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Welcome

Custom PC Issue 224

/ FROM THE EDITOR

PC gaming is affordable again

Do you know when we last did a build feature for a sub-£1,000 PC with a discrete GPU? It was in Issue 204, 20 months ago. Zen 3 was still months away, as were Ampere and RDNA2. Our last budget gaming PC build had a quad-core Ryzen 3 CPU and a Radeon RX 5600 XT – we haven't done a sub-£1,000 gaming build for nearly two years.

But that changes this month, as the graphics card market has slowly started correcting. It's not party time yet. GPU prices are still a long way from normal, and the £400+ eBay prices for the GeForce RTX 3050 (see p16) show that there's still plenty of silliness around. However, there has been a definite drop.

Since last issue, the cheapest price for the GeForce RTX 3070 Ti dropped from £949 to £839, and the RTX 3080 Ti price has dropped from £1,600 to £1,430. It's baby steps, but there's a definite trend. The GeForce RTX 3060 Ti is also £50 cheaper, while the Radeon RX 6600 XT is going for £420, down from £540.

Now, I'm aware that Amazon's price for the MSI Radeon RX 6600 XT card in our feature might not hold for a month, but at the time of going to press, there are several other Radeon RX 6600 XT cards for under £450 on **overclockers.co.uk**. I'm confident you'll be able to build our cover feature PC for a reasonable price.

With both the GeForce RTX 3050 and 3060 demanding silly sums of money for the performance on offer, the Radeon RX 6600 XT is now the card of the moment for 1080p gaming. None of these cards is realistically capable of running ray tracing at settings you'd actually want to use anyway, and the Radeon's raw shader performance is streets ahead of the budget Ampere cards. If you want to play PC games at 1080p with decent frame rates, the Radeon is the card to get.

It's been an absolute pleasure to finally show you how to build a sub-£1,000 PC with the latest components, including an Alder Lake CPU and a 1TB PCI-E SSD, and not have to rope in a retailer to reserve the stock, or be restricted to integrated graphics. If you've been holding off from building an affordable gaming PC, you can now get going. CPC

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CUSTOM PC

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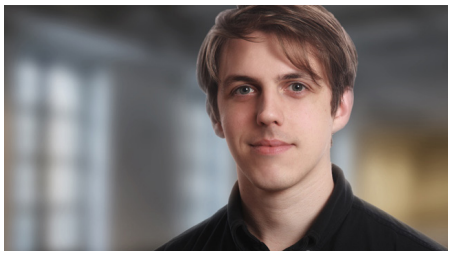

RICHARD SWINBURNE / VIEW FROM TAIWAN

NVIDIA DISARMED

The Nvidia Arm deal is off, but Richard Swinburne asks what this means for PCs

Like a slowly deflating balloon, Nvidia's Arm deal finally ran out of air after multiple governments took aim at it, and Nvidia was forced to let it go. It was a predictable outcome, given that the deal had opposition from practically everyone that makes chips using Arm's technology.

It's not the first time Nvidia has tried to get its own CPU IP. In the mid-2000s, it approached VIA with the intent to buy its x86 licence, but this was when VIA was facing legal hurdles with Intel. Based on agreements made with Cyrix in the 1990s, VIA argued it had the right to keep making x86 CPUs and use Intel's front side bus protocols in its designs, but Intel argued otherwise.

This was around the time that AMD and ATi were tying the knot, so Nvidia felt threatened. Nvidia was also making motherboard chipsets at this point, but that dried up after Intel released its first CPUs with integrated memory controllers. From there, Nvidia managed to get into servers through a partnership with IBM, bringing its NVLink tech to IBM's Power platforms in the past decade.

> Nvidia likes to have control over its tech

However, history shows us that Nvidia likes to have control over its tech, rather than collaborating. Jensen's ambition to have his own CPU IP kept fermenting over the years, and with Nvidia's stock recently in the stratosphere, it had enough cash to take a pop at Arm in 2019.

Now in 2022, where does this leave Nvidia, Arm and, for us, the PC ecosystem? I suspect Nvidia will now double-down on its strengths – graphics, AI and networking. Inevitably it will continue to build impressive GPUs, but this isn't a growth market, unlike AI. There's also increasing pressure for Microsoft to support apps that use AI in Windows PCs through dedicated AI accelerators.

We already have DLSS (AI-based image upscaling) in games, and RTX voice for audio, but there are also opportunities for improving the quality of webcams, streaming video, doing real-time translations and much more – features that are already found in smartphones.

If a program isn't specifically written for Nvidia GPUs, any AI tasks currently fall back to the CPU to process. We have plenty of CPU cores these days, so it's not really an issue, but this situation is of no value to Nvidia.

As Microsoft embraces Windows on Arm with some degree of enthusiasm, Nvidia – and others – could opt to make high-performance, custom Arm chips for laptops, or even desktop PCs, as long as the operating system evolves beyond 'Windows on Qualcomm Snapdragon'. Apple's M chips have proved that Arm CPUs can be extremely competitive at this level, and it would give the whole Intel/AMD duopoly a run for its money while also giving us much more choice for PC specs.

For Arm itself, the future is less clear. Softbank – the current owner – intends to put up an initial public offering (IPO) for it on the US Nasdaq, and it has just appointed a new CEO in the fallout from the Nvidia deal. Also, bear in mind that while Nvidia made a commitment to keep and grow UK-based jobs, Softbank has never echoed this sentiment during its ownership.

Combine this upcoming US IPO with a large contingent of Arm staff throughout the USA, plus the semiconductor industry growth in places such as Texas, and the future for the Cambridge HQ starts to look uncertain. I hope Softbank, and Arm's new CEO, Rene Haas, voices a commitment to keep Arm HQ in the UK, keeping the formula that made it successful. 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

ONE SIZE DOESN'T FIT ALL

Tracy King loves the idea of the Steam Deck, but is concerned about its size. Thankfully, Valve has an answer

I was a PC kid rather than a console kid, but I remember the early handheld wars well. I was 16, doing a BTEC in computer programming, poor as can be and intrigued by the Sega Game Gear. That was until a fellow student with rich parents brought one in, and I realised it was comically large for the tiny screen and kind of unwieldy. I went back home to my ancient creaking Amstrad 464 gratefully, while he burned through countless batteries and only two games.

But these days I spend a lot of time on handheld games, because schlepping a PC or gaming laptop around on the bus requires more strength, security and chutzpah than I possess. While Nintendo has allowed more variety on the Switch store, including some truly excellent indie games (I spent over a hundred hours on Terry Cavanagh's Dicey Dungeons, mainly because my sister bet me I couldn't get all the achievements by Christmas, which I absolutely did and she absolutely laughed at me), it's still a limited platform. Really, what I've always wanted is a handheld PC and it's very nice of technology to get to the point where I can be accommodated.

> The Steam Deck is here, and it's a major weapon

But. There's always a but and it's (hee hee) a big but. The Steam Deck is here, and it's a major weapon. I don't mean this 'in the increasingly competitive handheld gaming market' sense (its impact in that regard remains to be seen), I mean you could easily kill someone with this thing. It's massive. It's at least a third bigger and heavier than the Switch OLED – it's the Jack Reacher of handheld gaming devices – not the Tom Cruise one, the new one where he crushes a mobile phone in his bare hand.

It's a difficult trade-off. Making it smaller and lighter, even if that were possible, would increase costs way beyond a reasonable launch price. Affordability is as much part of accessibility as ergonomics. But it's also the case that a lot of people will struggle to use it for long periods. It's awkward, because what gamer wants to hold up their statistically smaller hand and say 'yo, this doesn't fit actually'? It's an invitation for ridicule and even abuse. But I'll take the risk, because it needs saying.

There's a history in tech design of using an average male hand span and grip strength to mean average *person*, which of course is greater than the average female. A few years ago, after experiencing hand pain while using a gaming mouse, I looked into the design and testing of various console and PC controllers and discovered that in most cases they simply don't test a variety of hand sizes. As it is, the Steam Deck is too heavy for me to hold comfortably for long, and my thumb span isn't sufficient for the button placement.

However, Valve isn't Nintendo or Sony. Valve knows full well that PC gamers want to customise and individualise, so it's released all the CAD files for the Steam Deck, so anyone with a 3D printer can make their own dock, case or any other mod they fancy.

Although this could be the excuse I've needed to buy a 3D printer, Valve has also invited contact from those looking to 3D print for the commercial market.

This is a really great compromise for the one-size-won't-fit-all problem, and those of us without Jack Reacher proportions are sure to find it handy. 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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MAR 31

Letters

Tell us what you think of the mag, ask us questions and suggest your own tips and tricks for other readers! Send all your correspondence to **custompc@raspberrypi.com**

FRACTAL UNLEASHES MINI TORRENTS

Fractal Design has miniaturised the design of its Torrent chassis with two new models. First up is the Torrent Compact; like Fractal's Define and Meshify Compact models, it reduces the space next to the motherboard tray to make an ATX case with a small footprint. It also comes with a pair of 180mm Fractal Prisma ARGB PWM fans to push air over the internals.

Meanwhile, the Torrent Nano shrinks down to a mini-ITX form factor, with just one of Fractal's big spinners in the front, but maintaining the distinctive grille pattern. Despite its smaller dimensions, the Nano can still house a three-slot graphics card up to 335mm long, with room for a CPU cooler up to 165mm tall.

CORSAIR K70 GETS PRO TREATMENT

Corsair's acclaimed K70 series of keyboards now has a new Pro-branded flagship, featuring a soft-touch wrist rest, double-shot PBT keycaps, reduced latency and a new dedicated 'tournament' switch. The latter immediately changes the backlight to a 'distraction-free' static colour, so your eyes don't get drawn to any breathing, pulsing or rainbow chasing effects, and disables accidentally activated macros.

The keyboard also comes with a detachable USB Type-C cable and a choice of five Cherry MX mechanical switches, including the Red, Brown, Blue and Speed varieties. Meanwhile, Corsair says the double-shot PBT keycaps are 'precision-moulded to resist wear and fading so your keys still look and feel fresh even for years to come, while allowing stunning per-key RGB lighting to shine brilliantly through'.

The new soft-touch wrist rest also marks a departure from the rigid rests applied with previous K70 models. It attaches magnetically and has a patterned surface to help grip. The aspects of the K70 that made it so popular also remain intact, including the dedicated media playback controls, volume roller and aluminium construction. We hope to get one in for a full review in our next issue.

ASROCK BRINGS ZEN 3 SUPPORT TO X370

Some of ASRock's 1st-gen Ryzen boards have been given new beta BIOS updates to support AMD's Zen 3 CPUs, meaning you could use a five-year-old motherboard to accommodate a brand-new Ryzen 5000-series chip.

Given the limited space on the motherboards' EEPROM flash memory, updating to these latest BIOS versions will result in losing support for some older CPUs. The BIOS notes state that there's no support for Bristol Ridge chips (AMD's cheaper A-series and Athlon X4 CPUs) with the new updates.

The X370 boards getting the Zen 3 treatment include the X370 Killer SLI, Fatal1ty X370 Gaming K4 and Fatal1ty X370 Professional Gaming. If you have an ASRock X370 motherboard, you can find the BIOS updates available for your board at **asrock.com**, and scroll down to the bottom to find the beta versions.

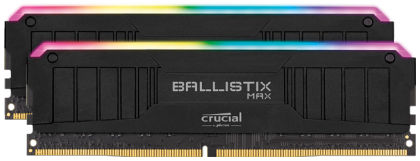
AMD's Zen 3 chips were originally only going to run on 500-series chipsets, but AMD eventually gave into pressure from the community to make them run on older 400-series motherboards with a BIOS update, again removing support for older CPUs. ASRock's latest move means that an AM4 motherboard bought in 2017 could have supported four generations of Ryzen CPUs.

BYE BYE BALLISTIX

The enthusiast memory market is about to become less diverse, as Crucial's high-end Ballistix brand has been binned by Crucial's parent company, Micron. The move applies to all products under the Ballistix brand, including the Ballistix Max and Max RGB lines.

The move marks a withdrawal from the enthusiast memory market, although Micron says Crucial will 'continue to support the performance compute and gaming communities with its award-winning SSD products,' which include NVMe PCI-E 4 SSDs. It now describes Ballistix as 'end of life'.

Teresa Kelley, vice president and general manager, Micron Commercial Products Group, said, 'We remain focused on growing our NVMe and Portable SSD product categories, which both offer storage solutions for PC and console gamers.' Ballistix RAM first appeared in 2004.



Rumour control

WE PRESENT SOME OF THE LATEST UNCONFIRMED TECH GOSSIP. TAKE THESE STORIES WITH THE APPROPRIATE PINCH OF SALT

RADEON REFRESH

There are many whispers doing the rounds about a new line of RDNA2 GPUs coming out in the first half of this year. According to the rumours, AMD is planning to beef up the specs of its Radeon RX 6600 XT, 6700 XT and 6900 XT products, adding a '50' to each of the numbers.

According to the rumours, AMD will be keeping the GPUs on the 7nm node, but will be partnering them with 2.25GHz (18GHz effective) GDDR6 memory, as opposed to the 2GHz (16GHz effective) memory on the current cards. The clock speeds of the GPUs are also reportedly getting a big boost.

Regular Twitter leaker **@greymon55** claims that the Radeon RX 6950 XT's boost clock is 'over 2.5GHz' – even at the bare minimum, that's at least 250MHz faster than the Radeon RX 6900 XT's max boost clock, and 485MHz faster than its game clock.

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Reviews

INTEL LGA1700 CPU

INTEL CORE i5-12400F / £170 inc VAT

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After the barnstorming performance of Intel's K-series Alder Lake CPUs, we were pretty excited to see whether the Core i5-12400F could still deliver decent gaming performance, especially with its wallet-friendly price of just £170 inc VAT.

Let's start with the bad news, which is that Intel's 10nm hybrid core architecture sees huge variations in core counts and types across the 12th-gen range, and the Core i5-12400F differs significantly to the Core i5-12600K. For starters, it lacks the four E-Cores of the Core i5-12600K that make it so potent in multi-threaded software. Instead, it only matches the six performance cores of its K-series sibling, meaning it has four fewer cores and threads as a result. This will likely mean a large reduction in multi-threaded performance.

SPEC

Base frequency
2.5GHz

Max boost frequency
4.4GHz

Core
Alder Lake

Manufacturing process
10nm

Number of cores
6 (12 threads)

Hyper-Threading
Yes

Cache
18MB L3, 7.5MB L2

Memory controller
Dual-channel DDR4 and DDR5

Packaging
LGA1700

Thermal design power (TDP)
65W

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

The P-Core boost frequencies are similar to those of previous generations, though, with the cheaper CPU peaking at 4.4GHz while the Core i5-12600K hits 4.9GHz. This is reflected in the power specifications too, with a base power of 65W compared to 125W for the K-series CPU and 117W vs 150W maximum turbo power for the Core i5-12400F and Core i5-12600K respectively. We saw both CPUs hit their single-core boost frequencies regularly, while under multi-threaded workloads, the Core i5-12600K fell back to 4.5GHz on its P-Cores, with the Core i5-12400F dropping further to just 4GHz.

While pairing the Core i5 12400F with an expensive motherboard might seem counter-intuitive, motherboard manufacturers are also in the process of rolling out BIOS versions for premium boards that allow the CPU to be overclocked using the base clock.

The F-version we're testing here is cheaper than the standard Core i5-12400, since it lacks integrated graphics, but the non-F version gets you the same Intel UHD 770 graphics as the Core i5-12600K too. As we've seen in this month's Labs test, B660 motherboards are available for under £150 too, meaning that £300 can now bag you a 6-core 12th-gen Intel CPU and motherboard with PCI-E 4 support.

AMD also has little to worry Intel in this market segment Core i5-12400F. The Ryzen 5 5600X and Ryzen 7 5700G are far more expensive, and any of its cheaper CPUs will be using the older Zen 2 architecture, which is completely trounced by Intel's 12th-gen CPUs.

Performance

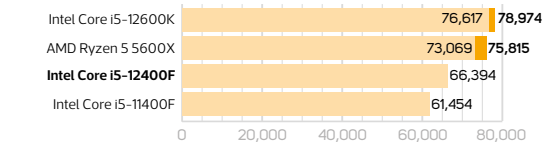
The Core i5-12400F's image editing test result of 66,394 was over 10,000 points lower than that of the Core i5-12600K, showing the difference those higher frequencies and core counts make, albeit costing you an extra £100 in the process. The Ryzen 5 5600X was also quicker here, but again, it's significantly more expensive.

Our heavily multi-threaded Handbrake video encoding test also revealed a gulf between the Core i5-12400F and the Core i5-12600K, but far less of a gap between the cheaper Intel CPU and the Ryzen 5, with barely 6 per cent between them.

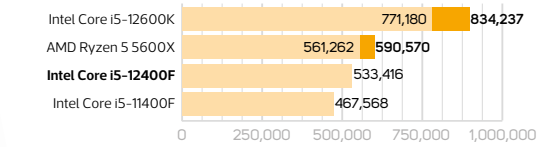
The system score of 220,553 was again snapping at the heels of the Ryzen 5 5600X, but a long way off matching the Core i5-12600K. Interestingly, the Core i5-12400F actually beat the AMD CPU in both Cinebench tests in a major blow, offering a noticeably higher single-threaded score. Once again, though, the Core i5-12600K was a lot faster in both tests.

BENCHMARK RESULTS

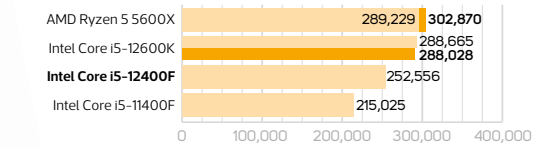
GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTI-TASKING



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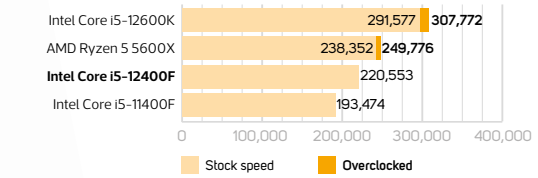
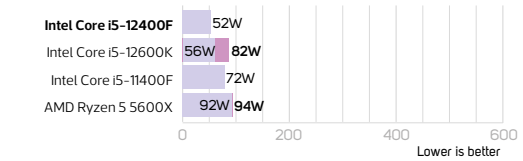


TOTAL SYSTEM POWER CONSUMPTION

Idle



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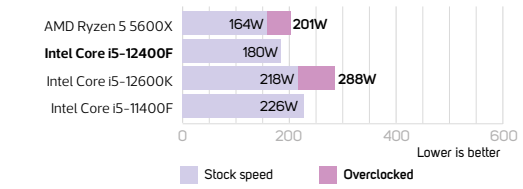
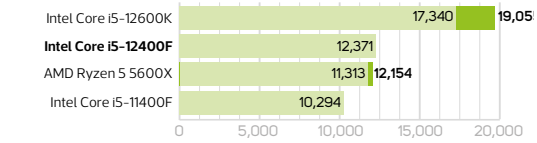
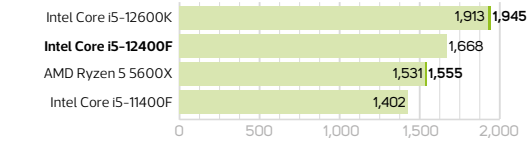


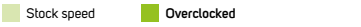
CINEBENCH R23

Multi-threaded



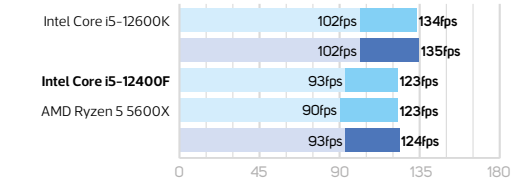
Single-threaded





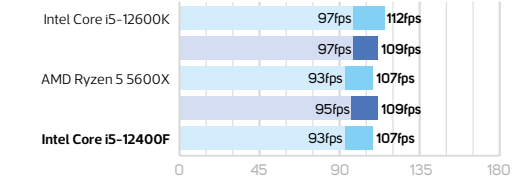
FAR CRY 6

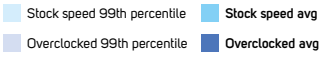
1,920 x 1,080, Ultra settings



DIRT 5

1,920 x 1,080, Ultra settings





ALDER PRESIDENT'S MEN

- \+ Decent gaming performance
- \+ Loads quicker than Core i5-11400F
- \+ Awesome price

ALDER LONELY PEOPLE

- – No E-Cores
- – Comparatively low boost clock
- – Lags behind Core i5-12600K

It was tit for tat with the AMD CPU in games, with the Core i5-12400F largely matching it in Dirt 5 and Far Cry 6, while the Core i5-12600K offered higher frame rates in both titles. This was at 1080p with a reasonably powerful RTX 3070 GPU though – there will be less of a difference at higher resolutions, where there's less of a load on the CPU. Importantly, the Core i5-12400F is also leagues ahead of its predecessor, the Core i5-11400F, across the board.

Conclusion

The gulf between Intel's cheapest and most expensive Core i5 CPUs is the biggest we've ever seen, thanks to differing core and thread counts. However, the price gap is significant too, and mostly in line with the performance differences, especially in multi-threaded workloads where the Core i5-12600K has proven to be light years ahead of its predecessor. The fact that the Core i5-12400F lags well behind in most tests is to be expected then, given the price difference.

Far more importantly, it trades blows with the pricier Ryzen 5 5600X, and with LGA1700 motherboards now available for under £150, the argument that AMD motherboards are cheaper is growing thin, especially given the very low cost of the Core i5-12400F. It's a mightily powerful CPU for the money, matching or bettering the more expensive Ryzen 5 5600X in some tests, despite only costing £170.

If you're building a budget-conscious PC and need a great all-rounder to sit in your CPU socket, the Core i5-12400F is fantastic and, unlike AMD's Socket AM4, Intel's LGA1700 socket has plenty of life in it yet too. For an example build guide that uses it, check out our feature on p76.

ANTONY LEATHER

VERDICT

A long way from the Core i5-12600K, but the price is amazing. A great all-round CPU for budget buyers.

PERFORMANCE **41/50**

FEATURES **13/15**

VALUE **34/35**

OVERALL SCORE **88%**

NVIDIA GEFORCE RTX 3050 / ~£400 inc VAT

SUPPLIER ebay.co.uk

If you like gallows humour and fancy a laugh with a dash of despair, take yourself over to Nvidia's online GeForce shop and look at the launch prices of the RTX 3000 series. Here you'll find the RTX 3060 Ti listed for just £369 inc VAT, and even the £1,399 price for the RTX 3090 seems reasonable after two years of chaos. On the US store, you'll even see RTX 3050 cards from board partners listed at $249 (around £220 inc VAT).

Of course, that didn't last long. As usual, the first batch of RTX 3050 cards all sold out on launch day, and then they started to appear for around £400 on eBay, where that still appears to be the going rate for them. In the meantime, AMD has released the Radeon RX 6500 XT, a card that no one will send us for review, presumably because it's had a panning in the online press. It has just 4GB of memory attached to a 64-bit interface, a 4x PCI-E 4 interface and 1,024 stream processors.

By all reports, it stinks, which in a normal world would be good for the RTX 3050. In the current chaos, though, the Radeon RX 6500 XT is still going for around £200, while the RTX 3050's price has become overinflated. As a result, the RTX 3050 is now really up against the Radeon RX 6600 and 6600 XT, rather than the 6500 XT, and this makes life much harder for Nvidia's new 'budget' GPU.

The price inflation is a shame, because the RTX 3050's spec means it's almost certainly significantly quicker than the Radeon RX 6500 XT. For starters, it has twice as much memory, with 8GB of GDDR6 memory running at 1750MHz (14GHz effective). It also has a much wider 128-bit memory interface, while the Radeon only has a 64-bit interface, giving the GeForce a total memory bandwidth of 224GB/sec. AMD has previously got around this by allocating loads of L3 Infinity Cache to its pricier RDNA2 GPUs, but the Radeon RX 6500 XT only has 16MB.

SPEC

Graphics processor
Nvidia GeForce RTX 3050, 1552MHz base clock, 1777MHz boost clock

Pipeline
2,560 stream processors, 32 ROPS

RT cores
20 (2nd-gen)

Tensor cores
80 (3rd-gen)

Memory
8GB GDDR6, 1750MHz (14GHz effective)

Memory interface
128-bit

Card interface
8x PCI-E 4

Memory bandwidth
224GB/sec

Power connections
1x 8-pin

In terms of the core spec, the RTX 3050 is based on the same GA106 GPU as Nvidia's GeForce RTX 3060, except it has just 20 of the streaming multiprocessors enabled. This gives it a total of 2,560 CUDA cores, along with 20 RT cores and 80 Tensor cores. It also has the same 1770MHz GPU boost clock as the RTX 3060, although the RTX 3050 does have a higher base clock.

Like AMD's lower-end Radeon cards, the GeForce RTX 3050 also doesn't have a full 16x PCI-E 4 interface. Its 8x PCI-E 4 interface will offer more than enough bandwidth for a budget card on PCI-E 4 systems, but older PCI-E 3 systems will take a small performance hit as the older interface will halve the bandwidth again. There's a lot of PCI-E 3 systems still doing the rounds, from Intel Comet Lake and Coffee Lake machines, to even AMD Zen 3 systems based on B450 and X470 motherboards. On the plus side, at least it doesn't have the 4x interface of the Radeon RX 6500 XT.

PERFORMANCE

After two years of awfulness in the PC GPU market, we really wanted to like the RTX 3050. We haven't had a decent budget GPU for a long time, and the RTX 3050 looked like it had potential. Sadly, however, it can't really cut it, even at 1,920 x 1,080.

For single-player games, we have a general frame rate target of a 60fps average with a 45fps 99th percentile (or within 1-2fps of that), but the RTX 3050 couldn't get close to this in Assassin's Creed Valhalla, Cyberpunk 2077 or Metro Exodus at our usual test settings. We had to drop down to the Medium preset in Cyberpunk 2077 to get a decent frame

rate in the end. That would be fine if this card only cost £150, but it's catastrophic for a card that currently goes for £400.

Comparatively, the Radeon RX 6600 XT we used in our cover feature this month, which currently goes for £420 inc VAT, produced decent playable frame rates in all three of these games. At this point, previous Nvidia Ampere GPU reviews would point out that Nvidia has the upper hand in ray tracing, but the situation isn't clear-cut when you're comparing the RTX 3050 with the Radeon RX 6600 XT.

The Radeon is faster in Metro Exodus with High ray tracing, for example, although the frame rates from both cards aren't amazing in this test. The RTX 3050 has the added bonus of getting a helping hand from DLSS, Nvidia's AI-based resolution scaling tech, which uses the GPU's Tensor cores. However, enabling DLSS made no difference to the frame rate on the RTX 3050 in this game.

Where DLSS did help the RTX 3050 was in our Cyberpunk 2077 test with Medium ray tracing, where it averaged 46fps with a 39fps 99th percentile result at 1,920 x 1,080. That's playable, even if it isn't smooth, but this game looks horrible with DLSS enabled at 1,920 x 1,080, with significant blurring. With a budget, GPU you're honestly better off running this game without ray tracing or DLSS.

On the plus side, the RTX 3050 can handle undemanding games at high frame rates, averaging 196fps in Doom Eternal at 1,920 x 1,080. The 8GB of memory means it can run this game at top settings too, unlike the 6GB RTX 2060. Again, though, the Radeons are quicker, with the 6600 XT running 64fps quicker.

If you have a supporting motherboard and CPU, you can gain a small performance boost from enabling Resizable

BAR, which is supported by the RTX 3050. This raised the Assassin's Creed Valhalla average from 52fps to 55fps, but this is still a fair way behind the Radeon 6600-series cards.

Finally, we tested the RTX 3050 with our motherboard set to PCI-E 3 rather than PCI-E 4, and it resulted in a small drop in performance of 1-2fps in Metro Exodus. This isn't a massive difference though – you'll still be able to get plenty out of this card on a PCI-E 3 system.

CONCLUSION

By all reports, the GeForce RTX 3050 is much better than the Radeon RX 6500 XT, but that's hardly relevant when the RTX 3050 is going for around £400. To make matters worse, cards with this level of performance (where you have to drop the settings even at 1,920 x 1,080) used to cost around £150. Even at £220, it was overpriced, but at £400, it simply can't compete with the AMD Radeon RX 6600 series.

Not even having DLSS at its disposal gives it an advantage here, as DLSS looks horrible at 1,920 x,1080, and the frame rates still aren't great. The RTX 3050 might technically be able to handle ray tracing, but realistically you wouldn't want to use it. The same also goes for the AMD GPUs, of course, and the RTX 3050 might have more ray-tracing power in Cyberpunk 2077, but the point is largely moot when none of them can produce decent frame rates with ray tracing anyway.

We could have forgiven the RTX 3050's disappointing performance if it had a genuinely affordable price, but it simply can't justify the current asking price. If you want to spend around £400 on a GPU, buy the Radeon RX 6600 XT instead.

BEN HARDWIDGE

VERDICT

£400 for this? Give us a break.

TRACING RAYS

+ Better spec than Radeon RX 6500 XT
+ Can play some games at 1080p
+ 8GB of memory

RACING TRAYS

– Disappointing performance
– Currently massively overpriced
– DLSS looks horrible at 1080p
– 8x PCI-E interface

PERFORMANCE **25/50**

FEATURES **17/20**

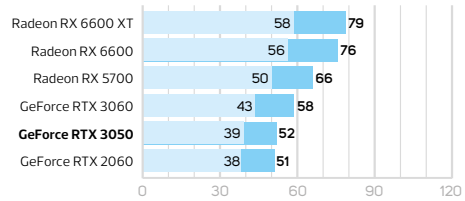
VALUE **12/30**

OVERALL SCORE **54%**

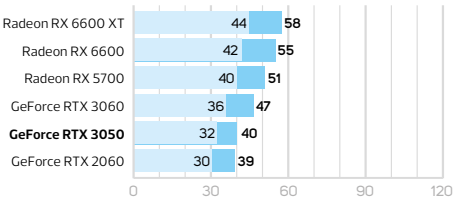
GEFORCE RTX 3050 RESULTS

ASSASSIN'S CREED VALHALLA

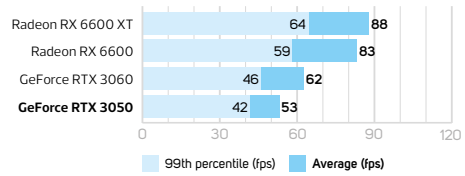
1,920 x 1,080
Ultra high settings, High AA



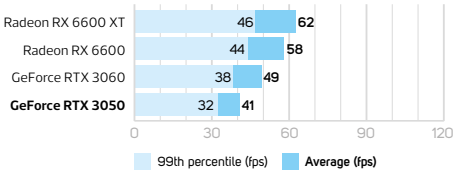
2,560 x 1,440
Ultra high settings, High AA



1,920 x 1,080 - RESIZABLE BAR
Ultra high settings, High AA

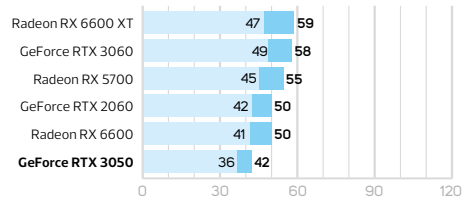


2,560 x 1,440 - RESIZABLE BAR
Ultra high settings, High AA

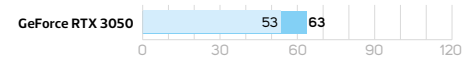


CYBERPUNK 2077

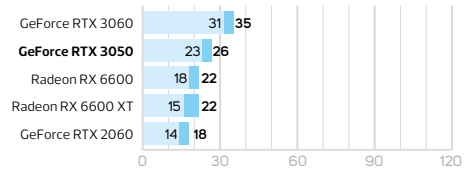
1,920 x 1,080
Ultra preset, no ray tracing



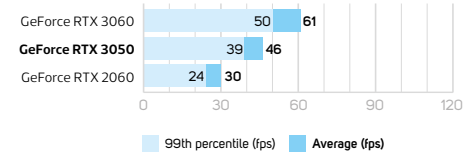
Medium preset, no ray tracing



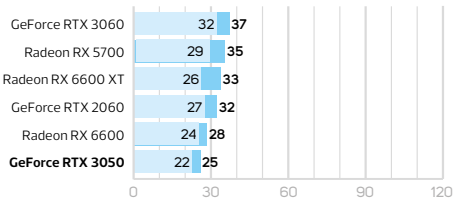
1,920 x 1,080 - RAY TRACING
Medium ray tracing preset, DLSS disabled



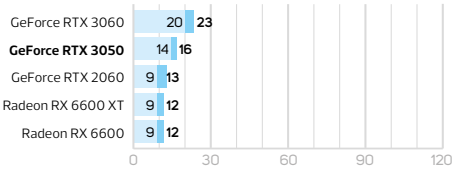
1,920 x 1,080 - RAY TRACING + DLSS
Medium ray tracing preset, DLSS Balanced



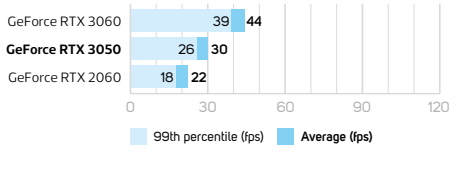
2,560 x 1,440
Ultra preset, no ray tracing



2,560 x 1,440 - RAY TRACING
Medium ray tracing preset, DLSS disabled



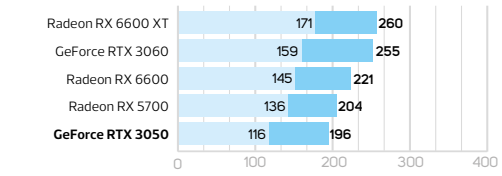
2,560 x 1,440 - RAY TRACING + DLSS
Medium ray tracing preset, DLSS Balanced



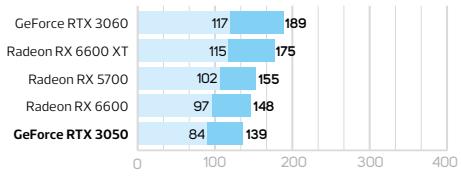
GEFORCE RTX 3050 RESULTS

DOOM ETERNAL

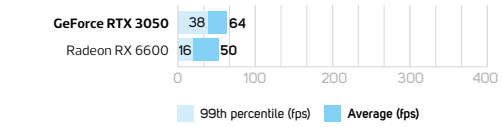
1,920 x 1,080
Ultra Nightmare settings



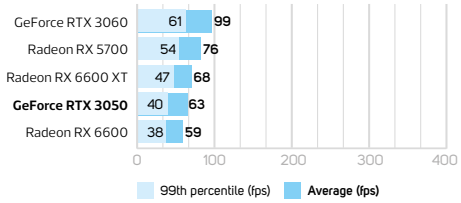
2,560 x 1,440
Ultra Nightmare settings



1,920 x 1,080 - RAY TRACING
Ultra Nightmare settings

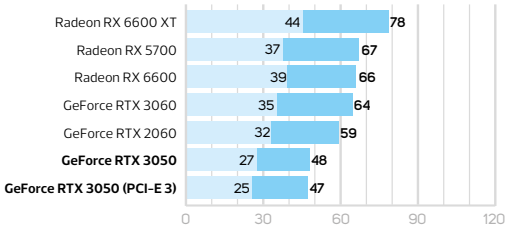


3,840 x 2,160
Ultra Nightmare settings

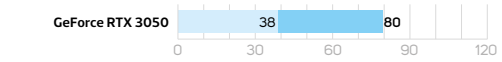


METRO EXODUS

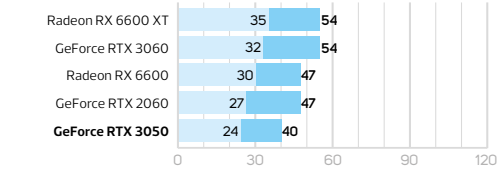
1,920 x 1,080
Ultra settings, HairWorks off, PhysX off



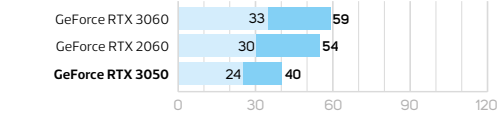
Medium settings, HairWorks off, PhysX off



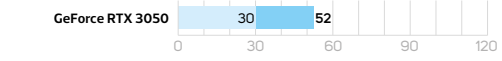
1,920 x 1,080 - RAY TRACING
Ultra settings, HairWorks off, PhysX off, High ray tracing



1,920 x 1,080 - RAY TRACING + DLSS
Ultra settings, HairWorks off, PhysX off, High ray tracing, DLSS

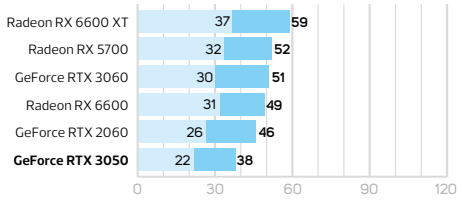


Medium settings, HairWorks off, PhysX off, High ray tracing, DLSS

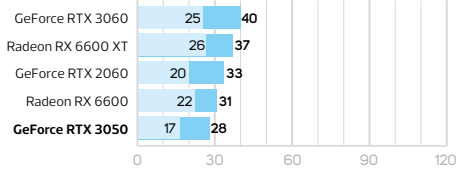


99th percentile (fps) Average (fps)

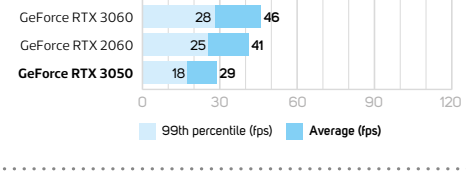
2,560 x 1,440
Ultra settings, HairWorks off, PhysX off



2,560 x 1,440 - RAY TRACING
Ultra settings, HairWorks off, PhysX off, High ray tracing

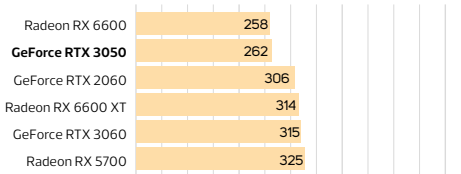


2,560 x 1,440 - RAY TRACING + DLSS
Ultra settings, HairWorks off, PhysX off, High ray tracing, DLSS



99th percentile (fps) Average (fps)

PEAK TOTAL SYSTEM POWER CONSUMPTION (WATTS)
Metro Exodus, 2,560 x 1,440, Ultra settings



Lower is better

ATX CASE

Cooler Master HAF 500 / £140 inc VAT

SUPPLIER scan.co.uk

Cooler Master has reached into its archive of retired trademarks and brought the HAF (high airflow) series back to life, with the company making a few tweaks to its H500 design to improve the airflow of the HAF 500 here. It retains the bevelled front edges, an ever present feature going back to at least the original HAF cases, but this time with a more traditional flat roof.

The front I/O panel sits atop the front on a sloped platform, which is well equipped, with two USB 3 ports, a USB Type-C port, a combined audio jack and a power button in the shape of the Cooler Master logo. Meanwhile, what would usually be the reset button is set up to control the RGB lighting on the fans through the included controller. There's also a small HAF logo below the front I/O panel, but it's easily missed.

You can also completely remove the new featureless roof section, which gives you great access to the main chamber for installing the bulk of the hardware in your build. The power supply shroud can be removed as well, although this part is entirely made from plastic, as are the front panel and case feet, and it doesn't feel like quality material.

The whole case, in fact, for all its feature-crammed spec list, does feel like a cheaper case. It's sturdy enough, but it's a bit light and the finishes aren't pleasing to the touch. Even the power button makes the whole case ring with a harsh plink-plonk.

Meanwhile, the PSU shroud only covers approximately half of the case floor, as there's a hard drive cage in this area. While this isn't unusual in itself, Cooler Master has added a 120mm fan to the top of the cage that can be pivoted to point at the GPU. Unlike the front 200mm and rear 120mm RGB fans, here you'll find a plain black, non-LED Sickleflow 120 fan. Sickleflow is another old Cooler Master product line and, ironically, Sickleflow fans originally launched as LED fans. It seems out of place for this one not to have RGB lighting.

There's enough room for a 60mm-thick 360mm radiator in the front without removing the hard drive cage, and the roof can also take up to a 360mm radiator. You can even fit a 120mm radiator to the GPU fan mount as long as you can sneak it under your graphics card. Interestingly, the roof also has mounting holes for 200mm fans. Sadly, though, any ideas about dual 400mm radiators were dashed upon discovering that the thinnest 200mm radiator available is a 45mm-thick Alphacool model, which would clash with the motherboard.

The hard drive cage itself will take two 2.5/3.5in drives. The trays are tool-less and have vibration dampening for the 3.5in drives, and there are two further 2.5in drive mounts at the back of the motherboard, also with substantial dampening washers.

Cable management should be easy in this case, as there's at least 25mm of depth in the rear and plenty of cable-tie points. However, in practice this isn't the case. Because of the

SPEC

Dimensions (mm)
224 x 516 x 510 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black, white

Weight
9.5kg

Front panel
Power, reset, 2 x USB 3, 1 x USB 3.2 Gen 2 Type-C, 1 x stereo/mic jack

Drive bays
2 x 2.5in, 2 x 2.5/3.5in

Form factor(s)
Mini ITX, micro-ATX, ATX, SSI CEB, E-ATX (305 x 358mm)

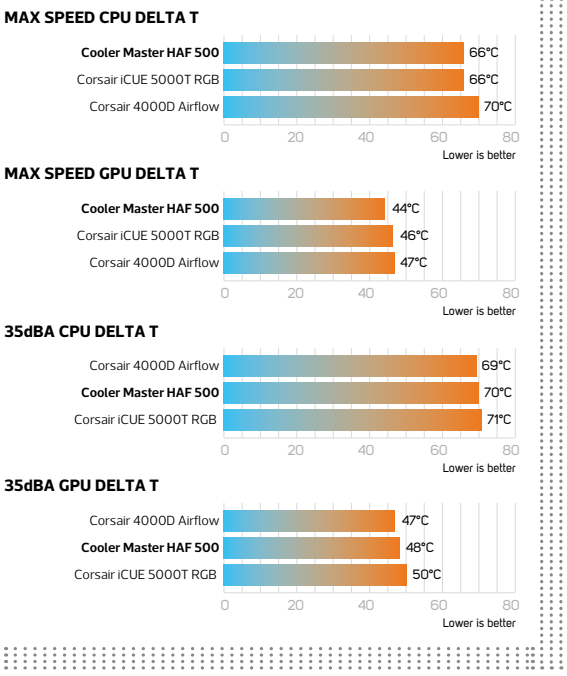
Cooling
3 x 120mm/2 x 140mm/2 x 200mm front fan mounts (2 x 200mm ARGB fans included), 1 x 120mm rear fan mount (120mm ARGB fan included), 3 x 120mm/2 x 140mm roof fan mounts (fans not included), 1 x 120mm GPU fan mount (120mm Sickleflow fan included)

CPU cooler clearance
167mm

Maximum graphics card length
410mm

Maximum PSU length
180mm

TEMPERATURE RESULTS



way the PSU shroud is mounted to the motherboard tray, there's just one small, single pass-through below the motherboard in the centre, which makes it awkward to route and tie down the front panel cables (as well as chunky graphics card cables).

