with fast frame rates for the money. However, the lack of hardware ray tracing puts them at a disadvantage compared with Nvidia's pricier RTX GPUs, making the latter the natural choice if you want to play games with realistic lighting, shadows and reflections.

AOC UNLEASHES 240Hz GAMING MONITOR

AOC has just released a super-fast monitor to cater for the growing esports market. The AGON AG273QZ not only has a fast 240Hz refresh rate, but AOC also claims it has an extremely quick response time of 0.5ms. Meanwhile, there's active sync support for owners of AMD GPUs, via FreeSync Premium Pro, which enables active sync for HDR content, eliminating tearing artefacts.

The AGON AG273QZ also officially supports the DisplayHDR 400 standard, and AOC claims that its TN panel can display 126.4 per cent of the sRGB colour gamut, with a peak brightness of 400 nits. Meanwhile, there's a customisable RGB lighting system on the back, and a stand that allows height, tilt and swivel adjustments. The AOC AGON AG273QZ has a recommended UK retail price of £659 inc VAT.

USE YOUR PC TO RESEARCH COVID-19

Join the **Custom PC** Folding@home team **35947**

Here's a great chance for you to use the processing power of your gaming PC for medical research. The Folding@home distributed computing project has started processing work units specifically for COVID-19 research, so now is a great time to put your PC's spare CPU and GPU clock cycles to work.

You can download the client from **foldingathome.org/start-folding**. If you then select 'Any disease' in the 'I support research fighting' pulldown menu, Folding@home will send you COVID-19 work units (among other research bits and pieces) for your PC to crunch.

'We're simulating the dynamics of COVID-19 proteins to hunt for new therapeutic opportunities,' said Professor Greg Bowman, leader of the Folding@home project in a recent blog post (**custompc.co.uk/StanfordCOVID19**). 'Viruses also have proteins that they use to suppress our immune systems and reproduce themselves. To help tackle coronavirus, we want to understand how these viral proteins work and how we can design therapeutics to stop them.'

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research, digitally simulating the incredibly complex science of protein folding.

We started the **Custom PC** folding team back in 2004, and we're currently number 12 on the world leaderboard. However, interest in the team dried up a couple of years ago, possibly because of the popularity of cryptocurrency mining.

We'd like to heartily thank some of the dedicated folders who have kept the team going in the meantime, such as Shirty, DocJonz, PC_Rich, Slavcho, BeezaBob and many others. We may well bring back our dedicated Folding@home page in the coming months, as our team can potentially really help with this research – let's kick the **Custom PC** Folding@home engine back into action.

You just need to download the client and use the **Custom PC** team's ID number of 35947, although feel free to fold for any other team if you want as well. The most important thing, of course, is that the work units are getting crunched, rather than competition between teams.

You may well have a bit of a wait for work units, so please be patient. Thanks largely to the PCMR team (number 225605), which has heavily promoted the project on Reddit and social media, and picked up plenty of momentum, loads of people have signed up to Folding@home recently, which is great news, although Folding@home has struggled to distribute work units to everyone quickly.

'We've had such an enthusiastic response to our COVID-19 work that you will see some intermittent downtime as we sprint to set up more simulations,' says Bowman. 'Please be patient with us! There's a lot of valuable science to be done, and we're getting it running as quickly as we can.'

Download foldingathome.org/start-folding
Custom PC's team 35947
More info on the COVID-19 research custompc.co.uk/StanfordCOVID19

What's that? Winner be quiet!

We're not running a 'What's that?' competition this month, but the winner from our Issue 199 competition was Stuart Henshaw, who correctly identified the ADATA Spectrix D60G memory from p57. Congratulations Stuart, we'll be in touch shortly to get your be quiet! Dark Base Pro 900 case sent on its way to you!

KOLINK LAUNCHES £50 RGB CHASSIS

If you fancy some RGB case bling, but think you can't afford, it Kolink's new £50 RGB chassis might be the answer. Coming in at £50 inc VAT, the Kolink Balance has a digitally addressable RGB LED strip down the front, which can be controlled by a switch on the I/O panel, or via your motherboard's RGB header.

The preinstalled 120mm exhaust fan also sports digitally addressable RGB lighting, which can be seen through the tempered glass side panel. Meanwhile, there's room for CPU coolers up to 162mm tall, and graphics cards up to 370mm wide, with a vertical mount for the latter, although it requires an optional PCI-E riser. There's even room for a 360mm/280mm radiator in the front, and you get a PSU shroud too. The Kolink Balance is available to order from **overclockers.co.uk** now.

Letters

Please send us your feedback and correspondence to
letters@custompcmag.org.uk

Asus' ROG Swift PG27UQ can run at 4K with a 144Hz refresh rate

When's the next issue out?

CUSTOM PC

MAY 7

Issue 202
on sale on Thursday, 7 May

Refreshing!

Any chance you could run a feature test on monitor refresh rates, to find a sweet spot between resolution and refresh rate? 4K is still (to my knowledge) locked to 60Hz, so I'm looking at changing my monitor for a lower resolution but higher refresh rate, and this feature test would be invaluable to me

STEWART AYERS

Ben: Most 4K monitors are indeed locked at 60Hz – you can get 144Hz from a monitor such as Asus' brilliant ROG Swift PG27UQ, but it costs the best part of two grand, and even the cheapest models come in at around £800. We'll look into doing a test on refresh rates in the future, but in the meantime, check out our monitor Labs on p52, which features 2,560 x 1,440 and 1,920 x 1,080 displays with 144Hz+ refresh rates.

Is AMD moving too fast?

It's been great to see AMD getting back on its feet. It's been developing astonishing hardware at a rate with which the industry and buying public can't keep up and, it would appear, the software developers can't keep up either! AMD Adrenalin is causing serious issues for some users, and I'm one of them, with my monitor dropping out, and getting blank screens at boot or after a few hours of use. Using a Ryzen 7 3700X on an X570 motherboard, I certainly expected no issues when upgrading to an AMD GPU (a Sapphire Radeon RX 5600 XT) from my RX 480 – I was wrong!

Then there's the chaos surrounding the Radeon RX 5600 BIOS update. Shifting hardware without giving enough time to ensure the software is fit for purpose is only losing AMD credibility, and it will result in returns and switching back to the competition. There's great potential in the market now, with AMD producing quality hardware again. However, I'll be very guarded before purchasing shiny new hardware from AMD in the future.

DAVE GWYTHER

AMD has issued BIOS updates for Radeon RX 5600 XT cards to boost clock speeds

Ben: Thanks for all the info, Dave – it's always really good to hear about users' experiences in the big wide world. There have certainly been some teething problems with the Radeon RX 5600 XT – even when we had our pre-release sample, AMD released a new BIOS update to increase the clock speeds before it was launched, and we then had to do all our tests again.

There were also a load of issues when the 1st-gen Ryzen products launched a couple of years ago, but I'm very glad to see that these have been ironed out with future generations. I'm hoping the same will also be true for future RDNA products. If anyone else reading this has been having problems with their GPU, we'd be very interested to hear from you.

Silicon heaven

I had to laugh at your reference to a certain TV show in the Ausein Smart Bulb review. 'When your big mining ship needs to go to Red Alert ...' Does this bulb also do a brown colour for the Brown Alert? Also, 'Green with NVMe' – your magazine is full of hidden gems.

I'm planning on building a new system and I was doing some research through your magazine. My missus is moaning at me that I've not chosen a new PC yet, but I wonder how many possible combinations of PC components exist! I'm still stuck with the usual AMD vs Intel battle, but a GeForce RTX 2080 Super will definitely be in it.

JAMIE 'BOYS FROM THE DWARF'

Ben: Glad the puns are hitting the spot Jamie! It's only a matter of time before Better than Life comes to VR, surely?

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Reviews

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SPEC

Base frequency
2.9GHz

Max boost frequency
4.3GHz

Core
Zen 2

Manufacturing process
7nm

Number of cores
64 x physical (128 threads)

IGP
None

Simultaneous Multithreading (SMT)
Yes

Cache
256MB L3, 32MB L2

Memory controller
Quad-channel DDR4, up to 3200MHz)

Packaging
AMD Socket TRX4

Thermal design power (TDP)
280W

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

Let's be honest, AMD's 64-core Threadripper 3990X is so far outside the envelope for most of us that it's a desktop CPU in name only. The high motherboard cost, eye-watering CPU price and sheer number of cores mean this monster CPU is not only out of reach for most of people, but completely unneeded too.

We already began to see the limits of standard Windows-based desktop PCs with AMD's Threadripper 3970X, with diminishing returns in many benchmarks that simply can't scale to use so many cores. Throwing a 64-core beast at them isn't likely to improve the situation, so while the Threadripper 3990X is undoubtedly a monster CPU, it's still a niche product that needs the right conditions to show its true potential.

Its specs certainly pack a punch, though, with a monumental 256MB L3 cache and 32MB L2 cache, thanks to all four Core Chiplet Dies and their corresponding eight Core Complexes being enabled. Despite this, AMD maintains the same 280W TDP as the other two 3rd-gen Threadripper CPUs, thanks to lower boost frequencies.

Indeed, we observed an all-core boost of 3.25GHz in Cinebench R20's multi-threaded test with our 240mm all-in-one liquid cooler, but the 32-core Threadripper 3970X regularly hit 3.9GHz. As such, unless all those cores are fully utilised, the cheaper Threadrippers may end up being faster in some lighter-threaded tests. The single-core boost is also 200MHz lower than the Threadripper 3950X, and our experience with Precision Boost Overdrive and manual overclocking Zen 2 CPUs is that it's unlikely you'll attain a higher peak boost than that.

Performance

At stock speed, our usual benchmarks failed to respond to the extra cores, which is to be expected. There was little difference in our mostly single-threaded GIMP image editing test between the 3990x and the 3970X, although both chips still outperformed Intel's Core i9-10980XE here. The result from our multi-threaded video encoding test was disappointing, but again, this is down to HandBrake simply not utilising this many cores. In fact, even Intel's 18-core CPUs represent poor value here, even if they show a little scaling. The system score in the end was similar to other 3rd-gen Threadripper CPUs, so the 3990X won't give you much more performance in general mainstream use, if any.

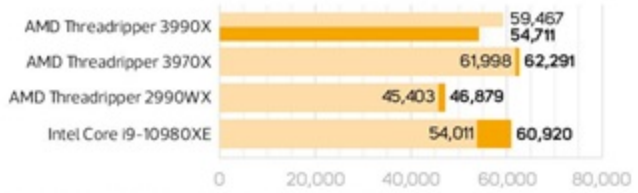
We then used two versions of Blender in our testing, as the latest version better supports high core-count CPUs. In version 2.79, the 3990X was only a couple of seconds quicker than the 3970X, but in the newer version, it was 37 per cent faster, showing much better scaling. Cinebench R20 also saw a sizeable improvement, with 3970X's 17,303 score eclipsed by the 3990X's 24,116.

Overclocking quickly results in a power supply-battering, cooler-melting exercise, but ultimately our goal was to improve that all-core boost frequency from 3.25GHz. Our powerful EKWB Phoenix liquid cooler certainly helped, as it meant that applying PBO and maximum automatic overclocking settings in Ryzen Master saw the CPU hit 3.9GHz across all cores under load.

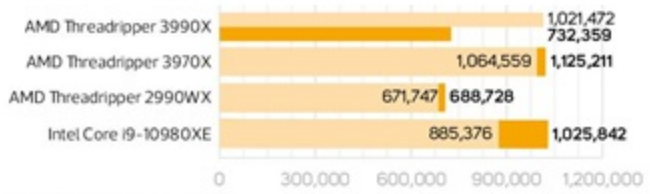
This saw the power draw rocket to 845W, but the Cinebench score rose to a massive 28,432 and the Blender 2.82 result fell from 31 seconds to just 24 seconds (although performance massively dropped in Handbrake). The CPU regularly topped 80°C at these settings, though, so you'll need monstrous cooling for long load periods.

BENCHMARK RESULTS

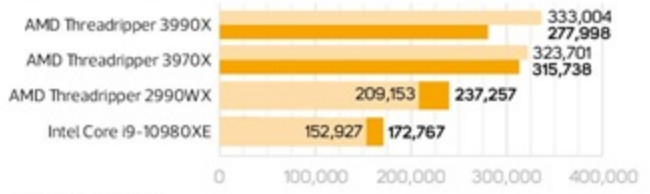
GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING



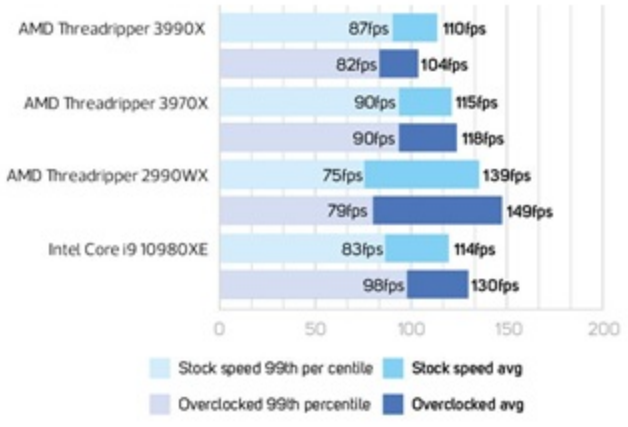
HEAVY MULTI-TASKING



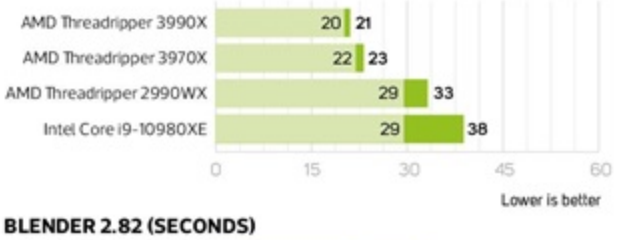
SYSTEM SCORE

FAR CRY 5

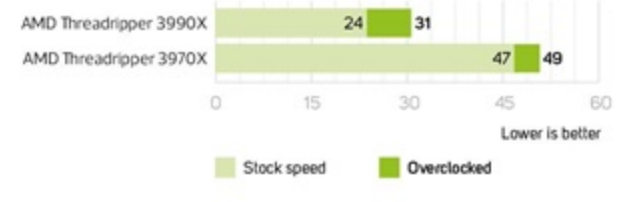
1,920 x 1,080, Ultra settings



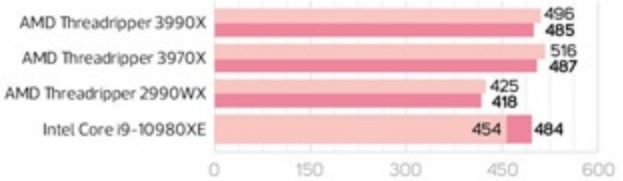
BLENDER 2.79 (SECONDS)



BLENDER 2.82 (SECONDS)

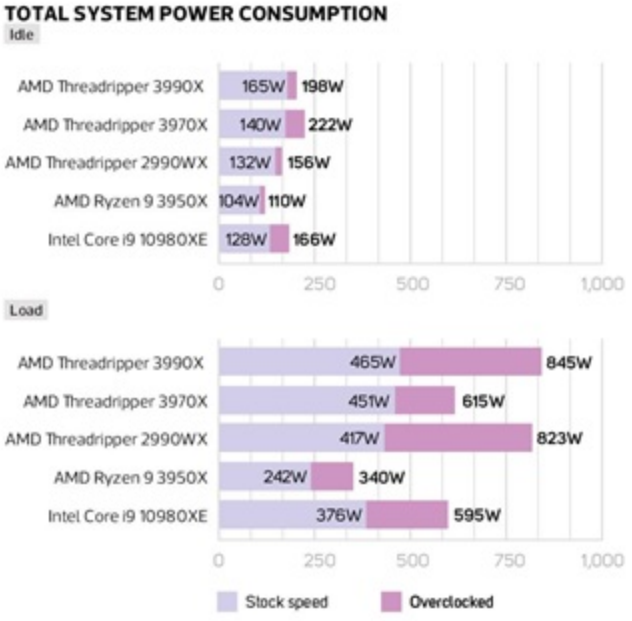


CINEBENCH R20 SINGLE-THREADED



CINEBENCH R20 MULTI-THREADED

TOTAL SYSTEM POWER CONSUMPTION



Conclusion

While the Threadripper 3960X makes for a compelling, super-powerful all-rounder, the Threadripper 3990X is more of a niche product for specific workloads. It's superb where all those cores and threads are fully utilised, tearing up the already powerful Threadripper 3970X and offering nearly double the performance once overclocked.

However, much cheaper CPUs are faster in most mainstream software, even when it's multi-threaded.

Despite its bragging rights potential, the 3990X is therefore not a CPU we should aspire to own. A Threadripper 3960X will be much more fitting for a hardcore gamer that hits content creation applications just as hard. For those with the budget and applications hungry for this amount of CPU horsepower, though, the Threadripper 3990X is undoubtedly the ultimate multi-threaded desktop CPU.

ANTONY LEATHER

VERDICT

Devastatingly powerful, but only in the right applications.

WORKSTATION

- \+ Most powerful ever desktop CPU
- \+ Huge multi-threaded performance
- \+ Still fast in most other apps

BUS STATION

- – Only select software uses extra cores
- – High temps and power draw when overclocked
- – Low peak boost

PERFORMANCE **46/50**

FEATURES **15/15**

VALUE **19/35**

OVERALL SCORE **80%**

ALL-IN-ONE LIQUID CPU COOLER

NZXT KRAKEN X53 / £120 inc VAT

SUPPLIER scan.co.uk

GIANT SQUID

- Good cooling
- Easy installation
- Software pump control

PRAWN

- No fan speed software control
- Some cheaper coolers perform better
- Barely improves over predecessor

We're very familiar with NZXT's Asetek-based AIO liquid coolers these days, as there have been several generations of successful products, which have often picked up **CPC** awards in spite of stiff competition from the likes of ARCTIC and Corsair. The company's Kraken coolers haven't received an update for a number of years, but it's now released several new coolers, including the X53 we're looking at here.

The Kraken X53 is the successor to the X52, and it uses a 240mm half-height radiator, so it sits at the bottom of the new stack, with 280mm and 360mm models above it. NZXT has apparently introduced its 7th-generation pump with it, although it has very similar credentials to the one used on the older cooler, with a speed of up to 2,800rpm. However, the Kraken X53's pump can apparently spin down to 800rpm, which is half the speed of the old cooler.

The two units use identical NZXT Aer P120 fans, which spin between 500rpm and 2,000rpm, dishing out a claimed noise of 21-36dBA. However, the X53 lacks software fan control. As such, while the pump hooks up to your PC using a USB cable via a spare USB 2 header, and can be controlled using NZXT's CAM software, the fans will need to be hooked up to your motherboard.

We were a little disappointed not to see a fan splitter cable to make cable tidying easier as well. That's a shame, as it was previously possible to have the fans respond to the coolant temperature, rather than the CPU temperature, which can result in a far quieter, but no less effective cooling system. It's still useful to be able to control the pump, though, as it becomes audible at full speed, and dropping this speed didn't have much impact on temperatures.

Other new bits include a 10 per cent bigger RGB LED ring on the waterblock unit, which still includes the Kraken X52's holographic infinity ring design. This still looks great, but it ultimately isn't much of an improvement compared with its predecessor, with precious few new features. The same can be said for a lot of new coolers from various manufacturers though.

However, the whole top can now also rotate, so you don't need to worry about trying to orientate the NZXT logo when you install it, as you can now do that afterwards. The tubing and barbs are identical too, with the latter still freely rotating, so you can orientate the tubing to suit your radiator position.

The radiator itself has the usual half-height design, and it measures 30mm thick and 275mm long, so it should fit into any area that claims to offer space for a 240mm radiator. The 400mm tube length should also allow for installation of the radiator in the roof or front of your case in all but the biggest chassis. Installation will feel very familiar to anyone that's

SPEC

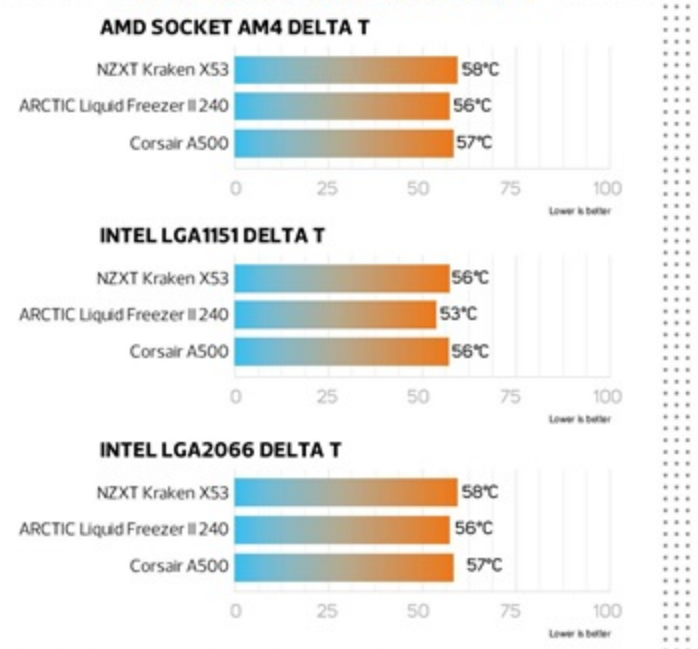
Compatibility Intel: LGA2011/v3, LGA2066, LGA115x; AMD: Socket AM4, TR4/X, AM3/+, AM2/+, FM2/+, FM1

Radiator size with fans (mm) 123 x 275 x 55 (W x D x H)

Fans 2 x 120mm

Stated noise 21-36dBA

TEMPERATURE RESULTS



used an Asetek-made cooler from the likes of Corsair or NZXT before, with the included plates securing to the pump section to allow mounting to Intel LGA2066 and LGA115x sockets, as well as AMD's Socket AM4.

However, you'll need to fish around in your Threadripper CPU's box for the adaptor AMD includes for Socket TR4 and TRX4 motherboards. All the mounts, except Socket AM4, use four-point mounting mechanisms and thumbscrews, while the AM4 mount relies on two clips in conjunction with the stock mounting mechanism on AM4 motherboards. Thermal paste is, as usual, pre-applied, so be extra careful not to dislodge it, as there's no spare paste in the box. Of course, this also means you'll need to invest in some paste if you upgrade your CPU.

Meanwhile, the accessory box includes enough fan screws to install a second row of fans, enabling you to boost cooling in a future upgrade. There are also smaller screws to mount the radiator directly to your case, which you'll likely want to do if you mount it in the roof.

Finally, we come to the cables. The pump is powered by a SATA cable, which also doubles as an RGB cable, allowing you to connect other NZXT HUE RGB products. Meanwhile, a micro-USB cable connects the pump to a USB 2 header on your motherboard.

Performance

We only have a slim number of cooling results since we updated our test systems, but overall, the Kraken X53 performed slightly below the ARCTIC Liquid Freezer II 240, sitting a degree or two behind it in all three of our systems. The biggest gap was in our LGA1151 system, with 3°C separating the two. In two tests, even the cheaper Corsair A500 air cooler managed to pip the X53 to the post, albeit with far higher noise levels. The ARCTIC Liquid Freezer II 240 was a little louder at full speed too, and also includes a small VRM cooling fan, but in general, the Kraken X53's performance sits roughly where we'd expect, given the fan speed and radiator size.

Conclusion

The Kraken X53 is a fine CPU cooler, but nothing really leaps out to make you want to buy it over the competition. The removal of software fan control definitely loses it brownie points too. If you're forced to use software rather than your motherboard's EFI to control the pump, then why not tie in fan control here too? It seems counterproductive to use two different pieces of software to control different parts of the same cooler, although admittedly you'll probably only need to set it up once.

With a price tag of well over £120, you'd expect fan control as part of the package, especially when the ARCTIC Liquid Freezer II 240 outstrips it in terms of performance, if not in aesthetics. However, we can't argue with the solid performance, snazzy, expandable RGB lighting and ease of installation. The ability to fine-tune the pump speed from the comfort of Windows is a boon too. It's just a shame NZXT didn't link more control features to its software.

ANTONY LEATHER

VERDICT

A decent cooler, but not much of an upgrade over the X52, and it misses out on software fan control.

LGA115x

COOLING **32/40**

FEATURES **16/20**

DESIGN **17/20**

VALUE **15/20**

FITTING **Easy**

OVERALL SCORE **80%**

AM4

COOLING **33/40**

FEATURES **16/20**

DESIGN **17/20**

VALUE **15/20**

FITTING **Easy**

OVERALL SCORE **81%**

LGA2066

COOLING **33/40**

FEATURES **16/20**

DESIGN **17/20**

VALUE **15/20**

FITTING **Easy**

OVERALL SCORE **81%**

MINI-ITX CASE

FRACTAL DESIGN ERA ITX / £139 inc VAT

SUPPLIER scan.co.uk

The Era ITX is the product of Fractal Design collaborating with Intel to create a new mini-ITX case, and it demands a serious premium at £139 inc VAT. This does make it noticeably more affordable than NZXT's H1 (see p24), but that case also includes an SFX PSU and a 140mm liquid-cooling system as standard.

So what's so special about the Era ITX? For starters, it's available in some very stylish colours, including options for top panels with wood finishes. Our black sample looks quite plain by comparison. Externally, there are very few vents, and there are also no tempered glass side panels or RGB lighting. This is a very minimalist case, at least from the outside. The roof sports a large vent where you can interchange a mesh panel with a tempered glass one that looks more attractive, but doing so will reduce airflow.

The chassis, which stands 310mm tall, 325mm deep and 166mm wide, is far from being a boring cuboid, though, with its curved aluminium panels no doubt contributing to the cost. You get a pair of USB 3 ports on the front panel, plus a Type-C port that requires a full-fat Type-C header to work. You'll need a fairly recent, feature-loaded motherboard if you want to take advantage of it.

The base of the case would be a great place for an extra vent, especially as the GPU sits face-down here. However, Fractal Design has instead included vents down the sides of the base, which won't be as effective. That's a shame, as the roof sports two 120mm fan mounts and the base offers two 140mm fan mounts, but the latter can only be occupied if you're using a single-slot PCI-E device.

There's definitely scope for added ventilation here, and if we were making changes, we'd start by adding vents to the base of the case. Meanwhile, the side panels pop off with no screws required, and they offer small diagonal vents, but in general, air has a far harder time here than with NZXT's H1, which is riddled with vents.

Inside, we can't argue with Fractal Design's use of space, though, which has been well used down to every square inch. Both SFX and ATX PSUs are supported, with adjustable mounts for both sizes, which allow you to slide the PSU up and down to make way for cables, fans and radiators in the roof.

If you use a modular SFX PSU and a graphics card up to 295mm wide, there's 67mm clearance in the roof, so a 30mm-thick 240mm radiator, or a pair of 120mm radiators and one row of fans (or two rows of half-height fans) are definite possibilities here. Space is limited if you want to fit a full custom water-cooling loop, unless you use a CPU or GPU waterblock with an integrated pump, but all-in-one liquid coolers are definitely on the cards.

Another limitation is the CPU cooler height of 120mm, which rules out tower heatsinks, but does offer space for reasonably

SPEC

Dimensions (mm)
166 x 325 x 310 (W x D x H)

Material
Steel, tempered glass

Available colours
Black, blue, gold, silver, grey

Weight
5kg

Front panel
Power, 2 x USB 3, 1 x USB 3.1 Type-C, audio jack

Drive bays
2 x 3.5in or 4 x 2.5in (SFX PSUs) or 1 x 3.5in, 2 x 2.5in (ATX PSUs)

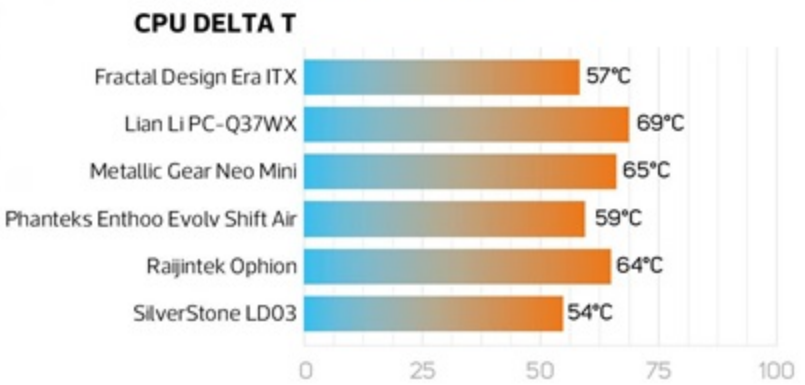
Form factor(s)
Mini-ITX

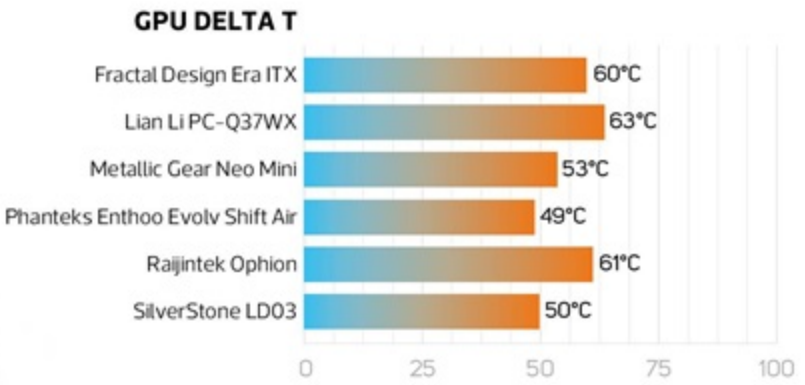
Cooling
2 x 120mm roof fan mounts (fans not included), 2 x 120/140 base fan mounts (fans not included), 1 x 80mm rear fan mount (fan included)

CPU cooler clearance
120mm (70mm with storage mount)

Maximum graphics card length
295mm (210mm/190mm with low-mounted SFX/ATX PSU)

TEMPERATURE RESULTS





chunky low-profile heatsinks. However, if you use the optional large plate that sits over the motherboard, and offers a home to either two 2.5in SSDs or a single 3.5in hard disk, that will see the CPU cooler height reduced to 70mm.

Thankfully, a second storage mount sits in front of the PSU bracket and offers an identical array of options. In short, there's space for a hard disk or 2.5in SSD without compromising on the Era ITX's liquid-cooling credentials, but you'll need to decide early on if you'll be cooling your CPU with liquid or air, as your choice will dictate your storage options, especially if you need to maximise either factor. Thankfully, cooling isn't left entirely to chance out of the box, as Fractal Design does include a single 80mm exhaust fan, which means the case will be cool enough with a low-end PC inside it.

Performance

With the mesh roof vent installed, the best cooling setup available saw a CPU delta T of 57°C, which was enough to see off the fanless mini-ITX cases from our recent group test, such as the Lian Li PC-Q37WX and Raijintek Ophion. The supplied 80mmm fan was surprisingly quiet too, although the SilverStone LD03 offered noticeably better CPU cooling, shaving 3°C off this temperature. When we added the tempered glass panel, the Era ITX's CPU delta T rose to 60°C. This isn't a disaster, so if you prefer the aesthetics of the glass panel, which is undeniably attractive, you won't be cooking your hardware.

The GPU delta T was 60°C and this figure only rose by 1°C with the glass panel installed. That's not in the danger zone, but there are some significantly better results here too, with the SilverStone LD03 shaving a massive 10°C off this result and the Phanteks Shift Air knocking 11°C off it. It's clear that our initial concerns about the lack of ventilation for GPUs in the base were on the money.

Conclusion

With a pair of 120mm all-in-one liquid cooler mounts, or space for a single 240mm radiator, Fractal Design has created a tiny case that's up to the task of cooling all but the most powerful mainstream desktop CPUs – even AMD's Ryzen 9 3950X should be tameable with a suitably powerful AIO liquid cooler. You have to deal with lots of screws and brackets, but the end result is a very flexible chassis with an above-average amount of storage and cooling options for its size.

The only downside is GPU cooling, thanks to the lack of lower ventilation, but this situation could also be improved by using a high-performance open-air GPU cooler, rather than the blower-style fan on our test card. The case is also a blank cooling canvas out of the box, with just a tiny 80mm fan included as standard. If anything, the main selling points of the Era ITX are its design and available colours. It's unique, attractive and very compact, so while it might not get top marks for cooling, it's still well worth considering if you want to build an eye-catching mini PC.

ANTONY LEATHER

VERDICT

A good-looking, flexible and tiny case, but the lack of ventilation means GPU cooling is poor.

GOLDEN ERA

+ Room for 240mm radiators
+ ATX and SFX PSU support
+ Flexible chassis

DARK AGES

– Poor GPU cooling
– Storage mounts limit cooling flexibility
– Expensive

COOLING	23/30
FEATURES	16/20
DESIGN	27/30
VALUE	15/20
OVERALL SCORE	81%

ATX CASE

LIAN LI LANCOOL II

/ £83 inc VAT

SUPPLIER overclockers.co.uk

There haven't been many sub-£100 PC cases that have wowed us as much as Lian Li's Lancool One recently. It offered good cooling, plenty of features, RGB lighting, decent water-cooling support and a unique, head-turning design. Lian Li has recently stepped up to claim the sub-£100 case crown again, though, with an updated version of the case, not surprisingly called the Lancool II. What's more, it offers even more features than its predecessor and will still leave you with change from £90.

You get a lot of case for your cash here. Let's start with the exterior, which includes hinged tempered glass side panels on both sides that require no tools to use. Below these, again on each side, you'll find panels that flip down, providing access to storage bays and the PSU area, covering up any potential cable spaghetti.

Unlike the original case, the Lancool II also sports two large mesh grilles on the front to boost cooling, although they're still fairly dainty compared with a full mesh panel, so we don't expect cooling to be improved much compared with the Lancool One. However, we love the way Lian Li has added RGB lighting to these mesh areas. The lighting is vivid yet tasteful, and the integrated RGB lighting controller enables you to cycle through various colour and effect modes, while a separate connector means you can also connect the lighting strips to your motherboard for control.

The front panel detaches too, providing access to the fan mounts beneath it, and we were amazed to see a slot-together RGB port for the lighting here too, which reconnects itself when you reinstall the panel. The vents do have removable dust filters, but you'll need to pop the front panel off to access them.

Meanwhile, the front panel sports two USB 3 ports, a 4-pole audio jack, plus power and reset buttons, and two more buttons to control the lighting. There's a USB Type-C port opening here too, but no port, with the module available separately. There are several other optional components too, such as a 3-way hot-swap SATA connector for the trio of 3.5in tool-free mounts in the base, although these can still be used as normal with SATA cables. Lian Li also offers a vertical GPU mounting kit that includes a replacement rear panel plus an anti-sag mount for the GPU.

Flipping open the far side panel reveals a large cable-tidying system, which includes numerous large plates that do a fantastic job of hiding cables, which is just as well, as the glass side panel gives a clear view of any mess. Inside the front panel, Lian Li includes a reversible fan bracket that can move forwards to provide more radiator clearance, although there's already room for 45mm-thick radiators in the front, in either 360mm or 280mm sizes.

The roof can play host to a 240mm radiator as well, and as this mount is offset, it can be a 45mm-thick model too – you could possibly install a larger radiator here too, depending on your choice of waterblock and fittings. There are three

SPEC

Dimensions (mm)
230 x 478 x 494 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black, white

Weight
13kg

Front panel
Power, reset 2 x USB 3, 1 x USB 3.1 Type-C (optional), audio, RGB lighting controls

Drive bays
3 x 2.5/3.5in, 4 x 2.5in

Form factor(s)
E-ATX, ATX, Micro-ATX

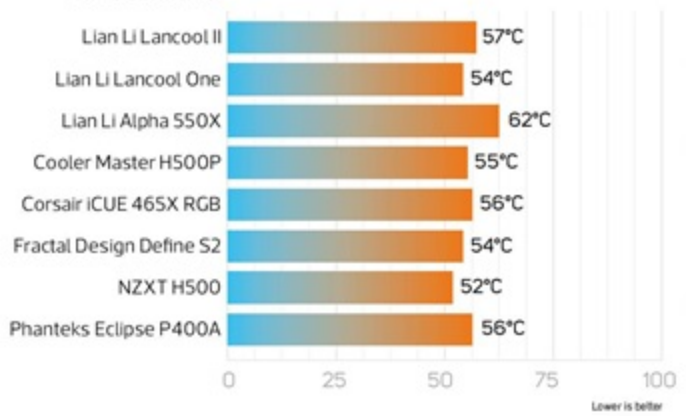
Cooling
3 x 120mm/2 x 140mm front fan mounts (1 x fan included), 1 x 120mm rear fan mount (fan included), 2 x 120mm/140mm roof fan mounts (1 x fan included), 2 x 120mm base fan mounts, (fans not included)

CPU cooler clearance
176mm

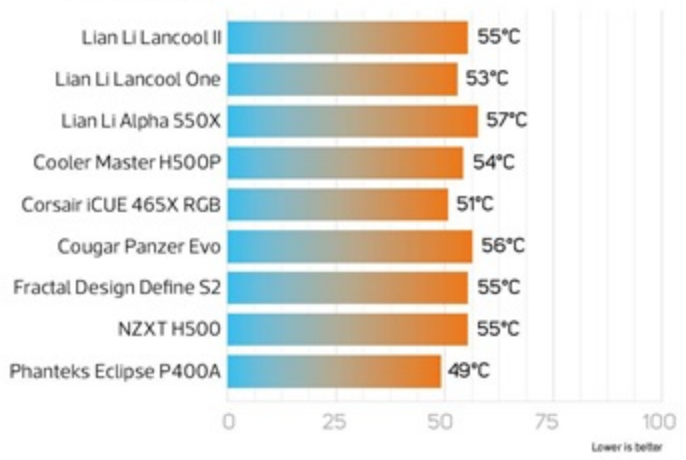
Maximum graphics card length
384mm

TEMPERATURE RESULTS

CPU DELTA T



GPU DELTA T



120mm fans included as standard in the front, rear and roof of the case, although we'd move the roof fan to the front of the case to promote positive air pressure, and to direct air at the CPU area.

Behind the motherboard tray, you'll also find two 2.5in SSD mounts, and a further pair of these mounts are sneakily hidden behind the far-side flip-down panel. There are three 3.5in hard disk mounts in a removeable cage in the base of the case as well, and these can also double as SSD mounts. As we mentioned earlier, these mounts can be upgraded with a hot-swap device too. If you plan on air-cooling your PC, then there's an ample 176mm CPU cooler clearance, largely brought about by the fact the case is quite wide for its height. It stands 49cm tall, and measures 23cm wide.

Building a PC in the case posed no problems, and the motherboard tray sports plenty of cable-routing holes, as

well as a large cable cover to hide any fan or power cables you decide to route through it. The roof and base also include dust filters to keep the interior clean as well.

Performance

The Lancool II's CPU delta T of 57°C is reasonable, but it was still a couple of degrees warmer than the original case's 54°C. The case performed similarly to the Corsair iCUE 465X RGB, but much better than the Lian Li Alpha 550X, which topped 60°C. The GPU delta T of 55°C was more competitive, matching the Fractal Design Define S2 and NZXT H500, but the Lancool One was a little cooler again. Thankfully, the fans were exceptionally quiet. Overall, the Lancool II is a capable and quiet case right out of the box.

