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Welcome

Custom PC Issue 221

/ FROM THE EDITOR

Number theory

What's your favourite number between 0 and 9? More to the point, would you avoid a product with a number you don't like in its name? That's honestly not a facetious question. Believe it or not, you wouldn't be alone.

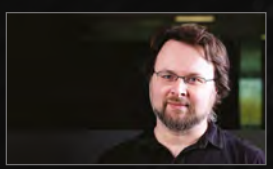
Recently, a tech-savvy friend asked me which GPU he should buy for gaming at 1,920 x 1,080. I told him the Radeon RX 6600 XT would be fine. 'No, no, I want GeForce,' he said, 'and I don't want a card with a "6" in it.' I raised my eyebrow and asked why. 'It just seems too low,' he replied. 'I usually go for components with at least a "7" in them.' He bought an RTX 3070 in the end.

Uncritical thinking is the PC enthusiast's enemy here, and I know I'm also guilty of it. I found myself doing it while editing Antony's excellent Alder Lake upgrade feature on p76. As you'll see from the analysis and the performance numbers, the Core i5-12600K is the real killer chip here. It's affordable, it's fast in both games and content creation, and it's more overclockable than the Core i9-12900K. It's very much the 'enthusiast' chip of the range, and it even beats the Ryzen 7 5800X in some tests.

This CPU isn't just adequate, it's absolutely amazing. Unless you're doing serious multi-threaded number crunching on your desktop PC, this is undoubtedly the CPU to buy. I know that this is the CPU that's best suited to my needs and, as our feature establishes, DDR4 memory is also plenty fast enough for it.

But when I'm pricing up my upgrades, I still keep finding myself drawn to the Core i7 and Core i9 Alder Lake chips, along with DDR5 memory and expensive motherboards. There's a perception that having a Core i5 with DDR4 memory won't give me enough bragging rights, that it's not fast enough for a 'power user' such as me.

If you also find yourself doing this, I urge you to fight this silliness. If your computing needs really warrant enormous multi-threaded power and the fastest performance possible (and there are plenty of people who do fit this description), then go for it. If you're primarily a gamer, though, do yourself a favour – fight your inner 'that number's not high enough troll', save yourself some money and buy the Core i5. CPC



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CUSTOM PC

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Contents

Welcome to Issue 221

Highlights

08 Scanning the airwaves
With the Wi-Fi Alliance having finalised the details of Wi-Fi 7, Richard Swinburne looks ahead to what features and performance it will bring.

10 Scam school
Tracy King explores Lloyds Bank and UKIE's new campaign to teach gamers to avoid scammers.

14 Z690 motherboards
The first flush of Z690 motherboards are here, ready to support the latest Intel Alder Lake CPUs – Antony Leather puts three of them to the test.

22 NZXT H150 Flow
NZXT's new airflow-optimised case is attractive, cool and quiet.

26 Corsair H150i Elite LCD
Corsair's monstrous new 360mm all-in-one cooler gets an LCD panel on its pump, LGA1700 support and a monstrous price tag to boot.

29 AOC U28G2XU
AOC brings 144Hz 4K gaming to a new low price point with this 28in monitor.

30 Razer Wolverine Chroma V2
Razer's new premium gamepad brings mecha-tactile action buttons to the market, making for a crisp and fast response.

38 Mince pie megatest
The test of the year is here! We taste-test 15 mince pies to find this year's best festive pastries.

44 High-end GPU Labs
If money's no object for your next graphics card upgrade, we've got the Labs test for you. We pit the five most powerful desktop gaming GPUs against each other.

52 Budget keyboard Labs
Want a decent gaming keyboard, but don't have the cash for a mechanical one? We've tested seven budget keyboards, most of which cost under £50.

70 Deathloop
Arkane Studios' latest immersive sim is stylish, spectacular and one of the best games of the year.

76 Alder Lake upgrade guide
From cooling requirements to which type of memory to buy, we guide you through the process of upgrading to Intel's new Alder Lake platform, whatever your budget.

88 Christmas gift guide
Stuck for stocking ideas? Here's our pick of the best techmas presents for friends, loved ones and yourself.

92 Raspberry Pi Zero 2 W
This tiny single-board computer comes with wireless features, and costs only £13.20.

106 VGA revolution
Stuart Andrews looks at the tech that transformed the PC into a 256-colour gaming powerhouse.

Cover guide

Regulars

3 From the editor
8 Richard Swinburne
10 Tracy King
12 Incoming
41 Custom kit
60 How we test
62 Elite products
68 Inverse look
74 Reality check
94 Hobby tech
98 Customised PC
100 How to guides
105 For the win
106 Retro tech
110 Readers' drives
114 James Gorbold

Reviewed

33 PRODUCTS REVIEWED

MOTHERBOARDS
14 MSI MAG Z690 Tomahawk WiFi DDR4
16 Asus TUF Z690-Plus WiFi D4
18 Asus ROG Maximus Z690 Hero

CASES
22 NZXT H510 Flow

CPU COOLERS
26 Corsair H150i Elite LCD

MONITORS
28 Huawei MateView GT 27
29 AOC U28G2XU

GAMEPADS
30 Razer Wolverine Chroma V2

KEYBOARDS
32 Logitech MX Keys Mini

PC SYSTEMS
34 Scan 3XS Vengeance Ti
36 Chillblast Fusion Panther

Custom kit

41 Nanoleaf Lines
41 Marshall Motif ANC

Graphics card Labs

45 AMD Radeon RX 6800 XT
46 Nvidia GeForce RTX 3080
47 AMD Radeon RX 6900 XT
48 Nvidia GeForce RTX 3080 Ti
49 Nvidia GeForce RTX 3090

Budget keyboard Labs

53 Asus TUF Gaming K1
54 Cooler Master MS110
55 Corsair K55 RGB Pro XT
56 Logitech G213
57 Razer Cynosa Chroma
58 Roccat Magma
59 SteelSeries Apex 3 TKL

Games

69 Hot Wheels Unleashed
70 Deathloop
72 Sable
73 The Eternal Cylinder
74 Song in the Smoke

Hobby tech

92 Raspberry Pi Zero 2 W
94 Sipeed Nezha D1
96 Not All Fairy Tales Have Happy Endings

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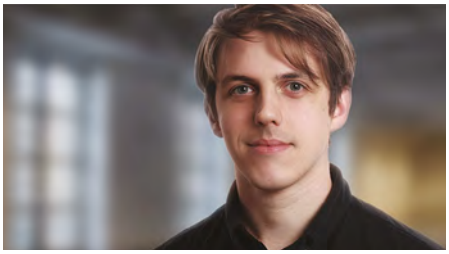

RICHARD SWINBURNE / VIEW FROM TAIWAN

WHAT'S NEW WITH WI-FI 7

Richard Swinburne delves into the latest upcoming wireless standard, although he'll be sticking with wired Ethernet

Last year (see Issue 201), I talked about Wi-Fi 7, the next-gen wireless standard. Even though we're only just starting to see Wi-Fi 6E hardware appearing on the market, the Wi-Fi Alliance has been pushing forwards with its successor's development. Now, 18 months later, I've obtained the road map.

The first official Wi-Fi 7 spec (Release 1) won't be launched until the end of 2023, but we're likely to see early hardware being shown off in the first half of next year, maybe even as early as CES in January. These will likely be proof of concept platforms that emulate how a real Wi-Fi 7 platform works. The first flagship 'draft spec' Wi-Fi 7 products should then hit the market a year later in early 2023, ahead of the official release.

The ink has dried on the details of Wi-Fi 7 (802.11be) since I last wrote about it. The core features are a doubling of channel bandwidth to 320MHz across 2.4GHz, 5GHz and 6GHz bands, giving a maximum potential performance peak of 19Gbps, up from 11Gbps with Wi-Fi 6E. The number of antennae used in the fastest devices will also increase by 50 per cent from eight to 12, which will be reflected in the cost.

However, the 19Gbps configuration is only available in the USA and Canada, where the 5.9-7.1GHz bands have been released as unlicensed frequency. The UK (and EU) have only released 5.9-6.4GHz, chopping off 500MHz of unlicensed spectrum and limiting the overall performance potential.

There are new features to make mesh networks more effective too. Device makers might also move away from the 'upside-down centipede' box design, and opt to try several micro-cell designs that can be dotted around a house instead, giving more opportunity to keep higher speeds as you move around.

Other new Wi-Fi 7 tech includes better interference avoidance techniques, improved use of wireless bands and a new tech called Multi-Link Operation (MLO). This enables carrier aggregation (CA) – another feature borrowed from 4G and 5G smartphones. CA combines several frequencies together across the three bands into one connection, significantly improving overall speeds and latency.

Whereas Wi-Fi 6/6E enables a device to connect across 2.4GHz, 5GHz and 6GHz bands, it can only send data via one band at a time. The switching overhead as it hops between frequencies can lead to delays of up to 100ms, whereas with an aggregated connection, that's expected to be cut as low as 1ms. This is obviously a huge benefit for areas such as game PING times, wireless VR headsets, cloud gaming and any activity that's sensitive to latency.

> This is a huge benefit for areas such as game PING times

Power efficiency is also a key area of improvement. As access points become more powerful in order to handle faster speeds and more users, they also become more power-hungry. Wi-Fi 7 introduces better energy management of the many radios and antennae through new real-time detection and power regulation mechanisms. As your router will be powered on 24/7, this is certainly welcome.

Despite all these awesome speeds, I'll still opt to use a wired connection when possible. A wire always works, the fastest wireless routers are now really expensive and even budget motherboards now have 2.5Gbps Ethernet.

Then again, however, there's a huge gulf between 2.5Gbps and 19Gbps network connections, and most router designers are often still only offering paltry Gigabit ports. QNAP now offers a couple of switches with four 2.5Gbps ports, but there's a big market gap for faster wired and wireless options together. **GPC**

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

SCAM SCHOOL

Tracy King looks at a campaign by Lloyds Bank and UKIE to teach gamers to avoid scams

In the past month I've had scam attempts via phone call, text, email, Twitter and Gumtree, but fortunately I'm tech-literate enough to spot them. Even so, some of them gave me pause. The journalist Alex Hern recently tweeted that he received a phishing text that Apple Messages automatically put in a thread of legitimate messages from the purported sender (in this case Royal Mail).

He's a tech writer, so he caught it, but if the app couldn't tell a fake courier from the real thing, what hope does the average non-techy have? The statistician Harry Carr replied to Alex saying, 'had a similar experience with Sky earlier this month – even as someone pretty tech savvy they're increasingly a nightmare to spot.'

Obviously, if you're reading **Custom PC**, you're not the target market for scammers, who are generally looking for people who use technology superficially but don't actually know how stuff works. However, I'd argue that this is most people. Scams are getting harder to spot, they're creeping into more and more platforms, and banks are getting sick of it.

In the UK, 'authorised' bank fraud (scams in which you give your card details believing the recipient is legitimate) is at an all-time high, costing victims nearly half a billion pounds a year. It's much harder to prevent this type of fraud, and prevention largely relies on the target having enough critical thinking and knowledge to spot the scam themselves. Basically, everyone needs scam school.

Less than half of authorised bank fraud is reimbursed, but that's still £200 million a year that the banking industry would rather not lose. I can't say I'm a particular fan of banks, but it's fair enough that they'd like to prevent scams rather than be forced to swallow the cost of fraudsters, so one of them has teamed up with UK Interactive Entertainment (UKIE), the gaming industry body, to target gamers.

Lloyds Bank and UKIE have launched SHIELD, a campaign to 'establish preventative advice for players of all ages to help combat fraud'. They claim (via their own research) that 'one in five (20 per cent) game players have been – or know someone who has been – the victim of a gaming-related scam'. So the idea is to educate the people who use tech, but aren't tech-savvy and they'll pass on that knowledge. Scam School!

The campaign report says the four most common scam tactics in gaming are phishing emails or texts, in-game chat functions, malware and impersonation of in-game support. The group aims to educate gamers in how to be way, way more suspicious.

> The campaign is a little cheesy, but it has some solid advice

Its graphics look like it's aimed at younger gamers (with non-trademark-infringing, generic 'game character' illustrations), so I'm not sure it will land with anyone older than twelve, despite the 'all ages' line. That said, it's also doing outreach to parents, so it's hard to be cynical. While late teens and early 20s are the demographic most likely to be scammed overall, it will skew younger in games such as Fortnite.

The campaign is a little cheesy, but it has some solid advice and links to some useful resources, so overall, it seems like it's a force for the greater good. Ultimately, fraud prevention education (or Scam School if I can make that stick) is an 'everybody' problem. While us tech-savvy nerds are better protected than most, we're also the ones who help everyone else with their tech issues. I've decided to send the link to family and friends who have kids, and suggest you do the same. You can find it at **custompc.co.uk/ScamSchool**. CPC

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

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Incoming

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Letters

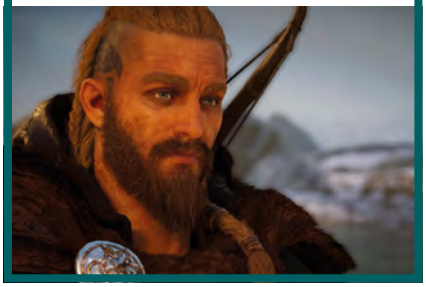
Tell us what you think of the mag, ask us questions and suggest your own tips and tricks for other readers! Send all your correspondence to **custompc@raspberrypi.com**

DRM LIMITS GAME ALDER LAKE GAME SUPPORT

Intel has confirmed that a number of games currently won't run on its Alder Lake CPUs, due to an incompatibility with the digital rights management (DRM) system they use. According to Intel, the issue is a result of third-party DRM software seeing the CPUs' E-Cores 'as another system'.

Intel says that the vendor of the DRM software is working on a software fix for the issue, and has also detailed a workaround by enabling Legacy Game Compatibility Mode in your motherboard's BIOS, which puts the E-Cores on standby if you hit the Scroll Lock key before running an affected game.

The full list of affected games can be found at **custompc.co.uk/AlderLakeDRM**, which will be updated as problems are resolved. The current list includes some high-profile titles, including Assassin's Creed Valhalla in Windows 10 and Anthem in Windows 11.



RAZER BRINGS OUT NON-GAMING 'PRO' PERIPHERALS

Renowned gaming peripherals maker Razer has now turned its hand to making a desktop setup for work rather than play. The company's new Pro range ditches the RGB lighting and black plastic but retains Razer's eye for style and ergonomics.

There are three new products in the Pro range – a keyboard, mouse and mouse mat. The Razer Pro Type Ultra keyboard features Razer's Yellow mechanical switches, which are geared towards quiet operation and are rated for up to 80 million key presses.

A plush leatherette wrist rest is also included with the keyboard, and you get a white ELD backlight and support for Razer's HyperSpeed Wireless Technology, as well as Bluetooth.

Meanwhile, the Razer Pro Click Mini mouse again features wireless and Bluetooth support, as well as seven programmable buttons, with switches optimised for quiet operation and a lifetime of 15 presses. There's also a four-way 'HyperScroll Tilt Wheel', which has tactile and free-spin modes. The Pro Click Mini features Razer's 5G Advanced Optical Sensor, with a resolution of 12,000dpi.

Finally, the Pro Glide XXL mouse mat has a huge surface area of 940 x 410mm, and features an anti-slip rubber base and a textured micro-weave cloth surface. The keyboard, mouse and mouse mat are all available now for £160, £80 and £30 inc VAT respectively.

NOCTUA INTRODUCES LGA1700-SPECIFIC COOLERS

Acclaimed PC cooling specialist Noctua has introduced LGA1700-specific versions of its low-profile NH-L9i coolers. There's a traditional brown and beige version, as well as a black version, with the LGA1700 support denoted by '17xx' at the end of the model name. Designed for use in small form factor cases, Noctua's NH-L9i coolers feature a 92mm fan on top of a 95 x 95mm heatsink that's only 23mm high.

Noctua doesn't quote a TDP rating for the coolers but gives it a Noctua Standardised Performance Rating (NSPR) rating of 59. According to Noctua's compatibility list, it's capable of cooling all the current Alder Lake CPUs, including the top-end Core i9-12900K. The Noctua NH-L9i-17xx coolers are available to buy now from **amazon.co.uk** for £40 inc VAT.

Rumour control

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

CORE i5-12400 BEATS RYZEN 5 5600X

Benchmark results for a Core i5-12400 CPU have appeared online, suggesting that the forthcoming budget CPU is going to be a monster for the price. The overall score of 712 in PugetBench has been spotted by numerous people at **pugetsystems.com**, from a system with a Core i5-12400, 16GB (2 x 8GB) of 2400MHz DDR4 memory and a GeForce RTX 3060 Ti.

As a point of comparison, a Ryzen 5 5600X system with the same GPU and faster (3600MHz) memory gets an overall score of 636 in the same benchmark. Intel's Core i5-11400 is currently on our Elite list for our 1,920 x 1,080 gaming system, with a price of £150 inc VAT. If the Core i5-12400 has a similarly competitive price then it has the potential to be a fantastic foundation for a budget gaming rig.

INTEL B660 CHIPSET LIMITED TO PCI-E 4

An alleged photo of the packaging for an Asus B660 motherboard indicates that it will only support PCI-E 4, rather than the new PCI-E 5 standard. An image of the spec sticker for the Asus Prime B660 Plus D4 was posted on **videocardz.com**, saying 'PCIE Gen4' at the end.

This has led several tech sites to speculate that Intel's B660 chipset won't support PCI-E 5. It wouldn't be a disaster if that were the case – there aren't any PCI-E 5 graphics cards available yet, and 16x PCI-E 4 should still offer more than enough bandwidth when the first cards do start to appear anyway.

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Reviews

Z690 MOTHERBOARD

MSI MAG Z690 TOMAHAWK WIFI DDR4 / £246 inc VAT

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The competition for Z690 chipset motherboards with sub-£300 price tags and DDR4 support seems to be fierce, and MSI undercuts the Asus TUF board on test this month by £14 with the MAG Z690 Tomahawk WiFi DDR4.

This MSI board's list of accessories is nearly as threadbare as that of the Asus TUF board, but MSI does at least include a 16GB USB flash drive with an image of the usual installation DVD on it. Unfortunately, though, the flash drive is USB 2, so it took an absolute age to mount the 5GB image file. If you want to do this instead of downloading up-to-date drivers from MSI's website, then be sure to copy the image file to a faster drive.

MSI's Windows software is still quite clunky compared with that of Asus as well, with no option for tweaking E-Cores and only basic overclocking options. The fan control section is also difficult to find, and while it offers reasonably granular control, we'd still prefer to head to the EFI. There's very little information about temperatures across the motherboard too, such as the VRM temperature, which we found in HWMonitor and the EFI, but MSI doesn't tap into this data for its own software.

The motherboard looks great, though, and in our opinion, it looks slightly smarter than the Asus TUF Z690-Plus WiFi D4. It's devoid of RGB lighting, although it has the usual RGB headers for added illumination if you want it, and the Asus board doesn't have much in the way of lighting anyway. However, the black design is attractive and the large heatsinks did a good job of keeping the 18-phase power delivery system below a peak of 56°C during stress tests with our Core i9-12900K.

SPEC

Chipset
Intel Z690

CPU socket
Intel LGA1700

Memory support
4 slots: max 128GB DDR4 (up to 5200MHz)

Expansion slots
One 16x PCI-E 5, two 16x PCI-E 3, one 4x PCI-E 3, one 1x PCI-E 3

Sound
8-channel Realtek HD Audio

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

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

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

Dimensions (mm)
305 x 244

It has a similar M.2 SSD arrangement to the Asus TUF Z690-Plus WiFi D4 too, with three PCI-E 4-capable M.2 ports and a fourth M.2 port that tops out at PCI-E 3. Here, though, MSI covers all of them with heatsinks and they even have similar tool-free latches to those of the Asus board, which is handy. When fitted to the large heatsink at the bottom of the PCB for best airflow, our PCI-E 4 SSD reached 63°C after our stress test ended, which is cool enough to stay away from throttling, but not quite as cool as on the Asus TUF Z690-Plus WiFi D4.

As you'd expect at this price, there's no Thunderbolt 4 support at all, but you do get the high-end Realtek ALC4080 audio codec, which produced some solid results of 110dBA dynamic range and -111dBA noise level, outperforming the audio on the Asus TUF Z690-Plus WiFi D4. Next to the audio ports are seven Type-A USB ports, five of which are USB 3 and above, and there's a single USB 3.1 Type-C port as well.

Like the Asus board, you get a 2.5Gbps Ethernet port, and the rear I/O panel also plays host to the connectors for the on-board 802.11ax Wi-Fi, plus the DisplayPort and HDMI 2.1 outputs. There's also a USB BIOS FlashBack port, which will be handy if you want to buy this board at the same time as a next-gen LGA1700 CPU.

There's a generous count of eight fan headers too, but sadly no other overclocking and testing tools. One feature we did like, though, were the two angled SATA ports hidden under the edge of a heatsink. While the Asus board has a similar arrangement, the ports aren't hidden, and the Asus also has fewer SATA ports than the MSI.

Performance

We had to apply a 1.37V vcore in the EFI, and open the taps on all the power limits, in order to get a stable overclock on this MSI board, but this did allow us to push the E-Cores on our Core i9-12900K to 4GHz instead of 3.9GHz, although the P-Cores still topped out at 5.1GHz. Interestingly, CPU-Z showed the vcore under load was hitting 1.4V, so it's clear there's some extra juice being applied.

This overclock also gave us some of the fastest results we've seen from our Core i9-12900K yet, with a score of 83,602 in the image editing test and 1,116,097 in the video encoding test, but for some reason, Cinebench's multi-threaded test fell a couple of thousand points, even though temperatures were within limits. What was sky-high, though, was the power consumption, which ballooned from 306W to 411W under full load.

We also saw some great results in Far Cry 6, with a peak 932fps 99th percentile result and 135fps average when overclocked, and both stock speed and overclocked results were faster than those from the much more expensive Asus ROG Maximus Z690 Hero. Meanwhile, our PCI-E 4 SSD managed a 4,963MB/sec read speed and 4,239MB/sec write speed, which is on the money. You can see the full performance results over on p20.

Conclusion

MSI's software is still clunky and leaves a lot to be desired compared with the Asus AI Suite; while not perfect, the latter is easier to use and offers greater control, although even it suffers from a lack of Windows 11 support for now. The cooling on the Asus TUF Z690-Plus WiFi D4 was slightly better for both VRMs and M.2 ports as well, but the MSI MAG Z690 Tomahawk WiFi DDR4 has a better design and layout, as well as superior audio quality and heatsinks for all its M.2 ports.

Both boards will be absolutely fine if you want to build a DDR4 Alder Lake system. We chose the Asus TUF board for our feature bundles this month, as it has a better EFI, but if better audio quality is a priority for you, this MSI board also comes recommended.

ANTONY LEATHER

TOMAHAWK

- \+ Attractive design
- \+ Full M.2 heatsink array
- \+ Excellent audio

POCKET KNIFE

- – Overclocking easier on competition
- – Software lacks polish
- – Average M.2 cooling

VERDICT

An attractive motherboard with slightly more features than the competition, including superior audio, although its software needs some work.

PERFORMANCE 33/35

FEATURES 27/35

VALUE 25/30

OVERALL SCORE 85%

Z690 MOTHERBOARD

ASUS TUF Z690-PLUS WIFI D4 / £260 inc VAT

SUPPLIER box.co.uk

It's been a very long time since we've had enthusiast motherboards supporting two types of memory from a single chipset, but that's exactly what's happened with Z690. There's a clear divide between Asus' upper and lower product stack, though, with its Prime and TUF ranges more likely to offer DDR4 support, while its ROG ranges are almost exclusively limited to DDR5. The TUF Z690-Plus WiFi D4, as its name suggests, supports DDR4 memory, but it still offers full support for Intel's 12th-gen Alder Lake processors.

If that comes as news to you – and we wouldn't be surprised if that's the case, as we've seen quite a few people on social media that missed this fact – then the main takeaway is that if you have DDR4 memory in your current system, you can transplant it into your new Z690 system to save cash.

That's quite handy, since DDR5 memory is certainly more expensive than DDR4 memory, but it also doesn't offer significant performance benefits, as we cover in our Alder Lake upgrade feature on p76 this month. What's more, at the time we wrote this review in mid-November, DDR5 kits still weren't available to buy, except in the form of bare-PCB Micron 4800MHz memory in hardware bundles at Scan. This means that the TUF Z690-Plus WiFi D4 could well offer a much cheaper and easier way for you to upgrade to 12th-gen Intel CPU.

SPEC

Chipset
Intel Z690

CPU socket
Intel LGA1700

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

Expansion slots
One 16x PCI-E 5, one 16x PCI-E 3, one 4x PCI-E 3, one 1x PCI-E 3

Sound
8-channel Realtek HD Audio

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

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

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

Dimensions (mm)
305 x 244

It's certainly cheaper than the ROG Maximus Z690 Hero (see p18), which costs twice as much money, but does splashing out over £250 still bag you a decent product? Well, you get the same nifty tool-free M.2 latches that we saw on the Hero, which are a very welcome inclusion, but there's no handy 16x PCI-E slot release button. However, it's not needed as much on this motherboard, due to its smaller heatsinks.

Underneath these VRM heatsinks sits a 15-stage power delivery system, and while there's no heatpipe linking the heatsinks, they're still very substantial and they kept the VRMs to a peak of 53°C in our stress test.

Meanwhile, three of this board's four M.2 ports are covered by heatsinks. The largest heatsink sits at the bottom of the PCB, and is probably the one you'll most want to use for a fast boot drive as a result – it returned a peak M.2 temperature with our PCI-E 4 SSD of 51°C.

Thankfully, all the M.2 ports support up to PCI-E 4 SSDs, but the only PCI-E 5 support comes from the primary 16x expansion slot, not that this makes any difference with current hardware. The SSDs are also cooled on just one side, unlike the Hero's double-sided M.2 heatsinks.

There's no Thunderbolt 4 port here either, unlike the Hero's numerous ports, but there is a Thunderbolt 4 header, so you can plug in an expansion card such as the Asus ThunderboltEX to provide actual Type-C Thunderbolt 4 ports. The audio is fairly basic too, and Asus has sneakily removed the actual codec model number from its specifications. Delving into the driver details suggests it's a Realtek ALC897 codec, and the performance would certainly confirm that, with a dynamic range of 95dBA and noise level of -95dBA, but we can't tell for sure. It's certainly not as good as the 120dBA we saw from the Hero, and it's not hi-fi quality audio, but it's fine for most people's needs.

There's certainly none of the Hero's fancy RGB lighting here either, but two small sections on the board do light up, plus you get four RGB headers on the PCB if you need to jazz up the interior of your system a bit further.

Thankfully, apart from a rather basic accessory box, that's all we have to moan about with this motherboard, as it otherwise covers the essentials, while also offering a few mod cons, including 802.11ax Wi-Fi and a USB 3.1 Type-C port on the rear panel, as well as a corresponding header on the PCB for compatible cases. You get six Type-A USB ports, which is good, but not exceptional, but all of these are either USB 3 or USB 3.1. There are also display outputs if you want to use your CPU's on-board graphics, as well as the full complement of audio outputs.

Asus is well known for having a decent software suite, but our Windows 11 test system threw up some issues with the software for this board. Chief among these issues were a couple of omissions from its AI Suite of Windows controls, specifically Fan Xpert.

This, along with its installer software Armory Crate, isn't currently compatible with Windows 11. However, Asus is working on a fix that should bring these features to the new OS. For now, if you want to tweak fan speeds, you'll either have to use Windows 10 or use the EFI's fan control suite, which thankfully is very good.

Performance

When it came to overclocking, we had to enable loadline calibration to deal with a fair amount of vdroop, and we also had to apply slightly more voltage than usual, with a 1.37V vcore. However, once we'd done that, we found that our usual settings of 5.1GHz across all P-Cores and 3.9GHz on the E-Cores was stable, and without temperatures peaking above 90°C.

Interestingly, this overclock didn't see the big drop in the image editing test we saw with the ROG Maximus Z690 Hero, with the score rising by 2,000 points instead.

We also saw higher frame rates in Far Cry 6 after overclocking, but the performance didn't rise across the board, with similar results in Cinebench and our heavily multi-threaded Handbrake video encoding test. Power consumption was quite restrained, especially at stock speed, but once overclocked, it was well over 300W for the system as a whole.

Conclusion

The Z690 platform offers two polarised choices. The first is to get a cheap DDR4-compatible motherboard, offering the most affordable upgrade path to owning a 12th-gen CPU. The Asus TUF Z690-Plus WiFi D4 definitely fits this category and achieves its aim with a minimum of fuss, while throwing decent cooling and Wi-Fi into the mix. You'll likely need to spend significantly more money and opt for DDR5 memory to get a significantly more lavish setup.

It's a solid motherboard, though, and one of the cheaper Z690 options available, even if £260 would have bought you a lot more even just a couple of years ago. Right now, though, if you want to get on the Intel 12th-gen bandwagon for as little money as possible, and maybe transplant your existing DDR4 memory, the TUF Z690-Plus WiFi D4 is a great choice, and it can cope with an overclocked Core i9-12900K too.

ANTONY LEATHER

TUF COOKIE

+ Attractive design
+ Good M.2 and VRM cooling
+ Excellent EFI

TUF LOVE

– Features are a little lacking
– Some software currently incompatible with Windows 11
– Mediocre on-board audio

VERDICT

A little lacking on features given the price tag, but you won't find more elsewhere and it's otherwise a solid option.

PERFORMANCE 32/35

FEATURES 26/35

VALUE 25/30

OVERALL SCORE 83%

Z690 MOTHERBOARD

ASUS ROG MAXIMUS Z690 HERO / £520 inc VAT

SUPPLIER novatech.co.uk

It's okay, we know what you're thinking. Sadly, that isn't a typo and the latest iteration of the popular Maximum Hero does indeed cost more than £500. The reason for this whopping price compared with previous Hero boards is likely down to several reasons, not least of all the absolute monster of a motherboard that you get in the ROG Maximus Z690 Hero's box.

In fact, that box has a surprising amount of weight to it – when it first arrived, we initially thought Asus had mistakenly sent us one of its pre-water-cooled motherboards. Instead, the Hero packs a massive punch in the air cooling department. It has two enormous stacks of heatsinks linked with a heatpipe, which cools the 21-stage 90A teamed power delivery system.

It's one of the biggest arrays of heatsinks we've seen, and it was no surprise to see the VRMs max out at just 50°C after a ten-minute stress test with a Core i9-12900K. If you're thinking about pushing your new Alder Lake CPU to its limits without worrying about VRM temperatures, then the Hero's cooling system certainly has you covered.

If you want to install loads of M.2 SSDs then this board has a mass of options here too. There are three slots on the PCB, two of which support PCI-E 4 NVMe SSDs – they're all covered by large heatsinks and Asus also includes an expansion card covered with a large heatsink. This card adds two more M.2 ports, one of which is PCI-E 5-ready, although there sadly aren't any PCI-E 5 SSDs available to take advantage of it yet.

Two of the three 16x PCI-E slots are PCI-E 5-compatible too, so you could still use your graphics card as well as a PCI-E 5 SSD on the expansion card when they're available. Installing a PCI-E 5 SSD in this card will drop the bandwidth of the two PCI-E 5 expansion slots from 16 to eight lanes, but that will still be plenty for graphics cards for a long time.

As you'd expect, there's the usual complement of six SATA 6Gbps ports as well, so if you want to drop in several terabytes of ultra-fast storage and half a dozen hard disks, you have all the connectors you need.

The M.2 heatsinks work well too. Even the lower heatsink on the PCB kept our PCI-E 4 M.2 SSD below 55°C, with the expansion card dropping this temperature to just 49°C. The M.2 ports also feature new tool-free latches, which enable

SPEC

Chipset
Intel Z690

CPU socket
Intel LGA1700

Memory support
4 slots: max 128GB DDR5 (up to 6400MHz)

Expansion slots
Two 16x PCI-E 5, One 16x PCI-E 4

Sound
8-channel Supreme FX 7.1 Realtek ALC4080

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

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

Ports
6 x SATA 6Gbps, 5 x M.2 PCI-E 4, 6 x USB 3.1 Type-A, 2 x USB 3.1 Type-C/ Thunderbolt 4, 1 x USB 3.1 Type-C, 2 x USB 2. 1 x USB 3.1 Type-C header, 1 x LAN, 3 x surround audio out

Dimensions (mm)
305 x 244

you to lock M.2 SSDs in place without dealing with tiny screws, which makes installation so much easier.

This motherboard even makes removing your graphics card less arduous than beforehand. There's now a button next to the primary 16x PCI-E slot, which allows you to pop open the slot latch and release your card, without having to fiddle under your graphics card cooler. This is just as well, as the heatsinks make it very tricky to access the latch otherwise.

You also get Realtek-based audio using a ROG SupremeFX ALC4082 codec with an ESS DAC. This setup performed exceptionally well in our tests, with a dynamic range of 120dBA and noise level of -120.2dBA.

Another reason for the cost is the two Thunderbolt 4 ports on the rear I/O panel, which bump up the price. You also get 802.11ax 2x2 Wi-Fi with Bluetooth 5.2, plus a 2.5Gbps Ethernet port, although the Z590 version of this board had two of the latter. More features that go some way to justifying the price are the Power and Reset switches on the PCB, as well as an LED POST code display, plus clear-CMOS and USB BIOS FlashBack buttons on the rear I/O panel.

In addition to the pair of Type-C Thunderbolt 4 ports on that back panel, there's a standard USB 3.1 Type-C port, eight Type-A USB ports and also an HDMI output should you wish to just use your CPU's on-board graphics. There's also an intriguing 6-pin connector next to the front-panel Type-C header, and this provides extra power to the header, so it can dish out up to 60W when charging your smartphone or laptop.

There's a total of nine fan headers that can be controlled using various temperature sensors, including a thermal probe input on the PCB, which is handy for water-cooled systems. The ROG Maximus Z690 Hero looks fantastic when you fire it up, with a large ROG-themed, animated RGB lighting array on top of the I/O shroud and most of the PCB covered in heatsinks. It certainly looks like it's worth its price tag when it gets going, plus you get DDR5 support.

Performance

Several BIOS updates have been released since our initial Alder Lake coverage last month, but the overclocking situation doesn't seem to be any better, with a 5.1GHz all-core overclock on the P-Cores and 4GHz across the E-Cores being the limit of our Core i9-12900K sample without pushing the vcore beyond 1.4V.

Overclocking all the P-Cores in this way results in a drop of the peak boost of several hundred megahertz, which explains slower results in some of the lightly threaded workloads, such as Far Cry 6 and our GIMP image editing test.

Out of the box, the Core i9-12900K is already running close to its limits, meaning that running it at stock speed is the best option for most people, and it's already very fast at these settings. Overclocking it yields small gains in multi-threaded tasks, such as a boost from 27,407 to 28,079 in Cinebench, but that's it.

However, the Hero did draw a fair amount of power here on the auto settings in the EFI, hitting 339W under load. Meanwhile, our M.2 SSD hit the usual read and write speeds of 4,978MB/sec and 4,249MB/sec respectively. You can see the full performance results on p20.

Conclusion

There's no denying that Z690 motherboards are expensive. The Hero is Asus' entry-level ROG Maximus board, and this Z690 version costs over £520 inc VAT. We don't doubt the Hero's credentials – it's utterly droolworthy and dripping with features, but the fact is that it's simply out of reach for many people, and that's a shame.

Were it to cost £150 or even £100 less, we'd be sorely tempted to splash out in it, but as it stands, it's only really a motherboard for people with an enormous amount of money to spend.

That's especially true when you consider that the Core i9-12900K doesn't seem to benefit much from overclocking, with plenty of examples we've seen offering limited gains and often slower lightly threaded performance after an all-core overclock.

ANTONY LEATHER

VERDICT

A monster motherboard that's dripping with features, but with a price to make your wallet cry.