The front I/O panel and fan cables also can't be completely hidden or tucked out of sight, with a large chasm for the cables to cross to reach your motherboard – there's a cable bar to hide some of them, but you can still see a good few centimetres of them in the corner.

The top half of the cable bar (where it won't foul graphics cards) increases the clearance from 18mm to 32mm, allowing for thick 24-pin cables. It's just a shame that it only covers the additional pass-throughs for EATX cables, leaving the ATX pass-throughs and grommets in plain sight. Having just one set of pass-throughs and grommets behind the bar would have looked much cleaner.

There's also a lack of routing holes above the motherboard. You have one in the rear corner for the exhaust fan and 12V EPS cables, then a second smaller hole on the near side corner of the motherboard. There really ought to be one in the middle, as this is almost always where CPU fan headers are located.

Performance

Not surprisingly for a case with only one layer of mesh per panel, the HAF 500 performs exceptionally well. With the fans running at maximum speed, the CPU delta T was just 66°C and the GPU delta T was just 44°C. It's a little noisy at full speed (41.2dBA), but not obnoxiously so. At 35dBA, the case still performs really well, and is only beaten by the 4000D Airflow in our recent case tests. The dedicated GPU fan is actually functional and not just a gimmick too, with the GPU temperature rising by 7°C when we removed it.

The likely reason for that dedicated GPU fan, though, is the 200mm intakes. While they can shift a large volume of air, their low static pressure denies them good penetration into the case, although they do look impressive behind the mesh front panel. As an experiment, we switched them out for three be quiet! 1,700rpm Light Wings fans and removed the GPU fan, and we got the same GPU temperature result as the stock setup.

Conclusion

The HAF 500 promised a lot on paper, and while it doesn't always deliver the quality you'd expect from a £140 case, there's a lot of additional features and performance for the most demanding of systems, whether you're cooling with air or water. Cable management was a letdown when it comes to pass-throughs, but at least there's a cable bar. Meanwhile, the GPU fan makes up for the lack of oomph from the front intake fans without adding too much noise. This is a good case, but it could have been great if it weren't let down by a few iffy design choices and a tightly squeezed bill of materials.

ANDY MAKIN

VERDICT

A decent feature set and solid airflow performance, but there's a bit too much plastic on show for this price, and the cable management could be better.

HAF DECENT

+ Huge performance on tap
+ Both air and water-cooling friendly
+ Easy access to components

HAF MEASURE

− Cable management needs work
− Cheap feel of materials

COOLING **29/30**

FEATURES **17/20**

DESIGN **21/30**

VALUE **14/20**

OVERALL SCORE **81%**

ATX CASE

CORSAIR iCUE 5000T RGB / £350 inc VAT

SUPPLIER scan.co.uk

The release of the 4000D Airflow nearly 18 months ago marked a triumphant comeback to the performance case market for Corsair, and subsequent releases of the 5000D and 7000D have cemented its standing in the raft of airflow cases now available. The attention to detail and finish of these cases made them easy on the eye too, so when Corsair told us about a new variant of the 5000 series with a focus on looks and RGB lighting, we were a little apprehensive. This new Corsair 5000T isn't here to be just desk candy, though, it's here to kick ass, chew bubble gum and, well, you know the rest.

While the 5000T is in essence a reskin of the 5000D, every aspect outside the core chassis has been completely redesigned. If you took off the Corsair badges, you wouldn't know the two cases were related from a cursory look. While the original was very square with tight corner radii, the 5000T has softer curves and heavily bevelled edges. Even the case feet are brand-new, with two pieces of solid steel running the full length of the case – they angle out from the very bottom, but end level with the side panels, so the footprint isn't made any bigger.

The roof and floor sections are pressed steel sheets, mounted to the rest of the chassis with plastic supports and push-pins. This approach gives an added feeling of quality, without making the case even heavier. These two panels mirror each other, angling forwards, so they overhang the side panels to reveal the side of the thick plastic front, while giving you somewhere to grab the hinged side panels to open them without an ugly handle.

All the edges have a 50mm wide bevelled face, with a repeating pattern of three trapezoidal cut-outs. It's through these gaps that you see this case's party piece – six LED strips that run along the length of the top, front and bottom of each side. The strips are bright with deep colours, and an opaque rubber cover that disperses the light evenly – they even produce white well. There's a total of 208 LEDs across the six strips, which are controlled through Corsair's iCUE software by way of a supplied Commander XT controller.

Along with all the preset routines, these LEDs are individually addressable, so you can get them looking just the way you want. Together with the three supplied LL120 RGB fans, the case's exterior is set to match any gear you put inside it, and it looks great from every angle.

However, the 5000T doesn't stray too far from the winning formula of the Airflow models, with both the front, top and side fan mounts all having mesh panels. The front panel has a relatively fine triangular metal mesh in front, with a finer cloth 10mm behind it, and it can also be removed from the front for easy maintenance.

The cloth mesh is in its own frame, so it can be removed separately, but the cloth hasn't been stuck to its frame tightly,

SPEC

Dimensions (mm)
251 x 530 x 560 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black, white and grey

Weight
17kg

Front panel
Power, reset, 4 x USB 3, 1 x USB 3.1 Type-C, 1 x stereo/mic jack

Drive bays
4 x 2.5in, 2 x 3.5in

Form factor(s)
Mini-ITX, micro-ATX, ATX, E-ATX (305 x 277mm)

Cooling
3 x 120mm/2 x 140mm front fan mounts (3 x 120mm LL120 included), 3 x 120mm side fan mounts (fans not included), 1 x 120mm rear fan mount (fan not included), 3 x 120mm/2 x 140mm roof fan mounts (fans not included), 3 x 120mm side fan mounts (fans not included)

CPU cooler clearance
170mm

Maximum graphics card length
400mm

Maximum PSU length
250mm

MRT

- + Superb looks
- + Good stock cooling and water-cooling potential
- + Great fit and finish

T-BAG

- – Cable cover restricts access
- – Fans loud at full speed
- – Expensive

and can get sucked against the fans if they're placed on the outside of the removable front fan rails.

Meanwhile, the roof's outer mesh has the same fine triangular pattern as the front, flush fit with the rest of the roof, and with another removable filter underneath. The ventilation in the right side panel comes from larger triangular cut-outs with fine triangular mesh acting as a filter.

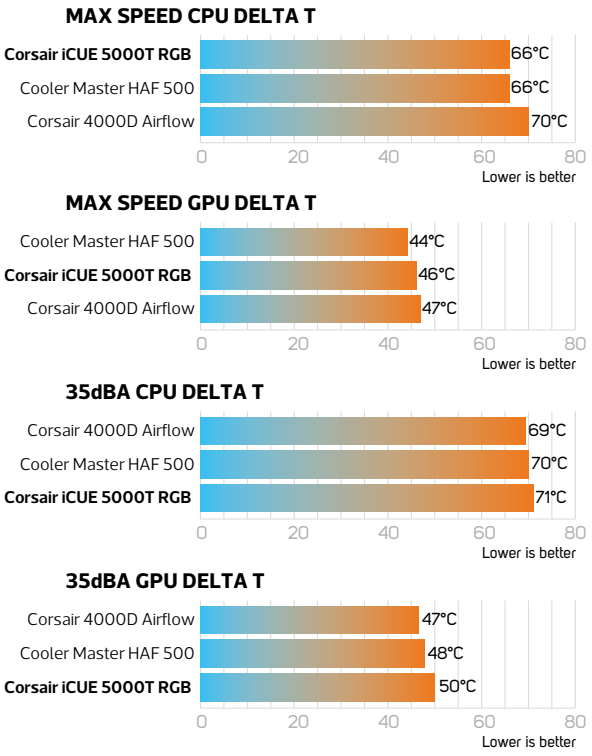
Internally, though, it's much the same story as Corsair's 5000D/X (see Issue 212, p44), with ample room in which to build, capacity for six storage drives, *just* enough room for three 360mm rads simultaneously, and cable channels with Velcro straps for routing most of your cables. It also has a stacked front I/O panel, with four USB 3 ports, a USB 3.1 Type-C port, a combined audio jack, plus power and reset switches. These are fixed to the chassis, leaving all the panels free from cable entanglement.

Building in the case is a pleasure for the most part, although the cable cover next to the motherboard tray struggles to make room for a chunky 24-pin ATX cable with individually sleeved cables. It would be better to raise the cover a bit higher, past the level of the expansion slots, in order to allow thicker cables a more direct route, so they don't have to double back on themselves.

PERFORMANCE

The three LL120 fans run at 2,200rpm at full speed, and are loud, so it's hardly surprising that this case's airflow system blasts its way to the top of the charts at full speed. When you tune it down to 35dBA (1,087rpm), though, it falls down, with a 71°C delta T on the CPU and 50°C on the GPU.

TEMPERATURE RESULTS



Adding additional exhaust fans did little to improve this situation, nor did removing the secondary filters, showing that the positive pressure setup works well with the case's design. Also, when the fans are turned right down to their minimum speed, they're essentially inaudible, so under light loads, browsing or streaming videos, you won't notice the noise.

CONCLUSION

Whether it's lying dormant, or lit up in your very own Aurora Borealis, the iCUE 5000T looks stunning, and it's really well made too – it's crying out to be crammed with custom water-cooling gear. The addition of an LED strip or two in the interior of the case wouldn't have gone amiss, though, especially to illuminate your PSU through the window.

As it is, the exterior LEDs can dominate and can't be dimmed independently of the fans. Stock performance is decent, though, and the case has been optimally set up out the box. At £350, the 5000T is very far from cheap, but buying the LED strips and controller would set you back £190 anyway. This case might make your wallet cry, but it's absolutely worth the money if you can afford it.

ANDY MAKIN

VERDICT

A premium case with premium features at a premium price, but it definitely delivers on looks, build quality and performance.

COOLING 26/30

FEATURES 20/20

DESIGN 27/30

VALUE 16/20

OVERALL SCORE 89%

PCSPECIALIST

CUSTOM GAMING

DESKTOPS & LAPTOPS

CUSTOM BUILT TO YOUR SPEC

EASY TO USE CONFIGURATOR

CUSTOM PCS & LAPTOPS

AWARD-WINNING SYSTEMS

MAGNUS PRO GAMING DESKTOP

- Intel® Core™ i7-12700K
- GIGABYTE Z690 Gaming X DDR4
- 16GB Corsair VENGEANCE RGB Pro 3600MHz
- 8GB GEFORCE RTX 3070 Ti
- 1TB PCS PCIe M.2 SSD
- 2TB SEAGATE BARRACUDA HDD
- Windows 11 Home

This spec from
£2,010.00*

TOPAZ ELITE GAMING DESKTOP

- AMD Ryzen 5 5600X
- ASUS® TUF Gaming B550-PLUS
- 16GB Corsair VENGEANCE RGB Pro 3600MHz
- 12GB AMD RADEON™ RX 6700 XT
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- 1TB SEAGATE BARRACUDA HDD
- Windows 11 Home

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ELIMINA® PRO SERIES LAPTOP

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PCSpecialist

MINI-ITX CASE

PHANTEKS EVOLV SHIFT XT / £160 inc VAT

SUPPLIER overclockers.co.uk

It's not raining, but pouring at the moment as far as mini-ITX cases go, with the Phanteks Evolv Shift XT joining NZXT's new H1 in this issue, and more to come next issue. This is Phanteks' fifth mini-ITX case, but rather than being a tweak of the aging vertical tower Shift design, the new Shift XT is Phanteks' first traditional sandwich style case. With the GPU and motherboard sitting back to back, and connected using a PCI-E 4 riser cable, it's shorter than the Shift and NZXT's H1, but takes up more desk space thanks to its horizontal orientation.

At £160 inc VAT, it's certainly pricey given that it lacks any bundled extra hardware, although Phanteks did tell us it will be including its new Revolt SFX PSUs and an all-in-one (AIO) liquid cooler at some point in the future. For now, the barebones option will need an SFX or SFX-L PSU, and either a low-profile CPU cooler shorter than 72mm, or a 240mm AIO liquid cooler. The former is lower than the limit of other mini-ITX cases that use a more traditional layout – even the smallest tower coolers, such as ARCTIC's Freezer 7X, will be far too tall for it, but you can still fit some decent coolers in here, such as Noctua's NH-L12S.

The Shift XT can also house triple-slot graphics cards up to 324mm long. This isn't your average shoebox-size sandwich-style case, then, but it also has one unique feature. The roof section can expand, turning a reasonably compact 13-litre case that's just 21cm tall into a 17.4-litre case that's 27cm tall and can house a 240mm radiator in the roof. Clearly, it won't be as refined as cases that stick to either air-cooled or AIO liquid cooler-focused arrangements, but in its Compact mode, the Evolv Shift XT is very compact indeed.

There are three height settings for the roof panel, with the lowest lacking clearance for roof fans entirely. The medium 'Airflow Boost' setting allows for two 120mm or 140mm fans to be placed here, while the tallest 'Water-Cooling' mode sees 60mm of clearance in the roof, which is enough for standard fans and a 240mm radiator up to 35mm thick. There are no fans included as standard, though, making the cheaper and fan-equipped Cooler Master NR200P look like better value, but then the NR200P isn't draped in aluminium.

To avoid gaping holes appearing in the edges of the case when you raise the top section, the front and sides simply slide over inner portions of the case. The sides comprise mesh panels, while a large RGB display panel sits at the front. In Compact mode, only a sliver of the display is visible, with it enlarging as the upper panel is raised, revealing more of the display. At the rear, though, inserts are included to plug the gap that appears as the roof is raised.

With just a single 240mm radiator mount, it's perhaps unlikely you'll want to fully water-cool your PC in the Shift XT,

SPEC

Dimensions (mm)
173 x 371 x 211 (W x D x H)

Material
Aluminium, steel

Available colours
Silver, black

Weight
5kg

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

Drive bays
1 x 2.5in

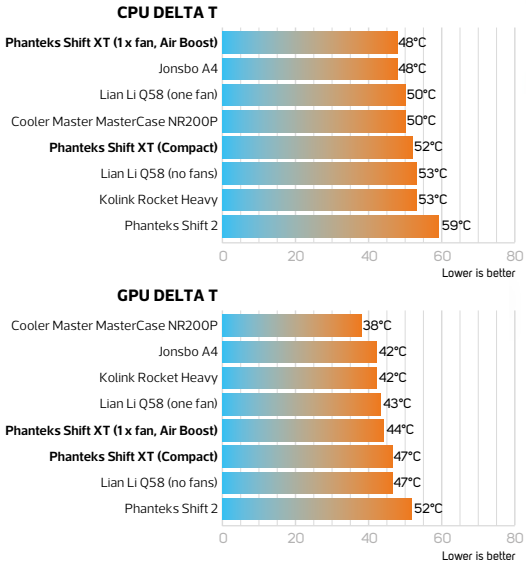
Form factor(s)
Mini-ITX

Cooling
2 x 120/140mm roof fan mounts (fans not included)

CPU cooler clearance
72mm

Maximum graphics card length
324mm

TEMPERATURE RESULTS



but a CPU or GPU-only loop could work, especially if you use a short graphics card that would leave space in front of it for a combined pump and reservoir. However, an AIO liquid cooler would make much more sense. Storage options are also extremely limited, with no space for 3.5in hard disks and only one 2.5in SSD mount.

The front panel is fairly basic too, with one USB 3 and one USB Type-C port, along with controls for the front RGB lighting. Cable-routing options are limited as well, but there are just enough places to stow them behind the PSU, or under the case, to avoid even a high-end PC looking like it lost a fight with a bowl of spaghetti.

Meanwhile, installing your hardware is made extremely easy, as the case fully dismantles down to its inner shell, with the top roof fan mount hinging open. Dust filters are present on the side in the form of removable mesh panels, but these don't quite cover the side vents in the expanded modes. To deal with this, Phanteks has included adhesive filters, which can also be used in the roof to prevent dust from falling into the case if you won't be using fans to exhaust air through it.

The case comes in black and silver options, with our sample being the latter, and it looks fantastic in a slightly retro, industrial kind of way. The vents and bends do a good job of breaking up what would otherwise be a rather bland exterior.

Performance

With large vents in the side panels aiding our low-profile CPU cooler and traditional graphics card, it wasn't a surprise to see decent thermals from the Shift XT, even in Compact mode with no case fans. Here, it closely matched the excellent Lian Li Q58, dipping below it by a couple of degrees once both cases had a single fan installed on the CPU delta T.

Cooling performance was closer with the GPU, though, and only the Cooler Master NR200P offered noticeably better cooling, with a GPU delta T of 38°C compared to 47°C for the Phanteks case in its Compact mode and 44°C when it was expanded into its (medium) Airflow Boost mode.

Conclusion

It's a shame the Shift XT's water-cooling support is very limited, and that you need to fully expand the case in order to fit a radiator in it at all, but the flexibility the Phanteks Evolv Shift XT offers is unparalleled. Its ability to switch between a good-looking, compact fanless cube into to a larger, liquid cooling-focused version of itself without suffering too many compromises is inspiring, although purists could point out that it's larger and slightly more limited than necessary in both modes, especially in its smallest configuration.

The Evolv Shift XT really does look fantastic as well. It's maybe a tad bulky and very limited in storage options, but if you're happy to live with flash-based storage, you like its flexible roof section and you're happy to pay the lofty price tag, it's a unique and versatile mini-ITX case that can definitely handle high-end hardware.

ANTONY LEATHER

VERDICT

No fans in the box and a high price, but the Shift XT has some killer aesthetics and unique features.

EXPANDABLE

- + Attractive design
- + Expandable roof section
- + Fully dismantles

EXPENDABLE

- – No fans included
- – Expensive
- – No 3.5in hard disk mounts

COOLING	26/30
FEATURES	17/20
DESIGN	28/30
VALUE	14/20
OVERALL SCORE	85%

MINI-ITX CASE

NZXT H1 V2 / £339 inc VAT

SUPPLIER ebuyer.com

VENTED PANEL

+ Attractive, unique design
+ Fixes original H1's issues
+ SFX PSU and AIO liquid cooler included

VENTED ANGER

− Optional mesh panel would be useful
− Cooling only marginally better than original design
− No 3.5in hard disk support

We loved the original H1 from NZXT for a number of reasons, and were pleased to see the company release a new version, the H2 V2, to boost cooling and solve a number of other issues that plagued the original case. Graphics card support wasn't ideal in the original case, for example. Its cooling wasn't particularly potent either, and not only did its PCI-E riser cable lack PCI-E 4 support, but it also had a fault that could short-circuit in rare cases. NZXT offered a replacement part, but the damage to one of the most distinctive mini-ITX cases of the last couple of years was done.

Thankfully, NZXT claims to have fixed all these issues with the new H1 V2. For starters, there's an entirely new riser cable and mounting mechanism that's now PCI-E 4-compliant. The graphics card length limit has been increased too, thanks to the case being a little taller and wider. Cooling has been boosted in two ways as well. Firstly, the three ventilated sides have larger perforated holes to allow air to be drawn in or expelled more easily, with the intake panels still sporting full-cover dust filters.

Secondly, NZXT has added a second fan in addition to the lone 140mm fan on the included AIO liquid cooler. A 92mm fan now sits at the top of the graphics card chamber to help expel the warm air that collected here in the previous version. In addition, the size of the motherboard tray has been reduced so that RTX 3000-series graphics cards with flow-through fans have somewhere to exhaust warm air. A small chamber now exists behind this area, which feeds the new 92mm fan, so cooling for these kinds of cards should see a particular improvement.

Another addition is a software-controlled fan controller. This uses NZXT's CAM software to control the two fans, but according to NZXT, the pump needs to be run at full speed and can't be fine-tuned in the software. Thankfully, the pump is quiet enough to be drowned out by the noise from the rest of our test hardware, but it also uses a proprietary connector, so there's no way to alter its speed any other way either.

The company was also keen to answer other questions before they arose, such as the decision not to include a replacement vented panel to replace the airflow-limiting glass panel fitted as standard. This has been a popular modification for the original H1, with custom vented panels available online that users claimed boosted cooling significantly. NZXT feels cooling is sufficient with the new case, given the improvements it's made, but would consider the option in future.

Despite its tiny desk-saving footprint and cramped interior, the fact that the original case's bundled SFX-L PSU and 140mm AIO liquid cooler were pre-installed and cable-tidied, meant that installing your own mini-ITX system in the H1 was actually a very quick and easy job. That remains the same with the H1 V2, with the familiar flip-down radiator panel revealing

SPEC

Dimensions (mm)
196 x 196 x 405 (W x D x H)

Material
Steel, glass

Available colours
White, black

Weight
7.6kg

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

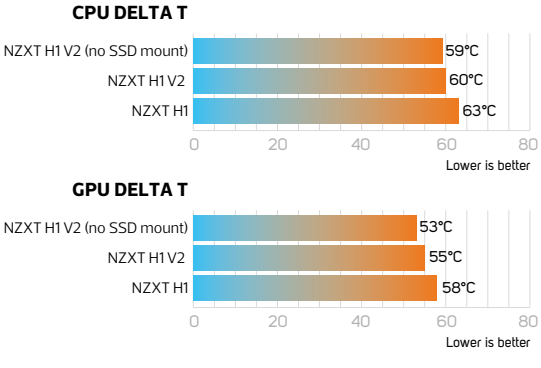
Drive bays
2 x 2.5in

Form factor(s)
Mini-ITX

Cooling
1 x 140mm AIO liquid cooler (140mm fan included), 1 x 92mm side fan mount (fan included)

Maximum graphics card length
324mm

TEMPERATURE RESULTS



the AIO liquid cooler and motherboard mount. The cooler is compatible with LGA1700 CPUs out of the box too, and NZXT has also boosted the PSU rating from 650W to 750W.

However, it has downsized the PSU to SFX from SFX-L, so using high-end graphics cards and CPUs could result in its small fan spinning up to create a little more noise than a larger fan in an SFX-L PSU.

The front panel is still on top of the case, but sports an extra USB 3 port, with Type-C here too, as well as an illuminated power button. The design of the case is otherwise identical to the original, with the top panel and two vented side panels together in one large U-shape section, and separate vented and glass panels clipping on to the sides.

Despite the slightly larger dimensions, there are no 3.5in hard disk mounts, and only a pair of 2.5in SSD mounts, so this isn't a case for people wanting to transplant large hard drives. Meanwhile, the SSDs are housed in a metal enclosure that can be removed to increase the space behind the graphics card.

Finally, the graphics card length limit now sits at 324mm, but it still lacks full triple-slot support, instead topping out at 2.5 slots. There's only 58mm of clearance here, so you'll need to check the depth of your graphics card to make sure its cooler will fit, even if it officially has a depth of 2.5 slots.

Performance

As the H1 V2 comes with its own PSU and CPU cooler, we couldn't use our usual test gear to get comparable numbers to other cases, so instead decided to focus on a head-to-head battle between the original H1 and new H1 V2. We strapped a Core i9-11900K to a Gigabyte Z590 Vision D and used an RTX 3070 Ti Founders Edition card to check thermals in our usual way, and to test the new cooling system's ability to aid a flow-through GPU fan design.

The CPU delta T of 63°C in the original case was, not surprisingly, bettered by the new case, which managed a 3°C drop in its standard configuration, and a 4°C drop if you remove the SSD mount to improve airflow to the new 92mm exhaust fan. It's not a huge improvement, but it's welcome.

The GPU delta T also fell by 3°C (5°C with the SSD cage removed), so there's a more noticeable benefit here. However, we also noticed that the boost frequency on the GPU was consistently higher by 40-50MHz in the new case, so the new case gives it a bit more headroom to run at higher frequencies. With a fixed clock speed, the temperature difference between the two would likely have been higher.

Conclusion

The original H1 was popular, despite its flaws, thanks to its unique, attractive design – it was a shame it never reached its full sales potential. The H1 V2 is basically the case that NZXT should have made originally. It's pricey for sure, but a 750W SFX PSU, 140mm AIO liquid cooler and software fan controller would cost you more than half the asking price alone. It could do with an optional mesh panel, and its cooling still isn't spectacular, but it's better across the board than the original, it can cope with high-end hardware and it's just as desirable.

ANTONY LEATHER

VERDICT

Better than the original H1, and only slightly larger. It's expensive, but this is a great mini-ITX chassis.

COOLING **23/30**

FEATURES **18/20**

DESIGN **28/30**

VALUE **15/20**

OVERALL SCORE **84%**

32IN GAMING MONITOR

IIYAMA G-MASTER GB3266QSU / £366 inc VAT

SUPPLIER ebuyer.com

BIG SCREEN

+ Large screen for modest price
+ High contrast and good default image quality
+ Solid gaming performance

BIG SCENE

– Chunky pixel density
– Sluggish response time

The iiyama G-Master GB3266QSU combines a large 32in screen with a 2,560 x 1,440 resolution and a high-contrast VA panel. The end result should be ideal for up-close gaming and desktop use, as well as sitting back and enjoying fantastic-looking video and games.

When it comes to styling, though, the all-black plastic construction tips towards mundane and utilitarian rather than minimalist sleekness. That said, the curve of its impressively slim panel does give it a certain elegance. That curve also helps ensure you get an optimal viewing angle, even for the edges of the screen, which is a legitimate concern for a panel this size.

While it may not have a flashy design, this display houses an impressive feature set. The stand offers height, pivot, rotation and tilt adjustment, while around the back are four video inputs, consisting of two DisplayPort and two HDMI inputs (one is limited to 75Hz at the screen's full resolution). Four is the magic number for USB ports too, with two USB 3 and two USB 2 sockets. Add a headphone jack and two 5W speakers that sound better than the typical 2-3W speakers and you're left wanting for little.

Meanwhile, the 32in screen and 2,560 x 1,440 resolution make for a modest pixel density of 91ppi. As such, up close it's not the sharpest display, and text can look a little rough, but it's great for gaming and watching video.

Out-of-the-box image quality is good too, with no obvious colour imbalance or a sense of a washed-out or overly dark image. In most regards, the display impressed in our tests, hitting a perfect gamma score of 2.2 and decent delta E colour accuracy.

Its contrast of 3,505:1 is decent for a VA panel and comfortably outclasses IPS and TN panels, while its maximum brightness of 427 nits impresses. However, the default colour temperature was just 5,971K, which is a fair way away from the ideal of 6500K. Also, the display hits 206 nits even at minimum brightness, which is a touch too bright in very dark environments.

Manually adjusting the colour balance only helped us to improve the colour temperature to 6,159K, and a full software calibration was required to pull it back into line. However, once calibrated there was only a slight difference in colour to the naked eye, so we feel comfortable saying that the GB3266QSU's out-of-the-box state is good enough for most people's needs.

The uniformity of the panel is middling, with an average brightness variance of 5.83 per cent and a spot in the bottom right corner dropping by 20 per cent. That's not a major problem for casual use but not ideal for image editing.

In gaming tests, the iiyama displayed the typical long ghosting trails of VA panels, making it not ideal for fast-paced competitive gaming. However, its 144Hz refresh rate means you still get smooth motion, and its backlight strobing blur reduction at least helps to sharpen the image in fast motion.

SPEC

Screen size
32in

Resolution
2,560 x 1,440

Panel technology
VA

Max refresh rate
144Hz

Response time
1ms

Max brightness
400cd/m²

Backlight zones
1

Stated contrast ratio
3,000:1

Adaptive sync
FreeSync and G-Sync

Display inputs
2 x DisplayPort, 2 x HDMI 2

Audio
2 x 5W speakers, headphone out

Stand adjustment
Height, pivot, rotation, tilt

Extras
100 x 100mm VESA mount, 4-port USB hub (2 x USB 3 up to 900mA, 2 x USB 2 up to 500mA)

Conclusion

With its big, bold, high-contrast image and solid 144Hz gaming performance, the iiyama GB3266QSU is a great option for those seeking a large screen but don't want to stretch to a 4K resolution. It also has a solid selection of features for a decent price. Its responsiveness will hold back esports fanatics, but it's otherwise a good all-rounder.

EDWARD CHESTER

VERDICT

A big, high-contrast gaming monitor for a good price. It's not responsive enough for fast-paced esports, but it's a great all-rounder.

IMAGE QUALITY 24/30

GAMING 22/30

FEATURES 18/20

VALUE 18/20

OVERALL SCORE 82%

HackSpace

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MECHANICAL KEYBOARD

AOC GK500 / £40 inc VAT

SUPPLIER amazon.co.uk

BARGAIN HUNT

+ Incredibly cheap
+ Reliable mechanical switches
+ Surprisingly sturdy base

RIP-OFF ADVENTURE

– Cheap-looking key legends
– Few extra features
– Loud keys

AOC has consistently churned out some of the best value gaming monitors on the market, offering a fantastic combination of performance and features for low prices. Now the company has entered the peripherals market with a new keyboard, mouse (p33) and headset. So, can it achieve the same great-value excellence?

Well, for just £40 inc VAT, the GK500 gets you a full-sized 104-key keyboard with Cherry MX-style mechanical switches and full RGB backlighting. That's impressive, even if the switches are clones made by a company we've never heard of before – Outemu.

The styling of this keyboard is basic, with a thin baseplate that stretches no wider than the footprint of the keys themselves. On its top is a very thin layer of aluminium that's painted black and has a bevel around its edges where the shiny metal shows through.

Combined with the rather rough-looking legends on the keys – the white painted-on secondary function labels are particularly shoddy – and you have a keyboard that largely looks as cheap as its price suggests.

Looks aren't everything, though, and the GK500 feels surprisingly solid. Despite its slimness, the base is quite rigid, so there's no annoying bounce while typing.

On the underside, a pair of single-level flip-down feet can raise the back edge by around 1cm and they have thick rubber pads on them to prevent the keyboard from sliding around – plenty of expensive keyboards aren't as surefooted. That said, the keyboard does easily slide around if the feet are stowed.

For physical features, the only extra you get is a magnetically attached wrist rest. It's good to see a magnetic system used on such a cheap keyboard, but the rest itself is hard plastic, so it isn't all that comfortable. Elsewhere, you get no extra keys, USB hub or multimedia controls. The cable is also fixed rather than detachable. It's a chunky, braided cable with an ample 1.8m length.

Media playback and lighting controls are available via secondary functions of the F keys and cursor keys, while further keys can be programmed via AOC's G-Menu software. This software package also lets you set the polling rate, repeat delay and repeat rate (when holding down a key), disable the Windows, Alt-Tab and Alt-F4 key shortcuts, set n-key rollover and adjust lighting. The latter only has preset lighting effects or a full static colour, not individual key control.

The switches are equivalent to Cherry MX Red, so they have the same linear (not clicky or tactile) action, with a 50g actuation force and lifespan of 50 million keystrokes. They feel as good as we'd expect, with a smooth, consistent and light action and reliable response. With nippy 1000Hz polling and 1ms response time, this board ticks all the key performance boxes.

The keys are quite noisy, with the lightweight housing doing little to absorb the key hits. However, you could quite easily tone down the worst of the noise with rubber ring dampers on the switch stems, or by adding some noise dampening or weight to the base.

As this keyboard is so cheap, it could be a great starter project for getting into mechanical keyboard modding. A quick paint job on the base and a new set of quality keycaps would give you a passable custom keyboard for less than the cost of most pricier models.

SPEC

Dimensions (mm)
431 x 124 x 36-50 (W x D x H)

Weight
871g with cable

Format
Full-size – 104 keys

Connectivity
Fixed 1.8m USB cable

Switch type
Outemu Red linear mechanical

Switch life
50 million key presses

Backlighting
6-zone RGB

Polling rate
1000Hz

Keyboard rollover
25-key

Extras
Magnetic wrist rest

Conclusion

The GK500 is a very cheap mechanical keyboard but its sturdy base and responsive keys mean it nails the essentials, making it a decent option for those on a tight budget. Plus, there's plenty of scope for modding it.

EDWARD CHESTER

VERDICT

Cheap but nails the basics – this is a decent entry into mechanical keyboards.

DESIGN 10/20
FEATURES 12/20
PERFORMANCE 20/30
VALUE 30/30

OVERALL SCORE 72%

BUDGET GAMING MOUSE

AOC GM500 / £11 inc VAT

SUPPLIER amazon.co.uk

CHEAP AT TWICE THE PRICE

+ Decent sensor and main button switches
+ Ambidextrous design
+ Ridiculously cheap

EXPENSIVE AT HALF THE PRICE

- Extra side buttons get in the way
- Heavy
- Poorly contoured shape
- Strange side button functions

If the low price of AOC's new GK500 keyboard is impressive (p32), the price of its new GM500 mouse is downright ludicrous. Available at the time of writing for just £11 inc VAT on **amazon.co.uk**, there are no other mice from reputable gaming mice companies that come even close to this price. Unfortunately, it would seem there's a good reason those companies don't go so low.

On paper, the GM500 has plenty going for it. Its sensor is the tried-and trusted PixArt PMW3325, which provides solid (if unspectacular) maximum performance figures of 5000 DPI, 20G acceleration and 100 inches per second movement speed. Meanwhile, Omron switches rated for 50 million clicks sit beneath the left and right click buttons. The spec is on par with plenty of lower-end gaming mice.

The presence of buttons on both sides of the mouse also makes it a truly ambidextrous design. However, in use we found these buttons problematic. The unused side buttons that sit under your ring or little finger are simply too easy to press accidentally, at least when used with a palm or fingertip grip – they're not as much of a problem with a claw grip.

The buttons under your thumb also lack definition from each other. There's no gap between them or contouring to make it easy to discern which button is which. What's more, they have a slightly mushy feel, and for some reason the default layout has some of the side buttons assigned to 'DPI shift' and 'browser homepage' functions, rather than Forward and Back, which makes for a frustrating experience.

The buttons can be reassigned in AOC's G-Menu software but it's a pain to have to install the software even to get this basic level of standard operation. You also can't just disable the unused side buttons, instead having to assign a null shortcut to get them to do nothing when they're pressed.

The design and build of the mouse is largely in line with its price, with a very basic shape that's surprisingly heavy at 104g. The contours of the mouse lack the little details that make for an easy grip too. AOC says the mouse is for claw and palm grip, and we'd agree – it's not suitable for fingertip grip. It's not really ideal for the other two grips styles either, but it's at least passable.

Extra features are non-existent on this mouse, other than the RGB lighting that illuminates the sides of the scroll wheel, the AOC logo on the rear and a strip that runs around the back of the mouse. The cable is also thick and stiff, and arrives very kinked, but it does flatten out reasonably well – a mouse bungee will be essential though.

In use, the performance of the main two buttons and sensor can't be faulted, but the shape, side button layout and heavy cable really held us back when gaming. It gets the job done, which is commendable at this price, but quite a bit of work is required to make the GM500 a truly comfortable gaming rodent.

SPEC

Weight
104g

Dimensions (mm)
74 x 127 x 40 (W x D x H)

Sensor
PixArt PMW3325, optical, 5,000 DPI, 20G acceleration and 100 IPS

Buttons
7 (left, right, scroll wheel, 2 x pairs of side buttons)

Cable
1.8m, braided

Extras
RGB lighting

Conclusion

With its decent sensor and button switches, plus an incredibly low price, the AOC GM500 delivers the basics for a gaming mouse if you can cope with its shape and weight. However, the latter two factors, as well as the side buttons that are too easy to hit accidentally, show what you gain by spending a bit more money on a well-designed gaming mouse.

EDWARD CHESTER

VERDICT

Solid performance for an astonishingly cheap price, but the shape and button layout could be a lot better.

DESIGN 8/20

FEATURES 10/20

PERFORMANCE 20/30

VALUE 28/30

OVERALL SCORE 66%

GAMING LAPTOP

LENOVO LEGION SLIM 7 / £1,399 inc VAT

SUPPLIER overclockers.co.uk

As its name suggests, the Lenovo Legion Slim 7 is designed to provide a leaner and lighter experience than most gaming laptops, and it immediately impresses with an 19mm-thick frame and a weight of 1.9kg. That's 8mm slimmer and more than half a kilo lighter than Lenovo's own Legion 5 Pro, which is our current favourite budget gaming laptop, and you save an extra 170g on the move, thanks to the Slim's lighter power brick.

Lenovo's lithe laptop maintains good build quality despite its cut-back dimensions. It's made of smooth black aluminium, it looks unfussy and discreet, and there's hardly any give in the screen or panels. That makes it easy to put this lightweight laptop in a bag without fear of breakages, and it will occupy less space than most 15.6in rivals.

The Legion has good features, despite its slimline body. There's an SD card reader on the left-hand side, and the rear has two USB 3.2 Gen 2 ports. The right-hand edge also has two USB 3.2 Gen 2 Type-C ports that handle DisplayPort and 100W of power delivery.

Meanwhile, the power button includes a fingerprint sensor, and the speakers are reasonable – punchy, loud and good enough for everyday use, despite a slightly muddy mid-range. The design isn't perfect – those USB Type-C ports could obstruct right-handed mouse users, the webcam has a privacy shutter but no Windows Hello support, and there's no HDMI output. There's also no Ethernet, although you do at least get dual-band Wi-Fi 6 and Bluetooth 5.1 support.

There's lots to like about the keyboard though. It has bright, bold per-key RGB backlighting, a numberpad and loads of secondary functions. The keys are fast and comfortable to use, although they're softer and shallower than the keys on most fatter laptops.

Shallow buttons are no surprise on a slim laptop, though, and neither are component compromises. The Legion's RTX 3060 has an entry-level 60W TDP and just 6GB of memory, while the Ryzen 7 5800H CPU peaks at 45W, so both parts run a long way short of their maximum potential. The Lenovo also has 16GB of dual-channel memory and a 512GB SSD with decent read and write speeds of 3,599MB/sec and 2,278MB/sec, although a 1TB drive would be better for accommodating large game installs.

There's a decent screen too. The 1080p panel has a 165Hz refresh rate and Nvidia G-Sync support. Its contrast ratio of 1,163:1 is punchy and vibrant, and the delta E of 1.8 means colours are accurate. The screen displayed 97.2 per cent of the sRGB colour gamut at a temperature of 6,947K, and it's bright enough for indoor and outdoor use. It's ideal for mainstream games, even if it doesn't have the extended gamut demanded by creatives.

This specification is good considering this machine's dimensions, but going for a slimmer chassis does result in compromises. Comparatively, Lenovo's £1,499 Legion 5 Pro may be thick and heavy, but it has an RTX 3070 that runs at 140W, a 2,560 x 1,600 display and more connection options.

SPEC

CPU
3.2GHz AMD Ryzen 7 5800H

Memory
16GB 3200MHz DDR4

Graphics
Nvidia GeForce RTX 3060 6GB

Screen
15.6in 1,920 x 1,080 IPS 165Hz G-Sync

Storage
512GB SK Hynix PC711 M.2 SSD

Networking
Dual-band 802.11ax Wi-Fi, Bluetooth 5

Weight
1.9kg

Ports
2 x USB 3.2 Gen 2, 2 x USB 3.2 Gen 2 Type-C/DisplayPort, 1 x audio, 1 x SD card reader

Dimensions (mm)
356 x 252 x 19 (W x D x H)

Operating system
Windows 10 Home 64-bit

Warranty
One year parts and labour return to base

PERFORMANCE

The Legion's modest RTX 3060 6GB GPU returned 99th percentile results of 35fps in Assassin's Creed Valhalla and Cyberpunk 2077. Those results are playable, but you'll need to drop the settings to hit 60fps averages in these sorts of demanding titles.

SLIMLINE

+ Slim, light and sturdy
+ Mainstream gaming and work ability
+ High-quality 1080p display
+ Decent battery life

SLIM PICKINGS

– Relatively weak performance
– Some missing connection options
– Better screens available elsewhere

You'll get underwhelming results with ray tracing too, even with DLSS enabled – activating both options in Cyberpunk 2077 dropped the 99th percentile result by 10fps, and enabling DLSS on Metro Exodus didn't make that game playable with ray tracing enabled either. With only 6GB of memory, the RTX 3060 can't run Doom Eternal at our usual Ultra Nightmare settings either, but its average of 162fps at Ultra settings shows the potential for playing undemanding titles in sync with the 165Hz display.

Not surprisingly, there's a clear gulf between this laptop and conventional machines. The Lenovo Legion 5 Pro and its RTX 3070 was 10fps faster in Cyberpunk 2077 and further ahead in other games. You'll also get a little more pace from RTX 3060 portables with more generous power limits.

Meanwhile, the 45W 5800H scored 58,827 in our image editing test and 432,467 in the Handbrake benchmark. Those are decent scores, and they mean that this laptop can tackle mainstream photo editing, content creation and multi-tasking. In the heftier Legion 5 Pro, though, the same CPU ran without power restrictions, and it hit scores of 66,123 and 531,406 in the image editing and Handbrake tests respectively.

These results were recorded with the Lenovo's default cooling mode. With this setting selected, the Legion was quiet and cool during games and work tests. That's good, but clock speeds suffered – the GPU peaked at just 1450MHz, and the processor's respective single and multi-core frequencies of 4.1GHz and 3.2GHz fall short of its top clocks.

Activating Performance mode saw the GPU's TDP increase to 90W and its clock speeds hover around 1785MHz. This added 12fps to the Doom Eternal 99th percentile result and 3fps to its Assassin's Creed Valhalla average. That's a reasonable boost, but you'll have to suffer with noticeable fan noise and an uncomfortably hot underside to get that extra performance.

Performance mode had less of impact on application benchmarks, with no change to single-core speeds and a revised multi-threaded clock of 3.7GHz. That improved the machine's overall system score to 203,070 and fan noise remained modest, but it still can't catch conventional laptops.

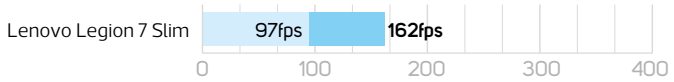
The Lenovo's 71Wh battery isn't particularly big either, and the Legion Slim 7 lasted for one hour, 13 minutes during gameplay. If you don't change the settings, then the Legion lasts for three hours during work tasks. As with the Legion 5 Pro, though, this rig has a hybrid mode that uses the CPU's integrated graphics. With that option deployed, and the screen brightness reduced by 50 per cent, the Lenovo lasted for six hours, 25 minutes in office tasks. If you're careful, you'll get most of the way through a working day on the move with this machine, and you can't say that about most gaming laptops.