Conclusion

With reasonable cooling, a low price, lots of features and a striking, tasteful RGB-equipped design, the Lancool II is a hit. It still includes most modern features, it has decent water-cooling support and it has more hard disk mounts than many of its peers. We also like the flexibility; if water cooling is your priority, you can remove the hard disk cage.

If air cooling is your game then you can swap other aspects about, and the addition of a full cable-hiding array of plates behind the motherboard tray means it's blissfully easy to make a great-looking PC too, as you can see in our feature on p76. The Lancool II's cable-tidying features, distinctive appearance and great design makes it one of the best sub-£100 cases available.

ANTONY LEATHER

VERDICT

A brilliant successor to the popular Lancool One, with practically no drawbacks other than middling cooling.

COOL DUDE

- \+ Plenty of features
- \+ Attractive RGB lighting
- \+ Decent water-cooling support

EMBARRASSING DAD

- – Cooling isn't chart-topping
- – No USB Type-C as standard
- – Negative air pressure by default

COOLING	25/30
FEATURES	16/20
DESIGN	26/30
VALUE	19/20
OVERALL SCORE	86%

MINI-ITX CASE

NZXT H1 / £299 inc VAT

SUPPLIER scan.co.uk

When it comes to PC cases, NZXT usually comes fairly close to nailing it, but for a lengthy period, the company completely lacked a mini-ITX case. It had small form factor designs years ago, such as the Rogue case, but until the H200 landed much more recently, it's been a mostly ATX-sized affair. We've since seen plenty of very interesting mini-ITX case designs, many of which have a skyscraper tower design, with tiny footprints, but enough height to rival some ATX cases. However, even the likes of the Phanteks Shift can't compete with NZXT's H1.

For starters, the case is tiny, making the already dinky Phanteks Shift look decidedly overweight by comparison. It stands less than 40cm tall, and its square footprint sits at 187mm on all sides, yet it has the ability to house pretty much any mini-ITX PC you can throw at it.

The price tag is also eye-watering, but there's a good reason why this case costs over twice as much as Fractal Design's already expensive Era ITX (see p20). NZXT includes a 650W SFX-L 80 Plus Gold PSU with the H1, as well as a basic 140mm AIO liquid cooler and a PCI-E riser cable. So really, that £300 price tag gets you around £180 worth of extra hardware on top of the case, which you may well need to buy for a new build anyway.

The exterior is perhaps a little Xbox Series X-like, but with a very different cooling arrangement. Three of the four sides sport mesh vents, so airflow shouldn't be a problem, with the third side using tempered glass, so you can see the interior. A large U-shaped section sits over the top of the case and makes up two of the vented side panels, which both act as intake areas as standard, and are suitably equipped with large dust filters.

The other side panels pop into place and anchor the larger section too. In short, there are no screws required to open the case. Meanwhile, the roof offers a pair of USB 3 ports, 4-pole audio port and a Type-C port, which requires a full-fat Type-C USB 3.1 header on your motherboard to work.

Internally, the H1 is extremely compact. Large parts of the case can be dismantled, thanks to its extensive screw-together construction, and there's next to no CPU cooler height clearance either, so it's clear that NZXT has designed the interior around the supplied liquid-cooling system.

This also means that you're barely able to see your hardware either, although if you have an Nvidia RTX Founders Edition graphics card, or another card with an illuminated logo on the side, you can see this logo through the tempered glass panel. Incredibly, you can even fit 305mm-long dual-slot graphics cards in the H1, with their ports sitting at the bottom of the case and fans pointing towards the vented side panel. This should mean that even high-end GPUs can be cooled adequately.

Thermal paste is pre-applied to the 140mm AIO liquid cooler's pump section, so you just need to fit it to your motherboard and connect the usual cables and you're nearly ready to go. The cables include a 4-pin fan cable that powers the pump and fans, plus the power cables that NZXT has already neatly laid out and cable-tied inside the case.

SPEC

Dimensions (mm)
187 x 187 x 305 (W x D x H)

Material
Steel, tempered glass

Available colours
Black, white

Weight
6.53kg

Front panel
Power, 2 x USB 3, 1 x USB 3.1 Type-C, audio jack

Drive bays
2 x 2.5in

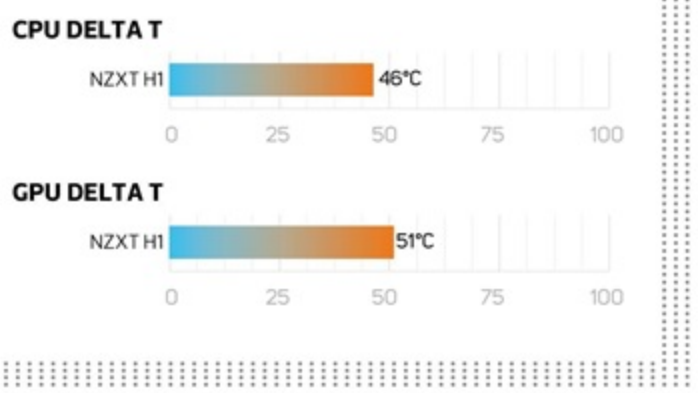
Form factor(s)
Mini-ITX

Cooling
1 x 140mm AIO liquid cooler

Extras
650W NZXT SFX-L PSU

Maximum graphics card length
305mm

TEMPERATURE RESULTS



The radiator pops out from the case to let you install your components more easily and, despite the tight confines, working with this case is remarkably simple. However, we weren't able to use our usual Corsair Vengeance RGB Pro memory modules, as there's a memory height limit of 45mm, so you'll need to check your memory height too.

Another limitation is the lack of 3.5in hard disk support. There's only room for 2.5in SSDs, with a pair of mounts in a bracket in the roof. Also, while the SFX-L PSU sits on its side, with an extension cable running to the base of the case allowing you to plug in your kettle lead, the actual PSU power switch can't be accessed with the side panels installed.

The design is mostly very well thought-out, although there's a couple of niggles. There are several areas around the base of the case that could let the GPU exhaust air recirculate back up towards its fans, but this is only likely to be small issue, and one that's limited to cards that exhaust most of their air out the rear. Even with open coolers, though, one side of the case is made from tempered glass, so air being expelled this way needs to find another way out of the case.

Performance

As our usual test kit wouldn't fit in the H1, we had to compromise and use a different set of gear. Not wanting to give the case an easy time, we opted for a Gigabyte X570 I Aorus Pro WiFi motherboard and an AMD Ryzen 9 3950X, along with an Nvidia GeForce RTX 2070 Super Founders Edition. We configured the system to respond as it would at default settings. The CPU delta T of 46°C was well away from any thermal throttling, with an absolute temperature reported in Ryzen Master of 69°C, so it's clear that the 140mm cooler is quite capable.

The GPU delta T of 51°C was also reasonable, and the graphics card remained quiet throughout testing too. The same can't be said for the radiator fan, which did spin up to quite noisy levels at full speed, but there's certainly a little leeway there to rein in the fan speeds in your motherboard's BIOS.

Conclusion

It might be a little plain-looking from the outside, but the H1's tiny stature and well-designed interior makes it a capable chassis, even for high-end systems, as long as you don't mind being spoon-fed a specific PSU and AIO liquid cooler.

The cost might seem high, but you're getting a liquid cooler, 650W SFX PSU and a PCI-E riser included too. The storage options mean you're probably limited to SSDs unless you want to use 2.5in hard disks, but the H1 is otherwise a superb home for a gaming or content-creation-focused mini PC. It has an exceptionally tiny footprint, and it also kept our hardware cool, despite a lack of dedicated case fans.

ANTONY LEATHER

VERDICT

A brilliant mini-ITX chassis design, as long as you don't need a hard drive and you're happy with the supplied PSU and cooler.

MINI COOPER

+ Copes with high-end hardware
+ Easy to build
+ Extremely compact

MINI ROUNDABOUT

– Radiator fan can be noisy
– No hard disk mounts
– Needs NZXT's supplied cooler and PSU

COOLING **25/30**

FEATURES **18/20**

DESIGN **27/30**

VALUE **15/20**

OVERALL SCORE **85%**

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/PCSPECIALIST @PCSPECIALIST

MSI OPTIX MAG272CQR / £339 inc VAT

SUPPLIER currys.co.uk

OPTICAL

+ Great contrast
+ Superb black point
+ G-Sync compatibility

TRACKBALL

– Not truly HDR
– Minor ghosting if overdriven
– Disappointing genre options

The Optix MAG272CQR aims to provide a great balance for all sorts of gaming, from single-player titles to esports. The 27in diagonal and 2,560 x 1,440 resolution are a good start, resulting in a pixel density of 109ppi. That's crisp and immersive without being too high for mainstream graphics cards to handle.

The MSI's VA panel has a 165Hz refresh rate, and like the IPS monitors in the Labs (see p52), its adaptive sync implementation works with both AMD FreeSync and Nvidia G-Sync, eliminating tearing artefacts on both company's GPUs. That refresh rate is high enough to ensure smooth, responsive gaming in high-speed esports, and the MSI's quoted 1ms response time is also excellent.

The MSI's 1500R radius is tighter than most curved displays, which are configured at 1800R, but that makes sense, because it helps immersion on smaller displays. Meanwhile, the DisplayPort and HDMI connections are joined by USB Type-C, which can be used as a DisplayPort input or device charging.

The Optix's stand also has height adjustment and can be tilted, although it has no swivel options. It looks good, with slim bezels and narrow legs, and it's sturdy too. There's a headphone hook and a slate of RGB LEDs at the rear. Meanwhile, the on-screen display menu is fast and straightforward to navigate, with key information always displayed. It's only navigated with one joystick, but it works – every key option is accessible.

The MSI also has good core image quality. Its default brightness measurement of 229cd/m^2 is decent, and its black point of 0.09cd/m^2 is stunning – deeper than most gaming displays, and low enough to give huge depth to shadowed and darker areas. The resulting contrast ratio of 2,544:1 is superb: better than any IPS display and high enough to deliver huge punch and vibrancy. It doesn't match MSI's claimed 3,000:1 figure, but it's still good.

The delta E of 2.07 is also decent, and the colour temperature of 5,989K is reasonable. That latter figure is a little warm, which leaves lighter areas with a slight red pall, but it's not hugely noticeable in games. The MSI also displayed an impressive 99.4 per cent of the sRGB colour gamut.

The maximum brightness of 293cd/m^2 is also reasonable, and contrast and colour accuracy were maintained with the backlight increased. The MSI is uniform too: its backlight only weakened by 11 per cent in the corners, which is a good result for a curved gaming panel.

The Optix isn't infallible, of course. Its genre modes all ruin the delta E, and the MSI isn't bright enough to handle HDR, despite the firm's claims that it's 'HDR Ready'. We also noticed a tiny bit of ghosting when using aggressive overdrive settings beyond the maximum 165Hz refresh rate, likely due to its reliance on VA technology rather than IPS or TN. Most people won't be bothered by this, but it's a minor complaint for competitive gamers who might be looking for the clearest response at high frame rates. The MSI has no speakers either, and its USB ports are awkwardly installed at the rear.

SPEC

Screen size 27in
Resolution 2,560 x 1,440
Panel technology VA
Maximum refresh rate 165Hz
Response time 1ms
Contrast 3,000:1
Adaptive sync FreeSync and G-Sync compatible
Display inputs 1 x DisplayPort 1.2a, 2 x HDMI 2b, USB Type-C DisplayPort
Audio None
Stand adjustment Height, tilt
Extras 100 x 100mm VESA mount, 2-port USB 2 hub

Conclusion

The MAG272CQR's resolution, refresh rate, size and curve make it an immersive, crisp option for gaming – from smooth single-player titles to fast-paced esports. It has great core image quality, top-notch contrast, deep black levels and reasonable colour accuracy. It can't handle true HDR, but the MSI is well-balanced and cheaper than most other displays with this sort of specification.

MIKE JENNINGS

VERDICT

A well-balanced specification joined by great core image quality and a fair price.

IMAGE QUALITY **48/55**
FEATURES **13/15**
VALUE **24/30**
OVERALL SCORE **85%**

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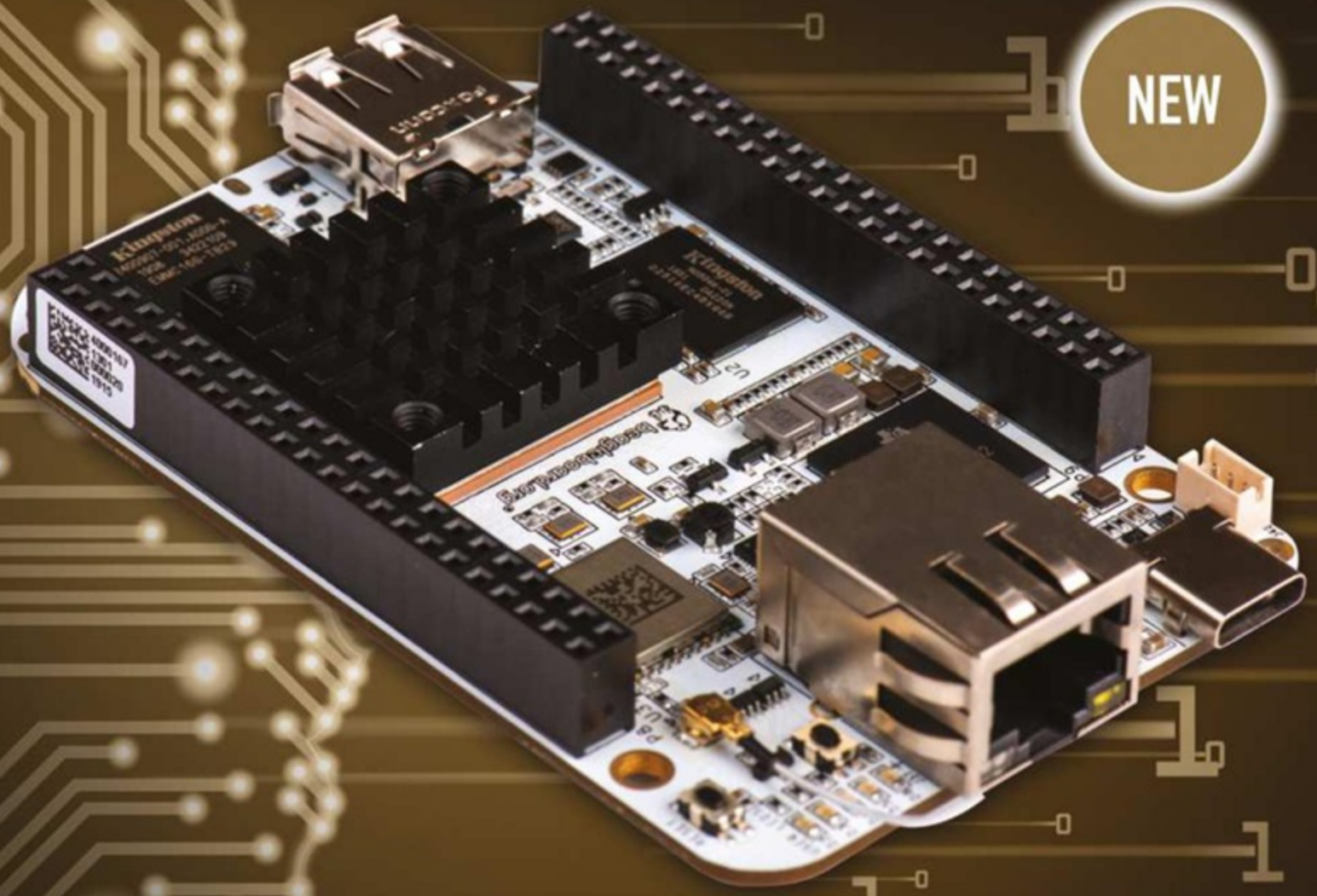

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+ Easy to set up

EXORBITANT

– Astonishingly expensive
– Limited extra features
– Overkill for most homes

The Netgear Orbi (RBK50) has been our favourite router/Wi-Fi system since it arrived back in 2016. Its range, performance and easy setup made it the ultimate router for larger homes. Now Netgear is back with a new flagship Orbi, the RBK852, which packs the latest Wi-Fi 6 (802.11ax) technology, with an astronomical price to boot.

Open the heavy box and you're greeted by two large, dense devices. Disappointingly, the silver trim around the outside isn't aluminium, as you might hope for the price. Instead, all the weight comes from an enormous aluminium heatsink inside each unit, enabling Netgear to omit fans.

This two-device system consists of a master router and a slave satellite. It's a different configuration to many other full-mesh Wi-Fi systems, where all units are treated equally. While the latter makes such systems more versatile, though, it generally doesn't help with peak performance.

The Orbi dedicates one of its three Wi-Fi bands to communication between the router and satellite, in theory making for a faster and more reliable setup. You can also add up to two more satellites. This two-unit system is sufficient to cover 5,000ft^2 according to Netgear, which in our experience is plenty for a three-storey UK home (router downstairs, satellite on the middle floor).

The router and satellite include four gigabit Ethernet LAN ports each, with the router also home to a 2.5Gbps port to connect to your internet/WAN. The RBK852 can also be setup as a Wi-Fi access point rather than a router, so the WAN connection could plumb into a faster LAN system, but otherwise, the 2.5Gbps port is fairly pointless, as few home internet connections reach such speeds. Also, while the previous Orbi unit had USB ports for sharing printers and USB storage devices, there are no USB ports on the new model. Indeed, overall, the RBK852 is relatively spartan when it comes to extra features.

Inside each unit is a tri-band Wi-Fi setup, with all three bands complying to the new Wi-Fi 6 standard. Wi-Fi 6 brings a boost to theoretical top speeds, and reduced lag and increased speed for multi-user setups, assuming you have compatible client devices.

Setup is easy. You can either use the Orbi app or browse to the default IP address. Going via the app requires you to create a Netgear account, but if you connect direct, you can set up the system without any external interference.

The browser interface and app aren't the most comprehensive, but get the basics done.

When it came to testing, we were hamstrung by coronavirus restrictions, meaning we didn't have access to our usual test location. Nonetheless, we were able to assess the new Orbi sufficiently to draw our main conclusions, but further testing will be needed for comparison to other systems.

With the two units one room (5m) apart, they maintained a Wi-Fi connection to each other fast enough to max out the LAN connections, and this speed was more or less maintained when moving the satellite around the rest of a small two-storey terraced home. Attaching a client device over Wi-Fi resulted in strong Wi-Fi coverage (300Mbps+) at the bottom of the garden, 20m away from the main router (12m from the satellite).

Conclusion

The Netgear Orbi RBK852 is an incredibly fast router that can cover a vast range. However, there's just no getting around that price. With the now relatively affordable Orbi RBK50 still offering excellent performance, there are few home situations where the RBK852 is justified right now.

EDWARD CHESTER

VERDICT

A mightily impressive Wi-Fi system, but its price puts it totally out of contention for most users.

SPEC

Weight
2 x 1297g (per unit)

Dimensions
254 x 71 x 191mm (per unit)

Ports
4 x Gigabit LAN (per unit), 1 x 2.5Gbps WAN

Wi-Fi
2 x 5GHz (1200Mbps), 1 x 2.4GHz (2400Mbps), 8 x internal antennae

DESIGN **16/20**

FEATURES **14/20**

PERFORMANCE **30/30**

VALUE **15/30**

OVERALL SCORE **75%**

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SMART CAMERA

D-Link Smart Full HD WiFi Camera DCS-8325LH / £132 inc VAT

SUPPLIER alternate.co.uk

STRONG LINK

- \+ Easy to use and set up
- \+ Compact and attractive design
- \+ AI detection works well
- \+ Excellent dynamic range

WEAK LINK

- – App needs work
- – Lacks image detail
- – One day recording limit

D-Link's DCS-8325LH home security camera features up to 1080p 30fps video recording, night vision and AI-based motion detection. It's designed to take on the likes of the Arlo Q, providing easy home security with cloud-based recording for easy access from anywhere.

It even looks like the Arlo Q. Both cameras are roughly the same size and sport a flat base with the camera attached to a stalk, making it easy to plonk on a window sill or shelf. Both units look smart with their largely matt white exterior, although the D-Link's glossy black front makes it a little more eye-catching. Neither camera is waterproof.

The DCS-8325LH offers tilt adjustment for the camera, and you then rotate the whole unit left and right to face the right direction. A micro-USB socket in the back of the base powers it, and D-Link provides a power adaptor with a plentiful 280mm long cable.

One potentially big plus of the D-Link is its microSD slot, so you can record to local storage (without needing to keep a NAS box running) instead of cloud storage. There's no way of recording to both though. The cloud recording service itself offers one day of recordings for up to three cameras for free. To keep your recordings for longer, you'll have to pay £21.99 or more per year. In comparison, Arlo offers seven days of recordings for free, but for just one camera, so your choice here largely depends on your needs.

Setup is very easy. You just download the MyDlink app, create a quick account and add the camera as a new device. The app uses the phone's camera to scan a QR code on the base of the camera to connect and add it – you just need to add in your Wi-Fi details.

While setup is relatively easy, though, the app isn't the slickest we've used. Because it's used to manage all the company's MyDlink-compatible devices, there's a lack of focus, so you have to jump through more hoops than you'd expect. Also, when you go to the devices section, the device icons move slightly, like they're floating, which is a bizarre UI decision.

We like the ability to set up One-Tap functions though. These are macros that will trigger a range of smart-home functions at once with a single tap. You can set up the usual motion detection for the camera and it will trigger a notification on your phone, even identifying what it has seen thanks to the AI detection. However, tap the notification and it doesn't take you to the clip, just to the camera home screen, and it doesn't close the notification. What's more, you can't set up geolocation to turn off the camera automatically when you're in the house.

The camera itself is mostly good quality. You get a sufficiently wide-angle view (151 degrees wide and 69 degrees tall), which is ample for capturing a whole room without placing the camera in an awkward position. The dynamic range particularly impressed. Where other cameras struggle to balance showing dark parts of an image without totally blowing out brighter parts, the DCS-8235LH coped well. However, finer details were noticeably below the level of the Arlo Q, even if the dynamic range made for a clearer picture overall.

SPEC

Max resolution
2 megapixel

Max video recording
1,920 x 1,080 @30fps

Field of view
151 x 69 degrees

Audio
Two-way

Wi-Fi
808.11n

Dimensions
84 x 74 x 109mm

Weight
140g

Conclusion

The D-Link DCS-8235LH is a good-quality, easy-to-use home security camera. Its headline AI-based motion detection also works well, successfully identifying humans and ignoring cats, for instance. However, its mobile app needs some work to bring it in line with the competition.

EDWARD CHESTER

DESIGN **18/20**

FEATURES **16/20**

PERFORMANCE **20/30**

VALUE **20/30**

OVERALL SCORE **74%**

VERDICT

A good-quality, easy-to-use smart camera, but its mobile app needs some work.

MINI-ITX GAMING PC

FIERCE PC ARDENT CORE / £2,399 incVAT

SUPPLIER fiercepc.co.uk

Fierce PC's Ardent Core immediately impresses with its striking design and custom water-cooling system. The CPU is topped with an Eisblock XPX Aurora with attractive cooling channels, and another Eisblock chills the RTX 2080 Super GPU. They're connected with Alphacool's hard tubing, and the front of the chassis is dominated by an Alphacool NexXxos ST30 240mm radiator with four 120mm fans.

Despite all this cooling hardware, the Ardent also uses a mini-ITX Corsair Crystal 280X case, which means Fierce PC has been clever with other cooling components. The sizeable cavity behind the motherboard tray houses the Alphacool Eisstation VPP reservoir, as well as the pump and a plug for draining the loop.

Meanwhile, the CPU and GPU waterblocks are illuminated with an attractive orange shade, along with the DIMMs and four intake fans, with the latter sporting some great-looking Fierce PC grilles. Meanwhile, a row of RGB LEDs along the bottom of the chassis illuminates the interior from below. The Ardent looks superb, and the case's 351mm height and 276mm width make this square-shaped system relatively easy to take to events. Build quality is great, too: the tempered glass and metal used throughout is sturdy.

As ever, though, mini-ITX enclosures mean compromises. There's no real room to add extra storage – the Corsair case has removable 2.5in and 3.5in cages, but the Ardent's water-cooling and lighting hardware means they can't be fitted here. This system isn't always the tidiest either. There are wayward cables around the rear and a handful of loose wires visible from the front.

The Ardent's smaller size doesn't mean a reduction in power, though. Fierce PC deploys an MSI GeForce RTX 2080 Super Ventus OC card here, which has 8GB of GDDR6 memory, 3,072 stream processors, and 48 RT cores. It also slightly overclocks the GPU boost frequency from 1815MHz to 1830MHz.

Meanwhile, an AMD Ryzen 7 3700X is left at its standard base and boost clocks of 3.6GHz and 4.4GHz, and the 16GB of DDR4 memory runs at a superb effective speed of 3600MHz. You also get a 1TB Seagate FireCuda 520 SSD, which makes use of the motherboard's PCI-E 4 interface, but there's no secondary hard disk.

It's all plugged into a Gigabyte X570 I Aorus Pro Wi-Fi motherboard, which has beefed-up ALC1220-VB audio, Bluetooth 5, and dual-band 802.11ax Wi-Fi 6. It's a top tier board in terms of connections – at the rear, it has five full-sized USB 3.2 ports, alongside a Type-C connector, and there's a Q-Flash button for EFI flashing too.

There are two M.2 connectors, with the SSD installed in the socket on the rear of the board. However, the second slot sits behind all the hefty graphics hardware, making it tricky to access. As ever with mini-ITX, there are only two DIMM slots and no additional PCI-E slots either. These are the compromises you always make when buying a mini machine, but it's great to see Corsair RM750x PSU included, which is fully modular and has an 80 Plus Gold rating.

We have no qualms about the warranty either. It's a generous five year return to base labour deal, with two years of parts coverage and six months of collect and return service.

SPEC

CPU
3.6GHz AMD Ryzen 7 3700X

Motherboard
Gigabyte X570 I Aorus Pro Wi-Fi

Memory
16GB Corsair Vengeance Pro RGB 3600MHz DDR4

Graphics
MSI GeForce RTX 2080 Super 8GB

Storage
1TB Seagate FireCuda 520 M.2 SSD

Networking
Dual-band 802.11ax, Gigabit Ethernet

Case
Corsair Crystal 280X

Cooling
CPU: Alphacool Eisblock XPX Aurora waterblock, Alphacool NexXxoS ST30 240mm radiator with 4 x 120mm fans, Alphacool Eisstation VPP reservoir, Alphacool Eispumpe VPP755; GPU: Alphacool Eisblock Aurora Plexi GPX-N waterblock, Alphacool Eisblock Aurora GPX-N backplate; roof: 1 x 120mm fan

PSU
Corsair RM750 – 750W

Ports
Front: 2 x USB 3.1, 2 x audio; rear: 1 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 2 Type-C, 4 x USB 3.1 Gen 1, 3 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
Two years parts and labour, followed by three years labour only. First six months collect and return, then return to base

BURNING

- + Consistently excellent performance
- + Superb water-cooled design
- + Fast PCI-E 4 SSD

BURNOUT

- – Water-cooling gear adds cost
- – Mini-ITX means few upgrade paths
- – CPU gets hot at full load

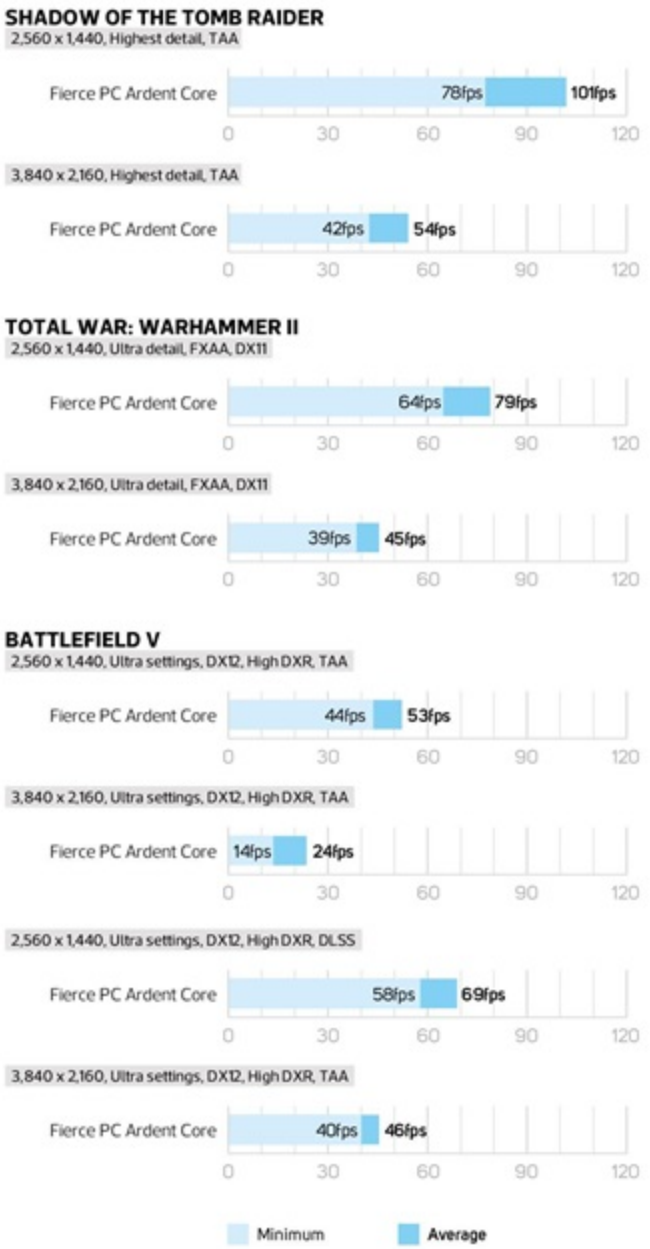
Performance

The RTX 2080 Super is excellent for gaming. At 1080p, it's able to handle games at high frame rates, and at 2,560 × 1,440, its minimum frame rates ranged between 44fps and 78fps. That means you'll be able to play the vast majority of games at smooth frame rates. It can even handle a bit of 4K gaming. It easily got beyond 30fps in Shadow of the Tomb Raider and Total War: Warhammer II, and if you use DLSS, you can also get a 40fps minimum in Battlefield V with High DXR, although it can't do it at this resolution otherwise.

The Ryzen 7 3700X CPU is a good choice too. Its image editing result of 59,800 is as fast as any other consumer Intel or AMD chip, and it returned impressive pace in our heavily multi-threaded HandBrake test. Its overall score of 227,388 is only a few thousand points behind systems based on the pricier Ryzen 7 3800X and Intel Core i9-9900KS. The SSD is great too. Its read and write speeds of 4,999MB/sec and 4,280MB/sec are fantastic – faster than any SSD you'll find in an Intel PC, and among the best results from any consumer drive right now.

In terms of thermals, the GPU's peak delta E of 35°C is great, thanks to the water-cooling system. However, the CPU's peak figure of 72°C is only just short of worrying temperature levels. Happily, this result was only achieved in a stress test – you're extremely unlikely to encounter it in normal use, including gaming. The Ardent produces a noticeable, low fan noise as well, but we've certainly heard worse. You just won't hear this PC in a LAN hall or beyond your headset, and the noise levels are pleasingly consistent.

BENCHMARK RESULTS



59,800
GIMP IMAGE EDITING

577,317
HANDBRAKE H.264 VIDEO ENCODING

122,999
LUXMARK OPENCL

247,839
HEAVY MULTI-TASKING

227,388
SYSTEM SCORE

Conclusion

The Ardent serves up great pace, fantastic design, and a custom water-cooling loop in a build that's small enough to easily take to LAN parties. The mini-ITX build means limited upgrade options, though, and the water-cooling gear also adds to the cost. You can undoubtedly get similar performance for less money in a standard, air-cooled ATX PC, but this is an excellent, well-built machine if you're looking for an attractive, powerful rig in a small package.

MIKE JENNINGS

VERDICT

Superb design and great speeds inside a compact, albeit expensive, build.

PERFORMANCE **23/25**

DESIGN **24/25**

HARDWARE **21/25**

VALUE **19/25**

OVERALL SCORE **87%**

ATX GAMING PC

CCL SABRE iCUE GAMING PC / £1,399 incVAT

SUPPLIER cclonline.com

SHARP

- + Solid gaming performance
- + Cheap price
- + Generous warranty

BLUNT

- – Basic motherboard
- – CPU could be quicker
- – No secondary hard disk

CCL's Sabre iCUE Gaming PC is a compact ATX rig that aims to provide a keen balance between graphical power and CPU grunt. Gaming ability comes from an MSI GeForce RTX 2070 Super Gaming X card, which ups the original RTX 2070 Super boost clock from 1770MHz to 1800MHz.

Elsewhere, the MSI card has a smart metal backplate and RGB LEDs, and CCL has added a metal arm beneath the card to prevent it from sagging. The overclocked GPU is joined by an AMD Ryzen 5 3600X CPU. It's a six-core chip with twelve threads via SMT, and it runs at its stock base and boost speeds of 3.8GHz and 4.4GHz respectively.

CCL has installed 16GB of 3200MHz memory, which is fine, and there's also 1TB ADATA XPG SX8200 SSD. The Corsair RM650 PSU impresses thanks to a modular design and 80 Plus certification. The only minor issue is the lack of a secondary hard disk. The 1TB SSD is generous, but a good selection of triple-A games will still fill it quickly.

The motherboard comes from MSI, too. The B450 Tomahawk Max, which we also used in our feature on p76, has two spare memory slots in this configuration, as well as modest Realtek ALC892 audio and Gigabit Ethernet. In several departments, though, it's basic. There are no spare M.2 slots here, and the use of the B450 chipset means there's no SLI support. The rear I/O also only has pairs of USB 3.2 Gen 2 and USB 3.2 Gen 1 connectors. There's a PS/2 connection and six audio jacks, but no optical S/PDIF.

CCL has used use the Corsair iCUE 220T chassis for this build. It looks smart, with tempered glass panels, and its three 120mm intake fans glow with RGB LEDs. It's small too, measuring just 395mm deep and 450mm tall. The Corsair Hydro H60 CPU cooler sits unobtrusively in the exhaust fan mount, which means the top half of the motherboard is accessible. Cabling is also tidy throughout the front section.

The cables are neat at the back too, and they don't get in the way of most storage options, although they do block one of the 2.5in mounts. The biggest access issues revolve around the graphics card. That supporting strut looks good, but it blocks access to the bottom half of the motherboard.

Build quality is mixed too. The tempered glass panels and internal skeleton are strong, but the top dust filter, PSU shroud, and 3.5in drive cages are weaker. The case's size also means there's less scope for upgrading to heftier cooling gear or longer graphics cards. It will be hard to add a 240mm radiator in the top without it clashing with the motherboard and memory.

Nevertheless, the Sabre still impresses for the money. Its £1,399 price plants it at the bottom end of the RTX 2070 Super market, and its generous three year collect and return warranty also covers parts and labour.

Performance

The RTX 2070 Super is ideal for 1080p and 2,560 × 1,440 gaming. At the lower resolution, its minimum frame rates ranged between 59fps and 94fps, so you'll get beyond 60fps in virtually any game. It didn't have any trouble with our Battlefield V ray-tracing test either, even without DLSS enabled. The CCL performed well at 2,560 × 1,440 as well. Its minimums here began at 42fps, which is comfortably above the playable threshold, and peaked at a rapid 69fps.

SPEC

CPU
3.8GHz AMD Ryzen 5 3600X

Motherboard
MSI B450 Tomahawk Max

Memory
16GB Corsair Vengeance RGB Pro 3200MHz DDR4

Graphics
MSI GeForce RTX 2070 Super 8GB

Storage
ADATA XPG SX8200 Pro 1TB M.2 SSD

Networking
Gigabit Ethernet

Case
Corsair iCUE 220T RGB TG

Cooling
CPU: Corsair Hydro H60 with 2 x 120mm fans; GPU: 2 x 90mm fans; front: 3 x 120mm fans

PSU
Corsair RM650 650W

Ports
Front: 2 x USB 3, 1 x audio; rear: 1 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 2 Type-C, 2 x USB 3.1 Gen 1, 2 x USB 2, 1 x PS/2, 6 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
Three years parts and labour collect and return

The RTX 2070 Super in this PC will handle any gaming task short of 4K, but most other RTX 2070 Super systems we've reviewed have been slightly faster at 1080p, albeit only by 2-3fps.

Meanwhile, the Ryzen 5 3600X proved itself to be a decent all-purpose CPU for the money. Its image editing score of 60,804 is fine, as is its HandBrake result of 461,130 is also reasonable, if not outstanding. The latter is a fair bit behind the scores we see from Ryzen 7 CPUs with their extra two cores, but it's still fine for most people's needs.

The SSD is good as well – its respective read and write speeds of 3,507MB/sec and 3,083MB/sec are only significantly bettered by PCI-E 4 drives, for which you'll need a pricier X570 motherboard anyway.

BENCHMARK RESULTS

60,804 GIMP IMAGE EDITING

461,130 HANDBRAKE H.264 VIDEO ENCODING

119,718 LUXMARK OPENCL

224,905 HEAVY MULTI-TASKING

192,695 SYSTEM SCORE

SHADOW OF THE TOMB RAIDER

1,920 x 1,080, Highest detail, TAA

2,560 x 1,440, Highest detail, TAA

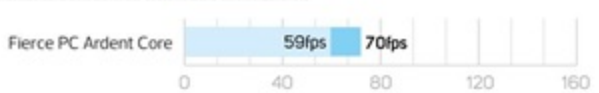
TOTAL WAR: WARHAMMER II

1,920 x 1,080, Ultra detail, FXAA, DX11

2,560 x 1,440, Ultra Detail, FXAA, DX11

BATTLEFIELD V

1,920 x 1,080, Ultra settings, DX12, High DXR, TAA



2,560 x 1,440, Ultra settings, DX12, High DXR, TAA

Minimum Average

The CCL's thermal performance is also fine, with solid CPU and GPU delta E temperatures of 65°C and 45°C. It produces a low rumble when idle and is only a little louder when gaming – there's noticeable noise, but it's quieter than most rivals.

Conclusion

The Sabre iCUE is one of the more affordable RTX 2070 Super PCs we've seen, although the relatively low price has an impact in several departments. It's not quite as quick in games as other machines based on the same GPU, and while the mid-range CPU is reasonable, it's not as versatile as other parts.

Meanwhile, the case looks good and is compact, but build quality could be better in places. The motherboard is also capable but basic, and there's no secondary storage. Not everyone will be bothered by these aspects though – and at its core, the CCL offers decent gaming performance, a solid CPU and a decent warranty for a generous price. It's an unfussy and affordable option, even if it isn't outstanding.

MIKE JENNINGS

PERFORMANCE 19/25

DESIGN 20/25

HARDWARE 19/25

VALUE 22/25

OVERALL SCORE 80%

VERDICT

Decent gaming performance for the money, but some of the supporting hardware is a bit basic.