HERO

+ Gorgeous design
+ Superb M.2 and VRM cooling
+ Loads of features

ZERO

– Monstrous price tag
– Only supports DDR5
– Core i9-12900K isn't a great overclocker

PERFORMANCE **32/35**

FEATURES **33/35**

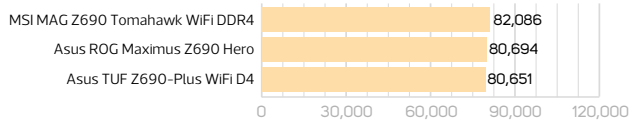
VALUE **15/30**

OVERALL SCORE **80%**

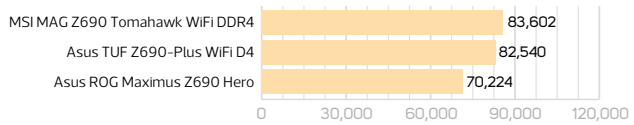
Z690 MOTHERBOARD BENCHMARK RESULTS

GIMP IMAGE EDITING

Stock speed

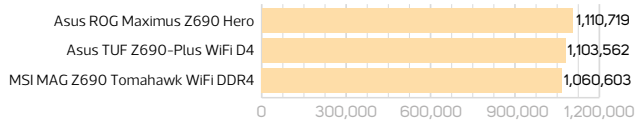


Overclocked

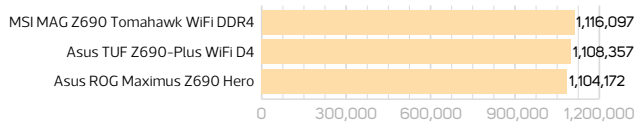


HANDBRAKE H.264 VIDEO ENCODING

Stock speed

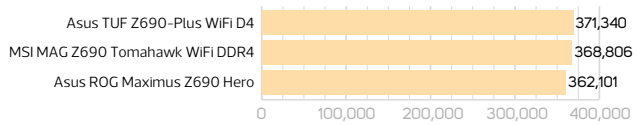


Overclocked

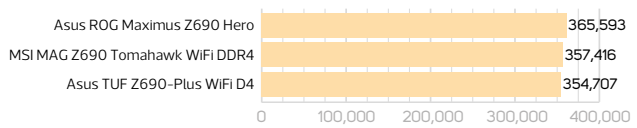


HEAVY MULTI-TASKING

Stock speed

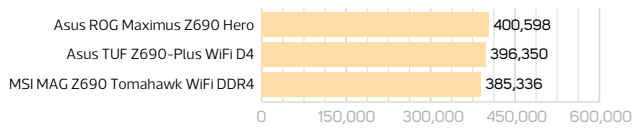


Overclocked

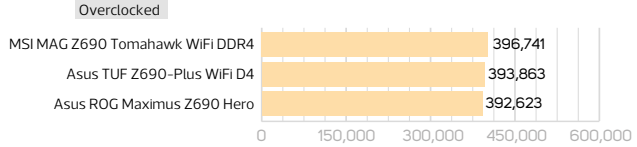


SYSTEM SCORE

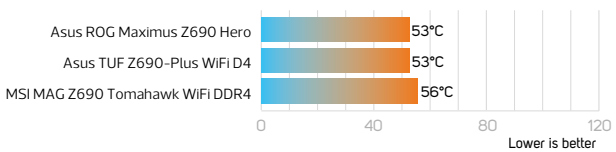
Stock speed



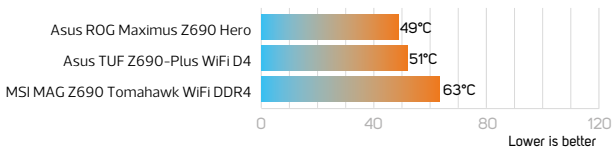
Overclocked



VRM TEMPERATURES

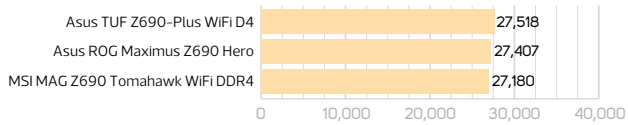


M.2 TEMPERATURES

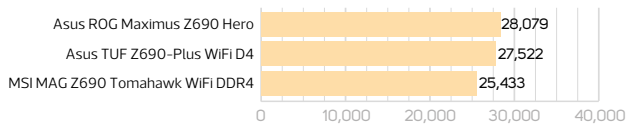


CINEBENCH R23 MULTI-THREADED

Stock speed

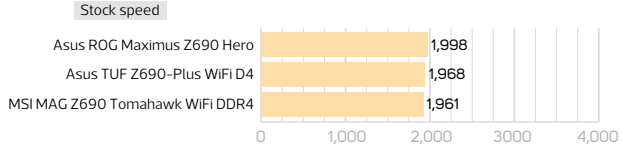


Overclocked

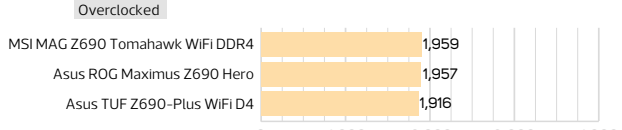


CINEBENCH R23 SINGLE-THREADED

Stock speed

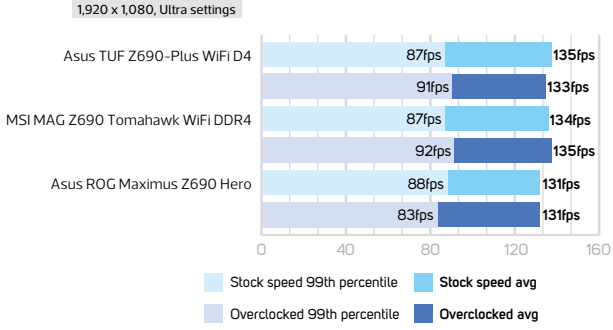


Overclocked



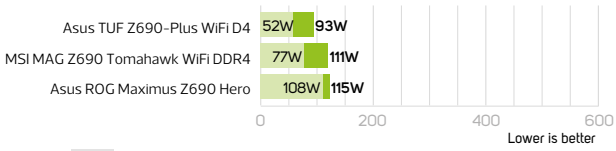
FAR CRY 6

1,920 x 1,080, Ultra settings

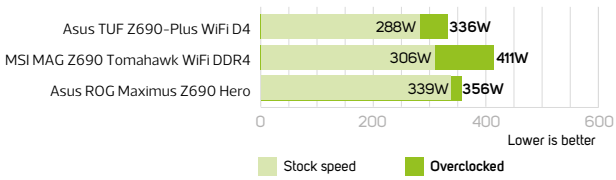


TOTAL SYSTEM POWER CONSUMPTION

Idle



Load



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ATX CASE

NZXT H510 FLOW / £90 inc VAT

SUPPLIER scan.co.uk

With NZXT's previous compact ATX chassis, such as the H510 Elite, the company went for a brute-force approach to ensure the cases had good airflow despite having a sealed front panel. We don't blame the designers at NZXT for making that decision, as the H510 Elite looked fantastic and was also the best-performing, sealed-front case we've tested. However, it could also be quite noisy when running its fans at full speed. With the new H510 Flow, NZXT is adding a front mesh to the equation in order to improve airflow.

This addition, NZXT claims, has not only enabled the company to reduce noise, but still maintain low case temperatures, and it comes with a different fan arrangement as a result. There's now just a single 120mm fan in the front, rather than two, with a second fan in the rear of the case, and this limited number of fans undoubtedly helps the H510 Flow to hit a rather attractive price point of just £90. The case fans spin 300rpm slower than those in the H510 Elite too, so they should generate fewer decibels, although the front mesh will probably also allow noise to escape more readily.

The new mesh panel only covers around two thirds of the front panel from the top, and we really liked the fact that it pops off easily, giving you access to the removable dust filter inside it, as well as the dual 120/140mm fan mounts beneath it. What's more, the whole fan mounting plate can be removed too, helping even further with the installation of fans and radiators. There are vents at the front of the case and beneath the PSU as well, and these are also covered with removable dust filters.

The rest of the case is largely the same as previous versions of the H510, including the two-third-height tinted glass side panel, which is held in place by a single thumbscrew and is easily removable.

Externally, the case's design is extremely clean, except for a 120/140mm fan vent in the roof, and NZXT has even kept the front panel as small as possible, with just a single Type-A USB 3 port and Type-C port, with the latter needing a Type-C header on your motherboard to work. There's also a power button and single audio jack, and if you need to use the latter, a tri-pole splitter cable is included in the box, so you can plug both speakers and a microphone into it.

Even with its large feet, the H510 Flow stands just 46cm tall on your desktop, and it measures just 43cm deep and 21cm wide. An ATX motherboard just fits inside it, so it's no surprise to learn that E-ATX is a no-go. Despite the limited interior space, though, NZXT has done a good job of making sure it's easy to route and tidy cables. There are holes in the full-length PSU cover, and along the side of the motherboard tray, with a metal plate covering them. In fact, cables are so well hidden that it's largely pointless buying a custom cable kit for your PSU if you're using this case.

Behind the motherboard tray, you'll find more cable-routing gadgets, with channels to direct and secure the 24-pin ATX and PCI-E cables neatly down to the PSU, as well as plenty of cable anchor points. This is just as well, as

SPEC

Dimensions (mm)
210 x 428 x 460 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black, black and white

Weight
6.6kg

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

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

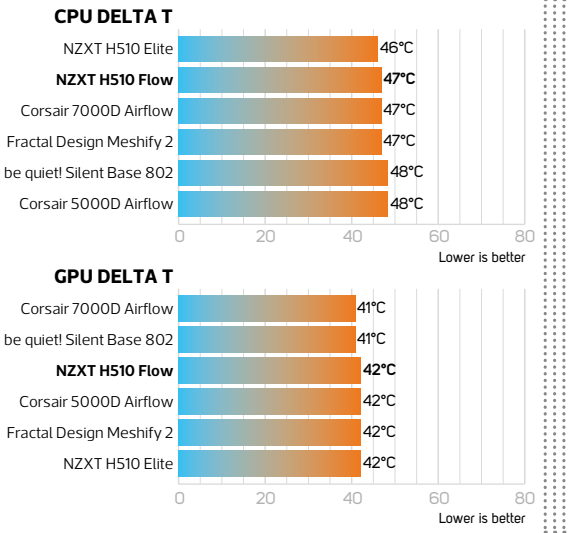
Form factor(s)
ATX, micro-ATX

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

CPU cooler clearance
165mm

Maximum graphics card length
360mm

TEMPERATURE RESULTS



the depth of clearance here is quite shallow, so you'll need to ensure you do a good job of tidying if you want to be able to refit the side panel without issues.

Thankfully, despite there being a dual 2.5/3.5in storage bay at the front of the case, there's still room to stow cables in front of the PSU, although limiting the number of SATA drives in your system will help you here, as space is quickly eaten away, especially with the closeness of the side panel.

Despite a width of just 21cm, the H510 Flow has a CPU cooler height limit of 165mm, which means all but the very tallest air coolers will fit. The front fan mounts can also offer a home to radiators for 240mm or 280mm all-in-one liquid coolers, and the case's tight dimensions mean it's possible to have the cooler's tubes sitting at the bottom and still reach the CPU socket, helping you to avoid long-term issues with air bubbles accumulating in the pump.

Performance

The H510 Flow's fans are certainly quieter than those in the H510 Elite, and you don't get too much sound bleeding from the new mesh panel either. At lower speeds, it's a very quiet case, and it's cool enough too. Our overclocked Ryzen 1600 was kept to a chilly 47°C, which is only a degree warmer than the H510 Elite, and cooler than the be quiet! Silent Base 802 and Corsair 5000D Airflow. The GPU delta T was a match for the H510 Elite, likely thanks to that front mesh allowing the front fan to point its airflow straight at our graphics card. It was only a degree off the pace of the best-performing cases we've tested too, so cooling high-end GPUs will be no problem at all.

Conclusion

The NZXT H510 Flow is compact and reasonably priced, and the addition of the mesh front over its sealed-front siblings confirms NZXT's claims that the new case can cool just as well as its brethren, but with fewer fans and less airflow. Coming in at £100, it's certainly a very appealing option that's clean and able to handle large, high-end components, plus it's relatively easy to work with this case.

There is plenty of competition out there, though, and the Fractal Design Meshify 2 Compact, for example, costs the same, and while it's a tad taller, it's even easier to work with than this case, plus it has even better water-cooling support and similar performance out of the box. We like the H510 Flow's black and white colour scheme option, though, which most of the competition can't match. The Meshify 2 Compact might be the perfect all-rounder, but for some added class and head-turning looks, the H510 flow comes a very close second.

ANTONY LEATHER

VERDICT

An attractive, cool and quiet take on one of our favourite compact cases.

AIR VENTING

+ Fantastic water-cooling support
+ Easy hardware installation
+ Flexible interior

ANGER VENTING

− Expensive
− No PCI-E riser cable included
− Extremely niche

COOLING	28/30
FEATURES	14/20
DESIGN	26/30
VALUE	18/20
OVERALL SCORE	86%

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PCSpecialist

360MM AIO LIQUID COOLER

CORSAIR H150i ELITE LCD / £250 inc VAT

SUPPLIER scan.co.uk

Custom PC Extreme Ultra

COMMANDER

- \+ Good cooling
- \+ Brilliant fan and lighting controller
- \+ Great-looking display

COMMANDEER

- – Expensive
- – RGB connectors are proprietary
- – Lots of cables

With a whopping price of £250 inc VAT, Corsair's fancy new H150i Elite LCD is one of the most expensive all-in-one (AIO) liquid coolers we've tested. Not only does it have a customisable screen on the pump/waterblock unit, but the cost is also bumped up by the inclusion of a Corsair iCUE Commander Core in the box, which is a combined fan and lighting controller.

Tweakable using Corsair's iCUE software and a USB 2 header, the controller can power up to six RGB components with Corsair's own connectors, as well as six PWM fans. It also connects to the new pump, which is no longer made by Asetek, with the software allowing to you select from various profiles or, in the case of the fans, create your own profile.

There are options for Quiet, Balanced, Extreme and Zero RPM, with the latter mode switching off the fans completely until the temperature reaches a certain level.

Out of the box, that temperature is read from the coolant rather than the CPU, since the coolant will actually absorb a lot of heat first, so spinning up the fans instantly when the CPU is loaded won't achieve anything other than making a lot of noise.

This works really well, as all of the fan modes wait a while before ramping up the fan speeds, with the more aggressive profiles spinning up the fans earlier than the quiet modes and to higher speeds. Even then, though, it remains very quiet for most of the time, and it's only after three or four minutes of full load that you'd typically hear the fans spin up. You can also pick from a range of other inputs, such as your graphics card, a 2-pin thermal probe input or even your motherboard's sensor data.

The motherboard sensor data isn't labelled, so you'll need to identify inputs such as VRMs or chipsets, but you could certainly use this feature to control the fan in front of your graphics card based on its temperature.

As we mentioned earlier, the pump/waterblock unit also features a new design with a snazzy 480 x 480 display; in addition to being able to display your own GIFs or animations, this has plenty of built-in options. It can show a range of data, such as the CPU temperature, coolant temperature, fan speed and pump speed, with the layout of the display being tweakable, including the colours.

The 30Hz 24-bit IPS display is clear and vibrant – it looks fantastic, and the display cap can pop off for easier installation

SPEC

Intel compatibility
LGA1700, LGA115x, LGA1200, LGA2066, LGA2011

AMD compatibility
Socket AM4, AM3+, TR4/X

Radiator size with fans (mm)
120 x 397 x 52 (W x D x H)

Fans
3 x 120mm

Stated noise
30dBA

as well, as the cables come away with it. That said, you do still have to deal with a mass of cables with this cooler. Each fan has two wires, which already means you have six cables with this 360mm, triple-fan model. You then have the SATA cable that powers the whole setup, two USB leads and another cable connecting the pump to the controller.

Thankfully, if you place the controller behind your motherboard, all the wires can be routed out of sight of the main interior, but you'll need to spend some time dealing with all the spaghetti. Installation is otherwise routine, with just the iCUE Commander Core controller to fit in addition to the usual pump backplate, pins and thumbscrews.

The Corsair H150i Elite LCD cooler and its siblings also have the advantage of coming with LGA1700 support straight out of the box, courtesy of a redesigned backplate and shorter mounting pins to cater for the lower-lying CPU heatspreader. This means you won't need to buy a separate adaptor if you want to attach this cooler to one of Intel's new Alder Lake CPUs. As well as supporting the standard AMD and Intel CPU sockets, the H150i Elite LCD also supports AMD Threadripper sockets and has an enlarged contact plate, which should help it to deal with large heatspreaders, including those on Alder Lake CPUs.

Performance

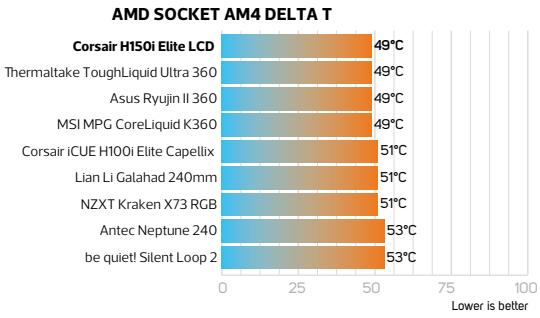
In our LGA1700 test system cooling a stock-speed Core i9-12900K, the H150i Elite LCD fared well, hitting a low delta T of 43°C on the P-Cores and 40°C on the E-Cores in its noisy Extreme mode. In its out-of-the-box mode with the pump on Silent and fans on Balanced mode, these temperatures rose to 49°C and 46°C respectively, which were slightly warmer results than those from the NZXT Kraken X73 RGB we tested in this month's Alder Lake upgrade guide (see p76).

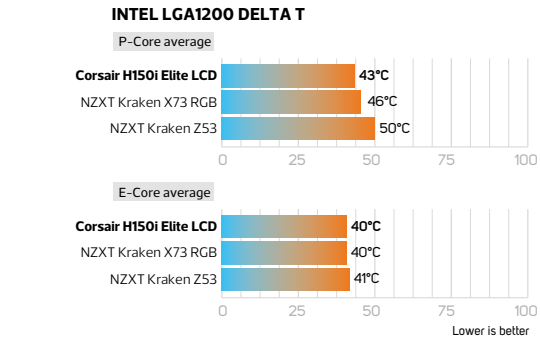
In Silent mode, meanwhile, the fans remained at very low levels, even after ten minutes of stress testing, with the P-Core temperature settling at a delta T of 52°C and the E-Core temperature peaking at 49°C.

In our AMD system dealing with an overclocked Ryzen 7 5800X, the CPU delta T hit 49°C with the cooler in Extreme mode, which matches the great results we've seen from the MSI MPG CoreLiquid K360 and Asus Ryujin II 360. Tuning it down to Balanced mode saw the delta T rise 52°C, while Silent mode pushed it up to 54°C.

In terms of noise, the ML Elite series fans can spin at up to 2,000rpm, and are fairly noisy in Extreme mode, although the noise is fine if you tune down the fan speeds. The CoolIT-made pump made a slight whine too, even in Silent mode, but you're unlikely to really notice it unless the rest of the components in your PC are absolutely silent.

TEMPERATURE RESULTS





Conclusion

There's no denying that £250 is a huge sum of money for an AIO liquid cooler, but we're still impressed by the Corsair H150i Elite LCD's overall package. You're not just getting a CPU cooler here, but a serious amount of customisable illumination, a cutting-edge display and, more importantly, a decent fan and lighting controller with thermal probe input and a polished software interface with granular control.

Performance-wise, this cooler is right up there – while it's noisy in Extreme mode, its large radiator still enables it to keep an overclocked Core i9-12900K in check in Quiet mode. It might be add a big chunk to that already high Alder Lake upgrade bill, but it certainly has what it takes to cool Intel's latest CPUs, with excellent results in our AMD system too.

ANTONY LEATHER

VERDICT

An awesome CPU cooler with a neat screen, decent control options and LGA1700 support, but it also has a price to match.

LGA1700

COOLING 39/40

FEATURES 18/20

DESIGN 17/20

VALUE 13/20

FITTING EASY

OVERALL SCORE 87%

Socket AM4

COOLING 39/40

FEATURES 18/20

DESIGN 17/20

VALUE 11/20

FITTING EASY

OVERALL SCORE 85%

27IN GAMING MONITOR

HUAWEI MATEVIEW GT 27 / £449 inc VAT

SUPPLIER huawei.com

ALRIGHT MATE?

+ Bold, bright colours
+ Sleek and mature design
+ High contrast ratio

OH MATE...

- Obvious ghosting
- Few features or adjustment options
- Expensive

This is the first time we've seen one of Huawei's gaming displays, and this 27in unit arrives with a 2,560 x 1,440 resolution, a 165Hz refresh rate and slick design. It's not cheap though – its £449 price makes it more expensive than any comparatively specified rival we've recently reviewed.

The solid resolution is paired with a 1500R curve, which increases immersion without hampering viewing angles. On the inside the MateView uses a VA panel and Huawei says it can display the sRGB and DCI-P3 gamuts. It supports AMD FreeSync Premium and works with Nvidia G-Sync too, but its refresh rate of 165Hz and listed response time of 1–4ms are middling attributes at this price that are outpaced by its immediate competitors.

The MateView's sleek metal base and stand look more mature than most gaming panels, and build quality is robust. It doesn't have the most flexible stand though – it has 110mm of height adjustment, 25 degrees of tilt and VESA-mount support, but that's it for adjustment. There are no USB ports or speakers, and the on-screen display is basic and badly designed – you have to go into a hidden menu to activate FreeSync, for example.

The MateView offers good image quality, but it rarely matches Huawei's claims. The panel's factory brightness level of 188cd/m^2 combines with a black point of 0.07cd/m^2 for a fantastic contrast ratio of 2,686:1, but that's still below Huawei's quoted 4,000:1 level. Similarly, the delta E of 2.61 is great, but it's not the sub-2 figure Huawei promised.

The panel also rendered 99.4 per cent of the sRGB gamut at 120.6 per cent volume, and it scored 85.5 per cent in both DCI-P3 measurements – but those DCI-P3 figures are below the 90 per cent stated by Huawei. At least the colour temperature of 6,581K is virtually flawless, and uniformity is excellent.

The Huawei MateView GT27's inability to live up to its billing has a real-world impact. On the positive side, the high contrast ratio, low black point and sRGB coverage results mean you get huge punch, depth and vibrancy in games. Sadly, the maximum brightness peaks at 411cd/m^2 and the panel has no contrast-boosting or sophisticated dimming features, so you don't see any meaningful improvement when you're running HDR titles either.

It's middling when it comes to motion too. At default settings, the Huawei displays noticeable ghosting when bright objects move against darker backgrounds. The panel uses its second of five overdrive modes by default, and moving to level five does improve motion, but the issue is never eradicated. These issues aren't ruinous for single-player games, but they're going to annoy you if you play fast-paced competitive games such as esports.

Conversely, the £480 AOC AG273QZ is a 2,560 x 1,440 IPS display with a 0.5ms response time and 240Hz refresh rate, while the Asus TUF Gaming VG27AQ costs just £320 and has ELMB for smoother motion, although its 144Hz refresh rate is a bit lower than that of the MateView GT. None of these displays has the Huawei's punchy colours, but they all supply crisper, faster gameplay, and the Asus displays have superior colour accuracy.

SPEC

Screen size
27in

Resolution
2,560 x 1,440

Panel technology
VA

Maximum refresh rate
165Hz

Stated response time
1-4ms

Stated contrast ratio
4,000:1

Active sync
AMD FreeSync Premium

Display inputs
1 x HDMI 2,
1 x DisplayPort 1.2

Stand adjustment
Height, tilt

Extras
100 x 100mm
VESA mount

Conclusion

The Huawei MateView GT 27 has a slick design and vibrant colours, as well as some decent gaming features, but it fails to live up to expectations. It's expensive, and cheaper rivals offer better motion, more features and more realistic colours. Huawei's panel could have been a vibrant alternative to big gaming brands, but it's just too expensive.

MIKE JENNINGS

VERDICT

The MateView is a reasonable gaming panel with vibrant colours, but it's expensive and doesn't live up to its billing.

DESIGN 22/30
FEATURES 20/30
PERFORMANCE 14/20
VALUE 12/20

OVERALL SCORE 68%

28in 4K gaming monitor

AOC U28G2XU

/ £568 inc VAT

SUPPLIER amazon.co.uk

The AOC U28G2XU is the cheapest 144Hz 4K display we've yet seen. As you'd expect for this price, the U28G2XU isn't a particularly flashy monitor. Its build is simple and minimalistic, but not to the point we'd be concerned about any build quality failings. The stand offers height, pivot, rotation and tilt adjustment, as well as a 100 x 100mm VESA mount for using alternative stands.

Connection options are decent too, with one DisplayPort 1.4 input and two HDMI connectors. However, only the DisplayPort 1.4 input can handle 4K at 144Hz – the HDMI inputs are only HDMI 2, so they're limited to 60Hz at this resolution. You also get a 4-port USB 3.2 hub, and the power supply is internal and uses an IEC C14 (kettle lead) connection, so it doesn't have an annoying power brick.

A pair of 3W speakers is also included, and they don't sound too bad. In addition, there's a headphone jack, which sounds clear and undistorted, if lacking the finesse of higher-end sound devices.

This 28in screen's extra inch of diagonal measurement over a 27in panel is welcome when working with such a fine resolution, although it doesn't have quite the impact of a 32in screen, such as the Asus ROG Swift PG32UQX. Meanwhile, across the board, image quality is generally excellent. The IPS panel technology keeps viewing angles wide, while contrast ratio is notably high, measuring 1,105:1 in our tests.

The display has an extended colour gamut of up to 86 per cent DCI-P3 (120 per cent sRGB), but this can be reduced back to 100 per cent sRGB in sRGB mode, although this fixes the brightness at 50 per cent (150 nits). Whether or not you choose to have more vivid colours, this display produces a superb colour balance, so there should be no need to adjust any of the settings (you get a 6,484K colour temperature and 2.24 gamma). The only letdown is poor panel uniformity, with the display dropping in brightness by up to 19 per cent at its outer edges.

As for gaming, this display doesn't set any response time records, but it doesn't suffer from any distracting smearing or ghosting. Meanwhile, the jump up from 60Hz to 144Hz at 4K is immediately noticeable, even just on the Windows desktop, making for some wonderfully smooth, pin-sharp gaming. Adaptive sync (FreeSync and G-Sync) support is included too, so you can eliminate tearing and stuttering in most scenarios, plus there's a backlight-strobing blur reduction mode to further increase the snappy feel. However, using this comes at the expense of adaptive sync.

If there's one problem, it's this monitor's on-screen display (OSD) control system. The controls consist of five tiny buttons on the underside of the screen's edge and they're fiddly to use. It's a struggle to find the right button when you start, and then it's all too easy to hit the wrong one or tap the power button and turn off the whole display. Thankfully, the menus themselves at least have all the options you should need.

SPEC

Screen size
28in

Resolution
3,840 x 2,160

Panel technology
IPS

Maximum refresh rate
144Hz

Stated response time
1ms

Max brightness
370cd/m²

Backlight zones
1

Stated contrast ratio
1,000:1

Adaptive sync
FreeSync and G-Sync-compatible

Display inputs
1 x DisplayPort 1.4, 2 x HDMI 2

Audio
2 x 3W speakers, headphone output jack

Stand adjustment
Height, pivot, rotation, tilt

Extras
100 x 100mm VESA mount, 4-port USB 3.2 hub

Conclusion

Bringing the world of 144Hz 4K gaming to a new low price, the AOC U28G2XU is a compelling proposition for those seeking the next level in image clarity and gaming performance. Its fiddly OSD controls and slightly iffy panel uniformity can't detract from what is otherwise an excellent monitor at this price.

EDWARD CHESTER

VERDICT

An excellent-value display for people seeking 4K gaming at a high refresh rate.

FAST AND SHARP

+ Low price for 4K at 144Hz
+ Excellent out-of-the-box image quality
+ Plenty of features

SLOW AND DULL

– Poor edge uniformity
– Only 60Hz for HDMI inputs
– Fiddly OSD controls

IMAGE QUALITY **26/30**

GAMING **24/30**

FEATURES **18/20**

VALUE **18/20**

OVERALL SCORE **86%**

GAMEPAD

RAZER WOLVERINE V2 CHROMA / £149 inc VAT

SUPPLIER razer.com

PROFESSOR X

+ High-quality buttons and ergonomic shape
+ Clever gaming features
+ Decent customisation options
+ RGB LEDs

MAGNETO

– No carry case
– No wireless features
– Expensive

There's no avoiding the fact that £149 is a considerable amount to spend on a gamepad, but you notice the difference between the Razer Wolverine V2 Chroma and a normal gamepad as soon as you hammer the face buttons. Razer describes them as 'mecha-tactile action buttons', and they move with an underlying mechanical switch rather than a conventional membrane.

Razer claims that this design delivers quicker actuation times than traditional pads, and the buttons do feel fantastic – they're crisp, comfortable and fast. The raised D-pad uses the same design, and it has the same impressive feel. The pad's other buttons don't have the same hardware, but they're enhanced elsewhere.

Meanwhile, glossy casings house the analogue sticks to ensure friction-free movement. Razer includes interchangeable caps in the box as well – a taller stick that encourages accuracy, and a short, convex model for improved speed. They both work well. The taller concave version gives you some extra precision but retains the design of the standard stick on top. The convex version is good as well, but it could do with some more texture on its surface.

The shoulder buttons are large too, and switches on the underside convert the triggers to 'hair trigger mode', which slashes their travel distance for faster actuation.

Again, it works well – the new actuation point feels very solid, so you can hammer against them without issue – we found they worked great in fast-paced games such as Call of Duty: Warzone.

Razer has added plenty of extra buttons to this second incarnation of the Wolverine as well. There are two extra bumpers next to the shoulder buttons and four triggers on the underside. By default, two of those triggers alter the sensitivity of the analogue sticks for precise, slow movement – like a sniper button on a gaming mouse.

Razer has also moved the menu and view buttons upwards compared with a standard Xbox pad, and there are two rings of RGB LEDs around the device. There's also an audio button that can increase your system's volume and adjust the balance between game and chat levels, plus a headphone jack.

It's a busy pad, but the Wolverine feels great in the hand – the textured grips work well, build quality is solid and its 270g weight makes it lighter than every official Xbox pad. It's easy to manage too – Razer's dedicated PC app allows users to change button assignments, alter the lighting, edit stick sensitivity and change vibration levels.

On the downside, this wired pad only comes with a removable 3m USB Type-C cable, but a longer wire would accommodate a wider range of rooms. The four extra buttons on the underside can be awkward to reach too, and you don't get a carry case.

The Wolverine's toughest competition is the Xbox Elite Wireless Controller Series 2, which has the same price. That pad has wireless and wired modes, more interchangeable buttons in the box and a carry case, plus its underside paddles are easier to reach, but it also doesn't have the Razer's superb button action.

Conclusion

The Wolverine Chroma V2's buttons feel fantastic, there's good customisation and you get smart features such as interchangeable analogue sticks, hair-trigger switches and the sensitivity clutch. It's ergonomically well designed too. The price is high, though, and the Xbox Elite Wireless Controller Series 2 arguably provides a more rounded experience thanks to its wireless operation, additional customisation options and included case. If your top priority is getting a fast-action pad that feels great in your hand, though, the Razer Wolverine Chroma V2 is awesome if you can afford it.

MIKE JENNINGS

VERDICT

A high-quality and effective choice for high-end gaming, but it's also very expensive.

DESIGN 19/20
FEATURES 16/20
PERFORMANCE 28/30
VALUE 17/30

OVERALL SCORE 80%

SPEC

Weight
270g

Dimensions (mm)
162 x 106 x 65 (W x D x H)

Buttons
21 (D-pad, action, analogue sticks, shoulder, underside, View, Menu, Share, Audio, Xbox)

Cable
3m, USB Type-C

Extras
Interchangeable analogue sticks, RGB lighting

Wireframe

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BLUETOOTH KEYBOARD

LOGITECH MX KEYS MINI / £100 inc VAT

SUPPLIER logitech.com

BMW MINI

+ Great design
+ Good typing performance
+ Easy multi-device connection

AUSTIN MAXI

– No USB data connection
– Non-replaceable battery
– Expensive

The full-sized version of Logitech's MX Keys keyboard impressed us when we reviewed it a few months ago, and now Logitech has added a mini model to the range that drops the numpad cluster, and squeezes the cursor keys under the right Shift and Enter keys. It makes for a much more compact keyboard but it also results in a few compromises.

What isn't compromised here is the design and build quality. The simple metallic dark grey (graphite) top and otherwise black plastic colouring is simple, subtle and smart, as is the overall shape with its gentle rounded edges. Fetching light pink and silver/white versions are also available. The tenkeyless design also helps with the smart appearance, as the lack of gaps between the alphanumeric keys, cursors and numpad makes the whole unit look uniform.

You don't get much in the way of physical features. There's a USB Type-C charging port on the back, alongside the power switch, but the USB port can't be used to interface with a computer – it's Bluetooth only. Meanwhile, the battery compartment doubles as a raised foot at the back of the keyboard to give it a better angle.

This compartment is sealed, so you can't replace the batteries. While such a setup is largely forgivable on really compact devices such as mice, it's an irritation for a device such as a keyboard, where the size of the battery compartment would make it easy to just use rechargeable AA batteries. That said, the supplied battery has a great lifespan, with ten days of non-stop use, and up to five months of standby charge.

This keyboard can also connect to three devices at once, and seamlessly switch between them at the touch of a button (F1-F3). The other F keys also provide backlight brightness adjustment (white only, with seven levels of brightness), voice command/assistant, an emoji menu, screenshot and mute, volume and media playback functions.

What's more, Logitech's Flow software enables you to copy and paste data between the devices connected to your keyboard. It simply routes the data via the software/Logitech's servers, rather than doing anything clever on the keyboard, but it still makes for a wonderfully easy way to move data.

The key layout here largely works well, given the loss of quite a few keys. The cursor keys don't feel too restrictive despite their small size, and although they're not labelled, they double up as Home/End/PgUp/PgDown keys when used with the Fn key. There's also a dedicated Del key so, at least that essential key isn't confined to a secondary function.

What's more, the MX Keys Mini has both Mac and PC key legends, so if you're swapping between devices for work and home, you won't be left having to remember which button doubles as which.

The action of the low-profile scissor switch keys is also very easygoing, providing a defined but not overly stiff actuation point, so you know when a key's been pressed but don't get finger fatigue. The keys are also very quiet, registering just 50dB in our test.

SPEC

Dimensions (mm)
296 x 132 x 21 (W x D x H)

Weight
506g

Format
TKL – 80 keys

Connections
Bluetooth, USB Type-C (charging only)

Switch type
Scissor membrane

Backlighting
White

Stated battery life
Ten days non-stop use / up to five months standby without backlight

Extras
Connects to three devices at once, emoji keys, Mac and PC key legends

Conclusion

The MX Keys Mini is a fantastic compact Bluetooth keyboard. It looks great, it's well built, it has a pleasant typing action and its multi-device connection feature is great.

The only downers are the high price and the non-replaceable battery, but we suspect the latter two features won't be overly missed by most users of a device such as this one.

EDWARD CHESTER

VERDICT

A great-looking, well-built compact Bluetooth keyboard with a pleasant typing action. It's not cheap, but it does its job well.

DESIGN 18/20
FEATURES 15/20
PERFORMANCE 24/30
VALUE 23/30

OVERALL SCORE 80%

HackSpace

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INTEL Z690 GAMING PC

SCAN 3XS VENGEANCE TI / £3,499 inc VAT

SUPPLIER scan.co.uk

It's been a long time coming, but Intel has finally deployed its first 10nm desktop CPUs, and Scan's 3XS Vengeance Ti is the first system we've seen with the barnstorming Core i9-12900K. Intel's new Alder Lake processors have two types of cores – P-Cores for performance and more power-efficient E-Cores, which take an intelligent approach to power management and thread direction.

As a result, the Core i9-12900K has eight P-Cores with base and boost speeds of 3.2GHz and 5.2GHz, along with eight E-Cores that run at 2.4GHz and 3.9GHz. Only the P-Cores support Hyper-Threading, so this chip supports 24 threads rather than 32. Scan has paired the new CPU with new memory too – the 3XS includes 32GB of Corsair Dominator Platinum DDR5 memory that zips along at a rapid speed of 5200MHz.

Meanwhile, the Asus ROG Strix Z690-G Gaming WiFi motherboard handles its job ably. It has a monster total of four M.2 slots, all of which support 4x PCI-E 4, and the board has a USB 3.2 Gen 2x2 port at the rear and another on the board. Three USB 3.2 Gen 2 ports and four USB 3.2 Gen 1 connectors bolster the rear, and the excellent connection options continue with 2.5Gbps Ethernet and dual-band 802.11ax Wi-Fi.

The board's top 16x PCI-E slot for the graphics card also supports PCI-E 5, although no GPUs support this standard yet. The board has a new Realtek ALC4080 audio codec too, and you even get an on-board cable organiser.

The main star of the show in terms of gaming, though, is the Nvidia GeForce RTX 3080 Ti GPU, which has 12GB of memory and 10,240 stream processors, plus the EVGA card used here ups the original 1665MHz boost speed to 1725MHz. Storage comes from a 2TB PCI-E 4 Samsung 980 Pro SSD, which offers superb read and write speeds of 7,066MB/sec and 5,221MB/sec. It's all powered by a Corsair RM850x PSU, which has a modular design and 80 Plus Gold certification.

It's all housed in a Corsair 5000D Airflow chassis, which is big and robust, with a PSU shroud, dust filters, smart cable management and plenty of room to work with, along with a tempered glass side panel and meshed front. The front of the chassis houses the radiator for the hefty 360mm Corsair H150i all-in-one liquid cooler and its three RGB fans, and around the rear, there's room to add pairs of 2.5in and 3.5in drives, alongside a fan hub with spare connectors. As usual, Scan's cable tidying is the best around – the build is immaculate.

You get a decent warranty too, with a three year deal that covers both parts and labour, plus a year of on site service. That's generous, and Scan has also secured stock for 50 of these builds in order to avoid part shortages.

SPEC

CPU
Intel Core i9-12900K

Motherboard
Asus ROG Strix Z690-F Gaming WiFi

Memory
32GB Corsair Dominator Platinum 5200MHz DDR5

Graphics
EVGA GeForce RTX 3080 Ti 12GB

Storage
2TB Samsung 980 Pro M.2 SSD

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

Case
Corsair 5000D Airflow

Cooling
CPU: Corsair Hydro H150i Pro RGB with 3 x 120mm fans; GPU: 3 x 90mm fans; rear: 1 x 120mm fan

PSU
Corsair RM850x 850W

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

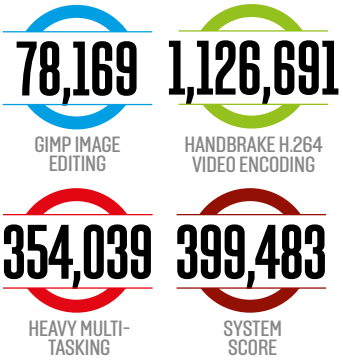
Operating system
Windows 11 Home 64-bit

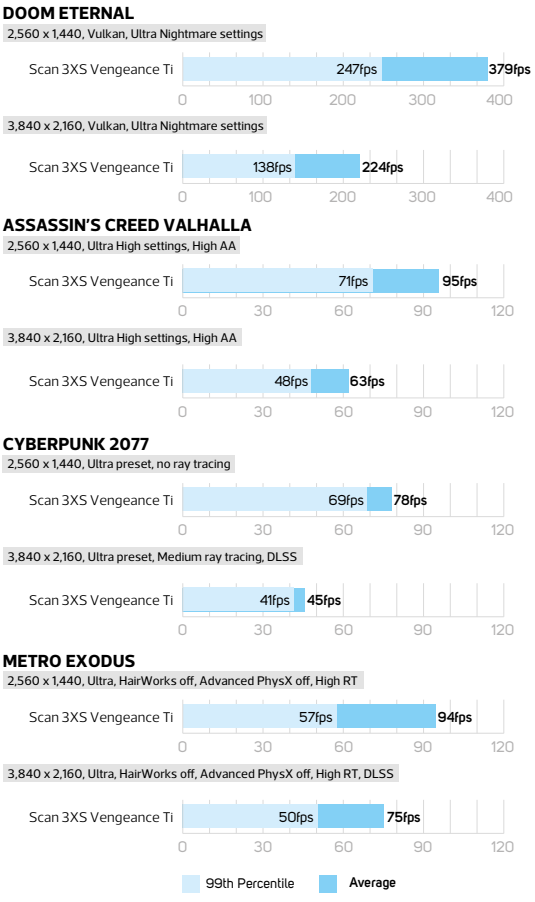
Warranty
Three years parts and labour. First year on site, then return to base

Performance

Intel's new processor is a beast. In Scan's machine, the Core i9 chip scored 78,169 in our image editing test and 1,126,691 in our heavily multi-threaded video encoding benchmark. Both results are a little bit behind the results from our

BENCHMARK RESULTS





review last month, but they both trounce any results from AMD CPUs, including the 16-core Ryzen 9 5950X.