BENCHMARK RESULTS

58,827	432,467	158,928	166,900
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	HEAVY MULTI-TASKING	SYSTEM SCORE

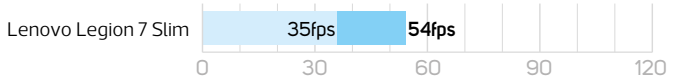
DOOM ETERNAL

1,920 x 1,080, Ultra settings



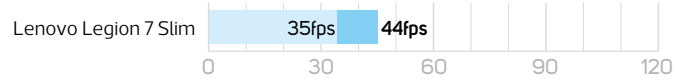
ASSASSIN'S CREED VALHALLA

1,920 x 1,080, Ultra High settings, High anti-aliasing



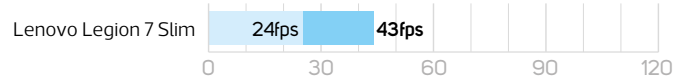
CYBERPUNK 2077

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



METRO EXODUS

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



99th percentile **Average**

CONCLUSION

The Legion Slim 7 isn't the quickest gaming laptop, but it's fast enough for mainstream games if you're happy to drop the settings a bit, and it excels elsewhere. It's slimmer and lighter than other 15.6in gaming machines, and it has a good keyboard, a vibrant display and better battery life than most rivals. The lack of graphical horsepower and the better screen and connection options on the Legion 5 Pro mean it's still our affordable favourite, but the Slim 7 is a good alternative if your top priority is getting a svelte machine.

MIKE JENNINGS

PERFORMANCE 17/25

DESIGN 23/25

HARDWARE 21/25

VALUE 20/25

OVERALL SCORE 81%

VERDICT

It's not the fastest machine, but it's ideal if you want a lightweight alternative to conventional gaming laptops.

INTEL B660 GAMING PC

CHILLBLAST FUSION SENTINEL / £1,049 inc VAT

SUPPLIER custompc.co.uk/FusionSentinel

Chillblast's Fusion Sentinel is the first PC we've seen with the RTX 3050 – Nvidia's newest and most affordable Ampere GPU (see p18). It's designed for 1080p gaming with an extra side of ray tracing and DLSS. The Palit card in this PC has the usual 2,560 stream processors and 8GB of memory, along with no overclock, so its boost speed remains at 1777MHz.

The Fusion Sentinel combines its entry-level graphics card with an Intel Core i5-12400F (see p16). It's an Alder Lake chip with six Hyper-Threaded cores, but this chip has modest base and boost speeds of 2.5GHz and 4.4GHz. The rest of the components are similarly fine, but unremarkable.

The 16GB of dual-channel DDR4 memory runs at 3200MHz, and the Seagate SSD delivered decent read and write speeds of 4,783MB/sec and 2,614MB/sec, but it's only got a 500GB capacity. Meanwhile, power comes from a 600W Aerocool unit with 80 Plus Bronze certification.

The Asus TUF Gaming motherboard doesn't look like much either, but it has some good features. Its main 16x PCI-E slot supports PCI-E 5, and two of its three M.2 connectors support 4x PCI-E 4. The board has 2.5Gbps Ethernet and dual-band 802.11ax Wi-Fi as well, plus it has two spare memory slots.

Impressively, at the rear, you'll find a USB 3.2 Gen 2x2 Type-C port that supports 20Gbps transfers. That's all great, but there are limits to this affordable board's talents. It doesn't support DDR5, and its secondary PCI-E slots only use PCI-E 3. The board also only has a couple of on-board USB 3.2 Gen 1 and Gen 2 connectors, and just four SATA ports.

Chillblast has picked a mid-tower NZXT H510 Flow chassis for this system. It looks like a typical NZXT case, with a meshed front panel, tempered glass side panel and PSU shroud, and its build quality is good, with steel used throughout. The Sentinel is tidy thanks to the cable cover at the front and neat wiring around the back, and it's easy to build inside, with easily accessible ports and room for a couple of 2.5in drives, and one 3.5in disk at the rear. Plus, if you want to upgrade, the NZXT has enough space to install a top-tier graphics card and a front-mounted radiator up to 280mm in size. It has a front-mounted USB Type-C port as well.

The Sentinel trades blows with the Wired2Fire Phoenix (see p40). That rig goes one better in the graphics department thanks to its RTX 3060, and it has faster memory and a larger SSD, but it's £50 more expensive than the Chillblast, and has a weaker case and motherboard.

This is also the first Chillblast system we've seen with the firm's upgraded warranty. It's a fantastic deal, with three years of on-site support for parts and labour, followed by two further years of labour coverage. Wired2Fire also supplies five years of labour protection, but no on-site service.

SPEC

CPU
2.5GHz Intel Core i5-12400F

Motherboard
Asus TUF Gaming B660-Plus WIFI D4

Memory
16GB Chillblast 3200MHz DDR4

Graphics
Palit GeForce RTX 3050 8GB

Storage
500GB Seagate Firecuda 520 M.2 SSD

Networking
2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5.2

Case
NZXT H510 Flow

Cooling
CPU: Chillblast Centurion with 1 x 120mm fan; GPU: 2 x 90mm fans; front: 3 x 120mm fan; front: 1 x 120mm fan; rear: 1 x 120mm fan

Ports
Front: 1 x USB 3.2 Gen 1, 1 x USB 3.2 Gen 2 Type-C, 1 x audio; rear: 1 x USB 3.2 Gen 2x2 Type-C, 1 x USB 3.2 Gen 2, 3 x USB 3.2 Gen 1, 1 x USB 2, 1 x optical S/PDIF, 5 x audio

Operating system
Windows 11 Home 64-bit

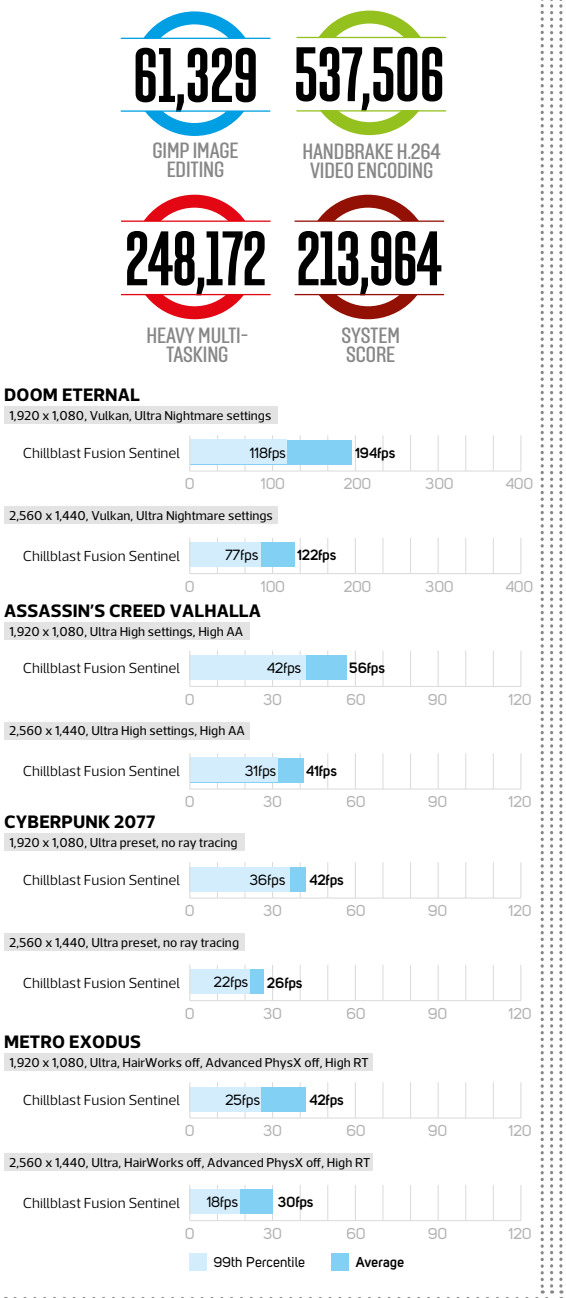
Warranty
Three years on-site parts and labour, plus two years labour only return to base

PERFORMANCE

The RTX 3050 doesn't set the world alight, but it can handle 1080p gaming if you're prepared to drop your settings a little. It played Assassin's Creed Valhalla with a 99th percentile of 42fps and 56fps average, which is playable. However, it dropped down to 36fps in Cyberpunk 2077. On the plus side, its Doom Eternal average of 194fps is excellent, showing the potential for running undemanding games at decent frame rates on this machine.

That's a good start, but the RTX 3050 does have weaknesses. It couldn't achieve playable speeds in Metro Exodus, for instance, and the toughest single-player titles will

BENCHMARK RESULTS



struggle unless you compromise on graphics quality. The RTX 3060 inside the Wired2Fire is noticeably faster, with double-digit leads in Assassin's Creed and Cyberpunk 2077.

There's an outside option too, if you're not fussed about ray tracing – the AMD Radeon RX 6600 XT. It's far quicker than the RTX 3050, and we've included it in this month's £949 build guide. It's far quicker than both the Nvidia GPUs in non-ray-traced games.

Meanwhile, the Core i5 CPU can handle any 1080p gaming situation, and it will tackle mainstream photo editing and other modest content-creation tasks as well. However, while the

CPU undoubtedly has a great price, it lacks the E-Cores and high clock speeds of its pricier siblings.

As a result, the Chillblast's result of 61,329 in the single-threaded image editing benchmark falls well behind the results from the AMD Ryzen 5 5600X and Core i5-12600K, and its score of 537,506 in our heavily multi-threaded Handbrake test lags behind every current mid-range chip from Intel and AMD. On the plus side, it's still faster than the older Core i5-11600K here, and it does cover all the basics.

The comparative lack of processing horsepower means that the Chillblast delivers fantastic thermal performance though. The CPU and GPU delta Ts of 44°C and 36°C are superb, and neither chip had issues hitting top speeds. No matter the situation, the Chillblast was virtually silent too – it's a tad quieter than the Wired2Fire and an excellent choice if you want a particularly discreet desktop.

CONCLUSION

Chillblast's Fusion Sentinel offers respectable 1080p gaming performance, a solid motherboard, a smart, sturdy chassis and a superb warranty alongside whisper-quiet operation. It also has a tempting price for a gaming PC equipped with the latest Alder Lake and Ampere silicon.

However, at this price, you're better off buying a machine based on the significantly quicker Radeon RX 6600 XT. If getting the fastest frame rates for your money isn't the be all and end all for you, though, the Chillblast is a decent option – it's a quiet, compact and sturdy 1080p gaming PC with a rock-solid warranty.

MIKE JENNINGS

FUSION

- \+ Respectable 1080p gaming pace
- \+ Robust, quiet build
- \+ Decent motherboard
- \+ Superb warranty

CONFUSION

- – GPU is a bit weedy
- – Uninspiring CPU performance
- – 500GB SSD

VERDICT

A quiet, solid 1080p gaming PC with a sturdy case, good motherboard and excellent warranty, although the GPU is a bit weedy.

PERFORMANCE **16/25**

DESIGN **21/25**

HARDWARE **20/25**

VALUE **20/25**

OVERALL SCORE **77%**

INTEL B660 GAMING PC

WIRED2FIRE PHOENIX INTEL – POWERED BY MSI / £1,099 inc VAT

SUPPLIER custompc.co.uk/Phoenix

Wired2Fire's new Phoenix system costs just £1,099 inc VAT, but the Surrey-based builder has found room for an overclocked RTX 3060 in its budget, which is impressive considering the state of the graphics market. The MSI-made graphics card in this rig pairs its usual 12GB of GDDR6 memory and 3,584 stream processors, and raises the boost clock from 1777MHz to 1807MHz.

The rest of the specification is reasonable. The 16GB of DDR4 memory rattles along at a decent 3600MHz, and the 1TB Lexar NM610 SSD offers a solid amount of storage space for games, even if its read and write speeds of 2,174MB/sec and 1,725MB/sec are decidedly mid-range.

Meanwhile, the Core i5-12400F is a new budget-friendly CPU from Intel's Alder Lake range, which means unimpressive base and boost clocks of 2.5GHz and 4.4GHz, but you do get its updated architecture and six Hyper-Threaded cores for a very reasonable price. It's all powered by a 550W MSI PSU with an 80 Plus Bronze rating.

These solid core components compare well with the rival Chillblast Fusion Sentinel (see p38). That rig is £50 cheaper than the Wired2Fire, and both use the same CPU, but the Chillblast has slower memory, a smaller SSD and a weaker RTX 3050 GPU.

The Wired2Fire's MSI MAG B660M Mortar motherboard also impresses, with 2.5Gbps Ethernet and dual-band 802.11ax Wi-Fi. It also has two spare memory slots, a pair of M.2 connectors that support PCI-E 4 and a super-fast USB 3.2 Gen 2x2 Type-C port at the rear. For everyday scenarios, it's a fine board, but this is one area where the Wired2Fire doesn't compare particularly well with the Chillblast, which has a full-sized ATX motherboard with more expansion room.

Wired2Fire's hardware sits inside an MSI Vampiric 100R chassis. The meshed front panel and RGB LEDs mean this case looks the part, and it measures just 457mm tall and 390mm deep, so it's smaller than the NZXT chassis deployed by Chillblast. In several areas, though, this case can't compete with that NZXT H510 Flow enclosure.

The MSI chassis isn't as sturdy, with a noticeably weak rear side panel, and it doesn't have as much space on the inside – there's only 300mm of graphics card clearance and it maxes out at support for 240mm radiators, with the NZXT case going further in both metrics. It also has less space for storage around the rear, the cables aren't quite as neat and it doesn't have a front-facing USB-C port. They're not terminal issues, especially if you don't want to upgrade or move the PC frequently, but the Chillblast system has more finesse and versatility.

Both PCs also have good warranties. The Phoenix has an impressive five years of labour coverage alongside two years of parts protection and collect and return service. That's one of the best deals around, but Chillblast also offers five years of labour coverage alongside three years of on-site service and parts protection.

SPEC

CPU
2.5GHz Intel Core i5-12400F

Motherboard
MSI B660M Mortar WiFi DDR4

Memory
16GB ADATA XPG GAMMIX 3600MHz DDR4

Graphics
MSI GeForce RTX 3060 12GB

Storage
1TB Lexar NM610 M.2 SSD

Networking
2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5.2

Case
MSI MAG Vampiric 100R

Cooling
CPU: ARCTIC Freezer 34 with 1 x 120mm fan; GPU: 3 x 90mm fans; front: 1 x 120mm fan; rear: 1 x 120mm fan

Ports
Front: 1 x USB 3.2 Gen 1, 2 x USB 2, 2 x audio; rear: 1 x USB 3.2 Gen 2x2 Type-C, 3 x USB 3.2 Gen 2, 4 x USB 2.0, 1 x optical S/PDIF, 5 x audio

Operating system
Windows 11 Home 64-bit

Warranty
Two years parts and labour and collect and return, plus three years labour only return to base

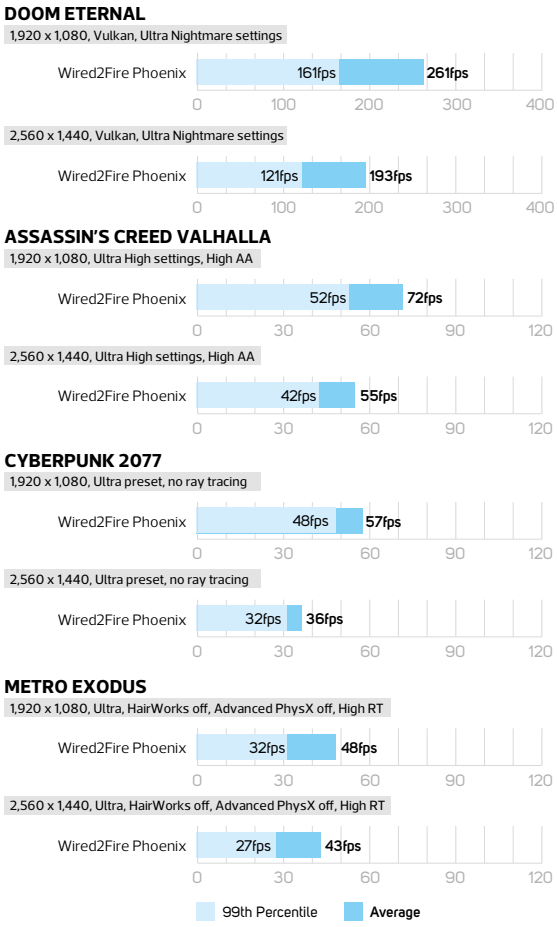
RISING FROM THE ASHES

+ Rock-solid 1080p gaming speeds
+ Compact, quiet build
+ Fast memory
+ 1TB SSD

FALLING FROM THE SKY

– Limited motherboard
– Underwhelming case
– Chillblast has better warranty

BENCHMARK RESULTS



67,877
GIMP IMAGE EDITING

536,639
HANDBRAKE H.264 VIDEO ENCODING

231,085
HEAVY MULTI-TASKING

212,097
SYSTEM SCORE

PERFORMANCE

The overclocked RTX 3060 is an impressive 1080p gaming GPU. Its 99th percentile minimum of 52fps was bolstered by an average beyond 60fps in Assassin's Creed Valhalla, and it nearly hit that mark in Cyberpunk 2077 too. Activating Medium ray tracing and DLSS in the latter game saw its 99th percentile result improve by 4fps, and the RTX 3060 remained playable in Metro Exodus at 1080p.

These scores easily outpace the RTX 3050 inside the cheaper Chillblast, making gameplay smooth at high settings, rather than borderline playable. The RTX 3060 may handily beat the RTX 3050, but the AMD Radeon RX 6600 XT is a more robust rival. That card is quicker in most non-ray-traced game tests, and you can realistically only enable ray tracing with DLSS at 1080p on the RTX 3060, which doesn't look great. We've designed a £949 PC with the RX 6600 XT (see p76), and this GPU is a very tempting alternative if you're not fussed about ray tracing.

Meanwhile, the Wired2Fire's fast memory enabled it to outpace the Chillblast in our image editing test, but the Chillblast fought back with a better multi-tasking score. Beyond this tit-for-tat squabbling, though, the i5-12400F's comparative lack of clock speed puts it behind chips such as the Core i5-12600K and AMD Ryzen 5 5600X, but it's also much cheaper. It's still a decent CPU for the money, though, with the Wired2Fire being capable of handling mainstream gaming and content creation without breaking a sweat.

Wired2Fire's machine is a good thermal performer too. Its clock speeds remained fine throughout our tests, and its CPU and GPU delta Ts of 31°C and 40°C are great. It's consistently quiet too, although the Chillblast makes even less noise.

CONCLUSION

Wired2Fire's extra £50 budget allows for a much more powerful gaming PC than the Chillblast, with a faster GPU, quicker memory and a larger SSD. For gaming, that's great, but the Chillblast does also offer a better case, motherboard and warranty. Looking beyond this PC, we also recommend considering the AMD Radeon RX 6600 XT for even faster gaming pace at this price level. If you want a ready-made PC with an Nvidia GPU and a decent warranty, though, the Wired2Fire is faster than its rival and has more storage space. It's a solid gaming PC for the money.

MIKE JENNINGS

PERFORMANCE	20/25
DESIGN	19/25
HARDWARE	20/25
VALUE	22/25
OVERALL SCORE	81%

VERDICT

Decent 1080p gaming power, plenty of storage space and a quiet build for a reasonable price.

Custom kit

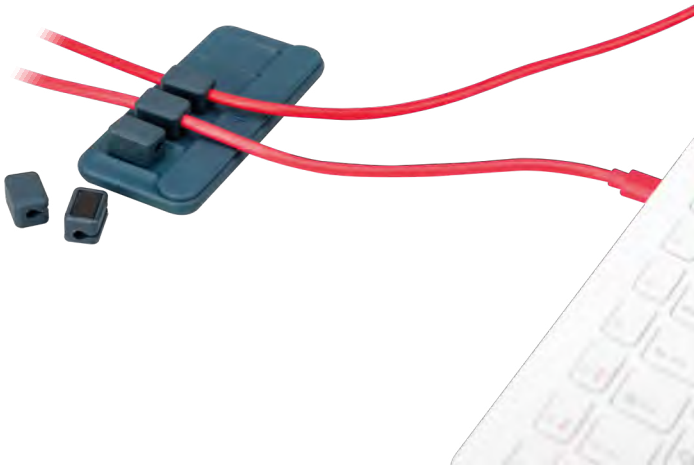
Phil Hartup checks out the latest gadgets, gizmos and geek toys

ANKER MAGNETIC CABLE MANAGEMENT / £20.99 inc VAT

SUPPLIER amazon.co.uk

Anker's magnetic cable management system is geared towards situations where you want wires and cables to be tidy, but are also able to pop them in and out of their tidied positions at will. You get ten gripping pieces that slot onto cables, and then two magnetic plates that you can attach to an agreeable metal surface. The gripping pieces then hold the cable onto the plate.

You can fit five cables to each plate in this way, and the result is a neat system that makes it easy to pop cables off the line and put them back again as needed. As long as your intention is only to tidy cables on a magnetic surface, such as a metal desk or case panel, the Anker system is fine (although pricey), but bear in mind there's no alternative attachment to the magnets for the main plates themselves, with no option of tape or a grippy base to hold them down.



Anchored ●●●○○ **Away**

COOLON USB HUB / £4.99 inc VAT

SUPPLIER amazon.co.uk

The Coolon USB hub doesn't try to do anything beyond giving you as many USB 3 ports in as little space as possible. It plugs directly into a port and then provides an additional two ports at the back and a third port in the raised hump on the top. The design clearly favours laptops and other horizontally orientated ports, but it can work pretty much anywhere due to the small size. For a laptop or a PC with relatively few USB ports in play, this is a great idea and the tiny doodad is a great way to turn one USB 3 slot into three.

The consideration with any USB hub such as this one, of course, is that it isn't bringing its own power input to the system, so you're essentially splitting the power being sent to one port into three. It's ideal if you need to discreetly add more USB ports to a laptop, but you don't want to load it with power-hungry devices.

Colon ●●●●○ **Coolon**

EVERLASTING COMFORT ARM REST / £22.95 inc VAT

SUPPLIER amazon.co.uk

Slapping extra layers of comfy squashiness onto a chair doesn't feel like an especially pro-gamer upgrade, but if you're going to be stuck in a chair working from home, playing games, or both if nobody is checking in, you might as well make the best of it. The Everlasting Comfort arm rests have two straps and Velcro pads, which attach over the existing arms of an office chair, or any chair that has an arm rest with a gap underneath it.

They're not difficult to install or remove, and the straps are supplemented by a grippy textured layer underneath. The latter helps to prevent the cushion from sliding over to the sides, which sometimes happens with cushions. The pad itself is the main event and it's extremely comfy. There's a soft mesh outer layer, with memory foam and cooling gel inside it. It isn't too doughy or squishy, and it's not too firm – it's just right.

Burglars ●●●●○ **Bears**

ATTENUO CREDIT CARD WALLET / **£22** inc VAT

SUPPLIER amazon.co.uk

The Attenuo wallet takes the concept of a minimalist design and runs with it. In fact, the Attenuo runs so far with the concept of a minimalist wallet that it's only a hair's breadth and around £20 away from just stuffing your credit cards in your pocket. Physically, it's a single piece of machined aluminium that acts as a sort of cage for up to eight credit cards, or other similarly shaped objects, such as tracking cards or RFID blockers.

This design makes the Attenuo light, strong and resistant to the elements (short of maybe a lightning strike) – there's not much that can go wrong with a single piece of metal. As a card wallet, the Attenuo works fine. It can be a bit of a fiddle getting one specific card out from the middle of the group, which is a problem faced by any wallet that stashes the cards in a deck, but otherwise, your cards snugly stay in place and the corners are neatly angled off in order to prevent your body getting poked by them through a pocket. If there's a flaw, it's the visibility that the cage-like design provides – you can see the top card as clear as day and so can anybody else.

Liminal ●●●○○ **Minimal**

RAZER SPHEX V3 / **£9.99** inc VAT

SUPPLIER razer.com

The Razer Sphex V3 almost defies definition as a mousepad or mouse mat, because both of these suggest a level of chunkiness. Conversely, there's no padding here and nothing that suggests a mat – it's more like a surface, or almost even a coating. The Sphex measurers just 0.4mm thick, with the top couple of fractions of a millimetre consisting of a lightly textured polycarbonate surface on which the mouse runs, and the bottom layer, which is a reusable sticky pad.

In effect, the Sphex operates like a sticker – you slap it down, it stays in place and it keeps such a low profile that you would be forgiven for forgetting it was installed in the first place. Installed is a key word here – you don't want the Sphex moving about, because unless the sticky base is comfortably attached to your surface, its light weight makes it prone to wandering. If you do need to remove it, there's a little cloth Razer tag on the side that peels it up easily enough, and wiping down the base with a damp cloth makes it sticky again. It works well enough as a gaming mouse surface, and it's a great addition if you want to keep your desktop sleek and tidy.

Tacky ●●●●○ **Sticky**

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

How we test

MOTHERBOARDS

TEST PROCESSORS

- **Intel LGA1700** Intel Core i5-12600K
- **Intel LGA1200** Intel Core i9-11900K
- **AMD AM4** AMD Ryzen 9 5900X

Common test hardware between our CPU test rigs includes a WD Red SN750 SSD, along with a WD Black SN850 SSD to test the speed of M.2 ports, and an Nvidia GeForce RTX 3070. We use 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz DDR4 RAM, or 32GB (2 x 16GB) of Kingston Fury 5200MHz DDR5 RAM.

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

PROCESSORS

TEST MOTHERBOARDS

- **Intel LGA1700**
  Asus ROG Strix Z690-I Gaming WiFi
- **Intel LGA1200** MSI MEG Z490 Ace
- **AMD AM4** MSI MPG Gaming B550 Carbon WiFi
- **AMD AM4 APU** MSI MEG X570 Unify

Common gear includes a 2TB Samsung 970 Evo SSD and Nvidia GeForce RTX 3070 FE graphics card. For LGA1700 CPUs, we use 32GB (2 x 16GB) of Kingston Fury 5200MHz DDR5 RAM and a Thermaltake Toughliquid Ultra 360 CPU cooler. For other systems, we use 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz RAM and a Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock.

We use the latest version of Windows 11 with security updates, plus the latest BIOS versions and drivers. We record results at stock and overclocked speeds, and tests include our RealBench suite, Cinebench, Far Cry 6 and Dirt 5.

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

MONITORS

We test image quality with an X-Rite iDisplay Pro colorimeter and DisplayCal software to check for colour accuracy, contrast and gamma, while assessing more subjective details such as pixel density and viewing angles by eye. For gaming, we test a monitor's responsiveness subjectively and then also use Blur Buster's excellent ghosting UFO test to check the sharpness of the display in high-speed motion.

CPU COOLERS

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

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

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

INTEL LGA1700
Intel Core i9-12900K at stock speed, Asus ROG Maximus Z690 Apex motherboard.

INTEL LGA1200
Intel Core i9-11900K at stock speed with Adaptive Boost enabled, MSI MEG Z590 Ace motherboard.

AMD AM4
Ryzen 7 5800X overclocked to 4.6GHz with 1.25V vcore, or Ryzen 5 5600X overclocked to 4.6GHz with 1.25V vcore on low-profile coolers, MSI MEG X570 Unify motherboard.

GRAPHICS CARDS

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

TEST KIT

AMD Ryzen 9 5900X, 16GB (2 x 8GB) of Corsair Vengeance RGB Pro SL 3600MHz DDR4 memory, Asus ROG Strix B550-E Gaming motherboard, Thermaltake Floe Riing 240 CPU cooler, Corsair HX750 PSU, Cooler Master MasterCase H500M case, Windows 10 Professional 64-bit.

GAME TESTS

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

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

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

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

POWER CONSUMPTION

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

CUSTOM PC AWARDS

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.

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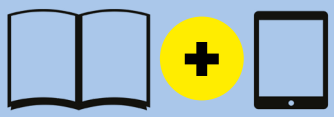

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LABS TEST

Afford a lake

Antony Leather takes a look at six of the latest LGA1700 motherboards based on Intel's cut-price B660 chipset

How we test

This month we're taking a look at some affordable ways to build a system based on one of Intel's 12th-gen CPUs. Motherboards based on Intel's B660 chipset have landed, offering a drop in prize compared with Z690 motherboards, and they offer a range of features to suite various budgets.

Our motherboard test kit includes a Core i5-12600K, a GeForce RTX 3070 Founders Edition graphics card and either 16GB of 3466MHz Corsair Vengeance RGB Pro DDR4 RAM, or 32GB of 5200MHz DDR5 memory, as B660 boards support one or the other.

We also use Windows 11 installed on a WD Red SN750 SSD, along with a WD Black SN850 SSD to test the speed of M.2 ports. We use the latter to test heatsink performance, tapping into the SSD's internal temperature sensor to see how well any M.2 heatsinks perform under load, using back-to-back runs of CrystalDiskMark's entire battery of storage tests.

We use the latest BIOS version for each motherboard, and our motherboard test rigs are built on a Barrow Rhopilema test bench, using full custom water-cooling systems, including two 240mm radiators and a Laing DDC pump in order to eliminate any cooling bottlenecks.

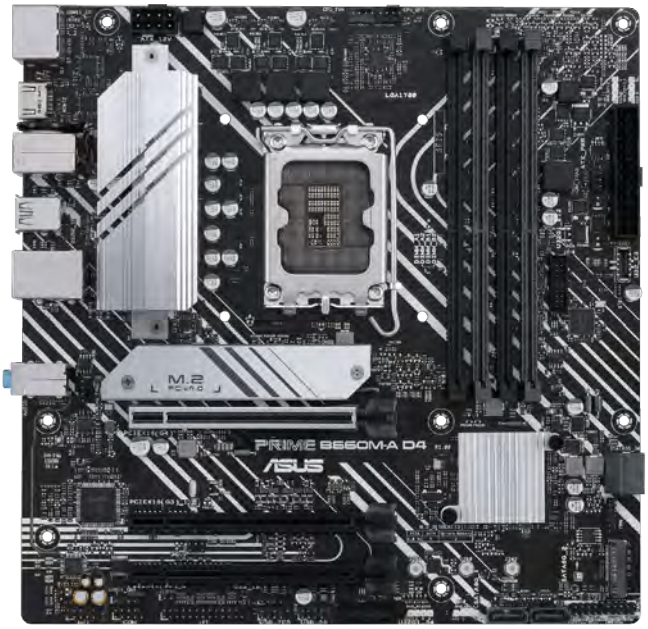
We use RightMark's Audio Analyzer software to measure the dynamic range, noise level and total harmonic distortion of the on-board audio. Other tests include our RealBench suite of application benchmarks, Far Cry 6, Cinebench R23's single and multi-threaded tests and total system power consumption at stock speed. Our scores are based on a weighted calculation, which includes performance, features and value, with the overall score being the sum of those three values.

Contents

- Asus Prime B660M-A D4 / p47
- Asus Prime B660-Plus D4 / p48
- Gigabyte B660 Aorus Master DDR4 / p49
- Gigabyte B660 Gaming X DDR4 / p50
- MSI MAG B660 Tomahawk WiFi / p51
- MSI MAG B660M Bazooka DDR4 / p52
- Results graphs / p54

ASUS PRIME B660M-A D4 / £140 inc VAT

SUPPLIER amazon.co.uk



As one of Asus' cheapest LGA1700 offerings for Intel's 12th-gen CPUs, the Prime B660M-A D4 has clearly had to cut a few corners to nip under the £150 barrier. For starters, only half of the usual area of VRMs is equipped with a heatsink, and the slab of aluminium that sits on top of the uppermost M.2 port is rather thin too. We measured a peak M.2 temperature of 66°C with our PCI-E 4 SSD under this heatsink, which was the highest on test, although admittedly only a degree or two higher than the Gigabyte B660 Gaming X DDR4 and MSI MAG B660M Bazooka DDR4.

Asus doesn't mention the power phases, but there appear to be at least eight in total. Annoyingly, though, neither of Asus' motherboards this month had VRM temperature sensors that our software could read, unlike all the other boards on test. The Prime B660M-A D4 had a peak VRM temperature of 60°C on the areas we could measure with our IR laser probe, which was reasonably high, although we measured the other motherboards slightly differently using software.

As its name suggests, the Prime B660M-A D4 supports DDR4 rather than DDR5 memory, which is sensible at this price, but while PCI-E 5 support doesn't make an appearance, both the main 16x PCI-E slot and both M.2 ports support PCI-E 4 devices. Disappointingly, there are also only four 4-pin fan headers to power your cooling equipment, though. What's more, while the Realtek ALC897 audio codec is adequate, it's quite dated now.

The rear I/O panel is equally sparse, with just six USB ports and no Wi-Fi included and no optical output for the audio. There's no USB Type-C port here either, but there is at least a Type-C header on the PCB to connect to your case if your chassis has a Type-C port on the front panel. You only get Gigabit Ethernet too, which is still fine for most networking kit at the moment, but isn't really futureproof – the MSI MAG B660 Bazooka also offers 2.5 Gigabit networking (plus better looks) for just £10 more.

Thankfully, in the performance tests, the Prime B660M-A D4 handled every test we threw at it with our Core i5-12600K installed. The system score of 147,589 was on par with the rest of the field, with only a slightly slow Cinebench R23 single-threaded score raising any eyebrows. The audio performance was typical of the ALC897 codec, outputting a dynamic range of 95dBA, for example, but only the much more expensive MSI MAG B660 Tomahawk WiFi fared much better here.

OPTIMUS PRIME

- \+ Reasonable price
- \+ Good EFI
- \+ Solid performance

SENTINEL PRIME

- – Lacklustre aesthetics
- – Feature set not as compelling as competition
- – Sub-par VRM readout and cooling

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Form factor Micro-ATX

Memory support 4 slots: max 128GB DDR4 (up to 5333MHz)

Expansion slots One 16x PCI-E 4, two 16x PCI-E 3

Sound Realtek ALC897

Networking 1 x Intel Gigabit LAN

Cooling Four 4-pin fan headers, VRM heatsink, M.2 heatsink

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 2 x USB 3.1, 4 x USB 2, 1 x USB 3.1 Type-C header, 1 x PS/2, 3 x audio jacks

Dimensions (mm) 244 x 244

Conclusion

There's nothing inherently wrong with the Asus Prime B660M-A D4 – it has a reasonable price tag and will make an excellent home for a non K-edition 12th-gen Intel CPU. However, it's lacking in terms of features and aesthetics compared with the competition. It's skinny in both these areas, and we'd definitely pick the MSI MAG B660 Bazooka over it this month for those reasons.

Prices of B660 boards have been fluctuating a lot, though, so if you find the Prime B660M-A D4 for a tenner or two less than this price, then it will make for a decent cut-price motherboard. It's plenty quick enough – it's just basic.

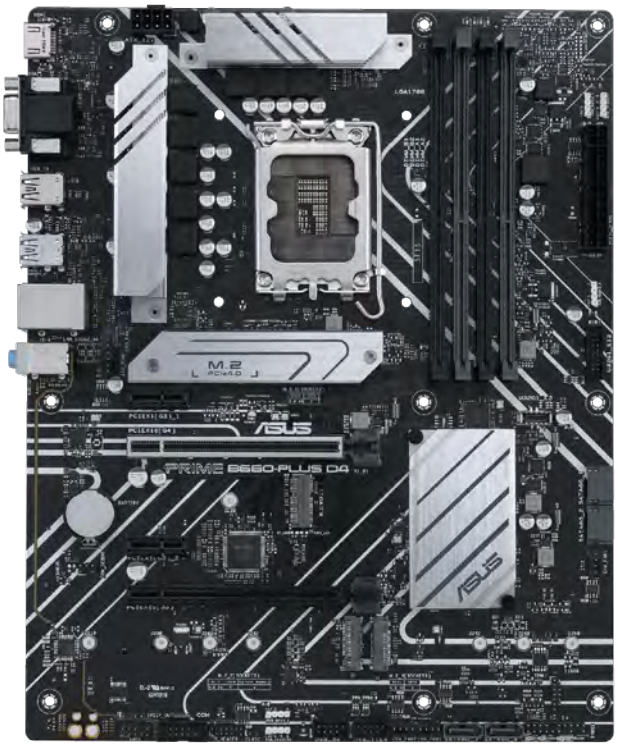
VERDICT

A solid effort in terms of performance, but even at this price, it cuts one too many corners.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
25/35	32/35	27/30	84%

ASUS PRIME B660-PLUS D4 / **£192** inc VAT

SUPPLIER box.co.uk



With a significantly higher price tag than its micro-ATX sibling, the Asus Prime B660-Plus D4 needs to offer noticeably more to justify its extra outlay, but at first glance, the boards appear to be very similar. There are the same eight power stages, along with a slightly bland design and no Wi-Fi included. The latter feels particularly tight on a board that costs nearly £200 inc VAT. It doesn't even include an integrated I/O shield.

Thankfully, on closer inspection, you do get a few extra bits and pieces. Both banks of VRMs are now heatsink-equipped, unlike the micro-ATX board, although temperatures were similar to its sister board this month at 58°C. There's an extra fan header as well, although the total here still stands at a paltry five. There's also a Type-C USB port on the rear I/O panel, 2.5 Gigabit Ethernet instead of Gigabit and, while it lacks Wi-Fi, it does at least include a shortened M.2 port to drop a cheap M.2 Wi-Fi card into the board instead of dealing with dongles or PCI-E cards.

This is just as well, as the amount of USB ports on the I/O panel is even worse than the line-up on the cheaper Asus board, with just five Type-A ports included, with a USB Type-C port occupying the place of the sixth port on the cheaper Prime B660M-A D4. The single M.2 heatsink is identical to that of the cheaper board too, so it was no surprise to see the same slightly toasty 66°C, which won't leave much room for throttling in a stuffy case on a warm day for extended heavy loads.

The on-board Realtek ALC897 audio is also fairly basic and lacks the full complement of ports, with just three standard 3.5mm mini-jacks, while the number of SATA 6Gbps ports sits at the bare minimum of four. The only real stand-out item is the trio of M.2 PCI-E 4 ports.

On the plus side, Asus' EFI and software are thankfully the best out there, with a particularly useful fan control suite in the EFI and Windows-based FanXpert 2+ software. It's a shame, then, that the board's cooling credentials sit at a bare minimum despite this board costing nearly £200.

Again, though, we can't really fault the Asus in our performance benchmarks, with the system score of 148,070 being similar to the rest of the field, as were the Cinebench R23 scores and audio performance. The Far Cry 6 frame rates were a frame per second or two lower than the competition, but this is a small difference. Likewise, the Asus had some of the higher power draw readings on test too, but the difference between other boards was only in single figures.

Conclusion

Once again, there's nothing inherently wrong with the Asus Prime B660-Plus D4, but we were expecting more for another £40 or so compared to the cheaper Asus Prime B660M-A D4.

It's mostly just as bland and unexciting, with just a few extra features to justify the higher price tag.

The Gigabyte B660 Gaming X DDR4 looks far more attractive, has more fan headers and more USB ports, so we suggest saving some cash and going for that board instead.

PLUS

- Solid performance
- USB Type-C port and header
- Good EFI and software

MINUS

- No integrated I/O shield
- M.2 and VRM temperatures are above average
- Mediocre on-board audio

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Form factor ATX

Memory support 4 slots: max 128GB DDR5 (up to 5066MHz)

Expansion slots One 16x PCI-E 4, one 16x PCI-E 3, two 1x PCI-E 3

Sound Realtek ALC897

Networking 1 x 2.5 Gigabit LAN

Cooling Five 4-pin fan headers, VRM heatsinks, M.2 heatsink

Ports 4 x SATA 6Gbps, 3 x M.2 PCI-E 4, 1 x USB 3.2 Gen 2x2 Type-C, 2 x USB 3.1, 1 x USB 3, 2 x USB 2, 1 x USB 3.1 Type-C header, 3 x audio jacks

Dimensions (mm) 305 x 244

VERDICT

Does the job, but it's a bit lacklustre for its price tag.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
29/35	33/35	21/30	83%

GIGABYTE B660 AORUS MASTER DDR4 / £220 inc VAT

SUPPLIER box.co.uk

A quick scan of popular etailers reveals quite a few Z690 motherboards available for under £200, so spending £220 on a B660 board that lacks multiplier overclocking for Intel's K-series CPUs might seem like a strange decision. Put simply, the Gigabyte B660 Aorus Master DDR4, which is also available in a DDR5 flavour, is for people who want all the extra features you get with a premium board, but have no intention of overclocking their hardware.

This makes sense, especially as the Z690 version of this board costs twice as much. You get an impressive count of eight fan headers, 802.11ax Wi-Fi, 2.5 Gigabit Ethernet and three M.2 ports covered by heatsinks. The latter helped the Aorus Master to get the second lowest M.2 temperature when stress-testing our PCI-E 4 SSD of 58°C, while its large VRM heatsinks helped to cool the 18-stage power delivery to 45°C, which was the lowest result on test. That bodes well for coping with a Core i7-12700 or Core i9-12900.

The rear I/O panel was night and day compared with the Asus B660-Plus D4 as well, with it including the Wi-Fi antenna outputs, nine USB Type-A ports, the full complement of audio outputs and even QFlash Plus – Gigabyte's USB BIOS FlashBack. You'll need to look elsewhere if you need more than four SATA ports, but this is enough for most people these days, especially if you'll be investing in an M.2 SSD and just need those ports for mass storage.

The lavish features continue with an on-board reset button and temperature sensors too, which can be handy for water-cooled systems, although admittedly that's an unlikely scenario given that potential owners won't be overclocking. Aesthetically, it looks fantastic too and it's hard to believe it costs just £30 more than the decidedly bland Asus B660-Plus D4.

Despite the board featuring RGB lighting and more gubbins than most other boards on test, it also had the lowest power draw this month, with our system sipping 192W from the wall under load and just 61W at idle with our Core i5-12600K. Performance numbers were on the money across the spectrum too. We were a bit disappointed with the audio performance though – despite the board sporting the reasonably premium Realtek ALC1220 codec, it could only offer a dynamic range of 93dBA and noise level of -93dBA.

Conclusion

For a motherboard, £220 is a lot to spend, especially one that lacks the ability to overclock K-series CPUs using their multipliers. However, not everyone wants to overclock, and the likes of the Core i9-12900K and Core i7-12700K have limited overclocking headroom anyway.