SUBSCRIBE TO CUSTOM PC

Custom kit

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

6AMLIFESTYLE ADJUSTABLE DUAL HEADPHONE HANGER / **£14.99** inc VAT

SUPPLIER amazon.co.uk

There seem to be two approaches to attaching under-desk headphone hangers – double-sided tape and clamps. The 6amLifestyle Dual Headphone Hanger uses the latter. The clamp itself is small but strong, with padded grips, so you won't mark your furniture if you attach it tightly.

The arm screws onto the clamp using a hex key, which is a little fiddly but doable. The clamp is expected to hold up to 5kg, which is plenty for even massive headsets. Still, that surplus strength is appreciated if you knock into it. Using a clamp means you have to place the hanger near the edge of your desk, and there's a small surface profile, which you don't get with a taped stand. The trade-off is that the 6amLifestyle hanger is reusable, and not a write-off if it gets detached by accident. There are no frills, but it's a solid headphone hanger – you can't ask for much more.

6am life ●●●●○ **10am life**

SABRENT 16-PORT USB 3.0 DATA HUB / **£49.99** inc VAT

SUPPLIER amazon.co.uk

The Sabrent USB Hub is perhaps the most aggressive attempt to cram USB sockets into a device we've seen. There are 16 USB 3 ports, and while some USB hubs with lots of ports limit the use of some of the sockets, each one of the Sabrent's ports is good for recharging, data transfer or plugging in other devices.

The hub is powered with a mains adaptor, and each individual socket has its own power switch. The benefits of this approach become clear as the hub starts to fill up – it's a tight squeeze for standard connectors, and devices with large plugs, or dongles, can end up taking up more than one space. That means switching devices in and out gets tricky, but the power switch enables you to power off devices without having to remove them.

The Sabrent is also supplied with a bracket you can screw into place, and then slot the 16-port hub in and out of it. That's a handy touch, as with 16 potential USB cables, as well as the power cable and USB host cable, the Sabrent could easily turn into the heart of a USB cable rat king. It's not cheap, but this is a solid and versatile approach to a many-port USB hub.

Hubcap ●●●●○ **Hubba Bubba**

KIROBO WIRELESS SPEAKER / **£15.99** inc VAT

SUPPLIER amazon.co.uk

The Kirobo is a small speaker that can work either via Bluetooth as a phone speaker capable of handling calls, or through a line-in connection. It also has a microSD card slot, so you can cram a stack of music onto a card and play it. However, good luck navigating a substantial music library with just the Next Track and Previous Track buttons, and no visible interface.

Visually, the Kirobo looks neat. The cut-out, mostly spherical shape gives it a Magic 8-Ball vibe, while the colourful lighting and shifting patterns look relatively understated, creating a kind of nightlight effect. Sound quality is fine for low-level noise needs, but you'll want more oomph for music above a low ambient volume.

You also get a decent battery life of around 60 hours on standby, and six hours for playback. However, it's not the most versatile speaker to take out and about. It's not waterproof to any standard, and while it's technically portable, its build quality isn't particularly solid either.

Nightmare ●●●○○ **Nightlight**

ZEEKER METAL WALLET / **£17.99** inc VAT

SUPPLIER amazon.co.uk

Sometimes a product is such a departure from the norm that it's hard to imagine how it came into being, and the Zeeker wallet fits into this category. This wallet carries credit cards and folding money, but it doesn't have the usual collection of pockets that folds in the middle. Instead, the Zeeker is made from two metal plates, which are laced together and secured at the front, with a metal lip to hold the lace loop. Your cards go between the two metal plates, and folding money goes into a clip on one side.

Meanwhile, two RFID blocking panels are supplied, which can be slotted alongside your cards for protection from the rare (but still technically possible) risk of your cards getting nefariously scanned. Using it doesn't feel that practical at first, though it's fine when you get used to it, and it looks great. A metal wallet sounds uncomfortable to have in your pocket, but the thick string around it mitigates this problem, and it keeps its contents flat too.

The money clip isn't ideal, due to the small size of the wallet – British or EU money is way too big, and even US dollars need to be folded down to a third. The weirdness of the Zeeker gives it plenty of charm, but be aware that it has a few practical shortcomings.

Searching low and high ●●●●○ **The Zeeker**

PICTEK WIRELESS CONTROLLER / **£24.99** inc VAT

SUPPLIER amazon.co.uk

The Pictek Wireless Controller not only works wirelessly over Bluetooth with Android phones and the Nintendo Switch, but also works with Windows 10 PCs using a USB connection. The USB connection is preferred on a PC, as it doesn't work properly using Bluetooth.

That's annoying, but the pad itself is lightweight, solid and rechargeable, with its controls in an Xbox pattern. It has vibration functions, as well as movement sensors for Switch games, and although some of the ancillary buttons aren't laid out the same way as on an Xbox pad, there are no surprises with the design. The ABXY buttons are a little lower-profile than usual for a pad – when pressed, they're almost flush to the surface. It's not bad, but it's an odd feeling, and it takes a while to get used to it.

The D-pad is also an inverted dish shape design by default, although an alternate standard button is included. Meanwhile, the trigger buttons stand out by virtue of having an extremely light touch, making them easy to control precisely. If it's being used for a phone, the Pictek also includes a bracket that can be swapped onto a rear mount to hold your phone while you play. The Pictek isn't revolutionary, but it tweaks the formula for a budget pad and does well with it, as long as you're aware of its quirks.

Light ●●●○○ **Fantastic**

Seen something worthy of appearing in Custom Kit? Send your suggestions to phil.hartup@gmail.com

LABS TEST

The key question

Mike Jennings tests eight of the best keyboards that can be bought on a budget – perfect if you want high-end gaming without the cost

How we test

Having the right keyboard can make or break your gaming setup, so it's worth taking some time to find out which is the best model for your needs. Do you need features first and foremost or is a high-quality typing experience more important? Whatever the case, you don't have to spend loads of cash in order to get a high-quality device, as right now it's easy to find fantastic keyboards for under £70.

Don't assume that spending less will get you a basic model, either. We've gone hands-on with eight different keyboards – with prices that start at £40 – and we've discovered a huge range of quality levels, designs, and features.

The group includes mechanical and membrane keyswitch types, so it's possible to choose between the firmer, faster-typing action of the latter more expensive devices or the softer, quieter, and more affordable membrane technology. You'll get far fewer features – and often fewer keys on these budget models – with mechanical keyboards but a superior typing experience and a much longer-lasting keyboard.

Elsewhere, this collection of keyboards is littered with RGB LEDs, spill-resistant designs, media buttons, and macro keys. We've also tested a tenkeyless model that's ideal if you need a more compact unit to travel to LAN parties and gaming events, or you just have limited desk space.

We've tested all eight of these keyboards in a bevy of popular games, from FPS and strategy titles to the most frantic esports environments so we can find out which can cope with the broadest range of gaming tasks.

We haven't just tested the keys themselves: we've evaluated build quality, the range of extra keys, and the ease of programmability of RGB LEDs and macro settings. Their fonts, finishes and extra features are all taken into account too, ensuring we can be certain which budget typing tool is the best overall.

Contents

ASUS TUF GAMING K5 / £59 incVAT

SUPPLIER scan.co.uk

The K5 is one of the more expensive membrane keyboards in this Labs – the only pricier model, the SteelSeries Apex 3, is just one pound more.

The Asus is also one of the loudest-looking units in this group. At the top is a patterned section with the TUF logo, and in the top-right corner, there are five large status lights. There are more TUF gaming logos elsewhere, and the large wrist rest is part of the main body of the keyboard, so can't be detached.

The bold physical design is paired with large dimensions, thanks in large part to that wrist rest. At 460mm wide and 218mm deep, this is one of the biggest units in the Labs. It's 40mm tall without its feet extended, too, making it the bulkiest keyboard here.

TOUGH

- \+ Decent typing action
- \+ Spill-resistant and robust
- \+ Good features

TENDER

- – Immature aesthetics
- – Poor lighting
- – A little expensive

SPEC

Connection Wired, USB

Cable 1.8m, unbraided

Material Plastic

Switch type Membrane

Backlighting 5-zone RGB

Extras Integrated wrist rest, spill-resistant, volume keys

The Gaming K5 is sturdier than most of the other membrane, plastic keyboards in the Labs, but its plastic body still can't compare to the rock-solid aluminium of the Logitech G413 or the tenkeyless HyperX.

The K5 has five-zone RGB LED lighting that includes a handful of common effects – so it's immediately more versatile than the G413. The lighting is weak and inconsistent on each key, though, and the SteelSeries is better – its illumination is stronger, and it has twice as many lighting zones.

Elsewhere, it has dedicated buttons to adjust the backlight strength and your PC's volume, and it uses a spill-resistant frame that is designed to cope with drinks and sweat. There isn't any USB pass-through, though, and no macro keys.

The K5 can store three different profiles and record macros, and it has 24-key rollover and anti-ghosting, and it uses membrane switches that are designed to mimic tactile, mechanical hardware.

The buttons strike a good balance between membrane and mechanical hardware. They're light, fast, and consistent, with an action that's snappier than most other membrane units. The keys have a 3.7mm travel distance, which is half a millimetre more than the Logitech, and almost level with the HyperX unit.

The K5's buttons have a pronounced tactile bump – even when compared with mechanical units – which adds to their solid feeling. In terms of popular mechanical hardware, the Asus is closest to Cherry MX Brown switches.

The Asus' keys are just as fast as the keys on the SteelSeries, although the SteelSeries does have bouncier buttons – if you play fast-paced games, the Apex will be a little better. Overall, though, the K5 has a fast, crisp gaming action, and it's better in this regard than the Romer-G mechanical switches inside the Logitech G413.

Elsewhere there are only minor problems. The keys have a good weight to them, but they feel a little off-balance and wobble a bit too much. The space bar isn't impressive, either. It feels hollow and markedly different from the rest of the buttons. The K5 is very loud, too.

Conclusion

The Gaming K5 is a rather inconsistent budget keyboard. Its buttons are just as quick as the SteelSeries' keys without the potentially annoying bounceback, and they're better than the Logitech's mechanical keys. The K5 also offers RGB LED lighting, profile storage, and a few extra buttons.

The decent, mechanical-style buttons are undermined by loud operation, underwhelming lighting, and divisive design – as well as the proper mechanical buttons on the similarly priced HyperX.

The Asus is hard-wearing and more versatile than the SteelSeries, but mechanical devices will still provide a purer typing experience for only a little more cash.

VERDICT

It's tough and has decent typing, but the Asus is hampered by inconsistent design.

DESIGN	FEATURES	VALUE	OVERALL SCORE
29/40	30/35	19/25	78%

COOLER MASTER MS110 / £53 inc VAT

SUPPLIER scan.co.uk

The Cooler Master MS110 arguably offers the best value in this Labs. While other keyboards are cheaper, this device includes a gaming mouse too.

The MS110 also features a bold design. The keyboard itself isn't too wild, physically – its body has neat, flared sides that barely extend past the buttons – but Cooler Master has added loads of lighting.

There's a ring of RGB LEDs around three sides of the unit with an illuminated Cooler Master logo at the front, and the keys themselves float above the membrane material, which is lit in six zones.

At first glance, it looks superb, with the matte plastic keycaps hovering above a sea of light, but closer inspection reveals superficial problems. The lighting underneath the buttons is a little inconsistent, and it's worse on the keycaps themselves: only half of the keys tend to be illuminated, which leaves lots of symbols barely lit at all.

No software is required for this keyboard, with colours and patterns instead altered with shortcuts on the function row. It saves having yet another piece of software installed, but it's a clunky system. The MS110's minimal physical design also means no extra buttons, with macro and media duties also relegated to secondary functionality. There's also no USB pass-through and no wrist rest.

If you're after a membrane keyboard with a better feature set, the Corsair is a stand-out option: it has a wrist rest, loads of extra buttons, and more intuitive software options, albeit with a lower key rollover figure.

On the inside, the MS110 serves up 26-key rollover and a membrane keyswitch design that's supposed to mimic mechanical hardware. In practice, the Cooler Master's buttons are likely to be divisive and offer a wildly different experience to most mechanical units.

The buttons are solid and consistent, and their soft-touch finish means they're comfortable. Get typing, though, and they're too bouncy: the buttons seem to rebound back up before they've even bottomed out. It feels like the MS110 is encouraging you to dance across the keys rather than hammer them down.

It's no surprise when the stats are considered: the MS110's reasonable 3.6mm travel distance is paired with a short 1.2mm actuation point and a 45g actuation force.

This elastic typing makes the MS110 feel floaty – it's like typing on a trampoline. Some people will prefer that, especially if you want a keyboard that can handle lots of typing while remaining light and comfortable – but the MS110 is not close to a mechanical unit at all.

SPEC

Connection Wired, USB

Cable 1.8m, unbraided

Material Plastic, aluminium

Switch type Membrane

Backlighting 6-zone RGB

Extras Gaming mouse included

BOILING

- \+ Lots of RGB LEDs
- \+ Includes a gaming mouse
- \+ 26-key rollover

FREEZING

- – Bouncy typing action
- – Underwhelming lighting
- – Few extra features

The Corsair and Razer Cynosa Lite both offer more traditional experiences: the Corsair buttons are firm and weighty with a noticeable bump, while the Razer keys are a little softer and lighter. Neither have that off-putting bounce.

The included mouse is a right-handed, six-button unit with three RGB LED zones, an optical sensor, and a 3,200 DPI sensitivity level. That latter figure won't sate keen esports or FPS players, but it's high enough for mainstream gaming. The buttons are fast, shallow, and responsive – perhaps a tad too bouncy, if we're being picky.

Conclusion

The Cooler Master MS110 offers good value – it's the only keyboard here that also comes with a mouse, and that extra peripheral is easily good enough to handle mainstream gaming.

The MS110 keyboard looks fantastic, but it doesn't have many features, and its typing action is divisive – it's comfortable but very springy.

If you prefer a floatier typing action and want to save some cash, this set is decent – but look elsewhere if you want a weightier and more conventional experience.

VERDICT

It's a good value set, but the bouncy typing action can be irritating.

DESIGN	FEATURES	VALUE	OVERALL SCORE
26/40	26/35	22/25	74%

CORSAIR GAMING K55 RGB / £40 incVAT

SUPPLIER game.co.uk

The K55 RGB is one of the cheapest keyboards in this test, which makes its feature set all the more impressive. Despite its price of just £40, this is the only keyboard here with dedicated macro keys, and it also has buttons for macro recording – to change the lighting brightness and disable the Windows keys – alongside separate media buttons.

The six macro keys are installed in a column on the left-hand side, with the other buttons in the top-right corner.

The macro keys and media buttons bolster the Corsair's main buttons, which are excellent. They're membrane units that offer more weight and a more reliable typing action than most of the other keyboards in this group, and they pair their solid action with a noticeable tactile bump and impressively quiet operation.

BLACKBEARD

- \+ Well-balanced typing action
- \+ Decent RGB LEDs
- \+ Loads of extra features

JACK SPARROW

- – Mediocre build quality
- – Some font issues
- – Middling rollover figure

SPEC

Connection Wired, USB

Cable 1.8m, unbraided

Material Plastic

Switch type Membrane

Backlighting 3-zone RGB

Extras Wrist rest, macro keys, media keys

The K55's keys are fast, firm and tactile, and they're comfortable: the buttons have a soft-touch finish and a concave shape that does a great job of securing and centring your fingers.

The Corsair has one of the better membrane designs in this group – these buttons are certainly faster and more satisfying than most. They're easily good enough for mainstream gaming and esports, and they bounce back rapidly without becoming too spongy.

However, the affordable K55 still can't match the clinical speed of the HyperX mechanical unit, and membrane devices like the Razer are lighter and softer. Both the Corsair and Razer are easily better than the bouncy and unsatisfying MSI, which has a similar price.

The Corsair has a good range of features elsewhere, even if there are compromises throughout. The RGB LED lighting is only available in three zones, but it's more solid and consistent than the lighting on the Razer. The installation of the lighting beneath the translucent membrane base layer also adds an attractive, ethereal glow to the K55.

Customisation and custom effects are available in the Corsair iCUE app, which is a boon – it's far easier to use that tool than the clumsy and restrictive shortcuts on the keyboard itself.

The Corsair only has eight-key rollover, which is a low figure. Most people won't be impacted by this, but bear it in mind if you play complex or competitive games where you push lots of buttons simultaneously.

The Corsair's font could be an issue, too – it's very small on many of the supplementary keys, which makes them tricky to read.

The Corsair looks good, with a detachable, rubberised wrist rest and smart plastic throughout, but build quality is middling. The media keys feel a little flimsy, and they're not backlit, and it's too easy to flex the plastic chassis back and forth. Units like the HyperX Alloy FPS Pro, which bolster their plastic designs with metal, are stronger.

The glossy band of plastic above the keyboard looks slightly incongruous, too, and it's a fingerprint magnet.

Conclusion

The Corsair is an excellent membrane option. It has a weighty, consistent, and fast typing action that isn't far away from the best mechanical units – you'll only want to head to a keyboard like the Razer if you want a lighter, softer feel.

Elsewhere, the Corsair has more features than its rivals and good software, even if its rollover and build quality isn't particularly good.

Still, those are acceptable compromises at this price. The Corsair may be one of the cheapest keyboards in the Labs, but it's one of the best too.

VERDICT

Loads of features and great typing make this a tempting bargain.

DESIGN	FEATURES	VALUE	OVERALL SCORE
32/40	32/35	23/25	87%

HYPERX ALLOY FPS PRO / £61 inc VAT

SUPPLIER amazon.co.uk

The Alloy FPS Pro is a unique product in this Labs, on two accounts. First, it's the only tenkeyless model, but perhaps more importantly, it's also the only mechanical keyboard here that uses the most popular Cherry MX switches.

The tenkeyless design means this keyboard has no numberpad. That cuts down on versatility, but it means this unit is smaller and lighter – so it's ideal for frequent transport – plus the fewer keys keeps the cost below our £70 cut off for this test. HyperX goes a step further on the portability front by including a removable power cable, which makes it far easier to pack away safely. Again, this is a feature unique to this keyboard in this Labs.

The compact Alloy FPS Pro is bolstered with a solid steel frame, which means this unit is extremely robust – just as strong as the aluminium on the Logitech, and sturdier than the all-plastic designs used for the membrane products in the Labs.

The Alloy may be compact and sturdy, but it does lack features elsewhere. There's no room for dedicated media or macro keys, and there's no USB pass-through and no wrist rest. There isn't any RGB LED lighting, either – just a red backlight, like the Logitech. The lighting is good here, though, with consistent and bright illumination. Those rivals with membrane keys tend to have room in the budget for RGB LEDs though.

There are no unnecessary aesthetic extras when it comes to the design. The Alloy has its metal and plastic base, its red-lit keys, and nothing else.

Instead, this keyboard's features concentrate on practical gaming performance. It's the only unit here with n-key rollover and 100 per cent anti-ghosting, plus of course, you get the excellent feel of those mechanical switches.

On the inside, the Alloy is available with Cherry MX Blue, Brown, or Red switches. The former switches are heavy and tactile, with a noticeable bump and audible click – they have a 4mm travel distance, a 2mm actuation point, and require 60g of force to actuate. Cherry MX Red switches are linear and noticeably lighter, with a 45g force alongside the same travel and actuation distances. The Browns also have a 45g activation force and have a bump but not click.

All three are excellent, though we tend to find Browns the best overall for typing and either Browns or Reds best for gaming. The Blue switches are for fans of loud keyboards only.

The Logitech G413's buttons have shorter actuation distances, but that keyboard's switches still pale in comparison to the Cherry MX hardware here. The Alloy's buttons are faster and firmer, with a more clinical action. The Cherry MX also have the advantage that you can buy thousands of different custom keycaps for them, whereas the Logitech's keycaps aren't widely available.

The Cherry MX switches also compare well to the best membrane keyboards. The Corsair is excellent, for instance, but it doesn't quite have the speed and precise feel. Razer's unit is fast, too, but that keyboard is noticeably lighter, without the weight of a good mechanical switch.

If you're not a competitive player, then alternatives like the Corsair offer more features, and the Logitech G413 is a full-size keyboard rather than a tenkeyless model yet still has mechanical switches.

If you want to stick with HyperX but have a full-size keyboard, expect to open your wallet: the Alloy FPS RGB uses faster, shallower Kailh Silver Speed mechanical switches and costs £70, while the Alloy Elite RGB sticks with Cherry MX Blue, Red, and Brown switches but costs £100.

Conclusion

The Alloy FPS Pro offers the best typing experience in the Labs thanks to its crisp, reliable, and fast Cherry MX switches, and it has top-notch build quality.

However, this model also has compromises. It's tenkeyless; it has no extra buttons, few additional features, and no RGB LEDs.

If you want a smaller, focused unit for travel and competition, though, it's superb, offering great quality and easy portability.

PROFESSIONAL

- \+ Excellent mechanical keys
- \+ Robust, compact design
- \+ Detachable USB cable

AMATEUR

- – Tenkeyless layout
- – No extra buttons
- – No RGB LEDs

SPEC

Connection Wired, USB

Cable 1.8m, braided

Material Steel, plastic

Switch type Cherry MX Blue, Cherry MX Red

Backlighting Red

Extras Tenkeyless design, detachable USB cable

VERDICT

It lacks features, but this tenkeyless model has great quality and is ideal for travel and competition.

DESIGN	FEATURES	VALUE	OVERALL SCORE
33/40	26/35	21/25	80%

Wireframe

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LOGITECH G413 CARBON / £70 inc VAT

SUPPLIER game.co.uk

The G413 Carbon is one of the priciest peripherals in this group test, but there's good reason for it. Along with the HyperX Alloy FPS Pro, it's one of only two keyboards to have long-lasting, more precisely engineered mechanical keyswitches, rather than cheaper rubber membrane switches.

What's more, unlike the HyperX model, you don't miss out on a numberpad here, instead getting a full-sized keyboard with the usual 105 keys. Such is the advantage of using the company's own Romer-G keyswitches.

It's a great-looking keyboard too, with a far more mature feel than many of its rivals, thanks to a brushed aluminium plate on its top surface. Underneath, it's all plastic, but build quality is superb, with the whole thing having a solid feel. That said, the relatively thin aluminium top plate overhangs the edge of the plastic below in a way that looks good but does make for a slightly sharp edge.

The G413 has cable management channels underneath, and in the box, you get twelve faceted keycaps that offer a little more grip than the conventional buttons, which are only slightly concave as on most keyboards.

This is also the only keyboard in the Labs to have USB pass-through, although it's a USB 2 connection – not faster USB 3.1. Unlike the HyperX, the cable isn't removable.

There are no dedicated macro or media buttons on the G413, although macros can be recorded to the function row and media controls are also available here. No wrist rest is included so you'll have to make do with an aftermarket one, which in fairness is generally preferable anyway as most included wrist rests pale in comparison with proper padded ones.

There's no RGB lighting on this keyboard, either, with the G413 sporting red backlighting throughout. The brightness can be set to four levels via one of the secondary functions of the F keys. It's bright and even, but only a couple of basic effects are available.

The G413 doesn't have extraneous features or RGB LEDs, then. Instead, Logitech lets the internals do the talking. Those Romer-G switches are rated for a superb lifespan of 70 million keypresses, and the keyboard has 26-key rollover and anti-ghosting. These tactile variants of the switches have a slight tactile bump but no audible click (linear and clicky versions of the switches are available but not on this keyboard). They have an operating force of 45g, a 3.2mm travel distance, and a 1.5mm actuation point.

The G413 squares up against the HyperX Alloy FPS Pro as the only other mechanical unit in the Labs. The HyperX uses Cherry MX switches which we do find slightly nicer in use but it's a close-run thing, and both far exceed the responsiveness of the other keyboards on test, and they'll last much longer too. Potentially crucial for some users, the Romer-G switches have shorter travel and actuation distances than the Cherry MX switches.

Unusually for a mechanical keyboard, the G413's buttons are surprisingly quiet, creating less din than most of the other keyboards on test, whether mechanical or membrane.

The Romer-G switches do still feel lighter and softer than most mechanical designs, though – including both of the faster, firmer Cherry MX switches inside the HyperX. The affordable, membrane Corsair feels a little weightier, too, even if those switches are also slower.

FIZZY

+ Decent mechanical switches
+ Sturdy build quality
+ Includes replacement keycaps

FLAT

– Few extra features
– Better mechanical options elsewhere
– No RGB LEDs

SPEC

Connection Wired, USB

Cable 1.8m, braided

Material Plastic, aluminium

Switch type Romer-G Tactile

Backlighting Red

Extras USB pass-through, additional keys, key puller

Conclusion

The G413's mechanical switches are a big boon at this budget, putting the G413 comfortably ahead of the membrane keyboards on test when it comes to typing speed and consistency. Plus, they'll last longer too.

We prefer the switches on the HyperX Alloy FPS Pro, but you pay a premium for those switches, with that keyboard missing out on a numberpad. Both mechanical keyboards also have minimal designs and feature sets, with no extra switches or RGB LEDs.

The Logitech G413 is a sturdy, robust mechanical unit, that while not flawless, offers a lot of value for its price.

VERDICT

Solid mechanical keys and robust design, but other options are better and more versatile.

DESIGN	FEATURES	VALUE	OVERALL SCORE
32/40	26/35	21/25	79%

MSI VIGOR GK30 / £40 inc VAT

SUPPLIER scan.co.uk

The Vigor GK30 only costs £40, which makes it one of the cheapest units in the group test, along with the excellent Corsair K55 RGB. The MSI punches above its weight when it comes to its RGB LED lighting, though. It has six lighting zones, which is twice as many as the Corsair, and the use of a translucent membrane layer lends the whole unit a smart, attractive glow.

There are none of the issues surrounding inconsistent or weak lighting here – unlike on the £45 Razer device – and MSI's Dragon Center app has a reasonable range of effects available. Crucially, though, only seven colours are available, so you can't pick any RGB LED shade.

The biggest lighting issue is the band of RGB LEDs installed on the right-hand side of the wrist rest. It's far brighter than the rest of the lighting, and it's often distracting. And, while the MSI does technically have a wrist rest, it's so small that they may as well not have bothered.

Elsewhere, the feature set is slim: there are no media or macro keys and no USB pass-through. It's similar here to the Razer, but the Corsair is a far better option if you want those extra buttons and a larger, more comfortable wrist rest.

The Vigor is made from underwhelming plastic, and build quality is not great. Its chassis is flimsier than the Corsair and noticeably weaker than pricier mechanical keyboards that are bolstered with metal. It's spill-resistant, like the Razer and Asus units, which bodes well for gaming with drinks around.

MSI's switches include a plunger mechanism that's designed to provide a more controlled, precise feel than conventional membrane switches. They're also rated to 12 million keystrokes, which is roughly double typical membrane switches, though a long way off the over 50 million keystrokes of true mechanical switches. The Vigor's switches do offer a crisp initial feeling, and they have a pronounced bump, just like Cherry MX Blue keys – and they're just as loud, too.

They're not nearly as satisfying, though. The buttons have decent speed, but they're lighter and less comfortable than their mechanical inspiration and even when compared with the keys on the Corsair. The buttons bounce when they bottom out too, which makes the typing action feel too spongy.

The MSI's keys aren't awful, but neither are they markedly better than decent-quality membrane switches. They're light, spongy and aren't comfortable when compared with the Corsair, which also costs £40. Step up a little to the £45 Razer Cynosa Lite and you'll get a membrane keyboard that's light, fast, and consistent without the irritating spongy feeling that you'll find on the Vigor.

Elsewhere, the MSI has 6-key rollover, which is only good enough for mainstream gaming – even the cheap Corsair was better here. It's the lowest rollover figure in the Labs.

SPEC

Connection Wired, USB

Cable 1.8m, unbraided

Material Plastic

Switch type Membrane

Backlighting 6-zone RGB

Extras Wrist rest

VIGOROUS

- \+ Bold, versatile lighting
- \+ Low price
- \+ Compact design

LETHARGIC

- – Springy, disappointing typing
- – Few extra features
- – Poor rollover figure

Conclusion

The MSI Vigor GK30 has good RGB lighting, with a consistent and bright glow across its keys and underneath all of those buttons, but that's the only area where this unit outpaces its rivals.

The wrist rest is so small as to be pointless, and there are no extra buttons. It has mediocre build quality, and its loud, fast buttons suffer because they're light and bouncy – not comfortable compared with the more solid Corsair options and the rapid units on the Razer.

When those rivals offer better typing and more features for hardly any extra cash, it's tricky to recommend the MSI – unless you're really committed to having a keyboard with bold, bright lights.

VERDICT

Good lighting, but few features and underwhelming typing hinder this unit.

DESIGN	FEATURES	VALUE	OVERALL SCORE
26/40	25/35	17/25	68%

RAZER CYNOSA LITE / £45 inc VAT

SUPPLIER amazon.co.uk

Razer is usually associated with its more expensive and outrageous gaming products, but the Cynosa Lite is a simple membrane keyboard with modest looks and a £45 price. The plastic Cynosa has an illuminated Razer logo on its slanted front edge, but that's it when it comes to ornamentation. Elsewhere, this device is smart and subtle.

Build quality is decent, too. This unit can't match the strength exhibited by more expensive keyboards that are bolstered with metal plates, but it's just as sturdy as the £40 Corsair K55 RGB and noticeably more robust than the MSI Vigor GK30.

The Razer is one of the most compact keyboards in the Labs. Its minimal design means there's not much plastic to be found beyond the keys, and the buttons themselves are recessed into the chassis so they don't stand proud like on so many mechanical keyboards in particular.

The Cynosa has subtle lighting, with just one backlit Razer logo along with the backlighting. This makes for a smart look, but you do miss out on the more impressive displays of some keyboards. The membrane layer on this keyboard isn't illuminated like it is on some rivals, though it's a feature that you can find in the pricier Cynosa models. You also don't get glowing lights around the chassis that can light up your desk.

As well as limited lighting zones, you also get limited lighting colour options, with the only option being the green seen here. This makes the Razer's lighting far less versatile than the RGB LEDs on other models, and even more disappointingly the lights aren't particularly impressive either: they're not very bright or consistent. You do get loads of customisation options in the Razer Synapse app, but this keyboard will never be as bold or as attractive as its rivals.

Elsewhere, the Razer has no dedicated media or macro keys, although on-the-fly macro recording is possible here. It has a middling 10-key rollover designation, and it's spill-resistant. The Corsair is better here, thanks to its dedicated media and macro buttons.

Razer's sunken keys strike a decent balance between the superb Corsair buttons and the lighter, weaker MSI design. The Cynosa's buttons are a little softer and lighter than the Corsair buttons, but they respond quickly and precisely – almost as quick as the best mechanical devices. They have a relatively linear motion with less of a pronounced bump than some keys. The keycaps have a nice comfortable soft-touch coating that provides a secure grip.

The Razer's buttons still can't compete with mechanical hardware, and especially with the HyperX Alloy FPS Pro. However, the Cynosa Lite is easily good enough for gaming, and it's a solid alternative to the Corsair if that unit will prove too heavy and tactile.

We only have one concern about the Razer's layout, which is its single-height Return key. It's quite common to find this with smaller brands that can't afford a full UK-style key layout variant of their keyboard, but we'd expect Razer to have a proper full-height Return key.

Conclusion

The Razer Cynosa Lite is a good alternative to the Corsair when it comes to typing: its buttons are light, soft, and almost as precise and snappy as the best mechanical devices. Plus, they're linear rather than tactile, so if the Corsair's heavier and more tactile buttons aren't suitable, the Razer is the best alternative at this price.

It's a shame that the Cynosa is inconsistent elsewhere: it's robust and spill-resistant, but it doesn't have extra buttons, and its lighting is poor.

This is a good option if you want an affordable keyboard with light, fast, and reliable buttons, but remember that sturdier units with more features are easy to find.

YES, SIR

- \+ Fast, light, and consistent typing
- \+ Spill-resistant
- \+ Robust build quality

NO, SIR

- – Poor lighting
- – Few extra features
- – A little more expensive than rivals

SPEC

Connection Wired, USB

Cable 1.8m, unbraided

Material Plastic

Switch type Membrane

Backlighting 1-zone RGB

Extras Wrist rest

VERDICT

Fast, light, and reliable typing are undermined by poor lighting and features.

DESIGN	FEATURES	VALUE	OVERALL SCORE
30/40	27/35	20/25	77%

STEELSERIES APEX 3 / £60 inc VAT

SUPPLIER game.co.uk

The SteelSeries Apex 3 is the most expensive membrane keyboard in the Labs, with its £60 price tag sitting just one pound above that of the Asus TUF Gaming K5 and one pound less than the tenkeyless, mechanical HyperX Alloy FPS Pro.

SteelSeries has tried to justify the price by loading the Apex up with features. It has ten-zone RGB LED lighting, which means you get more versatility than on virtually any other keyboard in the Labs. The lighting is bright and bold, and the translucent membrane beneath the floating keys gives the whole unit a nice even glow. The font on the keys is also big and bold, and the lighting here is a little more consistent than on most of the other membrane keyboards in the Labs.

The Apex has a volume roller alongside a single media button that can pause and play music, skip tracks, and reload the previous song depending on how many times it's clicked. It's a little awkward when compared with having separate keys for different tasks, but it's still a welcome addition.

STEELY

+ Fast, reliable typing action
+ Excellent lighting
+ Smart, compact design

FLIMSY

– Typing is a little bouncy
– Few extra features
– No Game Mode

SPEC

Connection Wired, USB

Cable 1.8m, unbraided

Material Plastic

Switch type Membrane

Backlighting 10-zone RGB

Extras Wrist rest, volume roller

The Apex is also spill-resistant, and it has cable-routing options underneath. An impressively deep and comfortable (though not padded) wrist rest is also included, and it conveniently attaches to the front via magnets. The keyboard has 24-key rollover, which is better than most membrane models, and the switches are rated for 20 million keypresses, which is again comfortably better than most membrane rivals, even if not up to the level of true mechanical keys.

On the missing feature list, the Apex 3 doesn't have a Game Mode, for disabling Windows key functions, and there's no USB pass-through, either. The Asus has a similar feature set, with 24-key rollover and media buttons, but it's also much larger than the Apex, with a more divisive design.

Build quality is a touch disappointing. This relatively expensive membrane unit looks the part, despite the use of plastic throughout, but the chassis flexes back and forth far too easily. The Asus and HyperX units are far sturdier, and more suitable for frequent transport.

The Apex's membrane buttons have nearly 4mm of travel, and they certainly feel tall. The buttons have a solid, weighty quality to them, though, and provide consistent movement and almost no wobble. This keyboard is also extremely quiet as befits SteelSeries calling these Whisper-Quiet switches.

The buttons have a fast, snappy response and bounce back very quickly once they've bottomed-out – they almost feel too springy. The buttons also have a more substantial bump than anything else in the Labs. The Asus has a tactile bump, too, but it's a little more gradual. The HyperX has a similar bump if you opt for its Cherry MX Blue or Brown switches, but linear Cherry MX Red switches are also available.

The springy, speedy nature of these buttons will be a boon for fast-paced gameplay and for people who also want to type at speed. However, they're definitely divisive thank to their height and that springy return. All of its rivals are better in this regard, with a more definitive feeling when the buttons are pushed down.

Conclusion

The SteelSeries does have some areas where it matches and beats rivals: it has similar rollover settings, very good lighting, and a more subtle and compact design, especially when compared with the Asus.

Its typing action won't suit everyone though, thanks to its pronounced tactile bump and springy kick-back. If that's the case, the Asus is more conventional, and the mechanical HyperX is faster and has more weight.

If you want a fast, springy keyboard with good lighting, the Apex is a reasonable option. Just be aware that rivals have more conventional typing actions and better build quality. CPC

VERDICT

It's fast, attractive, and compact, but not everyone will like the slightly springy typing.

DESIGN	FEATURES	VALUE	OVERALL SCORE
29/40	27/35	21/25	77%

LABS TEST

Panel show

With a fresh new crop of high-quality 27in, IPS gaming monitors now on the market, **Edward Chester** puts five of them to the test

How we test

We've long considered 27in IPS 144Hz+ monitors to be the ideal all-round spec for gaming, thanks to their balance of size, resolution, image quality and gaming performance, and some of these latest models have another ace up their sleeve.

Previous 144Hz+ IPS screens have been limited to a response time of around 4ms, whereas these new panels can all achieve a 1ms response time, putting them in line with TN LCDs for responsiveness. At least in theory. They all also include G-Sync-compatible adaptive sync, so they can provide tear and stutter-free gaming on both AMD and Nvidia cards.

Less welcome is the fact that all these displays also include extended colour gamuts in a nod towards HDR. However, none of them really produces proper HDR, so the extended range – which makes colours look oversaturated and unnatural in non-HDR content – is a hindrance.

As such, we're changing our testing slightly. Instead of reporting image quality before and after calibration, we've recorded image quality in the default extended gamut mode and in the sRGB mode. Opting for the latter mode (which is how we'd run these displays) generally locks out the ability to adjust any other image quality settings, so there's no point in us trying to calibrate them further.

We test image quality with an X1i1 Display pro colorimeter and DisplayCal software, with the brightness set to a sensible 150 nits (generally around 25/100 on a display's brightness scale). We also test the maximum brightness, and then turn on the sRGB mode to test how this crucial setting performs.

The colorimeter is also used to check uniformity, to see if the whole panel produces consistent image quality across its full area. We also check for any backlight bleed, viewing angles, excessive IPS glow and any image quality factors that can't be gauged by a colorimeter.

Next up, we turn to gaming. Here, we mainly concentrate on FPS games, where a fast response time, high refresh rate and adaptive sync are hugely important. We test subjectively and then also use BlurBuster's excellent ghosting UFO test to check for the sharpness of the display in high-speed motion. Finally, we also assess the connections, features, design and build quality of each display.

Contents

AOC 27G2U / £199 inc VAT

SUPPLIER cclonline.com

AOC's 27G2U might not have the 2,560 x 1,440 resolution of the other displays on test, but it offers amazingly good value for money. You get a 27in IPS panel, 144Hz+ refresh rate, fully adjustable stand, and even FreeSync and G-Sync support, all for under £200.

Of course, there are other areas where costs have been cut, such as build quality. While the stand offers height, tilt, rotation and pivot adjustment, it feels noticeably less sturdy than the other displays on test, although all the adjustments are easy to perform. The back of the display is also a bit thinner and less robust than the others, and you miss out on some extra features, with no flip-down headphone stands or RGB lights (oh the humanity!)

However, you miss out on little else. You even get a fancy 'frameless' design, where the bezels merge with the panel, making for a slim and sleek appearance. You also get a USB hub with four USB 3 ports, along with one DisplayPort, two HDMI ports and even a VGA input.

SPEC

Screen size 27in

Resolution 1,920 x 1,080

Panel technology IPS

Maximum refresh rate 144Hz

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.2, 2 x HDMI 1.4, 1 x VGA

Audio 2 x 2W speakers, line in, headphone out

Stand adjustment Height, rotation, pivot, tilt

Extras 100 x 100mm VESA mount, 4-port USB 3 hub

One disappointment, though, is the menu system. The buttons for navigating it are tiny, and their labelling is all but invisible in poor lighting. The menu layout isn't the worst, but the overall navigation experience is bad – you'll want to set up this display once and forget it.