The Scan's overall score of 399,483 is miles better than any AMD-based PC and more than 130,000 points ahead of systems based on the Core i9-11900K. The Intel chip couldn't quite overhaul AMD's CPUs in our heavy multi-tasking test, but that's the only minor issue and the Core i9-12900K was never far behind. This CPU will do practically any job, from high-end content creation to flawless streaming.

Intel's new processor combines with the overclocked RTX 3080 Ti to deliver stellar gaming performance. This

machine happily plays Assassin's Creed Valhalla and Metro Exodus at top settings at 4K, including High ray tracing in the latter if you enable DLSS. You ideally want a 99th percentile result of at least 45fps and an average of 60fps in these games, and the Scan does that fine.

The Scan couldn't quite pull of the same feat in Cyberpunk 2077 at 4K, but its 99th percentile of 41fps and average of 45fps with Medium ray tracing and DLSS isn't a terrible result either – some tweaking in the settings will make it playable at 4K. The Scan can handle games superbly at 2,560 x 1,440 as well, and its whopping average of 379fps in Doom Eternal at this resolution shows it can really deliver the goods when it comes to running less demanding games on monitors with high refresh rates.

The Scan does a good job in thermal tests too. It only ever emits modest fan noise, and the E-Cores hit their peak speed of 3.9GHz, while the P-Cores peaked at 4.9GHz and 5GHz in multi- and single-threaded tests respectively, which is barely behind the chip's theoretical pace. The CPU's delta T of 74°C in stress tests is a tad high, but it's not in danger territory either.

Conclusion

Intel's Core i9-12900K is the best choice available for both content creation and gaming, and Scan has paired it with tremendous components in a tidy and quiet build. The 3XS offers decent value too – it's barely pricier than machines that combine the RTX 3080 Ti with AMD Ryzen 9 chips. This CPU is overkill for gaming, of course, but if you want the best multi-threaded ability alongside lashings of gaming power, this is a superb PC.

MIKE JENNINGS

VERDICT

Incredible processing power paired with excellence in every other department.

AVENGERS

+ Fantastic processing power
+ High-end gaming ability
+ Great storage, PSU and motherboard
+ Tidy and quiet build

BLACK ORDER

– CPU is overkill for many
– It's still £3,499

PERFORMANCE **24/25**

DESIGN **23/25**

HARDWARE **24/25**

VALUE **22/25**

OVERALL SCORE **93%**

AMD B550 GAMING PC

CHILLBLAST FUSION PANTHER / £1,999 inc VAT

SUPPLIER chillblast.com

Chillblast's Fusion Panther is the first small form-factor system we've seen for a while, and Chillblast hasn't shied away from installing high-end kit in this modest box, despite its height of just 292mm height. For example, the Gigabyte RTX 3070 card inside this rig overclocks the GPU's original boost speed of 1725MHz to 1810MHz.

The other key component is the AMD Ryzen 5 5600X, which is now overshadowed by Intel's new i5-12600K, but its six SMT-enabled Zen 3 cores and boost speed of 4.6GHz are still perfectly fine for most people's needs.

The Panther has 16GB of dual-channel DDR4 memory clocked to 3200MHz, and storage comes from two solid state drives. A 500GB Samsung 980 Pro PCI-E 4 NVMe drive functions as the boot drive, and delivered great read and write speeds of 6,865MB/sec and 4,959MB/sec, while a 1TB Samsung 870 QVO 2.5in SATA secondary drive offers speeds of 565MB/sec and 537MB/sec, which still outpaces any hard disk.

It's powered by a mightily impressive SFX PSU – the Corsair SF750 is a small unit with fully modular design and 80 Plus Platinum certification. Chillblast's warranty remains one of the best around too, giving you a five year labour deal with two years of parts coverage.

You get a decent mini-ITX motherboard too. The Asus ROG Strix B550-I Gaming has dual-band 802.11ax Wi-Fi and 2.5Gbps Ethernet, along with two M.2 connectors – albeit only one with PCI-E 4 support. At the rear, you'll also find three USB 3.2 Gen 2 Type-A connectors and a Type-C port alongside a BIOS flashback button.

The board has SupremeFX S1220A audio as well, which sounds great. You lose the usual extras from going for mini-ITX, though, so you only get two (already populated) memory slots, and no PCI-E slots beyond the 16x GPU slot. The rear I/O panel only has three audio jacks as well.

The case itself is a Cooler Master MasterBox NR200P, which is a great choice. The external panels are robust, and the external panels pop free with tool-free mechanisms. The graphics card dominates the bottom half of the build, and above that you'll find a hefty Noctua CPU cooler with two 92mm fans.

The PSU is held in a cage, and behind the front panel, you'll find the 2.5in Samsung SSD and a fan hub. There are pairs of Noctua fans in the floor and roof as well, and Chillblast has kept the interior impressive tidy considering the small space. However, bear in mind that mini-ITX cases have inevitable restrictions. You have to remove loads of components to access the internals, and there's limited room for extra storage.

You'll also have to shell out £1,999 for the Panther, and that's relatively high when compared with conventional systems. You can buy ATX PCs from Chillblast, Scan and Ebuyer with the RTX 3070 and 5600X for prices between £1,549 and £1,900, and for £1,999, you can easily find PCs with the RTX 3070 Ti. If you want a small PC, you have to pay a bit extra for it.

Performance

The overclocked GeForce RTX 3070 zipped through all our game tests at 1,920 x 1,080, maintaining averages between 84fps and 95fps in three of our test games, and averaging a massive 335fps in Doom Eternal, showing great scope for running undemanding games on monitors with high refresh rates.

SPEC

CPU
3.7GHz AMD Ryzen 5 5600X

Motherboard
Asus ROG Strix B550-I Gaming

Memory
16GB Chillblast 3200MHz DDR4

Graphics
Gigabyte GeForce RTX 3070 8GB

Storage
500GB Samsung 980 Pro M.2 SSD, 1TB Samsung 870 QVO SSD

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

Case
Cooler Master MasterBox NR200P

Cooling
CPU: Noctua NH-U9S Chromax Black with 2 x 92mm fans; GPU: 3 x 80mm fans; floor: 2 x 120mm fans; roof: 2 x 120mm fans

PSU
Corsair SF750 750W

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

Operating system
Windows 10 Home 64-bit

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

BENCHMARK RESULTS

GIMP IMAGE EDITING

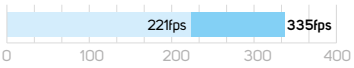
HANDBRAKE H.264 VIDEO ENCODING

HEAVY MULTI-TASKING

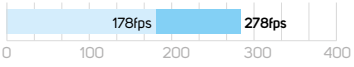
SYSTEM SCORE

DOOM ETERNAL

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

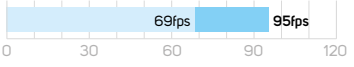


2,560 x 1,440, Vulkan, Ultra Nightmare settings

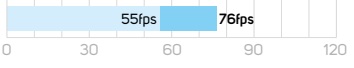


ASSASSIN'S CREED VALHALLA

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

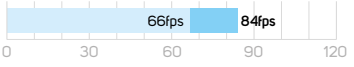


2,560 x 1,440, Ultra High settings, High AA

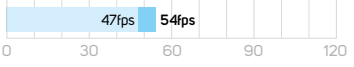


CYBERPUNK 2077

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

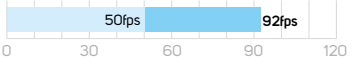


2,560 x 1,440, Ultra preset, no ray tracing

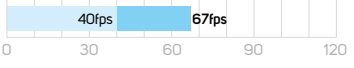


METRO EXODUS

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



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



It also coped well with gaming at 2,560 x 1,440, with a cracking average of 278fps in Doom Eternal and a superb average of 76fps with a 55fps 99th percentile result in Assassin's Creed Valhalla. Its 67fps average in Metro Exodus with High ray tracing is also a decent result. The only game that didn't hit our 60fps average target was Cyberpunk 2077 at Ultra settings, but its 54fps here is still a solid result, as is the 47fps 99th percentile – a little bit of tweaking in the graphics settings will easily see it go higher.

The Ryzen 5 5600X is still a good mid-range CPU as well, with enough pace to avoid gaming bottlenecks and the ability to tackle mainstream content-creation tasks and everyday streaming. That's great, but Intel's new Alder Lake-based i5-12600K is miles better in every metric – the Intel chip was more than 7,500 points quicker in the single-threaded image editing test, for instance, and 226,000 points faster in our heavily multi-threaded Handbrake benchmark.

The tiny Chillblast isn't the quietest PC either. No matter what you do on this rig, there's noticeable fan noise, and it's a little louder than most full-sized gaming systems. The processor is a little restricted too – its all-core turbo during a work benchmark sat at 4.2GHz, and this chip can hit 4.45GHz and beyond in ideal conditions. Happily, the noise levels don't increase if you push the components, and the CPU and GPU delta Ts of 46°C and 49°C respectively are absolutely fine.

You'll never be able to get near silence with this rig though. That's not a problem if you have beefy speakers or use a headset for gaming, but it's not ideal if you want a quiet machine for work as well.

Conclusion

Chillblast has done a great job with building this small, powerful PC – it's fast enough in games and applications, it's neat and compact, and its memory, storage, power supply and warranty all impress. If you want a small and powerful gaming system, it largely delivers the goods. However, it's also loud, Intel's latest processors are far faster and it's expensive for the spec on offer.

MIKE JENNINGS

VERDICT

A powerful small form factor gaming rig, although it's noisy and a bit pricey for the spec on offer.

WAKANDA

- \+ Impressive gaming power
- \+ Small, robust case
- \+ Excellent warranty
- \+ Good components throughout

VORMIR

- – Tricky case access
- – Loud operation
- – Intel's new CPUs are faster
- – Relatively expensive

PERFORMANCE **21/25**

DESIGN **20/25**

HARDWARE **20/25**

VALUE **19/25**

OVERALL SCORE **80%**

Taste testers: Antony Leather, Ben Hardwidge, Charlotte Milligan, Edward Chester, Mike Jennings, Phil Hartup and Rob Zwetsloot **Reviews:** Phil Hartup

CUSTOM PC

MINCE PIE MEGATEST

We apply our demanding testing principles to the latest festive pastry treats to find this year's top mince pie

ICELAND MINCE PIES / £1 for six

Iceland's effort is a happy little-star patterned pie with a sparkly sprinkling of sugar on top that mitigates the less than perfect construction. The sizeable quantity of the sugary sprinkles on top offsets fairly ordinary pastry and filling, with a noticeable but pleasant aftertaste. The whole thing lands squarely in the respectable bracket for quite nice pies to which you wouldn't say no, which is good enough, but there's nothing going on that really impressed the judges.

7/10

CO-OP IRRESISTIBLE ALL BUTTER / £2 for six

The vented star design on this pie seems superfluous as there are already vents around the edge. There's nothing wrong with the pastry itself – there just seems to be less of it than usual for a pie of this size.

However, the greater anomaly for this pie lies with the filling, which has a faintly crude artificial flavour – it tastes boosted, as though having more taste was the same as having better taste. The end result is a pie that is almost overbearing.

2/10

LIDL DELUXE ALL BUTTER / £1.49 for six

Lidl's top-end offering gives you a heftily sugar-dusted pie with a neatly crimped edge and a curious star-flake style pattern on the outside. The tasty buttery pastry is then quickly overwhelmed by the flavour of the potent filling, which delivers a punchy, almost boozy taste that lingers pleasantly for a while after eating.

Lidl's Deluxe offering is a substantial pie for the price, and it was tasty enough to leave the judges wanting more.

7/10

WAITROSE ALL BUTTER / £1.80 for six

A cleanly detailed snowflake with a sprinkle of sugar marks the lid of Waitrose's almost absurdly robust pie. This pie is a unit, built to take on all comers. The pastry is delicious and the filling is similarly on point, with a flavour strong enough to be enjoyable, while not hanging around on the palate so long you wonder if there's a problem. Plus the sheer size of the thing is impressive as hell. You could feed a family of four with one of these bad boys, and they'd eat well and thank you for it.

9/10

TESCO PLANT CHEF / £1.25 for six

Tesco's vegan-friendly Plant Chef effort is an extremely crumbly and powdery pie that struggles to hold together while being removed from its box, and it then melts in the mouth like wet cement in the rain.

It's not a strong combination from this perspective, although it's saved by not tasting as bad as you might expect after the first bite. It's not the only vegan option on this year's mince pie megatest but it's definitely the least appetising one.

3/10

ASDA MINCE PIES / £0.87 for six

The standard Asda pie has a lumpy pastry casing, with a star pattern and a little sugar that tries but fails to make the tedious pastry more exciting. It feels like there's so much pastry here. The pie becomes an effort to ingest, because the inordinate amounts of pastry crumble into stodge while you're eating it. When you do finally get to the filling among all the seemingly endless pastry, it feels like it wasn't worth the trip. It's just a mince pie filling, after all – it can't fix everything.

5/10

TESCO BUTTER ENRICHED / £0.87 for six

The lids don't quite cover the centres of these slightly clumsy-looking pies, looking less like a true lid and more like a plug. A little sugar on top adds some rudimentary appeal to the flavour, and frankly it needs all the help it can get. The pastry is very bland, with only a slight hint of the buttery taste you'd expect from a 'butter enriched' pie. The texture of the filling has also been smoothed down to the point of goo, and it offers little flavour. It's more sloppy than unpleasant, but still not one to recommend.

3/10

M&S CLASSIC ALL BUTTER / £1.80 for six

The M&S Classic All Butter pie dares to buck the design trend of stars and snowflakes, instead sporting holly leaves and a star-shaped hole on its lid, and as usual, we're all far too classy to make any comment about the appearance of the latter. There's a generous sprinkle of sugar on top, which complements the already good crumbly pastry. While the exterior is sound, what's inside is even better, with a vibrant filling that's spicy, chunky, sweet and sticky in all the right amounts.

8/10

ASDA EXTRA SPECIAL / £1.75 for six

A lumpen star and snowflake adorn this pie, which isn't deft presentation but it's solid enough, with a light sugar dusting to sweeten it up. What the construction lacks in finesse it makes up for in sturdiness, in a good way, and the pastry is tasty. There's plenty of chunky filling too, which doesn't try to do anything clever with the taste but hits all the marks. It would mark a victory for substance over style, but as the style for all these products is 'mince pie', it will have to settle for being tasty.

7/10

MR KIPLING DEEP FILLED / £1.50 for six

Trust us, we're as surprised as you. After years of churning out mediocre pies, Mr Kipling has changed its recipe and stormed it here. The concentric stars and snowflake pattern can look a little untidy depending on how the pastry settles, but the solid golden pastry is well cooked. This tasty pastry casing is also packed with a very pleasant filling – it's rather spicy but in a good way, making for a very substantial and agreeable pie. Tasty pastry, plenty of good filling – Mr Kipling makes it look easy.

9/10

GREGGS SWEET MINCE PIES / £1.50 for six

A big, wide and shallow pie without a fancy lid design, the Greggs pie is almost sticky and delivers on the 'sweet' promise. There's a lot of pastry for not so much filling, but that's not a huge problem here, as the pastry is very nice, and softer than usual too.

The Greggs pie is also vegan-friendly, but manages to accomplish this without feeling overly compromised. It's an unusual pie in many respects, but the overly sweet filling couldn't win over everyone on the judging panel.

5/10

SAINSBURY'S TASTE THE DIFFERENCE / £2 for six

This large, starry snowflake pie is solidly put together and surprisingly crisp, so the pastry and shape holds up really well even after a bite. This is a solid plus point for anybody who doesn't eat their pies in one go like a sea lion. The apparently superior tensile strength of the pastry doesn't compromise the flavour either. There's a subtle but unmissable boozy undertone to the filling that gives a warm and rich taste that places it comfortably among the better options.

7/10

MORRISONS MINCE PIES / £0.99 for six

There is usually one pie a year that comes along and, rather than falling at the first hurdle, hits the first hurdle, collects it, picks up the other hurdles and continues to rolls along the track like a baked tribute to Katamari Damacy. This is that pie. There's a slightly wonky snowflake motif on this smallish-sized contender, but it's not just the presentation that's lacking here. The pastry is bland, the filling is so insubstantial as to be almost a paste and the taste is a total non-event.

1/10

MARKS AND SPENCER COLLECTION / £2.50 for six

This M&S pie's interpretation of the common snowflake and star design looks a little bit like a star with moth antennas, but that's still festive in its own way. The pie has a little bit of wonkiness about the construction and the pastry, though, and while it's quite tasty, it's also rather prone to immediate disintegration. The flavour is also good, but it doesn't leap out at you, instead staying at a respectable distance. Ultimately, this leads to a pie that's good but perfectly ordinary.

6/10

ALDI HOLLY LANE DEEP FILLED / £0.79 for six

There are three stars on top of this remarkably well-assembled pie, with a light sugar coating that makes a good first impression. There is a quite light citrussy flavour to the filling, which isn't at all unpleasant but debatably isn't entirely in the spirit of a mince pie either.

Although the choice of direction for the flavour is curious, it's definitely not bad even if it's not expected. It's not weird enough to be compelling, but not normal enough to fit in. We see you, pie.

6/10

Custom kit

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

NANOLEAF LINES / £179.99 inc VAT

SUPPLIER nanoleaf.me

The idea of an understated set of wall-mounted room RGB lights might seem like a contradiction in terms, yet here we are with the Nanoleaf Lines. It's a modular lighting set that gives you nine light bars and nine hexagonal hub pieces that serve as attachments (and in one case, the controls).

Unusually, the lights don't face outwards into the room; instead, they project light onto the wall on which they're installed. This creates a much softer effect than having the lights facing outwards, and although the lights are bright and colourful, this muting effect tones them down.

Assembly is very easy. The lines slot into the hub pieces, a cover piece goes on top to hold them in place and the hexagons attach to the wall with double-sided tape.

When installed, they use either 2.4GHz Wi-Fi to connect to their app or you can install a set of buttons onto one of the hexagonal hubs to control them in a limited manner. One of these hexagonal hubs also connects to the power with a mains plug.

The Nanoleaf software works with a range of devices and systems, from Alexa and SmartThings to Google Assistant and HomeKit. It can also work with Razer Chroma if you want to really tie your computer room together with a colour scheme that's more impressive than a rug. The display options include screen mirroring, so the lines display the same colours as a screen, to give the room a complementary ambience, and there's also a music visualiser mode. The Nanoleaf Lines add pleasant, low-key ambience to a painted wall without overpowering the room.

More ●●●●○ **Less**

MARSHALL MOTIF ANC / £179.99 inc VAT for 2TB

SUPPLIER marshallheadphones.com

The Marshall Motif ANC is a pair of earbuds from a company whose name more traditionally appears on big hefty guitar amps. It's fair to say that the journey from amps to noise-cancelling earbuds was very much worth it though. They're small, even for earbuds, with only a tiny metal protrusion visible when they're worn.

However, in spite of their small size, they provide a rock-solid connection thanks to their Bluetooth 5.2 support with up to a 10m reach. The battery is good for 4.5 hours of play time with active noise cancelling, and six hours without it. This isn't a huge amount of time, but the case acts as a recharging port and can get you another 20 hours. The case can be recharged wirelessly on a charging plate or using a USB Type-C connector.

Sound quality is extremely good, being powerful where necessary without becoming noisy or indistinct at higher volumes. The active noise cancelling is also very effective, and there's a 'transparency' mode, which can be activated by a single button on one earbud and allows a user-defined amount of background noise through to your ears.

The amount of sound transparency you set, as well as controls and other settings, are handled by a simple phone app. There's a simplicity to this setup, but it's also very high quality, which is great way for a pair of earbuds.

Small ●●●●● **Perfectly formed**

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

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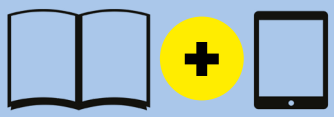

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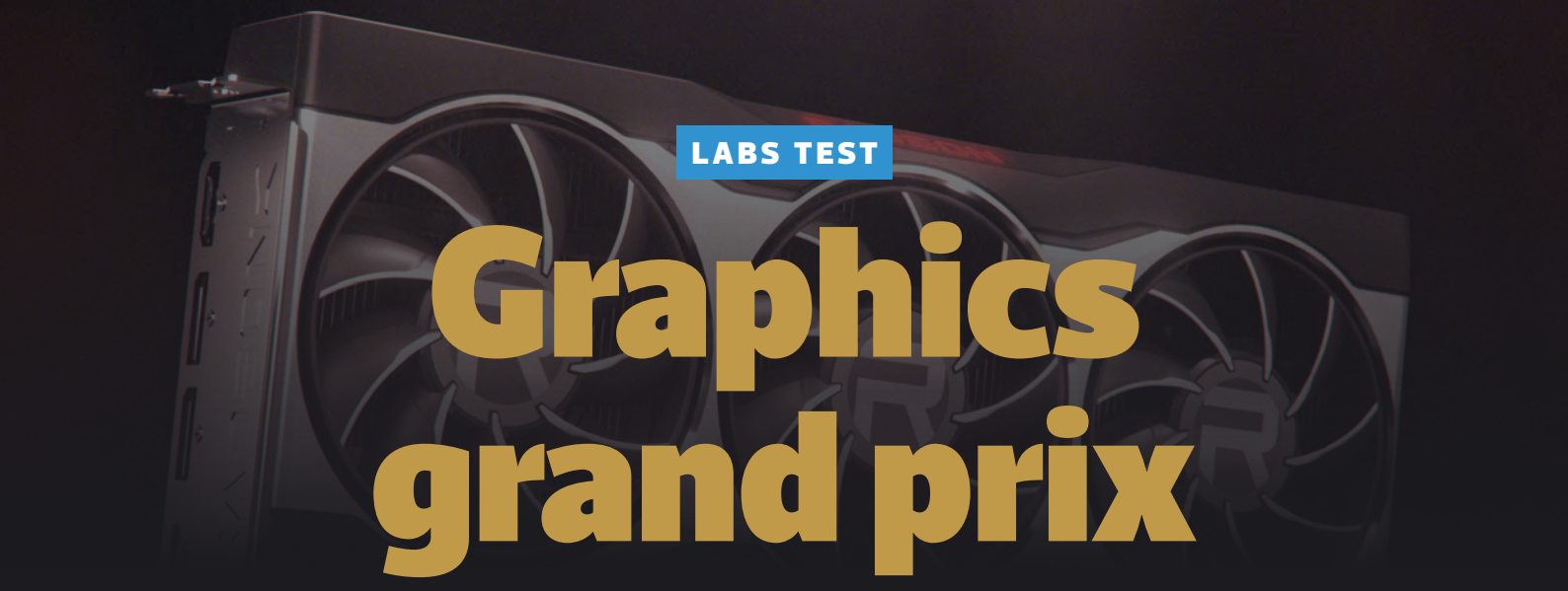


LABS TEST

Graphics grand prix

If you're lucky enough to have over a grand to spend on a new GPU, which one should you buy? **Ben Hardwidge** checks out the five top options at realistic retail prices

How we test

After giving our verdict on the sub-£1,000 GPU market last month, this month's first Labs test is dedicated to the cream of the crop – the top-end, 4K-capable GPUs that already cost a veritable arm and a leg when they were released, but now threaten to leave you with just your head and torso intact.

If you're willing to spend the cash necessary to get a top-end GPU, though, which one should you buy? Nvidia's low hash rate cards have lowered demand (a bit) over the past few months, while the price of AMD's RDNA2 cards has steadily increased. Where does that leave us now?

In order to make sense of the situation, we've tested five £1,000+ GPUs listed at the cheapest prices we could find them at UK retailers, and tested them in a number of games. As with last month's test, none of them is an award winner at these prices, but our testing and analysis will show you which cards are worth buying if you can afford them, and which ones to look for if you're buying a new system.

Cyberpunk 2077 is a high-profile and challenging game for even the latest GPUs. We run our own custom benchmark, which incorporates a 60-second drive around Night City recorded with FrameView. We run it at the Ultra preset with no ray tracing, and with the Medium Ray Tracing preset. You ideally want a 99th percentile result above 45fps with an average above 60fps.

Our second new test is the epically awesome Assassin's Creed Valhalla. We run the built-in benchmark at the Ultra High preset with resolution scaling at 100 per cent, recording the results with FrameView. Again, a 99th percentile result above 45fps and an average over 60fps will do the job.

Meanwhile, Doom Eternal is an undemanding game that scales superbly with more GPU power, making it great for monitors with a very high refresh rate. Again, we record the frame rate with FrameView. Finally, we run Metro Exodus with and without ray tracing, with the latter set to High.

All tests are conducted on an AMD Ryzen 9 5900X test rig with 16GB of Corsair Vengeance RGB Pro SL 3600MHz DDR4 memory, an Asus ROG Strix B550-E Gaming motherboard and Windows 10 Professional 64-bit.

Finally, we measure the total system power consumption of the whole test rig at the mains, while the GPU goes through three runs of our Metro Exodus ray-tracing benchmark at 2,560 x 1,440. We record the peak power draw of the whole system.

Contents

- AMD Radeon RX 6800 XT / p45
- Nvidia GeForce RTX 3080 / p46
- AMD Radeon RX 6900 XT / p47
- Nvidia GeForce RTX 3080 Ti / p48
- Nvidia GeForce RTX 3090 / p49
- Results graphs / p50

AMD RADEON RX 6800 XT

/ £1,070 inc VAT

SUPPLIER overclockers.co.uk

It seems weird the Radeon RX 6800 XT cost £680 inc VAT when it launched this time last year. At the time, even that price seemed too expensive when it couldn't outperform the similarly priced GeForce RTX 3080, but the price has now climbed stratospherically to well over a grand.

It's based on AMD's top-end Navi 21 GPU, with 72 compute units enabled, giving it 72 Ray Accelerators for ray tracing and a total of 4,608 stream processors. Like the Radeon RX 6900 XT, it also has 16GB of GDDR6 memory attached to a 256-bit wide memory interface.

With a 2GHz (16GHz effective) memory clock, that gives it a total memory bandwidth of 512GB/sec. That's a long way behind the 760GB/sec of the RTX 3080 with its GDDR6X memory and 320-bit wide interface, but AMD has also equipped the Radeon RX 6800 XT with a massive 128MB of Infinity Cache to help close the gap, and it has 6GB more memory than the RTX 3080.

The Radeon RX 6800 XT clearly has an awesome amount of shader power at its disposal. Its best showcase is Assassin's Creed Valhalla, where it even beats the GeForce RTX 3090 at 1,920 x 1,080 and 2,560 x 1,440, and stays ahead of the RTX 3080 at 4K. If you enable Resizable BAR, it even beats the RTX 3080 Ti at 4K, while exceeding our ideal frame rate target in this game.

The Radeon also stayed in front of the GeForce RTX 3080 in Doom Eternal at the lower two resolutions, clocking up an average of 449fps at 1,920 x 1,080. It couldn't quite beat it at 4K, but the difference was small. Performance in Metro Exodus was also strong, where the 6800 XT again stayed ahead of the RTX 3080 at 1,920 x 1,080 and 2,560 x 1,440, although there's not much between them at 4K.

Where the Radeon 6800 XT's performance started to disappoint was when we enabled ray tracing. It couldn't even hit a decent frame rate at 1,920 x 1,080 with Medium ray tracing in Cyberpunk 2077, let alone higher resolutions, while the RTX 3080 averaged 68fps at these settings, and was also smoothly playable at 2,560 x 1,440 with DLSS enabled.

AMD has a resolution-scaling feature in the form of FidelityFX Super Resolution, but its GPUs don't have any dedicated matrix processors (like Nvidia's Tensor cores), so it works quite differently, with inferior image quality, and it's not supported in any of our test games at the moment anyway.

The Radeon RX 6800 XT fared better in Metro Exodus with ray tracing, achieving a playable result at 2,560 x 1,440, which is a decent achievement. Again, though, the RTX 3080 is faster still, and you have the option to enable DLSS to squeeze out more performance.

Conclusion

If you don't care about ray tracing, and your priority is fast frame rates, the Radeon RX 6800 XT is a solid GPU. It becomes a bit less competitive at 4K, but it beats the GeForce RTX 3080 in non-ray-traced games at 2,560 x 1,440 and 1,920 x 1,080. However, the fact that it can't play a game such as Cyberpunk 2077 with ray tracing even at 1080p is a serious shortfall at this price, and the lack of a hardware-accelerated resolution scaling option hurts it too. It might have 16GB of memory, but the 10GB GeForce RTX 3080 still offers a better overall balance of performance.

SPEC

Graphics processor AMD Radeon RX 6800 XT, 2015MHz game clock, 2250MHz max boost clock

Pipeline 4,608 stream processors, 128 ROPS

Ray Accelerators 72

Memory 16GB GDDR6, 2GHz (16GHz effective)

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 512GB/sec

Power connections 2 x 8-pin

THE MATRIX

+ Superb shader performance
+ 16GB of memory
+ Cheaper than Nvidia competition

THE MATRIX REVOLUTIONS

- Massive price increase
- Poor ray-tracing performance
- Starts to struggle at 4K

VERDICT

Great shader performance and plenty of memory, but a huge price hike and a lack of ray-tracing performance make it hard to recommend.

PERFORMANCE 42/50 | FEATURES 16/20 | VALUE 7/30

OVERALL SCORE 65%

NVIDIA GEFORCE RTX 3080 / £1,184 inc VAT

SUPPLIER cclonline.com

Currently topping the 'hardest GPU to find in stock' charts is Nvidia's GeForce RTX 3080. We eventually found one at **cclonline.com** going for £1,184, but that demonstrates an extreme hike in price. The Founders Edition originally cost £649 when it launched – that's a price increase of £535.

When we last compared this GPU with the Radeon RX 6800 XT, back in Issue 211, it was a clear winner, offering a better balance of performance for a similar price. Now that it's so expensive, the gap has closed a little, but the RTX 3080 is still (just) the better all-round option.

It's based on the same GA102 Ampere GPU as the top-end RTX 3090, but it only has 68 Streaming Multiprocessors enabled, giving it 8,704 stream processors, 272 3rd-gen Tensor cores and 68 2nd-gen RT cores for ray tracing.

It also comes with fast GDDR6X memory running at an effective speed of 19GHz and attached to a 320-bit wide memory interface, giving it a total memory bandwidth of 760GB/sec.

TENSOR

- \+ Good balance of performance
- \+ Decent ray-tracing pace
- \+ DLSS support

TENSER

- – Starts to struggle at 4K
- – Only 10GB of memory
- – Massively overpriced
- – Hard to find in stock

SPEC

Graphics processor Nvidia GeForce RTX 3080, 1440MHz base clock, 1710MHz boost clock

Pipeline 8,704 stream processors, 96 ROPS

RT cores 68 (2nd-gen)

Tensor cores 272 (3rd-gen)

Memory 10GB GDDR6X, 1188MHz (19GHz effective)

Memory interface 320-bit

Card interface 16x PCI-E 4

Power connections 1x 12-pin / 2x 8-pin

The result is a GPU that's adept at both rasterisation and ray-tracing tasks, with its Tensor cores enabling a decent improvement in performance with the latter thanks to Nvidia's AI-based DLSS resolution-scaling tech.

In terms of rasterisation, the Radeon RX 6800 XT largely has the edge, particularly in Assassin's Creed Valhalla, where it was well in front of the GeForce. The difference is substantial in this game at 1,920 x 1,080 and 2,560 x 1,440, but it's also significant at 4K, where the RTX 3080's 99th percentile result of 39fps is disappointing.

In our other games tests, the Radeon was generally ahead in non-ray-traced games, although the RTX 3080 still always managed playable results at 2,560 x 1,440, and the differences are small at 4K – the RTX 3080 even pulls ahead in Doom Eternal at 4K, despite only having 10GB of memory compared to 16GB on the Radeon.

If you don't care about ray tracing then the Radeon RX 6800 XT is the better buy, but if you're paying over a grand for a GPU, we think you should be able to turn on the eye candy too, and this is where the GeForce RTX 3080 pulls ahead. Its average was a good 13fps higher than that of the Radeon RX 6800 XT in Metro Exodus with High ray tracing at 2,560 x 1,440, and it was a massive 27fps higher in Cyberpunk 2077 with Medium ray tracing at 1,920 x 1,080.

If you enable DLSS, the RTX 3080 will also happily play this game with Medium ray tracing at 2,560 x 1,440, maintaining a solid 63fps 99th percentile result and 80fps average. If there's one disappointment with the RTX 3080, it's that it can't quite cope with 4K gaming in some tests. It couldn't hit our 4K frame rate target in Metro Exodus or Assassin's Creed Valhalla, and it couldn't really handle Cyberpunk 2077 with Medium ray tracing and DLSS enabled either.

Conclusion

At its current price and miniscule stock level, it's hard to recommend the RTX 3080. It does offer a better balance of rasterisation and ray-tracing performance than the cheaper Radeon RX 6800 XT, but the latter has faster raw shader performance, and the RTX 3080 really struggles to justify its current price when it can't quite handle 4K gaming. If you're committed to paying so much money for a GPU, you're going to be disappointed by the RTX 3080 – it would be better to stump up for the RTX 3080 Ti instead.

VERDICT

A better performance balance than the Radeon RX 6800 XT, but it starts to struggle at 4K and can't justify its current price.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
44/50	17/20	5/30	66%

AMD RADEON RX 6900 XT / £1,350 inc VAT

SUPPLIER overclockers.co.uk

As we climb into next tier of graphics performance, you start to get slightly better value. That might sound like a bit of a laugh when we're discussing a £1,350 graphics card, but the Radeon RX 6900 XT launched with a £999 price anyway, and was already going for £1,200 in our Issue 211 Labs test. Proportionally, its price hasn't increased as far as the GPUs immediately below it.

There isn't an enormous difference between the Radeon RX 6900 XT and the 6800 XT. Both cards have 16GB of 2GHz (16GHz effective) GDDR6 memory attached to a 256-bit wide memory interface, giving you a total memory bandwidth of 512GB/sec, along with 128MB of AMD's Infinity Cache.

Both cards also use the same GA102 GPU clocked at the same frequency, it's just that the Radeon RX 6900 XT GPU has 80 of its compute units enabled, compared to 72 on the 6800 XT. That gives it eight more Ray Accelerators, along with 512 more stream processors for a total of 5,120.

The result is a GPU that offers a chunk more parallel processing power, but doesn't push up the power consumption. Indeed, there was a difference of just 2W between the two cards in our test system, with the 6900 XT drawing over 50W less than the GeForce RTX 3080 Ti at full load. The Radeon RX 6900 XT has slightly higher cooling requirements than the 6800 XT, though, with the AMD reference card having a wider heatsink design.

As with the Radeon RX 6800 XT, the 6900 XT is a monster in Assassin's Creed Valhalla. It was the only card to hit our frame rate target at 4K this month at standard settings, and if you enable Resizable BAR, it averages 67fps with a 51fps 99th percentile result. Thanks to its formidable raw shader power, it also coped well with Doom Eternal, outperforming the RTX 3080 Ti at 1,920 x 1,080 and 2,560 x 1,440.

Unlike the RTX 3080 and Radeon RX 6800 XT, the 6900 XT also hit our frame rate target in Metro Exodus at 4K, and it outperformed the former in Cyberpunk 2077 at Ultra settings at 2,560 x 1,440, with a great average of 79fps.

As with other RDNA2 GPUs, though, ray tracing is the Radeon RX 6900 XT's problem, despite having 80 Ray Accelerators. It couldn't even play Cyberpunk 2077 with Medium ray tracing at 1,920 x 1,080, and it lacks a hardware-based AI resolution scaling system such as DLSS. It performed better in Metro Exodus, with a decent 48fps 99th percentile and 73fps average at 2,560 x 1,440 with High ray tracing, but the RTX 3080 Ti was 18fps faster, plus it lets you even step up to 4K in this game if you enable DLSS.

SPEC

Graphics processor AMD Radeon RX 6900 XT, 2015MHz game clock, 2250MHz max boost clock

Pipeline 5,120 stream processors, 128 ROPS

Ray Accelerators 80

Memory 16GB GDDR6, 2GHz (16GHz effective)

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 512GB/sec

Power connections 2 x 8-pin

VALHALLA

+ Top-notch Valhalla performance
+ Decent 4K performance
+ Good power efficiency

HELHEIM

- Poor ray-tracing performance
- RTX 3080 Ti generally quicker at 4K
- It's still expensive

Conclusion

In the current market, the Radeon RX 6900 XT is now surprisingly competitive. Its ray-tracing performance can't match Nvidia's latest RTX GPUs, and it lacks DLSS, but it does have some awesome shader power. If you love Assassin's Creed Valhalla, this card will play it smoothly with all the settings maxed out at 4K.

The Radeon RX 6900 XT's main problem is that Nvidia's GeForce RTX 3080 Ti also hasn't had the same sort of price bump as other GPUs, and is generally quicker at 4K and has much better ray-tracing abilities. If you really don't care about ray tracing, this is a fast gaming card, but the RTX 3080 Ti offers a better balance for an extra £140.