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Form factor ATX

Memory support 4 slots: max 128GB DDR5 (up to 5333MHz)

Expansion slots One 16x PCI-E 4, two 16x PCI-E 3

Sound Realtek ALC1220

Networking 1x Intel 2.5 Gigabit LAN, 802.11ax Wi-Fi

Cooling Eight 4-pin fan headers, VRM heatsinks, M.2 heatsinks

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 1 x M.2 PCI-E 3, 1 x USB 3.2 Gen 2x2 Type-C, 4 x USB 3, 4 x USB 2, 1 x USB 3.1 Type-C header, 5 x audio jacks, optical audio out

Dimensions (mm) 305 x 244

MASTERMIND

- \+ Excellent feature set
- \+ Plenty of ports
- \+ Looks great

SUPERMARKET SWEEP

- − Expensive
- − Average audio performance
- − Cheaper alternatives perform just as well

Also, the typical non-Z-series motherboards are often rather lacklustre products devoid of any premium or exciting extras.

This is where the Gigabyte B660 Aorus Master DDR4 steps in. You get enough fan headers, USB ports, cooling headroom, heatsinks and networking hardware to cater for a modern high-end system, but for significantly less money than a premium Z690 board. Thunderbolt 4 support would have been welcome too, but for its price, the B660 Aorus Master wants for very little.

VERDICT

Ideal for a high-end PC if you don't plan to overclock your CPU.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
34/35	33/35	22/30	89%

GIGABYTE B660 GAMING X DDR4 / £133 inc VAT

SUPPLIER box.co.uk

We felt sure that spending under £150 on a B660 motherboard wouldn't always have to land you with a bland and uninspiring board, so we hoped that Gigabyte might have the answer with the B660 Gaming X DDR4. First up, it looks great and costs just £133 inc VAT, which means two very important boxes are ticked in our search for the ideal affordable LGA1700 board.

Unlike the Asus B660M-A D4 Prime, it has full VRM heatsink coverage and doesn't look half-bare as a result, and it has a much more substantial M.2 heatsink as well. However, this didn't prove to be as effective as that on the Gigabyte B660 Aorus Master DDR4, with a peak temperature of 65°C when cooling our PCI-E 4 SSD. This will only be an issue if you plan to throw hundreds of gigabytes at a very fast SSD on a regular basis though.

The VRM temperatures were also warmer than the rest of the field at 60°C, which was 15°C warmer than those on the Gigabyte B660 Aorus Master DDR4. They're still well away from causing any sort of throttling, but the MSI MAG B660M Bazooka DDR4 was noticeably cooler here, even if this won't amount to much of a difference in reality. Underneath the heatsinks sits a 10-phase power delivery system made up of 60A phases.

Not surprisingly, there's no Wi-Fi at this price, but you do at least get 2.5 Gigabit Ethernet, and Gigabyte has even managed to include eight USB ports and six fan headers, which is more than you get from the pricier Asus B660-Plus D4. You get all six of the usual audio ports and an integrated I/O shield as well, which is absent from both Asus boards, plus there's even a reset button.

Of course, hoping for advanced testing tools is asking too much at £133, as is expecting more than four SATA 6Gbps ports, but Gigabyte has struck a decent balance. Thankfully, the performance numbers were also on par too, with the Gigabyte's RealBench system score of 149,867 being level with the rest of the field. Meanwhile, the respective Cinebench single and multi-threaded results of 1,875 and 17,177 were within a few points of the Gigabyte B660 Aorus Master DDR4.

The only slight negative point is above average total system power consumption at 205W under load, but this was only 13W more than the lowest figure produced by the Gigabyte B660 Aorus Master DDR4. Audio performance was also mediocre, but was actually slightly better than its sibling and on par with the majority of other boards. Finally, Gigabyte's software and EFI is also decent, even if they're a little less slick than the best examples on test.

Conclusion

It's not perfect, but the Gigabyte B660 Gaming X DDR4 strikes a great balance between aesthetics, features and price with which other manufacturers struggled in our sample set this month. It lacks Wi-Fi, and its VRM and M.2 SSD temperatures weren't the lowest on test, but these factors won't impact on performance, especially when it comes to the VRMs, as overclocking isn't an option anyway. It even has more fan headers and USB ports than more expensive boards, and these are the aspects that really matter at this price.

CHEAP AND CHEERFUL

- \+ Plenty of USB ports
- \+ Decent amount of fan headers
- \+ Aesthetically pleasing

CHEAP AND NASTY

- – No Wi-Fi
- – M.2 and VRM temperatures are above average
- – Mediocre on-board audio

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Form factor ATX

Memory support 4 slots: max 128GB DDR5 (up to 4400MHz)

Expansion slots One 16x PCI-E 4, two 16x PCI-E 3

Sound Realtek ALC897

Networking 1 x Realtek 2.5 Gigabit LAN

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

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 1 x M.2 PCI-E 3, 2 x USB 3.1, 2 x USB 3, 4 x USB 2, 1 x USB 3.1 Type-C header, 6 x audio jacks

Dimensions (mm) 305 x 244

VERDICT

A well-rounded board with plenty of features for a super-low price tag.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
28/35	32/35	30/30	90%

MSI MAG B660 TOMAHAWK WIFI / £220 inc VAT

SUPPLIER ebuyer.com

Another pricey option for Intel's B660 chipset is MSI's MAG B660 Tomahawk WiFi, which is available in several guises, including versions with either DDR4 or DDR5 memory support. MSI sent us the latter, which is around £30 more expensive than the DDR4 version.

That's worth bearing in mind, as any conclusions we draw here would likely be bolstered by a lower price tag, given that DDR5 offers little benefits for most people. In fact, including it on a B660 board at all is a questionable decision.

The board itself offers 14 power phases cooled by two large heatsinks. With a super-low VRM load temperature of just 48°C, the MAG B660 Tomahawk WiFi is a perfect home for one of Intel's high-end 12th-gen CPUs. All three of the M.2 ports are also covered by large heatsinks, which did a great job of cooling our PCI-E 4 SSD, with a temperature of just 55°C, which was the lowest result on test.

As its name suggests, you also get 802.11ax Wi-Fi, which is in addition to a single Realtek 2.5 Gigabit LAN port. If you want to kit your system out with fans, then the seven fan headers will also come in handy, although we recommend using the excellent fan control suite in the EFI rather than MSI's poor Windows software. The Tomahawk is also the only board on test to include six SATA ports, so if you'll be building a system with a stack of hard disks to transplant, the MAG B660 is a good option.

Meanwhile, you'll find USB Type-C support both on the rear I/O panel and in the form of a header on the PCB for compatible cases, but you still get a generous count of eight Type-A USB ports as well. MSI has included the Realtek ALC1220 audio codec as well, and you get the full complement of audio outputs, including an optical S/PDIF output.

Audio performance was the best on test, with the Tomahawk being the only board to get to a dynamic range of 100dBA, with a noise level of 99dBA, although its total harmonic distortion (THD) was higher than the rest of the field. In power consumption, our system setup with the Tomahawk drew nearly 10W more than it did with the Gigabyte B660 Aorus Master DDR4 under load, but this is only a small difference.

Performance elsewhere was mostly indistinguishable from the rest of the field, except for some slightly lower M.2 speeds. Even here, though, the differences were small and pale in comparison with the board's very low VRM and M.2 temperatures.

Conclusion

MSI's Tomahawk range has a reputation for being value-conscious, but not skimping on features, and punching above its weight. It certainly offers a generous set of features, but this is marred by the fact that this DDR5 version doesn't quite match the Gigabyte B660 Aorus Master DDR4 in terms of specification. Had MSI sent us the DDR4 version, the situation could be very different – it's £30 cheaper and gets all the above for just £190, albeit with DDR4 support, and would be a much better deal indeed.

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Form factor ATX

Memory support 4 slots: max 128GB DDR5 (up to 4800MHz)

Expansion slots One 16x PCI-E 4, one 16x PCI-E 3, one 1x PCI-E 3

Sound Realtek ALC1220

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

Cooling Seven 4-pin fan headers, VRM heatsinks, M.2 heatsinks

Ports 6 x SATA 6Gbps, 3 x M.2 PCI-E 4, 1 x USB 3.2 Gen 2x2 Type-C, 4 x USB 3.1, 4 x USB 2, 1 x USB 3.1 Type-C header, 5 x audio jacks, optical audio out

Dimensions (mm) 305 x 244

TONY HAWK

+ Good feature set
+ Excellent VRM and M.2 temperatures
+ Plenty of ports and fan headers

HUDSON HAWK

– DDR5 support bumpsup the price
– Not quite as many features as competition
– Poor software

VERDICT

A great board for the cash, but go for the DDR4 version.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
32/35	33/35	21/30	86%

MSI MAG B660M BAZOOKA DDR4

£150 inc VAT

SUPPLIER ebuyer.com

Going with a colour as a motherboard theme is always a risky move, but with a name such as Bazooka, an army green seems apt. In real life, the board is actually much darker than the photo, but it looks very attractive and it certainly has a more striking appearance than the bland Asus B660M-A D4 Prime. At £150, though, it's the pricier of the three least expensive boards this month, and with the Gigabyte B660 Gaming X DDR4 retailing for £18 less, the MSI MAG B660M Bazooka DDR4 has its work cut out.

Being a micro-ATX board, there's less PCB real estate on offer than an ATX board for starters, but you still get two PCI-E 4 M.2 ports, plus a trio of PCI-E slots with the top one offering PCI-E 4 support. There's also a decent array of heatsinks for the top M.2 port and both banks of VRMs, which sit at a total of 14 phases.

According to the software we used, the VRMs hit 50°C under load, which was on the cooler side of the results from this month's test. However, the opposite was true for the MSI's tiny M.2 heatsink, with our M.2 SSD temperature sitting just a couple of degrees from the hottest result on test, although that's still a good 10-15°C away from potentially resulting in throttling.

You don't get Wi-Fi with the Bazooka, but unlike the Asus B660M-A D4 Prime, you do get an integrated I/O shield. The I/O panel is rather spartan, though, with six USB ports, just three 3.5mm mini-jacks for audio and no USB Type-C port. You do at least get 2.5 Gigabit Ethernet, and should you wish to use your 12th-gen CPU's on-board graphics, there are HDMI 2.1 and DisplayPort 1.4 outputs too.

Still, the feature set is lacking compared with that of the Gigabyte B660 Gaming X DDR4, which has more USB and audio ports and two extra fan headers, while costing less money. There isn't much else to write home about that would persuade you to get the Bazooka over the Gigabyte board either. You get a Type-C header and four SATA 6Gbps ports, which is line with most of the other boards on test. While Arnold Schwarzenegger would approve of the name and colour scheme, you're clearly paying a premium for it.

There was no miraculous turnaround in the benchmarks either, with no results that stood out from the crowd, but equally nothing of concern either. The RealBench system score of 149,555 was similar to the rest of the field, as was the minimum 99th percentile frame rate of 81fps in Far Cry 6, while it topped the rest of the field by 100 points or so in the Cinebench multi-threaded test. Sadly, even that wasn't anything to get excited about.

Conclusion

If you want a green-themed motherboard, or are otherwise taken in by the MSI MAG B660M Bazooka DDR4's design, then it's a solid effort with a reasonable amount of features for the cash. It's also a much better bet than the Asus B660M-A D4 Prime. However, if you can house a larger ATX motherboard, the Gigabyte B660 Gaming X DDR4 is better in nearly every way, and it costs less money too.

BAZOOKA

+ Attractive styling
+ Reasonable number of ports and headers
+ Decent VRM temperatures

VERUCA

− Fewer features than competition
− Green styling may not suit your build
− Mediocre on-board audio

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Memory support 4 slots: max 128GB DDR5 (up to 4800MHz)

Expansion slots One 16x PCI-E 4, one 16x PCI-E 3, one 1x PCI-E 3

Sound Realtek ALC897

Networking 1 x Realtek 2.5 Gigabit LAN

Cooling Four 4-pin fan headers, VRM heatsinks, M.2 heatsink

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 2 x USB 3.1, 2 x USB 3, 2 x USB 2, 1 x USB 3.1 Type-C header, 3 x audio jacks

Dimensions (mm) 244 x 244

VERDICT

An attractive micro-ATX B660 board, but it doesn't offer quite as good value as the ATX competition.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
27/35	33/35	25/30	85%

Wireframe

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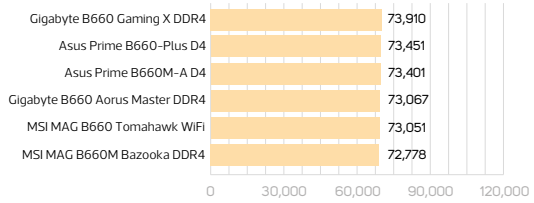
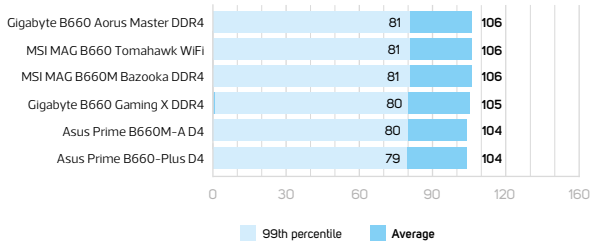
B660 MOTHERBOARDS LABS RESULTS

GIMP IMAGE EDITING

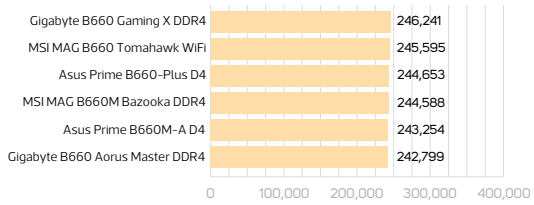


FAR CRY 6 (FPS)

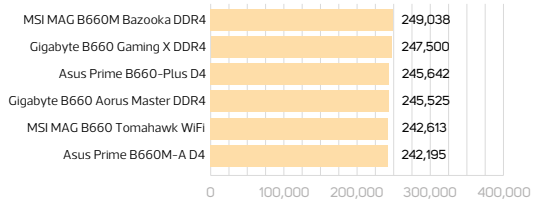
1,920 x 1080, Ultra settings



HANDBRAKE H.264 VIDEO ENCODING

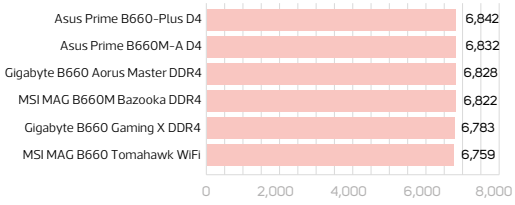


HEAVY MULTI-TASKING

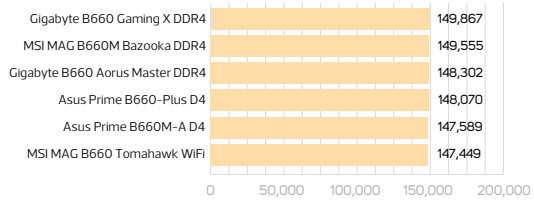


M.2 SEQUENTIAL READ (MB/SEC)

CrystalDiskMark 32-queue-depth

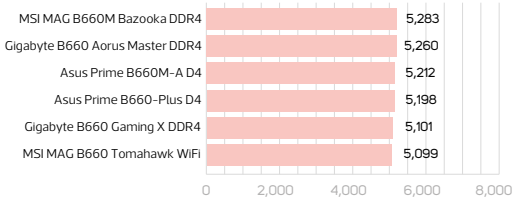


SYSTEM SCORE

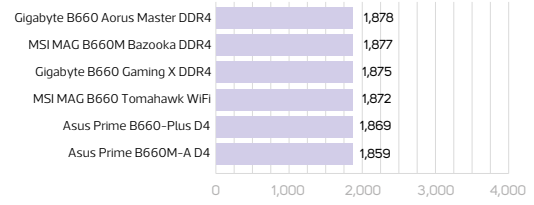


M.2 SEQUENTIAL WRITE (MB/SEC)

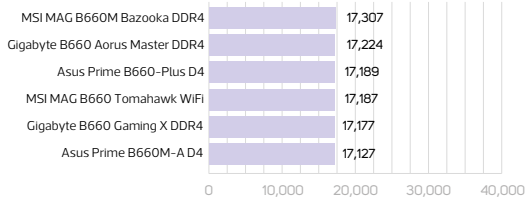
CrystalDiskMark 32-queue-depth



CINEBENCH R23 SINGLE-THREADED



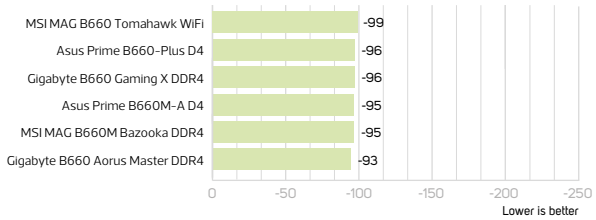
CINEBENCH R23 MULTI-THREADED



B660 MOTHERBOARDS LABS RESULTS

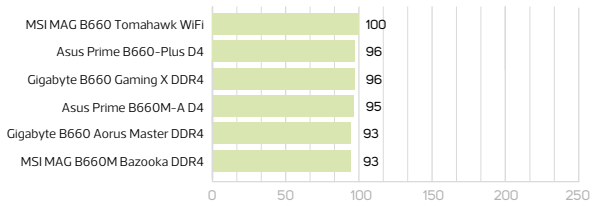
AUDIO NOISE LEVEL (dBA)

RightMark Audio Analyzer, 24-bit/192kHz



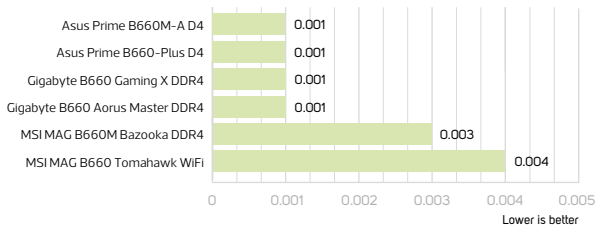
AUDIO DYNAMIC RANGE (dBA)

RightMark Audio Analyzer, 24-bit/192kHz



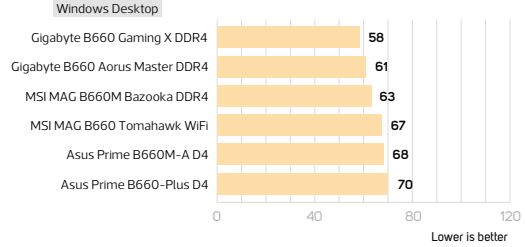
AUDIO TOTAL HARMONIC DISTORTION (PER CENT)

RightMark Audio Analyzer, 24-bit/192kHz



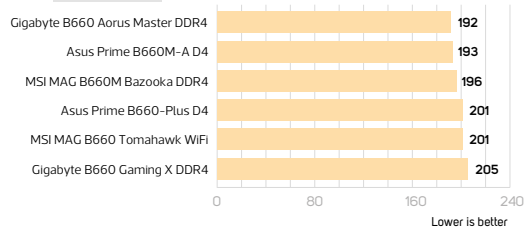
IDLE TOTAL SYSTEM POWER CONSUMPTION (W)

Windows Desktop

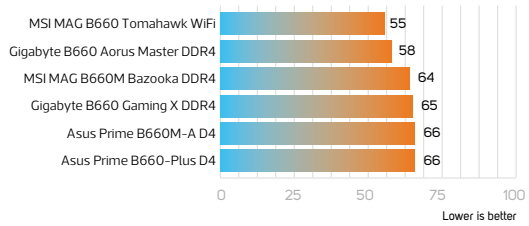


LOAD TOTAL SYSTEM POWER CONSUMPTION (W)

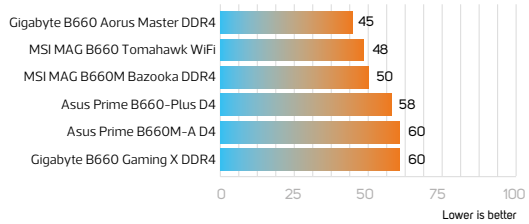
Prime95 smallFFT



LOWEST M.2 TEMPERATURE (°C)



LOWEST VRM TEMPERATURE (°C)



LABS TEST

Mini drivers

Edward Chester puts five sets of compact, desk space-saving speakers with decent sound quality to the test

How we test

If you quickly browse your favourite electronics etailer, you'll find dozens of options for budget PC speakers, and there are plenty of gems to be found for well under £100. However, if you're after a speaker set with a little more power and finesse, your options are quite limited.

Many manufacturers have simply abandoned the higher end of the market with even the likes of Logitech having no stereo speaker sets that cost more than £60. Step into the wider world of hi-fi speakers, and powered monitors aimed at recording studios, and there's a wealth of options, but they tend to be rather large for desktop use and lack convenient extra features. To find out just what options are available, we've rounded up a handful of the latest stereo speaker options priced between £100 and £330, and put them to the test.

We start our assessment looking at the design and build quality. When you're paying a premium, you expect premium materials and a sturdy design that will stand the test of time. Next, we look at the features on offer. All these speakers include Bluetooth support for convenient playback from portable devices.

Some also include USB audio interfaces, saving you having to buy a quality sound card to get the best from the speakers. Meanwhile, control systems, remote controls and connection arrangements can all make or break the ease of use of a speaker system, especially as it may well end up tucked away at the back of a desk behind a monitor.

Our final test is to simply listen to the speakers across a wide variety of music, games and video to see how they perform. Ideally with higher-end speakers, we're looking for excellent clarity in higher frequencies, which is crucial for drawing out the details of your listening matter.

An accomplished audio system should also deliver a good degree of bass presence, but with a smooth, unforced quality, rather than the random booms of cheap, badly tuned systems. Most of these speakers have an output for a separate subwoofer, so the speakers themselves shouldn't be forcing their bass presentation too much.

We score each speaker on design, features, sound quality and value, and then give a a final weighted score that's the sum of all these elements.

Contents

- Audioengine A1 / p57
- Creative T100 / p58
- Edifier R1280DB / p59
- Klipsch R-41PM / p60
- Ruark Audio MR1 Mk2 / p61

AUDIOENGINE A1 / £139 inc VAT

SUPPLIER amazon.co.uk

Audioengine has established itself as among the go-to options for premium PC speakers, thanks to its very compact and well-regarded A1 and A2+ speaker ranges. The A1 is the cheaper of the two options, lacking the USB input and painted finish of the A2+, and it's also based on a digital Class D amp rather than the more desirable analogue Class AB amp of the A2+.

Despite lacking a fancy painted exterior, the A1's speakers still look fantastic. In fact, they're one of those products where photos or renders really don't do them justice. The stark matt grey vinyl covering (over an MDF construction), slightly curved corners and lack of a covering for the drivers has a great minimalist charm to it.

The speakers are particularly compact too, making them ideal for cramped desk spaces, especially as the front-firing bass port means you can sit them against a wall. The downside is that the drivers are then that much closer to the desk surface, resulting in sound reflection interference, and further away from being directed at your ears. Of all the speakers on tests, the A1s would most benefit from some stands to raise and angle them up towards you. Audioengine sells matching stands for £30, which angle up the speakers slightly, and they're a worthwhile addition.

SPEC

Audio config 1 x 70mm woofer and 1 x 19mm tweeter per speaker with front bass port

Nominal power output 60W

Frequency range 65Hz – 22,000kHz

Connections 3.5mm stereo input, Bluetooth 5, phone output for subwoofer

Dimensions (mm) 102 x 133 x 152 (W x D x H)

Extras Volume knob on right speaker

Functionally, the A1 is the simplest speaker set on test, with no remote control, no buttons on the front or sides of the speakers and no USB or other physical digital input. However, you do get a Bluetooth connection.

Around the back of the right speaker is a single dial for turning on the speakers and adjusting volume. This combined feature means you can't set a volume and forget about it, but must dial in a setting each time you twist the dial to turn on the speakers. Combine this with the fact that the dial is around the back, and you have a power/volume system that's not very convenient if your speakers are slightly out of reach.

The main audio input is a 3.5mm stereo jack socket, plus there's a phono socket for hooking up an extra subwoofer. Each speaker also has a pair of spring clips for connecting the left speaker to the right speaker, while the right speaker is home to a figure-of-eight mains power socket and Bluetooth pairing button, which glows and flashes to indicate its status.

The subwoofer connection is a useful addition as, despite their impressive power, the A1 speakers are still small, so they benefit from a bass boost, particularly for higher volume listening. Having the upgrade path makes this a versatile speaker set.

ENGINE SHED

- \+ Great styling
- \+ Really compact design
- \+ Excellent clarity
- \+ Good value

GARDEN SHED

- − Inconvenient rear volume control
- − Lacking in bass
- − Short, so they need stands

In terms of power, these speakers certainly aren't lacking when it comes to normal desktop listening – they easily fill small-to-medium sized rooms. However, bass is definitely lacking, with even the Creative T100s having a slightly more impactful rumble in big dance music tracks.

What the A1 speakers lack in low-end, though, they make up for in mid-range warmth and top-end detail, providing far more sparkle and richness than the slightly boxy-sounding T100. The Edifier R1280DB speakers fill in that low end more but they don't sound as crisp at the top end.

Conclusion

With their combination of great styling, super-compact size and Bluetooth for easy connection, the Audioengine A1 speakers are ideal for a compact desk setup. They may lack bass, but they have loads of sparkling detail and mid-range warmth, plus the option to add a sub.

VERDICT

Ideal for those seeking compact desktop speakers, although they lack a little bass.

DESIGN	FEATURES	OVERALL SCORE
18/20	16/20	78%
SOUND QUALITY	VALUE	
24/30	20/30	

CREATIVE T100 / £100 inc VAT

SUPPLIER amazon.co.uk

Creative has consistently made some of the most well-regarded PC speakers for decades now, with its T20 speakers (£65 inc VAT) being a favourite of ours for many years. At the top end of its current range of stereo speakers, though, is the T100, which add Bluetooth and USB audio playback, as well as an infrared remote control, making for a far more convenient all-round package than the T20 set.

Another key improvement over the T20 is the design of the T100 speakers. Each speaker's oblong shape and curved front is covered completely by a painted black metal grille, giving them a much smarter overall look than the sparkly paint and yellow highlights of the T20 speakers.

That said, there's still a noticeable lightweight plasticky quality here when compared with the other speakers on test. That's to be expected given their lower price, but it's exacerbated by the choice of glossy plastic for the backs and sides of the units – a matt finish would mask the plastic build to a degree and certainly wouldn't be so prone to fingerprints and scratches.

CRYSTAL CLEAR

- \+ Slick design
- \+ Useful remote
- \+ Analogue and digital inputs

CLEAR AS MUD

- – Slightly boxy sound
- – Glossy plastic exterior
- – No USB PC connection

SPEC

Audio config 1x70mm woofer and 1x25mm tweeter per speaker with rear bass port

Nominal power output 40W

Frequency range 76Hz – 21,000kHz

Connections 3.5mm stereo input, digital optical input, USB audio input, Bluetooth 5

Dimensions (mm) 93 x 130 x 208 (W x D x H)

Extras Remote control, volume, source and power buttons on right speaker

The front grilles aren't removable, and neither is the cable that exits the back of the left speaker to plug into the right speaker. Its 2.4m length should be ample for most desktop setups, but if it does prove too short, you'll have a tough time fitting a longer cable.

Atop the right speaker are three rubber buttons for input, volume up/down and power, while an infrared remote provides a host of other controls, such as changing treble and bass levels, controlling Bluetooth playback and changing EQ. It doesn't come with batteries (two AAAs), though, and the buttons are rather unsatisfying rubber affairs. We also initially kept confusing the treble/bass controls for volume, but it gets the job done and beats having no remote.

Around the back of the right speaker are all the inputs and outputs, consisting of a 3.5mm analogue input, optical digital input, USB input, the left speaker output and the 18V power input. The USB input is an odd one, as it's not a Type-B port for connecting to a computer but rather a Type-A port for plugging in USB flash drives, providing the ability to play FLAC, WAV and MP3 audio files. In today's streaming-focused world, that feels like a real throwback feature – a digital PC hook-up would be far more useful.

When it comes to audio quality, the T100's 70mm drivers and 25mm tweeters deliver all the power you should need for desktop listening, easily filling a small room with undistorted sound. They're also ample for small late-night kitchen party duties and for use with smaller TVs.

Where they come up a little short is in fine detail and bass presence. The small cabinets and drivers simply can't drive the lowest rumbles, while the amp and driver combo can't reproduce the final bit of sparkle of more expensive units. The Edifier R1280DB speakers have more bass presence and smoother overall presentation, and the Audioengine A1 speakers have a much smoother, more detailed top end.

Conclusion

The Creative T100 set offers a great combination of features – even if the USB flash drive playback is a bit odd – and the speakers look great. They're also easy to use and sound okay for their size. If you're not fussed about the remote control, though, the much cheaper T20s will give you similar audio performance.

VERDICT

A touch pricey for their audio quality, but they look smart and have lots of useful features.

DESIGN	FEATURES	OVERALL SCORE
16/20	16/20	72%
SOUND QUALITY	VALUE	
20/30	20/30	

EDIFIER R1280DB

/ £110 inc VAT

SUPPLIER overclockers.co.uk

The Edifier R1280DB has been the only speaker set on our Elite list for many years, but does it still hold up several years later? When it comes to design, these speakers still more than hold their own, given their price. Available with either wood texture sides (all-black or a grey and wood-coloured finish) or plain gloss white, all the versions look great. There's a typical speaker aesthetic to them, but the rounded corners and clean lines have a distinct charm that remains if you remove the front cloth grilles.

Where the R1280DB can't compete with the likes of the Audioengine A1 and Ruark Audio MR1 Mk2 is the size of the speakers. The Edifiers are much larger units, more akin to full-sized hi-fi speakers, although they're at least a good bit (5cm) shorter in height than the Klipsch R-41PM. Nonetheless, you'll need a reasonable amount of desk space to accommodate them.

For features, the R1280DB offers up a similar range to the other speaker sets on test, adding Bluetooth support for convenient connection to a phone or other mobile device, and you get two analogue inputs in the form of two pairs of RCA inputs. Edifier includes RCA-to-RCA and RCA-to-3.5mm jack cables in the box.

All the connections are found around the back of the right speaker, with an optical and coaxial digital input joining the analogue inputs, plus you get a chunky mains power switch. Here you'll also find the spring clips for connecting up the left speaker and the (sadly) tethered power cable – a removable cable would be preferable here.

Around the side of the right speaker are the controls, consisting of three dials for treble, bass and combined volume/input/power. The latter controls volume when turned and switches the speakers on or changes inputs when tapped. Hold it down and the units will go into standby.

Alternatively, you can use the little button-cell remote control. It uses cheap popper-style buttons, which feel a little unsatisfying but it's simple to use with buttons for power, volume and Bluetooth playback. There are also individual buttons for each input, so you don't have to cycle through inputs as you do with the dial on the side.

Inside each speaker you'll find a 100mm bass driver, which puts these speakers in the same league as the Klipsch R-41PM for driver size, along with a 13mm tweeter and front-facing bass port, which means you don't have to worry about leaving a gap behind the speakers.

This combination of relatively large speaker housing and large main drivers makes for a very smooth, unforced and full sound. Bass isn't cranked up and booming as it can be for systems with a separate subwoofer, but there's none of the tailed-off bottom end that we see with the Audioengine and Creative speakers.

Top-end detail isn't the most striking, with the more expensive speakers on test delivering more crispness and definition, but again it's the smoothness of the presentation that makes the R1280DB so likeable. These speakers will play anything perfectly well and at very decent volumes too – they could easily step up from late-night kitchen party duties to full-on house party levels.

Conclusion

The Edifier R1280DB (and the Bluetooth-less R1280T) remains a fantastic mid-range PC speaker set. With a great balance of size, features, design, ease of use and audio performance, they're a steal for just over £100. Spending more certainly gets you more top-end detail, but these speakers are great for most uses.

SPEC

Audio config 1x100mm woofer and 1x13mm tweeter per speaker with a front bass port

Nominal power output 42W

Frequency range 55Hz – 20,000kHz

Connections 2 x stereo phono/RCA analogue inputs, digital optical and coaxial input, Bluetooth

Dimensions (mm) 146 x 196 x 234 (W x D x H)

Extras Remote control, treble, bass and volume/power/input knobs on right speaker

EDIFYING

+ Smart design
+ Packed with features
+ Great value
+ Smooth, well-balanced sound

MIND-NUMBING

– Quite large units
– Lacks a little top-end detail

VERDICT

A highly versatile and affordable speaker set that's still easy to recommend.

DESIGN	FEATURES	OVERALL SCORE
16/20	18/20	82%
SOUND QUALITY	VALUE	
24/30	24/30	

KLIPSCH R-41PM / £324 inc VAT

SUPPLIER amazon.co.uk

The Klipsch R-41PM pushes the limits of conventional desktop or PC speakers for one key reason – size. The R-41PM speakers have a height of 287mm and depth of 216mm, making them bigger than all the other units on test. When placed side by side with the other speakers on test, the R-41PM units dwarf those of the competition. However, that size brings a host of advantages for any speaker design, and sure enough, the R-41PM set delivers the sonic goods.

The large 100mm full-range drivers, high-quality tweeters and powerful amplifier make for a sound that's more than a match for many hi-fi systems. The most obvious factor, other than the sheer power on tap, is the overall range, with the wonderfully engaging top-end detail delivered alongside loads of mid-range warmth and driving bass.

In fact, the bass is almost a little much. From our past experience of Klipsch headphones, we know the company tends to push its bass presentation a little – as it's a very popular sound profile – and that's the case here too. It's a shame the company hasn't included bass and treble controls to allow users to tweak the tone balance themselves. The bass port is also rear-facing, so you'll need to provide some room behind the speakers to allow them to breathe.

Where these speakers are surprisingly less accomplished – especially given their hefty price – is in their physical design. The totally straight sides and sharp corners with a black wood-effect vinyl wrap looks just a bit plain. They certainly don't look cheap, but the curved corners of the Audioengine, Edifier and Ruark Audio options on test this month all have a little more charm to our eyes. One neat design feature, though, is that the fabric covers are magnetically attached, so you get a particularly clean-looking front if you remove them.

When it comes to features, the R-41PM speakers keep all their extras hidden, with the front, top and sides devoid of knobs or buttons. Just a small triangle of translucent black plastic on the front of the right speaker, under its grille, gives away this set's remote-control capability.

However, around the back of the right speaker you'll find plenty of extras. There's a volume and source-select dial, a ground point, USB and optical digital audio inputs, 3.5mm jack and twin RCA analogue inputs, a subwoofer output, a switch for selecting line or phono input levels (for use with a record player), the banana plug/screw points for the left speaker's very long and thick cable and the figure-of-eight mains input. It's an exhaustive selection that, when combined with the Bluetooth connection, makes for a versatile setup.

The remote control is handy too. You can adjust the volume of the speakers and sub, control Bluetooth playback and select input, as well as turn off the little LED that glows through the front of the right speaker.

Conclusion

Masses of power, a strong bass response and crystal-clear detail defines this highly accomplished desktop speaker set. If you're after a set of speakers that can handle both PC and party duties, these certainly deliver. Their design is a bit boxy and bulky, and some may find their bass presence a touch strong, but they're ideal if you don't mind a bit of bass.

SPEC

Audio config 1 x 100mm woofer and 1 x 25mm tweeter per speaker with rear bass port

Nominal power output 70W

Frequency range 76Hz – 21,000kHz

Connections Phono stereo input, 3.5mm stereo input, digital optical input, USB audio input, Bluetooth with aptX, RCA subwoofer output

Dimensions (mm) 146 x 216 x 287 (W x D x H)

Extras Remote control, USB audio playback

BIG BASS BOXES

+ Very powerful sound
+ Masses of detail
+ Loads of bass
+ Lots of features

TINY TINNY TIN CANS

– No front-mounted controls
– Rear bass port limits positioning
– Slightly boring design
– Bass a bit strong and non-adjustable

VERDICT

Big boxes with big bass, the Klipsch R-41PM speakers deliver everything you'd hope from a large, pricey desktop speaker set.

DESIGN	FEATURES	OVERALL SCORE
14/20	18/20	78%
SOUND QUALITY	VALUE	
28/30	18/30	

RUARK AUDIO MR1 MK2 / £350 inc VAT

SUPPLIER johnlewis.com

Ruark Audio has made a name for itself by specialising in DAB radios and other compact, all-in-one audio systems. As such, the MR1 Mk2 is a departure for the company, delivering a simple pair of powered speakers.

That pedigree in designing compact bedside and kitchen-based audio products that can be seen from all angles is clear with the MR1 Mk2. The speakers are small and effortlessly elegant, with their curved sides and mottled grey fabric covers. The dainty little feet also provide enough space under the speaker for its bass port to breathe – there are no placement restrictions with these speakers.

Available in either walnut veneer or a soft grey lacquer (it looks white to us), both options look fantastic, but we're a bit disappointed to find that below the pull-off fabric grilles, there's a plain MDF frame that means you can't run the speakers without the grilles and maintain a smart look.

PARTY PIECE

+ Slick design
+ Loads of features
+ Easily portable design

PARTLY IN PIECES

- Basic remote
- Lacks a big bass hit
- Top-end detail could be better

SPEC

Audio config 1x75mm woofer and 1x20mm tweeter per speaker with underside bass port

Nominal power output 20W

Frequency range 55Hz – 22,000Hz

Connections 3.5mm line input, digital optical input, Bluetooth with aptX, RCA subwoofer output

Dimensions (mm) 130 x 140 x 175 (W x D x H)

Extras Remote control, auto mono operation, battery pack compatible, volume control knob on top of right speaker

For features, you get a similar selection to the other speakers on test, with a digital optical input, 3.5mm jack analogue input, a subwoofer output and Bluetooth connection. You can also use the right speaker on its own and it will automatically run in a mono mode, which is a handy touch for portability. The left and right speakers also join via a mono jack cable, making for a tidy setup that's easy to unplug for portable mono use. This is particularly useful, as you can also buy battery packs for these speakers making them truly portable (£69 inc VAT).

On top of the right speaker is a dial that controls volume, sets the speakers into standby and switches between inputs. The volume dial is little wobbly and moves in larger volume increments than we'd prefer, but it's otherwise a convenient system.

A little popper button remote is also included, and it provides volume, power, input and Bluetooth connection control, but you can't control Bluetooth media playback. It would be good to see a slightly higher-quality remote for a speaker set of this price, but it gets the job done.

Despite their width rivalling that of the Klipsch R-41PM, the MR1 Mk2's speakers are overall quite small, so they only have room for 75mm main drivers rather than the 100mm drivers of the Edifier and Klipsch. As a result, these speakers don't have quite the same overall power, low-end rumble and smoothness of those speakers. There's still more low-end rumble and warmth than the Audioengine A1 and Creative T100, but nowhere near the level of those larger speakers.

However, while the Audioengine A1 falls behind in terms of the low end, it at least equals if not surpasses the MR1 Mk2 for top-end detail and smoothness of presentation There's a lack of sparkle and articulation to the Ruarks that we didn't expect at this price. We found it particularly noticeable when listening to heavy metal, where the MR1s tended to muddy the details. However, the greater low-end presence and warmth made listening to classic piano and dance music more enjoyable than on the A1.

Conclusion

A fetching, compact design, easy portability and plenty of features make the MR1 a great all-rounder. The speakers are powerful and detailed enough for PC listening and can easily stretch to kitchen party duties, while the addition of a battery pack allows for outdoor listening. However, there's a lack of real bass, and top-end detail could be better, especially considering their price. CPC

VERDICT

Great-looking and hugely versatile, but lacking in sonic performance for their price.

DESIGN	FEATURES	OVERALL SCORE
18/20	18/20	75%
SOUND QUALITY	VALUE	
23/30	16/30	

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.

8-core system with integrated graphics

8-core CPU, basic gaming

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 5700G	scan.co.uk	**#218** p20	£290
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#218** p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 8 integrated into CPU	N/A	**#218** p20	£0
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M 2B3200C16)	scan.co.uk	**#218** p78	£63
MOTHERBOARD	Asus TUF B450M-PLUS II (micro-ATX)*	awd-it.co.uk	**#218** p78	£75
STORAGE	500GB WD Blue SN570 (M.2 NVMe)	scan.co.uk	**#222** p20	£48
	Total £476			

***This motherboard may require a BIOS update in order to recognise the new CPU**

1,920 x 1,080 gaming

6-core CPU, 1080p gaming

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12400F	scan.co.uk	**#224** p14	£170
CPU COOLER	ARCTIC Freezer i13X	scan.co.uk	**#224** p76	£20
GRAPHICS CARD	AMD Radeon RX 6600 XT	amazon.co.uk	**#220** p53	£420
MEMORY	16GB (2 x8 GB) Corsair Vengeance LPX DDR4 3200MHz (CMK16GX4M2E 3200C16)	scan.co.uk	**#224** p76	£58
MOTHERBOARD	Gigabyte B660 Gaming X DDR4 (ATX)	box.co.uk	**#224** p50	£133
STORAGE	1TB WD Blue SN570 (M.2 NVMe)	scan.co.uk	**#222** p20	£75
	Total £876			
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	cclonline.com	**#220** p55	£649
SWAP STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£116

2,560 x 1,440 gaming system

10-core CPU, 1080p and some 2,560 x 1,440 gaming

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12600K	scan.co.uk	**#220** p19	£280
CPU COOLER	EK AIO 120 D-RGB (120mm AIO liquid cooler)	scan.co.uk	**#223** p40	£73
LGA1700 ADAPTOR	EK-AIO LGA1700 Upgrade Kit	ekwb.com	**#223** p40	£4
GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	cclonline.com	**#220** p55	£649
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£72
MOTHERBOARD	Gigabyte Z690 Gaming X DDR4	ebuyer.com	**#222** p46	£210
STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£116
	Total £1,404			

UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£78

Mid-range gaming system

12-core CPU, smooth 2,560 x 1,440 gaming and ray tracing

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i7-12700K	scan.co.uk	**#220** p18	£400
CPU COOLER	NZXT Kraken X53 (240mm AIO liquid cooler)	scan.co.uk	**#221** p76	£120
LGA1700 ADAPTOR	Asetek Premium Retention Kit LGA1700	overclockers.co.uk	**#221** p76	£5
GRAPHICS CARD	Nvidia GeForce RTX 3070 Ti	cclonline.com	**#220** p43	£839
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£72
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	cclonline.com	**#222** p48	£230
STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£116
	Total £1,782			

UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£78

Core component bundles cont ...