As for image quality, having a 1,920 x 1,080 resolution on a 27in display makes for a fairly chunky-looking image and a slightly cramped-feeling desktop. However, it's a boon for gaming, where the lower pixel count reduces the load on your GPU. The image also looks fantastic right out of the box, with a decent maximum brightness of 335 nits, a Labs test-topping contrast of 1,447:1 and excellent colour balance and gamma. There's also no egregious backlight bleed or IPS glow. Uniformity is okay too, with an average variance in brightness of 3.5 per cent and a peak drop of 13.6 per cent in the bottom left corner.

This display does have a slightly extended colour range, though, hitting 123.4 per cent sRGB colour space coverage, so it won't be ideal for colour-critical work. There's a dedicated sRGB mode that corrects this, and also makes for even better overall image quality, but it's fixed at 250 nits brightness, which is too bright. Thankfully, the gamut isn't extended too far to be unusable for desktop work, and the sRGB mode may also be usable in some bright environments.

The AOC held up well in gaming too. G-Sync compatibility is a huge boon at this price, meaning you can get tear- and stutter-free gaming on Nvidia GPUs without the extra cost of a true G-Sync display. However, the other monitors on test felt snappier in terms of response. The AOC is still decent for competitive gaming, but a little way back from the rest – and further back still from TN displays, which still feel snappier, despite matching the 1ms response time on paper.

HD MONITOR

+ Astonishingly good value for money
+ Great gaming performance
+ Ideal resolution for slower GPUs

HD FLOPPY DISK

– Resolution limits sharpness
– Stand feels cheap
– Terrible OSD buttons
– sRGB mode too bright

Conclusion

The AOC 27G2U is the single finest budget gaming display we've seen. Getting a 144Hz IPS panel with G-Sync support and full stand adjustability for under £200 is astonishing, and the drop to 1080p is a small price to pay. The low resolution and lack of a usable strict sRGB mode means it's not quite an ideal work and play all-rounder, but otherwise, we can't praise this monitor enough.

VERDICT

A 1080p resolution is all that holds back this otherwise fantastic budget gaming display.

IMAGE QUALITY	GAMING	OVERALL SCORE
22/30	24/30	84%
FEATURES	VALUE	
18/20	20/20	

ASUS TUF GAMING VG27AQ / £449 inc VAT

SUPPLIER overclockers.co.uk

Asus' TUF Gaming VG27AQ packs most of the same core essentials as the other monitors on test – aside from the lower-resolution AOC model. That means the VG27AQ has a 2,560 x 1,440 resolution, a maximum refresh rate of 144Hz (that's overclockable to 165Hz) and adaptive-sync support with G-Sync compatibility. That's a tempting list of features by any measure, and the VG27AQ has an ace up its sleeve, though elsewhere it's a little more mundane.

You do get a fully adjustable stand, with height, rotation, pivot and tilt movements (plus of course, 100 x 100mm VESA mount support), but otherwise the design is smart but decidedly drabber than all the others on test, bar the AOC. The plastic has a slightly cheaper-looking finish to it, the stand is just plain steel with a plastic outer and the bezels around the screen are clearly visible.

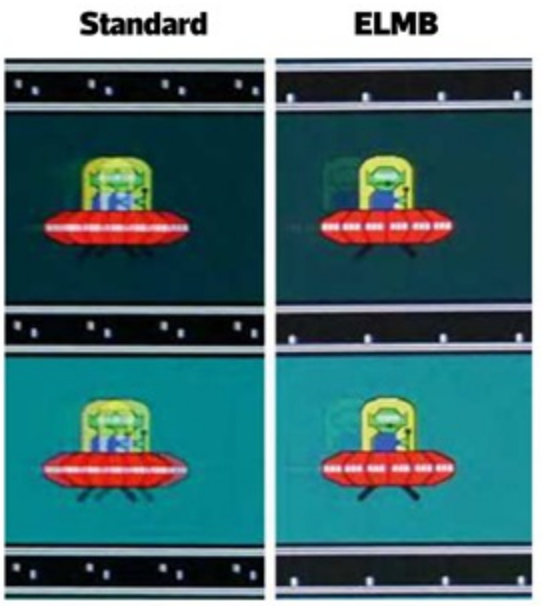
All the other displays here have those tiny 1mm bezels that sit flush with the screen's surface, with a small border that sits under the edge of the screen, creating a really slick, slim look. The Asus, though, has a 5mm wide bezel that sits atop the screen. It's still very slim but isn't quite as neat as the others. You also miss out on any extra features, such as a headphone stand, RGB lights or even a USB hub.

When it comes to the important stuff, though, the VG27AQ doesn't disappoint. Overall image quality is very good, with decent colour balance, contrast and gamma in the default mode. However, like the other displays here, the colour gamut is larger than sRGB, making it unsuitable for image and video editing – it's no good for HDR editing either.

You do get an sRGB mode that's fixed to a sensible 140 nits brightness, but the contrast drops to a woeful 504:1. It's a good setting for general desktop work – low contrast is actually easier on the eye, but it isn't good for gaming, watching video or photo and image editing. Thankfully, the 111 per cent sRGB coverage in the default mode isn't too far above 100 per cent, so you can get away with using it the vast majority of the time.

It's when you fire up a game that the VG27AQ's secret weapon comes into play. This otherwise modest display includes Asus' extreme low motion blur (ELMB) technology, which combines Nvidia's backlight-strobing motion blur reduction technology (ULMB) with adaptive sync support. Previously, ULMB hasn't been compatible with G-Sync but here it is, and the result is fantastic.

We've included a screen grab from the Blur Busters ghosting test to demonstrate the difference in clarity between ELMB and no ELMB. The upshot is that this display romps home with by far the best gaming performance on test, producing a crisp and clear image, without having to sacrifice G-Sync support.



TUF

- \+ Fantastic gaming performance
- \+ Great overall image quality
- \+ Decent value

FLUFF

- – Few extra features
- – Plasticky design
- – No low-profile bezel

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz (overclockable to 165Hz)

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.2, 2 x HDMI 2

Audio 2 x 2W speakers, headphone out

Stand adjustment Height, swivel, pivot, tilt

Extras 100 x 100mm VESA mount, HDR 10 compatibility

Conclusion

If you just want excellent gaming performance, the VG27AQ is a great option at a decent price. It lacks frills, but there are no serious compromises, and the gaming performance is superb. The only caveat is the lack of a usable sRGB mode. For most users, the slightly extended gamut won't be an issue, but there are better monitors if you're into your image and video editing.

VERDICT

The addition of ELMB transforms this display into a gaming powerhouse, and its image quality is solid too.

IMAGE QUALITY	GAMING	OVERALL SCORE
22/30	30/30	82%
FEATURES	VALUE	
12/20	18/20	

GIGABYTE AORUS FI27Q / £460 inc VAT

SUPPLIER ebuyer.com

The Gigabyte Aorus FI27Q packs in a huge number of features for its price, hitting the same £450 price as several other displays on test this month, yet including markedly more extras. For a start, you get RGB lighting (we know you'd been missing it so far!), with a couple of multi-coloured backlit wings on the back of the display, and an illuminated Aorus logo on the rear of the stand.

The stand itself is also a hefty premium metal contraption that gives this display a far firmer footing than the likes of the Asus VG27AQ. The full complement of adjustment movements are reassuringly smooth, yet firm, although the tilt mechanism is slightly too stiff for making quick and easy adjustments.

DYNAMIC RANGE

- \+ Loads of features
- \+ Great overall image quality
- \+ Excellent gaming performance

DYNAMIC RAGE

- – sRGB mode too bright
- – Pointless HDR certification
- – No ELMB support

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz (165Hz overclocked)

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.2, 2 x HDMI 2

Audio Headphone out, audio in

Stand adjustment Height, rotation, pivot, tilt

Extras DisplayHDR 400 compatibility, RGB lighting, 2-port USB 3 hub

Around the back of the display you'll find the same three digital video inputs as the rest of the displays on test, as well as a 2-port USB 3 hub and the connection for the internal power supply. The back is where the control for the on-screen display (OSD) menu resides. It's a mini-joystick affair that again feels a cut above the rest in terms of build quality. It's not quite as good as the LG's system, but it's the second best on test.

The menus themselves are clearly laid out and offer a wealth of options too. Like all the other displays on test, though, the crucial sRGB mode that's required to use these displays in a conventional, non-pseudo-HDR mode locks down all the other image quality adjustment controls.

Speaking of HDR, this is the only display in the Labs to actually offer compatibility with any of the DisplayHDR standards, in the form of the most basic DisplayHDR 400 standard. This requires a minimum of 400 nits maximum brightness, which only the Aorus and the ViewSonic display manage, although the ViewSonic hasn't obtained DisplayHDR 400 certification. It's rather by the by, though, as none of these displays delivers meaningful HDR – it's a pointless pursuit slapping a high colour gamut on these monitors.

It's good, then, that the sRGB mode offers very good image quality. Right across the board, it's all but perfect where it counts, and it doesn't drop contrast like some of the displays in the Labs. The only caveat is the fixed brightness. It's set to 180 nits, which is a bit higher than the ~150 nits target of most sRGB displays. This extra brightness is manageable but noticeable in general use, to the point where you feel a bit dazzled using this display for too long in a dark room.

Switch to any of the other colour profiles, and you can tweak to your heart's content, but you'll be stuck with a 143 per cent sRGB colour gamut, making for overly bright, unrealistic-looking colours – it's fine for some games and video but not for desktop use.

Gaming performance is helped out by the option to overclock the display to 165Hz and a maximum overdrive setting that doesn't noticeably introduce any inverse ghosting, making for a responsive, clear image. Gaming performance is excellent, and it's also good to have support for both FreeSync and G-Sync – the only notable omission is the EMLB support you get on the Asus VG27AQ.

Conclusion

The Aorus FI27Q is a fantastic, feature-rich gaming display for a great price, although it's a shame about its pointless HDR pretentions. If Gigabyte added an option to switch to sRGB colour space, or allow brightness adjustment in the sRGB mode, this display would have it all – other than ELMB.

VERDICT

A great price and plenty of extra features make for a decent gaming display, but don't get excited about its HDR certification.

IMAGE QUALITY	GAMING	OVERALL SCORE
25/30	24/30	81%
FEATURES	VALUE	
16/20	16/20	

LG 27GL850 / £499 inc VAT

SUPPLIER Overclockers.co.uk

It was the LG 27GL850 that kicked off this latest wave of improved 27in, IPS gaming screens. This monitor introduced us to LG's new 1ms IPS panels, which also power some of the other screens on test this month, so we were interested to see if LG's implementation could better the competition.

What you first notice about this display, upon placing it on a desk, is the strange lack of rotation in the stand. That oddity aside, first impressions are good. The stand doesn't have a particularly premium feel, and the red plastic highlights aren't to our taste, but it's still reasonably smart. The display itself also has the requisite tiny bezel and general slimness that we expect from this latest generation of displays.

Connection options are good too, with a 2-port USB 3 hub joining the DisplayPort socket and two HDMI inputs. You also get a headphone output but no speakers. One particularly impressive aspect of this monitor is the on-screen display (OSD) menu, which is responsive, neatly laid out and governed by a single joystick control on the underside of the display, which is very easy to use.

Then we get to the overall feature list. Like the other displays here, you get a 144Hz IPS panel with a 1ms response time and adaptive sync support with G-Sync compatibility. You even get HDR10 support, although HDR here is basically pointless, as on all the other displays in this test – an extended colour gamut isn't HDR.

Sadly, firing up this display reveals that contrast isn't its strong suit. It has a noticeably greyer look to what should be pure black (LCDs can never show true black) and, sure enough, in our tests, with the backlight calibrated to 150 nits, this display produced a black level of 0.27 nits compared to 0.15 or below for most of the other displays on test. This resulted in a contrast ratio of just 726:1, a figure we couldn't improve by tweaking any of the monitor's settings.

That's not a disastrous contrast level, and you may not pick it up as being low when viewed in isolation. However, it's plain to see when you're sitting next to the other displays on test this month. We were a touch disappointed by the colour balance too. 6,939K is reasonably close to the ideal of 6,500K but it's still the second worse result on test, and it gets even worse in the sRGB mode. This results in a blue tinge to the display that particularly makes reading text a touch harsh on the eyes (this mode locks out any colour adjustment).

Even more problematic is the high colour gamut. This display stretches all the way to 141 per cent sRGB coverage, making colours look far brighter and more unnatural than normal. You can fix this problem by enabling the sRGB mode, but then you have the even worse colour balance.

Jumping into our game tests, though, saw the 27GL850 performing well. Its sharpness in our motion blur test even rivalled the ELMB setting on the VG27AQ. This came across in games too, with a generally snappy feel throughout, plus it will also actively sync with both Nvidia and AMD GPUs, eliminating tearing artefacts.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS (nano IPS)

Maximum refresh rate 144Hz

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.2, 2 x HDMI 2

Audio Headphone out

Stand adjustment Height, pivot, tilt

Extras 100 x 100mm VESA mount, HDR 10 compatibility, 2-port USB 3 hub

Conclusion

The LG 27GL850 may have been at the forefront of the new wave of 1ms IPS gaming displays, but it no longer maintains a clear lead over its rivals. Competitors now offer more features and better image quality for less money. There's a lot to like about this monitor for gaming, but its price needs to drop a little to continue to compete.

LUCKY

+ Higher colour gamut
+ Good gaming performance
+ Generally good-quality display

UNLUCKY

− Low contrast
− Poor OOB colour balance
− No rotation on stand

VERDICT

A high price and a few niggling issues put this trailblazer behind its usurpers.

IMAGE QUALITY	GAMING	OVERALL SCORE
19/30	24/30	70%
FEATURES	VALUE	
14/20	13/20	

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VIEWSONIC ELITE XG270QG / **£708** inc VAT

SUPPLIER alza.co.uk

Like the Gigabyte Aorus FI27Q, the ViewSonic XG270QG sets itself apart with a host of extra features. You get RGB lighting, a USB hub, a headphone stand, mouse cable bungies and even sight shields for the sides.

It's also one of the smarter-looking displays on test, with a very stark, plain black look accented by subtle RGB lighting zones. There's a fetching hexagonal ring of light on the back, and the outer two quarters of the underside emit a glow too. Both lights combine to provide a gentle background glow that can genuinely help to reduce eyestrain if you're in an otherwise dark room.

All this elegance is rather nullified if you attach the side sight shields though. They supposedly help you concentrate by blocking out distractions, while preventing others from seeing your screen. Unless you're regularly rocking up to LANs, though, this is a niche feature.

SPEC

Screen size 27in

Resolution 2,560 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz (overclockable to 165Hz)

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync and G-Sync compatible

Display inputs 1 x DisplayPort 1.2, 2 x HDMI 2

Audio Headphone out, audio in, speakers

Stand adjustment Height, rotation, pivot, tilt

Extras RGB lighting, 3-port USB 3 hub, headphone stand, mouse bungie, side shields

The headphone and mouse bungie additions are really welcome though. The former flips down from the left and provides an ample length of plastic on which to hang your headphones without them encroaching on the screen. Meanwhile, the bungies are littler rubber arms that flip down from the underside of the screen, providing a bungie for either left or right-handed users. The positioning seems too central at first, but it actually works well, and they fit a handful of different mouse cords we tried.

The included stand is a hefty, sturdy affair as well. Its movements are a little stiff, but its sheer weight means the stand stays firmly planted whichever way you're trying to twist and turn the display.

The XG270QG has impressed so far, then, but the OSD menu is a problem. It uses a mini-joystick control on the underside that too easily tips to the side, making it tricky and fiddly to push directly inwards, and not off to the side at the same time. The menu layout is also decidedly unintuitive, making it a chore to use.

The second problem is that, although the XG270QG has an sRGB colour balance mode, it doesn't have an sRGB colour gamut mode, so you're always stuck with the extended colour gamut. That said, the extended range here didn't stand out as obviously as on the other displays, with colour largely looking quite natural, despite the 140 per cent sRGB colour space coverage.

Looking more generally at image quality, the XG270QG has a slightly disappointing contrast ratio of 882:1 in its default mode, and 908:1 in sRGB colour mode. That's a little behind some of the better displays, and it's noticeable in general use. Otherwise this display performs well, with a decent colour balance and gamma in both the colour modes we tested, as well as a plentiful maximum brightness. Average uniformity was decent too, although the top and bottom left corners showed quite noticeable drops in brightness of 8.2 per cent and 11.8 per cent respectively.

When it comes to gaming, you get the option to overclock the refresh rate to 165Hz, and the display also includes ULMB support, although not ELMB, so it sadly can't be enabled at the same time as G-Sync. Largely, performance was on a par with the other displays here, although you need to crank up the overdrive setting to make it as responsive as the others.

SONIC

- \+ Packed with features
- \+ Smart design
- \+ Good sRGB mode image quality

EGGMAN

- – Below-par contrast
- – Poor OSD controls
- – Middling gaming performance

Conclusion

The ViewSonic XG270QG packs in loads of features but demands a high price for the privilege. The extras are all welcome and well implemented, but they don't add up to justifying the extra cost. At this price, it could do with a proper sRGB mode as well. CPC

VERDICT

A cracking monitor, but it struggles against considerably cheaper competitors.

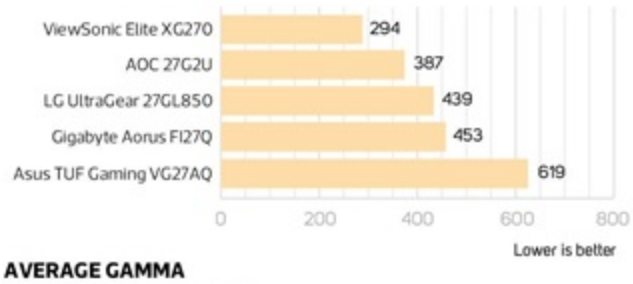
IMAGE QUALITY	GAMING	OVERALL SCORE
22/30	21/30	73%
FEATURES	VALUE	
20/20	10/20	

27IN IPS GAMING MONITOR LABS RESULTS

DEFAULT / HDR MODE

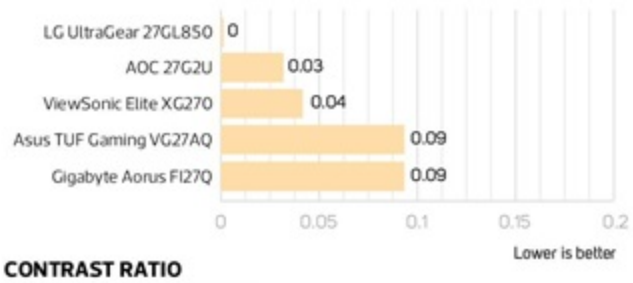
COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



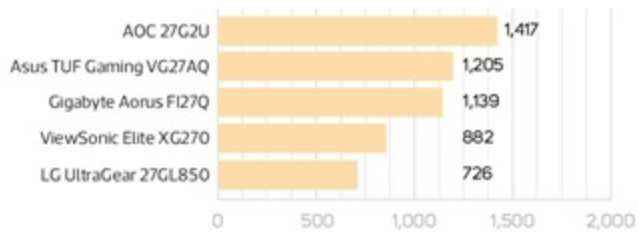
AVERAGE GAMMA

Deviation from ideal result (2.2)



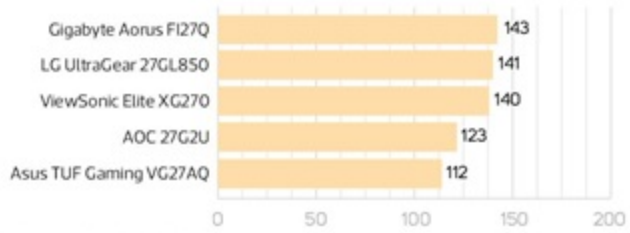
CONTRAST RATIO

Ratio of white-to-black luminance



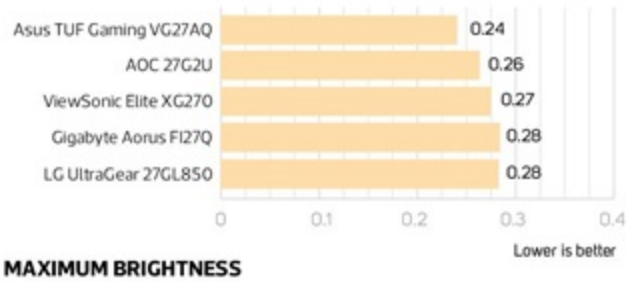
SRGB COLOUR SPACE*

Percentage of sRGB colour space covered



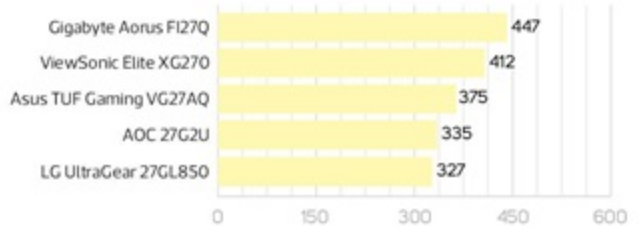
COLOUR ACCURACY

Average delta E 2000



MAXIMUM BRIGHTNESS

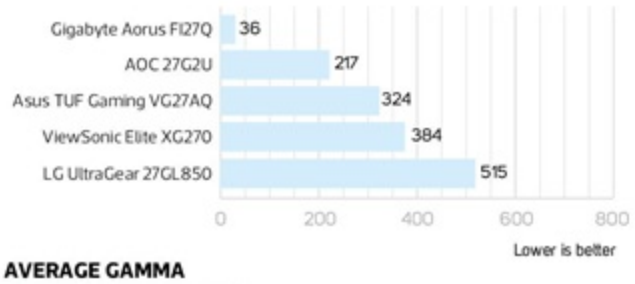
Brightness in cd/m² (nits)



SRGB MODE

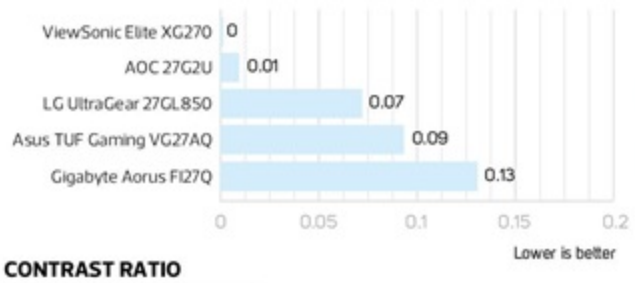
COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



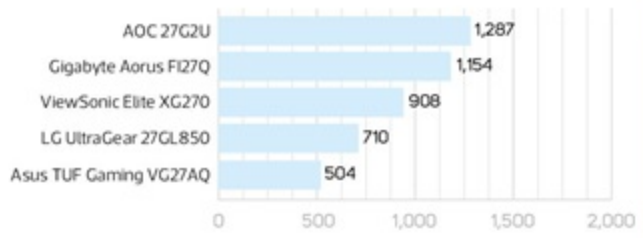
AVERAGE GAMMA

Deviation from ideal result (2.2)



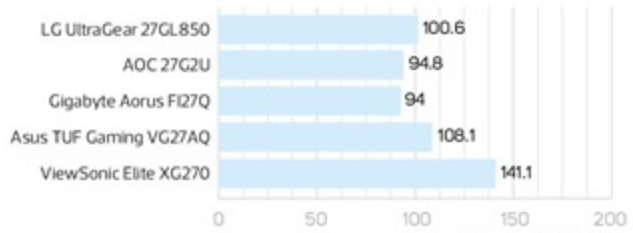
CONTRAST RATIO

Ratio of white-to-black luminance



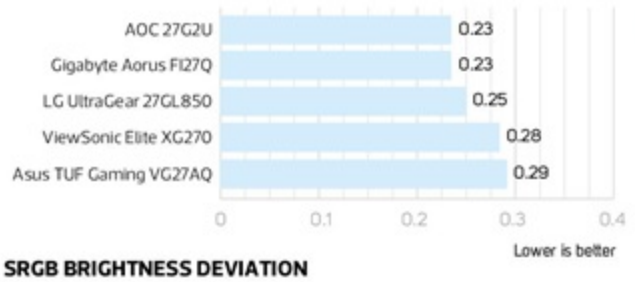
SRGB COLOUR SPACE*

Percentage of sRGB colour space covered



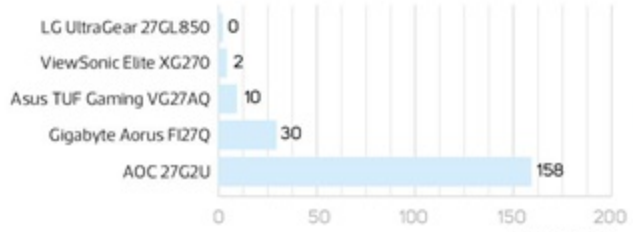
COLOUR ACCURACY

Average delta E 2000



SRGB BRIGHTNESS DEVIATION

Deviation from ideal 150cd/m² (nits)



* A higher colour space percentage is better in HDR, but as close to 100 per cent as possible is better for sRGB mode

How we test

MOTHERBOARDS

TEST PROCESSORS

- **Intel LGA1151** Intel Core i9-9900K
- **Intel LGA2066** Intel Core i9-7900X
- **AMD AM4** AMD Ryzen 9 3900X
- **AMD TRX4** AMD Threadripper 3970X

Our test gear comprises a GeForce RTX 2070 Super Founders Edition and a 2TB Samsung 970 Pro SSD (or a PCI-E 4 1TB Corsair MP600 SSD on X570 and TRX40 boards). We also use Corsair Vengeance RGB 3466MHz DDR4 RAM – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems.

We use **Custom PC**'s own RealBench suite, and Far Cry 5 installed on Windows 10 Home 64-bit to test basic performance. We also test the board's SATA and M.2 ports, and record the noise level and dynamic range of the integrated audio using RightMark Audio Analyzer. We try to overclock our test CPU to its maximum air-cooled level on each motherboard, and record the performance results.

PROCESSORS

TEST MOTHERBOARDS

- **Intel LGA1151** MSI MEG Z90 ACE
- **Intel LGA2066** MSI MEG X299 Creation
- **AMD AM4** Gigabyte X570 Aorus Master
- **AMD AM4 (APU)** MSI X470 Gaming Pro Carbon
- **AMD TRX4** Asus ROG Zenith II Extreme

We otherwise use the same core spec to test each CPU. Our test gear comprises an Nvidia GeForce RTX 2070 Super Founders Edition (or an APU's integrated GPU for gaming tests) and a 2TB Samsung 970 Pro SSD. We also use Corsair Vengeance RGB 3466MHz DDR4 memory – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems. We use Windows 10 Home 64-bit.

We use **Custom PC**'s RealBench suite (see opposite), as well as Cinebench for 3D rendering and Adobe Premiere Pro for video export times. We also use Far Cry New Dawn and Metro Exodus to test gaming performance. Finally, we record the total power draw of the test PC. We run all tests at both stock speed and at the CPU's highest overclocked frequency.

MONITORS

We test image quality with an Xrite iDisplay Pro colorimeter and DisplayCal software to check for colour accuracy, contrast and gamma, while assessing more subjective details such as pixel density and viewing angles by eye. We also run games on them to assess their responsiveness, and to see how well any adaptive sync tech works, and to gauge their performance at high refresh rates.

CPU COOLERS

We measure the CPU temperature with CoreTemp, and subtract the ambient air temperature to give a delta T result, enabling us to test in a lab that isn't temperature controlled. We load the CPU with Prime95's smallfft test and take the reading after ten minutes.

TEST KIT

Fractal Design Meshify C case, 3000MHz Corsair Vengeance LPX memory, 256GB Crucial MX100 SSD, be quiet! System Power 9 500W PSU, Windows 10 64-bit.

INTEL LGA1151

Intel Core i5-9600K CPU overclocked to 4.8GHz with 1.2V vcore, Asus ROG Strix Z370-E Gaming motherboard.

INTEL LGA2066

Intel Core i9-7900X overclocked to 4.2GHz with 1.15V vcore, MSI X299M Gaming Pro Carbon AC motherboard.

AMD AM4

AMD Ryzen 7 1700 overclocked to 3.9GHz with 1.425V vcore, MSI X470 Gaming Pro Carbon AC motherboard.

AMD TR4

AMD Threadripper 2950X overclocked to 4.1GHz with 1.425V vcore, AMD Threadripper 2990WX overclocked to 4GHz with 1.3375V vcore, ASRock X399M 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 graphics cards at 1,920 x 1,080, 2,560 x 1,440 and 3,840 x 2,160, although we omit the latter resolution on cheaper cards that can't produce playable frame rates at this setting.

TEST KIT

Intel Core i7-8700K overclocked to 4.7GHz on all cores, 16GB Corsair Vengeance LED 3000MHz DDR4 memory, Gigabyte Z370 Aorus motherboard, Cooler Master MasterLiquid 240 CPU cooler, Corsair HX750 PSU, Cooler Master MasterCase H500M case, Windows 10 Home 64-bit.

GAME TESTS

Red Dead Redemption 2 Tested at custom high settings. We run the game's built-in benchmark, and use FrameView to record the end portion, which is based on real gameplay. We report the 99th percentile and average frame rates.

Battlefield V Tested in DirectX 12 at Ultra settings on every card. If a GPU also supports real-time ray tracing, we then test it with DXR enabled on High settings with TAA, and also with DLSS if it's supported. We run through a one-minute custom benchmark in the 'Under No Flag' War Story, recording the 99th percentile and average frame rates with FrameView.

Shadow of the Tomb Raider Tested at the Highest settings preset with TAA. We run the built-in benchmark and record the 99th percentile and average frame rates with FrameView.

Total War: Warhammer II Tested in DirectX 11, as the DirectX 12 beta currently causes stuttering issues on some GPUs. We test at Ultra settings with FXAA, and run the built-in 'Battle' benchmark. We record the 99th percentile and average frame rates with FrameView.

POWER CONSUMPTION

We run Unigine Superposition at 4K Optimized DirectX settings. We measure the power consumption of our whole graphics test rig at the mains during the test, and record the peak power draw. This result is for the whole system, not the graphics card alone.

CUSTOM PC AWARDS

EXTREME ULTRA

Some products are gloriously over the top. They don't always offer amazing value, but they're outstanding if you have money to spend.

PREMIUM GRADE

Premium Grade products are utterly desirable, offering a superb balance of performance and features without an over-the-top price.

PROFESSIONAL

These products might not be appropriate for a gaming rig, but they'll do an ace job at workstation tasks.

APPROVED

Approved products do a great job for the money; they're the canny purchase for a great PC setup.

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.

Elite

Our choice of the best hardware available

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.

Budget system with integrated graphics

Quad-core CPU, basic gaming

Needs a micro-ATX or ATX case.
We recommend a 350W 80 Plus power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3400G	novatech.co.uk	**#194,** p20	£129
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#176** p80	£0
GRAPHICS CARD	AMD Radeon RX Vega 11 integrated into CPU	N/A	**#194** p20	£0
MEMORY	8GB (2 x 4GB) Corsair Vengeance LPX 3000MHz (CMK8GX4M2A 3000C16)	scan.co.uk	**#176** p80	£48
MOTHERBOARD	MSI B450M Mortar (micro-ATX)*	scan.co.uk	**#182** p50	£90
STORAGE	500GB WD Blue SN500 (M.2 NVMe)	ebuyer.com	**#191** p78	£69
	Total £336			

*This motherboard may require a BIOS update in order to recognise the new CPU, which can be performed without needing an old CPU, downloading the latest BIOS to a USB flash drive and pressing the Flash BIOS button

Budget gaming system

Quad-core CPU, 1080p gaming

Needs a micro-ATX case. We recommend a 450W 80 Plus power supply. See Issue 191, p78, for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i3-8100	cclonline.com	**#191** p78	£107
CPU COOLER	Raijintek Juno Pro RBW	overclockers.co.uk	**#191** p78	£12
GRAPHICS CARD	Zotac Gaming GeForce GTX 1660 Super	ebuyer.com	**#199** p46	£205
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX 3000MHz (CMK16GX4 M2A2666C16)	scan.co.uk	**#191** p78	£87
MOTHERBOARD	Gigabyte B360M DS3H (micro-ATX)	scan.co.uk	**#191** p78	£80
STORAGE	500GB WD Blue SN500 (M.2 NVMe)	ebuyer.com	**#191** p78	£69
	Total £519			

UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 2060 (1080p gaming with ray tracing and some 2,560 x 1,440 gaming)	ebuyer.com	**#199** p50	£270
SWAP STORAGE	Kingston A2000 1TB	box.co.uk	**#196** p30	£160

Sub-£1,000 gaming system

6-core CPU, 2,560 x 1,440 gaming, real-time ray tracing at 1080p

Needs an ATX case. We recommend a 550W 80 Plus Bronze power supply. See p76 for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3600	ebuyer.com	**#195** p16	£155
CPU COOLER	ARCTIC Liquid Freezer II 240	scan.co.uk	**#196** p26	£60
GRAPHICS CARD	Zotac GeForce RTX 2060 Super Mini	ebuyer.com	**#199** p53	£338
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U360038G17-DT60)	cclonline.com	**#199** p57	£109
MOTHERBOARD	MSI B450 Tomahawk Max (ATX)	ebuyer.com	**#201** p76	£99
STORAGE	500GB WD Blue SN500 (M.2 NVMe)	ebuyer.com	**#191** p78	£69
	Total £830			

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 Super (2,560 x 1,440 gaming with real-time ray tracing)	scan.co.uk	**#193** p16	£468
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£90
SWAP STORAGE	Kingston A2000 1TB	box.co.uk	**#196** p30	£160

Mid-range gaming system

8-core CPU, 2,560 x 1,440 gaming with real-time ray tracing, and some 4K gaming

Needs an ATX case with room for a 240mm all-in-one liquid cooler. We recommend a 600W 80 Plus Bronze power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 3700X	scan.co.uk	**#200** p51	£270
CPU COOLER	ARCTIC Liquid Freezer II 240	scan.co.uk	**#196** p26	£60
GRAPHICS CARD	Nvidia GeForce RTX 2070 Super	scan.co.uk	**#193** p16	£468
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U3600 38G17-DT60)	cclonline.com	**#199** p57	£109
MOTHERBOARD	Asus ROG Strix X570-E Gaming (ATX)	overclockers.co.uk	**#193** p44	£300
STORAGE	1TB Corsair MP600	amazon.co.uk	**#193** p26	£197
	Total £1,404			

UPGRADES

ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£90
SWAP CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	**#185** p82	£120

Core component bundles cont ...

4K gaming system

12-core CPU, 4K gaming with real-time ray-tracing abilities

Needs an E-ATX case with room for a 240mm all-in-one liquid cooler. We recommend a 650W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 9 3900X	overclockers.co.uk	**#200** p51	£420
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	**#175** p20	£120
GRAPHICS CARD	Nvidia GeForce RTX 2080 Ti	scan.co.uk	**#189** p20	£1,040
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U3600 38G17-DT60)	cclonline.com	**#199** p57	£109
MOTHERBOARD	MSI Prestige X570 Creation (E-ATX)	overclockers.co.uk	**#193** p48	£420
STORAGE	1TB Corsair MP600	amazon.co.uk	**#193** p26	£197
	Total £2,306			
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	**#166** p54	£90
SWAP CPU	AMD Ryzen 9 3950X (16 cores)	overclockers.co.uk	**#197** p24	£699

Heavy multi-threading workstation

Serious multi-threaded power, 1080p gaming

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Threadripper 3960X	overclockers.co.uk	**#197** p18	£1,350
CPU COOLER	Enermax Liqtech II TR4 240 (240mm AIO liquid cooler)	overclockers.co.uk	**#186** p44	£110
GRAPHICS CARD	Zotac Gaming GeForce GTX 1660 Super	ebuyer.com	**#199** p46	£205
MEMORY	32GB Corsair Dominator Platinum RGB 3466MHz (CMT32GX4 M4C3466C16)	scan.co.uk	**#197** p20	£315
MOTHERBOARD	ASRock TRX40 Taichi (E-ATX)	overclockers.co.uk	**#198** p44	£470
STORAGE	1TB Corsair MP600	amazon.co.uk	**#193** p26	£197
	Total £2,507			
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 Super (2,560 x 1,440 gaming with ray tracing, and some 4K gaming)	scan.co.uk	**#193** p16	£468
SWAP CPU	AMD Threadripper 3970X (32 cores - massive multi-threaded power)	overclockers.co.uk	**#197** p19	£1,890
ADD SECONDARY STORAGE	6TB Seagate BarraCuda Pro	cpc.farnell.com	**#166** p50	£216

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. We've also recommended a small PSU and a low-profile CPU cooler, if your chosen case requires them.