VERDICT

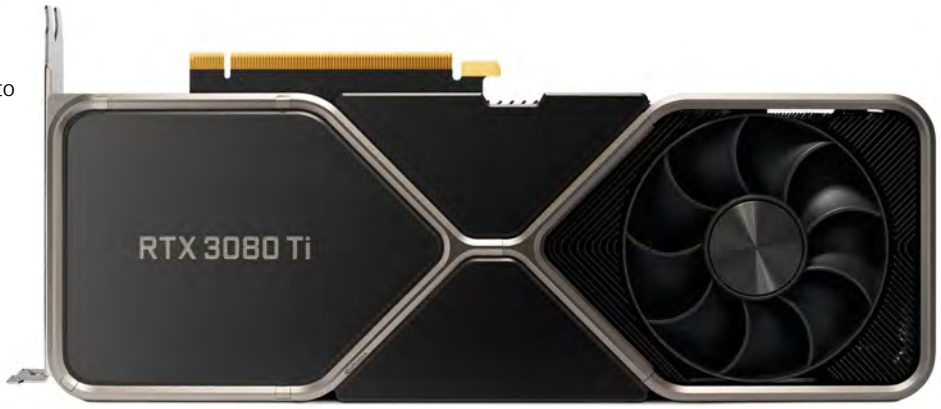
A decent 4K gaming GPU with a lot of rasterisation power, but it's worth spending the extra money on the RTX 3080 Ti.

PERFORMANCE 45/50 | FEATURES 16/20 | VALUE 6/30

OVERALL SCORE 67%

NVIDIA GEFORCE RTX 3080 Ti / **£1,490** inc VAT

SUPPLIER scan.co.uk



While the RTX 3080 is often harder to find than rocking horse teeth, and other mixed metaphors, the RTX 3080 Ti regularly turns up in stock. When it launched the 3080 Ti got off to a bad start with a £1,099 launch price, but thanks to Nvidia's low hash rate technology, and a steady stream of stock, its price has 'only' gone up by around 50 per cent rather than nearly doubling.

At the time of writing we found an EVGA on **scan.co.uk** for £1,490, but this retailer occasionally has the Founders Editions in stock at the launch price, so it's worth keeping an eye on the website. The RTX 3080 Ti's core spec isn't far off that of the RTX 3090 either, which looks like a good deal when the latter costs well over two grand.

The RTX 3080 Ti enables 80 streaming multiprocessors (SMs) on its GA102 GPU, giving you 80 corresponding RT processors, 320 Tensor cores and 10,240 stream processors. That's loads more than the 8,704 stream processors on the RTX 3080, and not far off the 10,496 in the RTX 3090. The RTX 3090's 1695MHz boost clock is slightly higher than the RTX 3080 Ti's 1665MHz, but there's not much in it.

Like the RTX 3090, it also has a wide 384-bit memory interface, giving it a total bandwidth of 912GB/sec with its 1188MHz (19GHz effective) GDDR6 memory. It only has 12GB of memory, compared to 24GB on the RTX 3090, but this doesn't appear to hold it back – at 4K, the RTX 3080 Ti largely pulls ahead of the Radeon RX 6900 XT, which has 16GB of GDDR6 memory at its disposal.

With such a similar spec to the RTX 3090, the RTX 3080 Ti isn't far behind it in most tests. The performance of the two GPUs was identical in Assassin's Creed Valhalla at 4K, and while the RTX 3080 Ti couldn't beat the Radeon RX 6900 XT in this test, it still hit our frame rate target, and enabling Resizable BAR will gain you an extra couple of frames per second too.

It's at 4K where the RTX 3080 Ti really shines, outperforming the Radeon RX 6900 XT in Doom Eternal and Metro Exodus, and, significantly, even enabling you to switch on ray tracing if you enable DLSS.

The RTX 3080 Ti hit our frame rate target in Metro Exodus with High ray tracing and DLSS at 4K, and it wasn't far off hitting it in Cyberpunk 2077 with Medium ray tracing and DLSS either. Its 99th percentile result of 44fps is pretty solid, and its average of 52fps is only 3fps behind the RTX 3090. Drop a few settings here and there, and it will be smoothly playable.

If you run your games at 2,560 x 1,440 you're also in for a treat with this card – it averaged a massive 88fps in Cyberpunk 2077 with Medium ray tracing and DLSS at this resolution, only 1fps off the pace of the RTX 3090.

SPEC

Graphics processor Nvidia GeForce RTX 3080 Ti, 1365MHz base clock, 1665MHz boost clock

Pipeline 10,240 stream processors, 112 ROPS

RT cores 80 (2nd-gen)

Tensor cores 320 (3rd-gen)

Memory 12GB GDDR6X, 1188MHz (19GHz effective)

Memory interface 384-bit

Card interface 16x PCI-E 4

Memory bandwidth 912GB/sec

Power connections 1x 12-pin / 2x 8-pin

INFLATED BALLOON

+ Superb ray-tracing performance
+ Decent 4K frame rates
+ Less inflated price than some GPUs

INFLATED EGO

– Beaten by Radeon RX 6900 XT in Valhalla
– Still very expensive

Conclusion

The GeForce RTX 3080 Ti is hardly a bargain, with a price of nearly £1,500, but it's the only card on test that nails every area of gaming, from rasterisation to ray tracing, without demanding the silly price of the RTX 3090. If you're paying over a grand for a graphics card, you want a card that can do it all, and that's currently the RTX 3080 Ti if you can afford it.

VERDICT

The only top-end GPU really worth buying at current prices. The RTX 3080 Ti nails the balance of performance with its comparatively less inflated price.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
47/50	18/20	6/30	71%

NVIDIA GEFORCE RTX 3090 / £2,150 inc VAT

SUPPLIER scan.co.uk

Nvidia's GeForce RTX 3090 was already hugely overpriced when it launched for £1,399, but the prices for RTX 3090 cards are now so over the top that it's perfectly acceptable to point and laugh at them. The cheapest card we could find was going for £2,150 – that's £660 more than the RTX 3080 Ti, and it really doesn't get you £660 worth of extra performance.

In fact, that £660 (which could buy you an Alder Lake Core i7 CPU and a Z690 motherboard), only buys you two extra streaming multiprocessors over the RTX 3080 Ti. That translates to 256 more stream processors and two more RT cores for ray tracing. It really isn't worth it.

There are other factors bumping up the cost, of course. The RTX 3090 comes with a whopping 24GB of GDDR6X memory clocked at 1219MHz (19.5GHz effective). However, our tests show that 12GB is fine for most people's gaming needs at the moment, even at 4K, and the RTX 3080 Ti's memory bandwidth is only slightly behind. The RTX 3090 is also the only current GPU that supports dual-GPU tech, meaning you can pair two of them together to improve performance. However, given the current lack of game support for SLI, we wouldn't recommend it.

Other than the price, another downside to cramming so much hardware onto one PCB is that the RTX 3090 has hefty cooling and power requirements. You'll need to measure up your case first if you want to install the monster Founders Edition card, and our system drew a massive 679W from the mains with the RTX 3090 running at full load – 153W more than with the RTX 3080 Ti.

But if you have money to burn, is it actually the fastest gaming GPU at the moment? The answer is largely 'yes'. The RTX 3090 was beaten by the Radeon RX 6900 XT in Assassin's Creed Valhalla at 4K, and even by the Radeon RX 6800 XT at 2,560 x 1,440, but it otherwise leads the performance charts.

However, while it is indeed a little faster than the RTX 3080 Ti, it still doesn't have enough power to make a meaningful difference to performance. It still can't hit a 60fps average in Cyberpunk 2077 at 4K with Medium ray tracing and DLSS, for example, nor can it get a 99th percentile result above 40fps in this game without DLSS.

We could almost forgive a GPU costing this amount of money if it actually offered a substantial bump in performance over the RTX 3080 Ti, but the difference is miniscule for the extra cash involved. Arguably, the GeForce RTX 3090 is more useful for compute tasks than gaming, but it's worth pointing out that it's not worth paying the extra money for the latter. The lack of a low hash rate (LHR) version means the price is likely to stay high as well.

Conclusion

Unless you've recently slain a dragon and shipped all its gold back to your house, the GeForce RTX 3090 is a GPU to avoid. Yes, it's fast and has loads of memory, but the RTX 3080 Ti costs much less money and is almost as fast in real game tests. You don't need 24GB of memory for today's games, even at 4K, and the RTX 3090 draws a lot of power as well. If you want a 4K gaming GPU, save yourself some money and buy the GeForce RTX 3080 Ti instead. CPC

REASSURINGLY EXPENSIVE

+ Very fast
+ Loads of memory

EXTORTIONATE

– Price bears no relation to reality
– Outperformed by much cheaper GPUs in some tests
– High power draw

SPEC

Graphics processor Nvidia GeForce RTX 3090, 1395Hz base clock, 1695MHz boost clock

Pipeline 10,496 CUDA cores, 96 ROPS

RT cores 82 (2nd-gen)

Tensor cores 328 (3rd-gen)

Memory 24GB GDDR6X, 1219MHz (19.5GHz effective)

Memory interface 384-bit

Card interface 16x PCI-E 4

Memory bandwidth 936GB/sec

Power connections 1 x 12-pin / 2 x 8-pin

VERDICT

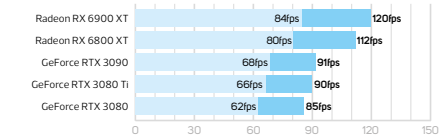
It might be the fastest GPU of the moment, but it's so expensive that it can't be recommended over the RTX 3080 Ti.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
48/50	20/20	1/30	69%

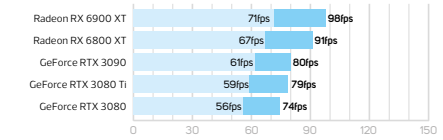
GRAPHICS CARD BENCHMARK RESULTS

ASSASSIN'S CREED VALHALLA

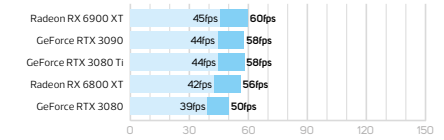
1,920 x 1,080
Ultra high settings, High AA



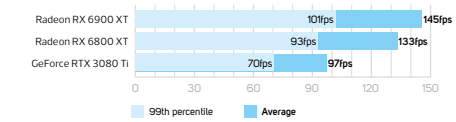
2,560 x 1,440
Ultra high settings, High AA



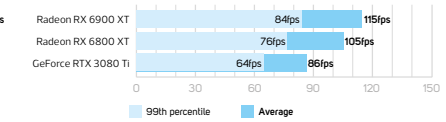
3,840 x 2,160
Ultra high settings, High AA



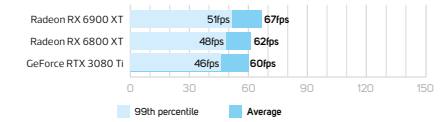
1,920 x 1,080 - RESIZABLE BAR
Ultra high settings, High AA



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

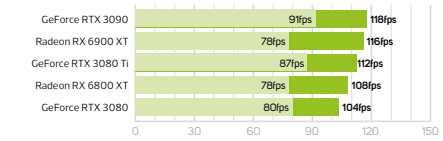


3,840 x 2,160 - RESIZABLE BAR
Ultra high settings, High AA

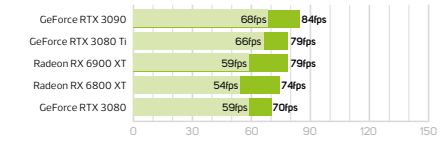


CYBERPUNK 2077

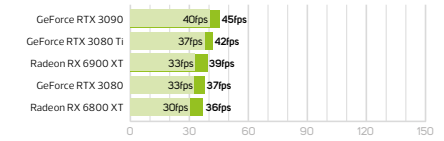
1,920 x 1,080
Ultra preset, no ray tracing



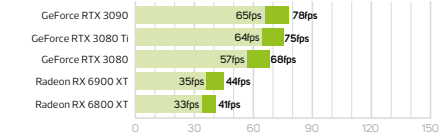
2,560 x 1,440
Ultra preset, no ray tracing



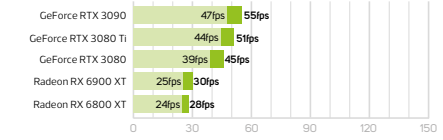
3,840 x 2,160
Ultra preset, no ray tracing



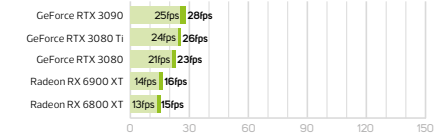
1,920 x 1,080 - RAY TRACING
Medium ray tracing preset, DLSS disabled



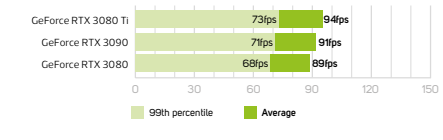
2,560 x 1,440 - RAY TRACING
Medium ray tracing preset, DLSS disabled



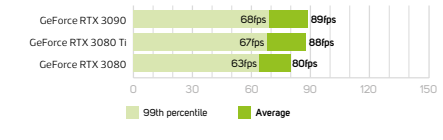
3,840 x 2,160 - RAY TRACING
Medium ray tracing preset, DLSS disabled



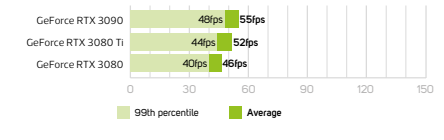
1,920 x 1,080 - RAY TRACING + DLSS
Medium ray tracing preset, DLSS Balanced



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

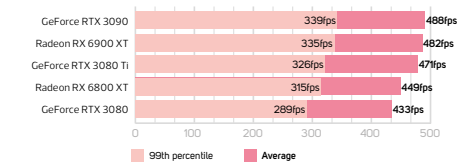


3,840 x 2,160 - RAY TRACING + DLSS
Medium ray tracing preset, DLSS Balanced

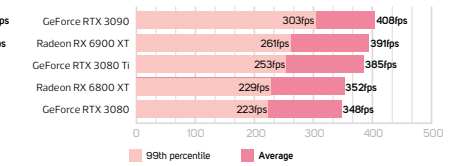


DOOM ETERNAL

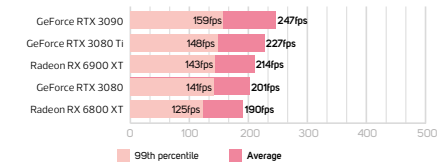
1,920 x 1,080
Ultra Nightmare settings



2,560 x 1,440
Ultra Nightmare settings



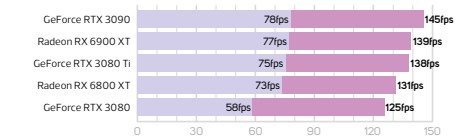
3,840 x 2,160
Ultra Nightmare settings



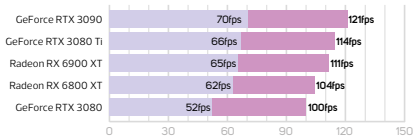
GRAPHICS CARD BENCHMARK RESULTS

METRO EXODUS

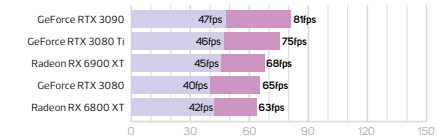
1,920 x 1,080
Ultra settings, HairWorks off, PhysX off



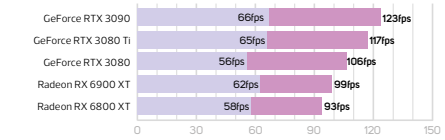
2,560 x 1,440
Ultra settings, HairWorks off, PhysX off



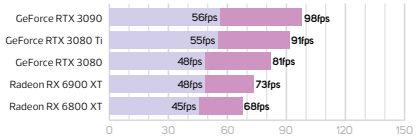
3,840 x 2,160
Ultra settings, HairWorks off, PhysX off



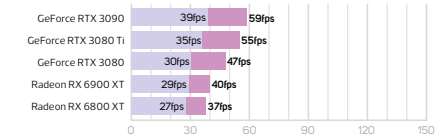
1,920 x 1,080 - RAY TRACING
Ultra settings, HairWorks off, PhysX off, High ray tracing



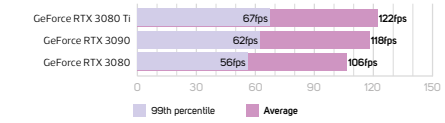
2,560 x 1,440 - RAY TRACING
Ultra settings, HairWorks off, PhysX off, High ray tracing



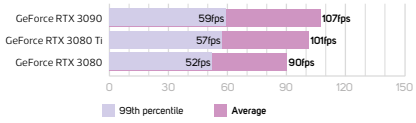
3,840 x 2,160 - RAY TRACING
Ultra settings, HairWorks off, PhysX off, High ray tracing



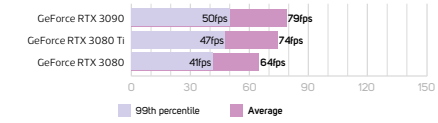
1,920 x 1,080 - RAY TRACING + DLSS
Ultra settings, HairWorks off, PhysX off, High ray tracing, DLSS



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

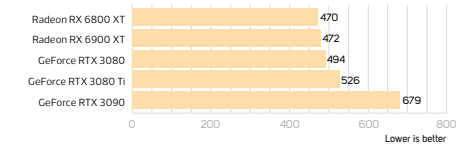


3,840 x 2,160 - RAY TRACING + DLSS
Ultra settings, HairWorks off, PhysX off, High ray tracing, DLSS



POWER DRAW

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



LABS TEST

Soft touch

If you're not keen on the clatter and cost of mechanical keyboards, then a rubber dome switch keyboard is your best bet. **Edward Chester** puts seven of them to the test

How we test

Most of the keyboards in this Labs test can be bought for under £50, which inherently means the features you get aren't quite at the same level as on more premium mechanical boards. None includes a USB pass-through, for instance, while per-key backlighting is a rarity, with lighting instead split into zones on most of these models. Premium touches, such as the aluminium top plates that Corsair favours for its expensive keyboards, are also out the window.

What you do still get with nearly all these keyboards, though, is some form of multimedia control, so you can adjust volume, and play and pause your media at the touch of a button. RGB lighting abounds too, while easy key remapping and macro recording is provided by software for most of these keyboards.

The rubber dome switches used in these keyboards don't have the longevity or variety of feedback available with mechanical switch keyboards. However, most of them are still rated to last for many millions of key presses, and offer an improvement in build quality over the very cheapest rubber membrane keyboards.

We tested each keyboard both in games and with multiple typing speed tests (**custompc.co.uk/TypeTest**) to ensure the keys provide an accurate, rapid response. We also assessed the feel of the keys to gauge the smoothness, definition and consistency of the response, while testing for noise with a decibel meter held at head height facing the keyboard. Any extra features were also tested and the general build quality, design and overall feature set was assessed.

Contents

- Asus TUF Gaming K1 / p53
- Cooler Master MS110 / p54
- Corsair K55 RGB Pro XT / p55
- Logitech G213 / p56
- Razer Cynosa Chroma p57
- Roccat Magma / p58
- SteelSeries Apex 3 TKL / p59

ASUS TUF GAMING K1 / £55 inc VAT

SUPPLIER amazon.co.uk

While most of the keyboards on test this month include some sort of multimedia controls, either via secondary functions of the standard keys or via dedicated buttons, the Asus TUF Gaming K1 is the only model to offer a proper big chunky volume wheel, and it makes for a surprisingly meaningful upgrade over those fiddlier alternatives. It's large enough to easily make small adjustments, helped by the detents that let you know each time you've moved the dial up or down a notch.

Unfortunately, adjusting volume is this dial's only purpose – you can't tap it to mute or play/pause media, or control any other aspect of your system. Given there are no other dedicated media controls, this feels like an oversight. That said, most of the time, it's easy enough to play/pause media with a tap of the spacebar, assuming the relevant window is highlighted, and fine volume adjustment is the most crucial element that needs a dedicated control. Plus, there are labelled secondary functions of the F9-F12 keys that provide back, play/pause, forward and mute controls. It's just not as quick to use them as having dedicated controls.

SPEC

Dimensions (mm) 451 x 155 x 36 (W x D x H)

Weight 810g

Format Full-size –105 keys

Connections Fixed USB 2 cable

Switch type Membrane

Switch life Not stated

Backlighting 5-zone RGB

Polling rate 1000Hz

Keyboard rollover 19-key

Extras Volume wheel and media buttons (play/pause, stop, forward and back), side RGB lighting bars, spill-resistant frame, large plastic wrist rest (451 x 66 x 18 mm)

Also available via secondary functions of the F1-F8 keys are macro recall and recording, using the keyboard's on-the-fly macro recording. Otherwise, that's it for extra keys and other functions. You do, though, get an included clip-on wrist rest that has a reasonable depth and slopes down to a pleasant shallow point. However, it isn't quite as deep as the rests on the Corsair and Roccat keyboards, so it doesn't offer quite as good support.

On the bottom of the keyboard, you'll find rubber-tipped, single-level flip-down feet for raising the back of the keyboard, while the fixed USB cable sprouts from the back of the board, around a third of the way in from the right edge. When it comes to styling, Asus has kept true to its long-standing TUF brand theme, with a chunky, militaristic vibe running throughout the keyboard. It has also added RGB strips to the sides, which provide a little extra eye candy.

The lighting is split into five zones, with a handful of wave and breathing type effects available, as well as the option for a static colour of your choosing. In terms of practicality, the lighting isn't the best we've seen. It isn't distributed all that evenly under each key, so there are dark patches that make the key legends unclear – it's not a problem when viewed top-down, but it's tricky to make out quite a few legends from a normal sitting angle.

We also struggled to get Asus' Armoury Crate software working. It would simply get stuck on a spinning circle loading screen whenever we selected the keyboard from the program's device menu.

More successful are the key switches, which offer a well-balanced action with a defined but not overly stiff bump. The keys also responded rapidly and the keycaps felt solid and secure, making for an easy and reasonably quiet (55.4dB) touch-typing experience (66 words per minute, at 98 per cent accuracy).

Conclusion

The Asus TUF Gaming K1's volume wheel is a great example of the benefits of proper chunky physical control surfaces. However, it's otherwise not the most feature-rich keyboard. The uneven backlighting when viewed from an angle also harms the readability of the key legends. Otherwise, it's a solid enough keyboard, with a good typing action.

TOUGH NUT

+ Great big volume knob
+ Solid performance
+ Reasonable value

TOUGH LUCK

– Unclear key legends
– Few extra features

VERDICT

A great volume knob and a solid typing tool, but it's not overly compelling elsewhere.

DESIGN	FEATURES	OVERALL SCORE
12/20	16/20	76%
PERFORMANCE	VALUE	
24/30	24/30	

COOLER MASTER MS110 / £50 inc VAT

SUPPLIER overclockers.co.uk

The Cooler Master MS110 is a distinctly different offering to the other keyboards on test this month, for several reasons. The first and most fundamental one is that it's not just a keyboard, but a keyboard and mouse combo.

There's a similar MK110 keyboard and CM110 mouse available separately, but the former isn't readily sold in the UK while the latter is slightly different to the mouse included in this set.

The second big difference is that this keyboard uses a so-called 'mem-chanical' key switch that emulates a mechanical switch's form but uses a rubber dome mechanism. The primary benefit of this, other than the impressive 50 million keystroke rating, is that you can actually pull off the keycaps and replace them with Cherry MX-style keycaps.

The downside to this approach is that the MS110 keyboard retains one of the main problems of mechanical switches, which is a clackity noise. This doesn't come from the keys bottoming out – as the rubber dome cushions the landing – but from the keys returning to their top position. The result is a keyboard that's considerably louder than the others on test, clocking in at 63.5dB.

SPEC

Dimensions (mm) 440 x 134 x 40 (W x D x H)

Weight 988g

Format Full-size – 105 keys

Connections Fixed USB cable

Switch type Mem-chanical

Switch life 50 million key presses

Backlighting 6-zone RGB

Polling rate 125Hz

Keyboard rollover 26-key

Extras Includes a mouse

The action of the keys feels very different to most of the others on test too. Rather than the pronounced initial stiffness followed by a collapse, which is the signature action of rubber dome switches, here it's much more linear. There is still a slight bump, but it's much less pronounced. The result is easily the most comfortable keyboard on test, with a far more gentle press required to register a key response. This didn't translate into faster or more accurate typing, but it was easier going on the fingers than some other keyboards.

Both the keyboard and mouse look great. Their simple black forms are punctuated by clean, simple and effective backlighting elements, such as the translucent sections below the keys, the thin strips of light around the edges of the keyboard and on the sides of the mouse, the glowing scroll wheel on the mouse and the elegant hexagonal Cooler Master logos.

Build quality is decent too. The keyboard is still very much all-plastic, but it's a little sturdier than some models, and while the mouse lacks a little of the premium feel of high-end mice, it still feels perfectly sturdy.

Weighing in at 89g and measuring 117 x 63 x 38mm, the relatively compact and short mouse is quite dense by today's standards, but it's not overly heavy. Its sensor model isn't stated, but it ramps up to 3,200dpi with a button in the centre for quick adjustment.

Unfortunately, it didn't keep up with our gaming demands, failing to maintain tracking in fast movements, resulting in skips in on-screen movement. Irritatingly, Cooler Master's MasterPlus+ software didn't recognise either device in testing either.

PERFECT PAIR

+ Stylish keyboard and mouse
+ Cherry MX-compatible keycaps
+ Good keyboard performance

GRUESOME TWOSOME

– Poor mouse gaming performance
– Loud keys
– Few extra keyboard features

The keyboard offers no extra features as such, but a dozen or so of the keys are labelled with secondary functions, such as backlight brightness and colour adjustment, Windows key lock, and multimedia playback and volume control. On the underside, you'll find rubberised, single-level flip-down feet, while the USB cable emerges from the middle of the back of the keyboard. No wrist rest is included.

Conclusion

The MS110 keyboard is a fantastic low-cost, rubber dome option, assuming you don't mind its slightly loud keys. Its stylish, well made and the upgradable keycaps are a real boon. The MS110 mouse looks the part too, but its sensor is a letdown for gaming.

VERDICT

A decent low-cost keyboard and mouse combo, as long as you don't need the mouse for fast-paced gaming.

DESIGN	FEATURES	OVERALL SCORE
18/20	16/20	76%
PERFORMANCE	VALUE	
15/30	27/30	

CORSAIR K55 RGB PRO XT / £75 inc VAT

SUPPLIER scan.co.uk

Corsair's K55 RGB Pro XT is the most feature-rich of all the keyboards on test this month, and it comes with a correspondingly higher price.

However, the price of £75 still puts this keyboard well below the price of most mechanical keyboards, and it really does come packed to the gills with features.

First off, this is an extended-range keyboard, with six extra dedicated gaming keys running down the left side. All the board's keys are fully programmable, but having dedicated ones means you don't have to worry about using awkward key combinations or losing any other functions. Just beware that there's a potentially frustrating learning curve involved with avoiding hitting the G keys when you're aiming for the column of Esc-to-Ctrl keys.

On the opposite end of the keyboard are all the multimedia buttons, of which there are plenty. You get dedicated buttons for stop, back, play/pause, forward, mute, volume down, volume up, macro record, backlight brightness and Windows key lock functions, putting pretty much every standard feature we can imagine to hand.

Next up on the hit list is the fact that this keyboard has individual backlighting for each key, which few of the other keyboards on test offers. This allows for smoother colour effects than zone-based lighting, and of course, means you can program the board to display whatever pattern you like. Corsair's software is also a cut above most offerings on test in terms of ease of use and features.

The final main physical feature is the inclusion of a wrist rest, which is a sizeable unit measuring 65mm deep and gently sloping down to provide a surprisingly comfortable rest. A higher, cushioned wrist rest – or simply keeping your hands raised – is always preferable, but this is definitely one of the more comfortable included rests we've used.

Around the back and on the underside, there's far less going on with this keyboard. There's none of the cable-routing channels of the SteelSeries, nor the USB pass-throughs you'll get on premium boards. The unbraided cable is fixed and juts straight out the middle of the back of the keyboard, and there are basic, single-level flip-down feet on the underside.

When it comes to build quality, all the keyboards on test are plastic fantastic, but the shiny upper section of the Corsair doesn't really do it any favours. That said, overall, it still feels decent enough, with a surprising lack of flex even when the rear is raised, despite the extra width of this keyboard. Corsair has also slapped an IP42 rating on this board, giving it the same splash resistance as the SteelSeries and one level higher of solid object protection – it's rated to keep out objects over 1mm in diameter, up from objects over 2.5mm on the SteelSeries.

Meanwhile, Corsair's rubber dome switches have a pronounced and quite stiff bump, making typing more of an effort than on some keyboards in this Labs, and markedly more than with mechanical boards. This didn't affect our typing speed or accuracy particularly, but it's more fatiguing in use. The keys are very quiet, though, with a noise measurement of just 53.2dB.

Conclusion

The K55 RGB Pro XT is a very versatile keyboard, with masses of extra buttons for getting the most out of your games and multimedia. The per-key lighting is also a major boon at this price range. The key switches are quite stiff, though, making typing quite an effort.

PER KEY

+ Lots of extra buttons
+ Per-key backlighting
+ Reasonable value

PORKY

– Heavy key action
– Shiny plastic top section
– G keys easy to hit accidentally

SPEC

Dimensions (mm) 481 x 167 x 36 (W x D x H)

Weight 940g

Format Extended – 110 keys

Connections Fixed USB 3 cable

Switch type Rubber dome

Switch life Not stated

Backlighting Per-key RGB

Polling rate 1000Hz

Keyboard rollover 12-key

Extras Six macro keys, volume wheel and media buttons (mute, play/pause, stop, forward and back), IP42 water resistance

VERDICT

Loads of features and per-key lighting make this a good-value board, despite its high price for a rubber dome keyboard.

DESIGN	FEATURES	OVERALL SCORE
16/20	19/20	79%
PERFORMANCE	VALUE	
22/30	22/30	

LOGITECH G213 / £35 inc VAT

SUPPLIER currys.co.uk

While most of the other keyboards on test hover around the £50 mark, the Logitech G213 stands apart with its exceptionally low price of just £35, yet it gives up very little in terms features. As well as its five-zone RGB backlighting, you get nine dedicated extra buttons and a built-in wrist rest, which is more than several other more expensive keyboards on test provide.

Take a closer look at this board and the first feature that strikes you is the integrated wrist rest. Presumably it reduces machining costs to just build the whole keyboard longer, rather than providing the clips and holes for attaching a wrist rest. Regardless, if you already have a preferred separate wrist rest, or prefer not to use one at all, this keyboard is immediately off the list. Thankfully, as hard plastic wrist rests go, it's a little longer and more supportive than some models, although it can't compete with the much more generous rests on the Corsair and Roccat models.

The other striking feature about this board is its styling. Logitech's gaming peripherals have a particularly simple look that's a cross between 'utilitarian' and 'child-safe', as demonstrated by the rather oversized multimedia buttons in the top right corner of this keyboard. It's a clean look but it's also a little drab.

One aspect of its appearance that makes a good impression, though, is the backlighting. Logitech has taken completely the opposite approach to most of the other manufacturers in this test and specifically tried to block any light from leaking out around the keys, instead confining the backlighting to just the legends of the keys. It makes for a really smart look that gives an impression of precise build quality, belying the £35 price tag. The lighting only has five zones, but effects such as the wave pattern flow far more smoothly than this spec would suggest.

In terms of extra features, the main additions are the extra buttons in the top-right corner. Here, you get a Windows key lock button, a backlight brightness control, mute and volume up/down, plus four media playback buttons.

On the underside, you also get single-level, flip-down feet, which provide a surprisingly large raise to the back of the keyboard. Meanwhile, the fixed cable exits towards the right-hand side of the back.

So far so good for the G213, assuming the wrist rest and styling are to your taste; however, we encountered a number of build quality issues in actual use. The first is that despite the extra rigidity you'd expect from the integrated wrist rest, this keyboard flexes a touch more than some others on test – it was just about noticeable while typing.

Even more problematic is that several of the keys and buttons didn't work properly on our brand-new review sample. The volume up button requires a hard press to register and it makes a loud click, while the volume down button pleasantly responds to a soft touch. The backlight brightness adjustment button simply didn't work on our sample, while the 'G' key was temperamental, requiring a hard press to register. Unfortunately, we weren't able to obtain a second sample for comparison before publication, but it looks as though there are some quality control and consistency issues.

Conclusion

With its integrated wrist rest and intriguing styling, the G213 is likely to divide opinion, but it certainly offers plenty of features for its price. Unfortunately, that low price is seemingly reflected in its quality control.

RAPID FIRE

+ Lots of features
+ Half-decent wrist rest
+ Low price

NO RESPONSE

− Wrist rest can't be removed
− Poor quality control
− Flexes slightly in use

SPEC

Dimensions (mm) 452 x 218 x 33 (W x D x H)

Weight 1kg

Format Full-size – 105 keys

Connections Fixed USB 2 cable

Switch type Mem-chanical

Switch life 50 million key presses

Backlighting 5-zone RGB

Polling rate Not stated

Keyboard rollover 26-key

Extras 60ml spill resistant, media buttons (volume up/down, mute, play/pause, stop, forward and back)

VERDICT

An impressively cheap price combined with some smart lighting and plenty of features, but there are quality control issues.

DESIGN	FEATURES	OVERALL SCORE
14/20	18/20	70%
PERFORMANCE	VALUE	
22/30	16/30	

RAZER CYNOSA CHROMA / £50 inc VAT

SUPPLIER amazon.co.uk

The Razer Cynosa Chroma is the slightly older variant of the two Cynosa rubber-dome keyboards you can currently buy, with the newer V2 model adding dedicated multimedia keys to the mix. The Cynosa Chroma has a comparatively basic feature set, but it includes per-key backlighting and it also benefits from Razer's ever-reliable eye for attractive design.

The styling here is quite simple, with just a single piece of unadorned black plastic wrapping over the top, back and front of the keyboard, which is punctuated only by the sunken translucent sections for the keys and the little cutout for the shiny piece of plastic with the Razer logo at the front. This simple, clean approach, along with a sharp choice of key legend font and Razer's neat-looking logo, makes for an effortlessly smart, if rather chunky-looking keyboard.

The backlighting looks very good too, thanks to the combination of translucent plates doing a good job of distributing yet containing the lighting, and of course, the per-key RGB programmability. This allows for pre-programmed lighting effects, such as wave, breathing and a rather funky fire-emulating effect, and they look far smoother than the effects on some keyboards on test this month with only limited lighting zones.

SPEC

Dimensions (mm) 463 x 154 x 31 (W x D x H)

Weight 950g

Format Full-size – 104 keys

Connections Fixed USB cable

Switch type Membrane

Switch life 20 million key presses

Backlighting Per-key RGB

Polling rate 1000Hz

Keyboard rollover 10-key

Extras None

However, we found the lighting could sometimes have a distracting flickering to it if you move your eyes rapidly. We've noticed this before on some RGB keyboards, and it's a product of the way they rapidly flash the LEDs on and off in order to regulate their brightness, in the same way as some old monitors (which is why many monitors now make a big point of claiming to be flicker-free). The other RGB keyboards on test didn't suffer from this problem, and we found it quite annoying on the Razer.

To program the lighting, you'll have to jump into Razer's Synapse software, which is frankly a bit overblown for its job. You have to sign up to a Razer account in order to access it, and it's all split up into confusing modules that require individual downloads. A more integrated, all-in-one approach – that doesn't require a sign-in – would be far preferable.

When it comes to features, this keyboard has no physical extras beyond the normal keys, but it does include multimedia and macro recording functions as secondary functions of the F keys.

On the underside there are two-level, plastic flip-down feet for raising the back, and the USB cable sprouts from the centre of the back of the keyboard. Meanwhile, build quality is surprisingly solid for the price, with the Cynosa Chroma being among the more rigid devices on test.

The key switches here are simply labelled as being of a rubber membrane type, with no lifetime rating. Nonetheless, they feel pretty good in action, with a slightly less aggressive push required to buckle the rubber dome than with some keyboards on test. There's still a distinct feedback, but it doesn't verge on being fatiguing. The feel is also reasonably consistent across the board.

Performance-wise, the board didn't lead the pack in our typing speed tests, but it didn't noticeably feel like it was holding us back. It's a reasonably quiet keyboard in action too, registering just 52.5dB in our tests.

Conclusion

The Razer Cynosa Chroma is a slightly older keyboard, and in some ways, that shows, with the newer V2 version offering multimedia buttons for a similar price. However, it's still a perfectly smart-looking, capable and quiet keyboard. It's just the slightly irritating flicker of the backlighting that holds it back.

CHROMATIC

+ Stylish design
+ Per-key backlighting
+ Quiet keys

ABERRATION

– Basic feature set
– Flickering backlights
– Lacks multimedia keys

VERDICT

A quiet and attractive keyboard but its newer sibling may be the better option.

DESIGN	FEATURES	OVERALL SCORE
18/20	13/20	73%
PERFORMANCE	VALUE	
22/30	20/30	

ROCCAT MAGMA / £50 inc VAT

SUPPLIER roccat.com

The big selling point of the Roccat Magma is its lighting setup. It makes use of a translucent top plate in order to provide lighting for not just the keys, but also for the entire top of the keyboard.

On paper, it might sound a bit gimmicky, and the look of the keyboard doesn't initially inspire confidence when you get it out of the box unplugged either. You're greeted by a big slab of white plastic that we suspect doesn't quite fit in with the aesthetic of most desk setups.

However, plug this keyboard into your PC and its party piece makes a more convincing case for itself, assuming that you love RGB lighting. The show put on here is quite striking and there's a certain practicality to it too. It lights up your keyboard/desk area, providing a little bit of ambient, eyestrain-reducing light. Plus, you'll certainly know when it's time for a keyboard clean-up.

The lighting is divided into just five zones. For effects, you get some basic breathing, heartbeat and wave effects, along with an AIMO intelligent mode that reacts to your interactions, plus a static colour choice. Beyond just choosing a static colour scheme, we have to admit to not really being taken in by any of the effects on offer, other than multicolour wave, but that's a matter for your own personal tastes.