4K gaming system

12-core CPU, 4K gaming

Needs an ATX case with room for a 240mm all-in-one liquid cooler. We recommend an 850W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i7-12700K	scan.co.uk	**#220** p18	£400
CPU COOLER	NZXT Kraken X53 (240mm AIO liquid cooler)	scan.co.uk	**#221** p76	£120
LGA1700 ADAPTOR	Asetek Premium Retention Kit LGA1700	overclockers.co.uk	**#221** p76	£5
GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	ebuyer.com	**#221** p48	£1,430
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX4M2 C3200C16)	scan.co.uk	**#221** p76	£72
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	cclonline.com	**#222** p48	£230
STORAGE	1TB WD Black SN850	box.co.uk	**#215** p49	£150

Total £2,407

UPGRADES

ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	**#166** p54	£78

Content creation system

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

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i9-12900K	scan.co.uk	**#220** p16	£580
CPU COOLER	NZXT Kraken X73 (360mm AIO liquid cooler)	scan.co.uk	**#221** p76	£160
LGA1700 ADAPTOR	Asetek Premium Retention Kit LGA1700	overclockers.co.uk	**#221** p76	£5
GRAPHICS CARD	AMD Radeon RX 6600 XT	amazon.co.uk	**#220** p53	£420
MEMORY	32GB (2 x 16GB) Corsair Dominator Platinum RGB 5200MHz DDR5 (CMT32GX5M2 B5200C38W)	corsair.com/uk	**#221** p76	£310
MOTHERBOARD	MSI MEG Z690 Unify	scan.co.uk	**#222** p50	£515
STORAGE	2TB WD Black SN850	scan.co.uk	**#215** p49	£300

Total £2,290

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	ebuyer.com	**#221** p48	£1,430
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	**#166** p54	£78

Mini PCs

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

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z690 (LGA1700)	Asus ROG Strix Z690-I Gaming WiFi	scan.co.uk	**#220** p22	£388
Intel Z590 (LGA1200)	Gigabyte Z590I Vision D	scan.co.uk	**#214** p18	£280
AMD B550 (AM4)	Asus ROG Strix B550-I Gaming	scan.co.uk	**#206** p44	£210

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	scan.co.uk	**#206** p18	£100
TOWER	Ssupd Meshlicious	overclockers.co.uk	**#219** p18	£92
PREMIUM	Streacom DA2 V2	quietpc.com	**#214** p51	£203

Other components

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE CPU COOLER	Noctua NH-L12S	scan.co.uk	**#219** p54	£55
SFX POWER SUPPLY	SilverStone SX750	scan.co.uk	**#219** p72	£130

ATX cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET RGB	Antec DF700 FLUX	scan.co.uk	**#214** p26	£80
SUB-£100 AIRFLOW	Corsair 4000D Airflow	scan.co.uk	**#222** p56	£90
COMPACT	Fractal Design Meshify 2 Compact	scan.co.uk	**#215** p20	£110
HIGH AIRFLOW	Fractal Design Meshify 2	scan.co.uk	**#212** p45	£140
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	**#202** p44	£140
SUB-£150	Fractal Design Define 7	overclockers.co.uk	**#204** p18	£140
PREMIUM	Corsair iCUE 5000T RGB	scan.co.uk	**#224** p22	£350

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD B450 (AM4)	Asus TUF B450M-PLUS II	awd-it.co.uk	**#218** p76	£75
AMD B550 (AM4)	MSI MAG B550M Mortar	ebuyer.com	**#204** p42	£130

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Kolink Citadel Mesh RGB	overclockers.co.uk	**#218** p26	£65

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET ROUTER	Belkin RT3200-UK	currys.co.uk	**#216** p52	£119
ROUTER	Asus RT-AX68U	scan.co.uk	**#216** p51	£170
MESH ROUTER	Asus AiMesh AX6100	amazon.co.uk	**#196** p54	£348
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	**#196** p58	£60
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	**#200** p22	£154
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£202
2.5 GIGABIT DUAL-BAY NAS BOX	QNAP TS-231P3	ebuyer.com	**#212** p25	£282

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

Monitors

Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144HZ, IPS, 1,920 X 1,080, F, G	AOC 24G2U	overclockers.co.uk	#214 p28	£190
25IN, 240HZ, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	box.co.uk	#209 p57	£200
25IN, 360HZ, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	amazon.co.uk	#212 p20	£522

Up to 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 144HZ, IPS, 1,920 X 1,080, F, G	AOC 27G2U	overclockers.co.uk	#201 p53	£230
27IN, 240HZ, IPS, 1,920 X 1,080, F, G	Asus TUF Gaming VG279QM	overclockers.co.uk	#209 p60	£340
27IN, 165HZ, VA, 2,560 X 1,440, F, G	AOC CQ27G3SU	box.co.uk	#223 p45	£338
27IN, 240HZ, TN, 2,560 X 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£590
27IN, 240HZ, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£700
28IN, 144HZ, IPS, 3,840 X 2,160, F, G	AOC U28G2XU	amazon.co.uk	#221 p29	£590

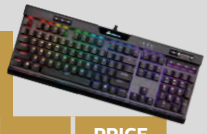
Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60HZ, VA, 4K, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£385
32IN, 144HZ, VA, 2,560 X 1,440, F, G	iiyama G-Master GB3266QSU	ebuyer.com	#224 p30	£366
32IN, 165HZ, IPS, 2,560 X 1,440, F, G	LG UltraGear 32GP850	overclockers.co.uk	#220 p38	£480
34IN, 144HZ, IPS, 3,440 X 1,440, W, F	iiyama G-Master GB3461WQSU	scan.co.uk	#206 p53	£460
34IN, 144HZ, IPS, 3,440 X 1,440, W, F, G	LG UltraGear 34GN850	currys.co.uk	#206 p55	£899
38IN, 144HZ, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	currys.co.uk	#208 p30	£1,399
32IN, 144HZ, IPS, 3,840 X 2,160, F, G, HDR	Asus ROG Swift PG32UQX	scan.co.uk	#218 p54	£3,299

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 75HZ, IPS, 2,560 X 1,440, F	LG 27QN880	box.co.uk	#210 p26	£404

Peripherals and audio



Gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET TKL	SteelSeries Apex 3 TKL	currys.co.uk	#221 p59	£48
OPTICAL ESPORTS	Asus ROG Strix Scope RX	amazon.co.uk	#209 p43	£70
MECHANICAL MMO	Corsair K95 RGB Platinum	scan.co.uk	#164 p26	£180
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	#193 p56	£150
PREMIUM TKL MECHANICAL	Corsair K70 RGB TKL	scan.co.uk	#214 p31	£140
WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	overclockers.co.uk	#208 p60	£180

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Corsair M55 RGB Pro	box.co.uk	#200 p24	£35
FIRST-PERSON SHOOTER	Glorious PC Gaming Race Model O	overclockers.co.uk	#215 p57	£45
AMBIDEXTROUS	Razer Viper 8K	currys.co.uk	#215 p59	£60
WIRELESS	Razer Viper Ultimate	amazon.co.uk	#217 p54	£110
PREMIUM WIRELESS	Razer Deathadder V2 Pro	ebuyer.com	#210 p28	£121
ULTRA LIGHTWEIGHT	Roccat Burst Pro	scan.co.uk	#211 p28	£48
PREMIUM LIGHTWEIGHT WIRELESS	Logitech G Pro X Superlight	currys.co.uk	#217 p52	£109

Peripherals and audio cont ...

Game controllers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	currys.co.uk	#202 p50	£269
GAMEPAD	Microsoft Xbox One Wireless Controller	argos.co.uk	#191 p56	£55
PREMIUM GAMEPAD	Razer Wolverine V2 Chroma	razer.com	#221 p30	£149
BUDGET FLIGHT STICK	Logitech Extreme 3D Pro Joystick	currys.co.uk	#207 p52	£37
FLIGHT STICK	Thrustmaster T.16000M FCS HOTAS	scan.co.uk	#207 p56	£140

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET STEREO	Roccat Elo X Stereo	scan.co.uk	#210 p56	£40
STEREO	Epos | Sennheiser GSP 300	amazon.co.uk	#210 p54	£65
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£125
PREMIUM WIRELESS	Razer BlackShark V2 Pro	scan.co.uk	#211 p26	£180

Speakers

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

Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
WIRELESS 84-KEY ELECTRO-CAPACATIVE	Niz Mini 84 Pro	keyboardco.com	#220 p29	£165
WIRELESS TKL MECHANICAL	Keychron K2 Version 2	keyboardco.com	#208 p57	£84
TKL MECHANICAL	Filco Majestouch Convertible 2 Tenkeyless	keyboardco.com	#203 p55	£140
BUCKLING SPRING MECHANICAL	Unicomp New Model M	keyboardco.com	#219 p26	£129

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD APU PC	Wired2Fire Ultima Ryzen Gamestation	AMD Ryzen 5 5600G	Integrated AMD Radeon RX Vega 7	custompc.co.uk/W2F	#222 p36	£688
BUDGET GAMING	Wired2Fire Phoenix Intel – Powered by MSI	Intel Core i5-12400F	Nvidia GeForce RTX 3060	custompc.co.uk/Phoenix	#224 p38	£1,099
MID-RANGE GAMING	PC Specialist Magnus Supreme	Intel Core i5-12600KF	Nvidia GeForce RTX 3070 Ti	custompc.co.uk/Magnus	#223 p26	£1,499
4K GAMING	Scan 3XS Vengeance Ti	Intel Core i9-12900K	Nvidia GeForce RTX 3080 Ti	custompc.co.uk/ScanVengeance	#221 p34	£3,499
WATER-COOLED ALDER LAKE	CyberPower Hyper Liquid Infinity X129	Intel Core i9-12900K	Nvidia GeForce RTX 3080	custompc.co.uk/CPHL	#222 p34	£4,015
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	Nvidia GeForce RTX 3090	custompc.co.uk/Barracuda	#145 p58	£14,490

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Lenovo Legion 5 Pro	AMD Ryzen 7 5800H	Nvidia GeForce RTX 3070 Laptop	16in, 2,560 x 1,600 IPS 165Hz G-Sync	custompc.co.uk/Legion5Pro	#222 p32	£1,499
ULTRA PORTABLE GAMING	Razer Blade 14	AMD Ryzen 9 5900HX	Nvidia GeForce RTX 3070 Laptop	14in 1,920 x 1,080 IPS 144Hz	custompc.co.uk/Blade14	#220 p40	£1,899
ULTRA PORTABLE GAMING + EGPU DOCK	Asus ROG Flow X13 GV301	AMD Ryzen 9 5980HS	Nvidia GeForce GTX 1650 Max-Q (laptop) / RTX 3080 Laptop (dock)	13.4in 1,920 x 1,200 IPS 120Hz	custompc.co.uk/ROGFlow	#219 p28	£2,956

RICK LANE / INVERSE LOOK

PRESERVATION AREA

Digital preservation of games has improved, but emerging trends in the industry put gaming history at risk, argues Rick Lane

Over the past decade, the game industry's attitude towards game preservation has improved. Services such as Steam and GoG now have extensive libraries of old PC games, while various studios such as Nightdive and Beamdog have optimised and remastered aging classics.

The motivations here are primarily profit-driven, of course, but making old game libraries available online is nonetheless good for us. However, not everything about this trend is so positive. In 2021, we saw several major games removed from Steam in favour of newer models. When Nightdive's remaster of Quake was launched on Steam, it outright replaced the original, unoptimised version.

A more egregious example came when Take Two Interactive removed GTA III, Vice City and San Andreas from Steam, replacing all three with GTA Trilogy: Definitive Edition. This purported remaster has been subject to intense criticism due to bugs, a questionable visual makeover, and a general lack of care and attention.

Outright replacing games in this manner can have multiple knock-on effects. For example, both Quake and the early 3D GTA games have active modding communities. With Quake, most mods based on the original game are supported by Quake Remastered, although this isn't true for mods that require a different source-port of Quake.

With the GTA Trilogy, however, not only has the removal of the three separate games hindered the modding community, but Take Two took a highly aggressive stance towards modders, filing takedown notices for various modding projects for GTA III and Vice City in the run-up to the Definitive Edition release.

Take Two took a highly aggressive stance towards modders

Even if a publisher ensures that a new version of a game offers an enhanced experience and continues to support its community, outright replacing an older version still neglects the intrinsic value of the original game. There's simply no reason to do this beyond pushing sales of a newer, higher-priced remaster, and such short-sightedness could be costly when it comes to long-term game preservation.

For Quake and the GTA Trilogy, this is unlikely to be an issue. Both games saw extensive physical releases, meaning the original versions are readily available for collectors and archivists. However, the issue of preservation becomes increasingly fraught for games made in the last ten to 15 years. Games delisted from Steam or other services that saw purely digital releases can't be so easily preserved by third parties, unless archivists have the foresight to copy those files ahead of time – an act many publishers consider piracy.

In future, game preservation is likely to become even more challenging, as gaming shifts to increasingly service-based models. Destiny 2 and Apex Legends, for example, frequently see complete overhauls of their maps, weapons, characters and so on, and there's no ability for external individuals or organisations to ensure that the media removed from those games is preserved.

It's increasingly up to developers and publishers to ensure that the history of their games is preserved and archived; depending on the studio, this may or may not be a priority. Short of a significant turnaround in the culture surrounding digital game ownership, we can only hope that publishers ensure these large bodies of gaming history aren't lost to time. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

The Gunk / £19.99 inc VAT

DEVELOPER Image & Form Games / **PUBLISHER** Thunderful

The Gunk is a great example of the importance of a game's feel, with a remarkable sense of tactility beneath the fingers. The Gunk tells the story of two space junkers, Rani and Beck, who discover an unclaimed planet in the far reaches of the galaxy. Landing in the hope of retrieving valuable resources, they find that the planet is covered in a viscous black substance they term the Gunk, which is suppressing the world's natural biosphere. Her curiosity piqued, Rani sets off alone into the Gunk's oozing wilderness, while Beck remains behind to fix up their spacecraft.

The game primarily revolves around using Rani's bionic arm to suck up the eponymous gunk. While the visual tech used to render the gunk is impressive, the act of clearing it is very simplistic, and isn't an especially interesting system around which to build a game.

That said, clearing an area of Gunk triggers a spectacular transformation, as the area instantly blooms into life. Trees grow in seconds, grass and mushrooms sprout from the ground, and giant leaves unfurl to create new pathways through the environment. It's a spectacular reward for your efforts.

Within these areas you'll also find smaller environmental puzzles, many of which involve 'clogging' your bionic arm with a large object such as a plant bulb, and then using the suction to pull it out of the ground in order to throw it to a different location. The way the bulb stretches and resists before abruptly snapping off makes this interaction hugely satisfying.

The Gunk's tactile design goes a long way towards carrying the game, which is just as well, as mechanically, the game is lightweight to the point of feeling underdeveloped. The platforming is slick, but the game never provides any substantial platforming challenges. Combat is rudimentary, existing mainly out of obligation. Similarly, the upgrade system is largely superfluous, with only one or two new abilities adding meaningfully to the experience.

Luckily, The Gunk moves too fast for these flaws to ever slow it down. The game's ecologically themed story is interesting, while the increasingly strained relationship between the adventurous Rani and the more cautious Beck is smartly written and superbly acted. The game is also well paced, delivering impressive new areas to explore every 20 minutes, and wrapping up proceedings in roughly five hours.

The Gunk is a transitional title for Image & Form Games, as the studio jumps from 2D to 3D design, and it feels like the primary focus here was getting the fundamentals right, rather than building a hugely innovative game. Nonetheless, The Gunk never hangs around long enough for its workmanlike systems to become dull. It's a breezy adventure that's fun while it lasts.

RICK LANE

GUNK & SOUL

+ Looks good
+ Feels great
+ Interesting, pacey story

GUNKED UP

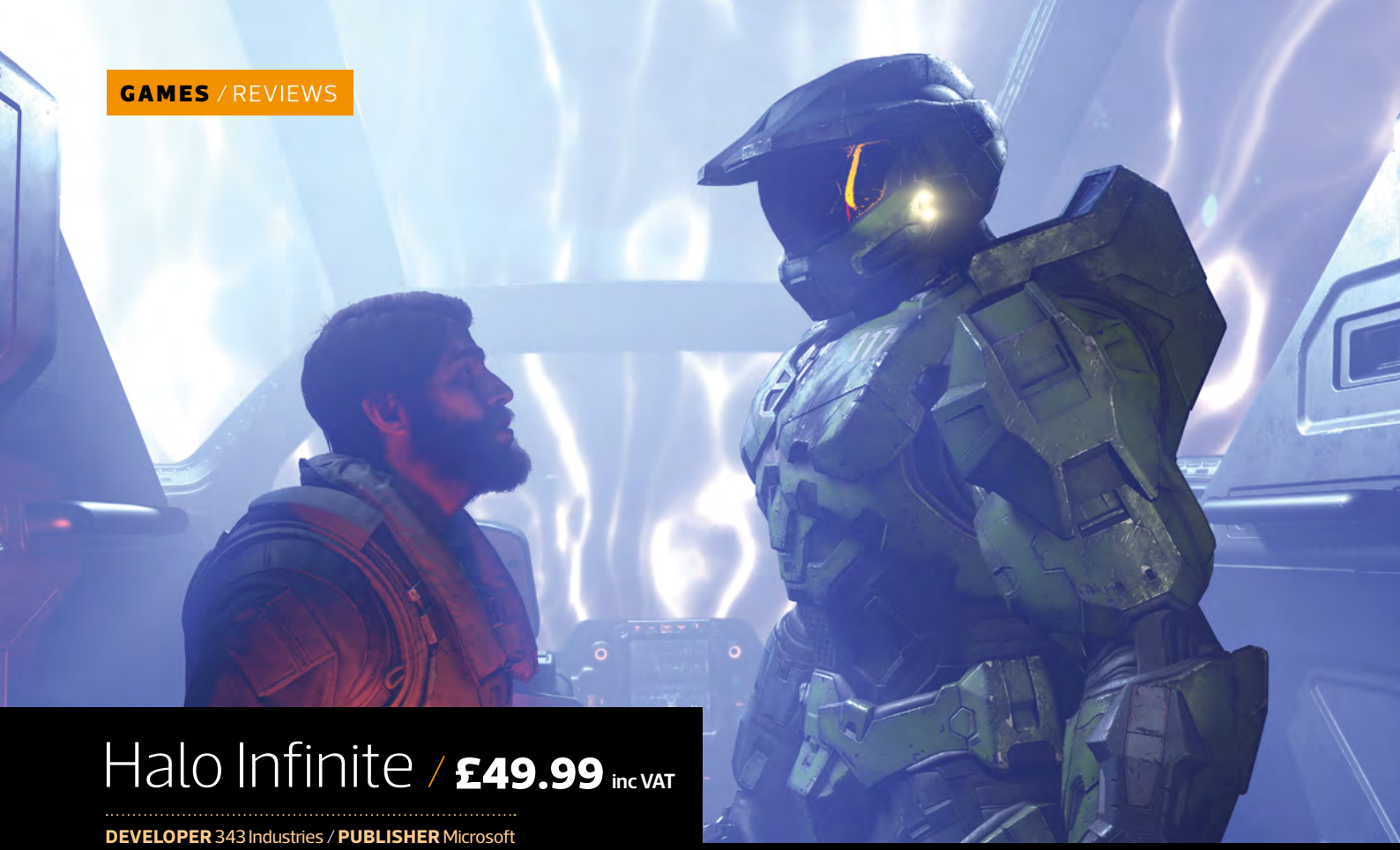
− Not much depth
− Clearing up gunk becomes repetitive

/ VERDICT

The Gunk's impressive visual spectacle and propulsive storytelling compensate for its unambitious mechanics.

OVERALL SCORE

74%



Halo Infinite / **£49.99** inc VAT

DEVELOPER 343 Industries / **PUBLISHER** Microsoft

The Halo series has always felt like it should have an open world. Never a strong corridor shooter, the series is most comfortable in wide open landscapes, combining infantry and vehicles in ways that allow its richly layered systems to create dynamic, spectacular battles.

With Halo Infinite, the Master Chief has finally made the jump. However, the open world is too conservative, failing to fully capitalise on its considerable potential. The campaign begins in orbit around a ringworld known as Zeta Halo, where Master Chief is defeated in combat by a Brute named Atriox, leader of an alien faction known as the Banished.

Found floating in space by a USNC pilot several months later, the Master Chief and his newfound companion make their way down to Zeta Halo's surface, where they begin liberating the ring from the grip of Atriox's Lieutenant Escharum, who has assumed control of Atriox's forces after the warrior died in mysterious circumstances.

The story is typically Halo – bombastic, extremely nerdy and a little too invested in its own importance. Escharum's tendency to monologue at you via hologram is a particularly annoying flaw, while the game fails to add much dimension to Master Chief as a character. Nonetheless, it gives you a fun thread to follow. After guiding you into the game with a couple of traditional linear Halo missions, Master Chief emerges into the open world of Zeta Halo.

Rather than being a contiguous space, this world is split into four distinct chunks, explored in sequence and bookended by linear missions. This allows the campaign to maintain the momentum of the series' linear heritage, while giving you room to explore at your own whims.

Halo slips naturally into an open-world mode. The game's art style is purpose-built for fantastic vistas, with the vast loop of the ringworld nearly always visible in the skybox. The area of Zeta Halo you explore has been shattered in the opening space battle, revealing the elaborate sci-fi architecture beneath its pastoral landscapes. This helps to lend an otherworldliness to the game's environments, its many hexagonal being columns a constant reminder of the ring's alien artifice.

However, the open world is less exciting in structure. Your exploration revolves around capturing forward-operating bases [FOBs], where you can pick up fresh weapons, request vehicle drops and recruit marines to join you in battle. From these points of safety, you venture out to pursue story missions, help squads of marines in distress, assassinate powerful Banished lieutenants and raid large-scale Banished facilities.

These activities are smartly tied together by a system that rewards you with new weapons and vehicles for completing objectives, helping to bind your various encounters together. Overall, though, the world is disappointingly static for a Halo game.

There are no large-scale battles, such the dual-scarab fight in Halo 3, and the game never really captures the grandeur of Halo at its very best. The closest Infinite gets is a mid-game sequence where you must destroy three giant anti-aircraft units on an isolated island of the ring. This is a thrilling extended sequence, but still one that's mostly done by Master Chief alone.

Fortunately, the incredible moment-to-moment combat compensates for the diminished scale of the game's battles. 343 has done an excellent job of modernising the feel of Halo, lending its weapons weight and power, and making Master Chief nimbler, without losing the unique sense of Halo's combat.

Classic weapons, such as the Assault Rifle and the Needler, have been given a much-needed mechanical makeover, while new weapons such as the VK78 Commando, and the spear-firing Skewer, help to round out the game's eclectic arsenal.

However, the secret sauce of Halo Infinite's combat system is the grappling hook, which allows Master Chief to swing around the environments like a heavily armoured Spider-Man. It's a brilliantly flexible tool, letting you quickly escape a fight where you're outnumbered, grapple onto enemies for a devastating melee attack, and grab a weapon from a distance when your ammo runs dry. Best of all, it can be used to pull in explosive plasma cores dotted around the level, which can be thrown like grenades in a wonderfully satisfying one-two-punch.

The grappling hook is accompanied by other abilities, such as an enemy sensor and deployable cover. While less versatile than the grapple, these abilities can be crucial to survival, highlighting enemies using cloaking devices, or giving you a brief window of protection while your energy suit recharges. Indeed, the way these abilities are designed gives Infinite's combat a Doom Eternal-like rhythm, where

you learn to instinctively respond to a specific enemy or challenge. This helps you to feel enormously powerful.

Overall, Halo Infinite's campaign is a success, although it's tempered by a disappointingly linear final act that mostly takes place in bland grey corridors. Fortunately, the game's quality is upheld by its fantastic multiplayer mode, which brings to bear the large-scale dynamism of Halo's combat that the single-player campaign lacks.

Halo's multiplayer game is divided into two categories. There's the smaller-scale format known as Firefight, which is primarily geared towards skill-based deathmatch. However, the centrepiece is the 24-player Big Team Battle format, where you duke it out across large, vehicle-strewn maps in a variety of game modes, such as Team Deathmatch and Stockpile, where you must gather items known as Power Seeds to trigger a match-ended weapon at your base.

Infinite's multiplayer game is a clever blend of old-school structure with more modern design sensibilities. The map design is typically Halo, with large, verdant landscapes featuring set spawn-points for weapon pick-ups, and liberally strewn jump-pads to help you get into the action quicker. However, the weapons and vehicles all benefit from a modern makeover, feeling punchier and more purposeful than in earlier Halo games. Yet with a slightly slower pace and more durable avatars than, say, Call of Duty, it's easier to get to grips with Infinite, and encounters are less reliant on who shoots first.

The best part of Big Team Battle is the way it embraces chaos. A 24-player match, with Warthogs, Moongooses and Banshees careering about the map, all underpinned by Halo's dynamic systems, is a just a superbly designed engine for surprising and hilarious encounters. Grappling onto an enemy banshee mid-flight, hijacking it from the other player, and then blasting them before they hit the ground, is an incredible feeling, and just a small example of the sandbox opportunities Halo's multiplayer offers.

Halo Infinite is 343's best attempt yet to drag Master Chief into the modern age, updating the series in most of the right places, without compromising the spirit of the series. There's still room for improvement, particularly in the single-player game, but Infinite nonetheless feels like a solid foundation upon which 343 can build a truly great game.

RICK LANE

INFINITE

+ Brilliant combat engine
+ Great multiplayer game
+ Good single-player game

LIMITED

− Campaign ends poorly
− Open-world design is slightly outdated
− Lacks the grandeur of the series at its best

/ VERDICT

Halo Infinite puts Master Chief firmly back in the fight, although the game's open-world campaign falls short of its potential.

OVERALL SCORE

80%

UNPACKING / £15.49 inc VAT

DEVELOPER Witch Beam / **PUBLISHER** Humble Games

UNPACKED

+ Interesting story device
+ Fun, chilled-out puzzles

PACK IT IN

– Can be too twee
– Can become repetitive

Unpacking is a coming-of-age tale told through the medium of a block-puzzler themed around moving house. Each 'level' in the game is set in a different place, commencing in your character's childhood bedroom in the late 1990s, then moving to subsequently larger locations such as a university dorm, a student flat and so on. Every available room will have a small stack of boxes in it. You click on the box to pull out an item, and then put it in an appropriate place in the room.

It's a simple but surprisingly enjoyable mechanic. The rooms and objects are beautifully drawn and highly tactile, with nuanced sound effects for putting down objects in difference places. As a puzzler, the game is rather flexible about where you put objects, although certain items, such as toilet roll, are exclusive to particular rooms, while others, such as clothes, can only be put in drawers and wardrobes. When you approach the end of a puzzle, the game will highlight objects that are in the wrong room, ensuring you're never stuck in one place for too long.

Unpacking's puzzling is serviceable enough, but the game's smartest trick is how it uses its domestic enigmas to quietly tell a story of how a person's life fits into a place. Initial puzzles give you considerable freedom to put stuff where you like, but later levels use theme or mechanical restrictions to convey your character's relationships with her unseen cohabitors. In the student flat, for example, you can't move anybody else's stuff, and must work around existing mess and clutter while unpacking your gear.

The most effective level sees your character move in with her first boyfriend, where your colourful, nerdy gear lies in stark contrast with his orderly, colour-coded flat. Here, you're forced to try to fit yourself into a relationship that very clearly isn't going to work, fitting your shoes awkwardly around his, and putting your university diploma under the bed, as there's no space to hang it on the wall.

Unpacking's subtle approach to narrative is admirable, but the game isn't without flaws. Tonally, it constantly teeters on the edge of twee overload, and the stickers you get for completing a level, complete with a bleepy-bloopy retro-game noise, feel a little patronising.

The bigger issue, though, is that the game's puzzling works best at a smaller scale. There are only so many times you can put a fictional person's underpants in a drawer before it stops being fun, which means repetition sets in during larger levels.

While it's best played in short bursts, Unpacking is worth a look if you're after a laid-back puzzler, or a game with an unusual narrative device. It also manages to make unpacking virtual boxes an enjoyable way to spend time, which is no mean feat.

RICK LANE

/ VERDICT

An intriguing, well-organised box of little surprises, although it's a little fragile in terms of staying power.

OVERALL SCORE

70%

FIGHTS IN TIGHT SPACES / £19.49 inc VAT

DEVELOPER Ground Shatter Games / **PUBLISHER** Mode7

Fights in Tight Spaces (FITS) puts you in the role of a stone-fisted superspy on a mission to beat five different gangs into bloody submission. The core is a turn-based battle system where you play cards from your virtual hand to perform different fighting moves. A wide range of techniques is available, from straightforward punches and kicks, to cards that let you block attacks, dodge or move around the game's cramped, whitewashed arenas.

Some attacks let you push enemies around, while others let you reach across extra spaces. A handful of attacks let you use the environment to your advantage, such as smashing an opponent's head off a wall.

These cards are used to battle an equally diverse number of opponents, who range from straightforward thugs to enemies equipped with firearms, to musclebound goons whose wild swings damage friend and foe alike.

The result is a highly flexible combat system that's accessible while also consistently challenging. Always outnumbered, your agent can be killed in a handful of hits, and you're only allowed a few actions per turns, so you need to balance eliminating opponents while avoiding taking damage yourself.

An armed enemy that gets you into their sights, for example, will fire regardless of whether you're actually there. So one tactic is to push enemies into the firing line of their accomplices, moving them out of attack range while also ensuring they take damage on that turn.

Completing a fight earns you new cards that provide new abilities, while each mission sees the stakes quickly escalate. After a few back-alley brawls, you're soon fighting prison guards armed with riot shields that make them invulnerable to frontal attacks, crazed doctors who follow you around the map attempting to jab you with poisoned syringes, and even ninjas.

FITS makes the most of its core concept, with you constantly feeling on the edge of defeat. The game is also slickly presented, with its block-colour visuals making fights easy to read and stylish, while the game has fantastic animations and sound design for attacks. You really feel it when your agent bounces an opponent's head off a table.

One slight disappointment is the replay mode, which doesn't cut out the pauses between turns, so replayed fights have a staggered quality that makes them less fun to watch back. Also, while the game's difficulty is generally well balanced, your fragile fighter means the game has a low tolerance for error. Mistakes can be costly, and being killed sends you back to the start of your run. That said, the game does give three opportunities to undo a move per encounter, so it's not entirely without a safety net.

Fights in Tight Spaces is otherwise an excellent twist on card-based battlers, combining an accessible scale and pacey encounters with a rich and versatile combat system.

RICK LANE

KNOCKOUT

+ Extremely stylish
+ Clever, satisfying combat system
+ Wide variety of cards and enemies

LOW BLOW

- Harsh punishment for failure
- Replay mode could be better

/ VERDICT

Fights in Tight Spaces mixes hard-nosed tactics with brutal melee combat in a refreshing take on the virtual deck-builder.

OVERALL SCORE

85%

REALITY CHECK

Rick Lane checks out both the instalments of the visually gorgeous Lone Echo in this month's VR roundup

REVIEW

LONE ECHO / £14.99 inc VAT

DEVELOPER Ready at Dawn / **PUBLISHER** Oculus

With the launch of Lone Echo's sequel (see opposite) we thought we'd revisit the first game from 2017. Set aboard the ice-mining platform Kronos II, you play Jack, a sentient android tasked with assisting astronaut Olivia Rhodes in maintaining the station's operations in orbit around Saturn.

As they enter their last week aboard the station, the pair's routine is interrupted by a mysterious anomaly appearing nearby, which they must investigate while repairing the station's damaged systems.

Developer Ready at Dawn clearly wanted to produce an experience that feels as believable as possible. Visually the game is far more detailed than most VR titles of the time, presenting spectacular sci-fi vistas and meticulously crafted environments.

However, perhaps the game's biggest success is its portrayal of Olivia, who makes for an incredibly convincing NPC companion.

The way she's written and acted; the way she moves around the station; and the ways she interacts with Jack – it's a truly remarkable example of NPC scripting.

Mechanically, Lone Echo combines Zero-G exploration with an array of light engineering puzzles. The game makes good use of VR's tactile controls, with you constantly pulling levers, pressing holographic buttons and using tools, such as a wrist-mounted laser cutter to slice through maintenance panels. While the puzzles are never especially challenging, it's fun to interact with them nonetheless. That said, it takes some time to get used to Zero-G movement, especially during the initial hour when you have no ability to stop your momentum.

Once you unlock your EVA pack, however, getting around the environments becomes faster and easier. The story builds on many familiar sci-fi tropes, but its strong characters and surprisingly moderate pacing help to set it apart from most other virtual science fiction. More of an adventure game than an action experience, Lone Echo is strongest in its mid-section, where you get to explore outside the station, visiting nearby asteroids and several other surprising locales.

But Lone Echo isn't without problems. It uses an autosave system with long stretches between saves, which isn't ideal considering the sometimes temperamental nature of VR gaming. Moreover, the second half becomes increasingly populated by 'the floor is lava' sequences, where you must navigate environments without touching any surfaces. These two problems come to a head in an extremely challenging spatial puzzle at the end, where touching any surface instantly sends you back to the last checkpoint.

The frustrating final act holds back Lone Echo from being an outright masterpiece, but its spectacular sci-fi vistas and well-told story nonetheless make it one of VR's must-play games, and the experience has lost little of its power since its release. It's well worth picking up Lone Echo if you missed it at launch.

SATURN

- \+ Visually stunning
- \+ Well-told story
- \+ Enjoyable if simple puzzles

URANUS

- – Poorly implemented autosave
- – Some frustrating navigation challenges

VERDICT

While a couple of elements haven't aged well, Lone Echo remains one of VR's best adventures.

OVERALL SCORE

87%

REVIEW

LONE ECHO II / £29.99 inc VAT

DEVELOPER Ready at Dawn / **PUBLISHER** Oculus

Lone Echo II's approach to sequel design is essentially 'Lone Echo, but more of it'. It features a longer story, larger locations to explore, new characters, new puzzles and a handful of new mechanics. The plot is difficult to summarise without spoiling it, but the basic outline sees Olivia and Jack back in orbit around Saturn, at a new location known as Chiron Station.

This expansive facility, which combines scientific research labs with an atmosphere mining operation, has been abandoned in mysterious circumstances. Together, Olivia and Jack must investigate the station to discover what's happened.

Lone Echo II's strengths are the same as the first game. Visually, it's comfortably the best-looking VR title around. Not only does it offer significant technical advances over the first game, but it's also stylistically more interesting, with the larger location used to add greater diversity and colour to environments. It's extremely demanding though – even mid-to-high-end PCs may struggle at high settings.

As for Chiron Station itself, it's another fantastic location to explore in VR. The station's cross-shaped cluster of asteroids are connected together by a tramline-system, with each asteroid playing a different role in the base's operation.

After a lengthy introduction, you're free to jet around this area as you like, venturing to the various facilities in pursuit of the story, or exploring the asteroid's hidden cave systems for optional side objectives.

Ready at Dawn also brings its writing talents to bear once more. Jack and Olivia are as wonderful as they were in the first game, while Lone Echo II introduces some intriguing new characters, such as the grave Dr Harlen, whose downbeat perspective conflicts well with Olivia and Jack's general optimism.

That said, Lone Echo II's story is arguably too restrained. With even slower pacing than the original, it features many lengthy dialogue sequences where you have no choice but to stand and listen, making you highly conscious of the headset weighing on your neck.

The game's biggest issue, though, is that it doesn't sufficiently evolve its systems to make the most of its extended running time. There are a couple of new mechanics, such as a telekinetic ability that lets you grab objects from a distance, but the puzzles are largely similar to those of the first game. It also adds some very light combat, but the only enemies you 'fight' are amorphous blobs known as Ticks, which don't make for compelling adversaries.

While not exactly a disappointment, Lone Echo II nonetheless fails to capitalise upon the success of the first game, taking too long to do too little that's new or interesting. That said, it's still an enjoyable adventure, and it visually represents the cutting edge of what VR can offer. CPC

ASTEROIDS

+ Even better visuals
+ Fantastic new location
+ Great character work

HAEMORRHOIDS

– Story too slow
– Mechanically too conservative

VERDICT

Lone Echo II paints on a bigger canvas than its predecessor, but the result is a slightly less interesting picture.

OVERALL SCORE

79%

BUILD A £978 6-CORE GAMING PC

ANTONY LEATHER SHOWS YOU HOW TO CONSTRUCT A CUTTING-EDGE, POWERFUL GAMING PC FOR UNDER A GRAND, WHILE STILL USING INTEL'S 12TH-GEN CPUS AND THE LATEST HARDWARE

Maybe, just maybe, hardware prices are starting to edge towards normal this month, as we've finally been able to build a decent PC for under a grand that didn't require twisting a retailer's arms or hitting well-known auction sites.

Instead, we've been scouring websites for the latest hardware you can actually buy, and we've come up with a great PC for under £1,000 that will offer smooth frame rates at 1080p and even at 2,560 x 1,440 in many games.

It's all about making your money go as far as possible and hunting for the best graphics card you can afford, which is why we've cherry-picked some of the best-value components we've used over the last few months to avoid skimping in some areas. As such, there are few compromises – we've included 1TB of fast M.2 NVMe storage, a 6-core 12th-gen Intel CPU, an LGA1700 motherboard and 16GB of DDR4 memory too.

When it comes to building a budget-focused PC, there are plenty of talking points to help you make the most of your cash, so we've explained our reasoning for each bit of kit, as well as offering alternatives should you have a little more or a little less money than our budget this month.

SHOPPING LIST

CPU

Intel Core i5-12400F

£170 inc VAT

scan.co.uk

AMD's Zen 3-powered Ryzen 5000-series CPUs still sit above the £200 mark, with the Ryzen 5 5600X coming in at £240 inc VAT. Meanwhile, AMD's cheaper 3000-series CPUs lack the huge benefits of AMD's latest CPU architecture. This means they'll be slower in many games than the latest architectures, not just from AMD but from Intel too – the latter's 12th-gen CPUs are spectacular in games.

This gives Intel an advantage below £200, and the Core i5-12400F is a great deal for the cash. This is the 'F' model without integrated graphics, which saves you some cash, and it's equipped with six Performance or P-Cores, ditching the efficient cores of more expensive models to allow it to hit a lower price point. For 1080p gaming, though, six fast cores are all you need, especially if you're not taking out a bank loan to buy a high-end graphics card.

Another reason the Core i5-12400F fits the bill is because it's a perfect match for motherboards based on Intel's B-series chipsets. Pricier Z690-based motherboards offer the ability to tweak the multiplier on K-series CPUs such as the Core i5-12600K, but as the Core i5-12400F is multiplier-locked, so you can opt for a cheaper B660 motherboard and get the same performance.

Alternatives

As the Core i5-12400F is multiplier-locked, it's best suited to a motherboard with a B660 chipset motherboards, but if you need more grunt, there are several other options to consider. There are non-K-series CPUs with more cores, such as the Core i7-12600, which has higher clock frequencies than the 12400F, which is always good for gaming.

If you'll be doing a balance of multi-threaded content creation as well as gaming, the Core i7-12700 offers both more cores and higher clock frequencies, which will speed up your PC in certain multi-threaded workloads, while still not requiring anything more lavish than a motherboard with a B660 chipset.

GRAPHICS CARD

AMD Radeon RX 6600 XT

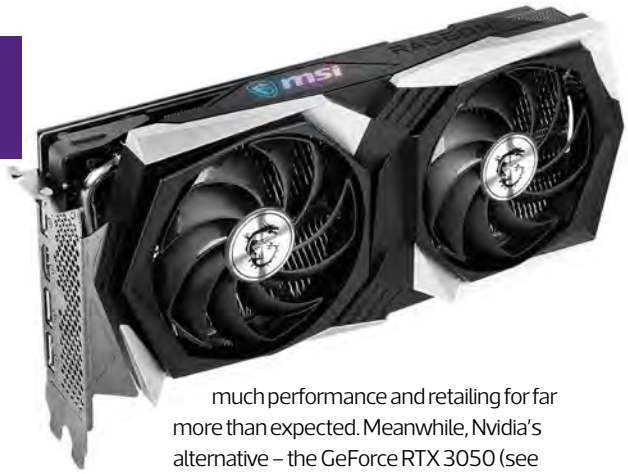
£420 inc VAT

amazon.co.uk

While motherboards, power supplies and processors are readily available for reasonable prices, the same still can't be said of graphics cards. It's still a case of hunting the best card you can find for the cash, but we've spotted that AMD's Radeon RX 6600 XT is now widely in stock most of the time and under £450 too.

In fact, there were several examples available when we wrote this feature, with the cheapest being the MSI Radeon RX 6600 XT Gaming X that we spotted on Amazon for just £420. Outside of ray tracing, it's generally faster than the GeForce RTX 3060, which wasn't in stock for under £550 at the time of writing, and it offers smooth frame rates at high settings in modern games at 1080p. In fact, as you can see in the benchmarks at the end, it's even capable of handling many titles at 2,560 x 1,440 with all the eye candy turned on too.

Two other factors came into play in the last month as well. AMD's Radeon RX 6500 XT turned out to be a poor offering, not giving much performance and retailing for far more than expected. Meanwhile, Nvidia's alternative – the GeForce RTX 3050 (see p16) – while better than the RX 6500 XT, cost far more than we'd hoped, not leaving you with any change from £400, which is a huge amount more than the suggested retail price.



Given that the Radeon RX 6600 XT can generally keep up with (and often outperform) the RTX 3050's bigger sibling – the RTX 3060 – it's not a surprise that the RX 6600 XT has become a very attraction option. It retails for more than it's intended price, but is by far the best option for decent 1080p gaming for less than £450, and it's significantly cheaper than the next step up from either AMD or Nvidia.

Alternatives

Normally, we'd recommend Nvidia's GeForce RTX 3060 Ti as the next logical step up from an RX 6600 XT – it's significantly quicker, and it has the horsepower to genuinely cope with ray tracing. However, the availability of these GPUs makes the situation far from clear-cut. Prices are better than they were six months ago, but there are still problems with availability and very high prices. Despite Nvidia introducing a hashrate limiter to make RTX 3060 Ti less attractive to miners, you'll still need to fork out around £700 for one if you can find one in stock.

MOTHERBOARD

Gigabyte B660 Gaming X DDR4

£133 inc VAT

box.co.uk

Motherboards that use Intel's B660 chipset have finally landed, but stock and pricing were a bit hit or miss at the time of writing. Some

models demanded hefty prices, making them rather pointless if you're going for a sub-£200 CPU. Intel's non-K-series CPUs are mostly about being budget-friendly, so you also want to aim for affordability when it comes to the motherboard.

Having a motherboard with lavish VRMs and power phases isn't going to make a Core i5-12400F run any faster, but it still pays to get a board that ticks the important feature boxes. We've opted for Gigabyte's B660 Gaming X DDR4, as it offers one of the best sets of features for around £130 of any B660 motherboard we've seen. It has six fan headers, three M.2 ports, a USB Type-C header and has Gigabyte's excellent EFI and Windows-based software fan control too.