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	ASRock Z390 Phantom Gaming-ITX/ac	scan.co.uk	**#185** p50	£193
AMD X570 (AM4 budget)	Gigabyte X570-I Aorus Pro WiFi	overclockers.co.uk	**#195** p24	£227
AMD X570 (AM4 mid-range)	Asus ROG Strix X570-I Gaming	overclockers.co.uk	**#198** p20	£270

Cases

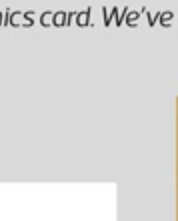
CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Metallic Gear Neo Mini	amazon.co.uk	**#195** p48	£73
MID-RANGE	Phanteks Enthoo Evolv Shift Air	overclockers.co.uk	**#195** p49	£95
PREMIUM	NZXT H1	scan.co.uk	**#201** p24	£299

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	**#143** p17	£46

Power supplies

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
800W SFX	SilverStone Strider SX800-LTI	scan.co.uk	**#185** p82	£165



Micro-ATX

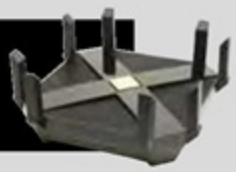
Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	Asus ROG Maximus XI Gene	overclockers.co.uk	**#189** p28	£285
AMD X399 (TR4)	ASRock X399M Taichi	scan.co.uk	**#179** p28	£318
AMD B450 (AM4)	MSI B450M Mortar	scan.co.uk	**#182** p50	£90

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	scan.co.uk	**#180** p46	£45
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	**#161** p26	£70

Networking



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER (WI-FI 6)	TP-Link Archer AX6000	amazon.co.uk	**#196** p57	£269
MESH ROUTER (WI-FI 5)	Netgear Orbi 2-Pack (RBK50)	amazon.co.uk	**#172** p57	£250
PREMIUM MESH ROUTER (WI-FI 6)	Asus AiMesh AX6100	box.co.uk	**#196** p54	£340
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	**#196** p58	£60
SINGLE-BAY NAS BOX	Synology DS118	box.co.uk	**#174** p34	£161
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	**# 200,** p22	£156
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£203

ATX Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	**#176** p28	£55
BUDGET QUIET	be quiet! Pure Base 500	aquatuning.co.uk	**#196** p24	£68
SUB-£100	Lian Li Lancool II	overclockers.co.uk	**#201** p22	£83
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	**#187** p24	£135
HIGH-END	NZXT H700i	overclockers.co.uk	**#196** p51	£170
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	**#187** p24	£200

Monitors

FreeSync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN BUDGET 1,920 X 1,080	AOC G2460VQ6	overclockers.co.uk	**#174** p52	£129
24IN MID-RANGE 1,920 X 1,080	AOC C24G1	cclonline.com	**#191** p28	£170
24IN 240Hz ESPORTS 1,920 X 1,080	AOC AGON AG251FZ	laptopsdirect.co.uk	**#187** p48	£290
27IN 2,560 X 1,440	Samsung C27HG70	ebuyer.com	**#171** p28	£445

FreeSync and G-Sync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN BUDGET 1,920 X 1,080	AOC G2590FX	overclockers.co.uk	**#190** p53	£170
27IN IPS 1,920 X 1,080	AOC 27G2U	cclonline.com	**#201** p53	£199
27IN VA 2,560 X 1,440	MSI Optix MAG272CQR	ebuyer.com	**#201** p28	£280
27IN IPS 2,560 X 1,440	Asus TUF Gaming VG27AQ	overclockers.co.uk	**#201** p54	£449

G-Sync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN 2,560 X 1,440	AOC AGON AG241QG	amazon.co.uk	**#169** p55	£395
27IN 2,560 X 1,440	Asus ROG Swift PG279Q	ebuyer.com	**#155** p48	£729
35IN ULTRA-WIDE 3,440 X 1,440	AOC AGON AG352UCG6	overclockers.co.uk	**#180** p52	£670
27IN 4K PREMIUM	Asus ROG Swift PG27UQ	scan.co.uk	**#181** p31	£1,849
35IN ULTRA-WIDE HDR 3,440 X 1,440	Asus ROG Swift PG35VQ	scan.co.uk	**#198** p58	£2,499

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN 4K	AOC U2790PQU	box.com	**#194** p30	£286
27IN 5,120 X 2,880	Iiyama ProLite XB2779QQS	scan.co.uk	**#179** p34	£695

Peripherals and audio

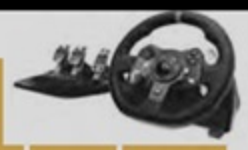
Gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
MEMBRANE	Corsair K55 RGB	game.co.uk	**#201** p45	£40
BUDGET MECHANICAL	HyperX Alloy FPS Pro	amazon.co.uk	**#201** p46	£61
MECHANICAL	Corsair K68 RGB	ebuyer.com	**#181** p53	£110
MECHANICAL MMO	Corsair K95 RGB Platinum	scan.co.uk	**#164** p26	£140
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	**#193** p56	£150
LUXURY MECHANICAL	Razer Hunstman Elite	scan.co.uk	**#193** p59	£189

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Corsair M55 RGB Pro	currys.co.uk	**#200,** p24	£40
FIRST-PERSON SHOOTER	SteelSeries Rival 600	box.co.uk	**#184** p59	£63
MMO	Razer Naga Trinity	scan.co.uk	**#186** p52	£79
AMBIDEXTROUS	Razer Lancehead Tournament Edition	currys.co.uk	**#177** p53	£60
ULTRA LIGHTWEIGHT	Glorious PC Gaming Race Model O	overclockers.co.uk	**#195** p58	£42

Peripherals and audio cont ...



Game controllers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEERING WHEEL & PEDALS	Logitech G920 Driving Force	currys.co.uk	**#159** p55	£180
GAMEPAD	Microsoft Xbox One Wireless Controller	argos.co.uk	**#191** p56	£40

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Edifier R1280DB	amazon.co.uk	**#192** p57	£120

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Sennheiser GSP 300	amazon.co.uk	**#194** p56	£75
SURROUND	Asus ROG Centurion	cclonline.com	**#163** p49	£216
WIRELESS	SteelSeries Arctis 7	currys.co.uk	**#178** p58	£130
PREMIUM WIRELESS	Corsair Virtuoso RGB Wireless SE	overclockers.co.uk	**#195** p30	£180

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET PC WITH INTEGRATED GRAPHICS	Falcon Raptor RX	AMD Ryzen 5 3400G stock speed	AMD Radeon RX Vega 11	falconcomputers.co.uk	**#176** p52	£454
SUB-£1,000 GAMING	AlphaBeta i5 RTX	Intel Core i5-9600KF stock speed	Nvidia GeForce RTX 2070 Super	alphabetapc.com	**#197** p40	£999
8-CORE GAMING	Wired2Fire Predator	AMD Ryzen 7 3700X stock speed	Nvidia GeForce RTX 2060 Super	wired2fire.co.uk	**#196** p40	£1,290
GEFORCE RTX 2080 SUPER GAMING	CyberPower Ultra 7 RTX	AMD Ryzen 7 3800X stock speed	Nvidia GeForce RTX 2080 Super	cyberpowersystem.co.uk	**#199** p34	£2,055
WATER-COOLED MINI-ITX	Fierce PC Ardent Core	AMD Ryzen 7 3700X stock speed	Nvidia GeForce RTX 2080 Super	fiercepc.co.uk	**#201** p34	£2,399
PREMIUM MINI-ITX	Corsair One i160	Intel Core i9-9900K stock speed	Nvidia GeForce RTX 2080 Ti	corsair.com	**#190** p32	£3,250
16-CORE GAMING	Scan 3XS Vengeance RTX Ti	AMD Ryzen 9 3950X stock speed	Nvidia GeForce RTX 2080 Ti	scan.co.uk	**#200** p32	£3,200
WATER-COOLED 16-CORE GAMING	Scan 3XS Vengeance RTX Ti Fluid	AMD Ryzen 9 3950X OC to 4.3GHz	Nvidia GeForce RTX 2080 Ti	scan.co.uk	**#197** p42	£4,499
THEADRIPPER PC	Chillblast Fusion Conqueror	AMD Ryzen Threadripper 3970X stock speed	Nvidia GeForce RTX 2080 Ti	chillblast.com	**#199** p32	£6,600
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	2 x Nvidia GeForce RTX 2080 Ti	scan.co.uk	**#145** p58	£13,264

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
GEFORCE RTX GAMING	Chillblast Phantom 17	Intel Core i7-9750H stock speed	Nvidia GeForce RTX 2070	17.3in 1,920 x 1,080 IPS 144Hz	chillblast.com	**#197** p53	£1,949
PREMIUM GAMING	Asus ROG Zephyrus S GX701GX	Intel Core i7-9750H stock speed	Nvidia GeForce RTX 2080 Max-Q	17.3in 1,920 x 1,080 IPS 144Hz G-Sync	amazon.co.uk	**#190** p28	£3,300

RICK LANE / INVERSE LOOK

CAPITALIST PUNISHMENT

Some games love anti-capitalist satire, but Rick Lane asks if such a fundamentally corporate industry can say much of note about capitalism

Since the days of Syndicate and Fallout, games have loved to have a dig at capitalism. Our corporate society is one of the five possible triggers for a virtual apocalypse, along with zombies, aliens, Nazis and viruses. Communism might occasionally threaten to destroy the world, but it never succeeds.

Lately, capitalism has been in for a right kicking. The past few months have seen the release of The Outer Worlds and Journey to the Savage Planet. Both are first-person sci-fi games about exploring distant planets, and both have got it in for large, oppressive corporations.

In The Outer Worlds, one planet is run by a company called Spacer's Choice, and its policies includes forcing employees to lease their own grave plots, and forcing their friends and colleagues to cover their funeral costs when they die. Meanwhile, Journey to the Savage Planet's Kindred Aerospace treats its employees as expendable property, sending you out on dangerous missions with almost no equipment, and forcing you to cobble together your own survival plan.

In addition to these similarities, both games' satirical humour is largely ineffective, with only surface-deep criticism. In Savage Planet, the hyperactive adverts for rubbish products and vaguely sociopathic messages from your CEO all happen at a distance from the actual meat of the game; you could ignore it entirely and your experience really wouldn't change.

The Outer Worlds, meanwhile, is keen to point out all the horrible events that occur in its society as a result of its runaway capitalism – the Spacer's Choice mascot forced to wear a suffocating helmet for his entire life, and the colonists being slowly poisoned by the only food available to them. However, it never delves into the root causes of all the suffering. It's all definitely the fault of capitalism, but nobody's able to say why.

Then again, the game industry routinely forces its employees to work 80-hour weeks for months on end, then lays them off once a project is complete. It's hardly surprising that games can't produce a coherent argument for why a corporatised society might not be good. Designers are routinely gagged by punitive non-disclosure agreements intended to prevent them from leaking information about new games, but which also make it difficult for them to discuss working practices in a particular company.

> It's all definitely the fault of capitalism, but nobody is able to say why

For large studios, this often involves doing months of 'crunch' – long periods of additional hours that often leads to mental and sometimes physical health problems.

Some recent indie games offer better examples of how games can criticise capitalism. Kentucky Route Zero shows us how companies exploit social and religious work ethics, mandating that a basic standard of living must be earned while also eroding existing employment structures from local communities.

The fantastic Disco Elysium, meanwhile, shows us how capitalism feeds on hope. One of the buildings you explore is a gravesite for almost a dozen failed businesses, all of which were created with the best of intentions and failed because of circumstances beyond their control.

For any satire to work, it needs to be specific about its targets, and the reasons why they should be the object of criticism or derision. Otherwise, such jokes ring hollow, and come off as paying lip service to ideas the creators don't really believe. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

Elderborn / £11.39 inc VAT

DEVELOPER Hyperstrange / **PUBLISHER** Hyperstrange

Conan the Barbarian has a surprisingly large gaming footprint, being the face of online survival games and tower-defence strategy experiences, all of which miss the razor-sharp point of Robert E. Howard's fast and furious short stories. Elderborn doesn't feature Conan, but this taut and breathless first-person slasher is nonetheless the best Conan game we've played.

The plot is classic sword and sorcery fare. You play a barbarian who ventures into an ancient city, which was once the terror of its fantasy realm, but fell silent after it was besieged by a massive rebel army. Dispatched by your tribe to investigate rumours of a great treasure hidden at its heart, you discover that the soldiers who attacked the city centuries ago are now defending it as cursed husks.

Elderborn's combat is inspired primarily by Dark Messiah and Dark Souls. The controls are like the former, with a combination of light and heavy attacks forming the foundation of fighting. There's also a powerful kick that can boot enemies off ledges or into conveniently placed spike traps, much like Dark Messiah.

The broader rhythms of the fighting, however, are more like Dark Souls. Combat is fierce and uncompromising, with death always hovering a few inches from your face. It's possible to fight defensively using weapons that prioritise blocking attacks, but it's more efficient to use parrying weapons such as spears and sickles. If timed correctly, parries open up enemies to devastating counterattacks that often separate their heads from their shoulders.

This thrilling combat is bolstered by an impressive variety of enemies, although a few, such as scorpions, are less fun to fight than their human counterparts. Weapon variety is more of a problem. Of Elderborn's eight weapons, only four are really worth using. The effectiveness of parrying weapons renders blocking weapons, such as swords and hammers, useless. Part of the fun of these games is experimenting with different weapons, so half your arsenal being ineffective is a problem.

Fortunately, the adventure makes up for this shortfall. Your journey begins in the city's undercrofts, tombs and dungeons filled with deadly traps. During the mid-game you battle through the city itself, which is one huge level that can be attacked from multiple angles. In its final act, Elderborn takes a turn for the surreal, as you venture into an astral plain that defies conventional Euclidian laws.

Clocking in at around five hours, Elderborn is short, and the deceptive lack of breadth to the combat causes problems in the latter half. However, it's one of few games that understands the spirit of old-school sword and sorcery, which means it's still worth playing regardless.

RICK LANE

ELDER

- \+ Thrilling combat
- \+ Solid fantasy adventure

JUNIOR

- – Lack of weapon variety
- – Some enemies aren't fun to fight

/VERDICT

An unofficial Conan the Barbarian story in game form, Elderborn is a thrilling hack-and-slash game, although it's slightly let down by a lack of weapon variety.

OVERALL SCORE

72%

The Walking Dead: Saints and Sinners / £30.99 inc VAT

DEVELOPER Skydance Interactive / **PUBLISHER** Skydance Interactive

Let's get straight to it. The Walking Dead: Saints and Sinners is one of the best VR games currently available. This might come as a surprise, given that it belongs to one of the most exhausted sub-genres in gaming – zombie survival. However, Skydance Interactive uses VR to breathe new life into this weary premise, producing a thrilling VR survival experience.

Saints and Sinners puts you in the role of a survivor seeking sanctuary in zombie-infested New Orleans. Making your way through the flooded city, you establish contact with another survivor hiding in the Reserve, a nuclear bunker filled to bursting with food, medicine and weapons – everything you need to wait out the apocalypse. Unfortunately, the Reserve is slowly flooding, while the only key to get into it is hidden somewhere in the city. Your job is to track down the key, and figure out a way to pump out the Reserve's flood water.

Structurally, Saints and Sinners is unusual. New Orleans is split up into several different districts. With each in-game day that passes, you can choose to explore one of these districts. Once you've arrived, you're free to approach the level how you wish.

You can chase the main story, which amounts to around 12 missions dotted around the city, or you can scavenge the area for resources, plucking bits of wood and other junk off the street, or venturing into houses for more valuable supplies. When you return to your base, these supplies can be broken down and crafted into new weapons and equipment, giving you a better chance of surviving the next time you venture out.

Meanwhile, of course, you'll have to contend with the undead. Zombie fighting is at the heart of Saints and Sinners' systems, and it's both fascinating and grisly. Because guns are noisy, most of your zombie fighting involves hand-to-hand combat, and I mean that quite literally. To kill a zombie with a melee weapon, you need to 'brain' it, by holding the weapon in your virtual hand, and swinging your arm with enough force to pierce the walker's skull.

It's an incredibly visceral system, to the point where it can be quite harrowing. Blades can stick inside a zombie's body, requiring you to either yank them out with force, or leave the blade stuck in the corpse if you're in immediate danger. Equally, a weak strike might simply glance off the zombie's head. This isn't much of a problem if it's just one zombie, as you can hold them at bay with your off-hand quite easily. However, if there are others encroaching on your position, then a poor strike can be the difference between life and death.

SAINT

+ Great presentation
+ Superbly designed melee combat
+ Underlying systems cleverly drive tension

SINNER

– Moral choice system doesn't really work
– Crafting could be better

Saints and Sinners' melee combat is among the best we've seen in any VR game, but the VR systems are also well refined across the whole experience. Every ranged weapon handles differently. Revolvers, for example, need to be reloaded with individual bullets before you flip the chamber back into place.

When wounded, you heal by manually wrapping a bandage around your wrist. You can grab your backpack by reaching over your left shoulder, then remove or insert objects you find, making for a wonderfully intuitive inventory system. The only slight disappointment is the crafting, which is more about picking items off a menu than physically building objects.

It all amounts to a fine VR experience, but it's the broader systems that make Saints and Sinners such a compelling survival game. With each day that passes, the number of available supplies in the city dwindle, while the number of zombies in the streets increases. This means you need to balance completing your objectives with ensuring you're sufficiently equipped to stay alive. Should you waste an entire day just looking for resources, or is it worth upgrading your weapons to make zombies easier to kill?

You don't just need to worry about the long-term problems either. Alongside the zombies, there are two human factions. One of these is known as the Tower. Each time you enter the city to explore, you have just half an hour before the Tower rings every church bell in New Orleans, causing the zombies to swarm onto the streets. Ideally, you want to be gone before this happens, so you have to think carefully about how you approach your chosen objective. Is it worth scouring the streets for scraps, or should you try to sneak into one of the faction bases where resources are more plentiful?

The result is a highly dynamic survival experience that constantly requires you to make difficult decisions, and where small actions can have much larger ramifications down the line. The production values are also superb, particularly for a VR game. The comic-book art style works well in a VR headset and the story, while not massively original, is sharply written and convincingly acted.

Strangely, Saints and Sinners' only real shortcoming is the one hinted at in the title. There's a morality system at play, but the game doesn't explicate it very well. As you explore, you'll come across survivors who you can help by giving them food, or kill to steal their loot. However, the effect of this isn't clear.

Similarly, the game doesn't explain whether killing faction members (which is often necessary to complete missions) affects your moral standing. There are also several side-quests that offer more clear-cut moral choices, but they're entirely optional. The whole system seems tacked onto the end, which is odd considering it's one of the game's main selling points.

Fortunately, Saints and Sinners is otherwise so well made that one weak system hardly matters. Half-Life: Alyx may be touted as the do or die moment for VR gaming, but Saints and Sinners has pipped it for demonstrating that VR can support quality full-length games.

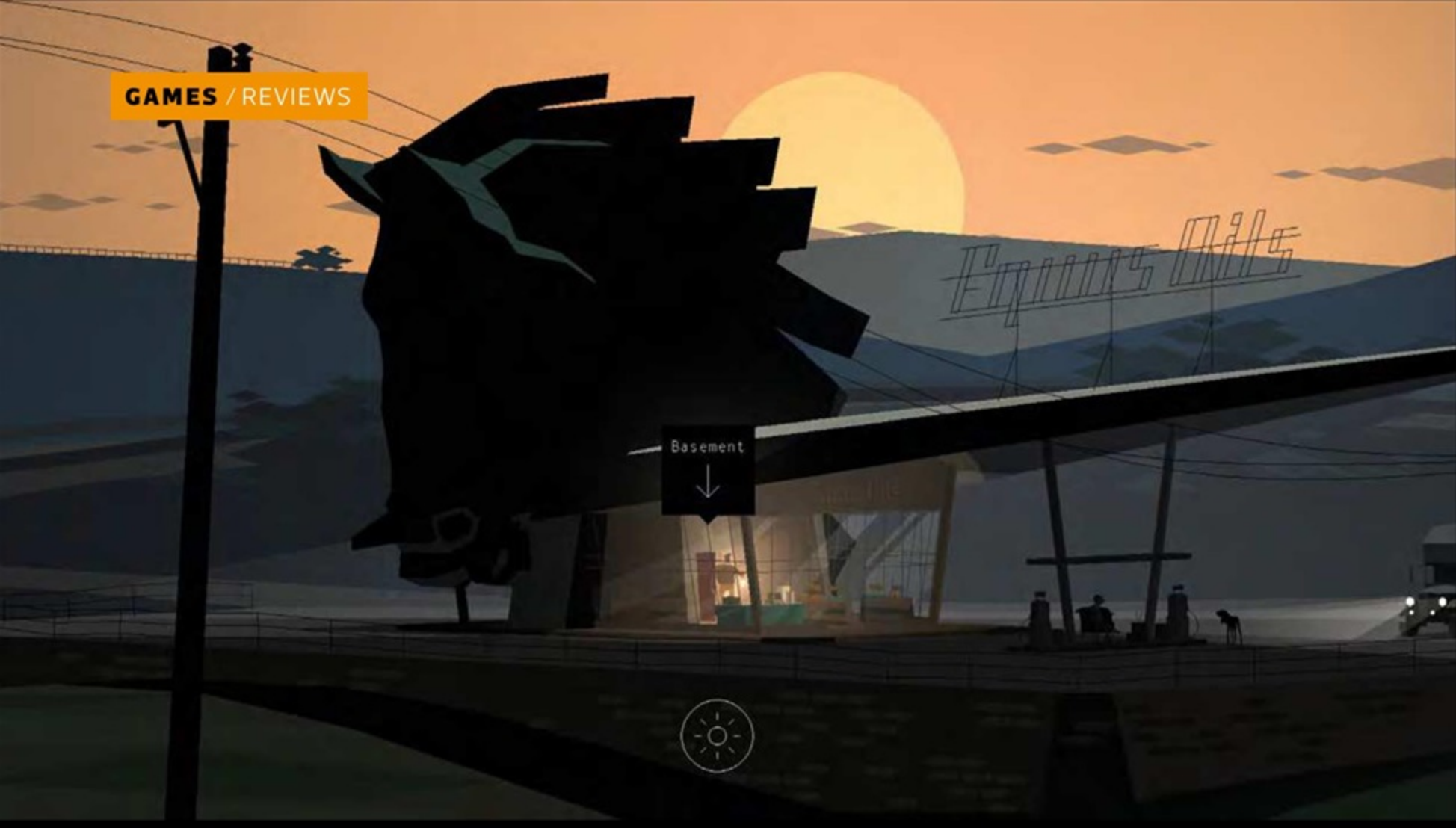
RICK LANE

/VERDICT

Saints and Sinners likely won't get the credit it's due, but its zombie survival simulation is a watershed moment for VR.

OVERALL SCORE

88%



Kentucky Route Zero / £18.99 incVAT

DEVELOPER Cardboard Computer / **PUBLISHER** Cardboard Computer

ZERO

+ Stellar writing
+ Lots of memorable moments

SUB-ZERO

– Narrative style becomes self-indulgent
– Mechanically very lightweight

/VERDICT

An admirable attempt to take adventure games in a different direction, but at times it's a little too smart for its own good.

OVERALL SCORE

65%

Kentucky Route Zero is a point and click adventure game inspired by American literary fiction. It began life in 2013, when developer Cardboard Computer launched the first of five planned episodes. Seven years on, it's finally complete.

The story initially centres around a delivery driver named Conroy, who pulls up his rusty old truck at a gas station named Equus Oils to ask for directions to 5 Dogwood Drive. He discovers that getting to Dogwood Drive requires him to travel along the Zero, a mysterious highway that runs through a cave system beneath Kentucky's Interstate 65.

So begins a surrealist adventure through the forgotten corners of American society. The game is heavily inspired by famous American prose stylists, such as John Steinbeck or William Faulkner, and the game's own writing is rarely less than excellent. While you can't alter the overall direction of the story, your response choices during dialogue can affect how the story is told.

Kentucky Route Zero's broader approach to narrative storytelling is intriguing, revealing its story by telling dozens of other, smaller stories. Every character you meet has their own tale to tell. Over time, it becomes apparent that the community that forms the Zero is under threat from a local power company that's slowly eroding the infrastructures upon which these people rely.

This game delights in the strange and eerie. As Conroy searches for and then travels along the Zero, he encounters a small boy who lives with a giant eagle, discovers a museum of housing in which people still live inside the exhibits, and stumbles upon a subterranean distillery where the employees have all transformed into glowing skeletons.

The first couple of episodes are arresting slices of interactive fiction, although the next two episodes are much longer, and the game's penchant for yarn-spinning shifts from being interesting to self-indulgent. There's one scene where half the characters take turns talking on a phone, which easily could have been cut out without making a difference to the story.

There's also an interminable interlude between the second and third episodes, which takes the form of an entire three-act play. It gets lost in its own meandering imaginings, losing sight of the key character relationships that hooked your interest in the early game.

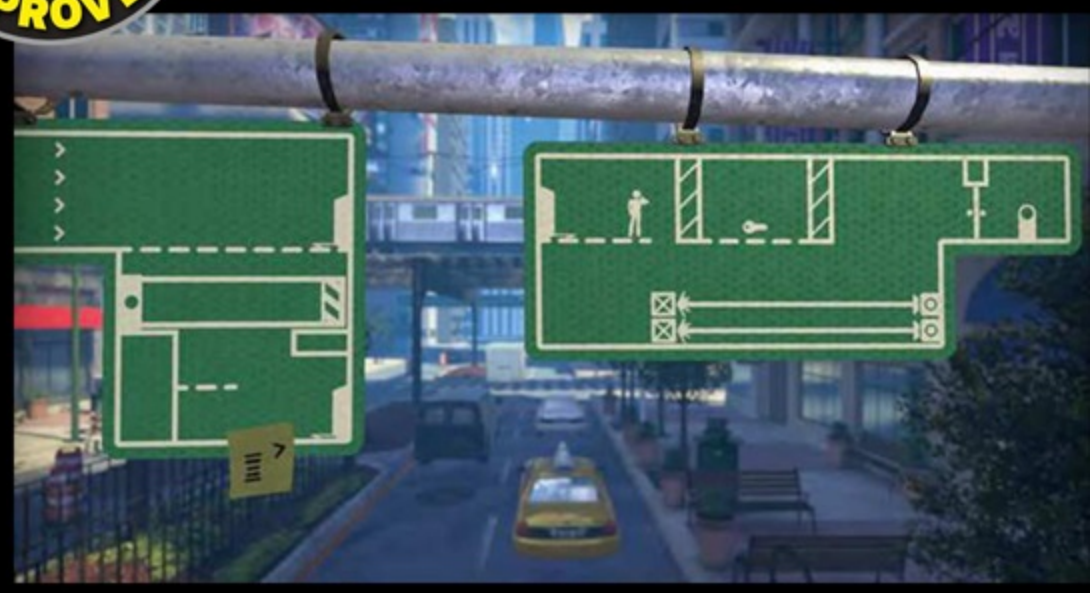
There are still great moments within these later acts, and the whole game generally exudes style and melancholy soul. However, with little in the way of other interactions, Kentucky Route Zero is entirely reliant on its storytelling. When that storytelling falters, the foundation is shaky, and it falters a little too often for us to recommend.

RICK LANE

The Pedestrian/

£15.49 inc VAT

DEVELOPER Skookum Arts/ **PUBLISHER** Skookum Arts



The Pedestrian is a puzzle-platformer where the platforms are also the puzzles. You control a human silhouette that you'd typically see on road signs and pedestrian crossings, guiding it through the signs and notices of a bustling city.

There are two key layers to puzzling. The first is inside the signs themselves. Here, The Pedestrian is a standard jumping game. You must navigate between platforms, push around boxes, collect keys and avoid hazards typically found on city signs, such as, er, lasers and circular saws. There's nothing wrong with this side of the game, although there's little remarkable about it either.

The second layer is outside the signs, and that's where The Pedestrian works its magic. Your pedestrian can move seamlessly between different signs using the doors and ladders painted onto them, but only if they're connected in the right way. Press F and the camera will zoom out, so you can move any signs on the screen and draw connections between their doors and ladders. Once a connection has been drawn, it can't be disconnected without resetting the entire puzzle.

It's a neat mechanical gimmick, and The Pedestrian constantly iterates upon this central concept. Early on, it introduces plugs with spools of wire that your pedestrian can carry and connect to sockets to form circuits. Later, it turns the signs themselves into electrical conduits, letting you move them around to complete circuits. It's constantly finding new ways to get you to play on two levels at once.

The Pedestrian excels visually as well. Your journey through the city is presented as one long take, with seamless transitions between each location. Starting in an industrial warehouse, your first job is to locate the elevator and activate it, which takes you down into the city's underground. Here, you need to find a train and complete the circuits to activate it, so it can transport you to the city centre. This is all communicated via elegant camera pans through stunningly detailed 3D environments.

The Pedestrian isn't short of great ideas, although ironically, it doesn't always communicate them well. On some puzzles you have to deliberately trigger a reset in order to progress, but the game never explains this. With only five hours of gameplay, it's also shorter than it deserves. The game throws ideas at you so quickly that you suddenly move onto another idea when you've only just got the hang of the previous one. The ending is also rather abrupt.

That said, those five hours represent some of the most enjoyable puzzling since the fantastic Gorogoa. The Pedestrian may not always be a walk in the park, but it definitely puts its best foot forward.

RICK LANE

GREEN MAN

+ Great concept
+ Looks stunning
+ Meticulously designed puzzles

RED MAN

– Bit short
– Some concepts poorly explained

/VERDICT

Combining cleverly designed puzzles with slick presentation, The Pedestrian is a splendid, if short, puzzle game.

OVERALL SCORE

85%

REALITY CHECK

Rick Lane tries tethering an Oculus Quest to his PC, and throws himself into the Half-Life-inspired world of Boneworks

NEWS

ROOM FOR IMPROVEMENT?

Fireproof games' The Room series has brought the studio enormous success, first on mobile and then on PC. Now Fireproof is bringing its escape room-style puzzling to VR, with The Room: A Dark Matter.

Set in 1908, A Dark Matter puts you on the trail of a missing Egyptologist who disappeared at the British Institute of Archaeology. It's a typical Room scenario, set in a single location filled with clever puzzles and lots of objects with which you can tinker. You'll be gazing into crystal balls, following footprints and fiddling with strange mechanisms, all with VR-enabled touch controls.

First-person puzzling can be tricky to pull off in VR. Being stuck on a puzzle is frustrating in a normal game, and being stuck with a box strapped to your face only compounds the frustration. The bods at Fireproof know their onions when it comes to puzzle games, however, so hopefully they can build a game that has just the right amount of complexity for VR.

REVIEW

BONEWORKS / £23.99 incVAT

DEVELOPER Stress Level Zero /
PUBLISHER Stress Level Zero

Boneworks has been described as 'VR Half-Life, although that description doesn't work so well when Half-Life: Alyx exists (full review coming next issue). It's also not entirely accurate. Stress Level Zero's physics-based FPS owes a lot to Valve's masterpiece, but a better summation would be 'VR Garry's Mod'.

Boneworks' story takes place in a game that's half-finished, a deliberate choice that lets the developers bring together Boneworks' broad range of mechanics. You play as Arthur Ford, head of security for software developer Monogon. Somehow, Ford becomes trapped in the company's digital city MythOS and must make his way to the city's clock tower to reset the program.

Boneworks' Half-Life inspirations are clear early on. Not only is one of the first weapons you pick up a crowbar, but the game's looming concrete buildings and distantly blaring alarms also feel like Black Mesa and City 17 blended together. There are even creepy spider-bots that leap at your face, essentially robotic headcrabs.

More broadly, the game blends exciting gunplay with physics-based puzzling, such as using planks of wood to create bridges or pulling levers to manoeuvre a crane. Most of

the core mechanics – shooting, throwing, climbing and so on – have been seen in VR before. What makes Boneworks different is the physicality of the world around you.

A huge amount of work has gone into making basic interactions feel satisfying. Boneworks' guns are incredibly tactile objects, possessing an inherent weight and power that their equivalents in other VR games lack. You can almost feel the recoil when you fire an assault rifle, and hear the impacts as bullets strike Boneworks' kooky enemies. The same goes for interactions, such as throwing a crate off a ledge to break it, or swinging a sledgehammer through a sheet of glass.

When it all works, Boneworks is one of the best VR experiences available. The gunfights are fantastic, and the puzzles enable a lot of creative ingenuity, such as using a breezeblock to prevent an automatically locking door from closing. Unfortunately, the physics simulation doesn't always work. If you're climbing, for example, it's easy to get your arms trapped in the geometry. Watching a physics ragdoll flip out in VR is a deeply unpleasant experience. Boneworks can also be quite frustrating. The save system is awkward, as you need to unload all your gear into a box before you activate a save point, then pick it all up again afterward. Moreover, some of the early puzzles are poorly signposted, and being stuck on a puzzle in VR is no fun at all.

Boneworks isn't for new VR players either. It involves a lot of jumping, fast movement and falling from large heights. Unless you're acclimatised to VR, there's a good chance it will turn your stomach inside out. That said, if you can deal with the nausea and/or the game's more obtuse moments, Boneworks is a thoroughly entertaining VR action game.

BONEWORKS

+ Highly tactile
+ Great guns
+ Imaginative story mode

BONEMEAL

– Physics can go haywire
– Puzzles can frustrate
– Requires strong VR sea legs

VERDICT

Despite some annoying puzzles, Boneworks nuanced physics simulation results in one of the best-feeling VR games yet.

OVERALL SCORE

80%

FIRST LOOK

OCULUS LINK

The Oculus Quest's wireless capabilities make it one of the best VR headsets, but its limited on-board hardware means games must be built specifically for it, resulting in a reduced games library compared to the Rift. Oculus Link is designed to solve this problem, letting Quest owners tether their headset to a PC via a USB-C cable, and use the Quest like a Rift or Rift-S. Having tested the Link, we can say that it's a fantastic upgrade to the Quest's versatility, although it does have a few stability issues.

To use it, you need a low-latency USB-C to USB 3 cable with a decent length (the charging cable bundled with the Quest isn't suitable). To get the Link running, you must have the Oculus app installed on your PC, then tick the 'Enable Oculus Link' option on the Quest's headset settings menu. After that, the Quest must be connected to a USB 3 port on the PC.

At this point, the Quest's headset menu is replaced by that of the Rift, and the Quest can be used like a tethered VR headset. Not only can you now play Rift games, but Steam VR exclusive games such as Boneworks can also be played through the Link with no obvious disadvantages. Being tethered to a PC also gives you higher visual fidelity, as the Quest's on-board hardware is bypassed in favour of your PC.

From a software perspective, Oculus Link works great. There's no discernible difference between using the Quest + Link and using a dedicated tethered headset. However, the bespoke Oculus Link cable (which has a mechanism to lock it in place) isn't available in the UK, and most compatible third-party cables aren't really ideal. We tested with an Anker PowerLine+ cable, which needed to be plugged into the headset a specific way around, otherwise the connection was constantly disrupted. There's also always the risk you might accidentally tug out the cable. Some games can handle being temporarily disconnected, while others will simply crash.

Hopefully, Oculus will release its bespoke cable in the UK soon. However, as long as you're careful, it's perfectly possible to play Rift or Steam VR games with minimal disruption. CPC

BUILD A £993 GAMING PC

ANTONY LEATHER SHOWS YOU HOW TO ASSEMBLE AND OVERCLOCK A SERIOUSLY POWERFUL GAMING PC FOR UNDER A GRAND

Now that AMD has well and truly kicked its competitive streak back into action, there's some seriously good-value hardware available, with both Intel and Nvidia having to react. As a result, now is an ideal time to assemble a budget-conscious PC, especially with COVID19 potentially threatening future supply shortages and price hikes.

Even if your budget can't stretch past the £1,000 barrier, you can still build a PC capable of high-end 1080p gaming, and even 2,560 x 1,440 gaming. Our example PC doesn't compromise either. It's equipped with a 6-core, 12-thread Ryzen 5 3600, 500GB of NVMe storage and a GeForce RTX 2060 Super graphics card with real-time ray-tracing support.

Over the next few pages, we'll take you through all the necessary steps to choose your components and build your PC, while throwing in plenty of tips and tricks for good measure. As this is **Custom PC**, we'll be overclocking the 3rd-gen Ryzen CPU as well, and showing you how to do it.

THE £993 PC SHOPPING LIST

CPU

AMD Ryzen 5 3600

155 inc VAT
ebuyer.com

To keep costs as low as possible, and to focus on gaming, you have two options when it comes to CPUs. Intel's Core i5-9400F is worth considering, as it offers decent gaming performance for the cash, and actually costs less than the Ryzen 5 3600 too. In fact, no AMD 3rd-gen Ryzen CPUs are available for a cheaper price.

However, even at 1080p with a powerful GPU, the Intel CPU is rarely much faster in games, if at all, than the Ryzen 5 3600. Plus, with the latter CPU's dominance in content creation and multi-threaded workloads, it's the more sensible option if you need a PC that packs a punch outside of games too. It's also much better in games than 2nd-gen Ryzen CPUs, so while the Ryzen 7 2700X costs around the same price, it's only worth considering if multi-threaded performance is a bigger priority for you than gaming performance.

Alternatives

The CPU market is crowded, with numerous options above and below the Ryzen 5 3600 in terms of price – it's great to have so much choice, of course, but it can make the situation confusing. The Ryzen 5 3600X is a little faster, with higher single and all-core boost frequencies, and our sample overclocked slightly further too. However, that's not enough to justify the price difference – you'd be better off ploughing the extra cash into more SSD storage or a beefier cooler.

As we've already said, if multi-threaded performance is a bigger priority for you than gaming, AMD's older Ryzen 7 2700X costs the same price as the Ryzen 5 3600 and offers an additional two cores and four threads. If gaming is your main concern, then Intel's Core i5-9400F is also worth considering, as it costs less money and is just as fast or faster in games. However, the AMD CPU is significantly quicker than the Intel one when it comes to multi-threaded performance. Intel maybe looking to change this situation with its 10th-gen desktop CPUs later this year, but for now, the Core i5-9400F is Intel's best option in this price bracket.

MOTHERBOARD

MSI B450 Tomahawk Max

£99 inc VAT
ebuyer.com

Despite their comparatively low prices, MSI's B450 Tomahawk AMD Socket AM4 motherboards have performed consistently well in our tests. They can handle overclocked 8-core CPUs with ease, so this one won't have any trouble handling our overclocked 6-core chip. The latest model is the B450 Tomahawk Max, which boasts a full-speed Type-C USB port and large heatsinks, along with a PCI-E M.2 port.

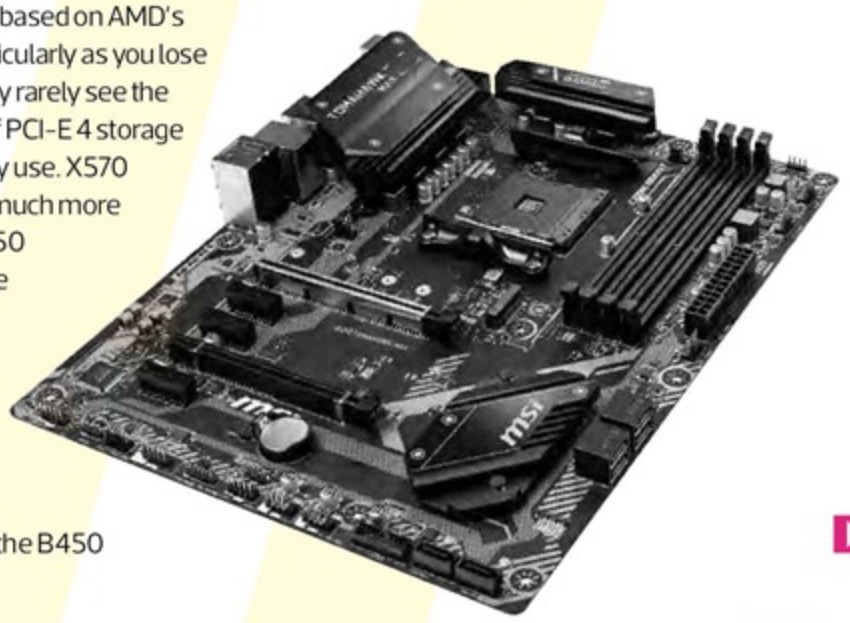
While it might sound odd to pair a 3rd-gen Ryzen CPU with a board based on AMD's older B450 chipset, particularly as you lose PCI-E 4 support, you very rarely see the performance benefits of PCI-E 4 storage performance in everyday use. X570 motherboards are also much more expensive than their B450 counterparts, and they're otherwise every bit as fast and overclockable elsewhere, so it makes sense to save cash here.

There's another very good reason to choose the B450 Tomahawk Max, though, which is that, unlike many of its peers, it includes MSI's version of USB BIOS Flashback feature. This allows you to update the board's BIOS without a compatible CPU installed, so you'll be able to get it up and running with a Ryzen 5 3600 with minimal faffing.

Unfortunately, many B450 boards are still being shipped without BIOS versions that are compatible with 3rd-gen Ryzen CPUs such as the Ryzen 5 3600 we've chosen for this build. Unless you have an older CPU for flashing available, you'd otherwise be left with a system that wouldn't boot if you installed a Ryzen 5 3600 into one of these boards. With USB BIOS Flashback, however, if you receive a board with an old BIOS, you can update it, drop in your shiny new 3rd-gen Ryzen CPU and be on your way.