SPEC

Dimensions (mm) 452 x 157 x 39 (W x D x H)

Weight 870g

Format Full-size – 105 keys

Connections Fixed USB cable

Switch type Membrane

Switch life Not stated

Backlighting 5-zone RGB

Extras Semi-transparent top plate, wrist rest

Otherwise, the styling of this keyboard is rather quirky, with a horizontal line motif running along the front edge and onto the included plastic wrist rest. The rounded corners of the keyboard, along with the white-on-black look, also has a toy-like or child-friendly appearance to it in our eyes, though again whether you like the styling or not is really just a matter of personal taste.

As for build quality, the keyboard has a disconcerting amount of flex in it in use – it's among the most flexible keyboards on test. It's not so bad that typing makes the whole unit wobble, as can happen with poor-quality laptop keyboards, but it's a touch more pliable than some of the other keyboards on test in this month's Labs.

In terms of features, you get the aforementioned wrist rest, which offers a decent depth to it, so it actually supports your wrist rather just filling space under your hand, as with some small wrist rests. Its hard surface will irritate your wrists after a while, though, so you'll need some sort of cushioning for it in the long term.

Otherwise, there are no real extra physical features. Instead, all this keyboard's extra abilities are confined to the secondary functions of the primary keys. All the keys are fully programmable, but by default, the F keys have various labelled secondary functions, such as volume control, media control and a profile switching button.

The keyboard uses Roccat's own membrane switches, for which the company hasn't provided a lifetime rating. However, they appear to use a very similar structure to the switches on the Corsair K55 RGB Pro XT. They feel different, though, with slightly less force required to push past the initial resistance, which we preferred. Typing performance was excellent, and the Roccat was the quietest unit on test.

LIQUID HOT MAGMA

+ Dazzling light show
+ Quiet key action
+ Reasonable value

ILL-TEMPERED SEA BASS

– Basic feature set
– Styling is a bit odd
– Flexes in use

Conclusion

If illumination is your inspiration, then the Roccat Magma certainly makes an impact. It's a shame the light show isn't a little more fine-tunable but it certainly looks the part when glowing away. There's not a lot else to this keyboard, but the key action is decent and it's also quiet.

VERDICT

Not for people who like the subtler things in life, but solid typing performance backs up this kaleidoscopic keyboard.

DESIGN	FEATURES	OVERALL SCORE
14/20	16/20	76%
PERFORMANCE	VALUE	
24/30	22/30	

STEELSERIES APEX 3 TKL / £50 inc VAT

SUPPLIER steelseries.com

If we had to pick our favourite keyboard on test based on design alone, the SteelSeries Apex 3 TKL would easily take the win. It certainly helps that the compact tenkeyless (TKL) form factor looks a little less bulky than the full-sized keyboards on test, but the full-sized version of this keyboard looks great too. Instead, it's the subtler details that really elevate this keyboard.

For a start, the backlighting is neatly contained in translucent, sunken sections that provide an attractive way for the lighting to fill out below the keys without spilling everywhere. The lighting is also split up into eight equal-size columns – more than some keyboards – allowing for a particularly attractive flowing, colour-shift effect. You can change the speed and colours of this effect, choose a breathing transition or opting for a static colour.

The shape is smart too, with sides that angle inwards towards the desk, creating a slim look. It also balances clean lines with just the right amount of rounding to its edges to soften the whole design. The compact volume wheel integrated into the top-right edge and the play/pause button below it are also handy additions. Tap the wheel and it will mute audio as well, while the play/pause button will also skip forwards a track when double pressed and go back a track when triple pressed.

You don't get too many other features on the top of the keyboard but there are marked secondary functions for the F10-F12 keys that provide macro recording and brightness adjustment plus the Del/PgUp cluster provides six macro shortcut keys.

Flip over the keyboard and you'll find that, although the USB cable is fixed, its cable can be routed to exit the back of the keyboard in three different locations, either from the middle or a couple of inches from either side of the keyboard. There are also surprisingly sturdy, rubberised flip-down feet. There's no included wrist rest though.

A further nod to the Apex 3's design is the font on the keys, which is very large, easy to read and smart-looking, although the way the letter legends are pushed to the top left of each key is a little odd.

The keys use SteelSeries' Whisper-Quiet switches, which are rated to 20 million key presses. They have a very stiff initial step to their action, so require a bit of force to press, which we found a touch fatiguing and slightly slowed our typing. They're very responsive, though, not requiring you to hammer down the keys to get a response, and the initial resistance may soften a little over time. To call the keys 'whisper-quiet' is certainly a stretch, but along with the Roccat Magma, they're the quietest on test, registering just 51.6dB.

SteelSeries also claims the Apex 3 is the first-ever water-resistant TKL gaming keyboard, which may well be true, but the waterproofing level claimed here certainly has its limits. The level of protection for an IP32 rating requires resistance to vertically dripping water with the device either flat or angled up to 15 degrees from its normal position, so it's more resistant to splashes than full-on spills.

TOP OF THE WORLD

- \+ Attractive design
- \+ Decent feature set
- \+ Quiet keys
- \+ Spill resistance

BOTTOM OF THE PILE

- – Quite stiff key response
- – Can get full-sized keyboards for the same price

SPEC

Dimensions (mm) 364 x 150 x 40 (W x D x H)

Weight 639g

Format TKL – 80 keys

Connections Fixed USB cable

Switch type Membrane

Switch life 20 million key presses

Backlighting 10-zone RGB

Polling rate Not stated

Keyboard rollover 24-key

Extras Volume wheel and play/pause button, multiple cable routing channels, IP32 water resistance

Conclusion

The SteelSeries Apex 3 TKL is a great little rubber dome keyboard. It looks smart and has a well-balanced feature set with its smart multi-function multimedia buttons. Add in the waterproofing, quiet keys and decent price, and you have a winner, if you don't mind the fairly heavy key press. CPC

VERDICT

Smart, capable and keenly priced, but it requires a hard key press.

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

How we test

MOTHERBOARDS

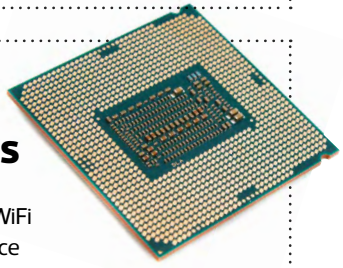
TEST PROCESSORS

- **Intel LGA1700** Intel Core i9-12900K
- **Intel LGA1200** Intel Core i9-11900K
- **AMD AM4** AMD Ryzen 9 5900X

Common test hardware between our CPU test rigs includes a 2TB Samsung 970 Evo SSD, a 1TB PCI-E 4 Corsair MP600 SSD 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.

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	£350
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	£69
MOTHERBOARD	Asus TUF B450M-PLUS II (micro-ATX)*	scan.co.uk	**#218** p78	£70
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£43
	Total £532			

***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.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-11400F	scan.co.uk	**#215** p16	£150
CPU COOLER	ARCTIC Freezer 7 X	scan.co.uk	**#202** p20	£16
GRAPHICS CARD	AMD Radeon RX 6600 XT	overclockers.co.uk	**#220** p53	£519
MEMORY	16GB (2 x8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M 2B3200C16)	scan.co.uk	**#204** p74	£69
MOTHERBOARD	MSI MAG B560 Tomahawk WiFi (ATX)	scan.co.uk	**#215** p18	£170
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£43
	Total £967			

UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	overclockers.co.uk	**#220** p55	£660
SWAP STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£113
SWAP CPU COOLER	SilverStone Hydrogon D120 ARGB	amazon.co.uk	**#217** p43	£50

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	overclockers.co.uk	**#220** p19	£280
CPU COOLER	NZXT Kraken 120 RGB (120mm AIO liquid cooler)	scan.co.uk	**#221** p76	£75
LGA1700 ADAPTOR	Asetek Premium Retention Kit LGA1700	overclockers.co.uk	**#221** p76	£4
GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	overclockers.co.uk	**#220** p55	£660
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£80
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	box.co.uk	**#221** p14	£246
STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£113
		Total £1,458		

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	overclockers.co.uk	**#220** p18	£400
CPU COOLER	NZXT Kraken X53 (240mm AIO liquid cooler)	scan.co.uk	**#221** p76	£110
LGA1700 ADAPTOR	Asetek Premium Retention Kit LGA1700	overclockers.co.uk	**#221** p76	£4
GRAPHICS CARD	Nvidia GeForce RTX 3070 Ti	cclonline.com	**#220** p43	£999
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£80
MOTHERBOARD	Asus TUF Gaming Z690-Plus WiFi D4	ebuyer.com	**#221** p16	£260
STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£113
		Total £1,970		

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	overclockers.co.uk	**#220** p18	£400
CPU COOLER	NZXT Kraken Z53 (240mm AIO liquid cooler)	amazon.co.uk	**#221** p76	£189
LGA1700 ADAPTOR	Asetek Premium Retention Kit LGA1700	overclockers.co.uk	**#221** p76	£4
GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	scan.co.uk	**#221** p48	£1,490
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX4M2 C3200C16)	scan.co.uk	**#221** p76	£80
MOTHERBOARD	Asus TUF Gaming Z690-Plus WiFi D4	ebuyer.com	**#221** p16	£260
STORAGE	1TB WD Black SN850	box.co.uk	**#215** p49	£150

Total £2,573

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	ebuyer.com	**#220** p16	£600
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	£4
GRAPHICS CARD	AMD Radeon RX 6600 XT	overclockers.co.uk	**#220** p53	£519
MEMORY	32GB (2 x 16GB) Corsair Dominator Platinum RGB 5200MHz DDR5 (CMT32GX5M2 B5200C38W)	corsair.com/uk	**#221** p76	£290
MOTHERBOARD	Asus ROG Maximus Z690 Hero	scan.co.uk	**#221** p18	£520
STORAGE	2TB WD Black SN850	scan.co.uk	**#215** p49	£317

Total £2,410

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	scan.co.uk	**#221** p48	£1,490
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	£375
Intel Z590 (LGA1200)	Gigabyte Z590I Vision D	scan.co.uk	**#214** p18	£270
AMD B550 (AM4)	Asus ROG Strix B550-I Gaming	scan.co.uk	**#206** p44	£197

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	£105
PREMIUM	Streacom DA2 V2	quietpc.com	**#214** p51	£190

Other components

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE CPU COOLER	Noctua NH-L12S	scan.co.uk	**#219** p54	£50
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	£75
SUB-£100	be quiet! Pure Base 500DX	scan.co.uk	**#202** p39	£99
COMPACT	Fractal Design Meshify 2 Compact	scan.co.uk	**#215** p20	£100
HIGH AIRFLOW	Fractal Design Meshify 2	scan.co.uk	**#212** p45	£130
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	**#202** p44	£139
SUB-£150	Fractal Design Define 7	overclockers.co.uk	**#204** p18	£140
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	**#187** p24	£215

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD B450 (AM4)	Asus TUF B450M-PLUS II (micro-ATX)	scan.co.uk	**#218** p76	£70
AMD B550 (AM4)	MSI MAG B550M Mortar	ebuyer.com	**#204** p42	£120

Cases

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

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET ROUTER	Belkin RT3200-UK	currys.co.uk	**#216** p52	£80
ROUTER	Asus RT-AX68U	scan.co.uk	**#216** p51	£170
MESH ROUTER	Asus AiMesh AX6100	amazon.co.uk	**#196** p54	£270
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	**#196** p58	£60
DUAL-BAY NAS BOX	Synology DS220j	laptopsdirect.co.uk	**#200** p22	£163
DUAL-BAY MEDIA NAS BOX	Synology DS218play	laptopsdirect.co.uk	**#174** p34	£208
2.5 GIGABIT DUAL-BAY NAS BOX	QNAP TS-231P3	ebuyer.com	**#212** p25	£317

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	box.co.uk	#214 p28	£160
25IN, 240Hz, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	amazon.co.uk	#209 p57	£300
25IN, 360Hz, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	overclockers.co.uk	#212 p20	£599

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	£180
27IN, 240Hz, IPS, 1,920 X 1,080, F, G	Asus TUF Gaming VG279QM	overclockers.co.uk	#209 p60	£340
27IN, 144Hz, IPS, 2,560 X 1,440, F, G	Asus TUF Gaming VG27AQ	overclockers.co.uk	#201 p54	£449
27IN, 240Hz, TN, 2,560 X 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£480
27IN, 240Hz, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£671
28IN, 144Hz, IPS, 3,840 X 2,160, F, G	AOC U28G2XU	amazon.co.uk	#221 p29	£568

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, 165Hz, IPS, 2,560 X 1,440, F, G	LG UltraGear 32GP850	overclockers.co.uk	#220 p38	£349
34IN, 144Hz, VA, 3,440 X 1,440, W, F, G	Cooler Master GM34-CW	ebuyer.com	#215 p30	£550
34IN, 144Hz, IPS, 3,440 X 1,440, W, F	iiyama G-Master GB3461WQSU	scan.co.uk	#206 p53	£399
34IN, 144Hz, IPS, 3,440 X 1,440, W, F, G	LG UltraGear 34GN850	currys.co.uk	#206 p55	£949
38IN, 144Hz, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	currys.co.uk	#208 p30	£1,199
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	ebuyer.com	#210 p26	£280

Peripherals and audio

Gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET TKL	SteelSeries Apex 3 TKL	steelseries.com	#221 p59	£55
OPTICAL ESPORTS	Asus ROG Strix Scope RX	ebuyer.com	#209 p43	£113
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
LUXURY MECHANICAL	Ducky Shine 7 RGB	overclockers.co.uk	#212 p53	£175
WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	overclockers.co.uk	#208 p60	£230

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	£52
MMO	Razer Naga Trinity	amazon.co.uk	#186 p52	£50
AMBIDEXTROUS	Razer Viper 8K	currys.co.uk	#215 p59	£60
WIRELESS	Razer Viper Ultimate	amazon.co.uk	#217 p54	£65
PREMIUM WIRELESS	Razer Deathadder V2 Pro	ebuyer.com	#210 p28	£117
ULTRA LIGHTWEIGHT	Roccat Burst Pro	scan.co.uk	#211 p28	£48
PREMIUM LIGHTWEIGHT WIRELESS	Logitech G Pro X Superlight	currys.co.uk	#217 p52	£100

Peripherals and audio cont ...

Game controllers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	currys.co.uk	#202 p50	£259
GAMEPAD	Microsoft Xbox One Wireless Controller	currys.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	£70
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£155
PREMIUM WIRELESS	Razer BlackShark V2 Pro	scan.co.uk	#211 p26	£200

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Edifier R1280DB	amazon.co.uk	#192 p57	£130

Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
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)
BUDGET GAMING	CyberPower Infinity X115 GT	Intel Core i5-11400	Nvidia GeForce RTX 3060	cyberpowersystem.co.uk	#217 p32	£1,299
MID-RANGE GAMING	CCL Horizon 5 3060 Ti Gaming PC	AMD Ryzen 5 5600X	Nvidia GeForce RTX 3060 Ti	cclonline.com	#220 p42	£1,499
4K GAMING	Scan 3XS Vengeance Ti	Intel Core i9-12900K	Nvidia GeForce RTX 3080 Ti	scan.co.uk	#221 p34	£3,499
PREMIUM WATER-COOLED 4K GAMING	Chillblast Fusion Kraken	AMD Ryzen 9 5950X	Nvidia GeForce RTX 3090	chillblast.com	#217 p34	£6,840

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Lenovo Legion 5 (82JU002YUK)	AMD Ryzen 7 5800H	Nvidia GeForce RTX 3070 Laptop	15.6in, 1,920 x 1,080 IPS 165Hz	currys.co.uk	#218 p48	£1,399
ULTRA PORTABLE GAMING	Razer Blade 14	AMD Ryzen 9 5900HX	Nvidia GeForce RTX 3070 Laptop	14in 1,920 x 1,080 IPS 144Hz	ebuyer.com	#220 p40	£1,999
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	ebuyer.com	#219 p28	£2,400
PREMIUM RTX GAMING	Asus ROG Strix Scar G733QSA	AMD Ryzen 9 5900HX	Nvidia GeForce RTX 3080 Laptop	17.3in 1,920 x 1,080 IPS 360Hz	scan.co.uk	#217 p28	£2,799

RICK LANE / INVERSE LOOK

IMMERSIVE SINS

Deathloop shows that it's time for the immersive sim to come out of its shell, argues Rick Lane

My favourite type of video game is the immersive sim. The genre was codified by games such as Ultima Underworld and System Shock, mastered in Deus Ex and kept in the limelight by games such as Dishonored and Prey. I love the way immersive sims provide players with tools to create their own solutions to problems, being built upon a consistent set of rules and systems that enable players to do activities the developers didn't anticipate.

Yet despite (or perhaps because of) these games' ambitions, the genre has always struggled to be popular. Looking Glass' biggest selling game was Thief, and that sold only half a million copies. Deus Ex, one of the genre's biggest names, took nine years to sell a million copies. Arkane Studios saw greater success with Dishonored, but its subsequent games, Dishonored II and Prey, failed to meet up to publisher Bethesda's sales expectations.

Various reasons have been given for the genre's apparent immunity to success. One possible cause is that the genre's entire existence has hinged on a handful of designers, such as Warren Spector, Harvey Smith and Raphael Colantonio. The games also tend to be primarily inspired by other immersive sims.

> The genre's entire existence has hinged on a handful of designers

Dishonored, for example, was inspired by Thief, while Prey was inspired by System Shock. Deus Ex, on the other hand, was inspired by both Thief and System Shock.

The genre has suffered from stagnation, with the core ideas not changing in at least 20 years, until Arkane Studios launched Deathloop (see p70). Deathloop takes the core principles of preceding immersive sims and blends them with ideas not from like-minded games, but from roguelikes, time-loop games and even multiplayer deathmatch titles. It also drops certain ideas considered sacred by the genre, most notably nonlethal combat options.

It retains the open-ended, creative play of an immersive sim, but it's far more reactive, encouraging players to explore *all* its options, rather than just a small percentage of them. The addition of competitive multiplayer lends a whole new verve to the sandbox, pushing players to think creatively about the tools they have at hand.

Deathloop demonstrates the untapped potential of immersive sims, and how the genre's rigid commitment to its rulebook outlined in the 1990s has done it more harm than good. It makes me wonder how else the genre could be expanded. For example, the systemic nature of immersive sims makes them frequently funny, yet nearly every game in the genre presents itself as a deadly serious affair.

There would be significant mileage in a comical immersive sim, one that uses its tools to create a dynamic slapstick simulator. There's also never been a child-friendly immersive sim, offering the genre's trademark creative problem solving, but without the violence and gore.

Ultimately, I'm tired of immersive sims exploring the same space station corridors and medieval streets that we've seen so many times already. I want the genre to be open to new ideas, so that in turn, new players will be attracted to the creative problem-solving techniques that are encouraged by these wonderful games. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

Hot Wheels Unleashed / £39.99 inc VAT

DEVELOPER Milestone / **PUBLISHER** Milestone

Hot Wheels Unleashed is a devilishly enticing mix of Micro Machines, Burnout and Trackmania, all wrapped in the orange and blue branding of the coolest die-cast vehicles in toytown. It's the most enjoyable arcade racer we've played since Forza Horizon 4, although it's dragged down by an unseemly emphasis on loot boxes.

Unleashed's racing is simple and spectacular. In single-player mode, you square off against 11 other cars on a wide range of twisting and looping Hot Wheels tracks, all represented to scale, with tracks snaking under pool tables and twisting around bookshelves. Racing relies heavily on drifting and a Burnout-style boost, and performing the former helps you to charge up the latter.

The racing is given complexity by the tracks themselves, which are brimming with bonuses, obstacles and hazards. These range from speed-boosting chevrons to breakable walls that hinder your progress, all the way up to giant spider toys that spit a sticky web on the track, bringing you screeching to a halt. The variety of tracks is impressive too, although sadly there are only five 'locations' that play host to races, including a skate-park, a school and a basement rumpus room.

The single-player campaign is unusual for an arcade racer. Known as Hot Wheels City Rumble, it sees you exploring a top-down city map split into various nodes, each of which comprises either a race, a time-attack scenario, a reward or a secret. Your ultimate goal is to find and win five Boss Races, double-length extravaganzas that have their own unique challenges, such as venom-spitting scorpions that drain your boost bar. It's a smartly thought-out structure, making you feel like you're doing more than simply progressing through a list of races.

Unleashed features 60 cars from the toy brand, which range from hot rods and Formula 1 cars to more eclectic vehicles, such as the dinosaur-themed Motorsaurus and Tricera-truck. They're all wonderfully recreated in digital form, and vary in terms of speed, handling and boost power.

However, the way they're collected leaves a bit of a sour taste. Some can be acquired through the City Rumble, while others must be purchased with in-game currency, either outright or through 'Blind Boxes', which give you a random car. The presence of this chance minigame is unsavoury in an experience clearly geared towards children.

Mercifully, developer Milestone avoids bringing real-world cash into the equation, making the Blind Boxes more of an ill-judged feature rather than an outright cynical one. Hot Wheels Unleashed is otherwise a thrilling, stylish and intelligently designed arcade racer, combining the best bits of some of the last decade's most novel racing games into a game that's far more than a branded cash-grab.

RICK LANE

CUSTOM PC APPROVED

HOT WHEELS

- \+ Fun arcade racing
- \+ Fantastic tracks
- \+ Smartly designed single-player

COLD ENGINE

- – Not enough track locations
- – Blind Boxes are a bit distasteful

/ VERDICT

Hot Wheels Unleashed is an excellent arcade racer, although the Blind Boxes are a splatter of bird poo on its otherwise gleaming chassis.

OVERALL SCORE

80%

Deathloop / £49.99 inc VAT

DEVELOPER Arkane Studios / **PUBLISHER** Bethesda

Deathloop seeks to solve a specific problem with immersive sim design, namely the player's tendency to become entrenched in a certain way of playing. It's a game designed to pull stealth fanatics out of the shadows, to teach gunslinging door-kickers that sometimes a quieter approach is more fruitful. It even seeks to show multiplayer haters that sometimes life can be better with other people around. It's bold, imaginative and more fun than a box of kittens.

Players initially assume the role of Colt Vahn, who awakes on the bracing shoreline of Blackreef island to find himself stuck in a time loop caused by a spacetime anomaly at the centre of the isle. If Colt dies or reaches the end of the day, the loop resets to the previous morning.

Colt wants to break this loop for reasons that aren't entirely clear even to himself, but he may have found a way to do it. The anomaly has attracted the world's brightest, richest, and most ruthless individuals, who call themselves Visionaries and have turned the island into an eternal Burning Man festival. It Colt can kill all eight visionaries in a single day, the loop will break and time will flow normally.

Pulling this off, however, is no mean feat. Blackreef is split into four different locations, while the day is split into four slices of time – morning, noon, afternoon and evening. The eight Visionaries all appear in different places at different times of day, making it impossible for Colt to kill all eight as the day currently stands.

On top of that, each Visionary wields a unique power called a Slab, and is guarded by a small army of hedonistic, heavily armed partygoers called Eternalists. Oh, and any weapons or abilities Colt picks up will be lost when the day resets. Apart from that, it's a great plan!

The point of this convoluted setup is to encourage players to create their own objectives. Since you begin the game unarmed, in the morning you might visit the library in the village of Updaam, which has been converted into an arsenal for the Eternalists. At noon, you might return to Updaam, where the bridge to hacker whiz Charlie Montague's islet fort has been lowered, and you can sneak into it to steal his personal Slab.

Then in the afternoon, you might head to the Complex, a huge research facility at the heat of Blackreef, following a rumour that the scientist Wenjie Evans has found a method

of carrying items across time loops. In this way, you slowly unpick Deathloop's many layers at your own discretion. Your early goals will likely focus on amassing power, figuring out the locations of unique weapons and Slabs, and learning how to keep hold of them at the end of each loop.

You'll also be exploring the various hidey-holes of the Visionaries, mastering the layout of each level and conjuring cunning ways to kill them. Over time, you'll gain abilities such as Shift, a short-range teleport akin to Dishonored's Blink, and weapons such as the Strelak Verso, a pair of twin pistols that can be connected to create a submachine gun.

Four locations may not sound like many, but each one is large and elaborate, containing levels within levels. The craggy peninsula of Fristad Rock, for example, includes both the fortified nightclub of Ramblin' Frank Spicer, and a nuclear bunker that pop artist Fia Zborowska has transformed into her personal art studio. The levels also change over time, with certain areas being accessible at specific times of day.

Repetition is a key element of Deathloop. You'll need to visit each location multiple times in order to gain all Slabs and their upgrades, and find ways to manipulate the loop, so you can kill multiple Visionaries at once. This repetition isn't for the sake of padding, but to encourage experimentation. If you ever played a level in Dishonored or Deus Ex and wondered how you might have done it differently, Deathloop makes this revisiting a part of the game, rewarding you for trying a level from a different angle.

There's one other element that guarantees each revisit will never be the same – Julianna Blake. Julianna is the eighth Visionary, and the only character alongside Colt whose memory is preserved between loops. She's also the only one who actively hunts Colt, appearing in any location Colt visits where another Visionary is also present. Plus there's one final twist – by default, Julianna is controlled by another player.

This may sound like a recipe for disaster, but the unpredictability a player-based Julianna brings to Deathloop is in many ways what makes it special, turning a straightforward assassination mission into a spectacular battle for survival, or a search for a specific weapon into a thrilling cat-and-mouse chase.

It all works thanks to some careful balancing on developer Arkane's part. Colt only has to kill an invading Julianna once, whereas Julianna has to kill Colt three times

before his loop resets. Colt can also try to evade Julianna, so he can complete his objectives and then slip away before she has a chance to kill him.

The result of all this is a game that's constantly surprising and engaging, where you're always coming up with new weapon and power combinations, new ideas about where to explore next, and new stories to tell about your latest encounter with Julianna.

We haven't even mentioned the incredible art design, which blends the dour stonework of a Hebridean fishing village with the glitz and kitsch of a 1970s celebrity home. The soundtrack, meanwhile, is one of the best of the year, mixing fabricated mid-century pop and rock with James Bond-style themes.

There are some weaker points. Deathloop's writing is much livelier and more engaging than either Dishonored title, and the unfolding mystery is compelling enough to keep you engaged. However, the Visionaries never feel particularly villainous. They're spoiled, obnoxious and sometimes cruel, but they're also stuck on an island in an infinite time loop, which seems like the best place for them. Also, when it comes to following the story, most of the actual detective work is done by Colt, with you simply following the thread to the next location.

Still, Deathloop's ambitions stretch much further than interactive mystery. It's a fabulous reworking of immersive sim ideas, breathing new life into a genre that was arguably becoming too inward-looking. Dying has never been so much fun.

RICK LANE

BLACKREEF

+ Ingenious concept and structure
+ Deep, creative systems
+ Incredibly stylish
+ Just excellent all round, really

BLACK SHEEP

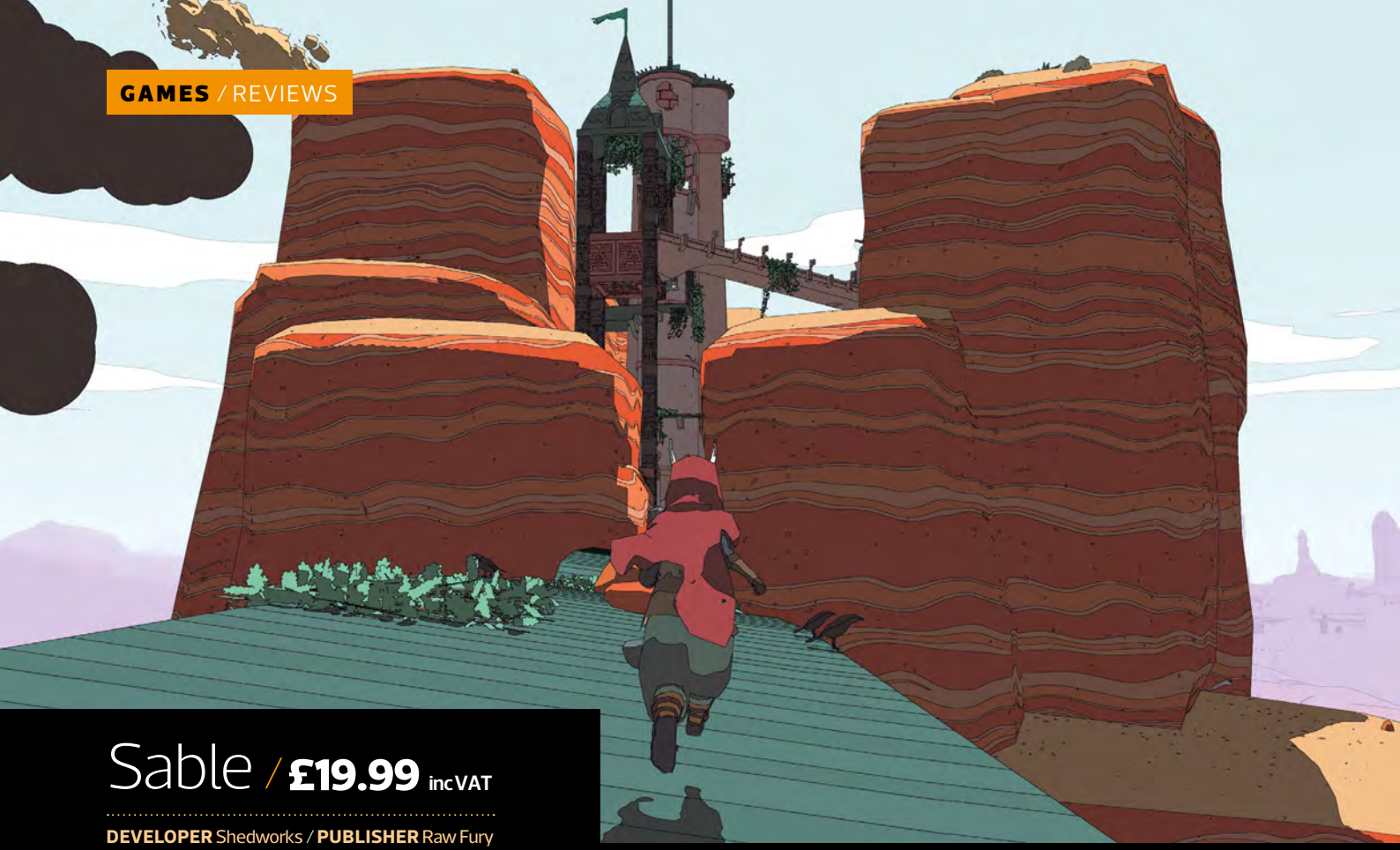
– Visionaries not especially great villains
– Central mystery could be more dynamic

/ VERDICT

Stylish, spectacular and brimming with ideas, Deathloop is one of the year's highlights.

OVERALL SCORE

92%



Sable / **£19.99** inc VAT

DEVELOPER Shedworks / **PUBLISHER** Raw Fury

Sable is a peaceful open-world game about exploring an alien desert world. Placing you in the role of a young woman (Sable) on a rite of passage, it sees you travelling through a world of dunes, canyons and mesas, delving into ancient ruins, performing jobs for various settlements, and slowly peeling back the many mysteries developer Shedworks has woven into its game.

Two factors separate Sable from other open-world experiences. The first is that it's entirely non-violent, instead focusing on exploration, dialogue and puzzle solving. The second is that, after completing a slightly overlong tutorial, you're free to go wherever you want. There's no level gating or predetermined quest structure. If you want to travel to the farthest reaches of the map the moment you begin your adventure, you're free to do so.

While there's no overarching plot, there are objectives and stories that you can choose to pursue. You can go scrap hunting for scavengers who reside in the game's settlements, or seek out the world's cartographers, found in the map's loftiest places. Completing such tasks rewards you with badges, and when you have enough of them, you can choose to don the mask of that particular profession, cementing Sable's place in the world.

It's frequently a spectacular game, thanks in no small part to its artwork, inspired by the illustrations of Jean Giraud, also known as Moebius. However, the production quality also extends to the audio design and writing. The game's wistful soundtrack is provided by the band Japanese Breakfast, while the script is frequently funny and touching without becoming twee.

Beyond its sights and sounds, though, Sable struggles to come up with compelling ways to engage with its world. Sable's glider isn't a particularly interesting vehicle to control, while the platform puzzling mostly involves pulling switches or finding batteries to power doors inside the ancient spacecraft scattered across the desert.

There are some more interesting quests, such as a vast windmill tower you need to climb in order to repair it, and an elaborate detective mystery that sees you hunting for clues all across a settlement. However, the game would benefit from a unique mechanic around which to wrap its puzzles, a non-violent system that better connects you to the world Shedworks has created.

Sable's commitment to delivering a non-violent open world game is commendable, but its failure to provide a compelling alternative to combat means it falls behind other peaceful open-world games, such as Eastshade. That said, if you're looking for a stress-free experience to while away an evening, you could do worse than Shedworks' freewheeling desert tale.

RICK LANE

SABLE

+ Fantastic artwork
+ Interesting world design
+ Very relaxing

UNABLE

- Glider is underwhelming
- Puzzling lacks imagination
- Needs a mechanic to call its own

/ VERDICT

Sable's pretty and peaceful world makes for a relaxing adventure, but one that also lacks an idea of its own to make it special.

OVERALL SCORE

68%

The Eternal Cylinder / £23.99 inc VAT

DEVELOPER ACE Team / **PUBLISHER** Good Shepherd Entertainment

The Eternal Cylinder sees you play as a group of cute creatures called Trebhum, on a planet that's slowly being crushed into dust by a giant rotating cylinder. Your goal is to evade this unstoppable rolling pin of death, finding ways to evolve your Trebhum while deciphering the mystery behind the curvilinear phenomenon that's destroying your home world.

You control one Trebhum directly, but recruit others to follow you – you can then switch between which Trebhum you control directly. As you explore the game's strange planet, you'll come across various plants and animals that can be consumed, which will change your Trebhum in different ways. Some adaptations give you better legs for jumping, or a fur coat to keep you warm in colder biomes. Stranger adaptations will turn you into a cube, or give you special eyes that let you analyse other fauna for ways to exploit them.

Unlike Spore, The Eternal Cylinder's procedural generation only extends to the basic terrain layout. It's a primarily linear experience, with you racing between giant stone towers that temporarily halt the march of the cylinder. Each tower generates a bubble of safety in which you can explore and complete objectives. When you're finished, you then proceed through the force field, whereupon the cylinder will begin chasing you once more.

The planet's other animals are all bizarre, ranging from an ostrich-like creature with three grabbing tentacles in place of a head, and a sort-of upturned clam shell with rows of human teeth. Then there's the cylinder itself, a terrifying mass of rock that stretches across the horizon, turning an infernal orange when it moves. Its speed is highly unpredictable. Sometimes you'll reach the next tower with ease; sometimes you'll barely make it or not at all.

The Eternal Cylinder doesn't always make the best use of its ideas though. You don't travel alone, but with other Trebhum who you pick up on your journey. Community is clearly a key theme, but beyond helping you open a few doors and acting as extra lives should your group leader die, this social element is rudimentary. The controls also lack a sense of connection with the game world.

Fortunately, The Eternal Cylinder has strong storytelling. It uses its linear progression to its advantage, introducing a new concept or plot point with almost every new tower at which you arrive. You'll encounter strange, giant lizards that descend from the sky, commune with Trebhum elders in secret underground temples, and even embark on a daring journey behind the cylinder itself.

The Eternal Cylinder is worth playing for its novelty alone, but there's far more to it than oddball gimmickry. It balances a compelling story with fun and intriguing mechanics, while the terrible might of the cylinder sticks with you long after the game has finished.

RICK LANE

Custom PC APPROVED

TREBHUM

+ Unique
+ Strong storytelling
+ Tense chases

TRÈS BUM

– Underwhelming controls
– Some poorly explored ideas

/ VERDICT

A fascinating design, The Eternal Cylinder blends unusual art and mechanics with a well-written story and heart-stopping chases.

OVERALL SCORE

83%

REALITY CHECK

Rick Lane physically crushes health potions in a virtual pestle and mortar, and looks at the prospect for HTC's new Vive Flow headset, in his latest VR roundup

REVIEW

SONG IN THE SMOKE / £22.99 inc VAT

DEVELOPER 7-bit / **PUBLISHER** 7-bit

Song in the Smoke is a spooky prehistoric survival sim revolving around a wonderfully physical crafting system. You play a strapping hunter-gatherer exploring a linear sequence of otherworldly open-ended levels. The broad goal of each level is to find three 'Song Stones' that summon a supernatural beast you need to battle in order to progress.

As with most survival games, you need to gather resources such as wood, stones and herbs and combine them to create useful items. However, where Song in the Smoke stands out is in the way it uses VR to bring physicality into the system.

To make a health potion, for example, you don't simply select the relevant herb and press a button. Instead, you place the herb into a mortar and pestle, physically crush it into a liquid, and then raise the bowl to your face to 'drink' it. It's one of the few crafting games to properly simulate craft, which makes interacting with its world much more tangible and rewarding.

It also makes you more attached to your equipment. Losing an arrow in a bush is a painful experience when you've whittled down the stick, attached the stone arrowhead and added the fletching by hand. There are only around 20 items to craft, but given the processes involved in making each one, that's more than sufficient.

The game's physical survivalism doesn't end with crafting. You need to hunt animals for meat with a bow and arrow, then rather gruesomely pull out the cuts of meat you want from the corpse. To build a fire, you physically throw logs into a pit, which you can then use to cook the meat. Build your fire too small at night, and not only might you succumb to cold, but you may also receive an unwanted visit from strange creatures going bump in the night. Hunger and fatigue are also constant threats, so you must capitalise on every waking moment, scavenging for supplies and keeping yourself healthy.

While the game's hunting and gathering systems are strong, it's less gripping during combat. Fighting one of the game's many beasts involves monotonously whacking them on the head until they fall over, which is effective if not particularly gratifying. The systems do most of the game's legwork too – the story is light and fragmentary, with most of the context for your adventure delivered through dreamlike cutscenes interspersed between levels.