Alternatives

There are plenty of other options for affordable B660 motherboards. If you want to use a micro-ATX case, MSI's MAG B660M Bazooka looks great and has most of the features of the Gigabyte board for the same price, while the MSI Pro B660M-A WiFi DDR4 costs £144 and, as its name suggests, includes Wi-Fi.

You don't need a Z-series chipset motherboard if you don't intend to overclock your processor. The only exception is if you have your heart set on a particular model, or if it offers features you need, such as Thunderbolt or additional fan headers. Otherwise you'll likely be wasting money.

However, some Z690 motherboards have dipped well below £200, while some B660 motherboards cost more than this, so it's definitely worth checking specifications tables. In some instances, it could be worth upgrading to a Core i5-12600K and a cheap Z690 motherboard, rather than using an expensive B660 motherboard and a Core i5-12400F.

MEMORY

16GB (2 x 8GB) Corsair Vengeance LPX DDR4 3200MHz

£58 inc VAT

scan.co.uk

Moving to a new memory standard is never easy, and the pandemic and global microchip shortages meant that not only was DDR5 memory extremely expensive when it launched, but there were severe supply shortages too. Speeds were also far lower than many had expected, and manufacturers are already advertising significantly higher frequencies, leaving anyone who bought one of the initial kits likely feeling a bit miffed.

It's no surprise, then, that we're still recommending you stick with DDR4 with Intel's Core i5 12th-gen CPUs, especially as DDR5 doesn't offer any significant benefits in most tasks. This means you can opt for a typical DDR4 kit without losing performance and save a considerable amount of cash too.

We still recommend 16GB as a minimum to ensure your PC can handle plenty of web browser tabs, but you won't need any more than 16GB for gaming. However, you do want to buy a two-module kit, rather than a single 16GB module, so you can run your memory in dual-channel mode.

We've opted for Corsair's Vengeance LPX 3200MHz kit, which has low-profile modules, is unlikely to interfere with air coolers and also offers great value. There's no RGB lighting, but neither does our motherboard, so it fits in perfectly.

Alternatives

Going for a faster frequency can provide a small uplift in performance in some situations, while RGB lighting just looks great on memory modules too. Both of those features can be had for a little more money, with a Corsair Vengeance RGB Pro 3600MHz kit, which will set you back around £15 more.

POWER SUPPLY

Corsair CV550

£45 inc VAT

scan.co.uk

There's very little point opting for a 1,000W power supply when your system will rarely draw more than 250W from the mains. In fact, you only need to add a few hundred watts above your predicted power rating to get the ideal PSU for your system.

You can see how much your planned system will draw by using Cooler Master's power supply calculator (**coolermaster.com/power-supply-calculator**), but 500W is plenty for our system and will also provide room for future upgrades, as well as headroom to keep the PSU's fan from spinning up all the time. We've picked Corsair's CV550, which has more than enough cables and connectors for our PC and 550W of power.

Alternatives

While you don't need more power than 550W for this PC, modular cables are a worthwhile upgrade. Our PSU has captive cables, which can't be removed if you don't need them, which makes cable tidying a bit harder. Corsair's CX650F RGB not only has fully modular cables, allowing you to remove the excess ones you don't need, but also features RGB lighting for around £70.

STORAGE

1TB WD SN570

£75 inc VAT

scan.co.uk

There's plenty to like about WD's new SN570 SSD. It has a generous 600TBW

endurance rating, 3,500MB/sec read speeds and 3,000MB/sec write speeds and its low price of £75 buys you 1TB of storage space. It might not have the lofty speeds of PCI-E 4 SSDs, but they offer little benefit unless you regularly transfer hundreds of gigabytes of data between devices.

Alternatives

WD's SN850 is a speed king of an SSD, with blistering read speeds of 7,000MB/sec thanks to it making use of PCI-E 4 and WD's in-house controller. If you need the best a mainstream M.2 SSD can offer, it's one seriously fast product, but you'll pay a premium for it. Our case also supports hard disks, so if you have a bunch of videos or want to house a photo collection on your PC, we recommend WD's Blue hard disks. For £80, you can bag 4TB of storage space, but always make sure you install Windows, application software and games on your SSD.

CASE

Kolink Nimbus RGB

£47 inc VAT

overclockers.co.uk

A case needs to offer a comfortable, cool home for your hardware, but it doesn't have to look dull and dreary, even if you're on a tight budget. The case market is crowded, which thankfully this means there are some great choices for not much cash. We've picked Kolink's Nimbus RGB, which crams a fantastic-looking RGB-illuminated front panel into its sub-£50 price tag, as well as a tempered glass side panel.

It only comes with a single 120mm fan out of the box, so we've added another fan in the front to balance out the airflow, but it's also more than capable of housing liquid-cooling radiators thanks to its fan mount arrangement, and its large vents in the front and roof.

Alternatives

Antec's DF700 FLUX is a fabulous case for the money, including a dedicated GPU-cooling fan, digital RGB lighting and a fan hub, as well as excellent airflow as standard for just £80. If you fancy taking advantage of one of the micro-ATX motherboards in this month's Labs test, then we also recommend Kolink's Citadel Mesh RGB case, which costs £60.

CPU COOLER

ARCTIC Freezer i13X

£20 inc VAT

scan.co.uk

The Core i5-12400F we're using in our budget build won't be dishing out anything like the heat of Intel's top-end Core i9-12900K, but you still ideally want to get a half-decent cooler for it.

Even a simple £20 cooler can work wonders in terms of cooling and lower noise levels compared with cheap coolers, as well as Intel's own stock cooler designs, so we've opted for ARCTIC's Freezer i13X.

It's compact, sitting well within our case's CPU cooler height limit of 160mm, and it has more than enough cooling power to deal with a 6-core CPU. You'll need to request an LGA1700 adaptor kit from ARCTIC, though, or you can pick up one for a few quid from most UK PC hardware websites.

Alternatives

For another £15 or so, Thermaltake's Toughair 310 CPU cooler provides a little extra cooling power and lower noise levels than the ARCTIC Freezer i13X, thanks to its larger fan and heatsink, plus it's LGA1700-compatible out of the box too. With our CPU, you really don't need any more cooling power than this so there's no need for liquid cooling.

EXTRAS

be quiet! Silent Wings 3

£10 inc VAT

scan.co.uk

We've added an additional 120mm fan in the form of a be quiet! Silent Wings 3. This will help to balance the airflow in the case, which only has a single fan, and also improve cooling to the graphics card if located in front of it.

TOTAL £978 INC VAT

BUILDING THE PC

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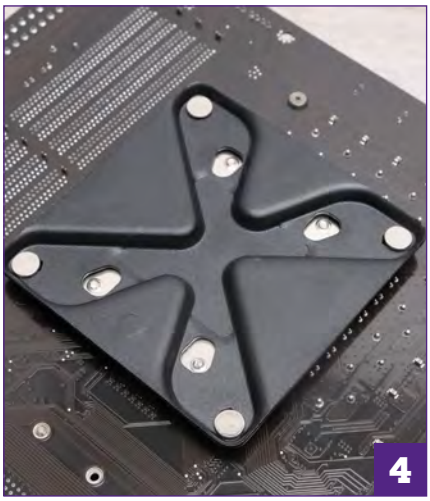
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1 INSTALL MEMORY

Start by installing the memory. With our two-module kit, you'll want to install them in the second and fourth slots to ensure you enable dual-channel mode to ensure best performance. Pull back the clips, and push down the modules to click them into place – the clips will then flip up to grip them.

2 INSTALL CPU

Open the CPU socket with the lever next to it, and very carefully move the CPU into place from the side as low as you can. Don't lower it down from a foot away. If you drop it, there's a good chance you'll bend the pins in the socket and ruin your day. The CPU has notches that only allow it to be installed the correct way round, so identify the right orientation first. When it's in the socket, gently close the lid and lock the lever back in place.

3 APPLY THERMAL PASTE

Apply the thermal paste included with the cooler in a cross shape across the CPU. This will ensure it spreads evenly once the cooler is secured and there won't be any uncovered spots.

4 INSTALL COOLER BACKPLATE

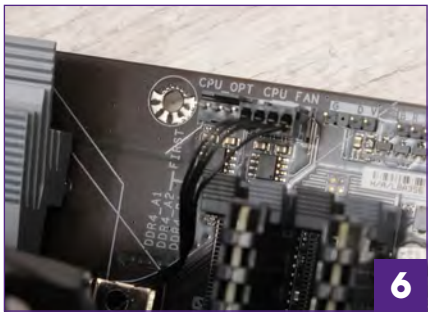
The LGA1700 mounting kit includes a replacement backplate for Intel's new CPU socket, so use the components in the kit to replace the ones that came with the cooler. This is due to the fact that the socket mounting holes are different with LGA1700 than previous Intel sockets, and the CPU sits slightly lower too.

5 MOUNT CPU COOLER

Install the CPU cooler so that the fan faces the memory slots. This way, the exhaust will be pointing towards the case's rear exhaust fan and its warm air will be dispatched out of the case. Also be sure to use the large black rubber supports and not the white plastic ones included in the kit.

5

INSTALL THE CPU COOLER SO THAT ITS FAN FACES THE MEMORY SLOTS



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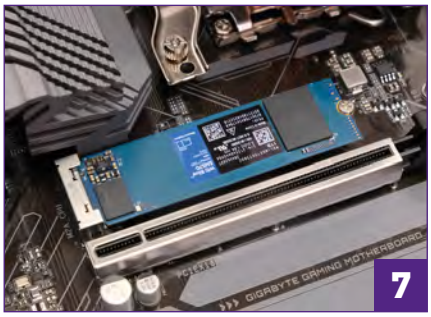

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6 CONNECT COOLER FAN TO CPU FAN HEADER

The motherboard has a CPU cooler fan dedicated to the fan that cools the heatsink on the ARCTIC cooler. It's important to use the right one, in order to make sure the motherboard's fan speed control correctly ramps up the fan speed according to the CPU temperature.

7 INSTALL M.2 SSD

Remove the motherboard's M.2 heatsink in the top slot and insert the WD SN570 into the slot. It can only slot into place one way around, and the logo side needs to be facing upwards, as shown here. Ensure it's fully inserted into the socket connector at the end, and then use the included screw to secure it in place.

8 FIT M.2 HEATSINK

It's always worth using your motherboard's M.2 heatsink, if only to improve the aesthetics of what are usually very plain-looking M.2 SSDs. Remove the protective layer on the thermal pad and then screw the heatsink into place on top of your SSD.

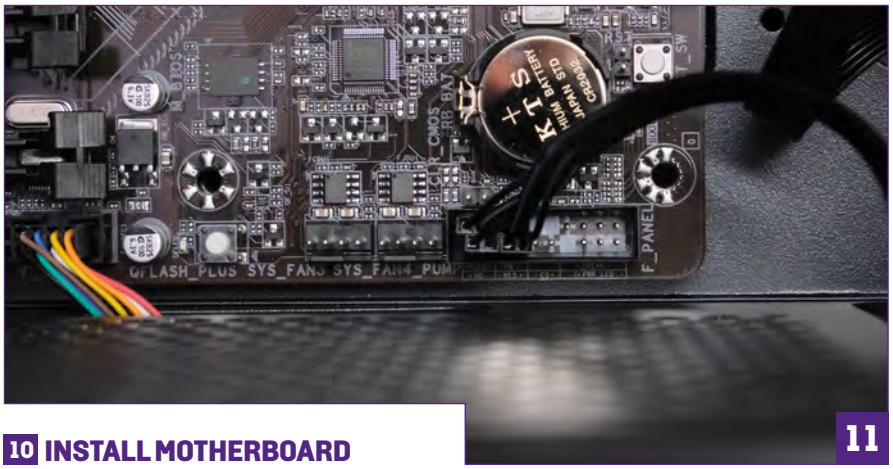
9 TEST YOUR HARDWARE

It's always a good idea to test your hardware out of the case first, in case you end up with a component that's dead on arrival. It's extremely rare you get faulty new components, but building your PC before testing will mean you'll have a harder time identifying the faulty component if you have one.

To do this, place the motherboard on a non-conductive surface, such as the motherboard box, install the graphics card into the motherboard's top large 16x PCI-E slot, connect the power cables to your motherboard and graphics card and connect the latter to your monitor.

Next, locate the power-on pins on the motherboard's front panel header, which will be listed in the motherboard manual, make sure your power supply is turned on and then use a metal pen tip or small screwdriver to short out the two pins momentarily to power on the PC. As long as the PC fires up and you get an output on your monitor, this should mean there are no gremlins lurking. When you're done, disconnect the power cables and remove the graphics card.

10



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10 INSTALL MOTHERBOARD

With the cooler, memory and SSD still installed, place the motherboard carefully into the case, slotting the I/O shield into the large hole in the back of the case and being careful not to scrape the traces on the bottom of the board on the metal standoffs inside the case. You can then screw it into place using the screws included with your case.

11 CONNECT FRONT PANEL CABLES

The case's ports and buttons need to be connected to the motherboard, and you'll find the instructions on how to do this in the motherboard manual. These include the connectors for the power and reset buttons, plus the audio jacks and USB ports.

12 CONNECT FANS

The two case fans need to be connected to the motherboard's system fan headers. It doesn't matter which ones you use, but try to route the cables out of sight and not have them trailing over the motherboard.

13 INSTALL GRAPHICS CARD

Remove the case's expansion slot covers that sit in the position of the graphics card and install the graphics card into the top-most 16x PCI-E slot.

14 FIT FRONT FAN

The front fan should be positioned so that the top of it lines up with the top of your graphics card. This will ensure that most of its airflow heads towards your graphics card to improve its cooling, but also that some air will help cool its backplate and improve air airflow in the top half of the case.

12

13

THE FRONT FAN SHOULD BE POSITIONED SO THAT THE TOP OF IT LINES UP WITH THE TOP OF YOUR GRAPHICS CARD

14

15 INSTALL PSU

Place the PSU into its mount in the bottom of the case and feed the cables in front of it behind the motherboard panel. Now thread the 24-pin, 8-pin CPU and 8-pin PCI-E graphics card power cables into the main chamber, using the cable-routing holes nearest these ports on those components. The case has cable-routing holes in these locations just for this reason.

16 CONNECT 24-PIN AND 8-PIN POWER CONNECTORS

Go ahead and connect the 24-pin ATX (right of the motherboard), 8-pin CPU (top of the motherboard) and 8-pin PCI-E graphics card power cables to those components. We'll be looking at how to tidy the cables in the next steps.

17 CONNECT RGB CABLE

Our case comes with a 3-pin RGB connector to control the front lighting, which you'll need to connect to an RGB header on the motherboard.

18 TIDY CABLES

Finally, all you need to do is to tidy the cables. The case includes ties to anchor cables to the motherboard tray, plus there's a handy area under the motherboard tray to stow the excess power supply cables as well.

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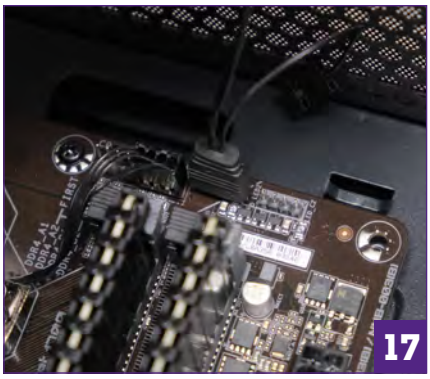
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18

BEWARE LGA1700 COOLER COMPATIBILITY

Intel's new CPU socket brought about a number of changes to the physical shape of CPUs, as well as the socket itself. With thinner CPUs, the height of the heatspreader on 12th-gen CPUs is actually slightly lower than that of previous Intel CPUs.

This means that many cooler mounting mechanisms may not apply enough pressure to the cooler to deal with a lower-sitting CPU, which could cause higher temperatures or even stability issues. In addition, the socket mounting holes are different from Intel's previous sockets, meaning many coolers will require adaptor kits unless they specify that they're compatible out of the box. Thankfully, most manufacturers offer adaptor kits free of charge or for a small fee.

However, there are plenty of manufacturers that don't specify anything about LGA1700 compatibility at all, while some others only offer decidedly sketchy information. Even with the ARCTIC cooler we chose, the QR code on the LGA1700 adaptor kit we got separately went to a dead page, rather than linking to specific instructions. We had to sift through support pages to work out how to install the cooler. In short, make sure you're certain the cooler you buy is compatible, or that an adaptor kit is available and that you follow the instructions.

EFI AND SOFTWARE SETUP

1 POWER ON AND ENTER THE EFI

Hopefully, your system will power on and you'll be given the option to enter the EFI. Press the Delete key as soon as you get a display on the monitor. From the main page, you can view the status of various components such as the M.2 SSD. It's worth making sure these components are recognised before you continue.

2 SET THE XMP PROFILE

Enter the Tweaker section, locate the option for Extreme Memory Profile (XMP) and select Profile1 from the menu. This will set the correct memory speed, voltage and timings.

3 CHECK YOUR SYSTEM FANS

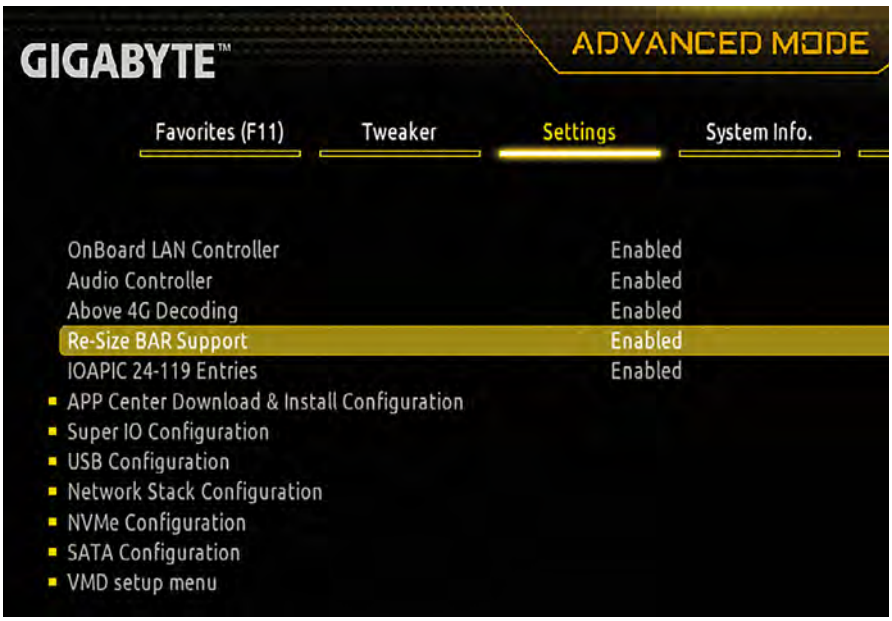
The fan control suite is useful for adjusting your system's fan speeds. If you find one or other of the fans to be a little too loud, you can reduce its speed here manually, or simply select the Silent profile, which will only spin it up when the CPU reaches higher temperatures.

It's also worth checking the control mode. PWM is the correct setting for 4-pin fans, but 3-pin fans need direct voltage control. Leaving the control mode on Auto should enable it to recognise the type of fan, but if the fan isn't spinning, or if it sits at full speed all the time, try manually changing it to Voltage mode.

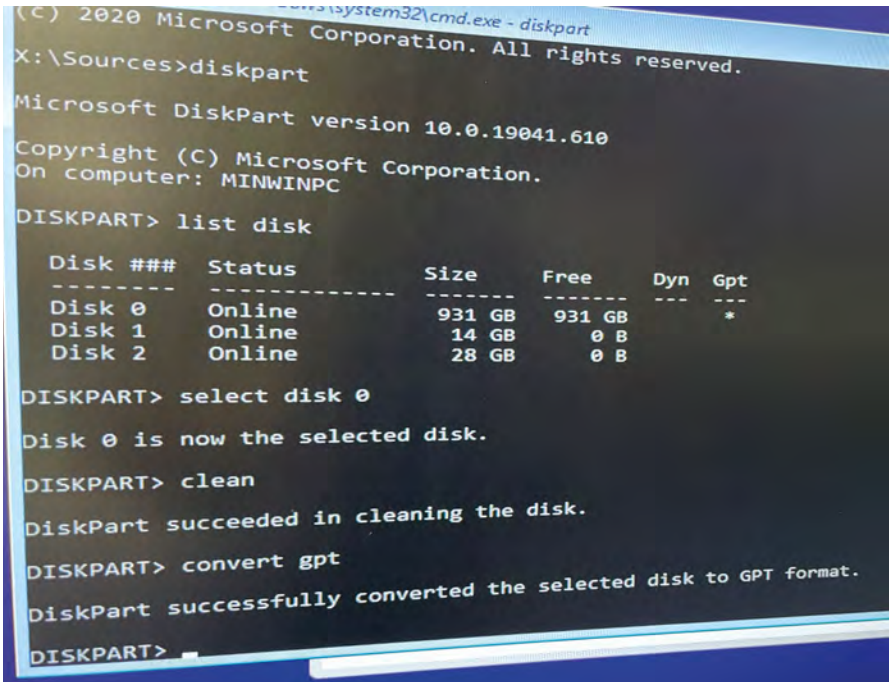
INSTALLING WINDOWS

The easiest way to install Windows is to grab Microsoft's Media Creation Tool for Windows 10 or 11 on another PC, and use it to create a USB flash drive installer, which will install Windows in a matter of minutes. However, we need to make a few further tweaks to the EFI in order to make sure we can use Resizable BAR on our graphics card. This allows the system to access the full amount of memory on the graphics card at the same time, boosting performance.

To avoid running into issues after Windows is installed, it's best to get your system ready beforehand. To start, enter the EFI again by restarting your PC and tapping the Delete key



Find the options for Above 4G Decoding and Re-Size BAR Support and enable both of them



Convert your drive to GPT to make sure you'll be able to install Windows 11 and/or enable Resizable BAR

TAP F12 TO SELECT YOUR FRESHLY MADE WINDOWS INSTALL FLASH DRIVE

when you see the option to enter the EFI. Then, under Settings, go to IO ports, find the options for Above 4G Decoding and Re-Size BAR Support and enable both of them. After that, head to the Boot menu, find the option for CSM and confirm it's disabled. Ours was by default.

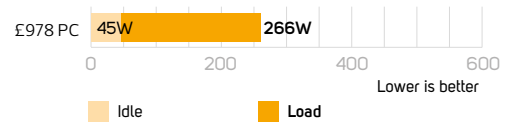
Next, save and restart the PC and tap F12 to select your freshly made Windows install flash drive as the boot device. We need to make one further change, which is to make sure you SSD uses the GPT drive format. This is needed for BAR support (and for Windows 11 if you're installing it), and checking this now can save you having to convert your SSD later, which can potentially mean losing data and reinstalling Windows.

From the Windows install setup, press shift+F10, which will open a command Window. Next type 'diskpart' and press Enter. Then type 'list disk' and identify the correct one to use – this will be the 1TB SSD. Next, type 'select disk' followed by the number with which your SSD was listed. For example, if your SSD was disk 0, type 'select disk 0'. Next type 'clean', then Enter, followed by 'convert GPT' then Enter. This will make sure your SSD is formatted using GPT as opposed to MBR.

Continue the Windows installation. We can highly recommend Ninite for installing popular programs automatically to save time (**ninite.com**). Once you've downloaded your Intel chipset and AMD GPU drivers, head to the tuning control in the AMD driver settings and, at the bottom of the screen, find the option for Resizable BAR. If everything has gone smoothly, this should be set to Enabled.

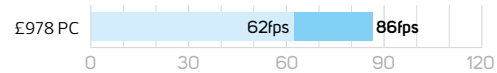
BENCHMARK RESULTS

TOTAL SYSTEM POWER CONSUMPTION

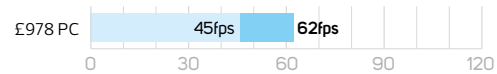


ASSASSIN'S CREED VALHALLA

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

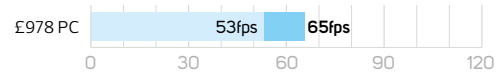


2,560 x 1,440, Ultra Settings, High AA



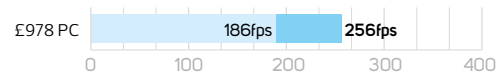
CYBERPUNK 2077

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

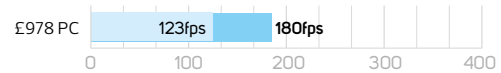


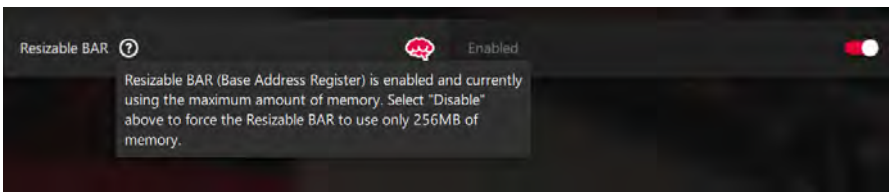
DOOM ETERNAL

1,920 x 1,080, Ultra Nightmare settings



2,560 x 1,440, Ultra Nightmare settings





Check that Resizable BAR is enabled in the AMD GPU driver software

If it isn't enabled, go back to the EFI and check that Above 4G Decoding and BAR support are enabled. You can turn BAR on and off to experiment with specific games, with some benefitting and others not, but it's worth having it on to boost frame rates where possible.

BENCHMARKING

The Core i5-12400F proved to be a great choice in our benchmarking, offering nearly double the image-editing scores we've seen with the Core i5-10400F and nearly matching the Core i5-11600K. It matched the Ryzen 5 5600X in the video encoding test and beat the Core i5-11600K in the system score too.

As we suspected, the Radeon RX 6600 XT was more than capable of playing the latest games at 1,920 x 1,080 – even in Cyberpunk 2077, it managed a minimum 99th percentile frame rate of 53fps. We were even able to play Assassin's Creed Valhalla at 2,560 x 1,440, with a 45fps 99th percentile result and a 62fps average, hitting our frame rate targets. CPC

MONITOR BUYER'S GUIDE

EDWARD CHESTER TELLS YOU ALL YOU NEED TO KNOW WHEN IT COMES TO CHOOSING YOUR NEXT MONITOR. FROM SIZE AND RESOLUTION, TO PANEL TECHNOLOGY AND REFRESH RATE, WE COVER THE LOT

Choosing a monitor can be a daunting task, especially if you're considering spending big money. Concerns over which size and resolution is right for you, responsiveness in gaming and whether the image quality is any good are all major headaches. However, armed with some key pieces of knowledge, you can whittle down your options and make a solid buying decision.

Choose your weapon

When it comes to choosing a monitor, start by thinking about exactly what you'll be using it for. In an ideal world, we'd all have a monitor that can do a bit of everything, but in the real world, there are inherent compromises in choosing any given display, so be honest with yourself about where your priorities lie.

In general, there are five main criteria for choosing a monitor. They are: high-speed gaming (think esports first-person shooters where lightning-fast responses are crucial); slower-paced cinematic games that value image quality over outright frame rate but still want smooth motion; sitting back to watch high-quality video; general desktop work (focused on text, web browsing and having lots of windows on screen); and professional image or video editing where high colour depth and accuracy are of utmost concern.

A few examples to consider are that you may think you want a 4K resolution, but if you also really like to play fast-paced competitive games, getting a 4K screen that can run at a high enough refresh rate to get the most from those games can be expensive. On the other end of the spectrum, if you only want a monitor for work, or really aren't into fast-paced games, then you can generally prioritise resolution over other factors.

Meanwhile, if sitting back and watching video is a priority – perhaps your PC monitor is your main entertainment screen in your bedroom or bedsit – then a large, high-contrast display might be a priority. However, if you mainly work at your machine reading a lot of text then a high-contrast display can be straining on the eyes. It's worth spending a week or so logging what you spend most of your time doing at your screen, and using this information to help weigh up your priorities.

In many instances, multiple smaller monitors may be a better choice than a single wide monitor, if your graphics card supports them

Panel size and shape

Once you've picked out the overarching criteria that are most important to you, it's time to choose a screen size and shape. Monitor sizes are generally quoted in inches, measured from one corner of the screen to the diagonally opposite corner. This can lead to some confusion when you get panels of different shapes – such as ultrawide or square panels – but it's a relatively easy way to understand the rough size of a panel in one number.

As with many aspects of life, the larger you go the more expensive your options get, so working out your rough maximum budget may go a considerable way to finding your size options. However, you can still get large screens for relatively little money, if you're willing to compromise on other features.

The advantages of larger screens are numerous and fairly obvious. You can sit further back to watch videos or play games, or you can enjoy a peripheral vision-filling experience when you're sat up close to them. Combine a large screen size with a high resolution and you also get a larger desktop space on which to work, allowing you to have multiple windows on-screen at once.

PC monitors have expanded in recent years but going super-wide can be costly and may not bring the benefits you expect

Conversely, if desk space is limited, there are plenty of high-quality small screens and, depending on your priority, getting one or several smaller screens may work better for you. Two or three smaller monitors can be easier to manage in terms of laying out windows on your desktop than one really large screen – it's also an ideal layout for flying and driving sims. It can also be easier to just dedicate one screen to gaming, reducing the load on your graphics card compared with a single, wide and high-resolution screen.

Talking of wider screens, the options for larger screens have become considerably more complicated in recent years. Historically, screens have been close to square-shaped, using a width to height ratio (aspect ratio) of 4:3 or 5:4, but with the advent of widescreen HD video, the whole industry moved to a widescreen format of either 16:10 or 16:9.

These days, screens have grown even wider, with 21:9 ultrawide screens now commonplace and even 32:9 screens available – that's the equivalent of two 16:9 screens side by side.

Going for a single, wider screen can be great for getting a more immersive view while gaming than on a standard 16:9 screen, and 21:9 screens in particular are much closer to the aspect ratio used in many films, so you don't have black bars of wasted pixels above and below the film. These wider screens can also be fantastic for productivity, giving you a single seamless desktop on which to spread around your windows. Typically, 21:9 screens will allow for two or three windows (a Word doc and Outlook for instance) side by side, while 32:9 screens can fit three or four windows, depending on the screen's resolution.

Resolution

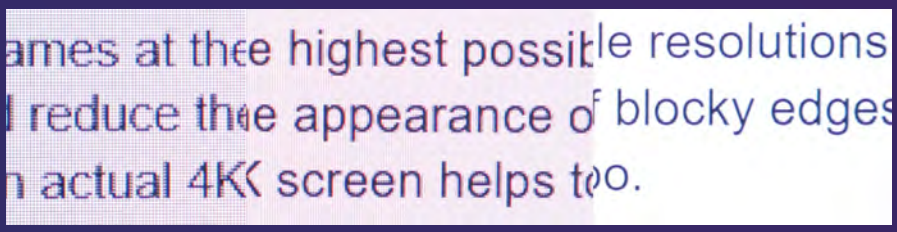
Your next consideration is resolution. As you no doubt already know, resolution is simply the measure of how many pixels are packed into a screen, usually stating the number of horizontal columns by the number of vertical rows. Sometimes, resolution is also stated in shorthand using just the number of vertical rows, so 1080p is often shorthand for 1,920 x 1,080 pixels.

Resolution and screen size aren't directly linked, of course. You can have a 4K screen that spans 24in or one that stretches to 42in.

UNLESS YOU HAVE A VERY POWERFUL GPU, YOU'LL NEED TO SCALE DOWN THE RESOLUTION TO GET THE FASTEST FRAME RATE

The larger screen just uses larger pixels and/or spreads them out a little farther from each other. This distance between pixels is known as pixel pitch and is measured in millimetres. Correspondingly, you have pixel density, which is the measure of how many pixels are found in a given area, and is generally measured in pixels per inch (ppi).

Typical desktop monitors range from 70ppi for a large 32in monitor with a relatively low 1080p resolution, and go up to 180ppi for a small 24in monitor with a high 4K (3,840 x 2,160) resolution. Meanwhile, laptops can hit

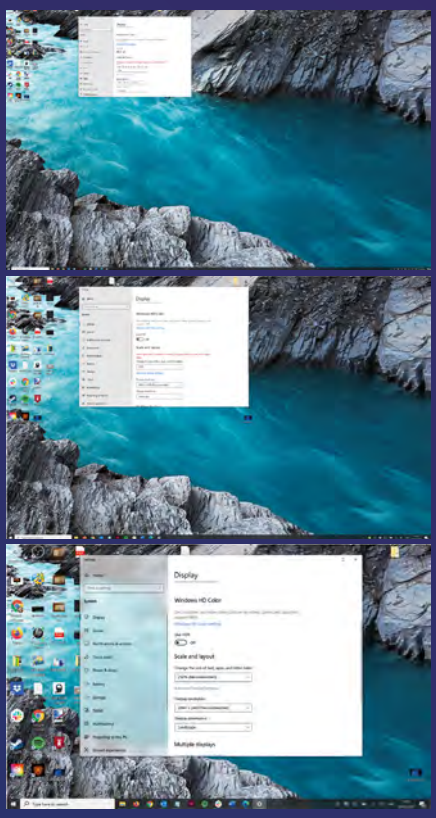


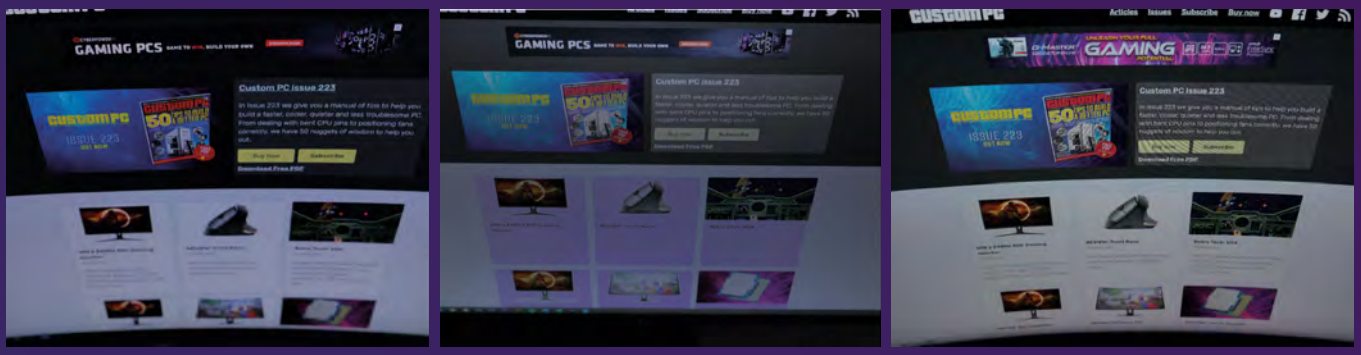
A higher resolution and pixel density makes for clearer text once you've enabled software scaling

upwards of 330ppi by packing a 4K resolution into a 13in screen and phones reach ludicrous levels of over 800ppi. When Apple introduced the Retina display on its iPhone 4, it claimed it had a high enough resolution for the individual pixels to not be visible to the naked eye, and that phone was 'just' 326ppi.

Crucially, while the pixel density of a display is fixed, that's not true of the visibility of individual pixels: it all depends how closely you view the display. For phones, 326ppi might be Retina quality, but for laptops that are generally a little further away from your face, any density over 200ppi is sharp enough to still look small and not pixelated. Meanwhile, for desktop screens that are further away still, you can drop

A 4K resolution on a small screen, as found on a 13in laptop, results in a comically unreadable desktop and requires scaling up by 250 per cent to become readable





IPS (left) and VA (right) LCD panels maintain a much more consistent image when viewed at odd angles, compared to TN (middle)

down to as low as 160ppi and still get a pin-sharp-looking image.

Higher pixel densities can be great for producing sharp text, watching high-resolution video and playing visually detailed games, creating a more immersive experience and reducing the appearance of blocky edges and other visual artefacts. Likewise, for image and video editing, the higher density is great for taking in so much more visual information without having to zoom right into an image.

However, high pixel density screens have a problem, which is that to make text and other desktop elements a readable size, your PC's operating system needs to scale up the interface, increasing the size of text, buttons and other desktop elements. Images and icons are still rendered at full resolution and you get a sharp image but your actual desktop space ends up being reduced.

Typically, a 32in screen with a 4K resolution will have to scale by 125 per cent, making for an equivalent desktop area of 2,880 x 1,620, while a 27in 4K screen will effectively give you a 2,560 x 1,440 resolution desktop in terms of workspace. If you've just spent big money on a 4K screen and find yourself still limited by a cramped desktop, you might be a bit miffed.

The upshot is that you need to find a balance between screen size and resolution. For general desktop work, it's sometimes best to stick to a pixel density in the region of 100ppi if you don't want to bother with software scaling. To be fair, Windows is much better at scaling on high-resolution screens now than it used to be, but there's still some software that doesn't scale properly in Windows (you can usually Google for 'hidpi mode' to see if it will work).

A pixel density of 100ppi won't give you as sharp an image as higher density screens, but you get to use and appreciate every pixel. The same goes for competitive gaming. Unless you have a very powerful GPU, you'll need to scale down the resolution in order to get the fastest frame rate possible, and there's no point wasting money on unused/scaled pixels. However, if you play single-player games where graphical quality is more important than playing at 144fps+ frame rates, a 4K screen will make a massive difference to fidelity.

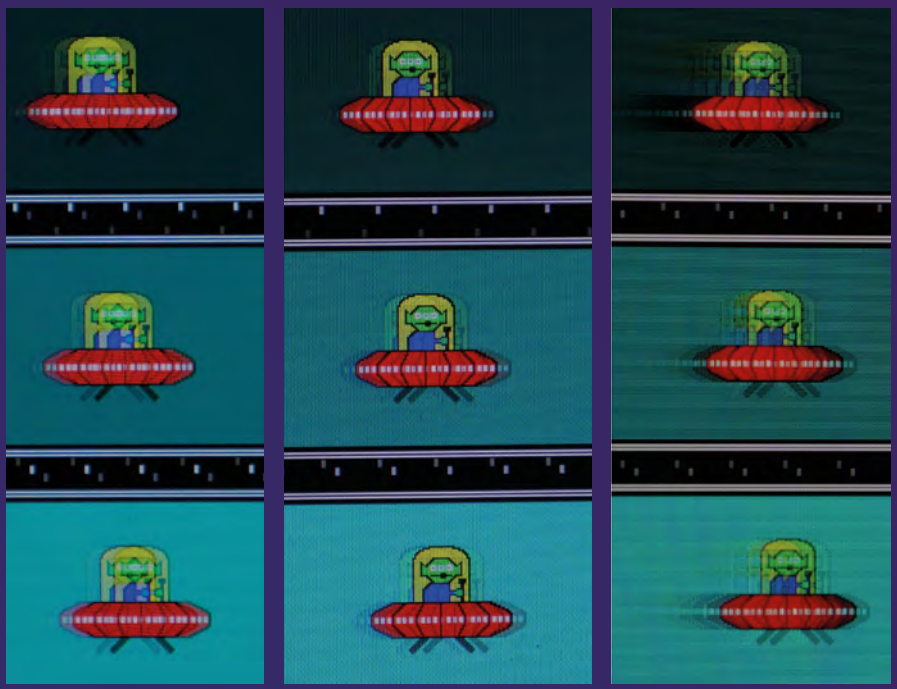
LCD panel type

Once you've nailed down the size and resolution of your screen, the next big consideration is to pick an LCD panel type. As a recap, LCDs work by producing an even source of light (the backlight), then they use a series of polarising filters and a layer of liquid crystal pixels (that can alter the polarisation of light) to block some or all of the light passing through them. Combined with colour filters, and sometimes technologies such as quantum dots, monitor makers can create the dazzling displays we all know and love.

Within that basic framework, though, there are three competing LCD technology types: in-plane switching (IPS), twisted nematic (TN) and vertical alignment (VA). While there is a smattering of other screen technologies used for computer monitors – such as OLED and of course older CRT screens – they're not readily available.

TN is the oldest LCD monitor technology, and its liquid crystal pixels are the fastest to respond of any LCD panel type, flipping between different colours far quicker than other panel types. This fast response time makes it the top choice for fast-paced gaming.

However, TN panels have a major downside, which is poor viewing angles. They tend to be



The very long, smeary ghost images produced with fast motion on VA panels (right) makes them much less viable for gaming than IPS (left) and TN (middle)

Viewed straight on (left) IPS panels look fine but from some angles they can show IPS glow (middle) but this isn't very noticeable on normal images (right). Note, these images have been edited to exaggerate the effect

stable enough when viewed within the normal range of head movements while sat directly in front of a screen, but there can still be a little bit of noticeable colour shift and shimmer, and they can be unusable if viewed from somewhere else in a room.

This is where IPS and VA panels come in, as both have much better viewing angles than TN. IPS in particular maintains a very stable image at all viewing angles, although it does suffer from what's known as IPS glow, which is where a lightness can appear in parts of the image when viewed at an angle. It's generally far less distracting than the viewing angle problems of TN panels, but it can be particularly noticeable when watching movies or playing atmospheric games, where the lightness can wash out dark parts of the image.

VA panels don't suffer from this same problem, but they tend to have a slightly less stable image quality overall when viewed from different angles and tend not to look as sharp when reproducing fine details such as text. It's for this reason we recommend IPS for desktop work and reading text, while VA can be better for video and some types of games.

The big advantage of VA-type panels is that they produce a far higher contrast than other panel types. Contrast is the ratio of the brightest and darkest colours a screen can show at the same time. IPS and TN screens generally top out at a 1,000:1 contrast ratio, while VA panels can regularly hit 5,000:1. This is down to VA being better able to block light to produce deeper black levels. A high contrast is particularly beneficial for watching videos (films especially) and playing dark, moody, atmospheric games, though it's less desirable for reading text and other desktop use.

Where VA seriously falls down is pixel responsiveness. While TN is the fastest tech around, VA is generally the slowest. This slowness can result in pixels still showing their previous colour despite being told to change colour. When fast motion is on screen, this slowness can result in ghostly trails from three or four preceding frames still being visible and resulting in a very blurry experience.

That's why we don't recommend VA panels for high-speed gaming. You can get VA displays that are perfectly able to play such games to a level where you'll still have fun, but an IPS or TN panel will provide a significantly better experience in terms of responsiveness.

Meanwhile, the response times of IPS panels sit between those of TN and VA. Typical average response times for TN gaming monitors are 3-4ms while for VA they can be 9-15ms (although there are some notably faster options) and IPS sits at around 4-6ms. That's why we generally view IPS as the ultimate all-rounder panel choice: great viewing angles, a very stable image and a decent response time make it great for desktop work and a range of gaming scenarios, and it's still decent for video. Meanwhile TN is the choice for competitive gaming and VA is great for watching movies and playing slower paced games.