Alternatives

If you fancy a smaller form factor PC, then MSI also offers the B450M Mortar, which features USB BIOS Flashback as well. Going smaller still means there are both B450 and X470 mini-ITX boards on offer too, including the excellent Asus ROG Strix B450-I Gaming. If you want more features, such as better audio, additional M.2 ports and PCI-E 4 support, then MSI's X570-A Pro only costs £50 more than the B450 Tomahawk Max.



MEMORY

16GB (2 x 8GB) Corsair Vengeance RGB Pro 3466MHz DDR4

£125 inc VAT

scan.co.uk

Corsair's Vengeance RGB Pro memory is still one of our favourite RGB memory ranges. It simply looks fantastic, with vivid diffuse lighting that's easily controllable via Corsair's iCUE software, which can also be synced with Corsair's other RGB products and some motherboards now too.

We consider 16GB to be the minimum amount of memory you need in order to ensure a degree of futureproofing, and you'll likely see plenty of situations that use more than 8GB these days. With 3466MHz kits costing barely any more money than 3000MHz ones, it definitely makes sense to get the speedier kit. Avoid using just one module too. It may be cheaper than a pair, but you won't be able to operate your memory in dual-channel mode, which will affect performance.

Alternatives

ADATA's XPG Spectrix memory is a no less spectacular option for RGB lighting fans, and it's a little cheaper than the Corsair kit too, albeit with slightly less flexibility on the lighting side. If you're not fussed by RGB lighting, then Corsair's Vengeance LPX memory is even cheaper, and is still available in speeds above 3200MHz, making it ideal for AMD systems.

GRAPHICS CARD

Zotac GeForce RTX 2060 Super Mini

£338 inc VAT

ebuyer.com

Graphics card prices have fallen since the majority of current cards were launched last year, and one of our favourites, the Zotac Gaming GeForce RTX 2060 Super Mini, now costs just £338 inc VAT. It's a monstrous card for 1080p gaming, and it easily handles 2,560 x 1,440 gaming in the latest titles at high settings too.

Then there's DLSS and ray-tracing support, both of which offer compelling reasons to go with the green team in this price league, especially as support for the latter is growing. Ray-traced shadows and reflections look amazing in games that support this feature, so if you want the best eye candy in games, you want to pick an Nvidia RTX GPU over the current AMD competition.

Alternatives

The Nvidia GeForce RTX 2070 Super is a more capable option if you want faster performance at 2,560 x 1,440, particularly if you're enabling ray tracing, but it will set you back around £100 more. The AMD Radeon RX 5700 XT is a viable alternative to the RTX 2060 Super too, outperforming it in most titles for similar cash, but it lacks ray tracing. If you can't quite stretch to our budget this month, then you also have several other options. The GeForce RTX 2060 is still a great graphics card and can be had for as little as £270, and if you're not bothered about ray tracing, AMD's RX 5600 XT shaves even more off that price, while offering similar performance.

CASE

Lian Li Lancool II

£88 inc VAT

overclockers.co.uk

Lian Li's Lancool One was one of our favourite sub-£100 cases when we reviewed it last year. It's very reasonably priced, looks unique, has excellent water-cooling support and even includes tempered glass and aluminium. This month, however, we got our hands on its successor, the Lancool II.

You can read our full review on p22, but the gist is that it's even better than the original Lancool One. It has digital RGB lighting, a trio of included fans, better ventilation and a revamped cable-tidying system, making it a great choice for air and water-cooled systems, as well as people who want their PC to stand out from the crowd of other black boxes.

Alternatives

For a little more cash, Phantek's Eclipse P600S gets our vote as a superb, feature-rich and flexible case that's equipped with a few more creature comforts. Alternatively, if you need to shave another couple of tenners off the price, the be quiet! Pure Base 500 is an excellent quiet ATX case that costs under £70.

OUR TOP UPGRADES

If you have a little extra cash to spare, we have a couple of recommendations to get more out of your PC for a little extra outlay. Firstly, we'd upgrade the SSD to WD's Blue SN550 1TB. It costs an extra £30 and bags you another half a terabyte of storage space. With games regularly topping 50GB these days, every gigabyte counts.

If you fancy a set of custom individually braided PSU cables, then you'll also need a fully modular PSU. For an extra £30, Corsair's RM550x not only has an 80 Plus Gold efficiency rating, but is also fully modular, allowing you pick from a variety of third-party cable sellers, or from Corsair's own custom cable sets, to give your PC's cabling an attractive custom finish.

CPU COOLER

ARCTIC Liquid Freezer II 240

£60 inc VAT
scan.co.uk

Whether you plan on overclocking the Ryzen 5 3600 or running it at stock speed, AMD has ensured that its 7nm Zen 2 microarchitecture is relatively easy to cool. As such, you don't need monstrous cooling to keep it your 6-core CPU in check at reasonable noise levels, even under load. AMD includes its tiny Wraith Stealth cooler in the box, but you can get much better cooling and far lower noise levels by opting for a decent third-party cooler.

We've managed to stretch to ARCTIC's Liquid Freezer II 240 liquid cooler within our sub-£1,000 budget this month. It costs £60 inc VAT, but offers decent cooling at low noise levels, and will handle an overclocked Ryzen 5 3600 with ease. It sports a large 240mm radiator, two 120mm fans and it even has a third small fan directed at your motherboard to cool the VRMs. It's also a perfect fit with our chosen case this month.

Alternatives

Even a decent air cooler will offer much better results than the included stock cooler, so if you want to save around £30, Deepcool's Gammax GT cooler is an excellent choice. It coped easily with our 8-core AMD Ryzen CPU in our last CPU air cooler Labs test, it looks great and sports RGB lighting, all for just £35 inc VAT. If you need to save as much cash as possible then AMD includes its Wraith Stealth cooler in the box with the Ryzen 5 3600. It won't give you much overclocking headroom, though, and under heavy loads you may see a small reduction in peak boost speed, as well as significantly higher noise levels.

PSU

Corsair CX550M

£59 inc VAT
ebuyer.com

Even when overclocked, our Ryzen 5 3600 test system barely drew more than 200W from the mains, and with a mid-range graphics card, it's unlikely our system will ever be able to pull more than 350W from the wall. However, it's sensible to build in some redundancy for future upgrades, as well as cutting the load you put on your PSU, because overcapacity can also mean lower PSU fan speeds. We've opted for Corsair's CX550M, which offers 550W of power and semi-modular cables, allowing you to disconnect unused ones to make cable tidying easier.

STORAGE

WD Blue SN500 500GB

£69 inc VAT
ebuyer.com

It's now the case that PCI-E M.2 SSDs are barely any more expensive than their slower, SATA-controlled 2.5in counterparts. This means that for under £70, you can bag 500GB of super-speedy PCI-E NVMe storage, which can shift your data at up to 1,700MB/sec – that's three times faster than a SATA SSD. Even better, an M.2 SSD requires no power or data cables, so it cuts down on cable clutter too. We've

chosen the 500GB version of WD's Blue SN500, which offers space for Windows and a decent helping of the latest games and other software.

Alternatives

If you need a little more space, but want to stick with super-fast PCI-E NVMe storage, WD's new SN550 SSD comes in capacities up to 1TB and only costs another £30 or so. If you need storage space for photos and videos then it's also worth investing in a hard disk – a 2TB Seagate BarraCuda will currently set you back an extra £51 inc VAT from scan.co.uk

TOTAL
£993 INC VAT

BUILDING THE PC

1

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4

5

1 REMOVE CPU COOLER MOUNT

The cooler we've chosen needs to be screwed directly to the backplate behind your motherboard, which means you need to detach the standard mounting clips on the top side. This is an easy job, as they're simply held in place using four large screws.

2 INSTALL CPU

Lift the handle next to the CPU socket. AMD Ryzen CPUs have a small gold triangle in one corner that matches up to a triangle symbol in the CPU socket, allowing you align them. Failing that, the CPU model text on the heatspreader sits next to the socket hinge into which the socket lever sits, and you can align it that way too. When your CPU is the right way around, gently push it into place, then push down the handle to the secure the CPU in the socket.

3 APPLY THERMAL PASTE

Some CPU coolers come with pre-applied thermal paste, but the Liquid Freezer II has a small sachet of paste that you'll need to manually apply. It can be tricky to make an elaborate shape here, as the sachet doesn't give you much precision, so we've opted for a simple north-south line of paste.

4 INSTALL CPU COOLER

The pump section of our cooler requires four mounting arms to be attached, so secure them, while remembering to remove the protective film on the base. Now go ahead and use the included screws to secure the pump section to the CPU socket backplate.

5 CONNECT PUMP AND FAN CABLE

The Liquid Freezer II uses just one cable to power the pump and two 120mm fans. You'll need to connect this cable to your motherboard's CPU fan header, and not the pump header, or the fans may sit at high speed all the time, instead of winding down under low loads.

6 INSTALL MEMORY

Our dual-channel memory kit comprises two modules, which you'll need to place in slots two and four in order to make sure dual-channel memory mode can work. Flip back the clips on each side of the DIMM slot, then put the memory in place; it will only fit one way around – just line up the notch on the memory with the notch in the socket. Push the top of the memory down firmly, so it goes into the slot, and the clips will flip back up to secure it in place.

7 INSTALL SSD

Our motherboard only has one M.2 slot, and it comes with a screw to secure the SSD. However, you'll need to move the securing nut from the outer hole to the next one in on the motherboard, so it lines up with the mounting point on the SSD as shown. Put the SSD's edge connector into the slot at an angle, then gently push it down before screwing it into place.

8 TEST HARDWARE

Before you install the hardware in the case, it's a good idea to test it, so if any of your parts don't work, you can identify them now without having to dismantle your PC. Some B450 motherboards may have old BIOS versions too, which will prevent them from working with 3rd-gen Ryzen CPUs, such as our Ryzen 5 3600, out of the box.

One reason we've opted for MSI's B450 Tomahawk Max is that it sports a feature called Flash BIOS, which allows you to update the BIOS without a CPU installed. Thankfully, our retail-sourced motherboard was equipped with a BIOS new enough to support our CPU, so you shouldn't have any problems either, but it's good to know you have the feature as a backup.

First, install the fans to the radiator, then put your motherboard on top of its motherboard box and install your graphics card in the top 16x PCI-E slot nearest the CPU socket. Finally, connect your PSU's 24-pin ATX plug to the socket on the right edge of the board, the 8-pin EPS 12V plug to the socket at the top of the board near the CPU socket and an 8-pin PCI-E graphics plug to your graphics card's power connector on the top edge.

Then, to power on your system, you can either connect the case front panel power connector to the appropriate pins on the motherboard (see your motherboard manual to find out which cables go where), or you can use a screwdriver to short the power button pins on the motherboard. This will power on the PC, allowing you to check that it all works. If you hook up a monitor to your graphics card, your skeleton system should boot up. If not, try removing and then reseating each component.

9 INSTALL I/O SHIELD

Sadly, the B450 Tomahawk doesn't have an integrated I/O shield. You'll need to grab it out of the box and install it in the hole at the back of your case before you install the motherboard. Once you're done, locate the box of screws that come with the case, as you'll need them to install your hardware.

10 INSTALL MOTHERBOARD

Leave the cooler attached to the motherboard, as installing it separately after the motherboard has been fitted can be difficult. Install the motherboard using the supplied M3 screws with your case. The motherboard standoffs are pre-installed, so you just need to slot the motherboard into the I/O panel, line up the holes with the standoffs (taking care not to scrape the traces on the bottom of the motherboard), and screw it in place.

BUILDING THE PC

11 REMOVE TOP FAN

The Lancool II case includes three fans, with one in the roof. We need to remove the latter, so we can fit our Liquid Freezer II radiator, but don't discard it, as we can move it to the front section to boost airflow.

12 INSTALL RADIATOR

You want the fans positioned on the radiator, so they're exhausting air out of the case, with the backs against the radiator. Use the small screws included with the cooler to secure the radiator from the top of the case, using its radiator mounting rails.

13 INSTALL SPARE FAN

The spare fan is best placed in the front of the case, in order to increase airflow and prevent too much negative air pressure. The two CPU cooler fans will only spin up under heavy loads, so most of the time the airflow should be balanced. The front panel of the case pops off easily, revealing the fan mounts beneath, into which you can fit your spare fan.

14 CONNECT CASE FANS

The motherboard has plenty of fan headers, two of which are ideally located next to the front case fans. Run the cables through the nearby cable-hiding plate, then bring them back to the motherboard to plug into the fan header.

15 REMOVE UNUSED PSU CABLES

The Corsair CX550M PSU is semi-modular, which means most of its cables can be detached, so you can give yourself a much easier time when it comes to cable tidying. Detach the cables you won't need, such as the SATA and Molex cables, and leave them in the PSU box in case you need to return or sell the PSU at a later date.

16 INSTALL PSU

The PSU slides into place from the far side of the case using the flip-down panel on the Lancool II. Secure it from the rear using the included screws, and position it so that the fan points down. There's an air vent and dust filter here to keep it cool and dust-free.

17 FIT GRAPHICS CARD

Unscrew and remove the two expansion slot blanking plates next to the top 16x PCI-E slot, and then carefully slot your graphics card into place, before securing it with the two screws you just removed at the back.

18 CONNECT FRONT PANEL CABLES

If you want to use your case's microphone and headphone audio connectors, locate the audio header on your motherboard and connect it to the case's audio connector cable. Now do the same for the USB and front panel connectors. If you're not sure how to do this, the procedure is well documented in the motherboard manual.

19 CONNECT POWER PLUGS

You only need to deal with four power connectors in this build, and two of them hook up to the motherboard. Thread the 8-pin EPS 12V connector from the PSU through the hole in the top corner of the motherboard tray and then push it into the 8-pin connector on your motherboard above the I/O ports. Next, do the same with the 24-pin ATX connector, which sits on the opposite side of your motherboard next to the memory slots.

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20 CONNECT OTHER POWER CABLES

The other two power cables are a single SATA connector for case's RGB lighting, and the single 8-pin PCI-E connector lead that goes to your graphics card. Connect these, and you can proceed to everyone's least favourite (Editor: or my actual favourite!) part of PC building – cable tidying.

21 TIDY CABLES

Thankfully, you don't need to spend hours here, as the Lancool II includes large cable covers that do a great job of covering the cables. Bundle your cables together in groups, and anchor them in place with the supplied Velcro ties. You can then let the neat cable covers do the rest of the work, leaving you with a clean view through your side panel window.


21

FINAL SETUP

1 SET XMP PROFILE

Once you've installed Windows, there are some general housekeeping jobs to make sure your PC is running smoothly. Firstly, head into the EFI, go to the OC section and enable the XMP profile for your memory, which should set the memory to its correct speed of 3466MHz.

2 SET RAM VOLTAGE

The XMP profile should also set the right timings and voltage for your memory, in which case you can skip this step. However, if you have any stability issues, especially once you've overclocked the PC, it's worth manually setting the DDR voltage and, if necessary, nudging it up from 1.35V to 1.37V.

3 SET FAN PROFILE

We've also set the three case fans to be powered using MSI's Smart Fan Mode. This saw them spin down a little quicker and slightly further than the standard profile, which also meant the PC was noticeably quieter when idle.

4 STRESS-TEST

Once you're at the Windows desktop, download AMD's Ryzen Master software from **amd.com**. This will provide an accurate temperature reading for the CPU, so you can check the cooler is performing properly, and you can also use it to apply quick overclocks from the comfort of the desktop.

You can then apply your overclocks in a more permanent fashion in the EFI once you know they're stable (which we'll cover in a minute).

Run the stress test in Ryzen Master and check the temperature. We found our system's maximum CPU temperature was 52°C, so as long as yours is below 65°C (the actual temperature can be affected by ambient temperature) then there's plenty of room for overclocking.

STOCK SPEED

53,573 GIMP IMAGE EDITING

404,999 HANDBRAKE H.264 VIDEO ENCODING

206,368 HEAVY MULTI-TASKING

172,014 SYSTEM SCORE

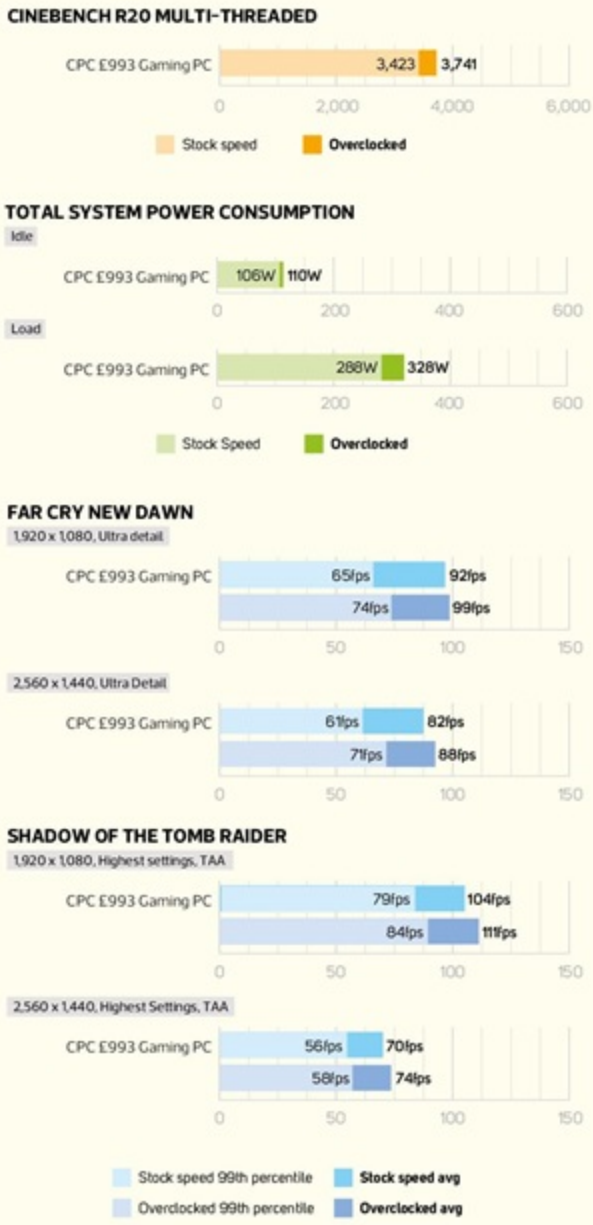
OVERCLOCKED

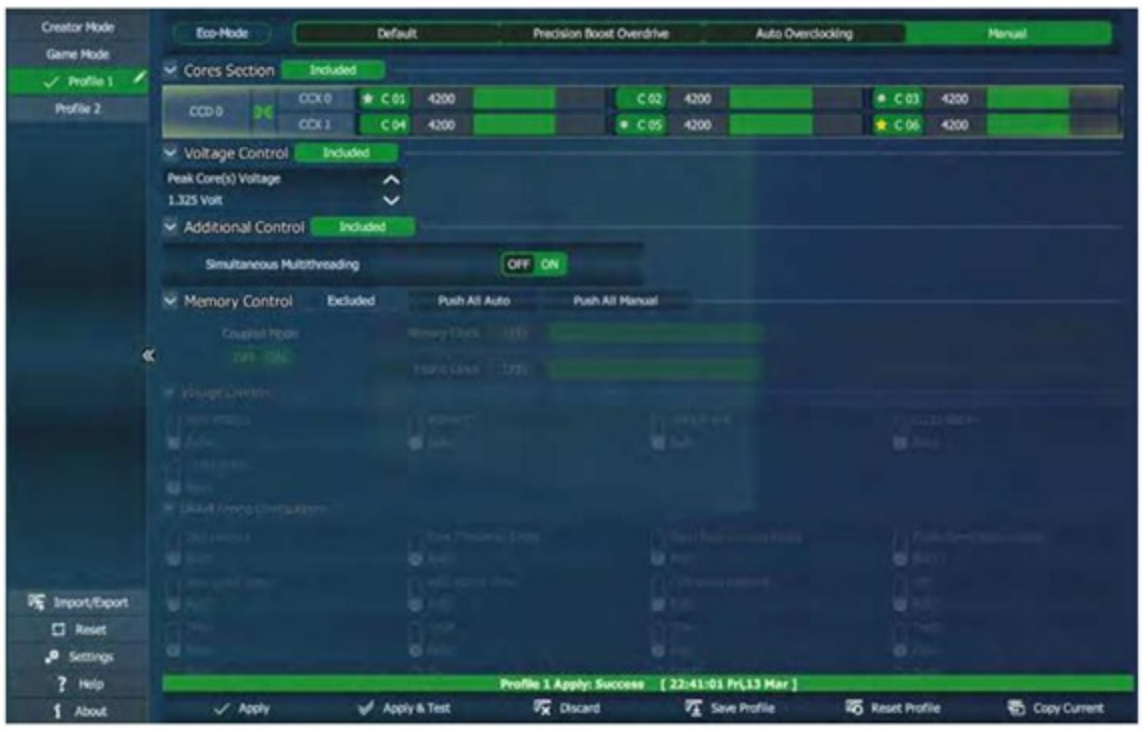
63,301 GIMP IMAGE EDITING

462,268 HANDBRAKE H.264 VIDEO ENCODING

233,675 HEAVY MULTI-TASKING

195,632 SYSTEM SCORE





PERFORMANCE AND OVERCLOCKING

Manually set the CPU voltage to 1.325V using the Override Mode

Setting the CPU ratio to 42 will force all six CPU cores to run at 4.2GHz

Use MSI Afterburner to overclock your GPU – there's plenty of headroom

YOU CAN APPLY YOUR OVERCLOCKS IN A MORE PERMANENT FASHION IN THE EFI ONCE YOU KNOW THEY'RE STABLE

Download MSI Afterburner from **guru3d.com** and GPU-Z from **techpowerup.com**. Fire up both programs and, in MSI Afterburner, set the temperature limit to maximum, the core clock to +170MHz and memory clock to +600MHz. We found these frequencies to be perfectly stable, and resulted in a peak GPU boost frequency of 1820MHz compared to 1650MHz at stock speed, while the effective memory frequency rose from 7000MHz to 7600MHz.

We also found that 4.2GHz was an easy target for our Ryzen 5 3600 with the ARCTIC liquid cooler, although you may fare better, as it's a silicon lottery out there. We first tried out our settings in Ryzen Master, and then applied them in the EFI.

To get there, we used a vcore of 1.325V – you need to set the CPU Core Voltage to Override Mode, and then input the voltage to be specific. We then set the CPU ratio to 42 in the OC section. This overclock saw the peak CPU temperature rise to 67°C under load – you'll want to be below 80°C here.

This is a manual all-core overclock, and the Ryzen 5 3600's peak single-core boost frequency is also 4.2GHz, so doing this tweak won't result in you losing any lightly threaded performance. At stock speed, the CPU usually hovers just below 4GHz in multi-threaded tests, but we've added 200MHz to that frequency. To stress-test the CPU, download Prime95 version 26.6 from **technic3d.com** and run the smallfft test for ten minutes to check stability and temperatures.

At stock speed, our PC scored 172,014 overall in our RealBench test suite, but this figure rose to 195,632 once it was overclocked, with a big increase in the image editing score. The Cinebench score rose from 3,423 to 3,741 too, which is an increase of just under 10 per cent. It was in games that we saw the biggest benefits, though, with a 10fps boost to the minimum 99th percentile frame rate in Far Cry New Dawn at 2,540 x 1,440, and 9fps at 1,920 x 1,080.

Shadow of the Tomb Raider wasn't quite as responsive, seeing 5fps added to the 99th percentile result at 1,920 x 1,080 and just 2fps at 2,560 x 1,440. The gains were achieved with a power draw that rose from 288W under load to just 328W, which gives over 200W of headroom on our PSU for future upgrades. CPC

Scan sent us a high-end Ryzen 3950X system, with several EVGA graphics cards, for SLI testing

SLI PICKINGS

IS SLI STILL A VIABLE OPTION FOR GAMING PCS? EDWARD CHESTER AND BEN HARDWIDGE INVESTIGATE WHETHER IT'S STILL WORTH PAIRING UP TWO GPUS IN GAMES

Ever since Nvidia reintroduced the SLI brand in 2004, adding two or more graphics cards to a system has been seen as the ultimate way to get the best graphics performance possible. However, particularly in the last handful of years, there has been less and less emphasis on the technology, and fewer and fewer systems implementing it.

In fact, with its latest Navi-based graphics cards, AMD dropped support for its rival CrossFire technology, killing stone-dead any chance of tying multiple AMD GPUs together with full support from AMD. Technically, you can still get two AMD GPUs to work together in some games using the API's own multi-GPU system, but you won't get any official driver support from AMD.

So, is multi-GPU gaming still a going concern, and if it is, just what are the benefits, and should you invest in such a setup? We'll answer these questions and more over the next few pages.

3dfx's Voodoo5 5500 card featured two chips, which communicated using SLI, when it stood for Scan Line Interleave

After buying much of 3dfx's assets, Nvidia relaunched SLI as Scalable Link Interface, with the GeForce 6800 series

HOW SLI WORKS

Scalable Link Interface

The very first iteration of SLI actually dates back to 1998 when 3dfx implanted a technology that used two GPUs to render a 3D scene. Here, while the acronym was the same, the technology was called Scan Line Interleave. You linked up two matching 3dfx Voodoo 2 cards with a ribbon cable, and they would split each frame into lines, with each card handling alternate lines. In some games you could even see the split between the lines as the two cards worked on them.

This didn't just get you higher frame rates – it also enabled you to hit higher resolutions. Voodoo2 cards were generally limited to 800 x 600 in games, but you could push your system to 1,024 x 768 with an SLI setup. Sadly, the technology proved too tricky and expensive to obtain widespread use.

The last gasp for this form of SLI was seen on the Voodoo5 range, with the Voodoo5 5500 featuring two chips on the same card, working in tandem in SLI. There were even plans for a four-chip SLI card, the monstrous Voodoo5 6000, but it didn't get released before 3dfx folded, with much of its assets bought by Nvidia.

Six years later, Nvidia repurposed the now defunct brand name, refashioning it to stand for Scalable Link Interface. This new version of SLI achieved essentially the same job, splitting up the workload of rendering a 3D scene into as many chunks as there were GPUs (some graphics cards, such as the GeForce 7950 GX2, also implemented SLI on a single card) to provide double, triple or even quadruple the theoretical processing power.

At its core, the technology is quite simple, with the graphics driver deciding which chunk of the scene should be handled by which card and the card then going off and doing the number crunching. The results are then added together to produce the final stream of frames that we see.

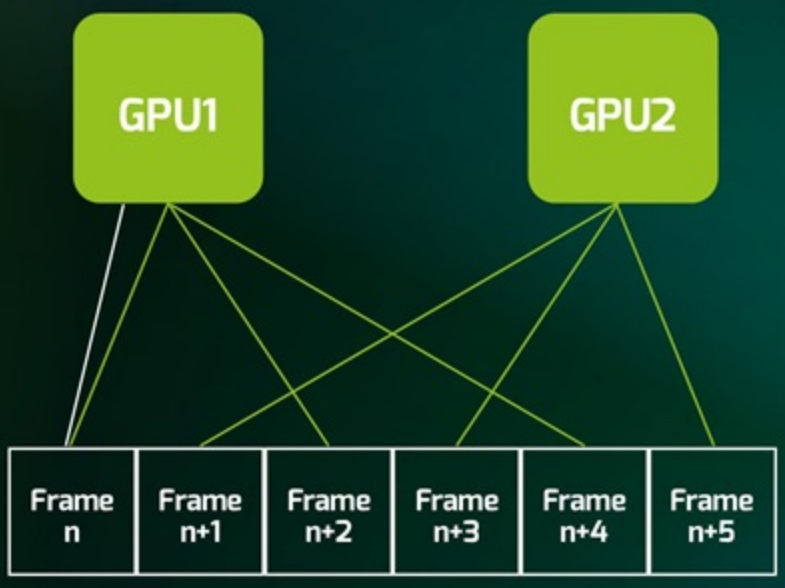
As has long been established, performance with multiple GPUs doesn't scale linearly, but with the right games, a quad SLI setup was the ultimate gaming rig for a while, until Nvidia abandoned support for any SLI setup with more than two graphics cards.

SLI modes

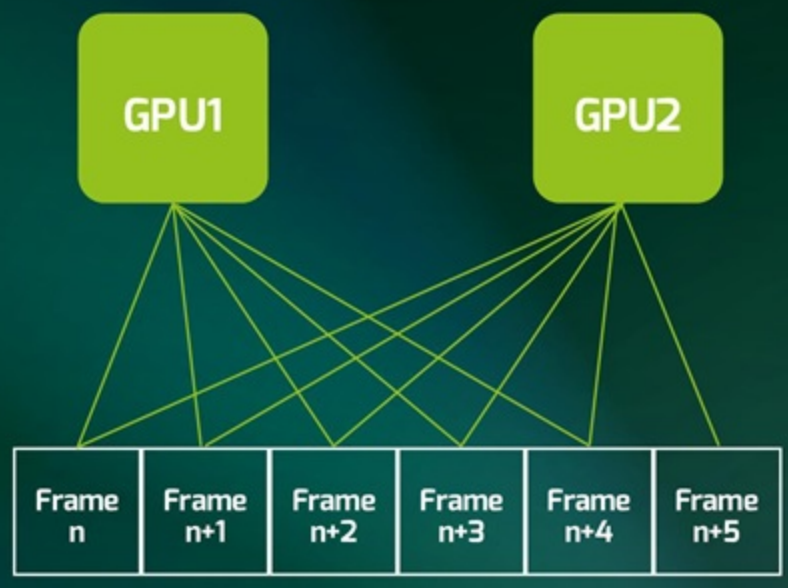
At the heart of the way SLI works is the choice between two different rendering modes: Alternate Frame Rendering (AFR) and Split Frame Rendering (SFR). As their names suggest, AFR simply sends each frame to alternate GPUs; for SFR, the driver splits the scene into multiple parts, with each one sent to a GPU and combined again at the end.

As you might expect, AFR is the far simpler version, and requires less overhead in terms of communication between the two GPUs, so it's preferred by developers and Nvidia alike. However, it also has the higher potential for introducing lag, as the system may need to wait a split second for a frame to fully finish being rendered. SFR requires much more communication and some of the work is duplicated, although it can result in better performance when implemented properly.

This also hints at the reason why SLI setups with three or four cards produce diminishing returns. With AFR, you potentially have one GPU sitting idle for some time while it's waiting for all three other GPUs to finish rendering their



AFR mode simply sends each frame to alternate GPUs



SFR mode sees each GPU working on the same frames together

IT'S ONLY WHEN WE REACH THE UPPER ECHELONS OF PERFORMANCE THAT MULTI-GPU SETUPS START TO MAKE SENSE

frames, creating inefficiency. Meanwhile, for SFR, there's ever more overhead in managing the splitting and restitching of frames. Quad SLI did introduce an alternative rendering mode that had each pair of GPUs work on alternate frames, with each frame then split using SFR between those to GPUs. However, this is all by the by, as quad SLI is no longer supported.

What do you need for SLI?

Since its launch, SLI has remained a remarkably unchanged technology, at least in terms of its fundamentals. You require two or more graphics cards that have identical GPUs and memory configurations, although they can be a mix of card vendors. You'll also need a hefty enough power supply with sufficient cables to power all the cards. With SLI now limited to only the highest-end GPUs (from the RTX 2070 Super upwards), you'll likely be looking at needing either two each of 6-pin and 8-pin graphics power connections, or four 8-pin connections.

Next, you need an SLI-compatible motherboard, which are usually based on the latest high-end chipsets from AMD or Intel, although not all of these boards support SLI. Look for an SLI badge on the box, or check the manual or online specs list of your board first. You'll also want two appropriately positioned 16x PCI-E slots on your board for SLI operation, with at least space for three slots between them. That way, there's still room for a dual-slot card to get air through its cooling system.

There were also considerations for PCI-E bandwidth back when three and four-card SLI was an option, but with a maximum of two cards, it's no longer an issue. Generally, a mainstream desktop board will split its two 16x PCI-E slots into two eight-lane slots for SLI operation, while some HEDT boards will let you get the full 16 lanes of bandwidth in both slots. It rarely makes much of a difference though – eight PCI-E 3 lanes is still enough for SLI, even on a top-end RTX card.

One reason why PCI-E bandwidth is less of an issue than you might expect is because much of the communication between cards isn't done over PCI-E but the SLI bridge. This is a separate physical connection between cards, which plugs into the top ridge of the cards. These bridges have taken various forms over the years, including generic flexible ribbon cables, more rigid PCBs and even illuminated plastic doohickeys, but fundamentally they've remained very similar, allowing SLI bridges to span multiple generations of GPU, at least until recently.

HB-SLI and NVLink

While the fundamentals of SLI have remained very similar over the years, there has been a couple of recent tweaks to the formula. For a start, with the GTX 10-series Pascal line-up, Nvidia introduced a new high-bandwidth SLI bridge, which doubled the width of the bridge and in turn doubled

The evolution of the SLI connector. From left to right, an Asus HB-SLI connector, an EVGA NVLink bridge and the very first SLI connector

the bandwidth. This move was mainly necessary due to the ever increasing take-up of 4K and higher resolutions.

Even more recently, with the launch of RTX, Nvidia brought over its NVLink technology that had previously featured only on its Quadro cards. NVLink brings a massive leap in bandwidth, from the 2GB/sec of HB SLI to 900GB/sec, plus it works in a fundamentally different way. While SLI purely sets up a master/slave relationship between the first graphics card (which handles all your video connections) and any other cards, with NVLink, the data communication is bi-directional and the cards operate in a mesh fashion, with no master/slave relationship.

That's all great for computational workloads, but it doesn't actually translate that well to GPU workloads where latency is so crucial. Moreover, Nvidia simply hasn't enabled true NVLink compatibility on its consumer graphics cards. While you get the connector fingers on the top of RTX cards and you'll have to buy an NVLink bridge, the connection still actually operates in the same SLI mode as before.

This master/slave relationship is also part of the reason why SLI (and CrossFire) doesn't see a doubling of your VRAM when you add two cards together, unlike with true NVLink. That's because all the data in VRAM is basically managed by the master card and then duplicated on the other cards, rather than being an independent data set.

Which cards will work?

As both consumers and manufacturers alike have shown less and less enthusiasm for multi-GPU setups, so has support for the technology steadily dwindled. As we mentioned earlier, AMD simply no longer supports CrossFire in its latest GPUs, while Nvidia has limited support to only some of its newest models.

Out of its latest raft of RTX 20-series cards, only the 2070 Super, 2080, 2080 Super and 2080 Ti support SLI. That means the likes of the RTX 2070 and 2060 aren't supported, and neither are any of the company's Turing-based GTX cards. On a certain level, this makes a lot of sense. If you're seeking better performance when you only have a GTX 1660, it's unequivocally a better bet to just upgrade to a faster card. There are plenty of much faster cards available that aren't ludicrously expensive.

It's only when we reach the upper echelons of performance that multi-GPU setups start to make sense. Here, there's either nowhere to go in terms of faster single cards if you already have an RTX 2080 Ti. Or, if you have an RTX 2080 Super, that's just one rung down from the best in terms of performance, and doubling up this card's performance would put it significantly above the fastest single card.

There are occasionally circumstances where you're rocking a three or four-

You need at least a pair of GeForce RTX 2070 Super cards if you want to enable SLI

IF YOU'RE LOOKING TO PLAY MORE OBSCURE OR INDIE TITLES, THERE'S LITTLE CHANCE SLI WILL ADD MUCH TO YOUR GAMING EXPERIENCE

year-old card, and you can pick up a second one very cheaply second-hand, so it would be good to at least have the option of SLI. However, it's still much more likely that simply upgrading to a faster card will be a better bet.

Game compatibility

If there's a single reason why multi-GPU has struggled to take off and stick with us, it's simply game compatibility. Unfortunately, SLI can't just work silently in the background and accelerate every single game that's thrown at it. Instead, each game needs an SLI profile to tell the graphics driver how to best manage the game's renderer.

What's more, some games simply don't work either very well or at all with SLI. This can be for all manner of reasons, but the reality is that many games either just crash, will only run on one GPU or will have stutter or visual artefacts. We tested a handful of the most popular modern games and several had major issues. If you're looking to play slightly more obscure or indie titles, there's little chance SLI will add much to your gaming experience.

Other downsides

While the potential positives of SLI are fairly clear, with up to a doubling of performance on the cards, the negatives aren't just confined to game compatibility. First, there's the cost. Even when dealing with high-end cards, it can still sometimes be worth spending the extra on a full single-card upgrade instead, even if you do get good compatibility and performance improvement using SLI in many of the games you play. More expensive cards can potentially provide a larger VRAM pool as well, and provide more consistent frames in many games as well.

Then there's heat and noise to consider. While some motherboards and SLI bridges may allow for a large gap between cards, in most setups one card will be right next to the other, which can severely restrict airflow, in turn boosting temperatures and noise levels. In fact, you could potentially even see thermal throttling hamper performance if airflow isn't kept in check.

This leads onto the third consideration, which is power consumption. With modern graphics cards being very sophisticated with their power management, the drain of an extra card while idle is potentially quite modest. However, once two cards are cranked up, you'll see a serious increase in power draw.

PERFORMANCE ANALYSIS

With dwindling game support and expensive hardware requirements, is it still worth setting up an SLI system? To find out, we enlisted Scan (**scan.co.uk**), which kindly loaned us a top-end SLI rig for testing. Carefully built inside a smart and subtle NZXT H710 case, the Scan test rig features a Ryzen 9 3950X CPU cooled by a Corsair all-in-one liquid cooler with a 360mm radiator in the front.

It also comes with a 2TB PCI-E 4 SSD and a pair of EVGA GeForce RTX 2080 Ti graphics cards with a light-up EVGA NVLink connector. In addition, Scan sent us a pair of EVGA GeForce RTX 2080 Super cards, so we could test two SLI configurations. It all plugs into an Asus ROG Strix X570 motherboard, which has an SLI-friendly design, putting a slot space between the two dual-slot graphics cards, giving them a bit of space to breathe. It's a good-looking machine, with well-tidied cables and smart lighting.

Problems

It's fair to say that our experience with SLI wasn't entirely smooth from the outset. The first issue we spotted was that Nvidia FrameView wasn't properly recording the frame rates, which is a little ironic, given that both FrameView and SLI are Nvidia technologies. Basically, the frame rates reported in FrameView in DirectX were significantly lower than the frame rates reported by FRAPS and in-game frame rate counters. You could also visibly see that the FrameView results were incorrect – some games were running smoothly, while FrameView was reporting results that should have meant they were unplayable.

As a result, we've had to go back to reporting the minimum and average for this test, rather than the 99th percentile, for DirectX games. FrameView still worked fine in Vulkan, though, so we've reported 99th percentile results for our Red Dead Redemption 2 test.

The other problem we had was that not all of our usual test games support SLI as standard. Our standard ray-tracing test game, Battlefield V, is restricted to single-GPU rendering. In the past, there were ways around this problem, as with other games, by making a custom profile.

Profile Inspector is downloadable from **nvidiaprofileinspector.com**, and enables you to force some game executables to use a custom SLI profile – this sometimes improves performance over the default profile, and can also force games limited to one GPU to use two GPUs. If you have an SLI setup, it's worth Googling to see how other people have optimised their games with custom profiles.