Yet the thinly sketched plot only adds to Song in the Smoke's eerie primordial atmosphere. This survival sim is undoubtedly one of the better VR games of this year, offering a unique suite of mechanics and enough flesh on the bone to keep you occupied for a good 15-20 hours.

PRIMAL

- \+ Excellent crafting
- \+ Pleasingly physical survival
- \+ Tense and spooky atmosphere

PRIMITIVE

- – Thin story
- – Rudimentary combat

VERDICT

Song in the Smoke is a smart and stylish VR survive 'em up with one of the best crafting systems around.

OVERALL SCORE

82%

NEWS

AFTER THE FALL

From the creator of popular VR game Arizona Sunshine, After the Fall is a cooperative zombie-blasting action game in which four players team up in an alternate 1980s LA, where the apocalypse happened 20 years before. Not only is the City of Angels frozen over like a giant, celebrity-filled ice rink, but the streets are also prowled by the undead.

After the Fall is essentially a cooler, VR version of Left 4 Dead. Players assume the role of 'Runners' working together to complete missions, while battling hordes of zombies known as 'Snowbreed', alongside 'Special' undead enemies that have unique powers, plus a handful of towering boss enemies. Although the game aligns itself closely with Valve's classic, there's a handful of minor differences, such as zombies being able to crawl across ceilings.

The main question is whether the game's four-player coop mode is realistic or not. We'd struggle to find one other person with whom to play a VR multiplayer game, let alone three, and it doesn't seem like the kind of experience you'd want to play with random Internet folk. Left 4 Dead was always better with friends, and there aren't many people with three other pals equipped with VR rigs.

Still, Vertigo has already established a VR following through Arizona Sunshine, so After the Fall's cooperative ambitions may be more feasible than they initially seem. The game is scheduled for release on Steam VR, Oculus Rift S and Oculus Quest 2 at the end of the year, with a Quest 1 version coming in 2022. CPC

NEWS

VIVE FLOW

HTC has announced the Vive Flow, a new standalone headset that's a little different from the company's usual fare. Unlike bulkier, gaming-focused headsets, the Flow is a compact and lightweight device apparently designed for wellbeing and social interaction. Instead of being a large box that hangs off your face, the Flow is essentially an extra-thick pair of glasses, sitting over your ears with arms that can fold away. Weighing just 189g, it's lighter than any other major VR headset.

The Flow's twin lenses have a 3.2K resolution, which likely translates to 1,600 x 1,600 pixels per eye (HTC has yet to confirm the ppi resolution), combined with a 75Hz refresh rate and a field-of-view of 100 degrees. The headset doesn't require a connection to a PC but relies on an external battery pack for power.

HTC states that the Flow is intended for 'wellbeing, brain training, productivity and light gaming'. Given examples of its function include the mindfulness app Tripp, VR videos and the company's social interaction app, Vive Sync. The company doesn't explain what 'light gaming' means, but we're guessing you won't be able to play Half-Life: Alyx on it.

Priced at $500 US, the Flow is considerably cheaper than HTC's other headsets, but still more expensive than the more versatile Oculus Quest 2, which has the same abilities but also has enough power for proper gaming. The Flow's success will likely hinge on the additional comfort and convenience offered by its design, but it's interesting to see HTC pivoting towards a more universal headset design, potentially indicating the growing mainstream appeal of VR.

INTEL ALDER LAKE UPGRADE GUIDE

WITH NEW CPUs, NEW MOTHERBOARDS AND EVEN NEW MEMORY TRYING TO TEMPT YOU THEIR WAY, ANTONY LEATHER GUIDES YOU THROUGH THE PROCESS OF UPGRADING TO ALDER LAKE, WHATEVER YOUR BUDGET

If you're building a new PC or upgrading from one that's several years old, Intel's new 12th-gen 'Alder Lake' CPUs are the logical choice. They're the fastest CPUs for mainstream desktop PCs, they're fantastic for gaming and they're adept at multi-threaded content creation too. The new LGA1700 socket also provides a modicum of futureproofing, while AMD's Socket AM4 will likely be phased out when Zen 4 CPUs arrive next year. Conversely, there's at least another generation of CPUs planned for Z690 motherboards in the future.

Upgrading to Alder Lake isn't without its issues though. You have the option of DDR5 memory, but you can also use current DDR4 memory with select motherboards, potentially saving hundreds of pounds. We'll be looking at the differences in performance between DDR4 and DDR5 in this feature. You'll also need to make sure your cooler is compatible. The new LGA1700 socket has wider-spaced mounting holes that don't line up with LGA1200 and LGA115x holes, meaning you'll need an adaptor kit or a new cooler.

However, some manufacturers, such as Asus, have included both LGA1200 and LGA1700 socket mounting holes on their motherboards, potentially allowing all coolers to fit them.

We'll be investigating whether this is a good idea, especially as the CPU-Z height is now lower thanks to a thinner die. While we're on the subject of cooling, we'll also be looking at what level of cooling you need for each of the new CPUs and whether some situations might mean the monstrous Core i9-12900K flagship is off-limits.

We've also included an upgrade flowchart. Whatever current hardware you own, and whether you're building a whole new PC or transplanting older hardware, this chart will take you through building your ideal Alder Lake PC for as little money as possible, avoiding potential compatibility issues and suggesting potential upgrades. Finally, we'll be building our own awesome Alder Lake PC to give you an example of how it's done.

COOLING ALDER LAKE

COOLING ALDER LAKE

There are two issues when it comes to transplanting your existing cooler or buying a new one, when it comes to Alder Lake. The first is that the LGA1700 socket's mounting holes sit wider apart than on previous Intel mainstream sockets, meaning some kits simply won't fit, especially if they rely on fixed backplates. Even if you can tweak your cooler to fit the new mounting holes, or in the case of some Asus Z690 motherboards, use LGA1200 mounting holes, the CPU height has also changed.

The latter means that many mounts might not apply the right pressure, even if your cooler is otherwise compatible. We confirmed this with one of our NZXT coolers, which had much poorer temperatures with its LGA1200 mount kit than with the LGA1700 adaptor kit.

Some Asus motherboards have both LGA1200 and LGA1700 cooler-mounting holes

This means you'll need to do some investigative work to make sure your new CPU is cooled properly and that your cooler is working effectively. Thankfully, many cooler manufacturers are offering free cooler adaptor kits, while others will ship them for a small fee. You need to check your cooler manufacturer's website for details on how to obtain one.

Many mounts might not apply the right pressure, even if your cooler is otherwise compatible

Many big cooler manufacturers have some of their coolers built by Asetek, and if yours is one of them, you can bypass the cooler manufacturer and get an Asetek adaptor kit within a day or two from **overclockers.co.uk** for £4 inc VAT plus delivery.

This adaptor kit includes a replacement backplate, mounting screws and mounting plate and may well be a quicker option than getting one from the manufacturer. Similarly, Noctua's LGA1700 kits are also available for a small fee from retailers including **overclockers.co.uk**, as well as for free from Noctua itself.

The Asetek LGA1700 adaptor kit

Another important factor is compatibility with new coolers. Sadly, all the coolers we've reviewed up to this point haven't included LGA1700 components, and coolers are still being sold that lack compatibility. This will likely see a lot of disappointed people when it comes to building their PCs, so if you're buying a new cooler, make sure it's LGA1700-compatible or ensure you've ordered the correct adaptor kit to go with it.

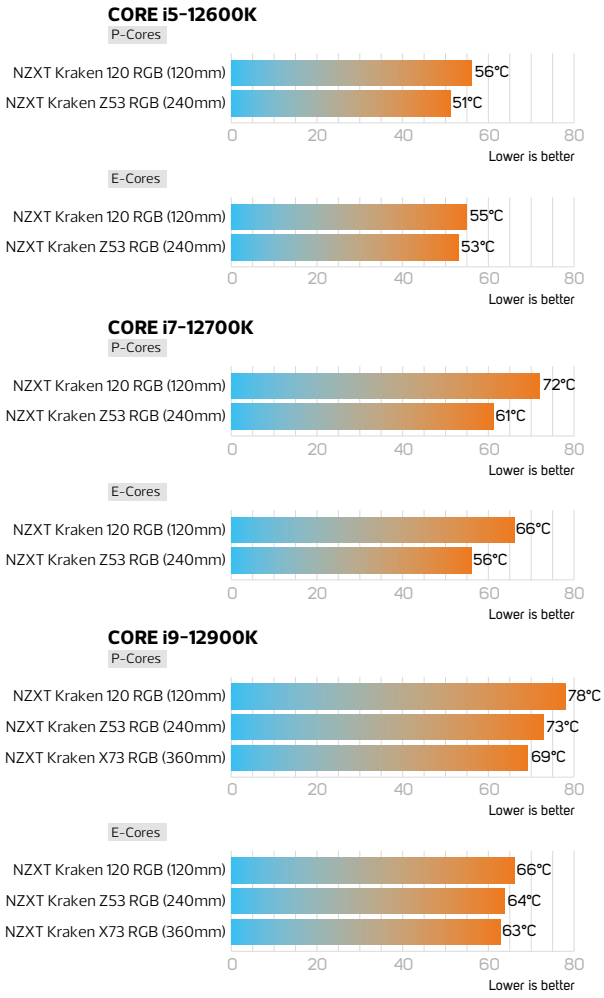
COOLING REQUIREMENTS

There's a big difference between the thermal output of the Core i9-12900K and Core i5-12600K. We're still waiting for our air cooler adaptor kits to arrive, but we've tested the CPUs with a selection of AIO liquid coolers, in order to gauge the size of radiator you ideally need to cool Intel's 12th-gen CPUs.

Cooling performance is important, of course, but so is noise. We want to establish whether you actually need large radiators to keep noise to a minimum, or whether a modest cooler can actually handle the temperature and provide some headroom

NZXT's Kraken coolers work well on LGA1700 as long as you have the correct mounting kit

AVERAGE CPU TEMPERATURE RESULTS



An NZXT cooler with an Asetek LGA1700 adaptor

for overclocking, as well as keeping decibels in check. To get an understanding of this situation, we've tested the Core i5-12600K, Core i7-12700K and Core i9-12900K using a variety of NZXT AIO liquid coolers.

The 120mm Kraken 120 RGB and 240mm Kraken Z53 RGB have been pitched against all three CPUs, while we also added a 360mm Kraken X73 RGB to the mix when cooling the Core i9-12900K, as this CPU generates considerably more heat than the other two.

A cooler with a larger radiator could gain you decent cooling at lower noise levels, although there are obviously slight differences in pump and radiator performance between the three coolers, despite the fact they're all made by NZXT.

We've used a mixture of adaptor kits to get them to work, with the Kraken Z53 RGB and Kraken X73 RGB working with the standard Asetek adaptor kit, while the Kraken 120 RGB required slightly different components that will, according to NZXT, be included as standard by the time you read this feature.

The NZXT Kraken 120 RGB has a single 120mm fan and a 120mm radiator, so it will perform similarly to a decent mid-range air cooler, giving you an indication of how an affordable air cooler will perform when cooling an Alder Lake CPU.

The Kraken Z53 RGB's 240mm radiator and powerful pump will perform at the upper end of the cooling scale, while the 360mm Kraken X73 RGB will probably slightly better it at lower noise levels – that's potentially useful for keeping a Core i9-12900K in check without making an irritating racket.

COOLING THE CORE i5-12600K

Starting with the Core i5-12600K, this CPU doesn't need a hefty cooling setup to get the most out of it or keep it cool. Even with the modest Kraken 120 RGB, the P-Cores were kept at an average of 56°C under full load in our ten-minute stress test, with the E-Cores sitting at 55°C.

This is clearly more than enough cooling power to deal with the CPU and provide plenty of overclocking headroom. The cooler remained quiet here too, with the PWM-controlled fan and pump not even spinning up to full speed, which by default, our EFI initiates at around 65°C.

Stepping up to the 240mm Kraken Z53 RGB saw the CPU temperature fall from 56°C to 51°C for the average P-Core reading, but just 2°C for the E-Core temperature. The Kraken 120 RGB was already very quiet under load, so it will suffice for the vast majority of people, even if you want to overclock your CPU.

The bigger cooler did offer lower temperatures and slightly lower noise levels, but only if we switched to Silent mode using the software and its USB interface. Needless to say, there's no point opting for a 360mm radiator AIO liquid cooler or custom water cooling with the Core i5-12600K, as it's easily tameable with modest cooling, especially at stock speed.

COOLING THE CORE i7-12700K

With lower frequencies and fewer E-Cores than the Core i9-12900K, the Core i7-12700K is potentially a lot easier to cool than Intel's Alder Lake flagship.

The 120mm Kraken 120 RGB saw an average P-Core temperature of 72°C and E-Core average of 55°C, which was reasonable and clearly offered a degree of overclocking headroom, although the fan had to spin up to higher speeds than with the Core i5-12600K, producing more noise as a result.

The NZXT Kraken 120 RGB

NZXT's Kraken Z53 RGB

Stepping up to the 240mm Kraken Z53 RGB saw a big improvement, with the average P-Core temperature falling from 72°C to 61°C and the E-Core average from 66°C to just 56°C. Clearly, if you'll be putting your Core i7-12700K under sustained heavy loads, it will quickly saturate a smaller cooler with heat, driving its fan up to full speed quite quickly.

The Kraken Z53 RGB, though, was quieter and far cooler thanks to a bigger radiator and coolant capacity, offering significantly more overclocking headroom and better cooling at lower noise levels.

COOLING THE CORE i9-12900K

Finally, there's the Core i9-12900K, which dishes out the most heat with its eight P-Cores and eight E-Cores. We'll start by making some more comments on overclocking, having had more time to play with it since last issue and, really, we don't think overclocking is worth it.

There's very little overclocking headroom, especially compared with the Core i5-12600K, and performing an all-core overclock drastically increases power consumption and temperatures for little gain.

Even with the modest Kraken 120 RGB, the P-Cores were kept at an average of 56°C under full load

The end result is that modest coolers can certainly cope with the Core i7-12700K, and 120mm AIO liquid coolers can handle it at stock speed and even with a modest overclock, but a larger cooler will definitely help to extend overclocking headroom and allow you to achieve lower temperatures at quieter noise levels.

Thankfully, it's still really fast at stock speed, but what cooling power does it require? We decided to try the Kraken 120 RGB again, since it coped with both the Core i5-12600K and Core i7-12700K reasonably well. We saw a peak P-Core average temperature of 78°C and E-Core average of 66°C on the Core i9-12900K, which are within limits, but not exactly cool.

The fan and pump were also running flat out to deal with the heat, although this was in Prime95's smallest FFT test loading all 16 cores, therefore generating far more heat than your typical gaming session.

Moving on to the 240mm Kraken Z53 RGB saw the temperature fall by 5°C on the P-Cores and 2°C on the E-Cores, but it was the NZXT Kraken X73 RGB that produced the best result, seeing the P-Core average temperature fall to 69°C with the E-Cores averaging 63°C. The largest cooler also produced considerably lower noise levels than the Kraken Z53 RGB, which had to ramp up its fans and pump full speed after 20 seconds or so.

The Core i9-12900K is a toasty customer, and while a 120mm AIO liquid cooler can cope with its needs, it will need to run flat out and temperatures could get very toasty on hot days. A 240mm AIO liquid cooler offers more comfort, but a 360mm cooler will give you the best balance of noise and cooling.

NZXT's Kraken X73 RGB

DDR4 VS DDR5

Motherboard manufacturers have plenty of DDR4-based Z690 motherboards available, although they tend to be at the lower end of the spectrum

If you read our Alder Lake coverage last issue, you'll know that Intel's new chipset and 12th-gen CPUs don't just bring a new CPU socket, but also new memory in the form of DDR5. It offers higher frequencies and greater bandwidth than DDR4, as well as on-board voltage control and more besides.

However, as with any new technology, there are teething issues and early DDR5 kits have quite high timings for starters, plus they're only available in very small quantities at the moment. There's also the fact that faster kits will be launched in the near future, as we learned last month in our Q&A with memory manufacturer Kingston.

If you're looking to buy a premium motherboard, then you may well have to opt for DDR5 memory regardless, as DDR4 options are usually only available at the cheaper end of the scale. Taking this route would likely offer the best degree of futureproofing too, since you'll likely be able to transfer your new memory kit to future Intel and AMD systems, but for now, you'll have to pay more money for it.

A Corsair DDR5 module (top) and a DDR4 module (bottom)

For example, a 32GB Corsair Dominator Platinum RGB 3600MHz kit currently costs £180 inc VAT, while the similar kit in DDR5 form at 5200MHz will set you back £290.

Below we've carried out a series of tests across all three CPUs in an Asus ROG Maximus Z690 Apex and TUF Z690-Plus WiFi D4 motherboard. The former is DDR5-enabled and the latter still limited to DDR4, so we can see if either offers tangible benefits over the other and whether you should think twice about splashing out.

Starting with the Core i9-12900K, our image editing test, which stresses single-threaded performance, offered a small advantage with DDR5, with a score of 80,694 vs 80,011, and another small gain in our heavily multi-threaded video encoding test, which rose from 1,101,433 to 1,110,719 when shifting to DDR5. It's not a massive difference, but DDR5 is slightly faster nonetheless.

If you're looking to buy a premium motherboard, then you may well have to opt for DDR5 memory regardless

However, the multi-tasking test was slightly slower, even if the overall system score gave a slight advantage to DDR5. Far Cry 6 again saw a small advantage with DDR4 on this CPU, but only on the average frame rate, which rose from 137fps to 140fps. In Cinebench, the score again rose slightly from 27,292 to 27,407. Overall, there are slight improvements, but nothing worthy of the upgrade cost.

The Core i7-12700K mirrored the Core i9-12900K's RealBench results exactly, with

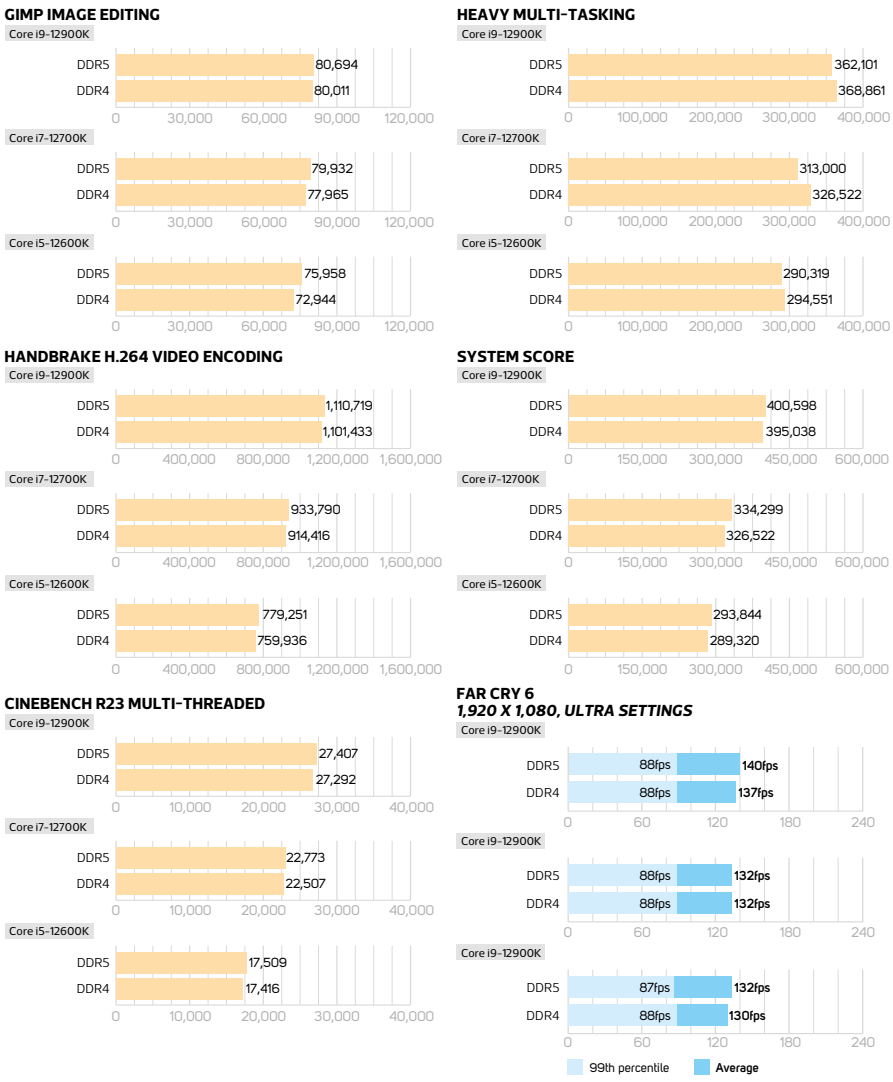
Transplanting your old DDR4 memory into a new Z690 motherboard could save you lots of money

DDR5 offering a slight upshift in the image editing test and video encoding test, and in the system score, but similarly saw a lower multi-threaded score with DDR5 memory. Cinebench again saw a slightly higher result with DDR5 memory, but practically within the margin of error at 22,773 vs 22,507. Finally, Far Cry 6 offered no benefit, with the exact same 88fps 99th percentile and 132fps average being obtained from both systems.

The same trend was shown by the Core i5-12600K, with the DDR5 system offering a lower DDR5-based multi-tasking result in RealBench, while the rest of the scores were slightly higher.

Cinebench saw less than a 100-point improvement with DDR5 over the DDR4 system's 17,416 score and Far Cry 6 performance was nearly identical too, with 1fps lost to DDR5 on the 99th percentile frame rate and 2fps gained on the average frame rate.

DDR4 VS DDR5



THE VERDICT

It seems that, for the moment, DDR5 offers little benefit in performance in everyday software, at least in the benchmarks we've used here.

There are slight gains from using DDR5 over DDR4 in most tests, but it's very clear that, given the current pricing, it's not really worth opting for DDR5 right now. The main reason to buy it, as we mentioned earlier, is if you've fallen in love with a particular motherboard that's DDR5-only.

Even if you were buying and building a new PC, we'd still lean towards DDR4 at the moment, until the price of DDR5 memory comes down. When we wrote this, we couldn't find any DDR5 kits in stock anywhere either.

A 32GB Corsair Dominator Platinum RGB 5200MHz DDR5 kit currently costs £290

WHAT ABOUT XMP 3.0?

One DDR5 memory feature we've yet to try is XMP 3.0. The new DDR5 memory modules have extra space on-board that can be used for additional memory profiles, such as the ones you see when you select XMP in your motherboard's BIOS. With XMP 3.0, there's space for more profiles, including those you create yourself.

For example, if you want to create your own profiles with higher frequencies or lower timings, you can do this from the EFI, Intel's XTU software or memory manufacturers' software, such as Corsair's iCUE. You can even load profiles in real time in Windows, perhaps when a specific program is launched.

Sadly, XMP 3.0 isn't up and running yet, so we were unable to test it here, but according to Corsair, it should be working on select motherboards and its iCUE software by the end of this year (2021). It does look as though this feature will be more useful to extreme overclockers than typical end users, but we'll have to wait and see.

RECOMMENDED UPGRADE GEAR

Each of Intel's new CPUs has its own merits, but all are great choices whether you're looking for an awesome gaming system, content creation monster or a mix of both. If you're looking to upgrade, here are three component packages we've used that we can recommend.

UNDER £600

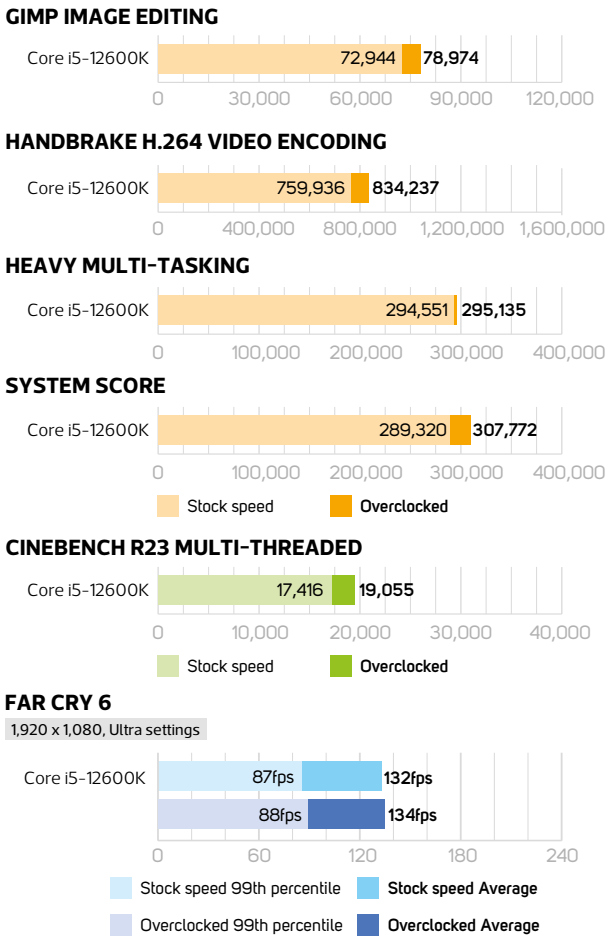
The Core i5-12600K's value and prowess are unmatched in its price range at the moment, making it the go-to CPU if you have around £300 to spend. We were amazed at how much more multi-threaded performance it offered compared with the Core i5-11600K and it even beats the Ryzen 7 5800X in plenty of instances too.

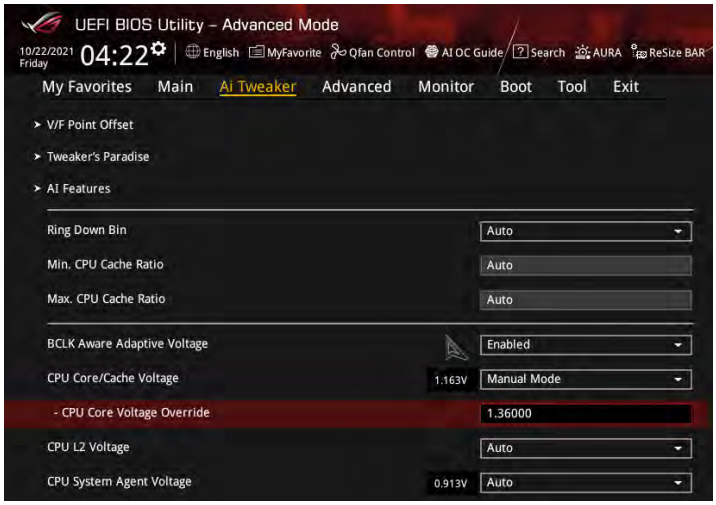
Critically, though, while it packs enough of a punch to be a great all-rounder, its gaming performance was so close to the Core i9-12900K that only a very high-end GPU would stand a hope of edging out a noticeable lead with the more expensive CPU.

As a result, the Core i5-12600K is great for the full spectrum of gamers, while the Core i5-11600K was decidedly mid-range. However, you'll need a new motherboard, and these aren't cheap at the moment.

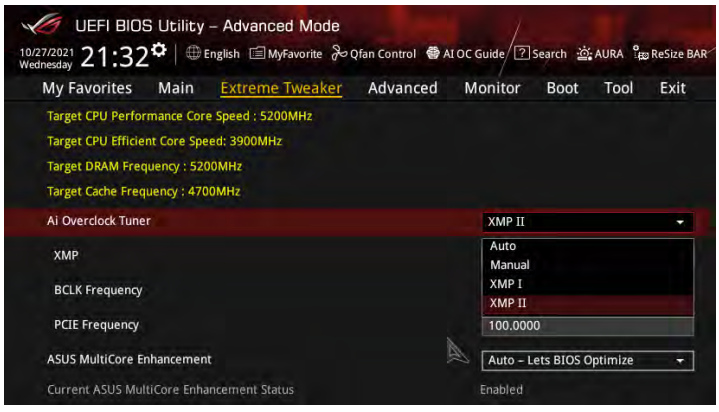
We've opted for the Asus TUF Gaming Z690-Plus WiFi D4 motherboard for our Core i5 bundle. It looks great, has plenty of features including on-board WiFi, decent cooling for the VRMs and your M.2 SSDs as well as a generous total of seven fan headers. You can also transplant your DDR4 memory from an existing system, if you have one, to save yourself some money.

CORE i5-12600K UPGRADE PERFORMANCE





Set a vcore of 1.36V in the CPU Core Voltage Override section



Make sure you set your XMP profile in the motherboard's EFI

WHAT TO BUY

Core i5-12600K
£280 inc VAT / overclockers.co.uk

Asus TUF Gaming Z690-Plus WiFi D4
£260 inc VAT / ebuyer.com

TOTAL: £540 inc VAT

COOLING AND MEMORY

We're assuming you have some DDR4 memory to transplant from an existing system here, but if not, we can recommend 16GB of Corsair's 3200MHz Vengeance Pro RGB memory, which costs around £77 for a dual-channel (2 x 8GB) kit. In terms of CPU coolers, we've been very impressed with NZXT's Kraken 120 RGB. It costs under £80 and we're happy to recommend it.

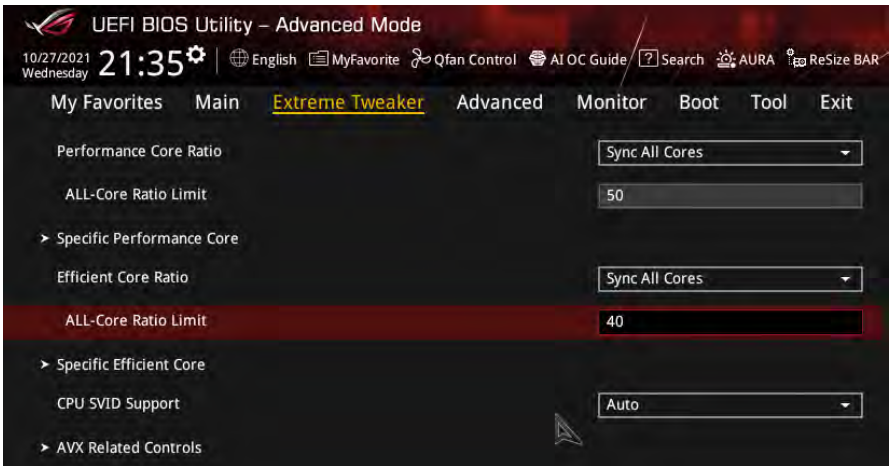
SETUP AND OVERCLOCKING

Unlike the Core i9-12900K, the Core i5-12600K does respond well to overclocking, gaining on both all-core and single-core boosts on both its P-Cores and E-Cores. We managed to hit a frequency of 5GHz across all its P-Cores and 4GHz on all of the E-Cores, using a vcore of 1.36V, and we found that the CPU was still fairly easy to cool.

All CPUs are different, though, so we suggest starting with a P-Core all-core frequency of 4.9GHz and E-Core frequency of 3.9GHz at that voltage, then try for higher settings. Also, make sure your XMP profile is set in the BIOS and, to be on safe side, also set the memory frequency to its correct speed – in this case 3200MHz.

UP TO £1,000

Intel's Core i7-12700K is a beast of a CPU across the board, offering more performance



Set the Performance Core Ratio's ALL-Core Ratio Limit to 50 to overclock the P-Cores to 5GHz, and set it to 40 in the Efficient Core Ratio to overclock the E-Cores to 4GHz

than the Ryzen 9 5900X for less cash and extending its multi-threaded prowess so far that it not only annihilates Intel's previous mainstream CPUs, but even snaps at the heels of the Ryzen 9 5950X on occasions.

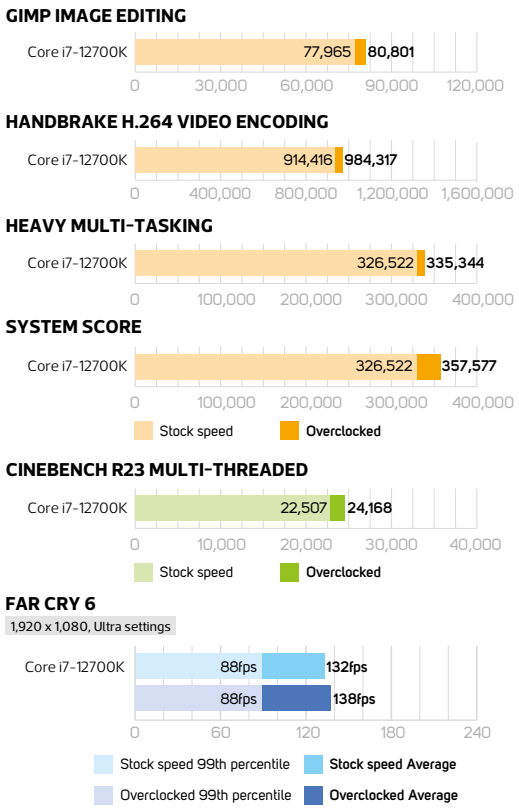
Bear in mind, though, that the Core i7-12700K doesn't offer noticeably better gaming performance than the Core i5-12600K – a reason why the latter CPU offers such fantastic value, so this CPU is only for people who want more multi-threaded grunt than the Core i5 can offer, but can't spend another £200 on the Core i9-12900K.

Given that large price difference, we suspect many Core i7-12700K owners will be erring on the side of caution when it comes to their wallets and opting for more affordable DDR4 memory and motherboards, perhaps transplanting their current DDR4 memory kit too. You might want to go all-out and invest in a premium motherboard and DDR5 memory, but the latter won't offer much extra performance, even if it's a necessity in order to get you a lavish motherboard.

For the latter, we recommend the Asus ROG Maximus Z690 Hero. This is the most high-end and feature-packed Hero board we've seen from Asus by far, but it will result in our upgrade price ballooning to £920. We recommend pairing it with Corsair's 5200MHz Dominator Platinum RGB kit. This 32GB kit will cost £290 inc VAT when it eventually becomes available from **corsair.com/uk**, but a 16GB kit will suffice for most of us and should retail for around half that price.

However, for our recommended CPU and motherboard here, we'd go for a DDR4 setup. It makes the most sense if you're looking to rein in your spending by going for the Core i7-12700K and here, we'd again recommend going with the Asus TUF Gaming Z690-Plus

CORE i7-12700K UPGRADE PERFORMANCE



WiFi D4. This motherboard makes for a solid base for a high-end system, with plenty of M.2 ports and fan headers, plus it costs half the price of the ROG Maximus Z690 Hero.

WHAT TO BUY
Core i7-12700K
£400 inc VAT / overclockers.co.uk

Asus TUF Gaming Z690-Plus WiFi D4
£260 inc VAT / ebuyer.com

TOTAL: £660 inc VAT

SETUP AND OVERCLOCKING
We managed to overclock the Core i7-12700K to the same level as the Core i5-12600K, hitting 5GHz on all the P-Cores and 4GHz on all E-Cores with a vcore of 1.36V. You can follow the instructions in the previous section to achieve the same result.

However, we didn't see much of a boost over stock speed on this CPU. As a result, we suggest leaving this CPU stock speed, where it will draw less power and be easier to cool, but yours may fare better than ours so it's always worth a go. Again, make sure your XMP profile is set in the EFI and, to be on safe side, also set the memory frequency to its correct speed.

COOLING AND MEMORY
As with the Core i5 system, DDR4 memory is a great transplant you can make from your existing rig if you have some, but if not, we can recommend snapping up 16GB of Corsair's 3200MHz Vengeance Pro RGB memory, which costs around £77 inc VAT for a dual-channel kit.

Our recommended cooler is a 240mm AIO liquid cooler such as NZXT's Kraken Z53. This offered significantly better cooling and lower noise under sustained heavy loads than the NZXT Kraken 120 RGB.

I WANT THAT CORE i9 AND DDR5!
It's easy to look past the fact that Intel's Core i9-12900K is right up there as one of the most powerful desktop PC processors ever made, matching or bettering the more expensive Ryzen 9 5950X and Core i9-10980XE in multi-threaded tests. What's more, unlike Intel's HEDT CPUs, it also has fantastic single and lightly threaded performance, plus top-notch frame rates in games.

Even so, it still costs £600, and when you're paying this amount of money for a CPU, you may well want get every last drop of performance out of it as possible, and get a feature-rich system.

That's not to say you can't run it on an Asus TUF motherboard with DDR4 memory from your old system – you can do that and still build a PC that's nearly as fast as one with all the latest bells and whistles.

Our pick, though, would be to go all-out with this CPU and opt for the amazing Asus ROG Maximus Z690 Hero. It's not a cheap motherboard, but its lavish cooling, huge storage potential, high-end enthusiast features, as well as its features for gaming and content creation, make it a great partner for Intel's top-end Core i9-12900K if you want to go all out on your brand new machine.

WHAT TO BUY
Core i9-12900K
£600 inc VAT / ebuyer.com

Asus ROG Maximus Z690 Hero
£520 inc VAT / scan.co.uk

32GB Corsair 5200MHz Dominator Platinum RGB DDR5
£290 inc VAT / corsair.com/uk

TOTAL: £1,410 inc VAT

SETUP AND OVERCLOCKING
We've come to the conclusion that overclocking the Core i9-12900K simply isn't worth it, seeing as we were barely able to squeeze any more frequency out of the P-Cores or E-Cores, and that doing so massively increased the power consumption and heatload.

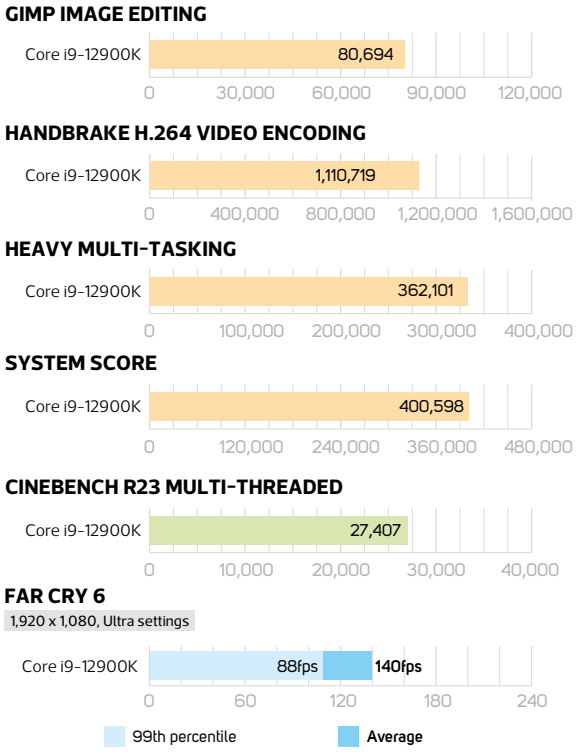
Unless you bag an exceptional example and can overclock the P-Cores to 5.2GHz or more, we recommend sticking to stock speed. Even then, this CPU's lofty boost frequencies mean it still outstrips both the other 12th-gen CPUs, even when they're overclocked.