IF YOU'RE REALLY PUSHING FOR THE UTMOST IN RESPONSIVENESS, IT'S GENERALLY WORTH STEPPING UP TO A 240Hz REFRESH RATE

Be wary of the quoted response times in monitor spec lists too. Manufacturers tend not to report an average response time but a minimum response time, which is why you'll see VA gaming monitors with 1ms response time slapped on the box. Unfortunately, you generally can't find out the real-world average response times from the manufacturer and instead you have to rely on reviews to test for and report about each monitor's responsiveness.

The other tricky factor is that response time can vary greatly within panel types. Again, the real picture can be difficult to discern without reviews, so it's worth putting in extra research to this one crucial measurement, if gaming response is a key concern for you.

Refresh rate

Only recently, people still debated the need for refresh rates higher than 60Hz (60 new images per second) on PC monitors, because the human eye supposedly couldn't perceive a higher refresh rate. However, now we're regularly seeing PC monitors going over 240Hz, and 120Hz screens are in demand on phones for buttery smooth scrolling.

Nonetheless, 60Hz is still fine for desktop work, image and video editing, and slower gaming, but moving up to a higher refresh rate makes a huge difference. It improves the readability of text while scrolling, smooths out the motion of moving windows and, of course, makes for smooth, responsive gaming.

The tipping point, we've found, for a screen to move from the slightly juddery motion found at 60Hz to the smooth-feeling motion of higher refresh rates is around 100Hz, but even a bump up to 75Hz or 85Hz can be worthwhile. There are relatively few monitors on the market that deliver more than 60Hz but less than 120Hz, but if your budget is very tight, there's a handful of 75Hz screens around.

For fast-paced games, opt for at least a 120Hz screen. Most gaming monitors top out

at 144Hz or 165Hz, which is ample for the vast majority of even the most competitive gaming scenarios, providing smooth-looking motion with the most extreme of mouse movements.

However, if you're really pushing for the utmost in responsiveness, it's generally worth stepping up to a 240Hz refresh rate. The change in smoothness from 144Hz or 165Hz up to 240Hz is relatively small, and certainly not worth it unless you're regularly playing competitive first-person shooters, but it is perceivable. Meanwhile, 360Hz and higher screens really start to see diminishing returns.

Bear in mind that you'll also need a GPU that's powerful enough to churn out the frame rates needed to synchronise with these high refresh rates in your favourite games. If you're still using a GeForce GTX 960, you're not going to hit 144Hz on a 4K monitor.

Motion blur reduction

One of the oldest techniques in cinema to improve the perception of motion is to insert black frames in between pictures to momentarily prevent your eyes from tracking the moving image, in effect resetting your eyes ready for the next picture. It's why zoetropes work and why many gaming monitors now come with a motion blur reduction mode, which flashes the backlight of the LCD on and off very rapidly in between each frame.

These blur reduction modes are often given acronyms, such as ULMB (ultra low motion blur) or MBR (motion blur reduction), but they all work the same basic way and, in general, we've found them to be very effective at reducing motion blur while gaming. The effect is more subtle than a faster refresh rate – you may not notice a faster response all the time, but there's definitively an extra sharpness and clarity in extreme movements in games, making it easier to track enemies and hit your shots. You can see the effectiveness of the technique at increasing the clarity of the moving alien image in the image below.

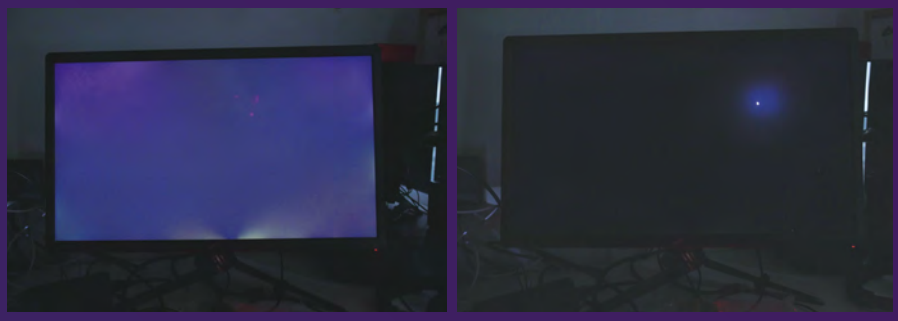
Turning on backlight strobing blur reduction (right) greatly increases image clarity for fast motion

Blur reduction modes are a great addition for gamers but, unlike faster refresh rates, they have no benefits for any application outside of gaming. Technically, they can smooth video too, but we would seldom recommend keeping blur reduction turned on just for that. There's also a potential drawback, which is that blur reduction often tops out at 120Hz, even on screens with faster refresh rates, so you may have to try 120Hz with blur reduction against 165Hz without it and see which you prefer.

Most blur reduction techniques also don't work with adaptive sync (see below), so you'll have to choose whether a smoother frame rate and no screen tearing, or crisper images in fast motion, is more important to you. However, there's a handful of monitors that do support both, such as some Asus displays, which include a mode called Extreme Low Motion Blur Sync (ELMB Sync).

Adaptive sync

A few years ago Nvidia introduced a pioneering screen tech called G-Sync, which looked to solve two fundamental issues with gaming on PC monitors. The first is screen tearing, which is where a monitor's refresh rate is out of sync with the rate at which a graphics card produces each new frame. This lack of synchronisation would mean that the monitor could end up showing parts of multiple different frames at once, resulting in visible step changes in the image known as screen tearing.



Without local dimming normal LCD monitors leak too much light to produce meaningful HDR, but full array local dimming backlights can illuminate only the backlight zones that are needed (images edited to exaggerate the effect)

This could be removed with a setting called vertical sync (v-sync), which ensures the monitor always waits for a full new frame before updating its image – it's a relic of the CRT era where you needed a 60Hz refresh rate to reduce visible flickering. The problem was that, even with v-sync enabled, if a graphics card ever dipped below the maximum refresh rate of the monitor, it would then have to wait a whole extra frame to change its image, resulting in a single frame being shown for twice as long as it should be. This can create a distracting juddering effect.

G-Sync fixed both these issues by allowing a monitor to adapt its refresh rate to match the speed at which a GPU completes rendering each frame. It was brilliant technology and a real premium selling point for high-end monitors, until the rest of the industry came along with a non-proprietary alternative that's now commonplace in most screens.

Nowadays the generic version of G-Sync – called adaptive sync – is widely supported by most gaming monitors and should work on both AMD and Nvidia cards, but double-check whether any given model does actually support both before you buy your screen.

We consider adaptive sync to be a must-have technology for gaming, and in fact consider it more important for games where fast motion isn't so much of a concern as it is in competitive first-person shooters. The longer time each frame is shown at lower frame rates, the more the judder from v-sync becomes noticeable, while screen tearing will ruin your lovely cinematic-looking game.

HDR

High dynamic range (HDR) has been a key buzzword of all visual media for a few years now, but it remains a niche feature and one

Unless you invest in a colorimeter to calibrate your display, you'll want to ensure you're buying a monitor with good out-of-the-box calibration

that muddies the waters when it comes to PC monitors. The basic premise of HDR is to provide a much greater range of contrast (10,000:1 and higher) and colour saturation, to better reflect the vast range of colours and brightness levels we experience in real life. And sure enough, when it's done well, HDR can look stunning. However, its implementation can be problematic on PC monitors for a couple of key reasons.

The first is that LCD monitors can't produce the extreme brightness and black levels to achieve the high contrast HDR requires to make its full impact. VA monitors can get close, due to their natively low black levels, but they're still a long way off the pure blacks that OLED screens can provide, for instance.

The only way round this is to dynamically control the backlight's brightness to increase the range of brightness levels the display can produce. On cheap displays, this is done by simply altering the brightness of the whole backlight – if the average brightness of a frame is quite dark, the backlight will dim slightly, and if the whole frame is quite light, the backlight will brighten. However, put simply, this workaround is a bit rubbish. These models aren't worthy of being called HDR.

Instead, what you need is a backlight that can be controlled more granularly, so that its brightness can vary in different zones within one frame. Some monitors do this by splitting up the backlight into just a handful of columns of light (most backlights are lit from the top or bottom edges allowing for control along these edges) but again these aren't very good.

The only viable system for creating a proper HDR image on PC monitors is by using a grid of independently controlled LEDs across the whole expanse of the backlight. These are known as full array local dimming (FALD) backlights. You still only get a few hundred backlight zones compared to the millions of pixels on-screen but it's enough to get a worthwhile range of brightness in one image. Unfortunately, such displays don't come cheap, with no models costing under £1,000.

The other main feature of HDR is a higher colour range, and this feature is supported by many monitors. However, they often don't cover the full range of extra colours stipulated by the most demanding HDR standards so it can be a very hit or miss process.

Perhaps most importantly, many of these displays don't offer a means to limit the colour range back to the standard sRGB colour space that's used to produce most of the normal content we watch on our screens. As such, colours can look unnaturally oversaturated. That's why we always emphasise whether a display has a dedicated sRGB mode, which allows you to rein in any extended colour range so the display can show colours as intended.

Imaging professionals

Talking of extended colour ranges, this is what some image and video editing professionals will need from their monitor. If you're working in HDR video production, or use the extended AdobeRGB colour space for image editing, then you'll need a screen that can reproduce those colours accurately.

The same goes for displays that don't reproduce colours evenly across the whole expanse of the screen. What you may think is a dark or yellow patch in the corner of an image that needs fixing may turn out to be just your monitor playing up. Unfortunately, you will seldom find these criteria listed in the specs for anything but professional displays, but we check them in our reviews, so look for these tests if these use cases are a concern for you.

Extra features

Once you've whittled down the key features you need from your new monitor's LCD panel, you can finally start looking at the other extra features, and there are plenty to consider.

First up is the stand. Unless you're investing in a separate wall or desk mount, your stand needs as much adjustability as possible so you can easily get it set to the right height, twisted and tilted to face the right direction or even pivoted into a portrait orientation if that's a requirement. The cheapest displays will offer only tilt adjustment, while some only offer height and tilt adjustment, but won't let you rotate the display left and right.

Another key consideration is connection options, with the number of and type of display connections being crucial for those that want to connect multiple devices. Most displays these days come with one DisplayPort and two HDMI inputs, which is generally sufficient, but be sure to check whether the ports support all your devices at the right spec – if you want to run the latest consoles at 120Hz, or run a 4K screen at 144Hz, these ports will need to be of the right standard. Look for DisplayPort 1.4 and HDMI 2.

LCD MONITORS CAN'T PRODUCE THE EXTREME BRIGHTNESS AND BLACK LEVELS TO ACHIEVE THE HIGH CONTRAST HDR REQUIRES

Now, a full discussion of the options for professional-grade editing gear is beyond the scope of this article, but for those dabbling in image and video editing at home, there's a couple of key aspects to consider.

The first is good out-of-the-box calibration. Unless you're willing to invest in a colorimeter to manually calibrate your monitor, you're reliant on manufacturers shipping monitors in a sufficiently good state to ensure colours look correct. If you edit an image or video then upload it to Instagram or YouTube, you want to know that it will look as you hoped on other devices, and a badly calibrated monitor will prevent that.

A USB hub can also be really useful, allowing you to plug in desktop devices such as your keyboard and mouse to the monitor, then only trailing one USB plug to your PC. Again, check for the which generation of USB the hub supports if you care about connecting any high-speed or high-power devices. Some monitors offer a USB Type-C connection for video too, so you can hook up your keyboard, mouse and monitor to a laptop all via one connection.

Then there are speakers, which for many people are entirely superfluous but they can be useful as an emergency extra, or if you really don't want to bother with separate desktop speakers. Many monitors omit them completely, or have terrible ones, so it's worth checking reviews to see if the speakers are at least passable. Some multimedia-focused monitors make a point of including better quality speakers than usual too.

Other extras can include flip-down or popout headphone stands, which can be super-useful to hang up your headset after an evening's play, and of course, if you're into RGB lighting then plenty of monitors are festooned with extra lights too.

Recommendations

We've battled our way through all the jargon and options for picking a new monitor, but ultimately, which would we recommend? Well, you can check out our Elite list for our latest top picks, but we've also put together a quick table of general recommendations for any given budget. Not every option will be covered, and not every choice will suit your needs, but that's why it's important to be sure about where your priorities lie when it comes to choosing your next monitor purchase. Ultimately, the choice is yours. CPC

BUDGET / INTENDED USE	PRIORITIES	AVOIDANCES
£100-£200 DESKTOP USE	IPS or VA panel for best image quality; 24-27in size; 1080p or 1440p resolution; fully adjustable stand	Avoid TN panels; high refresh rate not a priority; don't pay attention to HDR at this budget
£100-£200 FOR GENERAL USE AND GAMING	IPS or VA panel for balance of image quality and performance; 24-27in size; 1080p resolution; refresh rate of 75Hz or higher; adaptive sync	Avoid TN panels for best desktop image quality; cut out extras to maximise budget for image quality / performance; don't pay attention to HDR
£100-£200 ESPORTS USE	1080p resolution; 24-27in size; refresh rate is key (at least 120Hz); TN panel for best performance	Avoid VA panels for optimal performance, cut out extras such as adjustable stands to maximise budget for performance
£200-£400 DESKTOP USE	IPS or VA panel for best image quality; 24-27in size; aim for at least 1440p resolution for more desktop / better image quality; fully adjustable stand	Avoid TN panels; high refresh rate not a priority; don't pay attention to HDR at this budget
£200-£400 GENERAL USE AND GAMING	IPS or VA panel for best image quality; 1080p or 1440p resolution; refresh rate of 75Hz or higher; adaptive sync	Avoid TN panels; 1080p may feel limiting for desktop use; don't pay attention to HDR at this budget
£200-£400 ESPORTS USE	Stick to 1080p resolution and TN panels; at least 144Hz refresh rate; adaptive sync support; blur reduction	Avoid VA panels for optimal performance
£400-£600 DESKTOP USE	IPS or VA panel for best image quality; at least 1440p resolution; fully adjustable stand; 34in ultrawide panels are a great choice; this should be peak budget for a general desktop monitor	Avoid TN panels; high refresh rate not a priority; HDR still not great at this budget
£400-£600 GENERAL USE AND GAMING	IPS or VA panel for best image quality; at least 1440p resolution; at least 120Hz refresh rate; fully adjustable stand; 34in ultrawide panels are a great choice	Avoid TN panels for best image quality; HDR still not great at this budget
£400-£600 ESPORTS USE	Stick to 1080p resolution and TN panels; at least 240Hz refresh rate; adaptive sync support; blur reduction; this is peak budget for esports monitors	Avoid VA panels for optimal performance
£600-£1,000 GENERAL USE AND GAMING	IPS or VA panel for best image quality; at least a 34in ultrawide panel, at least 1440p resolution, at least 144Hz refresh rate; HDR can start to be usable at this price level	HDR can still be fairly underwhelming at below £1,000 so proceed with caution
£1,000+ GENERAL USE AND GAMING	IPS or VA panel for best image quality; at least a 34in ultrawide panel, at least 1440p resolution, at least 144Hz refresh rate; FALD backlight for proper HDR	Saving money

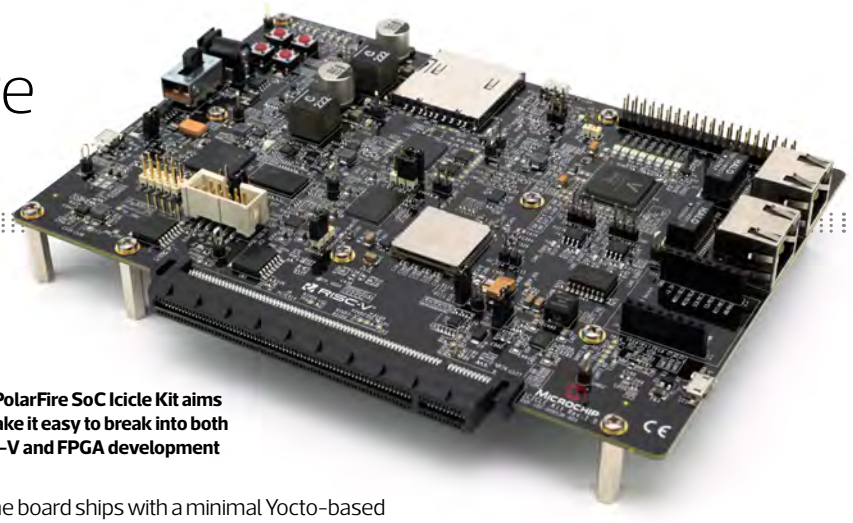
GARETH HALFACREE'S

Hobby tech

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

REVIEW

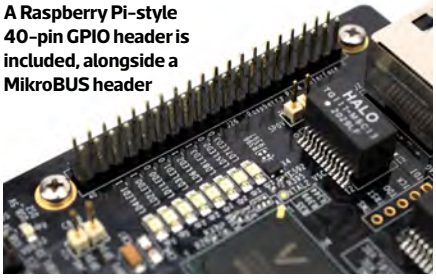
Microchip PolarFire SoC Icicle Kit



The PolarFire SoC Icicle Kit aims to make it easy to break into both RISC-V and FPGA development

Microchip's PolarFire SoC Icicle Kit isn't your average single-board computer, and not only because it uses the free and open-source RISC-V instruction set architecture for its five processor cores, albeit in proprietary form from SiFive.

What makes the PolarFire SoC Icicle Kit special is right there in the name: the PolarFire system-on-chip (SoC), which features a real-time core, multi-processing cores and a field-programmable gate array (FPGA) with 245,000 logic elements (LEs) and 784 math blocks, allowing the hardware to be reconfigured in a variety of interesting ways.



A Raspberry Pi-style 40-pin GPIO header is included, alongside a MikroBUS header

The board ships with a minimal Yocto-based Linux environment pre-loaded on the 8GB eMMC, but there are significant improvements to be found by updating to the latest version – including a doubling of performance in certain workloads. There's a JTAG debugger built into the board, so no extra hardware is needed, and the relevant software to flash the FPGA with the latest bitstream is available for Linux and Windows. You then just need to use a tool such as Balena Etcher to write the latest Linux image to the eMMC over USB.

It's still a work in progress though. There are still a few bugs being ironed out, including a strange performance drop in AES cryptographic operations and an inability to use the full 2GB of RAM on the board – the latter is due to be addressed in the next image release.

Once updated, the performance of the PolarFire SoC's CPU complex impresses. It has four SiFive RV64GC cores – shorthand for RV64IMAFDC, missing the recently ratified vector extensions – plus a fifth RV64IMAC core reserved for a real-time companion operating system such as FreeRTOS.

These cores are clocked at just 600MHz, but punch well above their weight – the system is responsively snappy, and Linpack, Whetstone and Dhrystone trade blows with an admittedly aging Raspberry Pi Zero (reviewed in Issue 150) despite the latter running at 1GHz.

Switching to real-life workloads lets you take advantage of the quad-core complex, too, where a 49.28-second file compression

The SoC at the heart of the board offers surprisingly robust performance, plus plenty of room for FPGA gateware

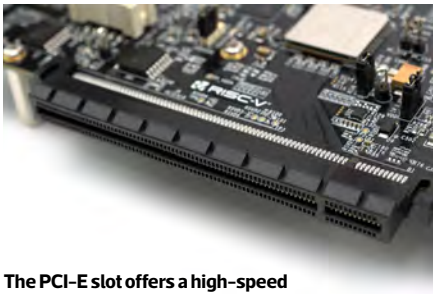
It's not cheap, but there's a lot to like about the Icicle

test drops to 16.3 seconds, over four times as fast as the Raspberry Pi Zero could manage.

A more even comparison is the Nezha D1 (Issue 221), another RISC-V board. Here, the Nezha pulls ahead in most benchmarks thanks to its 1GHz clock speed – although, impressively, the PolarFire SoC outperformed the D1 in the single-threaded file compression test despite running at a 400MHz deficit. If your workload can take advantage of all four cores, though, there's no contest between the two – the PolarFire SoC is a clear winner.

Treating the Icicle as a single-board computer for running Linux applications would entirely miss the point. It's an engineering platform that's designed around the FPGA, rather than the fixed-function processor cores. By loading new gateware onto the FPGA, you can reconfigure the hardware in a variety of ways – and the four 600MHz RISC-V cores are plenty powerful enough to keep whatever you load into the FPGA busy.

If you want to customise your own Linux for the board, you'll need to make sure you have plenty of hard drive space. Building a new operating system image using the Yocto Linux board support package (BSP) takes around 100GB of space and several hours of compilation time.



The PCI-E slot offers a high-speed connection to peripherals, or even a GPU

For harnessing the power of the FPGA, meanwhile, you'll need another fistful of gigabytes free for Microchip's Libero SoC software suite – a proprietary, closed-source development package for which Microchip provides a free licence that's renewable annually. At the time of writing, the PolarFire SoC wasn't supported in any of the major open-source toolchains.

Meanwhile, the on-board FlashPro JTAG debugger, introduced in the board's latest revision, makes it possible to work with the FPGA and flash new gateware without an additional device cluttering your desk. It also has 52 test points, a Raspberry Pi-compatible general-purpose input/output (GPIO) header, and two Gigabit Ethernet ports capable of sustaining around 934Mbps.

There's potential for expansion too. The board includes a full-sized PCI-E slot to one edge, ready to accept additional hardware. Theoretically, it's possible to fit a GPU to add a video output, although at the time of writing, the only card supported by the GNOME desktop environment on the Icicle is the aging ATi (AMD) Radeon HD 6450, and even then it doesn't offer hardware acceleration.

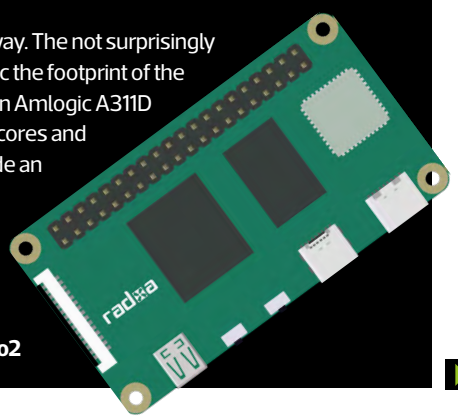
At £425.55 (inc VAT) the Icicle isn't cheap, and its best features will go to waste if you're only looking to experiment with RISC-V. For engineers already working with FPGAs, and for those who want to venture into the field and are happy to spend the money on a device they won't quickly outgrow, though, it ticks an awful lot of boxes.

The Icicle kit is available to purchase from **uk.farnell.com** now, and there's also an open-hardware accessory to add an HDMI port for framebuffer output, which is available at **custompc.co.uk/HDMIBreakout**

NEWS IN BRIEF

Radxa teases compact 6-core Zero 2

There's a successor to the Radxa Zero on the way. The not surprisingly titled Radxa Zero 2 is designed to roughly mimic the footprint of the Raspberry Pi Zero family, and is set to include an Amlogic A311D 6-core chip with four 2.2GHz Arm Cortex-A73 cores and two 1.8GHz Cortex-A53 cores. It will also include an Arm Mali-G52 MP4 GPU, INT8 neural network accelerator, 4GB of RAM and up to 128GB of eMMC storage. At the time of writing, Radxa hadn't announced pricing or availability and had only shared a rough illustration; more information is available at **wiki.radxa.com/zero2**



REVIEW

Arducam 16MP Autofocus Camera Module

If you're sick of blurry photos and videos, Arducam's latest camera module could be for you

Raspberry Pi's range of MIPI CSI camera modules have long been popular, and the launch of the HQ Camera Module (reviewed in Issue 205) brought a major boost in resolution with it, along with increased flexibility through the use of interchangeable lenses.

Arducam, best known for building all-in-one machine learning cameras, thinks it can do better with a 16-megapixel camera module of its own, and while it lacks the interchangeable lens support of the Raspberry Pi HQ Camera Module, it has a clever trick up its sleeve – autofocus capabilities.

This isn't the first time Arducam has added autofocus to the Raspberry Pi – the company previously modified official Raspberry Pi Camera Modules to include motorised autofocus. Its latest launch, though, packs a Sony IMX519 16-megapixel sensor – up from the 12.3-megapixel IMX477 found in the HQ Camera Module.

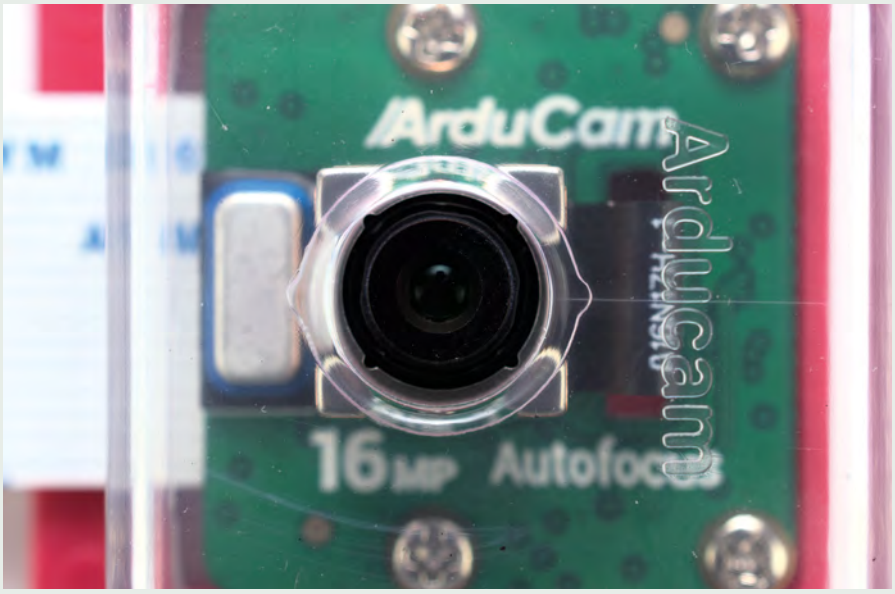
Hardware installation is straightforward, using the same ribbon cable as the original Raspberry Pi Camera Module range. In fact, the module itself mimics the Camera Module footprint exactly – to the point where you can remove it from its bundled protective case and pop a Raspberry Pi camera Module in there instead.

Software installation, sadly, is where this product begins to fall apart. Arducam provides an installation tool, which you have to run three times in order to install a development package, the application package and a kernel driver. While both Raspberry Pi OS Buster and the current Bullseye release are supposedly supported, kernel driver installation will fail on a Bullseye install that's been upgraded past the 5.10.73 build released in October 2021.

Even rolling back the kernel version isn't guaranteed.

The software kept crashing on Bullseye when we tested it, but it worked once the test system was rolled all the way back to a Buster build from May last year.

The patchy software is a shame, because the hardware is seriously impressive. Stills taken at the sensor's full resolution of 4,656 x 3,496 show fantastic levels of detail – far in excess of what you could manage to get from a regular Raspberry Pi Camera Module. In this



The module itself is enclosed in protective plastic, but the lens is left exposed

There's a tripod mount on the rear, but your tripod needs to be adjustable to 90 degrees to use it

Colour reproduction is a really strong feature of the Arducam module

respect, it's better even than the HQ Camera Module, although the latter benefits from improved light-gathering when paired with a decent lens. Images do soften towards the edges, however, but that's only to be expected with a lens this small.

Colour reproduction is impressive too, as we found when we tested it against a board of known colour values. While whites can come out a little muted, most colours are reproduced with a high level of accuracy, and with no manual tweaking required.

The autofocus system, meanwhile, is a little hard to master. The camera is accessed through customised versions of the new libcamera utilities, and a separate Python tool allows for manual focus adjustment.

The latter is installed by cloning a GitHub repository, adding a fourth step to the software installation process. Keep the preview window open, and you can then tap the up and down arrows on the keyboard to shift the camera lens through its entire focal range one step at a time.

There's an autofocus mode too, but it's a one-shot system – there's no option for continuous autofocus, nor advanced features such as subject tracking. It's not even possible to change the autofocus point – the camera will always focus on whatever is in the dead centre of its view.

One of the promises made by Arducam on the camera module's crowdfunding campaign, which recently closed with over HK$1,000,000 (around £94,500) raised, is that it can also be used as a simple microscope. That's technically true, but you'll never get results as impressive as the company's demo shots. In testing, close-up imagery showed clear barrel distortion and blurring at the edges, while the preview window proved unsuitable for live inspection and the bundled 15cm ribbon cable leaves little room for manoeuvre.

That said, still images captured at maximum resolution do allow for after-the-fact close-up investigation. For example, the images are clear enough to see individual fibres and specks of dust sat next to compact surface-mount resistors on a circuitboard left on a desk for a few months.

The Arducam autofocus camera module isn't perfect then, and the company has a lot of work to do on the software front before it can even be recommended.

It does have one factor in its favour, though, which is the price. Once crowdfunding backers have their cameras in-hand, Arducam plans to sell the modules for just $25 US (around £22 inc VAT) – undercutting the 8MP Raspberry Pi Camera Module and costing less than half the price of the HQ Camera Module.

There's one big caveat though. For reasons the company has not disclosed, the Arducam camera module can't be used alongside the Raspberry Pi PoE HAT or PoE HAT+, nor the Raspberry Pi Touchscreen Display.

By the time this issue goes to print, the Arducam 16MP Autofocus Camera Module should be available to order from UK reseller **thepihut.com**. If not, contact **arducam.com** for availability information.

Mid to long-range images are impressively detailed, although they soften at the edges

NEWS IN BRIEF

Jolly brings Wi-Fi to Arduino Uno

Gianluca Martino, one of the Arduino co-founders, has unveiled a drop-in upgrade for the Arduino Uno development board – boosting storage and adding Wi-Fi support.

'Thanks to our Jolly module it will be possible for all Arduino enthusiasts and Uno owners to bring existing projects to the next level,' Martino claims, 'turning the historic Arduino Uno into a modern IoT [Internet of Things] board.' The upgrade PCB drops into the Uno in place of the DIP-packaged ATmega328P, and includes an ATmega328 of its own, Espressif ESP8285, chip antenna and 2MB of flash storage. More information is available on **jolly-dev.com**

REVIEW

Warez: The Infrastructure and Aesthetics of Piracy

Martin Paul Eve's Warez: The Infrastructure and Aesthetics of Piracy proclaims itself 'the first scholarly research book about the Warez Scene', and it delivers its promise. This isn't a coffee table book, and there are very few illustrations to break up the text. Even the fifth chapter, dedicated to aesthetics, has only four images – two screenshots of a demo released in 2009, largely unrelated to the central topic, and two examples of the ASCII art commonly found at the top of NFO (info) files – one rendered using the wrong codepage, the other rendered correctly.

Compared with a book such as Crackers I: The Gold Rush (reviewed in Issue 218), with its double-page image spreads and full-colour gloss, Warez is positively spartan, despite treading much of the same ground. Both books look at groups responsible for distributing copyright material, although Eve's focus is less on software and more on media.

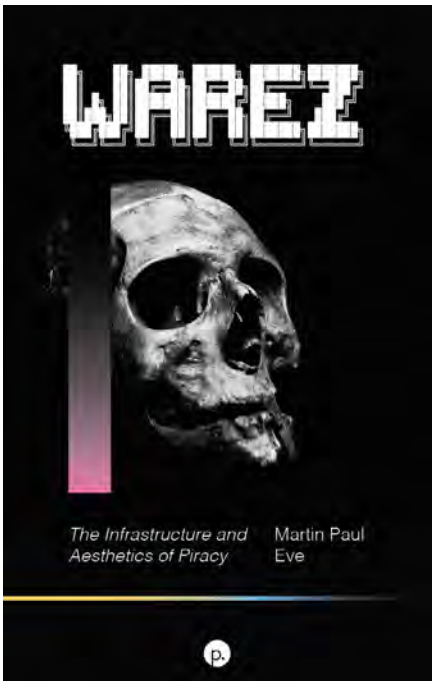
Many academic publications are dry, and Eve has struck a balance with Warez that manages to avoid this pitfall while still adhering to the requirements of a scholarly tome. Impressively, it manages to take a beat or two to entertain the reader as well.

His approach to research may raise some eyebrows, however. At no point during the preparation of the book did he speak directly to anyone in the warez scene, past or present. Instead, he sought to 'infer its operation from [...] archival objects' – in particular, archives of NFO files, messenger logs and digital magazines.

There are direct quotes to be found, leaning on interviews published by others on the same topic. There are also lifts straight from the archives in question, complete with l33tsp33k and the occasional swear word. Eve takes a detour at one point to discuss the subject of hate speech, 'usually homophobia', in scene publications – then later looks at the 'translation of certain non-English characters to blocks' for ASCII art as a form of 'computational, linguistic colonialism'.

Eve's biggest take, and one that's argued persuasively, is that the warez scene – despite being entirely about the redistribution of others' copyrighted intellectual properties without permission or recompense – is, effectively, a giant alternate reality game in which participants vie for recognition and respect among their peers, while at the same time trying to hide their illicit activities from the world.

There's little imagery, but plenty of footnotes – and a 72-page bibliography



Don't let the cover fool you: Warez is a real academic study of the subject

Warez is extremely thoroughly researched, albeit primarily through digital archaeology, as the 72-page bibliography and impressively detailed appendix proves. It covers 'topsites' and 'dumps', with dozens of pages of tabulated data including site names, operator aliases, known affiliates and more.

The overall feel of the book, however, is rather scattershot. The bulk focuses on the turn of the century, from which the digital corpus used as a primary source was extracted, but the chapter on legal takedowns reaches right up to 2020 – and even discusses Bitcoin.

There are moments when Eve is clearly operating outside his field of expertise. One comes early in the book, in its four-page glossary ahead of the first proper chapter. Here, the author attempts to describe the operation of a RAID array but claims striping – rather than mirroring or parity – exists to 'protect against the risk of catastrophic drive failure and data loss'.

Despite these moments, Warez is a detailed and even enjoyable look at a relatively understudied field, and one that largely avoids lauding or demonising its occupants. Warez is available as a free download from **punctumbooks.com**, or in print from amazon.co.uk at £22 (zero-rated for VAT). CPC

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at **freelance.halfacree.co.uk** @ghalfacree

WIN

A PATRIOT AND COUGAR KIT BUNDLE

CASE, PSU, CPU COOLER, SSD AND RAM UP FOR GRABS

Our kind-hearted pals at Patriot and Cougar have put together a cracking bundle of kit to get you started on a new PC build, or to help you upgrade some of your current gear. Patriot is providing a 1TB PCI-E 4 NVMe SSD, along with a 16GB (2 x 8GB) dual-channel 3600MHz memory kit.

Meanwhile, Cougar is providing a 240mm AIO liquid cooler for your CPU, along with a 650W 80 Plus Bronze PSU and an Archon 2 Mesh RGB case. One winner will get all the parts in the bundle sent to their home. Add your own choice of CPU, motherboard and graphics card, and you'll effectively have a whole new PC build.

PATRIOT MEMORY (VIPER GAMING)

Patriot is a brand that gained its recognition and status from its performance memory (with over 25 years of experience building memory kits), which has since also extended its expertise into gaming peripherals. Patriot is offering the following components in the bundle.

- 1TB Patriot P400 PCI-E 4 NVMe SSD
- 16GB (2 x 8GB) Patriot Viper Steel 3600MHz DDR4 memory kit

COUGAR GAMING

Established in 2008, Cougar offers multiple products for the serious gamer who isn't afraid to stand out from the crowd, with unique peripheral and case designs. Cougar is offering the following components in the bundle.

- Cougar Archon 2 Mesh RGB Black case
- Cougar VTE X2 650W 80 Plus Bronze PSU
- Cougar Aqua ARGB 240mm AIO liquid CPU cooler

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

Competition closes on Friday, 1 April. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation and Raspberry Pi Ltd, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. 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

LGA1700 cooler compatibility is a mess

If you're buying a new LGA1700 motherboard, choosing a cooler for your processor won't be straightforward. Outside of the manufacturers that have been clear about their coolers that are and aren't compatible with the new socket, there are rafts of other manufacturers that haven't made any statement about compatibility.

This has annoyed me for several different reasons. Firstly, from my perspective when I'm testing numerous coolers in a group test, it makes my job far trickier if I have to check whether every cooler is compatible and, if not, then checking whether an adaptor kit is available and then ordering it. This essentially doubles the number of items I need to think about, increasing the time it takes to deal with testing.

For anyone not well versed in this mess, it can be extremely daunting, especially as some manufacturers simply don't have the necessary information on their websites – not even a simple note to say yes or no. That's poor in my opinion. However, what's really silly is that in some cases with our 120mm AIO cooler Labs (see Issue 223), some officially incompatible coolers did actually work reasonably well on LGA1700 CPUs, with the additional mounting holes on Asus motherboards increasing the likelihood of compatibility.

This means that if you already owned such a cooler, you wouldn't actually need to replace it, even though the product's web page may lack information about LGA1700 compatibility. That's just poor form; I can only assume some manufacturers are keen to increase sales of newer coolers that are listed as compatible.

The trouble is, unless you have guaranteed compatibility, you won't know if your cooler is actually making good contact with the lower-riding heatspreader. In some cases in the Labs, a cooler seemed to work, but it was only when I compared the results with those of better-fitting coolers that it was clear that it wasn't making the best thermal contact, even though the thermal paste appeared to have spread well and enough pressure was being applied.

In short, unless you have a cooler with guaranteed LGA1700 compatibility, or you've purchased an adaptor kit from the likes of NZXT, ARCTIC or Corsair, then I'd err on the side of caution.

Not all LGA1700 motherboards have LGA1200 mounting holes, and even if they do, there's no guarantee a cooler will apply enough pressure

Are 120mm AIO liquid coolers worth it?

I'd been looking forward to last month's group test of 120mm AIO liquid coolers for a while. I'd heard plenty of comments online about them being pointless compared with larger models with bigger radiators, but what surprised me was testing NZXT's Kraken 120 when Intel launched its 12th-gen CPUs recently.

It actually managed to tame the mighty Core i9-12900K at stock speed, which is significant news for small form factor systems. It means that while many small or low-profile air coolers would struggle, using a 120mm AIO liquid cooler could be sufficient and would also dump the heat straight out of your case via the radiator.

These coolers are cheaper than larger models and easy to install, especially in cases with limited cooler height limits. There is a flip side to these positives, though, which relates to radiator size. The key benefit of larger radiators – and this applies to custom liquid cooling too – is that they have a much greater ability to dissipate heat.

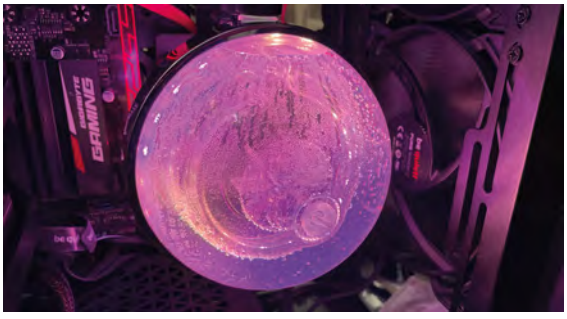
This is due to their larger heatsink surface area and greater number of fans, which combine to offer better cooling at lower noise levels, as the fans don't need to spin as fast to offer similar or better cooling. In addition, there's more coolant in the loop, as radiators have large cavities for it to flow through them. The high heat capacity of coolants means they can absorb a lot of heat before they actually warm up – the more coolant in the loop, the longer it takes before the fans need to spin up. As a result, larger AIO liquid coolers will remain quieter for longer.

While a 120mm AIO cooler can cope with a Core i9-12900K under full load, it will likely need to spin up its fan to full speed quickly to deal with the heat. A larger liquid cooler won't have to do this, even if the pump, flow rate and contact plate are identical. If you're using a less powerful CPU, though, such as the Core i5-12600K, a 120mm AIO liquid cooler can clearly do the job fine.

The be quiet! Silent Loop 2 offered good cooling for both high-end AMD and Intel CPUs, despite only having a 120mm radiator

My brother's Alphacool Eisball

Water cooling is usually concerned with efficiency; cramming as much cooling potential into as small a space as possible. For this reason, I often try to avoid having components that are larger than necessary, even if there's plenty of space in an ATX case.



Alphacool's orb-like Eisball features a D5 pump and RGB lighting

However, when my brother expressed an interest in water-cooling his PC recently (for which I'd offered my help), I was surprised to see he'd chosen a rather funky-looking component from Alphacool to use as his PC's centrepiece. The part in question was Alphacool's Eisball combined pump and reservoir.

I first saw it at CES a couple of years ago – a very large, ball-shaped reservoir with a couple of ports, a D5 pump mount and a bright ring of RGB lighting illuminating it. It's huge and the complete opposite to the reservoirs I use, but I have to admit that it looks fantastic once installed.

You can mount it in various places, thanks to Velcro and screw mountings, and it looks great, with a similar aesthetic to a Star Trek Borg regeneration unit or a mystical orb. The pump-equipped version uses Alphacool's own D5 variant with an adjustable speed dial that could be set at a very low speed in most cases, especially if you're just cooling the CPU. It won't be finding its way into any of my mini-ITX builds any time soon, but if you want to stand out from the crowd or just want to gaze at your very own mystical orb, check out the Eisball. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Vinyl-wrap your case

Antony Leather shows you how give your case a new colour and finish by wrapping it in vinyl

TOTAL PROJECT TIME / 2 HOURS

If you want to give your case a makeover with a new colour scheme, and maybe some fancy effects and patterns, using vinyl is often cheaper, quicker, less messy and easier to work with than spray painting. What's more, it's also simpler to remove than paint, whether you mess up or if you just want to change colours.

We've also looked at vinyl-wrapping your graphics card this month on p104, but vinyl-wrapping your case needs a slightly different method. That's because you need to deal with large surface areas, a greater risk of air bubbles and you also need to make sure your case can still breathe, with its panels still fitting correctly. Dealing with large sheets can be tricky, and you'll need to allocate extra time to get into hard-to-reach areas on panels and PSU covers.

TOOLS YOU'LL NEED

Adhesive vinyl
amazon.co.uk

Hairdryer
amazon.co.uk

Vinyl tool kit
ebay.co.uk

1 / MEASURE SURFACE AREAS

You'll need plenty of self-adhesive vinyl to cover case panels, so estimate the surface area you need to cover to ensure you buy enough. Pay careful attention to the widths of the panels, and ensure the vinyl sheet is both wide and long enough, not only to cover the panels, but also fold over the edges.

2 / ALIGN ANY PATTERNS

Before you start cutting, it's important to align any patterns in the vinyl with your case panel. Here, we're using a carbon fibre effect, so it makes sense to have it sitting square rather than diagonally.