In Battlefield V, you used to be able to set it to use the Battlefield 4 SLI profile and then force it to use AFR. However, a later patch for the game knocked this on the head. You can still get it working in SLI if you're prepared to do a lot of faffing, which also involves disabling several graphical settings, but for this feature we instead decided to concentrate on games that could run with SLI out of the box, so we've tested ray tracing with the ray-traced shadows feature in Shadow of the Tomb Raider.

There's a slot space between the two EVGA RTX 2080 Ti cards, so they can breathe

Scan sent us an air-cooled SLI rig for testing, although most of its customers sensibly prefer their SLI gear to be water-cooled

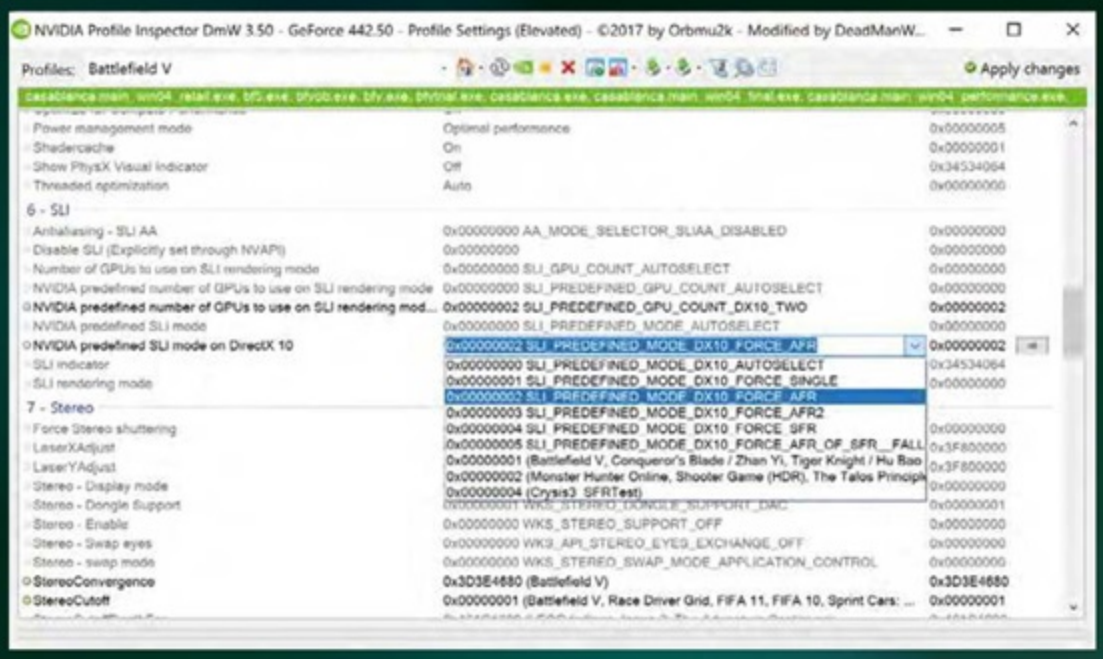
Likewise, Unigine Superposition, which we usually use to test load power consumption, also doesn't work with SLI, so we've instead tested load power consumption with Shadow of the Tomb Raider.

As we expected, SLI performance is variable across titles, but the scaling you can expect also varies wildly between cards and resolutions. In several of our games, we saw better scaling from our pair of RTX 2080 Supers than the RTX 2080 Tis, and vice versa.

This makes it hard to make claims for any hard and fast rules. In theory, you might expect SLI scaling to be better at one resolution than another, but it also depends on the drivers and compatibility issues. For example, Shadow of the Tomb Raider at 4K

flickered a lot for the first few seconds when using the RTX 2080 Super SLI setup with ray tracing, affecting scaling performance. It didn't do this on the RTX 2080 Ti setup.

We sometimes saw the same flickering when starting Red Dead Redemption 2 with both setups as well, and had to run this test a number of times to get reliably repeatable results. We naively thought that SLI might be a mature and largely problem-free technology by now, but with declining interest from game developers (and Nvidia to an extent too), there's still plenty of problems. Be warned that if you do go down the SLI route, you'll have to put up with some compatibility issues, as well as faffing with graphics settings, drivers and profiles.



You can use ProfileInspector to create custom SLI profiles and optimise SLI performance, as well as force some non-SLI games to support it

Performance and scaling

So, when it does work, is SLI any good? Let's start with the good news, which is that when you have a game and driver that properly supports SLI, the performance and scaling is superb. We saw this in Shadow of the Tomb Raider when using the RTX 2080 Ti SLI setup. With 97 per cent scaling at 2,560 x 1,440, we saw an average frame rate of 211fps, and a 164fps minimum – superb results that could enable you to run this game at a super-high refresh rate if your monitor supports it.

Enabling ray-traced shadows (at the High setting) also resulted in smooth performance at 2,560 x 1,440, with a 120fps average and 80fps minimum – scaling 76 per cent over using a single card. You could even run the game at 4K with these settings, with the RTX 2080 Ti SLI rig never dropping below 45fps, compared to a 24fps minimum with a single card.

As we mentioned earlier, the RTX 2080 Super had problems in this game, but it worked fine once you got past the initial few seconds of flickering. An RTX 2080 Super SLI setup can't really cope with high ray tracing at 4K, but it can do it well at 2,560 x 1,440 (with a 67fps minimum). This setup had the same 67fps minimum at 4K without ray tracing too.

You'll want a hefty PSU for an SLI build, such as this 850W Corsair model

While these results aren't problem-free, they show the potential for SLI when it works well. If you want all the ray-traced eye candy turned on at 4K, an RTX 2080 Ti SLI setup is pretty much the only way to achieve it at the moment.

Most of the other games we tested didn't scale anywhere near to the 97 per cent we saw in Shadow of the Tomb Raider, but SLI usually had at least some benefit. For this feature, we also tested some older games, so we could get a larger picture of SLI support, and to see if we could finally turn up every single graphics setting on these games now.

One example is The Witcher 3, which we tested at Ultra settings with Nvidia HairWorks maxed out. Running this game at 4K showed reasonable scaling with SLI, showing a 67 per cent average frame rate increase with the RTX 2080 Ti SLI setup, and 70 per cent with the RTX 2080 Super cards. On its own, an RTX 2080 Super drops down to 49fps in this game at 4K, which is perfectly playable, but this minimum goes right up to 84fps when you add a second card.

We also tried out Deus Ex: Mankind Divided on Ultra settings for the same reason. We didn't have high hopes for big SLI performance in this game, as it's an AMD Gaming Evolved title, and sure enough, the SLI scaling was pretty uninspiring, particularly at 2,560 x 1,440. At 4K, the results were a bit better, with the RTX 2080 Ti SLI setup averaging 72fps with a 58fps minimum, compared to a 48fps average with one card. Adding a second RTX 2080 Super also makes this game properly playable, taking the minimum from 33fps to 45fps. The scaling might not be huge, but there's still a definite benefit.

Back to the newer games, Red Dead Redemption 2 wouldn't scale with SLI at all in DirectX mode, but it scaled a bit with Vulkan. There wasn't much difference between the 99th percentile frame rates here, but adding a second card did boost the average frame rate a fair bit, with scaling varying from 40–48 per cent.

Scaling in Total War: Warhammer II at 2,560 x 1,440 was barely worth mentioning either, particularly on the RTX 2080 Ti SLI setup. Although, to be fair, a single card already averages 94fps in this game, which is plenty for a strategy game. We saw better scaling in this game at 4K, with SLI bringing the minimum frame rates above 60fps on both setups.

Noise and power

Aside from compatibility issues, the other main concerns are power draw and noise. With two cards running at full pelt, the Scan machine made an awful lot of noise. It's not just that you have fans from two graphics cards making noise, but there also isn't much room for the fans to draw air through their coolers.

Even with a slot space between them, there's still little room for the cards to breathe, and the second card ends up being quite close to the PSU shroud too. The Scan was significantly quieter with just one of either card installed (much quieter than you would normally expect), as the fans don't have to work as hard to draw air into the cooler.

When we discussed this feature with Scan, the company told us that very few of the SLI systems it sells use air-cooled GPUs, with most SLI buyers looking for a water-cooled system. This makes a lot of sense, and not just because people who can afford SLI can probably afford water cooling too. Water-cooling the GPUs means you can direct the cooling to the radiators, with no concerns about airflow between the two cards. A water-cooled SLI system will be massively quieter than an air-cooled one, and the GPUs will be less likely to throttle too.

Don't underestimate the power requirements either. With both the RTX 2080 Ti and Super, our system went from drawing around 400W from the mains at peak load, to well over 600W (and nearly 700W in the case of the RTX 2080 Ti SLI setup). The Scan test rig had an 850W PSU to cope with this load, and you'll want the same or higher if you're planning to do it too.

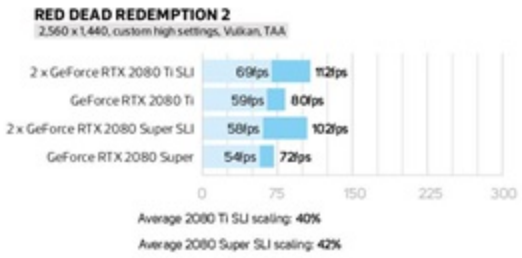
Conclusion

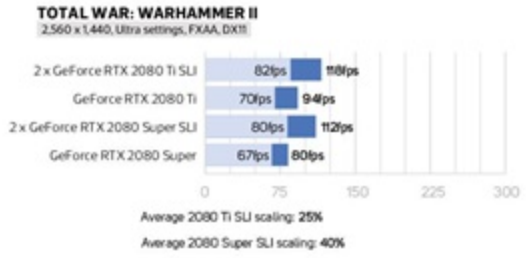
Is it still worth using SLI in games? The answer is a very hesitant yes from us, with the caveat that it very much depends on your circumstances. If you have the money, and you want to be able to play the latest games at 4K with all the top eye candy and ray tracing, then SLI is the only way to do it at the moment. Even then, though, we'd be tempted to wait and see what Nvidia and AMD might have waiting in the wings for later this year instead, as a single-GPU setup will involve much less stress.

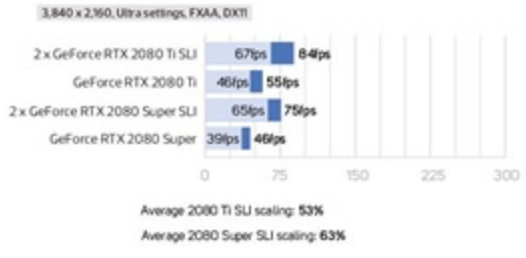
Throughout testing, we encountered compatibility problems, from visual artefacts to games without SLI support, as well as occasional stuttering and poor scaling. A lot of these tests had to be run several times before we could get reliable results. What's more, you may well have to spend a lot of time faffing in Profile Inspector just to enable SLI in some games, let alone optimising it to run faster.

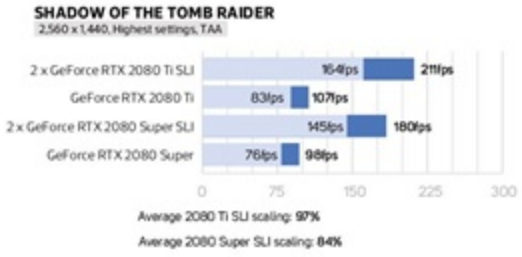
If you have the money, time and patience, and you want the best performance now, then go ahead and build yourself a (water-cooled) RTX SLI system. For anyone else, though, we advise sticking to a single GPU and lowering your graphics settings a bit. With dwindling dual-GPU game support, AMD dropping CrossFire and Nvidia only enabling SLI on four GPUs, it's clear that the concept of multi-GPU may also be on the way out. We'd be surprised if Nvidia canned SLI entirely any time soon, but don't expect it to still be here in a few years. **OPC**

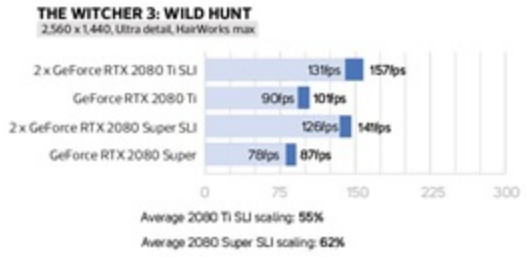
BENCHMARK RESULTS

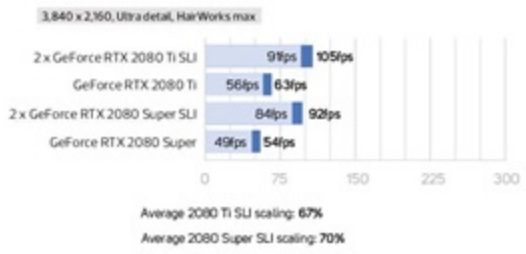


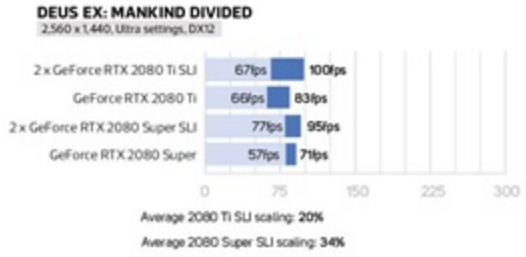


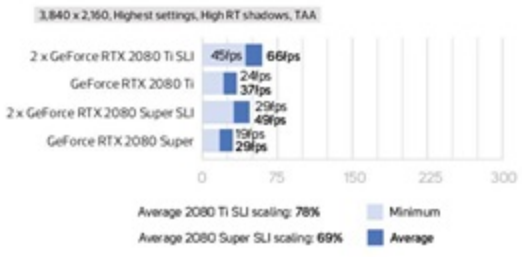


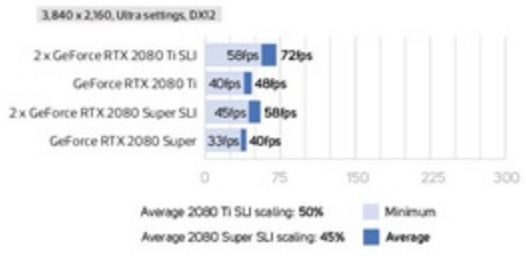


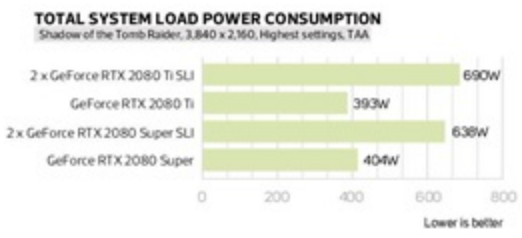












GARETH HALFACREE'S

Hobby tech

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

PREVIEW

Mooltipass BLE

The Mooltipass BLE features a built-in battery and Bluetooth Low Energy radio

Security in the early days of computing was physical: a locked control panel on a machine housed in a guarded building at the centre of a military base. The birth of multi-user computing, then the Internet, saw that change. Now, electronic security is the watchword, and it's ever-difficult to guarantee, owing to the sheer volume of sites and services with which modern computer users are obliged to register.

There are innumerable software packages that take aim at the central problem. Password managers, from open-source tools such as KeePassX, to subscription services such as LastPass, generate highly-complex passwords unique to each site and service and remember them for you in encrypted databases. There are attempts at doing away with passwords using hardware too, with Microsoft's Windows Hello offering facial recognition for authentication, and Google now offering its own Bluetooth-connected security dongles with which to authenticate access to its services.

Then there are devices such as the Mooltipass Mini (reviewed in Issue 168), an open-hardware gadget that stores all your passwords in a physical device. The passwords themselves are, of course, encrypted; the key for this encryption is stored on a smartcard and protected with a four-digit hexadecimal PIN. Get the PIN right, you can access the passwords; get it wrong three times in a row and the encryption key is permanently wiped. As such, step one of using the device should always be to back up the key to a second smartcard.

The Mooltipass Mini, a more compact successor to the original Mooltipass, is a cross-platform device. People running Linux, macOS, or Windows can use the Mooltricute software tool to manage the passwords on the device, alongside browser plug-ins for auto-fill and credential capture. On other hardware, the Mooltipass shows up as a USB keyboard – and, if all else fails, connecting a USB power bank will allow you to recall passwords that can be displayed on its built-in OLED panel.

For desktop users, that's plenty. For mobile users, though, having to pull out a micro-USB cable and USB OTG adaptor every time you need to log in to somewhere is a chore. That's where the Mooltipass BLE comes in. It's a wholly new variant of the

The BLE variant is slightly larger than the original Mooltipass Mini, with a higher-resolution display

Mini that's still under active development and incorporates a Bluetooth Low Energy radio for wireless communication with compatible host devices.

Theoretically, there's no change to the security model despite the presence of the radio. Passwords are still encrypted using a key located on a smartcard, and a PIN is still required to unlock the key. Also, unless a new 'simple' mode is enabled – a mode that auto-fills passwords without requiring the user to confirm the validity of each request – every password request requires physical confirmation by pressing the multi-function wheel on the side of the device.

A hidden tab in Moolticute offers features for Mooltipass BLE beta testers

The Mooltipass BLE is supported by the same Moolticute software as earlier versions

For more cautious folks, the Bluetooth feature can be quickly disabled and enabled using the new icon-based menu system. This pops up on the higher-resolution OLED, and it's controlled in the same manner as the Mini, using a rocker wheel on the side of the device body.

For the mobile user, Bluetooth will likely prove to be a must-have feature. An internal battery, charged using the same USB Type-C connector used for wired data communication, lets the Mooltipass BLE run entirely wirelessly, with each password being 'typed' over an encrypted connection as though it were a Bluetooth keyboard. Work is also underway on a mobile version of Moolticute, which will allow for full device management from smartphones and tablets.

For the desktop user, it's handy but not quite so important – when connected via Bluetooth or USB, the device is handled via Moolticute in the same way. That's not to say, however, that there's no reason for Mooltipass Mini users to upgrade. The Mooltipass BLE stores more data, supports passwords beyond the original device's 31-character limit, and an in-development firmware upgrade will allow it to act as a FIDO2 second-factor authentication token.

There's a lot of future-gazing here, though. At the time of writing, the Mooltipass BLE was still under heavy development. While the hardware – impressively swish and, as with its predecessors, open-source – is functionally complete, the software and firmware side has yet to be finished.

NEWS IN BRIEF

ZX Spectrum Next finally ships

The crowdfunded ZX Spectrum Next project (reviewed in board-only format in Issue 176) has finally reached a successful conclusion, with fully-finished units shipping two years after the original target. Recreating a souped-up Sinclair ZX Spectrum on an FPGA, the Spectrum Next includes impressive compatibility along with upgraded memory, Wi-Fi and even a Raspberry Pi coprocessor, housed in a keyboard casing that proved to be late industrial designer Rick Dickinson's last project. A review of the top-end ZX Spectrum Next Accelerated will follow in Hobby Tech next issue.

The Bluetooth feature, in particular, is proving a tough nut to crack, and one that may push the device's launch date beyond the targeted late-April/early-May slot. During testing, it absolutely refused to fill in any passwords on a Nokia 7.2 running Android 9, despite other beta unit users reporting success with similar Android 9 devices.

For the latest on development, follow the developers at **twitter.com/themooltipass**; when it's on sale, the Mooltipass BLE will be available from **themooltipass.com**

As before, the Mooltipass BLE is protected with a smartcard and PIN combination

HANDS ON
FLIR ETS320

The FLIR ETS320 is an impressive machine, but built for one very specific task

Traditionally, thermal analysis of electronic components has been rather unscientific. You would run a device at full-tilt for a bit and poke it with your finger; if it hurt, that component would probably need a heatsink. Burnt fingers gave way to temperature probes; temperature probes gave way to non-contact thermometers; finally, non-contact thermometers gave way to thermal imaging equipment, capturing thermal data in the same way a traditional camera captures light.

Over the past few years, the cost of thermal imaging devices has been steadily dropping (see Issue 146). It has now reached the point where it's possible to buy smartphone add-ons for only a few hundred pounds, or imaging modules that allow the suitably clever to build their own thermal cameras.

Regular readers will be aware of the frequent use of thermal imaging analysis in Hobby tech, using a relatively entry-level FLIR C2 handheld camera. While functional, the device is used outside its designed environment here. The C2 is a semi-rugged and compact camera aimed at people such as site surveyors, typically targeting the investigation of buildings and infrastructure rather than compact electronic components.

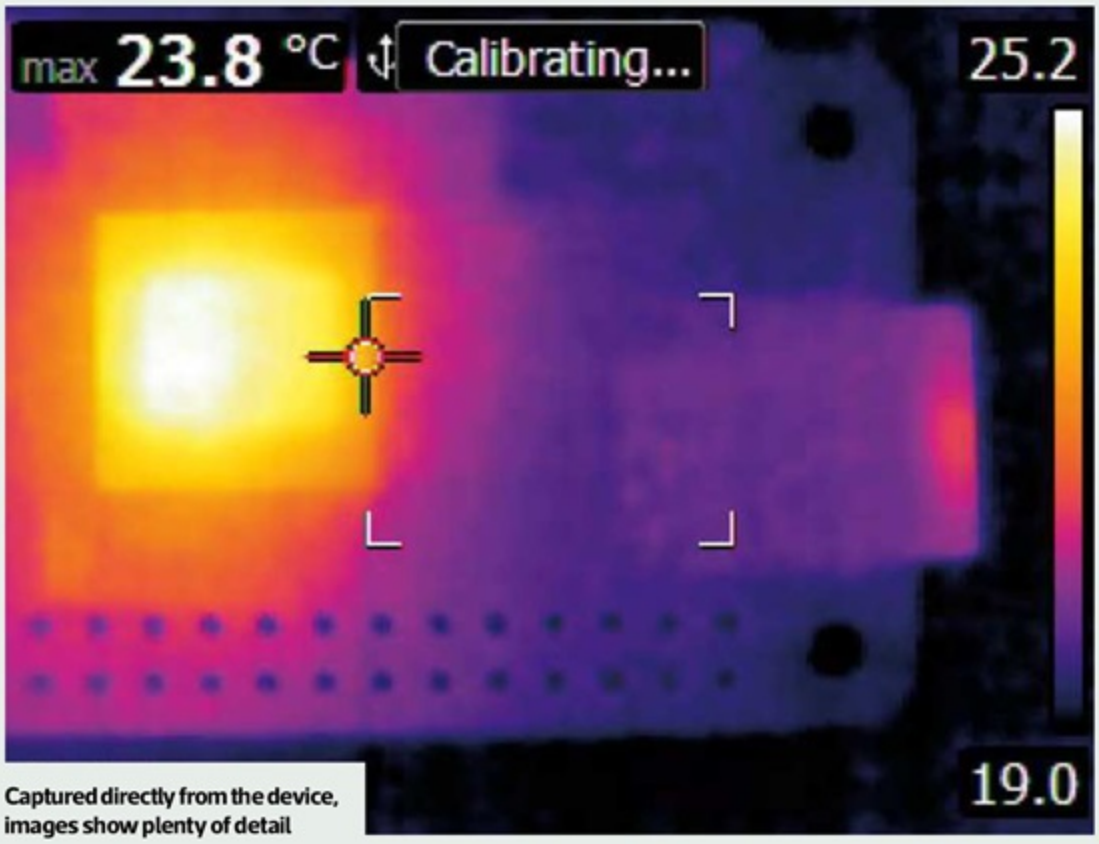
The FLIR ETS320, by contrast, is designed specifically for the analysis of electronic components. It's bundled with a stand, complete with a clever non-IR-reflective textured base and grounding clip to protect the piece under analysis from electrostatic discharge (ESD) damage. It also features hands-free operation through either the FLIR Tools+ software package or, cleverly, by showing up as a standard webcam via its micro-USB port. It's FLIR's attempt at really selling detailed component-level thermal analysis to the electronics industry.

Unlike the handheld C2, there's no touch-screen on the ETS320

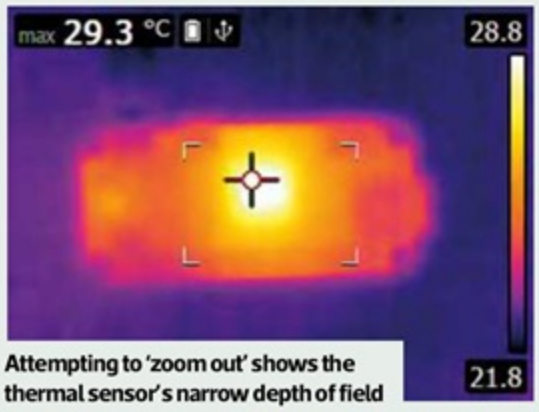
Compared with the C2, the ETS320 is a major upgrade in terms of its sensor. Where the C2 offers a limited 80 x 60 thermal resolution for 4,800 measurement points per image, the ETS320 has a 320 x 240 resolution. As such, each capture includes 76,800 individual measurements, each of which is accurate to ±3°C as calibrated at the factory.

That resolution is enough to pick out individual component-level details from a part on test, as the promotional imagery for the device showcases, but there are a couple of catches. The first is specific to the ETS320. As it's designed for close-up detail work, the camera is unable to focus at distances further than around 70mm from the object on test. That translates to a workable viewing area of just 49 x 37.5mm at its largest – that's enough to focus on specific sections, but not enough to get an overview of an entire board's thermal footprint for any but the smallest of devices.

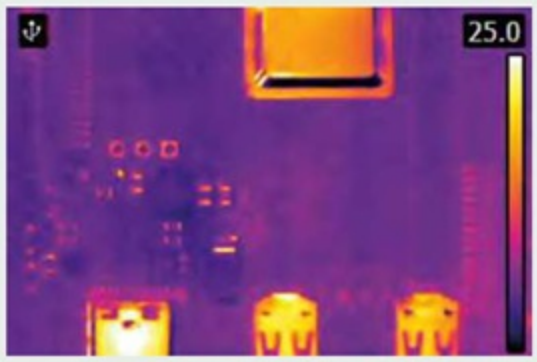
A ground connector is included to protect devices from ESD



Captured directly from the device, images show plenty of detail



Attempting to 'zoom out' shows the thermal sensor's narrow depth of field



Without pre-treatment, components will show false detail; everything in this pic is room temperature

The second caveat is shared by all IR-based thermal cameras – the need for careful handling and pre-imaging treatment of the part on test. Placing a common single-board computer beneath the ETS320's thermal lens and focusing brings up an incredibly detailed picture, where each individual component stands out in stark contrast. However, it's all false detail – the 'hot' areas of the board are polished metal, reflecting the sensor's heat back on itself – these parts are in fact the same temperature as every other part at the time of capture.

The solution is to coat the board in a less reflective material – a suspended powder used for crack detection in metal works well, as does matt-finish paint if you don't care about cleaning it off afterwards. Once painted, though, most of those fine details are lost. Plus, unlike the C2, there's no sign of FLIR's MSX image blending, where the thermal data is overlaid on a visible-light image to bring out otherwise invisible details.

Once a part has been properly treated, the image may look less impressive, but the data is a lot more useful. Connecting the ETS320 to a Linux desktop to capture a live video feed from the sensor, and booting a Raspberry Pi Zero, not only revealed how the system-on-chip spreads its heat throughout the board, but the image was even detailed enough to spot the cadence in the read operations on the connected microSD card, which were visible as pulses of heat. Raw thermal data can also be captured live, but only using the exclusively Windows and macOS FLIR Tools+ software bundled with the camera.

The ETS320 is an impressive device, and a specialised one. It's cheaper than more general-purpose FLIR cameras of a similar resolution, but more limited. It offers considerable detail, but only over a very small physical space. Plus, if you want to use the automatic hot/cold spot measurement system, that space becomes smaller still.

It's also priced well out of the reach of hobbyists, at least for now. The camera, including the FLIR Tools+ licence, which allows for post-capture analysis, live radiometric data streaming and detail report generation, is priced at £3,119 inc VAT, with a two-year device and ten-year sensor warranty. With the admittedly lower-resolution FLIR C2 costing around £480 inc VAT, that's a hard sell for any but the most dedicated thermal imaging enthusiast. More information on the FLIR ETS320 is available at **custompc.co.uk/FLIR**

NEWS IN BRIEF

Copy and paste pioneer dies aged 74

Computer scientist Larry Tesler, who with colleague Tim Mott developed the concepts of cut, copy, and paste in computing, has passed away aged 74. Tesler migrated from the Stanford Artificial Intelligence Laboratory (SAIL) to Xerox's infamous Palo Alto Research Centre (PARC) in 1973. Here, work on a word processor and the Smalltalk programming language would give rise to the ability to cut and copy chunks of text or program code and paste them elsewhere in a file. This was a common task in physical print layout, but at the time unheard of in computing. Tesler was a key proponent for ease of use, and his contribution to the field cannot be understated.

Image credit: YAHOO! BLOG, CC-BY 2.

NEWS

Raspberry Pi 4 2GB price drop

The Raspberry Pi 4 Model B 1GB is dead; long live the Raspberry Pi 4 Model B 2GB!

When the Raspberry Pi 4 single-board computer launched last year (see Issue 193), it had multiple RAM capacities. For the standard target recommended retail price of $35 US, a figure to which Raspberry Pi Trading has stuck with remarkable tenacity over the years, despite the specifications climbing and inflation pushing the real-world value of $35 down closer to $30, buyers got the same 1GB capacity as the previous Raspberry Pi 3 Model B+, albeit in faster LPDDR4 form.

Anyone needing more memory had the choice of 2GB or 4GB models, the first time any Raspberry Pi broke the 1GB barrier, albeit at additional cost. Now, eight or so months on, there's been a rethink. It's resulted in the retirement of the 1GB model, with the 2GB model being pushed down to take its place at that headline $35 price.

'2GB is a much more viable desktop platform than 1GB,' Raspberry Pi Trading chief Eben Upton explains of the move. '1GB is great for embedded, but for a desktop platform it's just a little bit too tight. What it means is that we're now back to having a really viable desktop machine at our signature price point.

'If you look at the last eight years, you've now got eight times as much memory, about 40 times as much processing power, and about ten times as much I/O bandwidth. You've got four times as many pixels on-screen, two screens and you've added Wi-Fi and Bluetooth.'

While the news may disappoint people who had already splashed out on the 1GB model, this couldn't have happened at launch – only the falling price of the required DRAM module has made it possible now. It's not just doubling the RAM that makes the Raspberry Pi 4 Model B 2GB a usable desktop platform either – it's an entirely different approach to development than you find in the desktop or laptop markets.

'Compared to either a Windows platform, or even to a traditional Linux platform, there's been a sort of relaxation,' says Upton. 'As there's been more memory people have loosened their belts a little bit, and sort of flumped down and started consuming more memory – when we really haven't. We're still using an LXDE-derived desktop environment. We do care about every 10MB; that's the reason why the 2GB is our really, really useful desktop.'

There have also been other changes since launch, which even early adopters can enjoy. Updates to the Debian-derived Raspbian operating system and the firmware for the Raspberry Pi 4 have slashed power draw and heat output – both undeniable issues with the full Raspberry Pi 4 family at launch. The very latest firmware revisions have been tested as dropping idle power draw from 2.89W to 2.1W and load from a hair-raising 7.28W to 6.41W.

For those upgrading from earlier devices or coming fresh to the ecosystem, the choice is simple: 2GB or 4GB? The former is now the cheapest Raspberry Pi 4 around, and has more than enough power for everything from basic desktop and educational use to retro gaming. The 4GB board will set you back a little more, but offers a chunk more headroom – the sort of space you might need if using a Raspberry Pi 4 as a file server, database server, or if you're fiddling about with machine learning.

Both models are available now from the usual resellers. If you think you can get away with just 1GB of RAM, you may also find old stock steeply discounted, though this is likely to run out relatively quickly. **CPC**

There's effectively no difference between the 1GB and 2GB models, bar the DRAM module used

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at **freelance.halfacree.co.uk** @ghalfacree

WIN

A BE QUIET! PURE BASE 500 CASE

In your choice of colour

We've teamed up with the lovely folks at be quiet! to offer a brand-new Pure Base 500 ATX case to one lucky **Custom PC** reader. Available with and without a side panel window, the Pure Base 500 provides ample space for high-end graphics cards and CPU coolers.

Meanwhile, the switchable top cover and two preinstalled Pure Wings 2 140mm fans give you the option to focus your system build on low-noise or airflow performance, with space for radiators up to 360mm in size. The sophisticated design of the Pure Base 500 means you can hide nearly all your cables, and highlight up to two SSDs, helping you to build a neat system with great illumination.

The case is available in a window and non-window version in three colours each: Metallic Grey, Black and White. You can pick the model you would like to win.

SUBMIT YOUR ENTRY AT
CUSTOMPC.CO.UK/WIN

be quiet!®

3 TO BE WON!

Competition closes on Friday, 8 May. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation, 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. Participants agree to receive occasional newsletters from Custom PC magazine. 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.

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Why I still love mini-ITX

ASRock's X570 mini-ITX board is more than capable of handling AMD's Ryzen 9 3950X

Like many people working from home in the UK, I've had to contend with a fairly limited amount of space until recently, resulting in me reducing the size of my PC. However, this hasn't resulted in slower frame rates or lack of power in other departments. Thanks to the small form factor scene really taking off over the last decade, the choice of PC cases, motherboards and other compact hardware has grown, and I honestly haven't missed the giant PCs I used to own at all.

Mini-ITX has meant that, despite owning a PC with a smaller footprint than a shoebox, it's been easy to find ways of using high-end desktop processors and graphics cards, along with the latest storage technology. My current PC is more than capable of handling the latest games on my ultra-wide 1440p monitor and, as it's mine, it's water-cooled and super-quiet too.

Building a small form factor machine might mean an extra hour or two dealing with cable tidying in the tight confines of a mini-ITX case, but it's definitely worth it and saves a huge amount of space. The sacrifices are, for most of us, non-existent too, as long as you only need a single PCI-E card. Many mini-ITX cases can house full-length graphics cards, ATX power supplies and hard disks too.

More recently, though, I moved house and now have a much bigger room where my PC is based. With the launch of AMD's fantastic 3rd-gen Threadripper CPUs and the power that can be had inside an ATX PC now, I've been seriously tempted to go back to a full-sized system. Admittedly, I was hoping there would be a micro-ATX TRX40 motherboard, as I've had my eye on several micro-ATX cases recently, but sadly it looks as though ASRock isn't planning a follow-up to its spectacular X399M Taichi board.

Building the front cover water-cooled Threadripper PC a few issues ago inside Phanteks' gorgeous Evolv X case made this proposition even more tempting. The PC was quieter than my current mini-ITX PC, and it fitted snugly under my desk without taking up too much space, thanks to my new house's extra room.

However, even though a bigger PC is easier to maintain than a small one (my current system needs half a day to strip down and rebuild if something goes wrong, which is certainly not ideal), I'm still as obsessed as ever with mini-ITX. For me, it's by far the most interesting form factor of cases and motherboards, and for one clear reason. It forces manufacturers to

think differently. Space is usually a huge premium, and this means they can't approach design in the same way as with ATX cases or motherboards.

The latter, for example, have seen manufacturers placing M.2 ports on the rear of the PCB, large VRM daughterboards and, more recently with the X570 chipset, all manner of ways of cooling the toasty chipset and placing the necessary heatsinks and heatpipes around the motherboard. There's so much more innovation and variation here than you see between similarly priced ATX motherboards, which is partly why mini-ITX motherboards cost a little more than their equivalent ATX counterparts.

It's with cases that the really interesting ideas occur though. Again, the variation between the current stack of mini-ITX cases dwarfs that of ATX and micro-ATX models. I still get a buzz looking at them, simply because manufacturers often start from scratch, which is rare with their larger models. The SilverStone LD03 and Phanteks Evolv Shift, for example, are two completely different examples of tower mini-ITX cases.

NZXT's H1 shows just how much R&D is required to cram high-end hardware into small spaces

This month we also looked at NZXT's H1 (see p24), which is yet another very different take on this style of mini-ITX case and I love it. It's even smaller than my Phanteks Shift but is incredibly well thought-out and premium-feeling. Going even smaller, Kolink's Rocket might not have space for liquid cooling, but it can house a high-end air-cooled PC. Raijintek has several takes on this style of super-small case too, and the Ophion Evo even has space for liquid cooling.

The fact is that, even though I was tempted to go down the ATX route again, I can't see me ever getting there when companies are still churning out so much great small form factor kit. I'm still working on a Raijintek Ophion Evo case mod, and I can see myself turning my attention to NZXT's H1 before long too.

One issue is that ASRock's X299E-ITX/ac motherboard seems to now be at the end of its shelf life, meaning that using Intel's HEDT CPUs is no longer possible on mini-ITX boards. Thankfully, there are numerous options for using AMD's Ryzen 9 3950X, though, so whether you need serious multi-threaded grunt or fast frame rates, there are still loads of options. So, despite me getting a bigger place, mini-ITX is still way more interesting to me than any other form factor – I can't see myself upsizing any time soon.

Corsair's XD3 pump is ideal for smaller cases

Corsair's entrance into the custom water-cooling scene went fairly smoothly, and I've been impressed by the quality and flexibility of its products, especially the XD5 pump and reservoir combination. However, while Corsair offers 120mm and 240mm radiators, as well as waterblocks, which are compatible with smaller cases, the XD5 res/pump combo is a large product that struggles to fit in many cases.

Thankfully, the company has this month launched the XD3 – a compact pump and reservoir combination. It can fit into 120mm fan mounts and uses a PWM-controlled DDC pump. This means you get the power and low noise of a custom water-cooling pump, as well as a 180ml reservoir that can be mounted in practically any case with a 120mm fan mount.

These kinds of contraptions make building a small water-cooled PC possible, and without needing to cut away large areas of your case with a Dremel, or spending weeks figuring out how to fit all the necessary cooling hardware inside. I'll be taking a look at the XD3 soon – check out Customised PC in our next issue to see how I get on with it. CPC

Corsair's new XD3 pump can fit into a 120mm fan mount

Antony Leather is Custom PC's modding editor @antonyleather

How to Spray-paint motherboards

Antony Leather shows you how to jazz up your motherboard's shrouds and heatsinks with a coat of spray paint

TOTAL PROJECT TIME / 48 HOURS

Your motherboard might sport RGB lighting, but that's usually the only way you can customise it to add a splash of colour. However, it's quite easy to spice up your board further using spray paints. Traditional spray paints are easy to use and, as we're only talking about small areas, you don't need to be a rattle-can expert to get a good finish, nor do you need a huge amount of space.

As long as you have a well-ventilated area, you can spray the various removable parts of your motherboard in a host of different colours, and even spray the motherboard itself. If you want to be able to sell your board later then you can still have some fun. Plastidip might not be as good-looking as glossy acrylic spray paint, but it's easy to apply and removable too.