To set up your system, you just need to head into your motherboard's EFI, apply the XMP memory profile, as for the other CPUs, and manually set the memory frequency of the DDR5 memory to 5200MHz.

COOLING
You have a few options for cooling. If space is limited, perhaps in a small form factor PC, and you only have space for a 120mm AIO liquid cooler, then NZXT's Kraken 120 RGB did manage to keep this CPU in check, albeit with relatively high noise levels under load.

However, a 240mm cooler such as the NZXT Kraken Z53 RGB does a much better job and at lower noise levels, and our top recommendation is to use a 360mm cooler, such as the NZXT Kraken X73, which offered cooler temperatures and quieter noise levels, thanks to its bigger radiator.

CORE i9-12900K UPGRADE PERFORMANCE



ALDER LAKE UPGRADE FLOWCHART

With choices to be made about your memory, motherboards and cooler, and different people coming from various positions in terms of hardware they already own, we'd forgive you for being a tad confused when it comes to upgrading to Alder Lake.

Thankfully, our testing this month and experience with Alder Lake so far has enabled us to create a flowchart, which you can follow to help guide you on your path to building your deal Alder Lake PC.

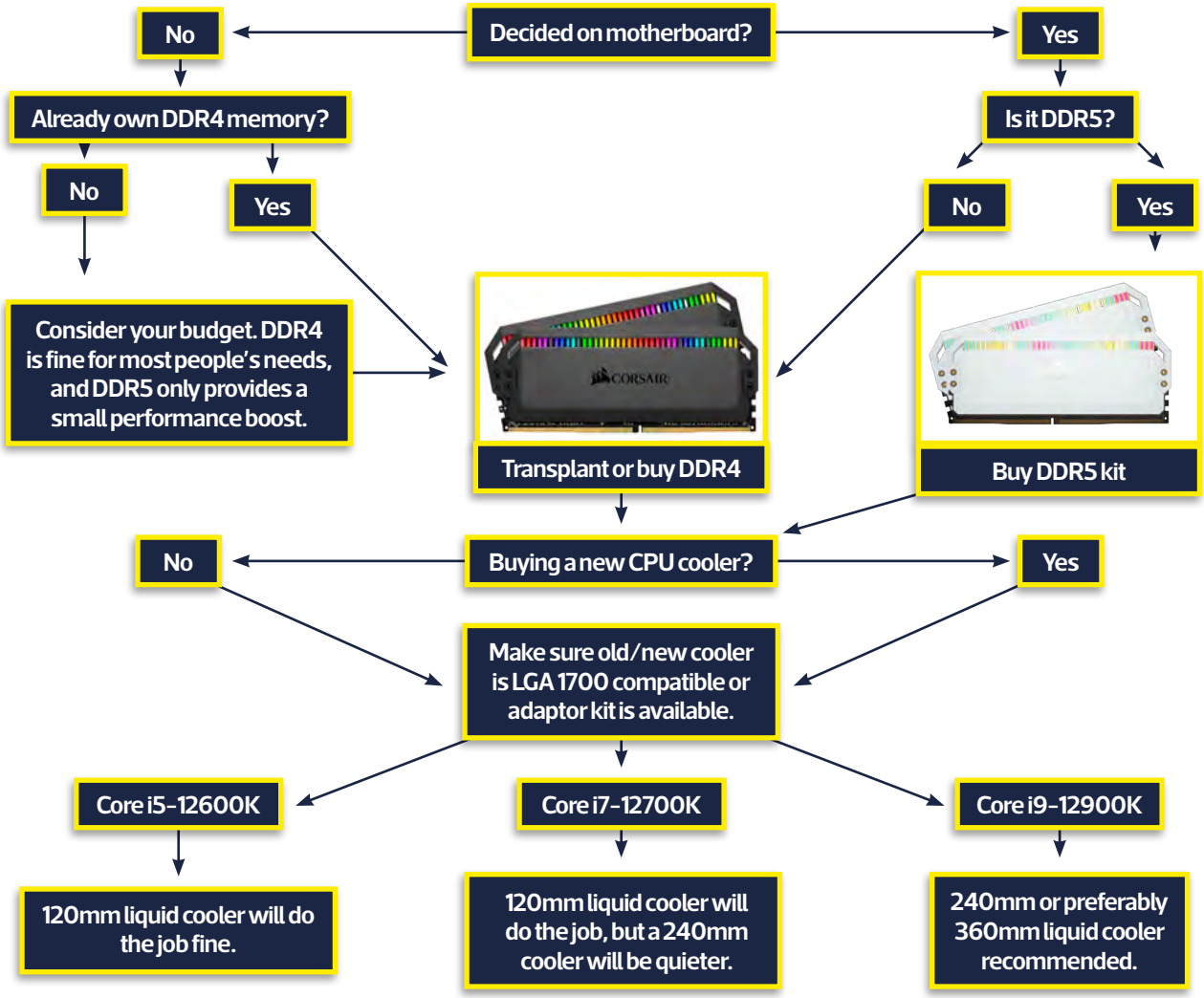
The chart takes into account whether you're looking to buy a specific motherboard, as well as whether you want to keep the budget as small as possible. You can also use it to decide whether to go with DDR4 or DDR5, how to avoid cooler compatibility issues and also make sure you get the right cooler for your CPU.

OTHER OPTIONS

To avoid making the chart too complicated, we've omitted some components, as they're not likely to require Alder Lake-specific choices. For example, you can use a SATA-based hard disk or SSD on Z690 motherboards, but we recommend buying a new M.2 NVMe PCI-E 3 or PCI-E 4 SSD if you don't already have one, which can greatly increase sequential read and write performance.

Your GPU might be a trickier upgrade since prices are still sky-high, but the new PCI-E 5 interface included with Z690 motherboards currently offers no real-world benefits, since no SSDs or graphics cards exist that can take advantage of it yet.

If you have an existing PC that's only a couple of years old, then its case and PSU will probably also do the job fine. Alder Lake doesn't consume significantly more power or output more heat than previous equivalent mainstream desktop CPU generations. As such, a PSU for a Ryzen 7 3800X or Core i7-9700K system will also be fine for a Core i7-12700K system.



BUILDING AN ALDER LAKE PC

Once you have all the components you need, you can follow this guide to make sure you get it right. We've picked a few choice components for our Core i9-12900K example system, such as WD's 1TB SN850 Black M.2 SSD, an NZXT 510 Flow case and NZXT Kraken Z53 cooler, along with a Corsair RM850X PSU and Nvidia GeForce RTX 3070 Ti Founders Edition graphics card.

For this guide, we're mainly focusing on aspects that make an Alder Lake build with one of our bundles different from builds you might have done previously. If you've never built a PC before, we recommend reading our 'Build a better PC guide' in Issue 215, which you can pick up from **custompc.co.uk/215**

1 Alder Lake CPUs are larger and heavier than previous mainstream desktop CPUs, so be careful when handling your new CPU and take care not to drop it onto the delicate socket pins on your motherboard.

2 We'll be installing the radiator in the front of our case, so start by removing the fan already located there. Don't chuck the fan away just yet, though, as there's a spare slot in the roof of the case for it.

3 The Asetek LGA1700 adaptor kit we've purchased separately from **overclockers.co.uk** has a different backplate for the NZXT cooler, so fit this first and make sure you don't mix up the new parts with the original ones that came in the box.

4 Next, fit the LGA1700 pump bracket. This has oval holes instead of the two slots you'll see on the standard bracket. This setup allows the mounting pins for the new socket to fit properly, which won't happen if you use the original bracket designed for LGA1200 motherboards.

5 Next, install the pump and connect its cables. You need to deal with quite a few wires with this one, as there's software control for the lighting, pump and fans via a USB cable, and you also have cables to power the components themselves.

6 It's best to install the memory after you install the pump, as it will give you more room to work when you're securing the

thumbscrews. The modules for DDR5 still have the familiar notch in their base, so you can only install them the correct way around. As usual, you need to use slots two and four to enable dual-channel mode.

7 On the ROG Maximus Z690 Hero, only two of the M.2 slots support PCI-E 4 SSDs, and we've picked the lower one of them, as it has a larger heatsink. Plus, as it's further away from the graphics card, it's easier to access and will run cooler too.

8 Install the motherboard into the case, then lift the radiator into position in the front fan mounts. There's only one position in which it can be installed, so line up the holes with the fans and then use the included long screws to secure the fans to the radiator, passing through the fan-mounting holes in the case.

9 It's important to orientate the components correctly, or air can get trapped in the pump, increasing noise and potentially impacting cooling performance. Ideally you want the radiator above the pump or, at the very least, have the end section of the radiator above the pump, so air gets trapped there. It might not look as neat, but your cooler will work better.

10 With the motherboard installed, reinstall the front fan you removed earlier into the top fan mount. It fitted fine here and will provide extra airflow, helping to cool the VRMs on your motherboard.

11 The side-mounted power sockets on RTX Founders Edition cards can be annoying when it comes to cable tidying, but thankfully you can improve the situation a little by using a custom cable. We found replacement 12-pin to dual 8-pin cables on Amazon for around £15 and can highly recommend them.

12 Connect the cables you'll need to the PSU and leave the rest in the box. The case does a great job of hiding these cables, so there's little point in buying a custom cable set, except for the graphics card's connector, which is very much on show.

13 As usual, when you power on your PC, check all the thermals are okay and follow our steps on the previous pages to get it set up. CPC

CUSTOM PC

CHRISTMAS WISH LIST

Pick out the perfect present for your tech-loving friends with our selection of the finest festive tech treats. Whether you're looking for a low-cost stocking-sized trinket or a big gift for a big occasion, we've got ideas for all budgets

STOCKING FILLERS

Small but perfectly formed, this list of stocking filler presents should all fit in most people's Christmas stockings – with a bit of stretching – and can be had for £30 or under

TOOLS OF THE TRADE

Having exactly the right tool for the job is essential, and there's no better place to start PC tinkering than with a good screwdriver in your hand. Most of the screws used in PCs – the ones used for motherboard mounts, expansion card slots, PSU mounts, fan mounts, cooler mounts and so on – use the Philips No.2 head.

A long-necked screwdriver is essential for reaching into your case's crevices. Our pick remains the Stanley FatMax 250mm PH2 model (£6.90 from **amazon.co.uk**), thanks to its good build quality and comfortable handle.

For the various smaller screws in your PC, such as the ones used to attach the arms to cooler mounts or hold down M.2 SSDs, you'll want a set of micro screwdrivers. For very little cash, you can pick up a basic set, such as this 11-piece RS Components own-brand set (£8.34 from **rs-online.com**).

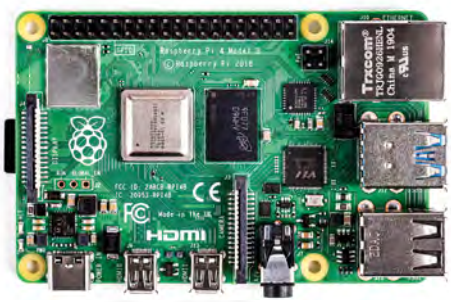
MINI COMPUTER

For the those that really like to tinker, an easily programmable mini computer, such as the Raspberry Pi 4 Model B (from £34 from **thepihut.com**) or Arduino Due (£34 from **store.arduino.cc**) can offer a great way to learn to code, engage kids with computers or just give you a way to finally work out how to catch those pesky house mice (**custompc.co.uk/Mice**). You can also help get your giftee started with a copy of The Official Raspberry Pi Beginner's Guide (£10 from **custompc.co.uk/PiGuide**) or Get Started with Arduino (£10 from **custompc.co.uk/ArduinoGuide**).

COOLING GOODIES

There are plenty of stocking-sized, affordable gifts that will help to improve your PC's cooling. One is an upgrade for the thermal interface material (TIM) of your CPU and other components that use heatsinks. Arctic Silver 5 (£6 from **overclockers.co.uk**) has been a favourite for many years and remains an excellent choice. Some TIM cleaning fluid, such as Arctic Silver's ArctiClean remover and purifier kit (£7 from **overclockers.co.uk**), for cleaning up your components before applying new TIM, is a great option too.

If your giftee is rocking a system with a lower-end CPU and a basic stock cooler, it's well worth upgrading them to a basic aftermarket CPU cooler. You might need to stretch the stocking a little to fit it, but the likes of the ARCTIC Freezer 7X (£18 from **scan.co.uk**) will lower CPU temperatures and noise levels in one fell swoop.



DESK DELIGHTS

Keeping your mouse's cable tidy and out the way when gaming is crucial, and the best way to do that is with a mouse bungee. The likes of the Endgame Gear MB1 and Glorious PC Gaming Race Mouse Bungee (both £14 from **overclockers.co.uk**) offer a particularly good balance of value and build quality.

Having ample light for your desk area is important too. While RGB LEDs are in components everywhere these days, they don't often help you see what's actually on your desk or help to reduce eyestrain from staring at a bright screen. As such, slapping a few lights around your desk can offer a great little upgrade. You can pick up RGB LED strips powered by USB and controlled with an IR remote for under £5 from **amazon.co.uk**

FUN FOR ALL

If your nerdier friends and family already have all the tech they need, here are a few on-brand gift ideas. On **gametee.co.uk**, you can find a range of DND-themed candles (from dwarven mead to dragon fire for £7 each), along with similarly themed dice sets (from £25) and t-shirts (£19).

MAIN PRESENTS

If your present buying budget is a little bigger, or you just like your giftee that little bit more, here are our picks for how to spend up to £200 on your friends, loved ones or maybe just yourself

PRO TOOLS

Starting off with the practical stuff again, if your giftee is looking for a complete electronics toolkit, the iFixit Pro Tech toolkit (£60 from **ifixit.co.uk**) includes a comprehensive micro screwdriver set that will get you into just about any electronic gear.

It also has all manner of prying tools for gently prising pieces apart, plus useful tweezers and other tools that generally make it easy to handle the tiny components once you've broken into your device.

A Dremel (£60 from **screwfix.com**) is another modder's dream toolkit addition. Whether you want to carve, engrave, cut or polish, these handy tools can do the lot. Need to cut your a fan blowhole, or get rid of that unneeded drive mount? It's a good old Dremel to the rescue.

BOOKS

For a bit of extra intellectual engagement, there are few better gift options than a book, and there are plenty of excellent options. For budding coders, there's Raspberry Pi Press' own Code the Classics – Volume 1 (£8 from **custompc.co.uk/CTC**) and Build Your Own First-Person Shooter in Unity (£10 from **custompc.co.uk/FPS**). If you love a bit of computing history, then you'll also love Tim Danton's The Computers That Made Britain (£10 from **custompc.co.uk/TCTMB**).

KEYBOARD

A keyboard upgrade is an ideal Christmas present. You get a big box to unwrap, and a good-quality keyboard will make for a genuine upgrade to your productivity, while adding extra ambience to the Christmas decorations with all that RGB backlighting!

If your budget's a little tight, you can opt for the winner of this month's budget gaming keyboard Labs test, the SteelSeries Apex 3 TKL. For under £50, you get a great-looking, compact keyboard with a clever multi-function volume wheel. For those with slightly larger budgets, the Corsair K70 Mk.2 (£150 from **scan.co.uk**) is our full-sized mechanical keyboard recommendation. It's stylish, packed with features and really well made.

AUDIO AUGMENTATIONS

A decent-quality gaming headset is a must-have for multiplayer gamers, and our current top pick is the Corsair Virtuoso RGB Wireless (£155 from **ebuyer.com**) or if money's a little tighter, there's the excellent Epos GSP 300 (£69 from **epos.com**).

Other worthwhile audio upgrades include a quality microphone, such as the superbly versatile and great-sounding Blue Yeti (£119 from **currys.co.uk**). Meanwhile, if your giftee is already well equipped on that front, you could always upgrade the audio capability of their gaming room with sound-deadening panels. You can pick up some generic foam panels from Amazon for under £50 or get the more stylish Wave Panels from Elgato (£110 for six panels from **elgato.com**).

GAMING MOUSE

The gaming mouse market has really come alive in recent years, with the latest models offering incredibly low weights, great designs and fantastic sensors. What's more, the latest wireless technology is now as good as wired, so you can get the freedom of no wires without giving up anything in performance.

A couple of our favourite wired models are the Glorious PC Gaming Race Model O (£52 from **overclockers.co.uk**) and Razer Viper 8K (£60 from **currys.co.uk**), both of which offer a really comfortable symmetrical design, incredibly low weights and fantastic overall performance, while the Viper is also ambidextrous.

For wireless models, the Logitech G Pro X Superlight is the pick for performance, and after a recent price drop from £120 to £100, it's approaching reasonable value too. If your giftee is left-handed, the ambidextrous Razer Viper Ultimate comes to the rescue. It comes with a little charging dock, making it easy to keep your mouse topped up and, amazingly, it currently costs just £65 from **amazon.co.uk**

EMBER MUG

Taking the crown for possibly the most indulgent gift on this list, despite its not overly astronomic price of £100 from **currys.co.uk**, the Ember mug is, well, a mug that keeps your drink warm. Yup, that's kind of it. However, it also has an app to which it connects via Bluetooth, and you can fine-tune the desired drinking temperature of your drink and the app will alert you when it's reached that temperature and maintain it.

It's also well made and attractive, making drinking a cup of tea a pleasure. It charges through the metal contact on its base, which interfaces with the contacts on the charming saucer-cum-docking unit. Frivolous for essentially just a mug, it brings genuine joy to your daily desktop life.

WEBCAMS AND STREAMING GEAR

For budding game streamers, or even those who just like to play online with friends, a proper webcam is a great present. The venerable and excellent Logitech C920 can be had for just £60 from **johnlewis.com**

If you're looking for a more directly streaming-focused cam, then the Elgato Facecam (£190 from **currys.co.uk**) offers superb image quality and endless tweakability. Or you can use Elgato's Cam Link (£90 from **amazon.co.uk**) to use a standard camera as a webcam.

Another great tool for budding streamers is a dedicated control surface for managing your stream. Whether its switching camera angles, turning your comment feed on or off, switching audio feeds and much more, there's a surprising amount involved in trying to both play a game and manage a stream at the same time. The best way we've encountered to make this process easier is the Elgato Stream Deck, with its easy-to-program buttons with customisable OLED displays. The full-sized one costs £140, but the mini version is just £70 (both direct from **elgato.com**).

COOLING AND LIGHTING

Corsair's excellent iCUE Commander Pro (£60 from **overclockers.co.uk**) is a great main present. This fan and RGB lighting controller includes six fan headers, four thermistor ports for manually probing temperatures and two RGB channels for controlling up to 12 RGB fans or strips. It's all controllable via Corsair's iCUE software using its USB connection, it's super-easy to set up and it allows for precise fine tuning of your cooling setup.

If your CPU cooler needs upgrading, there are oodles of options. For a simple air cooler, there's the SilverStone Hydrogon D120 ARGB (£48 from **amazon.co.uk**), while the Antec Neptune 240 (£74 from **cclonline.com**) is a great, affordable and RGB-equipped liquid cooler.

SPECIAL PRESENTS

If money is no object for your Christmas giving this year then these are the presents for you.

WATER-COOLING KIT

What better way to upgrade your whole PC than with a gorgeous-looking, cool and quiet water-cooling kit? Several companies offer a wide range of kits for all manner of different system setups and price ranges, from the £210 Raijintek Scylla Elite CA240 CPU kit, through to Corsair's £400 Hydro XH303i and the monstrous £500 EKWB EK-Quantum P360.

TOP-LINE COMPONENTS

Right now, the top of the pile for home PC/gaming performance is Intel's new Core i9-12900K (£600 from **ebuyer.com**), so that would be the basis for any top-of-the-line system we would build right now. Slap that into an Asus ROG Maximus Z690 Hero (£520 from **scan.co.uk**) and add DDR5 memory (if you can find some) and you have the start of a smashing system.

LEGO AT-AT

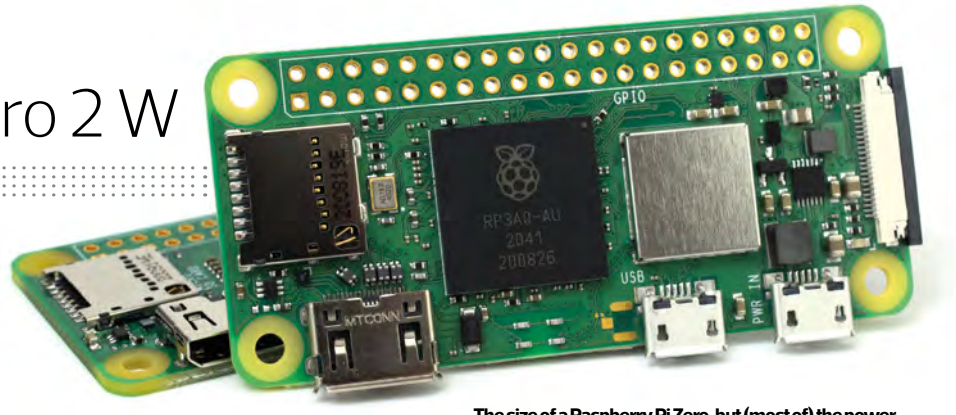
Moving onto the really important stuff, and what better table ornament can you imagine than a 2ft-tall LEGO replica of an AT-AT walker. Made from 6,785 pieces and costing a whopping £750 direct from **lego.com**, it's basically a bargain for the number of hours of entertainment it will provide when you're building it. That's what you need to tell yourself, anyway. CPC

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

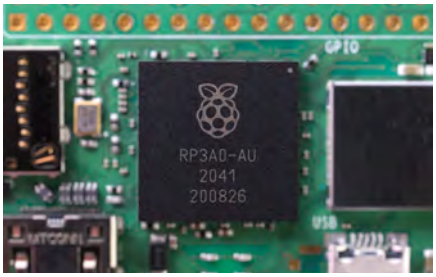
REVIEW
Raspberry Pi Zero 2 W



The size of a Raspberry Pi Zero, but (most of) the power of a Raspberry Pi 3 A+ – the Raspberry Pi Zero 2 W

What do you get if you cross a Raspberry Pi 3 Model A+ with a Raspberry Pi Zero W? The punchline isn't very funny, but it's sure to raise a smile from anyone looking for a bit more grunt from their ultra-compact embedded projects: Raspberry Pi Zero 2.

The original Raspberry Pi Zero (see Issue 150) launched for just £4 (inc VAT), a price so low it ended up cover-mounted on The MagPi magazine – a world first. The Raspberry Pi Zero W added a Bluetooth and wireless LAN radio chip, and now the Raspberry Pi Zero 2 offers a true successor.



This chip packs the SoC and 512MB of RAM in two dies

Externally, the Zero 2 W is near-identical to the Zero or Zero W. It's even possible to use it in existing Zero cases. The biggest change is the introduction of a metal lid where the raw silicon radio chip used to be located.

A closer look at the system-in-package, meanwhile, reveals a change that's quite a bit bigger – and with good reason. The original Raspberry Pi Zero range relied on the same package-on-package sandwich as the first Raspberry Pi, putting the SoC below a RAM chip in a footprint the size of a single chip.

That wasn't possible this time, which is why it's taken so long to see a follow-up. Instead, the job was passed across to the Raspberry Pi application specific integrated circuit (ASIC) team to create an all-in-one chip containing both the SoC and RAM. For those counting, that makes the Raspberry Pi Zero 2 the second product to launch from the ASIC team – after the RP2040 microcontroller on the Raspberry Pi Pico – albeit using third-party dies.

Otherwise, there's little to note. You get micro-USB power, USB On-The-Go (OTG) and a mini-HDMI port, a compact Camera Serial Interface (CSI) port to the right, and a micro-SD slot to the left. There's the 40-pin general-purpose input/output (GPIO) header, of course, still unpopulated by default – but the 'run' and 'TV' headers, which offered a way to halt execution and a composite video output respectively, have gone to make room for new power circuitry, which is only accessible now through test pads.

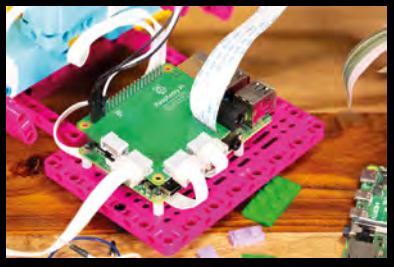
Not all the pads are in quite the same location as before, which means accessories

NEWS IN BRIEF

Raspberry Pi Build HAT adds LEGO compatibility

Raspberry Pi has partnered with the educational division of LEGO to launch a Hardware Attached on Top (HAT) add-on that links Raspberry Pi computers to LEGO Technic hardware – it's called the Raspberry Pi Build HAT.

Powered by the same RP2040 microcontroller as the Raspberry Pi Pico (see Issue 212), the HAT includes four connectors that are compatible with motors and sensors from the LEGO Technic and LEGO SPIKE ranges respectively. The Build HAT is available to purchase from **raspberrypi.com** for £22.50, while an optional 48W power supply is available for an additional £13.50 (both inc VAT).

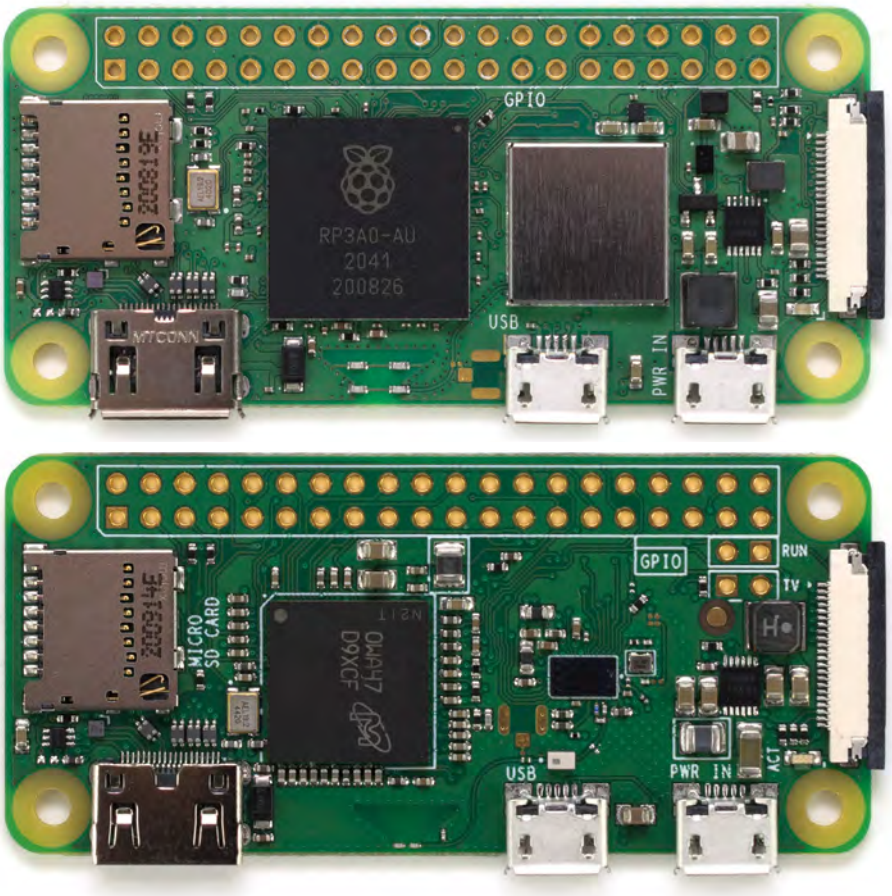


connecting via pogo pins may need to be redesigned for the Raspberry Pi Zero 2 W – you should definitely check compatibility before connecting any of them.

Inside that custom chip, meanwhile, is 512MB of RAM and the BCM2710A1 processor – the same one powering the Raspberry Pi 3 Model A+ and Model B+, albeit clocked down to 1GHz to compensate for reduced cooling performance from the smaller PCB.

To say it's an upgrade is no understatement – the original Raspberry Pi Zero relied on a BCM2835, a single-core ARMv6 part with performance that was mediocre at launch and hasn't improved with age. The shift to the BCM2837B0 moves the Zero 2 W from one core to four, and from 32-bit ARMv6 to 64-bit ARMv8.

The new model includes full compatibility with cases and other accessories, bar some that connect via pogo pins to test pads



The footprint is entirely unchanged, and you still get the camera connector to the right

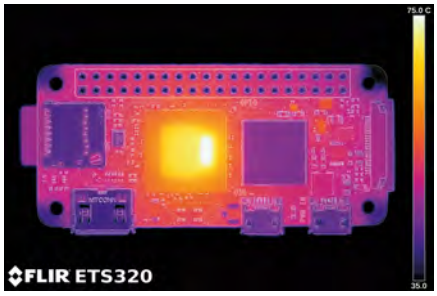
The new processor opens up a new world of potential use cases. Where the Raspberry Pi Zero peaks at 1.2fps when transcoding a 1080p video to H.264, the Zero 2 manages 19fps. Running optical character recognition (OCR) over a selection of magazine pages takes 2,430 seconds on a Raspberry PI Zero, but just 303 seconds on the Zero 2. Similarly, the browser-based Speedometer 2.0 benchmark struggles to hit a single run per minute on the Raspberry Pi Zero yet achieves 6.14 runs per minute on the Zero 2.

Perhaps the biggest and most interesting gain, though, is machine learning performance. While it was possible, though far from easy, to run limited machine learning workloads on the Raspberry Pi Zero, the Zero 2 brings broader compatibility. The object detection network SSDLite-MobileNet-v2 won't run at all on an original Zero, for example, but managed a stable 1.71fps on the Zero 2 – admittedly lagging behind the 4.95fps of a Raspberry Pi 4.

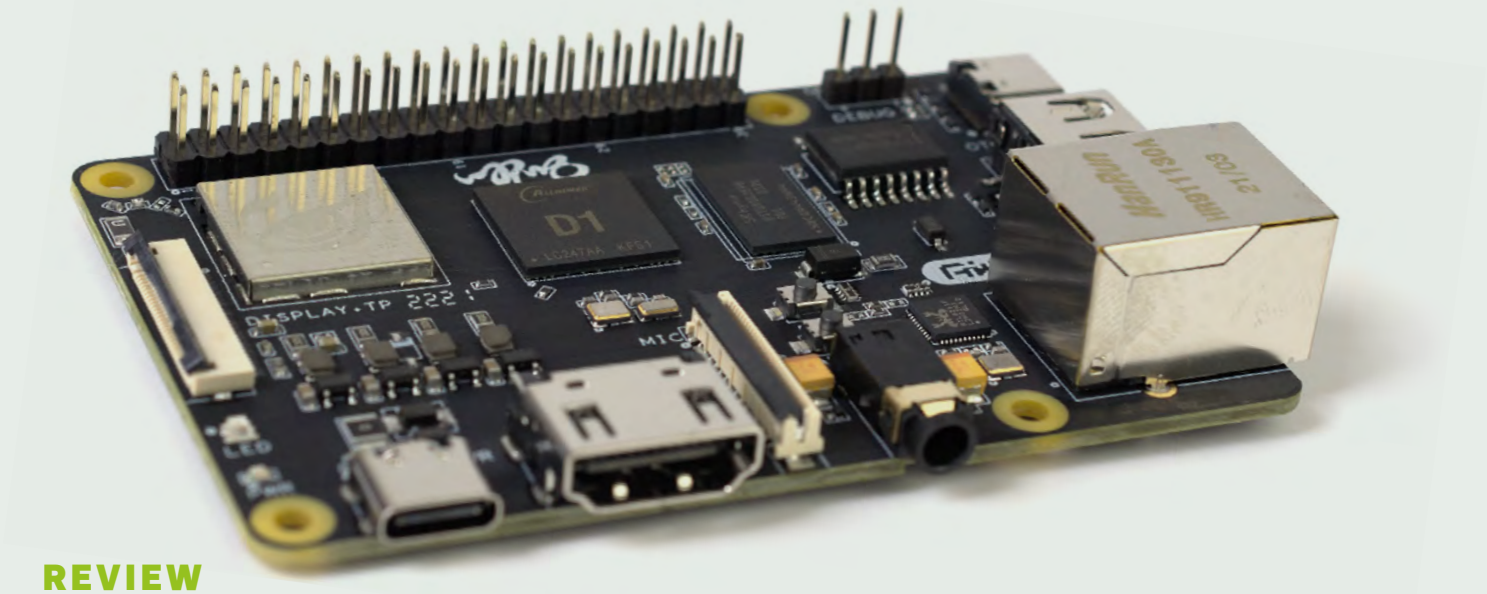
As always, there are costs involved, and not just from the higher launch price. While the Zero and Zero 2W's idle power draws of 0.72W and 0.73W were neck and neck in testing, the Zero 2 hit 2.9W under load – well above the 1.66W of the original Zero, but comfortably below the 4.74W of the admittedly faster Raspberry Pi 3 Model A+.

For anyone building around a Raspberry Pi Zero, upgrading to the Zero 2 W is a no-brainer. For Raspberry Pi 3 Model A+ projects, the switch saves a decent amount of power – and overclocking, with a decent heatsink, could close the performance gap. For power-hungry workloads, though, the Raspberry Pi 4 remains the model to beat.

The Raspberry Pi Zero 2 is available from **raspberrypi.com** now for £13.20 (inc VAT).



Impressively, the Zero 2 W didn't throttle during testing, but it does get hot to the touch



REVIEW

Sipeed Nezha D1

The Nezha D1 is one of the first Linux-capable RISC-V SBCs you can buy, but that doesn't mean you should

It would be easy to look at the Nezha and see just another Raspberry Pi clone. It has all the hallmarks – near-identical footprint, 40-pin general-purpose input/output (GPIO) header, Ethernet and USB to the left, HDMI, 3.5mm audio jack socket and power to the bottom, a radio module to the top left, and a system-on-chip – the Allwinner D1 – towards the rough centre.

It's the Allwinner D1 that makes the Nezha different though. It's not an Arm-based part at all, but one built around the free and open-source RISC-V instruction set architecture.

The D1 implements a Xuantie C906 RV64IMAFDCVU core, recently open-sourced by Alibaba's T-Head division, meaning it's a 64-bit part with the performance-boosting vector extensions included. While that's true, it's only part of the story. To get the chip out the door as quickly as possible, Allwinner started building it before the standard was ratified, meaning it's not technically compliant with the finished standard.

That's a problem. Efforts to upstream support for the chip in the Linux kernel have hit a snag, while developers try to figure out the best approach. They could include it as a specific platform, try to work around the issue with errata in more general RISC-V support, or abandon it to a lifetime of vendor-specific patches with no upstream support.

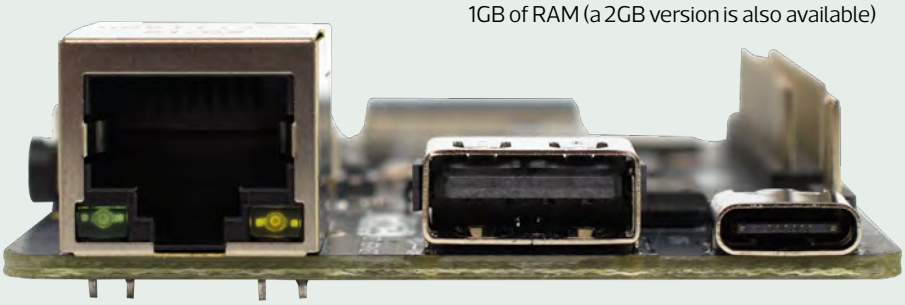
This isn't the only pain a bleeding-edge adopter will encounter when picking up the Nezha D1 either. General software support is still very much in the early stages, aided by a scheme by RISC-V International, which has seen a number of the Nezha boards sent out to developers around the world.

The board comes with Tina Linux running on its 256MB NAND flash storage, a custom distribution built around a long-out-of-support version of OpenWRT. Popping a micro-SD card in the slot to the left gives you the option to try an operating system that's little more mainstream – a custom version of Debian 10, Fedora or an educational operating system dubbed xv6.

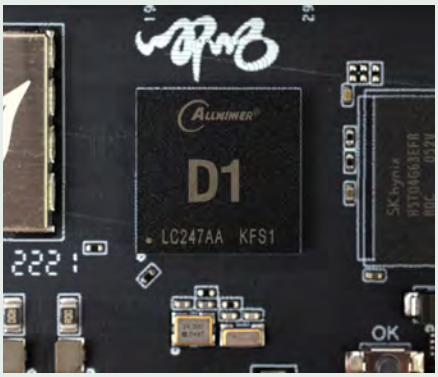
Installing Debian isn't easy though. The operating system image needs to be downloaded and flashed using a Windows-only program available exclusively in Chinese – like the majority of the platform's documentation. Thankfully, unofficial Fedora images are more readily available as raw disk image downloads and were, therefore, chosen for testing.