3 / CUT TO SIZE

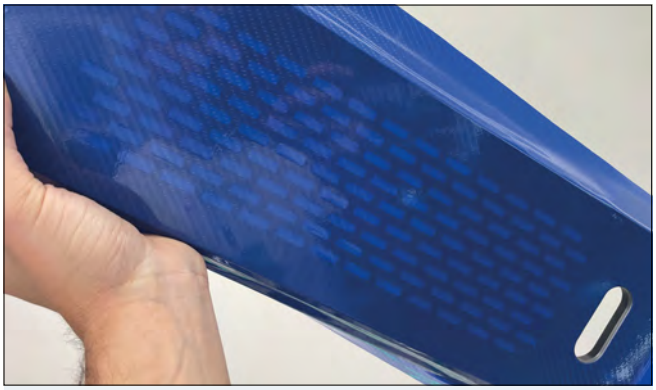
When cutting large sheets, it's best to use a vinyl sheet cutting tool, which is included in many vinyl wrapping kits. This will cut the vinyl in one go, meaning there are none of the jagged edges you might get from using scissors.

4 / HEAT WITH HAIRDRYER

A hairdryer will make the vinyl more malleable, making it easier to press into case recesses and stretch over components. Heat it with a hairdryer for 30 seconds on a high setting, moving the heat over the whole surface area and warming individual areas as you fix them as needed.

5 / USE A SQUEEGEE

Remove the backing paper to reveal the adhesive side, then press one edge against your case panel. Now use the squeegee to smooth the sheet over the panel and work out any air bubbles. If they prove stubborn, lift the sheet and try again.



6 / PRESS OVER VENTS AND BUTTONS

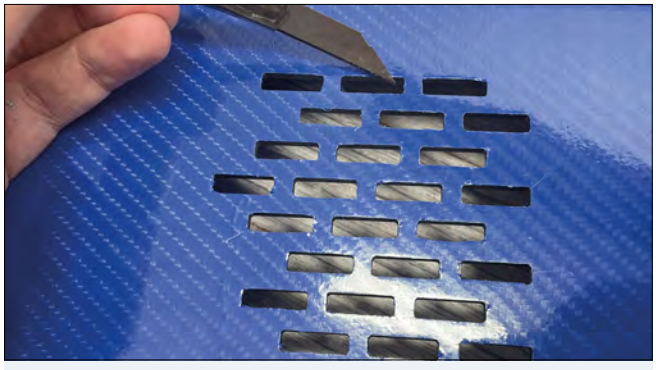
Now press the vinyl into any areas you'll need to cut out, such as vents and buttons. You'll be able to see some of these by illuminating the panel from beneath, allowing you to see the sections you need to cut out.

7 / STRETCH AND PRESS INTO CORNERS

It's important to anchor the vinyl into crevices in order to prevent it from lifting over time, and also to cover the edges of panels. Use the wrapping spatulas to work the vinyl into these areas and use plenty of force to stick the vinyl down.

8 / WRAP AROUND EDGES

To secure your vinyl in place, cut the edges into sections so you can wrap straight pieces around the edges of the case and cover them. Use the squeegee to press down these pieces, and make sure there's a tight fit around all the edges in order to avoid air bubbles.



9 / CUT OUT CASE FEATURES

Finally, cut out any covered air vents with a scalpel, so you don't impact airflow. Large vents such as the ones pictured will take a while to cut out, but cutting out really small vents can become tedious – don't start vinyl-wrapping a case with small vents unless you're willing to put in the work.

How to Apply vinyl to your GPU

Antony Leather shows you how to jazz up your graphics card with a removable splash of colour

TOTAL PROJECT TIME / 2 HOURS

Your graphics card probably looks reasonably attractive with its large cooler and maybe even some RGB lighting, but if you want to add a personal touch that (unlike spray painting) is completely reversible, you should definitely give vinyl wrapping a go.

Easy to apply and available in a huge range of colours and patterns, vinyl can add some colour to your graphics card to make it stand out or colour-match the rest of your PC. Of course, you also need to avoid hindering cooling and damaging your card when you trim the vinyl sheet to fit, but we'll be covering all of this in the guide.

TOOLS YOU'LL NEED

Adhesive vinyl
amazon.co.uk

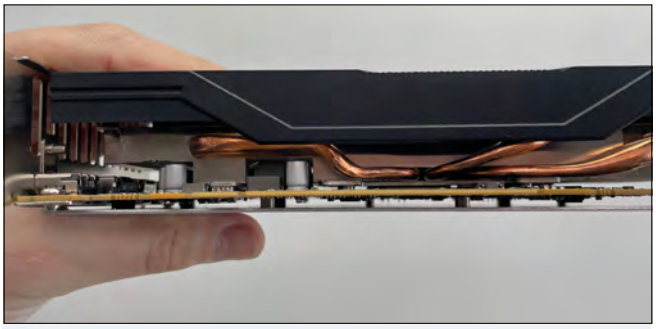
Scissors
Most hardware stores

Hairdryer
amazon.co.uk

Vinyl tool kit
ebay.co.uk

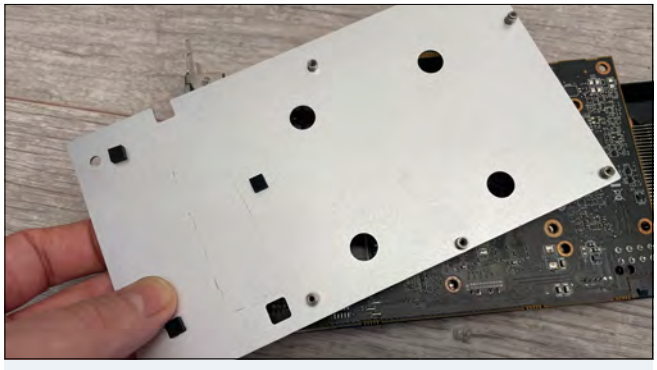
1 / CHECK FOR SUITABLE SURFACES

It's best to stick to flat surfaces with vinyl, as too many curves, bumps and corners can result in the vinyl lifting or become tricky to stick down. Backplates can be great for vinyl wrapping, as are square-shaped shrouds. However, don't cover a backplate if it dissipates heat, as this can cause higher core or memory temperatures.



2 / CHECK BACKPLATE

Check if the backplate is metal and see if thermal pads are visible. If not, it's probably just there for aesthetic reasons. If in doubt, play a game for an hour to see if the backplate gets hot, but even then bear in mind that this could still be down to residual heat from the heatsink.



3 / CHECK FOR THERMAL PADS

Remove the backplate – if it's used for thermal reasons, pads will be visible, usually connecting it to the PCB to cool memory modules or the rear of the GPU core. If so, don't apply vinyl to it, as the backplate's cooling will be hampered if it's covered. Our example only has rubber spacers between the PCB and the backplate, so it's fine.

4 / CLEAN SURFACES

The vinyl secures using adhesive, so it's important to ensure the surfaces are clean. Use isopropyl alcohol applied to a microfibre cloth to clean the areas, then allow it to dry before applying the vinyl.

5 / CUT VINYL TO SIZE

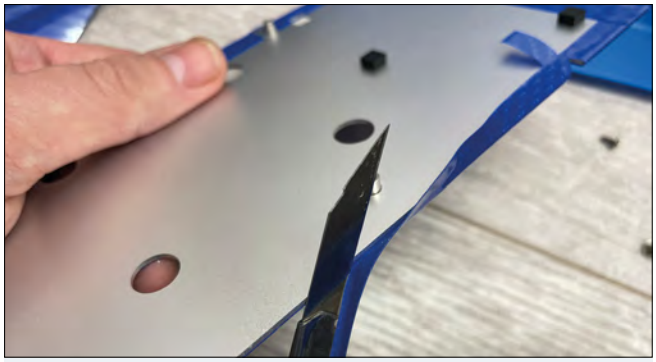
Use the backplate as a template to cut out the necessary vinyl, adding a centimetre extra, so you can wrap the vinyl around the edges and stick it onto the other side. We recommend using scissors to cut the vinyl here, as using a scalpel on large cuts can result in you inadvertently scrunching up the protective layer on the vinyl.

6 / WARM VINYL WITH HAIRDRYER

It's best to warm the vinyl before you to try to apply it, as it then becomes more flexible, which can help you when you're bending it over edges and into corners.

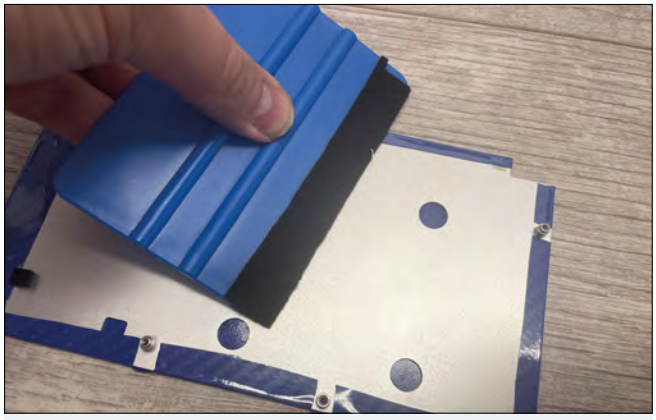
7 / USE SQUEEGEE TO APPLY

For curves, depressions and edges, heat the vinyl using a hairdryer, so it's hot to the touch, then use a squeegee to press it onto these areas, working it into the surface, so it sticks firmly. It can also be used to remove air bubbles.



8 / CUT THE EDGES

Once you're left with loose ends, trim the edges with a scalpel (giving you more precision than the scissors), so that no more than 5mm is left to secure the vinyl on the other side of the backplate. Alternatively, if you'd rather not wrap the vinyl around the backplate, simply trim it in line with the backplate's edges using a scalpel.



9 / FOLD OVER EDGES

Ensuring the edges of the vinyl are heated, use the other fitting tools in the kit to work the vinyl into any nooks and crannies, wrapping it over the edges of the backplate and squeezing out any air bubbles.

10 / CUT OUT SCREW HOLES

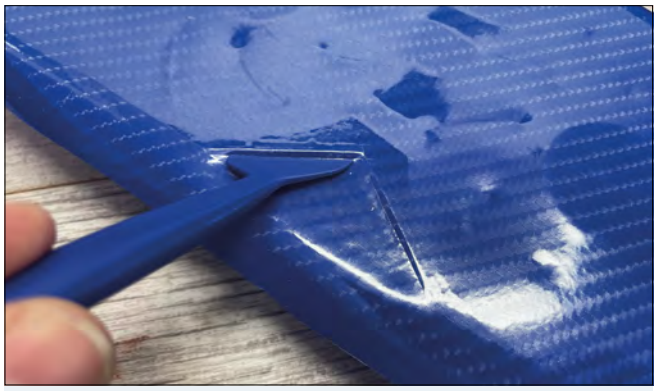
Most backplates have holes for screw access, and these should be cut out to avoid the vinyl adhesive being exposed underneath – it could then dry out causing the rest of the backplate to lift. Use a scalpel to cut them out, creating a cross shape then cutting out the quarter sections.

11 / PLACE ON TOP OF SHROUD

Place the vinyl sheet onto the graphics card cooler's shroud. If your fans protrude upwards above the shroud, cut their holes out first, as it will be tricky to do this later.

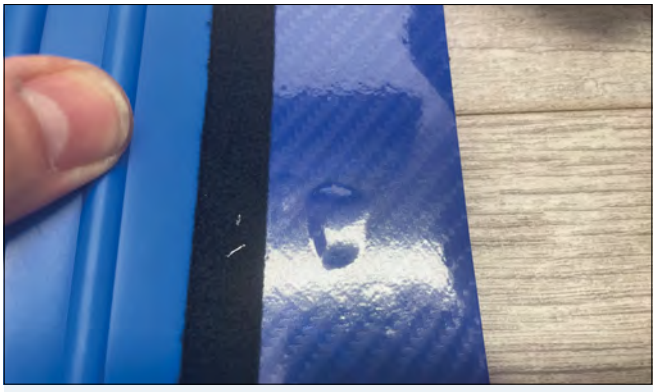
12 / HEAT THE VINYL

Heat the vinyl using a hairdryer again, focusing on the specific areas on which you're working, and press it onto the larger surfaces, using a squeegee and other tools to fix it in place.



13 / WORK INTO RECESSES

Use the angled spatula tools to work the vinyl into any corners or recesses. It's important to keep the vinyl heated here, so it can stretch to fit. Don't secure it to the edges of the shroud yet, as this will add tension to the vinyl that will prevent you from sticking it to recesses.



14 / REMOVE AIR BUBBLES

If there are any air bubbles under the vinyl you can work these out with the squeegee, as most vinyl sheets have channels to allow this to happen. You can then secure the edges of the vinyl to the shroud in the same way as with the backplate earlier.

15 / SECURE VINYL TO EDGES

Finally, cut out the fan holes with a scalpel if you haven't already done it in step 11, and your vinyl-wrapped graphics card is ready to go. If you make a mistake, you can lift the vinyl on smaller flat surfaces and start again, but if all else fails, vinyl is cheap, so you can always start again from scratch. CPC

Retro tech

AMD ATHLON

Stuart Andrews recalls the first AMD x86 CPU that properly put the wind up Intel

The summer of 1999 wasn't a great time for Intel, and it really should have been. In February it had launched the Pentium III, a supercharged upgrade of the P6 microarchitecture. Cyrix, whose 6x86 processors had embarrassed some 1st-generation Pentiums, was effectively finished, its tech now in the hands of VIA Technologies. That just left AMD, whose K6 line of processors had captured some of the budget PC market, but didn't have the optimised pipelines, cache or floating point performance to give Intel any serious competition.

But when AMD released its first K7 Athlon processors to reviewers in June, something unexpected happened. Sure, there was already some buzz about the new 'K7' CPU, thanks to intriguing early demos and briefings, but a Pentium III killer? Not likely. Yet when the final production samples hit magazine labs and website testbenches, it became clear that the new Athlon was pretty special

AMD's chip wasn't just matching Pentium III, clock speed for clock speed, but beating it. Worse, it was beating it in the kind of floating point intensive apps that Intel considered home territory, including 3D games. Athlon was kicking Intel right where it hurt, and that eye-watering discomfort wasn't going to let up any time soon.

Shipping in 550, 600 and 650MHz versions, the original K7 Athlon took the benchmark battle to Intel – and won. Image credit: Maddmaxstar CC BY-SA 3.0

K7 COMES TOGETHER

How exactly did AMD manage this feat? Well, as with so many standout products in the hardware space, the answer involves several developments all coming together at the same time. On the one hand, the success of the K6 II and III had left AMD in a surprisingly strong position.

The K6 architecture had made the most of technology bought in with the company's 1996 acquisition of NexGen and had pumped money into AMD's war chest. It had also cemented AMD's position as Intel's most credible rival.

What's more, AMD also had new CPU and bus technology developed by the Digital Equipment Corporation (DEC) for its Alpha RISC processors. It had even taken on most of DEC's RISC CPU design team, including key architects, Dirk Meyer and Jim Keller.

Thanks to a patent cross-licensing deal with Motorola, AMD also had a head start on new copper-based die manufacturing technologies, not to mention a new chip fab in Dresden on its way to use them. This would become important later on.

All this helped lead to a revolutionary design – the first 7th-generation x86 processor.

The original 0.25-micron (250nm) Athlon had a die with over 22 million transistors – the highest transistor count of any x86 processor to date. It also had an ingenious split cache system, with 128KB of on-chip L1 cache operating at clock speed, plus another 512KB of L2 cache included in the processor module.

This L2 cache operated at a fraction of the clock speed – half-speed on the initial models – but with breathing room to scale to cover higher and slower speeds later on. This arrangement gave Athlon a performance advantage over the

While it was codenamed the K7 right up until launch, AMD named its 7th-gen processor to make it clear it was a break from the K5/K6 past

earlier K6 processors, even before you factored any other architectural improvements into the equation.

But these improvements were just as significant. Meyer, Keller and their team designed an architecture that was capable of decoding three x86 instructions simultaneously and – crucially – symmetrically, unlike the Pentium III.

True, the Pentium III's instruction pipeline could handle three simple instructions at once, but feed it more than one lengthy, complex instruction and it choked, as only one pipeline could manage the workload. The Athlon, by contrast, could chew through three complex instructions without any trouble. You got three instructions at a time, every time.

The final kicker was that AMD was no longer second rate on floating point operations

What's more, the design featured a new level of optimised branch prediction, which was not only more accurate in guessing what the next operation would be, but faster to recover when it got that guess wrong.

Like the team brought in from NexGen, the team brought in from DEC had serious skills and experience in RISC chip design, and AMD put this to good use. The Athlon architecture converted x86 instructions into more efficient 'macro ops' and then those 'MOPS' into RISC operations, which the CPU's execution units could work on, nine to a clock.

This design was incredibly efficient by the standards of the day, but it was also conducive to scaling upwards. Where the K6-III had been stuck at 500MHz, the Athlon launched at 500, 550 and 600MHz speeds, matching the 600MHz of Intel's top-end Pentium III. As if that wasn't enough, AMD added a 650MHz version in fewer than six weeks after launch. The final kicker was that AMD was no longer second rate on floating point operations.

Not only were the Athlon's floating point units (FPUs) much faster than the weedy FPUs of the K6 line, but AMD built on the SIMD instructions of its 3DNow! Technology, with 24 new instructions on top of the original 21. Most mimicked the cache and streaming controls seen in Intel's mighty SSE tech, but AMD also bundled in new DSP and complex maths extensions, plus MP3 and Dolby Digital decoding tools. This chip was built to game and entertain.

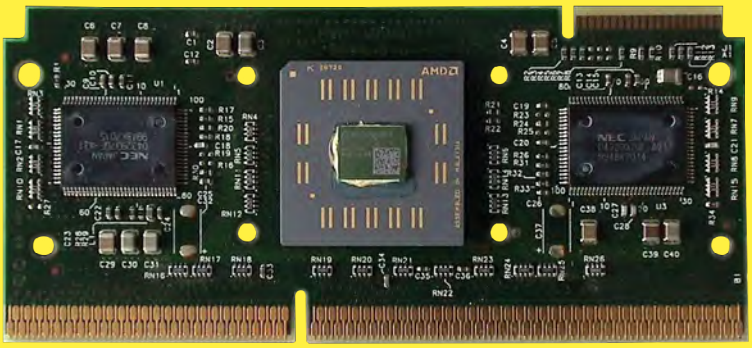
There was one final way that AMD now matched Intel – the Athlon was AMD's first chip to abandon sockets and embrace the slot. AMD's Slot-A connector harnessed DEC's EV6 bus and bus protocol, which allowed for burst data transfers at double the rate of Intel's equivalent GTL+, giving you a whopping 1.6GB/sec of bandwidth between the CPU and the motherboard chipset.

The Athlon's front side bus operated at double the 100MHz speed of the memory bus, and as faster RAM became available, this gave AMD scope to up the FSB speed even further, to 266MHz or even 400MHz. What's more, with a slot design, AMD could combine its CPU die and L2 cache in the one package, and that package was a whole lot easier to fit. And to make sure dozy upgraders didn't try to stuff AMD CPUs into Intel slots or vice versa, it cleverly reversed the physical design.

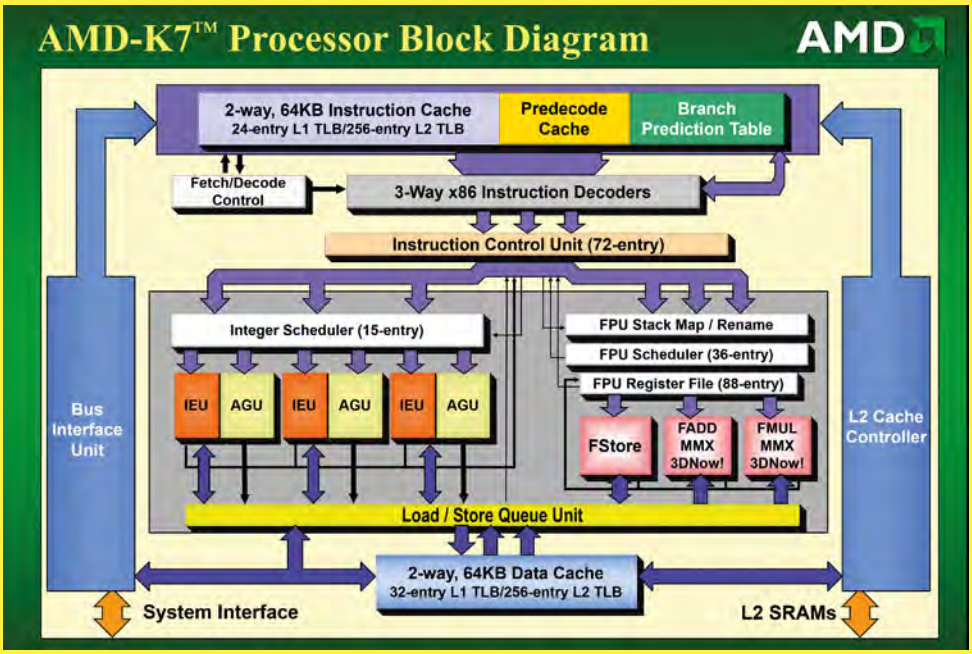
AWESOME ATHLON

Talk about architectures and specs was all very well, of course, but nothing really prepared those of us benchmarking PCs in the late 1990s for the sheer undeniable awesomeness of Athlon. The results of benchmarks wouldn't have made comfortable reading for Intel, especially once the Athlon 650 rolled out in August. Both the Athlon 600 and Athlon 650 were faster than the Pentium III 600 in Quake III: Arena, whether paired with the hero graphics chip of the day – Nvidia's Riva TNT2 – or with 3dfx's still speedy Voodoo 3.

The Athlon was around 10 per cent faster in standard Windows applications, and up to 20 per cent faster in gaming benchmarks. The Athlon 600 was 10fps faster than the Pentium III 600 in the fiendishly demanding Quake II Crusher benchmark. As further tests from the likes of AnandTech proved, even a Pentium III overclocked to 650MHz couldn't keep up.



Inside the Athlon cartridge. Check out the Slot-A connector, the CPU core and the two modules of L2 cache. Image credit: Tullius CC BY-SA 3.0



The Athlon's microarchitecture was a revolutionary leap from the relatively simple K6, with more advanced pipelines, faster FPUs, more cache and a three-wide instruction decoder

And this was just the beginning. In September, Intel launched the Pentium III 600B – a variant of the 'Katmai' Pentium III with a 133MHz front side bus. It couldn't match the Athlon 550 in many benchmarks, let alone the 600 and 650MHz versions, and still lagged behind the Athlon in when it came to gaming performance

In October, AMD responded with a 700MHz Athlon that pulled even further ahead. AnandTech's benchmarks of the time put it 20 per cent faster than the Pentium III 600B in the Quake II Crusher benchmark. It was nearly 27 per cent ahead in Quake III.

It was only with the launch of its Coppermine Pentium III processors in October 1999 that Intel could claw back the lead. Yet while the Pentium III 733EB was now king of the hill, an Athlon 700 could still benchmark faster in many tests than Intel's 700MHz Coppermine Pentium III.

As the clock speeds rose, the competition just grew hotter. In November 1999, AMD launched a new series of Athlons with a 0.18-micron (180nm) K75 core, taking the top speed up to 750MHz. In January and February, these were followed with 800 and 850MHz CPUs. Then just as Intel geared up to launch a (gasp!) 1GHz Coppermine Pentium III in March 2000, AMD stole its thunder by launching the Athlon 1000. To really take the proverbial, it did it two days earlier, giving AMD the first 1000MHz x86 CPU.

Athlon was first, but it wasn't fastest. The Pentium III 1000EB was actually ahead of the Athlon 1000 in many tests, partly due to superior SSE support in many popular benchmark games.

Yet there was only a few frames per second in it, and Athlon systems often had the edge on price. What's more, the Pentium III 1000 was only available to system builders at the time of launch. Anyone could get their hands on the 1GHz Athlon at the time.

ISSUES AND OVERCLOCKS

Of course, no new CPU comes without teething troubles. Early buyers found a range of compatibility issues with specific hardware, partly because Athlon was a complex, power-hungry CPU, and partly because of AGP slot power issues affecting many motherboards and driver issues with the latest Nvidia cards. With certain VIA chipsets and less consistent power supplies, you could find yourself in a world of instability. Nvidia even released a driver update for its graphics chips that disabled the high-performance 2x mode on the AGP slot when Athlon was detected.

Some enthusiasts were also disappointed with the Athlon's limited overclocking potential. The K6 line had been a treat for overclockers – gamers upped 450MHz CPUs to 600MHz routinely, and there was much debate in PC magazines about whether we should allow manufacturers to send in pre-overclocked systems.

The Athlon wasn't having any of that. The only ways to overclock the original CPUs were to crack open the modules and interfere manually with the resistors, or to purchase a third-party 'Goldfingers' device which did it all for you. Through either method you could increase your multiplier and give your Athlon a healthy speed boost, although it meant invalidating your warranty along the way.

THE AGE OF ATHLON

The Athlon set the stage for a golden age of PC CPUs. Intel struck back with Coppermine, then AMD replaced the K7's old aluminium interconnects with copper, and ran the L2 cache at the full speed of the CPU. The 2nd-generation Athlon 'Thunderbird' processors could match and even beat the Coppermine Intel Pentium IIIs, causing Intel to push even further with its Coppermine T CPUs.

Before we knew it, 1GHz was starting to look like old hat. 1333MHz and 1400MHz were the new targets. Meanwhile, the K7 architecture was making waves at the budget end. Where Intel's cheap, cache-less Celeron processors couldn't handle Deus Ex, Half-Life or Unreal Tournament, AMD's K7 Duron CPUs were storming through them.

There's still a lot of affection for the Athlon in the PC enthusiast community. At a time when Intel seemed unassailable, it was the first chip to really knock it off its feet. This made Intel try a little harder, and the result was that everybody won. In fact, it's a mark of that affection that when AMD created a new budget Zen-based processor line-up in 2018, it still used the Athlon brand, with the Athlon 3000G coming out in November 2019. It's a sign of a classic brand when it's still being used 20 years later. CPC

Readers' drives

Little Drakon

Simon Beacock went all out with his first go at hard line water cooling, creating this great-looking system with his own case mods, a custom etching and several tubing bends

/MEET THY MAKER

Name Simon Beacock

Age 35

Occupation Property maintenance

Location Slough

Main uses for PC Gaming

Likes Motorbikes, DIY, action films and sci-fi tv shows such as Star Trek and Stargate

Dislikes Hot drinks, rom coms

CPC: So how did this build start?
Simon: My plan was for this to be my first hard line tubing build, having previously worked on soft tubing builds. I wanted to create a PC that looked a bit different from the norm, and I was inspired by reviews of water-cooling components online. I've been interested in the orange, black and white colour scheme for a while, as I think it's unique and I've used it for my last couple of builds – it's becoming a signature for me.

CPC: What made you choose the Raijintek Paean case as the foundation?
Simon: I chose this case as it looked quite different from most of the other cases I've seen in online PC building groups. I looked though multiple options online before deciding on the Raijintek for a few reasons.

Firstly, I had my eye on the EK-Quantum Volume FLT 360 Reservoir, as I thought it looked different from the usual setup, so I really needed a case big enough to house it comfortably. I also wanted a basement for the radiators so they were out of sight, and to use pass-through fittings. This case ticked all the boxes for me.

CPC: We love the artwork on the front panel window. What's the design and how did you make it?
Simon: I etched the design myself onto the front panel using a vinyl stencil I created with my own tools. However, the design itself was created by an artist I found online. I knew what I wanted but I also needed an artist's touch, so I gave him some ideas – I wanted it to involve a dragon and have a tribal look. After a couple of drafts and revisions, I was very happy with the result – I think it really makes a difference to an otherwise plain-looking front.

CPC: How did you get the graphics card to lean like that, and how do you access the display outputs?
Simon: I've been experimenting with different mounts in order to get a different look from normal vertical mounts, and I found this EZDIY-FAB Vertical Graphics Card Holder on Amazon, which was perfect for what I wanted. Using this graphics card holder did present some challenges for accessing the outputs, so I used a 90-degree display port extension cable, which did the trick.

CPC: What material did you use for the tubing, and how did you cut and bend it to shape?
Simon: I used EK-HD PETG 12/16mm tubing. It was my first time using hard line tubing, so I thought the bigger the better! It actually wasn't too hard to bend into shape – I cut it with a hacksaw and used an EK tool to get the 90-degree bends.

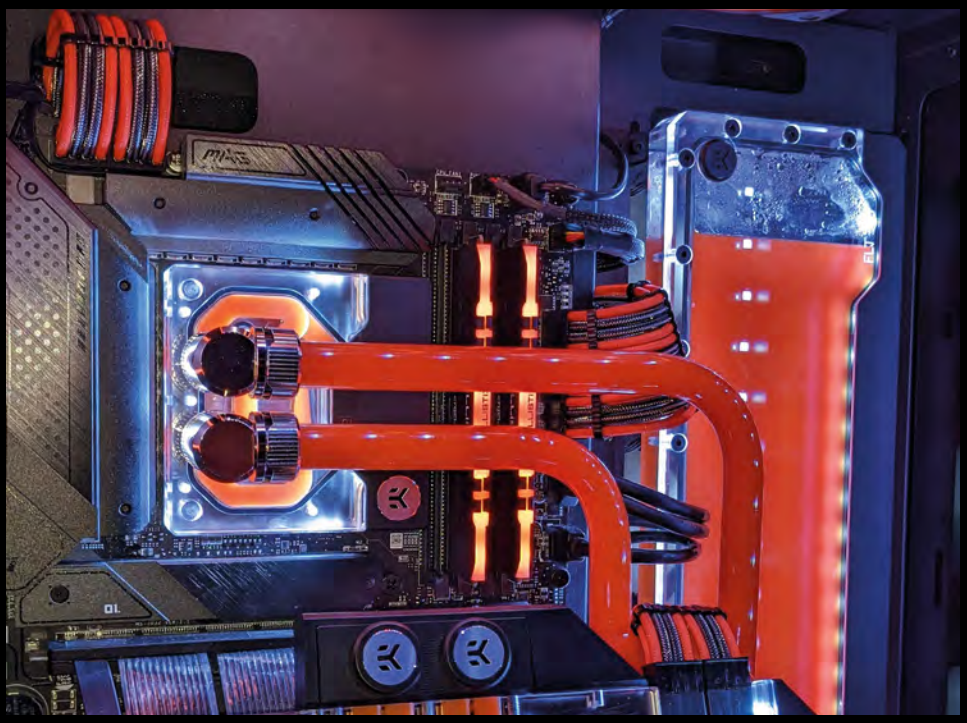
CPC: That's a very clean loop. How did you plan, measure and make the holes for the pass-through fittings, and how does the tubing all link up under the PSU shroud?
Simon: This case is perfect for allowing the tubing to go down to the basement where the radiators are located.

However, I did have to modify the case slightly by replacing the original plate for the pass-through with an acrylic replacement. I used FreeCAD software to design an acrylic plate to my specifications, so that I could use pass-through fittings for the visible hard line tubing at the top.

From there they go to the hidden soft tubing in the basement, linking up the radiators, pump and drain valve. I used the flat reservoir as a basis for measuring, so I could make the holes for the pass-through ports line up perfectly. I used a third-party company to manufacture the acrylic plate to my specifications.

CPC: What peachy coolant is that?
Simon: I went with EK Cryofuel solid fire orange coolant in the end, after first trying amber orange. I preferred its more solid look. I was already using EK products, so it just made sense.

CPC: Tell us about any other custom parts and modifications you made to the case.
Simon: I had to cut a hole out of the back of the case to allow all the cabling to come from the basement through to the rear. I used a Dremel with a cutting disc to do this work, and the cable management worked out pretty well for me in the end. I also added some adhesive fixing



mounts for cable ties, which came in very handy. In addition, I had to add another hole at the rear for the drain valve using a step drill bit. It's a bit nerve-wracking drilling and cutting into a £200+ case, but I'm happy with the result.

CPC: How did you plan the lighting for this build, and how is it all controlled?
Simon: As the theme is black and orange, I wanted some white lighting to illuminate the components and the case itself. I thought this would show off the build adequately; without the white lighting it would be too dark to enjoy. The fans in the main part of the case are white with an orange ring to coordinate with the rest of the theme.

The lighting in the basement (fans and pump) is a more subtle plain orange, which I think gives it a nice glow while still keeping the focus on the main part of the build. There are three Corsair LL 140mm fans and two Corsair RGB strips, which are controlled by Corsair's iCUE software. Meanwhile, the EK reservoir/blocks are controlled by MSI's Mystic Light system, as are the lights from the three 120mm EK fans in the basement.

CPC: What hardware specs did you choose and why?
Simon: I chose an Intel Core i7-12700K CPU paired with a GeForce RTX 3080 Ti GPU. I went with this hardware, as I want to keep this build for a good few years, but still have the option to upgrade to DDR5 in the future (I'm sticking to DDR4 for the time being).

This is an upgrade from my previous build, which I'd been using for a good few years. I've always used Intel and Nvidia components – I've never had an issue with them previously, and I wanted to see what Intel's 12th-gen CPUs had to offer when combined with Windows 11. I also have 32GB of RAM, which is an upgrade from the 16GB in my previous build.

> As much as I love the look of the graphics card at an angle, it was really difficult to line up the tubing behind the card

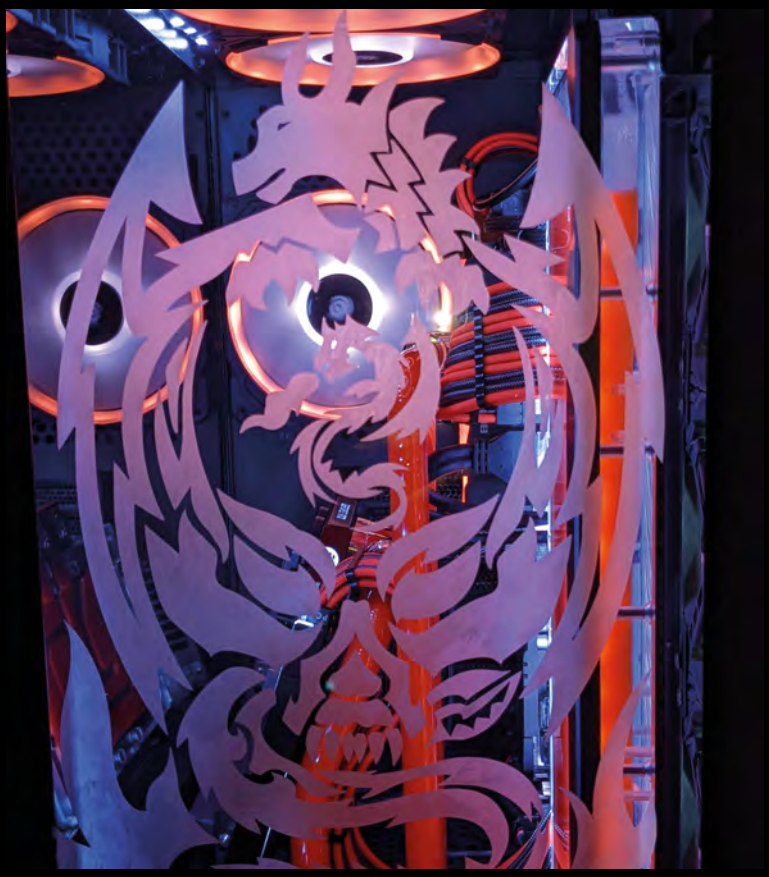
CPC: What do you use this PC for?
Simon: I mainly use this PC for hardcore gaming, where I can max out the settings to enjoy ray tracing eye candy. Other than that, I use it for Netflix and social media.

CPC: Did you come across any difficulties?
Simon: As much as I love the look of the graphics card at an angle, it was really difficult to line up the tubing behind the card – I had to make two 90-degree bends close together while tilting the tubing at the same angle as the card. The card isn't locked in place, as the bracket is only magnetically fixed, so I had to eyeball the tubing before the graphics card was installed. It took about half a day to set it up in the end, but I finally got it right after the third attempt.

Also, I bought an EK leak and pressure testing tool to test the loop before adding the fluid. I had a blowout during the test, which I think was down to me forgetting to debur the end of the tube going to the CPU. Luckily it didn't do any damage to the O-rings, so I was able to fix it and then the pressure test was a success.

CPC: How long did it take you to complete this build, from start to finish?
Simon: From start to finish it took four months. I did change my mind quite a lot about what parts I wanted to use, and the difficulties with sourcing a graphics card at a reasonable price slowed me down.

Once I had decided on the parts, I had to wait a while for shipping too. For example, I had to buy the EK blocks directly from the source due to shortages, and I had to wait a while for the cables, as they were made specifically to my length



and colour needs. Once I had all the parts and was ready to begin, it was complete within three days, including case mods.

CPC: Are you completely happy with the end result?

Simon: Yes, I'm happy with the end result. In retrospect, I wish I'd made the entire bottom plate from acrylic, so I could install the GPU at a sharper angle and then hide the tubing directly behind the card. I think this would have given it a tidier, simpler look.

I plan to upgrade the memory to Corsair Dominator Platinum. They weren't available at the time I was putting this build together. This memory replacement is going to cause problems with the clearance of the tubing though. I'll have to redo the tubing line to the CPU so that it clears the larger memory modules. I might also upgrade the motherboard if DDR5 memory becomes more affordable. CPC

SYSTEM SPECS

CPU Intel Core i7-12700K

Case Raijintek Paean

GPU Asus TUF GeForce RTX 3080 Ti

Storage 500GB WD Black SN850, 1TB WD Blue SN550, 2TB Crucial P2

Memory 32GB (2 x 16GB) Crucial Ballistix RGB DDR4 3600MHz

Motherboard MSI MAG Z690 Tomahawk WIFI DDR4

PSU Corsair RM1000x

Cooling 2 x EK-CoolStream SE 360 radiators, EK-Quantum Volume FLT 360 D-RGB reservoir, EK-Quantum Inertia D5 PWM D-RGB pump, EK-Quantum Velocity² D-RGB CPU waterblock, EK-Quantum Vector TUF RTX 3080 D-RGB Nickel 3 GPU waterblock, EK-Vardar X3M fans, Corsair LL 140mm fans

WIN CORSAIR HYDRO X WATER-COOLING GEAR

To enter your rig for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (@**CustomPCMag**) or Facebook (**CPCMagazine**), or email low-res ones to **ben.hardwidge@raspberrypi.com**. Fame isn't the only prize; you'll also get your hands on some fabulous prizes, courtesy of Corsair.

Corsair Hydro X Series XD3 RGB Pump/Reservoir C

WORTH £151

The Corsair Hydro X Series XD3 RGB Pump/Reservoir Combo features a high-performance DDC PWM pump, integrated RGB lighting and in-loop temperature sensor to drive even the most compact custom cooling systems. It has a high-performance Xylem DDC PWM pump controlled via PWM to deliver the perfect flow balance for your loop. There are also 16 individually addressable RGB LEDs, which light up the pump head to produce stunning, customisable lighting effects to match your build.

Corsair Hydro X Series XC7 RGB CPU Water Block

WORTH £70

The Corsair Hydro X Series XC7 RGB CPU Water Block combines premium construction, vivid RGB lighting and extreme cooling performance to become the centrepiece of your water-cooling loop. It has a nickel-plated copper cold plate and more than 60 high-efficiency micro-cooling fins, which efficiently draw heat away from your CPU, lowering operating temperatures and allowing for maximum overclocks. You can choose a version for Intel or AMD CPU sockets.

Corsair Hydro X Series XR5 240mm Radiator

WORTH £55

The Corsair Hydro X Series XR5 240mm Water Cooling Radiator delivers extreme custom cooling performance, with a 30mm radiator thickness and premium copper core. Its dual 120mm fan mounts on each side are ready for your most ambitious custom cooling build, and its 25 micron-thick cooling fins offer a high thermal transfer rate.

JAMES GORBOLD / HARDWARE ACCELERATED

THE DEATH OF CPU OVERCLOCKING

In the age of multi-threaded workloads and well-engineered boosting algorithms, James Gorbold argues that CPU overclocking is now irrelevant

While I've never really identified myself as an overclocker, or a modder or gamer for that matter, preferring the term PC enthusiast, I'm in some ways sad that's it's come to this – overclocking is dead.

Overclocking used to be one of the driving forces for many early PC enthusiasts, such as myself and **Custom PC**'s editor, Ben, getting into PCs in the first place, as it provided a way for us to get faster PCs without buying premium-priced hardware.

By spending time fiddling with DIP switches and jumpers on the motherboard, or if you were feeling particularly brave, using tiny pieces of wire to short pins in the CPU socket, you didn't have to spend as much on a new CPU as everybody else. It was smart, it was underground and it was also a little bit thrilling, providing a feeling of sticking it to the man. Casting my mind back, I overclocked pretty much every PC I owned from the early 1990s to the mid-2010s.

In many ways, the early era was the heyday of overclocking, with many important brands establishing themselves, such as Asus Republic of Gamers and even **Custom PC**. There were even overclocking competitions, which for a short while could lead to a new career – professional overclockers zoomed around the world, pouring increasingly exotic fluids onto PCs to squeeze more performance out of them, even if it was just to run wPrime for the few seconds long enough to get a score before the hardware died.

While these competitions were a bit ridiculous, they helped to spur on real interest from the CPU makers themselves, Intel and AMD, in overclocking. Until then, overclocking had largely been ignored or actively discouraged by the CPU giants. Of course, like many underground trends, overclocking eventually went mainstream, with the dark knowledge of bus speeds and chip pin-outs rendered irrelevant in an era of overclocking menus in EFIs and Windows applications that could even test an overclock for you.

We didn't know this at the time, but 2008 was the beginning of the end for overclocking, as that's when Intel released the first version of Turbo Boost, which automatically overclocked 1st-generation Core i5 and i7 CPUs. While it took several revisions for Turbo Boost, and AMD's equivalent Turbo Core (later rebranded as Precision Boost in the Zen era), to be truly effective, modern CPUs can overclock themselves far more easily, effectively and safely than any end user can manage.

> It's far better to let the CPU overclock itself dynamically

This situation isn't just down to how well Turbo Boost and Precision Boost work, but also because modern CPUs and applications are so much more complex than their single-threaded forebears. Back in the day, you simply wanted to get the highest possible multiplier and bus frequency from your PC's CPU, but in today's ragtag mix of single-threaded, lightly threaded and heavily multi-threaded software, it's far better to let the CPU overclock itself dynamically on the fly for whatever it's running at the time.

There's less incentive to overclock now too, as the CPU has largely been overtaken by the GPU as the main driver of game performance. You could even argue that, aside from system bootup and the OS, the roles have been reversed, and the CPU is now the GPU's coprocessor. However, just like CPUs, GPUs are pretty damn good at overclocking themselves too. Are you still manually overclocking your CPU? Let us know at **custompc@raspberrypi.com** CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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