TOOLS YOU'LL NEED

Frog tape
Most hardware stores

Microfibre cloth
amazon.co.uk

Plastidip
plastidip.co.uk

Wet and dry sand paper
Most hardware stores

Liquid electrical tape
amazon.co.uk

Mini plastic greenhouse
amazon.co.uk

Acrylic spray paint and primer
fatbuddhastore.com

Mask and goggles
Most hardware stores

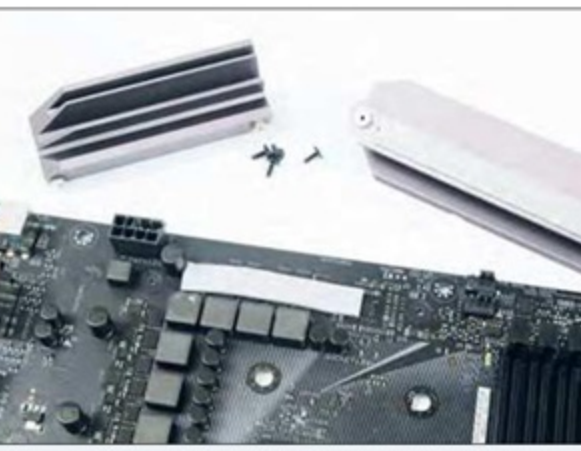
USING ACRYLIC PAINTS

1 / IDENTIFY PAINTABLE ITEMS

Most large items on your motherboard can be painted, but you'll need to check whether there are fans lodged inside heatsinks, or if there are displays on I/O shrouds, which you'll need to mask later.

2 / USE SPRAY BOOTH AND PROTECTIVE GEAR

Wear a face mask and goggles in a ventilated area while spraying, and it's also worth donning some gloves. We recommend creating a booth to contain fumes, and also to protect your objects while they dry. A mini plastic greenhouse is ideal and also relatively cheap.



3 / REMOVE HEATSINKS

Remove your heatsink screws, taking care to support the heatsinks from the top side. Sometimes the heatsinks can be tricky to remove, as the thermal paste acts like glue. Use a hairdryer on full power from close range in 15-second bursts until the heatsink warms enough to dislodge the paste.

4 / REMOVE I/O SHROUD

The I/O shroud is another easy item to paint, but some premium motherboards have fans and OLED displays lodged within them, so take care when removing it, disconnecting any cables underneath it.

5 / REMOVE THERMAL PADS

Heatsinks, especially those on VRMs, often use thermal pads rather than paste for heat transfer. Keep these pads in good condition, so you can replace them later. If you're just spraying the heatsinks, place the pads in their corresponding positions on the motherboard.

6 / CLEAN THERMAL PASTE

Any thermal paste needs to be cleaned off the chips or VRMs, as well as the heatsinks, using a microfibre cloth and either TIM cleaner or isopropyl alcohol. This saves you getting covered in paste while you handle the parts, and replacing the stock paste with high-performing paste can improve heat transfer too.

7 / CLEAN OBJECTS

Once you've removed the components, clean them up. They might look fine, but they'll likely be covered in dust and any other small particles that have been blown through your PC. You can use diluted washing-up liquid and warm water, rinsed thoroughly with a cloth, or isopropyl alcohol.

8 / MASK OBJECTS

You might not want to paint all the heatsinks and components. For example, there may be manufacturers' logos or LED displays you want to avoid spraying, as well as thermal contact areas. Cut frog tape to size, so you can mask these parts and, if necessary, use edging tape for large curved areas.

9 / USE PLASTIC PRIMER

Some plastics don't offer a great surface for spray paint to adhere to, but there is a way around this problem by using plastic primer. This primer bonds to the plastic and gives the spray paint a textured matt surface to which the paint can stick.

10 / SPRAY UNDERCOAT

Use a normal primer or undercoat on metal objects. This creates an even surface and uniform colour before you add the colour coat. Apply it in thin coats, spraying two or three times across the object from 8in away, and applying as many coats as necessary to cover it, turning the object to get into crevices.

13 / CONSIDER CLEAR COAT

Most gloss coats offer enough shine themselves and, as you won't be banging into the motherboard on a regular basis, clear coat or lacquer isn't strictly necessary. However, for more protection and the ultimate shine, it's worth adding, and you only need two or three light coats.

11 / USE WET AND DRY SANDPAPER

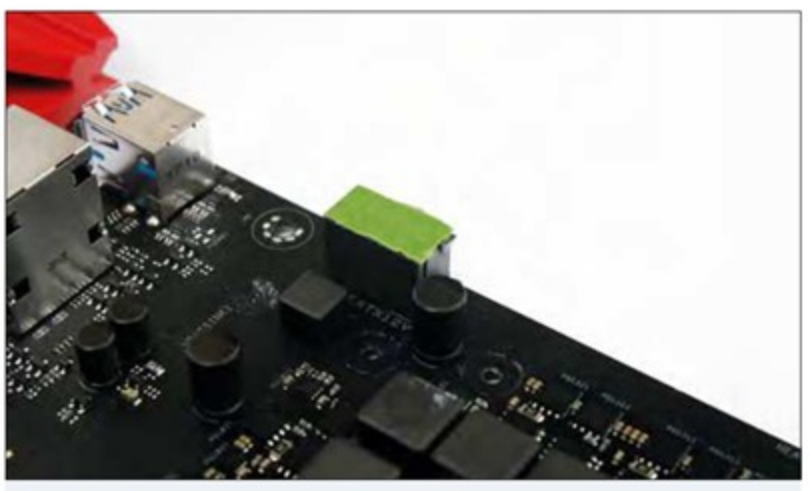
Allow the primer to dry for an hour. Then, so you can achieve the smoothest surface as possible for your colour coat, tear off small sections of 1,000-grit wet and dry sandpaper and use water to lubricate them. Rub them lightly for just ten seconds or so on each area of the object.

14 / ALLOW TO DRY

Once you've applied all your paint, allow the objects to dry naturally in a well-ventilated area for 48 hours before you handle them and reinstall them on your motherboard.

12 / SPRAY COLOUR COAT

Colour coat has a tendency to run, which can be made worse on angled heatsinks, so apply it in multiple light layers, spraying from different angles and allowing each one to dry thoroughly. Once you're done, remove the masking, as doing this job later can tear the paint. If necessary, reapply the masking prior to adding a clear coat.

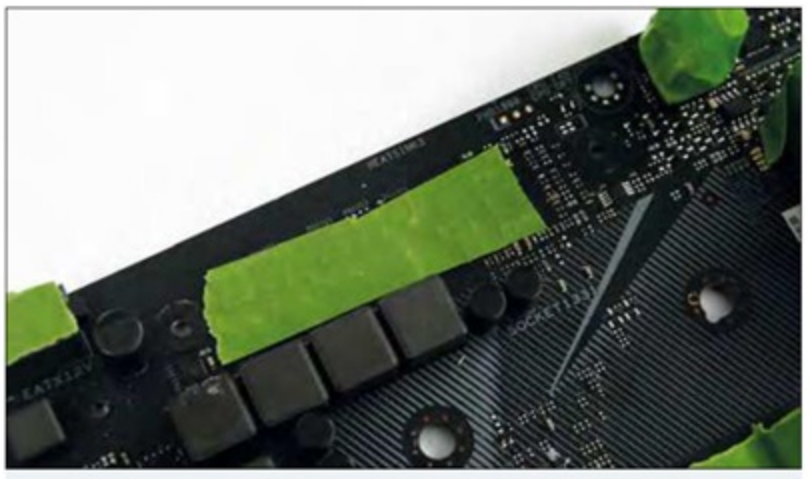


15 / MASK POWER SOCKETS

To spray your motherboard, you'll need to mask all the important bits. Start by masking the port openings, although you can leave the covers of items such as SATA and USB 3 ports, if you want them to receive a coat of paint too.

16 / MASK SLOTS

You'll need to paint M.2 heatsinks separately, and you'll also need to block off the M.2 ports themselves. To do this, wrap the entire connector in frog tape from the base up. Don't risk paint running into the port itself. Similarly, you will also need to cover any PCI-E slots.



17 / MASK HEATSINK CONTACTS

Just as with the heatsinks themselves, cover any VRMs, chipsets or other hotspots that need good thermal contact with the heatsinks, so they don't get paint on them.

18 / USE SEALANT

You also need to avoid painting pins and open ports. You can either wrap them up in frog tape or, if that proves haphazard, use silicon sealant or liquid electrical tape. This can be peeled off afterwards.

19 / SPRAY MOTHERBOARD

Lay your motherboard flat, and follow steps 10, 11 and 12, to apply both the primer and colour coat. You'll also need to follow step 13 to apply the clear coat, as it's easy to chip the paint when installing your hardware.

20 / REMOVE MASKING

With the paints applied, remove the masking as soon as you finish spraying the last coat of lacquer. This will ensure you don't tear it once it's dry.

21 / REASSEMBLE MOTHERBOARD

Leave the motherboard for 48 hours to dry, then reassemble the heatsinks and any other parts you removed, remembering to reinstall any thermal pads or reapply thermal paste to heatsinks. You'll also need to reconnect any fans and LED cables.

USING PLASTIDIP

1 / WHAT IS PLASTIDIP?

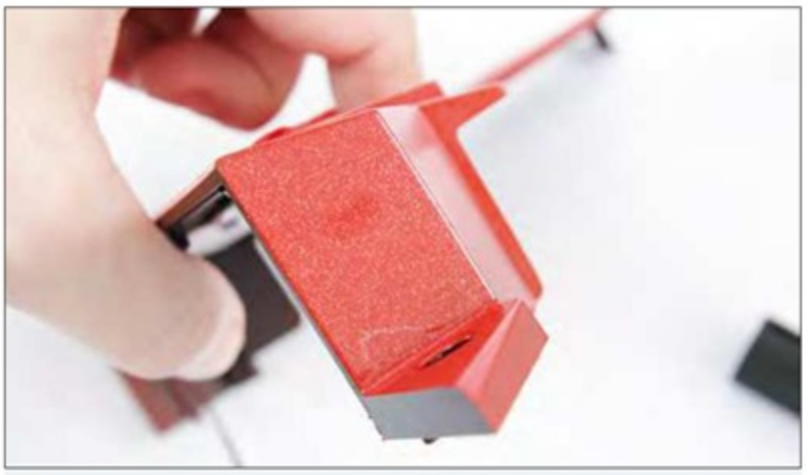
You can also consider using Plastidip to paint your components. This creates a thin, rubber-like film over the surface, which can make it easier to achieve a decent finish than acrylic spray paint. What's more, it can easily peel off, allowing you to sell your motherboard at a later date.

2 / USE PRIMER

If you intend to use Plastidip on a long-term basis, it's beneficial to use Plastidip primer. Like normal primer, it allows the Plastidip to adhere more securely to surfaces and prevent it from peeling.

3 / SPRAY ON COLOUR COAT

Plastidip otherwise doesn't need primer and is very forgiving. Once you've masked your motherboard, as in the previous acrylic paint section, spray it liberally from 12in away, applying three passes over each object. After that, allow it to dry for five minutes before repeating the process until you can't see any colours beneath it.



4 / ADD METALLIC EFFECT

There's a huge array of Plastidip colours from which to choose, and you can even add a metallic effect. It comes in a separate spray can and needs to be applied after you apply the main colour coat.

5 / APPLY CLEAR COAT

Plastidip can look quite dull compared with glossy acrylic paint, but there's a clear coat available to add some shine. After the colour and metallic coats are dry, apply the clear coat using three or four thin coats, in the same manner as the colour coat, allowing each coat to dry for five minutes.

6 / REMOVE PLASTIDIP

To remove the Plastidip, simply pick at an edge and then lift it away. You should be able to peel most of a large area off in one go, making its removal simple if you want to change the colour or go back to the stock colour. CPC

Athlon 64

K.G. Orphanides looks back at AMD's K8 years, when Athlon 64 CPUs were smashing Intel's NetBurst chips into a pulp

It's September 2003, and AMD is about to swing a 64-bit wrecking ball straight into Intel's desktop CPU stronghold. The company's Athlon XP chips have already been giving Intel's Pentium 4 CPUs a run for their money, but AMD's new K8 chips are about to change everything. Not only will they bring 64-bit instructions to the mainstream desktop for the first time, but they'll also bring an integrated memory controller with them.

The first consumer 64-bit processor, the AMD Athlon 64 3200+, was unleashed on the world on 23 September, 2003, with two 130nm product lines launching at once. The mainstream Athlon 64 design, codenamed Clawhammer had an integrated single-channel memory controller and used the Socket 754 motherboard socket, with the very first 3200+ model being clocked at 2GHz.

Then, at the top of pile was the Athlon 64 FX line-up, starting with the FX-51, which was quite different. Using the same Sledgehammer core and Socket 940 motherboard socket as AMD's Opteron server-orientated CPUs (released in April the same year), the FX-51 required registered memory, but had two 64-bit channels to transfer data between the RAM and CPU. This meant that two registered DDR DIMMs (or RDIMMs) of identical size, frequency and CAS 2 latency could work in concert, using a pair of 64-bit data connections to read and write to two modules at once, boosting memory bandwidth.

Both processor families had 64KB of L1 cache for data and 64KB of L1 cache for instructions, and an exclusive 1MB of L2 cache. However, some later processors in the series, as it expanded into more budget-conscious price categories, would have 512KB of L2 cache. The FX-51 also had an unlocked multiplier for overclocking, taking firm aim at enthusiasts.

AMD64 CPUs weren't the first 64-bit processors, of course. Their many notable precursors include Silicon Graphics' 1991 R4000 and its successors, and the RISC-based DEC Alpha, introduced in 1992, while IBM's PowerPC G5 processors were used in Apple's Power Mac G5 workstations starting in June 2003. Intel's 64-bit Itanium server CPUs were also around at this time, although they were extremely expensive.

But it was the Athlon 64 that pushed the boundaries of what was expected from a standard x86 desktop PC, because it not only worked perfectly with 32-bit operating systems and applications, but also outperformed Intel's rival 32-bit CPUs when running them.

Remember this?

The best-known advantage of a 64-bit processor is the ability to address more memory than the 4GB maximum of 32-bit CPUs, and AMD put a great deal of attention into memory handling.

While contemporary Intel and previous AMD CPUs had relied on a dedicated memory controller in the motherboard chipset's northbridge, AMD64 CPUs introduced an on-CPU memory controller with a direct link to the RAM. This meant there was no front side bus (FSB) – or EV6 bus in AMD's case – involved in shuttling data between the CPU, northbridge memory controller hub and RAM.

Having the memory controller on the CPU means that RAM speed is a fixed fraction of the CPU speed, rather than being pegged directly to the FSB speed. Early Athlon 64

The top-line FX models had unlocked multipliers, and were aimed squarely at enthusiasts

processors typically supported up to 166MHz (333MHz effective) buffered – that is, registered – and 200MHz (400MHz effective) unbuffered DIMMs.

Although the Athlon 64's physical address space supports up to 1TB of RAM, breaking the 4GB barrier imposed by 32-bit instruction sets, initial Socket 754 and Socket 940 motherboards typically supported up to four 1GB sticks of RAM. Support for 8GB of memory also bypassed the improved Socket 939 motherboards and wouldn't become commonplace until 2006, on the new Socket AM2 motherboards and processors with support for DDR2 RAM.

However, bear in mind that it's not just system RAM that comes under the 32-bit limit. That 4GB of addressable space has to be shared with graphics memory, cache and any other addressable memory in your PC. As such, if you were lucky enough to have 4GB of RAM and a 64-bit operating system at the time, you could use all your memory.

As well as reducing the distance travelled to communicate data between memory and the processor, reducing latency, the dedicated memory connection also eliminated the potential for bottlenecks suffered by the motherboard northbridge. This chip also handled communication between the CPU and other components, such as graphics cards and the southbridge (controlling IDE channels, the ISA bus, USB, storage and so on), as well as memory.

In 2005, the Athlon 64 X2 introduced a second core to the package

Like many features introduced by the K8 series, on-CPU memory controllers would become standard across the industry, with Intel introducing its own integrated memory controller four years later in its first Nehalem Core i7 processors. The K8 CPUs also included an integrated HyperTransport interconnect to create a low-latency, point-to-point link for direct communication between the CPU and all other components on the motherboard. It operated at 800MHz on Socket 754 processors and 1000MHz on Socket 940, 939 and AM2 CPUs.

This is a pipe

A less headline-grabbing advantage that made AMD's K8 processors top-of-the-line choices for many tasks was their comparatively short 12-stage integer instruction pipeline (17-stage for floating point instructions), compared with the rival Pentium 4's NetBurst microarchitecture. Intel's Willamette and Gallatin processors both had a 20-stage pipeline, while the Prescott CPUs, released in February 2004, had a whopping 31-stage pipeline.

An advantage of lengthening the pipeline is that it gives you more headroom to increase the clock speed, making for a potent setup if your software is giving the CPU regular, predictable instructions, giving Intel the edge on paper in terms of raw clock speed. That's great for tasks such as media encoding – long jobs that repeatedly use predictable instructions.

However, if you're using software that's less predictable, the pipeline can stall if the branch prediction system makes the wrong call, and will then need to be flushed before it starts again, creating latency. NetBurst was an interesting idea in theory, but the short pipeline of the Athlon

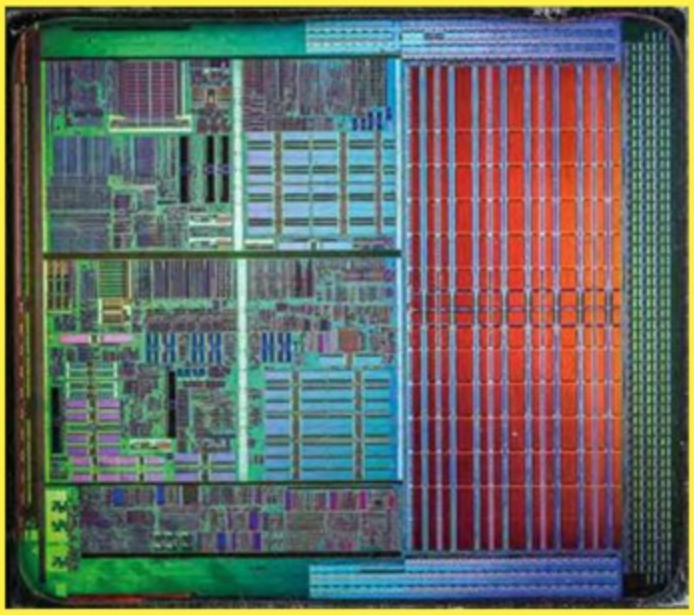
THE K8 ADDED THE AMD64 INSTRUCTION SET TO INTEL'S X86 CPU STANDARD

64 CPUs gave them a considerable advantage in a lot of software, despite their comparative lack of clock speed. Intel eventually ditched NetBurst, and went back to a short pipeline design with its first Core-branded CPUs.

Software support

While previous 64-bit processors could only run 64-bit software – in some cases with 32-bit application support handled by an emulation layer in the OS – the K8 added the now ubiquitous AMD64 (x86-64) instruction set to Intel's x86 CPU standard, with full backwards compatibility for 32-bit x86 instructions. That included a legacy mode with the ability to run 16-bit and 32-bit software natively, so you could go ahead and install a normal 32-bit edition of Windows XP on your Athlon 64 system and use it like any other CPU.

The original Athlon 64 3200+ used Socket 754. Credit: Thomas Nguyen



AMD64 TIMELINE

2000
- AMD releases AMD64 spec

2001
- Linux gets gains AMD64 support

2003
- AMD releases K8 Opteron
- Socket 754 Athlon 64 and Socket 940 Athlon 64 FX released

2004
- Socket 939 introduced

2005
- Microsoft launches Windows XP with AMD64 support
- Dual-core Athlon 64 X2 released

2006
- Athlon 64 X2 moves to Socket AM2 and gains DDR2 memory support

2007
- AMD renames Athlon64 X2 the Athlon X2
- AMD releases first Opteron K10 server processors
- First K10-based Phenom desktop processor released

2009
- Last processors based on the K8 microarchitecture released as a part of AMD's Athlon Neo X2 for Ultrathin Notebooks range

However, the most significant feature when it came to pushing OS and software development towards today's 64-bit standard was 'long mode', in which the Athlon 64 ran 64-bit applications natively, with the ability to conveniently run standard x86 software from a 64-bit OS.

This meant users could take advantage of the more sophisticated memory handling of 64-bit software, while still running their core 32-bit applications, eliminating a key hurdle to widespread 64-bit adoption. Dedicated 64-bit operating systems had existed for years, and support for AMD64 CPUs rapidly emerged. Linux had a head start, with x86-64 instructions already functional under emulation since 2001, and distributions including SUSE, Debian and Red Hat adding AMD64 support over 2004 and 2005.

Microsoft was a little slower off the mark. Despite having already developed a 64-bit version of Windows XP for the Intel Itanium (IA-64) processor in 2001, full AMD64 support only came to Windows in March 2005, with the official release of Windows XP Professional x64 Edition and Windows Server 2003 x64 Edition.

Despite the lack of OS and software support at the time, system builders immediately started putting the Athlon 64 to work, and some reviewers received 'pre-beta' editions of a 64-bit Windows XP at the processors' September 2003 launch. Meanwhile, games such as Unreal Tournament 2004 and Far Cry were released or patched to provide AMD64 support.

In nearly all our benchmark tests at the time, the first Athlon 64 processors routinely outperformed Intel's rival 32-bit Pentium 4 everywhere, from business applications to photo editing, 3D rendering and gaming, although the Pentium 4 tended to do a little better in some media encoding tasks.

Left: Die of the Socket 939 Athlon 64 'Venice' 3400+, released in 2005. Credit: Fritzchens Fritz

Evolving the Athlon 64

By mid-2004, Socket 754 was replaced on desktop motherboards by Socket 939, which supported dual-channel DDR memory at a bandwidth of 6.4GB/sec and, unlike Socket 940, didn't require registered memory. All future iterations of the Athlon 64 would use this socket until AM2's release two years later.

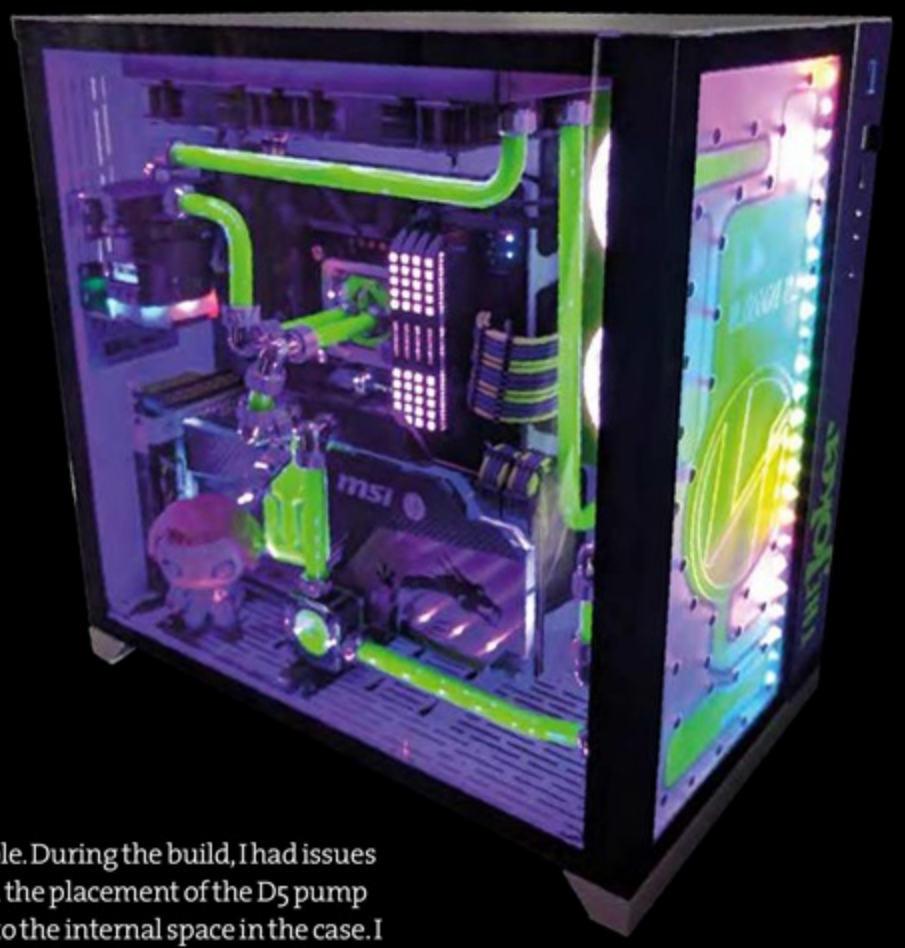
AMD's first dual-core processor family, the Athlon 64 X2, was then released in May 2005, just as x86-64 software support started to get proper traction. Once again, it put in a solid performance in our reviews. The initial X2 models were codenamed Toledo – available with either 512KB or 1MB of L2 cache per core, depending on which model you chose – and Manchester, which cost less and was available in models with either 256KB or 512KB of L2 cache per core. However, it wasn't until a move to Socket AM2 in May 2006, with the Windsor and Orleans CPUs, that the Athlon 64 X2 started supporting DDR2 RAM.

These dual-core CPUs were initially positioned as ideal for video editing, digital media and other 'prosumer' areas where applications were already capable of taking advantage of multiple cores. Single-core FX processors continued to be AMD's flagship gaming CPUs until the FX-60 came out in January 2006. CPC

Readers' Drives

Operation Jack Napier

Taking inspiration from Tim Burton's 1989 Batman film, Stephen Wells built this water-cooled project based on The Joker, going all out on the purple and green colour scheme



/MEET THY MAKER

Name Stephen Wells

Age 35

Occupation IT

Location Lincoln

Main uses for PC Gaming

Likes Movies, WWII model planes, and PC building

Dislikes Console gaming

CPC: How did this project start? What inspired you to build a Joker-themed PC mod?
Stephen: As a big movie fan, Tim Burton's 1989 version of Batman was a big inspiration. I've also seen similarly themed builds, and I liked the colour combination.

CPC: Why did you choose to base it on the Lian Li O11 Dynamic case, and how did you find working with it?
Stephen: I chose this case because it had great reviews in relation to cooling and airflow. It also has glass on both the front and side, which allows more of the build to be visible. During the build, I had issues with the placement of the D5 pump due to the internal space in the case. I solved this problem by mounting the pump at the back of the case, above the graphics card.

CPC: Did you perform any custom modifications to the case?
Stephen: I modified the case by adding a Joker vinyl sticker to the front in green and purple colours. This sticker was supplied by Kasim Malik of Gorilla Gaming, which is part of Computer Orbit.

CPC: What's on the other side of the motherboard tray?
Stephen: Not very much in all honesty – just extremely neat cable management, the power supply and a 2TB hard disk. I also added a Joker figure underneath one of the radiators to add more character to the build.

CPC: How did you go about designing and making the custom fan grilles on the front radiator?
Stephen: Once again, I used Kasim Malik of Gorilla Gaming. I contacted him on Facebook and explained my idea and what I was looking for. He then came back to me with several options. I chose the design that I thought would work best with the theme and lighting.

CPC: Where did you get that bright green coolant from?
Stephen: The coolant is CFX Vivid Green, which I bought from Amazon. During the build, I was undecided whether to use the final colour combination you can see here, or to go for the CFX Purple Violet coolant with green lighting

instead. I went with the green, as it's more vivid than the purple and really adds to the wow factor.

CPC: How did you achieve that internal purple sheen? Is it all down to lighting, or is some of the interior painted?

Stephen: The purple sheen was created with the Corsair LL120 RGB fans and the four Corsair RGB lighting strips. I used Corsair's iCUE software to select the colour for the fans and strips, as well as the Corsair Dominator RAM lights, which glow in a green and purple pattern. This is why I chose to use this particular RAM, and not the Corsair Vengeance RGB Pro, as I was able to select the colour for each individual square. The vivid green coolant then contrasts with the purple lighting to really bring the colours to life.

SYSTEM SPECS

CPU Intel Core i9-9900K Overclocked to 5GHz

GPU MSI RTX 2080 Sea Hawk EK

Case Lian Li 011 Dynamic, with Lian Li riser cable PCI slot bezel

Storage Samsung 970 Pro 512GB, Intel Optane Memory 32GB, 2TB WD hard disk

Memory 32GB (4 x 8GB Corsair 3200MHz Dominator Platinum RGB

Motherboard Asus Z390 ROG Maximus XI Formula

PSU EVGA SuperNOVA 750 G2

Cooling EK-Velocity D-RGB CPU waterblock, 2 x EK-CoolStream SE 240 Radiators, Barrow Waterway Distribution Panel Reservoir, Aqua Computer D5 Next RGB pump, Aqua Computer D5 ULTITOP pump adaptor, Alphacool Eiszapfen 13mm chrome hard tube compression fittings, Alphacool Eiszapfen flow indicator, 4 x Corsair LL120 RGB fans

CPC: We love the way the power supply cables change colour on either side of the cable comb. How did you do this?
Stephen: The power supply cables were made by To The Wire – Mods, which I found on Facebook. To The Wire - Mods provided me with cables that perfectly matched the colours of my theme, and which also kept my build looking tidy and professional.

CPC: What material is the tubing made from, and how did you go about planning the tubing routes and physically making the bends?
Stephen: I used clear PETG hard tubing for this build, and I made the bends using a heat gun and a rubber insert. I used a pipe cutter to ensure the cuts were clean. The route was planned as I went along, with lots of changes needing to be made before I arrived at the end result.

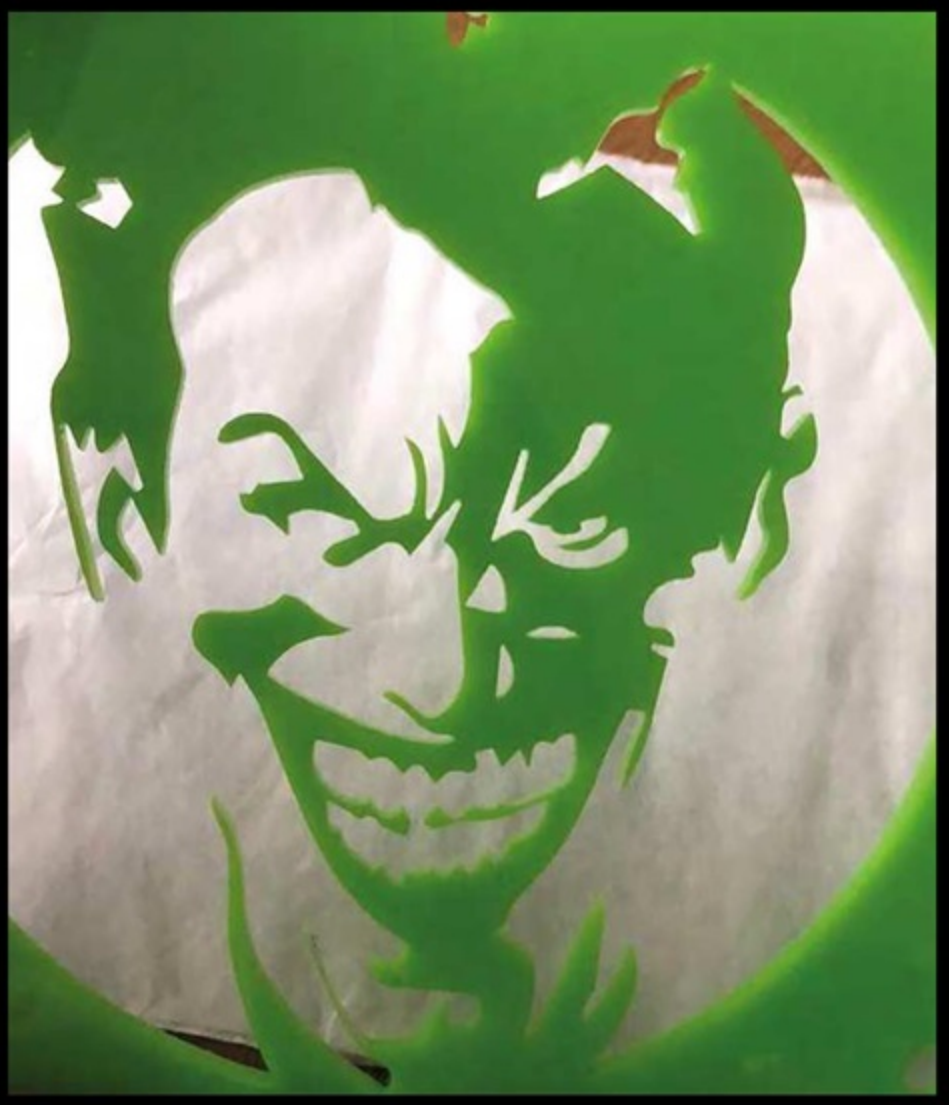
CPC: Take us through the components of the water-cooling loop.
Stephen: For the water-cooling loop, I used two radiators, with an Aqua Computer D5 pump. I used chrome fittings to match the EK waterblock, and then used black LL120 fans to match the black on the EK radiators. There's also a flow indicator under the graphics card, and a Barrow RGB Waterway Distribution Panel Reservoir at the front of the case.

CPC: Did you come across any difficulties?
Stephen: The greatest challenge was using up all the reservoirs on the distribution plate at the front, as the image of the distribution tank online when purchasing it was different to the one I received. Because of this difference, I had to change the water-cooling loop, although it actually turned out brilliantly in the end.

I had to change the water-cooling loop, although it actually turned out brilliantly in the end

Building the water-cooling loop itself was a huge challenge as well. Trying to bend the tubing without creating any bubbles or creases, and figuring out where to place the drainage valve, were among the many difficulties I faced during this part of the build.

CPC: What specs did you choose and why?
Stephen: I chose the specs that would enable me to build a high-end gaming PC, and I was trying to get the best components on the market. The only area where I held back was the graphics card – the GeForce RTX 2080 TI cards were too expensive, so I instead opted for an MSI RTX 2080 Sea Hawk EK, which already has an EK waterblock attached to it.



CPC: How long did it take you to complete this build, from start to finish?
Stephen: It took about five weeks on and off to complete the build, including the planning and research. I also took my time to ensure that every part of it was perfect.

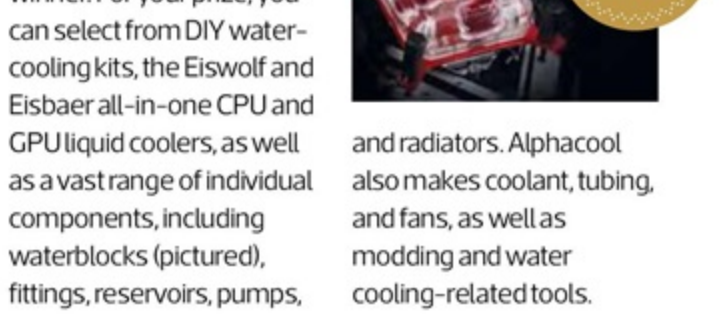
CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?
Stephen: If my budget could stretch far enough, I would have used a GeForce RTX 2080 Ti graphics card. Other than that, I was over the moon with both the appearance and the performance of the build – I'm very proud of it. Just out of curiosity, I would like to have seen how it would have turned out if I'd used the alternative colour scheme, with purple coolant, purple fan grilles, and green lighting. Maybe that's a project for the future! CPC

BE A WINNER

To enter your machine 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 **editor@custompcmag.org.uk**. Fame isn't the only prize; you'll also get your hands on some fabulous prizes.

Corsair K70 RGB MK.2 SE – Cherry MX Speed

CORSAIR



The Corsair K70 RGB MK.2 SE is a premium mechanical gaming keyboard that's built to last. It has a silver anodised brushed aluminium frame, as well as stunning white precision-moulded, double-shot keycaps. It's built to turn heads and withstand a lifetime of gaming. There's a detachable, soft-touch wrist rest too.

Meanwhile, its Cherry MX Speed mechanical keyswitches provide the reliability and accuracy you demand, with blisteringly fast 1.2mm actuation. There's also stunning per-key RGB dynamic backlighting, 100 per cent anti-ghosting with full-key rollover, 8MB of on-board memory, plus dedicated media controls.

Alphacool water-cooling gear

Water-cooling hardware manufacturer Alphacool is offering a choice of £150 worth of gear to every featured Readers' Drives winner. For your prize, you can select from DIY water-cooling kits, the Eiswolf and Eisbaer all-in-one CPU and GPU liquid coolers, as well as a vast range of individual components, including waterblocks (pictured), fittings, reservoirs, pumps, and radiators. Alphacool also makes coolant, tubing, and fans, as well as modding and water cooling-related tools.

JAMES GORBOLD / HARDWARE ACCELERATED

STRATEGIC THINKING

James Gorbold discusses smart ways for the PC industry to react to the coronavirus crisis, and PC enthusiasts can help with research too

You can tell a lot about individuals, groups of people and organisations by how they deal with the unexpected. From irrational panic buying to more measured responses, the whole spectrum of human behaviour has been on display over the past few months.

All companies have to deal with issues such as supply shortages, peaks and troughs in demand. This is particularly true of the computer industry, which requires successful companies to successfully navigate around complex supply chains and short product life cycles. As part of my role at Scan involves liaising with our partners to find the best products to use in our systems, it has been particularly interesting to see how different organisations deal with the impacts of COVID19.

It has been widely reported how many companies have been cancelling events such as trade shows, conferences and exhibitions, so I'm not going to dwell on that. What hasn't been reported, because it's all under non-disclosure agreements of course, is that several product launches have also been pushed back to later in the year.

Several product launches have been pushed back to later in the year

However, it's not all doom and gloom, and despite many manufacturers still struggling to get their manufacturing lines fully up to speed again, I've seen some great examples of organised and strategic responses to the current crisis.

For instance, motherboard market leader Asus worked with Scan and other leading system builders to identify key models from its product range, and has temporarily slimmed down its product range to those select models.

This strategy has had multiple positive effects, the most important one being that, rather than delivering dribs and drabs of every part of its product line-up, Asus is better positioned to deliver those key models consistently.

After all, while under normal conditions it's good to have umpteen different Z390, X299 and X570 motherboards, to name just three chipsets, only a handful of these boards are truly necessary to meet the requirements of most of our customers. In addition to helping smooth supply, this approach also helps to keep pricing relatively stable and sends a clear message to purchasing managers, customer service teams and, ultimately you – the end customer, about what is and what isn't available.

Scan itself has also put measures in place to minimise disruption for our customers, such as building more resilient teams and systems. For example, dividing departments into three teams, each of which work physically independently from each other, can help to slow the spread of the disease.

In addition, we're also putting an increased focus on forecasting to help our purchasing team order sufficient stock of the right products at the right price. That's a real challenge when the dollar rate is all over the place, thanks to the turbulence of the global financial markets.

Meanwhile, I've seen some truly inspirational responses, including one of our customers, a top UK university to which we recently delivered a GPU cluster. This was originally purchased to run deep learning algorithms for human genomics research, and has now been temporarily retasked to help look for a cure for coronavirus.

Readers of **Custom PC** can do their part too, contributing spare CPU and GPU clock cycles to the Folding@home project (see p13). This not-for-profit distributed computing project has already made some great contributions to medical research over the years, and recently announced that it's simulating the dynamics of coronavirus proteins to hunt for new therapeutic opportunities. Check out **foldingathome.org/start-folding** to download the client onto your PC, and you can join us and other **Custom PC** readers on team number 35947. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

PHILIPS

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