Performance-wise, once the surprisingly slow boot sequence has completed, the D1 impresses. With a single 1GHz core and just 1GB of RAM (a 2GB version is also available)

A lot of attention has been paid to packaging, but less to the documentation



The layout roughly mimics a Raspberry Pi computer, though it's not compatible with Raspberry Pi cases



The RISC-V core at the heart of Allwinner's D1 chip has just been open-sourced by Alibaba's T-Head

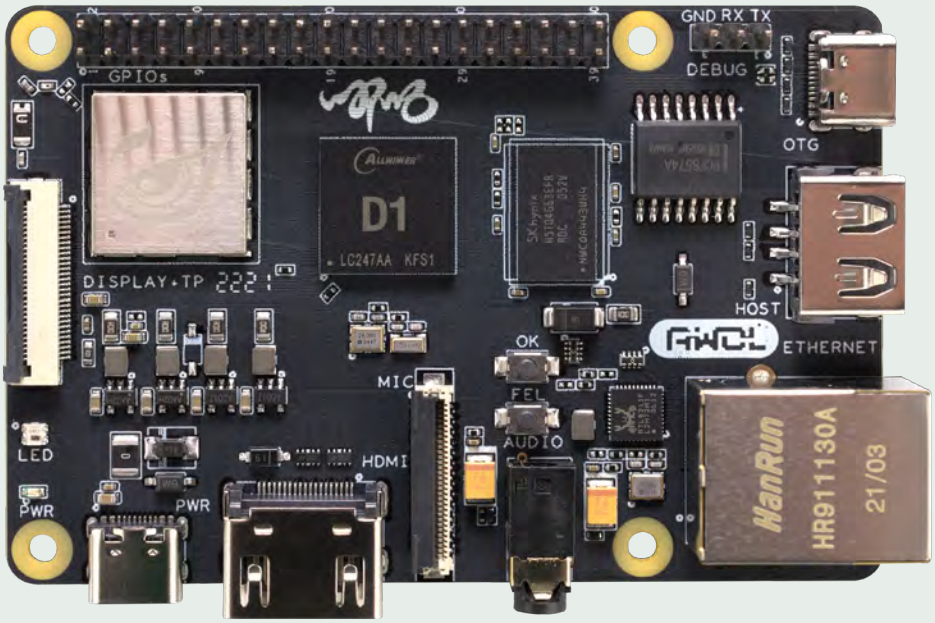
it's no speed demon, of course, but it actually outperforms the Raspberry Pi Zero with its rather better-established Arm core.

In benchmarks, the D1 managed to finish a file compression task around 16 per cent faster than the Raspberry Pi Zero. The gap was closer in the GIMP image editing benchmark, but it still finished 7.5 per cent faster. Finally, in an optical character recognition test, the D1 managed an impressive 26 per cent gain over the Raspberry Pi Zero, likely thanks to the D1's improved memory bandwidth.

There's one workload class that the Sipeed Nexha D1 can't handle, though, and that's 3D graphics. There's no GPU on-board, at least in the initial run, although there are hardware acceleration blocks for H.265, H.264, VC1 and MJPEG video.

That's not to say you can't get any video out of the device. There's an HDMI port and an LVDS connector, and it has theoretical support for outputting a 4K resolution at 30Hz. I say 'theoretical' because at the time of writing, the only display output the review sample could manage was a bizarrely vertical layout at 800 x 1,280 – designed more for the optional LVDS display than connection to an external monitor.

The Sipeed Nezha D1 is a hard device to recommend, and not just because of the lack of a GPU. Official support is largely limited to a Chinese-language Telegram group. The software, both official and otherwise, is still extremely rough around the edges, and the D1's existence outside the finalised RISC-V specifications means porting efforts may never reach mainline Linux.



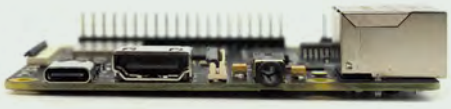
It's a promising start, but there's a lot of work to do on the software front

The Nezha D1 is also expensive, at least in comparison to the Arm-based competition. The board sells for $112 US (around £82 ex VAT), whereas a Raspberry Pi Zero W with similar performance will set you back under £10 (inc VAT).

On the plus side, though, the Nezha D1 includes two USB Type-C cables, a US-style power supply and a very handy (if annoyingly unlabelled) USB-TTL serial adaptor to hook up to the board's debug header.

That said, there's something special about firing up Linux – whether a graphical environment or not – on a RISC-V chip. For the earliest of early adopters, the Nezha D1 is considerably cheaper than higher-performance rivals such as the SiFive HiFive Unleashed, and it gives you more than enough to get started developing software for RISC-V, even if you need to pay attention to where the D1 diverts from the ratified specifications.

For everyone else, there's little reason bar raw curiosity to pick up the Nezha D1. If you're curious enough, it's available to order from **aliexpress.com** for $112 US (which works out at around £82 ex VAT).



The HDMI output is theoretically capable of outputting a 4K signal at 30Hz, but couldn't manage it during testing

NEWS IN BRIEF

Pine launches higher-spec PinePhone Pro

Open hardware specialist Pine has launched a follow-up to its PinePhone smartphone, the PinePhone Pro, but plans to sell the two phones side by side, rather than launch the new model as a successor. Built around the Rockchip RK3399S, the new phone includes 4GB of LPDDR4 memory, 128GB of eMMC storage, two cameras, a 6in 1,440 x 720 IPS display, and the company's trademark hardware privacy switches for all the applicable parts, from the cameras to the radios.

'You could say that it denotes a shift from being 'primarily development-focused' to 'technically-inclined end-users centered,' Pine's Lukasz Ericinksi claimed of the launch. Pre-orders are open at **pine64.org** at $399 US (around £290 ex VAT).

REVIEW

Not All Fairy Tales Have Happy Endings

Despite the cover of Not All Fairy Tales Have Happy Endings promising 'the rise and fall of Sierra On-Line, as told by the ultimate insider,' this book by Sierra On-Line cofounder Ken Williams is purely a memoir. Some small contact was made with former colleagues, and there's evidence of research to get the core facts right, but you're primarily reading the personal recollections of Williams himself, and his wife.

'Roberta is the true founder of Sierra and was always Sierra's bestselling author,' Williams explains, long after covering how he pushed his wife into programming – and how her interest wasn't piqued until he introduced her to Will Crowther's seminal Colossal Cave Adventure, at which point she kicked him off the computer to play it herself.

'Roberta should be the one writing this book,' Williams admits, but her lack of interest in revisiting the Sierra years means it's Ken who is responsible for telling the tale. The book begins in the pre-Sierra years and ends after the release of King's Quest 8 – launched in 1998 after a troubled development period at post-Ken Williams Sierra and the last game Roberta would write.

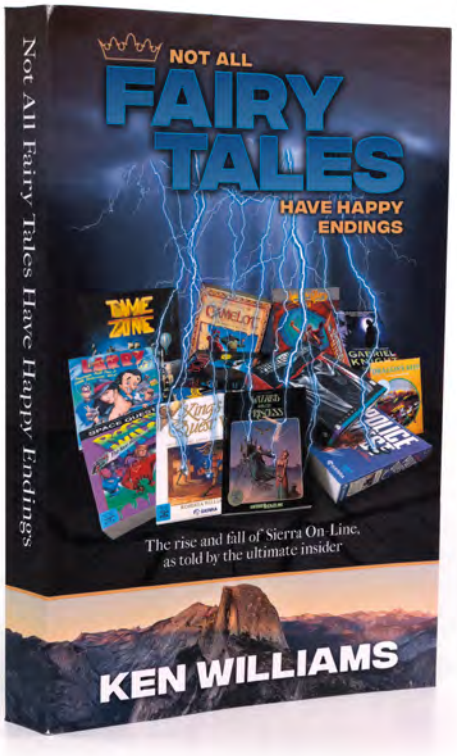
The book could have done with an editing and layout pass, but the stories are fascinating

Williams paints a clear picture of his motivations and personality, but it's hard to say whether he does so out of honesty or pride. He certainly isn't shy about admitting that his motivations in life, at least initially, were financial – jumping between jobs, shifting his young family between houses to capitalise on a rising market, and pushing his wife from a stay-at-home parenting role into the workplace, despite her lack of experience for and interest in the role of systems programmer.

He's also keen that you understand, if not appreciate, his self-described micromanagement style and desire for control – and his glorification of overwork and strong anti-union opinions.

The only hints of shame come when Williams admits that Steven Levy's portrayal of a chaotic 'frat house' culture during Sierra's early days, in his book Hackers: Heroes of the Computer Revolution, was 'overall [...] right', without going into details himself. He also discusses the company's partnership with controversial police chief Darryl Gates, and talks about the mass layoffs that followed the video game market crash of 1983 and Sierra's acquisition by CUC – the company that would find itself, a year after Ken Williams' departure, with executives sent to prison over fraudulent accounting.

All the major highlights of Sierra's storied history are included: the Softporn Adventure hot-tub photo shoot starring Roberta herself; a failed initial public offering (IPO) derailed by Black Monday; the ambitious Sierra Network online service; a failed attempt to acquire id Software, which faltered when Williams balked at a $100,000 cash bonus; and the deal to publish Valve's Half-Life.



Written during the pandemic, Williams' book is a must-read for Sierra fans

These stories are interspersed with 'interludes', chapters that don't fit into the otherwise roughly chronological narrative. One interlude offers advice for engineers and engineering managers; another one offers tips on programming; yet another one provides recommendations for how to break into the game industry. Full-colour, though often low-quality, photographs are sprinkled throughout.

For Sierra fans, it's a must-read, although this self-published title would have benefited from a professional editorial pass to fix numerous typographical errors and layout problems. Not All Fairy Tales Have Happy Endings is available digitally from **kensbook.com** or in print from **blackwells.co.uk** under ISBN 978-1-71-672736-8 for £26.52 (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

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- **Software programmable** Supports macro for all buttons
- **Polling rate** 125, 250, 500 and 1000Hz switchable
- **Tracking speed** 220 inches per second
- **Acceleration** 30G
- **Weight** 72g
- **Ascended cord** Light and flexible
- **Dimensions (mm)** 67 x 128 x 38 (W x D x H)

WORTH £40

Custom PC APPROVED

Our generous pals at Chillblast are kindly offering an award-winning Aero RGB gaming mouse (see Issue 208, p33) to anyone who takes out a 12-month UK subscription to **Custom PC** magazine.

Designed in Poole, Dorset, by Chillblast's team of gaming experts, the Aero RGB is designed for competitive gaming. Its honeycomb mesh design retains incredible strength, while allowing ventilation to keep your palm cool and fresh. Meanwhile, its carefully optimised 72g weight is ideal for gamers who want the fastest possible reaction times.

The PixArt PAW3327DB sensor allows for high DPI levels, while the all-Huano switches provide longevity and a tactile click response. Chillblast's braided, ascended cord also means you're never impeded by the cable, while support for horizontal acceleration of up to 30G means even professional esports players will never overwhelm its tracking hardware.

A plethora of customisation also awaits in the software, where you can program sensitivity, polling rate, recordable macros and RGB lighting effects. The Aero RGB is an awesome weapon for your favourite MOBA, FPS or strategy title.

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Order your LGA1700 adaptor now to avoid disappointment

Believe it or not, cooling Intel's new Alder Lake CPUs is quite tricky at the moment. As you'll likely be aware now, the motherboards require an LGA1700-specific cooler or adaptor kit to be used. Firstly, the gaps between the CPU socket mounting holes are slightly wider on Z690 motherboards than their predecessors. It does seem like a bit of a silly move, given the difference is just a few millimetres, but we have to deal with it all the same.

Interestingly, Asus is including both LGA1700 and LGA115x/LGA1200 mounting holes on its boards, but you should be very wary of mounting older coolers on new Z690 boards, even if you have a mounting kit and backplate that fits. There's another reason for compatibility issues and that's the CPU-Z height.

Alder Lake CPU sit lower than previous Intel CPUs, thanks to their thinner die, and Intel has even applied a thinner layer of solder between the CPU and heatspreader. Many coolers may not cater for this height, and your heatsink or waterblock might not have enough pressure applied to make good contact with the heatspreader, even if it fits in your motherboard's mounting holes.

You need a fair amount of force to make good contact between your CPU and cooler contact plate, and not just for raw heat transfer reasons. The cooler may not sit square on the heatspreader, for example, making better contact with one side of the CPU than the other, and not even copious amounts of thermal paste will fix that gap. The paste itself also needs pressure to spread properly, so it can

Most CPU coolers will need an adaptor kit in order to deal with LGA1700 sockets

fill all the microscopic gaps between the cooler and heatspreader. All of this can potentially fail if your cooler doesn't have the right mounting kit.

The trouble is that adaptor kits are quite tricky to find at the moment. I have several on order from a range of manufacturers, and nearly had to modify a waterblock myself in order to carry out the CPU testing last month.

Thankfully, Thermaltake came up trumps and sent me the LGA1700 kit for its fabulous Toughliquid Ultra 360 cooler at the last minute, which worked brilliantly.

However, despite having a bunch of coolers to test, including waterblocks, I only have one waterblock and one AIO cooler that explicitly offer LGA1700 support out of the box.

I'm sure I'll survive, of course, but if you're planning on upgrading to Alder Lake soon, make sure you order a cooler adaptor kit or a new cooler as soon as possible, as they seem to be in short supply right now. You don't want to be sitting there waiting for your free adaptor kit, while all the rest of your components are ready to go on Christmas morning.

Is it worth water-cooling Alder Lake?

Cooling is an important factor for Alder Lake, and I wanted to get a feel for the cooling requirements of the Core i9-12900K. We already know that a 360mm AIO liquid cooler will do the job from last month's reviews, but I wondered if a modest 120mm AIO cooler could also be up to the job, and how a custom loop with a 240mm radiator would cope.

To find out, I decided to try cooling the chip with an NZXT Kraken 120 RGB – a sub-£100 120mm liquid cooler that's relatively modest in its cooling ability and akin to a high-end air cooler in terms of performance, as well as a custom water-cooling loop using a Corsair XC7 RGB Pro waterblock and LGA1700.

Starting with the CPU running at stock speed, the custom water-cooling loop managed to maintain an average P-Core temperature of 73°C at stock setting, which isn't bad and clearly gives you plenty of room for overclocking.

NZXT's Kraken 120 RGB coped surprisingly well with cooling the Core i9-12900K

Corsair's XC7 RGB Pro waterblock comes with LGA1700 socket mounting parts in the box

It's also a fair bit cooler than the toasty Core i9-11900K at stock speed with the same setup, but if you were hoping for sub-70°C temperatures from your water-cooling loop, you might be disappointed by the new Core i9. The E-Cores, on the other hand, sat at an average of 59°C, so are far less of a concern.

Meanwhile, the Kraken cooler was a fair bit warmer, with our looped five-minute Cinebench R23 test seeing it quickly shoot past 70°C and continue climbing to an average of 78°C across all eight P-Cores. The E-Cores were also 7°C warmer, with an average of 66°C.

It's clear that, even at stock speed, beefier cooling setups can definitely help with Intel's new flagship if you'll be putting them under heavy loads for more than a minute or two.

Overclocking the Core i9-12900K to 5.1GHz on the P-Cores and 3.9GHz on the E-Cores saw the P-Core average hit 84°C on the dinky Kraken cooler with the E-Cores at 69°C. By contrast, the custom loop kept the average P-Core temperature 7°C lower at 77°C, and the E-Cores were 4°C cooler too.

Ultimately, while there are differences, both cooling setups returned usable results in Cinebench at stock speed and when overclocked. If you wanted to save some money, the Kraken 120 RGB can cope with cooling the Core i9-12900K and, depending on the temperature of the air being drawn into the radiator, it could probably just about cope with an overclock as well.

However, for prolonged loads (especially at overclocked speeds), a more potent cooler is definitely a good idea. The ability of our custom water-cooling loop to keep the overclocked Core i9-12900K at 77°C under load shows that Alder Lake CPUs do respond well to extra cooling power. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Install a motherboard monoblock

Antony Leather shows you how to fit a full-cover waterblock to your motherboard

TOTAL PROJECT TIME / 1 HOUR

Full-cover waterblocks, or monoblocks as they're often called, are better than standard CPU waterblocks for a few reasons. Firstly, they look fantastic, adding a larger area of water-cooled awesomeness to your motherboard rather than a single small block. They can also water-cool more of the hot spots on your motherboard than the CPU, such as your VRMs and chipset. This means that less heat will be dumped into your case and instead transferred straight to the radiator, which can be really useful with mini-ITX systems.

Finally, using a monoblock can greatly reduce the number of ports you have to plumb into your water-cooling system. Installing separate blocks for chipsets and VRMs can double or treble the number of inlets and outlets, and a full-cover block cools some or all of those areas with just two ports. The process of installing a full-cover waterblock can be quite involved, though, so in this guide, we'll look at how to find one for your motherboard, how to install it and check it's working properly.

TOOLS YOU'LL NEED

Scalpel
Most hardware stores

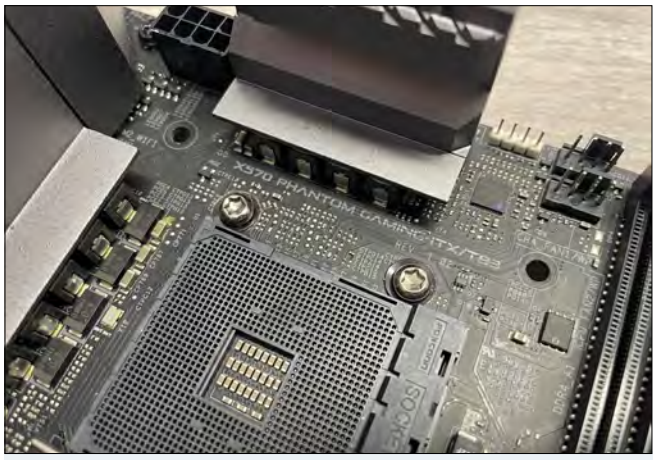
Micro screwdriver
Most hardware stores

Motherboard full-cover waterblock
ekwb.com or bitspower.com

Hairdryer
amazon.co.uk

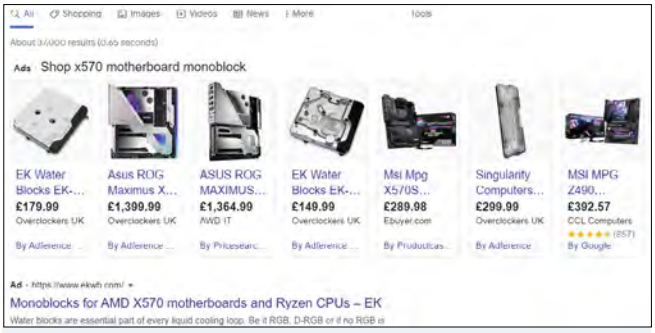
Lint-free cloth
Most hardware stores

Thermal paste cleaner
overclockers.co.uk



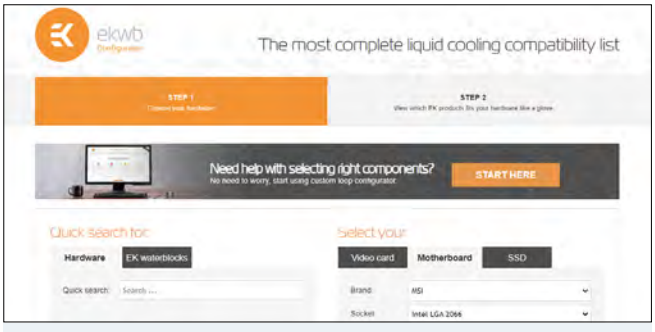
1 / IDENTIFY MOTHERBOARD MODEL

Making sure you identify the correct full-cover block for your motherboard is essential, as even a slight variation could mean it won't fit. You'll need your exact model number or name, including any suffixes such as 'WiFi', as there can be small component differences even between similar models.



2 / DO A GOOGLE SEARCH

There are dozens of water-cooling manufacturers, but only a handful offer full-cover motherboard blocks. A great way to identify a block for your board is to Google 'full cover block' with your motherboard's model name. This can be especially useful for older motherboards, and may even find you some used products on auction sites.



3 / CHECK MANUFACTURER COMPATIBILITY

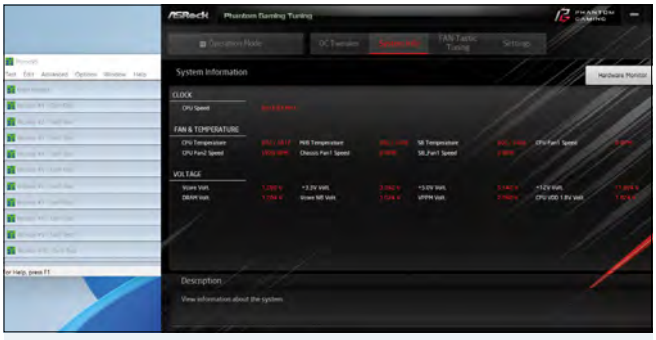
Another way to locate a compatible full-cover block is to use water-cooling manufacturers' compatibility lists. Both EK and Bitspower offer these features on their websites, with the former allowing you to enter your motherboard's model name to reveal all compatible waterblocks.

4 / PICK BLOCK TOP MATERIAL

It's likely that there will be different options for the top material of your block, such as clear acrylic or black acetal. Your decision here will largely depend on your choice of other components. If you intend to add other clear components to your loop that expose the coolant, it's a good idea to use a similar-looking full-cover block.

5 / CHECK COMPONENT ACCESS

Full-cover blocks usually take up a lot of space, so it's important to check how a block might impact other components. Your M.2 ports might be trickier to access or suffer reduced airflow, for example, in which case it might be wise to put your SSD in a different M.2.



6 / CHECK CURRENT TEMPERATURES

Before you install the waterblock, run Prime95's smallest FFT test and load your motherboard's monitoring software to check the VRM and CPU temperatures. The VRM temperature isn't always shown, but at the very least, make sure you check the CPU temperature before and after your efforts.

7 / IDENTIFY MOTHERBOARD SCREWS

On the rear of your motherboard there will be screws you'll need to remove in order to detach the heatsinks. These locations can stretch around most of the motherboard, so familiarise yourself with their locations and identify them all first.

8 / USE A HAIRDRYER

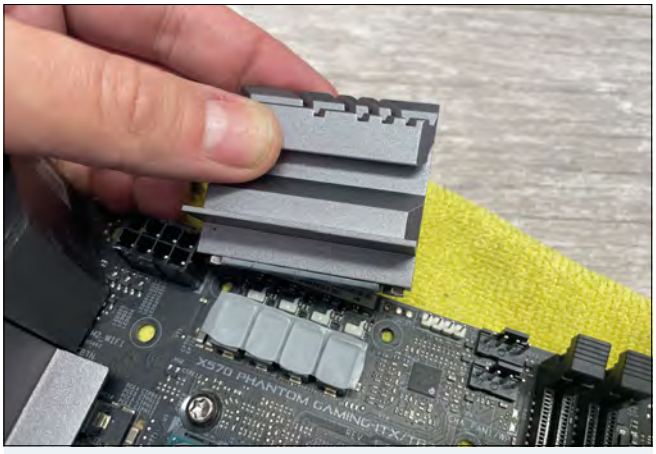
If you find the heatsinks tricky to detach, that might be because thermal pads or paste have stuck them fast to the motherboard. Warming them to loosen the material can help to work them loose – using a hairdryer on a hot setting from ten inches away for 20 seconds usually does the trick.

9 / REMOVE SCREWS

Now go ahead and remove the screws, with the motherboard positioned face down and the heatsinks supported from underneath using a towel or microfibre cloth. You'll likely need a micro screwdriver for this job, and you'll need to be very gentle, so you don't scratch the rear of your motherboard.

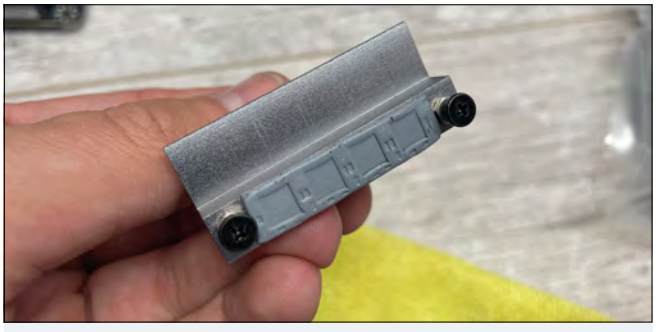
10 / DETACH FAN AND LIGHTING CABLES

You often have to contend with wires on the motherboard for RGB lighting and chipset fans, so make sure you detach these cables before yanking off the heatsinks, as the wires can be easily damaged.



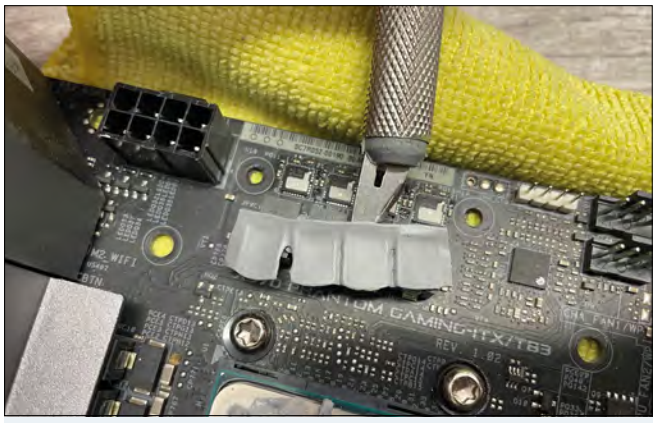
11 / LIFT AWAY HEATSINKS

With any cables detached, go ahead and lift the heatsinks off the motherboard. To do this, hold the towel or cloth underneath the heatsinks, than flip over the board while you're holding the heatsinks in place. You can then lift the heatsinks off the motherboard from above.



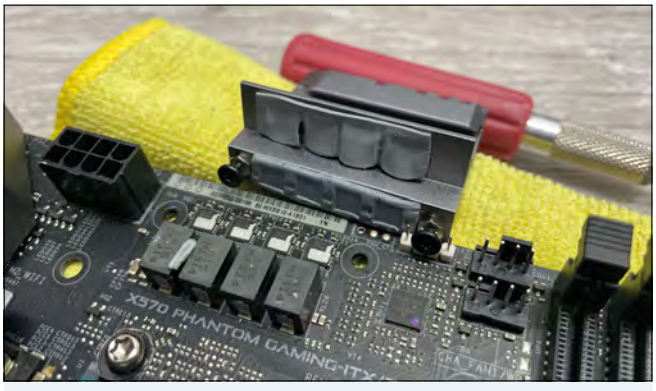
12 / REINSERT SCREWS

It's vital to keep the heatsink screws safe in case you need to return the motherboard to its original state, especially if you might want to sell it later. To do this, replace the screws into the holes in the heatsinks and then place them in your motherboard's box.



13 / REMOVE THERMAL PADS

Quite often you'll find thermal pads are left behind on the motherboard when you remove the heatsinks. You'll need to remove these pads in order to install the new block. Use a scalpel or spatula to gently lift them off. Ideally, you want them intact.



14 / REPLACE THERMAL PADS

Next, place the pads back onto the heatsinks from which they were lifted. If you damage them, it's possible to obtain replacement thermal pads from companies such as Gelid or Alphacool.

15 / CLEAN SURFACES

With the pads and heatsinks removed, clean the surfaces of the VRMs, chipsets and your CPU to ensure your new cooling gear can perform as well as possible. Isopropyl alcohol can remove paste or pad residues, as can a dedicated thermal paste (TIM) cleaner, along with a lint-free cloth.

16 / TEST-FIT WATERBLOCK

Full-cover blocks are heavier and larger than normal waterblocks, and will slot into place among dozens of other components on the motherboard. For this reason, it's best to do a test-fit first without any pads or paste being applied, so you know how to fit it quickly.

17 / APPLY THERMAL PADS

Thermal contact between the block and VRMs is usually achieved with thermal pads, so start by trimming them to size if necessary and applying them to the motherboard. Remember to remove both sides of the protective plastic first.

18 / APPLY THERMAL PASTE

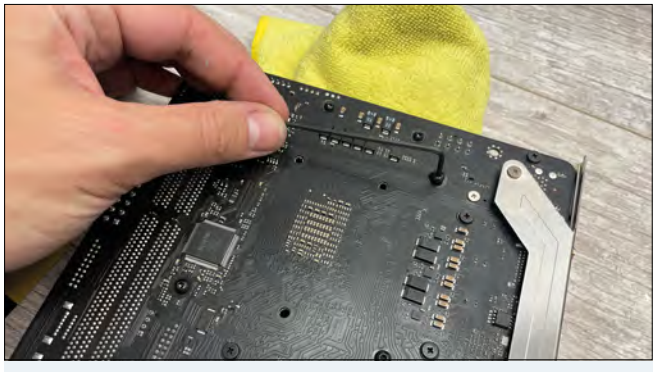
The CPU will need thermal paste applied as normal. You might want to consider using liquid metal paste rather than standard ceramic paste here, in order to maximise cooling for your CPU (see p104).

19 / CONNECT RGB CABLES

If your block includes RGB lighting then connect the cable for the lighting before fitting the block. This way, if the RGB header sits between your block and other components on the motherboard, it will be much easier to access.

20 / FIT WATERBLOCK

With the motherboard ready for its new waterblock, place the motherboard on a flat surface and then lower the block into place. Try to prevent it from sliding around, as this can affect the thermal paste and pads, and reduce the quality of contact between the block and your components.



21 / SECURE WITH SCREWS

Follow the block's instructions to install the screws, flipping the board over and supporting it from underneath with a towel or cloth, so the block is held in place first. Insert the screws with a few turns each to start, then tighten them a few more turns at a time, moving diagonally between screws, until they're all tight.

How to Apply liquid metal paste

Antony Leather shows you how to reduce your CPU temperatures by putting a shiny layer of liquid metal between your CPU and cooler

TOTAL PROJECT TIME / 30 MINUTES

If you're fitting a new waterblock to your PC, such as the one we've used in or guide on p100, then you'll want to consider using liquid metal thermal paste between the CPU heatspreader and the block's contact plate. Liquid metal paste is highly thermally conductive, which means that you can get the most out of your water-cooling system and knock a few extra degrees off your CPU temperature compared with normal ceramic paste as well.

Dealing with liquid metal paste isn't easy, though, and it needs some attention – unlike ceramic paste, you can't rely on the force from your cooler's mounting system to spread the paste evenly. However, once you've mastered its application, you can rest assured that you're using the very best thermal paste you can buy, and then enjoy watching your CPU temperatures drop.

TOOLS YOU'LL NEED

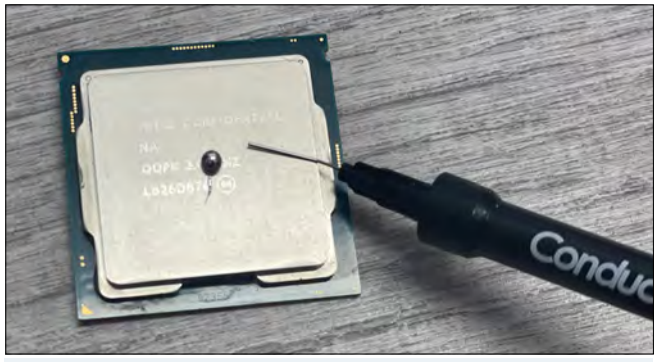
Lint-free cloth
Most hardware stores

Thermal Grizzly Conductonaut
overclockers.co.uk

Thermal paste cleaner
overclockers.co.uk

1 / REMOVE OLD PASTE AND CLEAN SURFACES

It's vital to remove any old paste first, so clean the surface of your CPU's heatspreader with TIM cleaner and a lint-free cloth to ensure the new paste works as well as possible. You'll also need to clean the contact plate of your CPU if it's been used previously.



2 / APPLY LIQUID METAL PASTE

Using the right amount of liquid metal paste is important. It's expensive, so you don't want to waste it and you only need a small amount to cover even the largest CPUs. Aim for a blob that's the size grain of rice – if you apply more by accident, you can use the syringe to suck up the excess.

3 / RUB INTO SURFACE

The Thermal Grizzly Conductonaut paste we used includes buds to rub the compound into the heatspreader. This can take a few minutes as the particles begin to adhere to the surface, but eventually the paste will turn the surface mirror silver. Ensure you cover the entire heatspreader and you're then ready to fit your cooler. CPC

WIN

A 27IN 240HZ AOC GAMING MONITOR

WORTH **£239!**

If you like your frame rates fast and your screen immersive then make sure you submit an entry to this month's competition. We have a 27in AOC C27G2ZU gaming monitor up for grabs, with a 1500R curved screen and a super-fast 240Hz refresh rate.

The latter completely unleashes top-end GPUs, bringing unprecedented fluidity to the picture on your screen. With every detail brought sharply into focus and every movement shown with crystal clarity, you can feel your reactions become one with the action and elevate your game.

Meanwhile, the screen's pixel response time of 0.5ms means smear-free gaming, with fast-moving action and dramatic transitions rendered smoothly without ghosting. What's more, the 1500R curve wraps around you, putting you at the centre of the action and providing an immersive gaming experience.

SPEC

- 240Hz refresh rate
- 27in curved VA panel
- FreeSync Premium Pro
- 1,920 x 1,080 resolution
- 0.5ms response time (MPRT)
- 300 nits brightness
- 3,000:1 static contrast ratio

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

Competition closes on Friday, 7 January. 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.

Retro tech

VGA

Stuart Andrews looks at the tech that transformed the PC into a gaming and graphics powerhouse, 256 colours at a time

The technology that put PC graphics firmly on the map arrived in April 1987 as part of IBM's PS/2 line of PCs. IBM saw the PS/2 as the answer to its biggest problems, putting Big Blue (as we all used to call it) back in control of the PC architecture and one step ahead of the clone manufacturers.

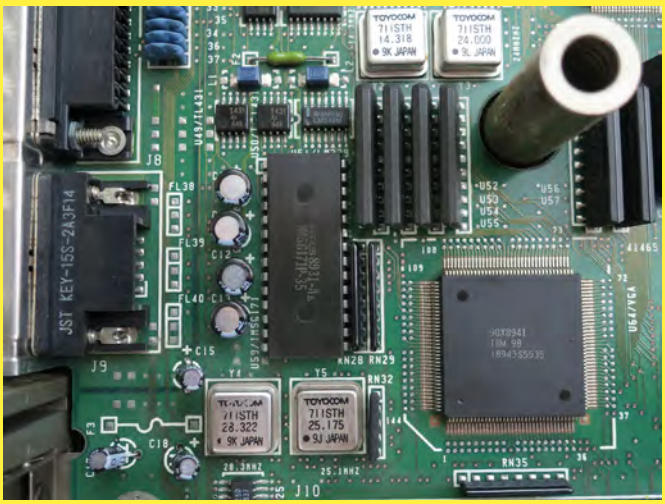
To do so, it had Intel's latest processors, cutting-edge connection options and the fastest floppy disk storage, not to mention a revolutionary new high-bandwidth system bus. But what turned out to be the PS/2's most important feature was its new graphics hardware – the Video Graphics Array, or VGA.

In 1987 the PC wasn't exactly considered a graphics powerhouse

In 1987 the PC wasn't exactly considered a graphics powerhouse. Apple's Mac II, launched in March the same year, had a graphics card that could support up to 256 colours at 512 x 384. The Commodore Amiga could display full-screen animated graphics with up to 64 colours at 320 x 240, or 4,096 colours in still images using its legendary, flicker-tastic HAM mode.

The best the PC had to offer was the EGA (Enhanced Graphics Adapter) standard, covering resolutions of up to 640 x 350, but with only 16 simultaneous colours from a fixed palette of 64. If you wanted to create graphics or play games on your PC, you needed to really like basic colours with a strange preponderance of green and purple. Graphics enthusiasts were rendering ray-traced 3D graphics on their Amigas, albeit very slowly, but nobody sensible would even think of doing so on a PC.

VGA didn't put the PC at the graphics cutting edge, but it did put it back in the race. The new hardware supported resolutions of up to 640 x 480 with 16 colours, or 320 x 200 with up to 256. What's more, those 256 colours could be redefined at any time, from an 18-bit palette of 262,144 colours. With VGA, you could put a photo on the screen and it kind of looked like a photo. Artists could create 2D images with sophisticated colour and shading effects. PC games went from looking shocking to looking seriously awesome. VGA was literally a game changer.

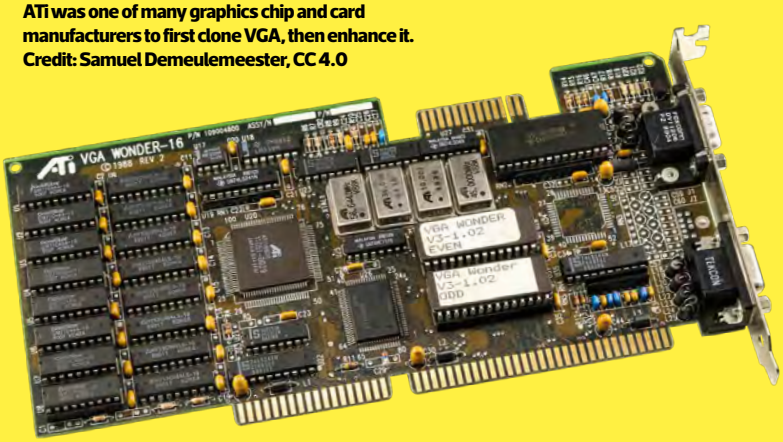


The VGA section of a 1988 IBM PS/55 model 5550-T. You can see the VGA chip, the INMOS RAMDAC, the two timing crystals and 256KB of video RAM. Credit: Darklanlan, CC 4.0 custompc.co.uk/CC4

PC GRAPHICS GET THE WOW FACTOR

Weirdly, VGA didn't arrive as a new standard, or even as an add-in graphics card. On the first PS/2 PCs, it came in the form of a chip containing the display controller, along with 256KB of dedicated RAM, a pair of timing crystals and an external RAMDAC.

This already made it a much more integrated technology than the original EGA chipsets, which contained dozens of processors, and put it more in line with the integrated chips coming from third parties. What's more, it was the higher-



ATi was one of many graphics chip and card manufacturers to first clone VGA, then enhance it. Credit: Samuel Demeulemeester, CC 4.0

end option of two new graphics standards. The cheaper PS/2 models were stuck with the Multi Colour Graphics Adapter (MCGA) which had the same 256-colour mode but lacked VGA's higher resolutions.

Like IBM's new MCA bus architecture, MCGA didn't last long beyond the PS/2, but VGA developed a life of its own. Beyond hardware-level support for smooth scrolling, and a barrel shifter designed to shift incoming data from the CPU to the display at seven bits at a time, it didn't actually do much in the way of graphics acceleration.

However, it did set a new baseline standard for PC graphics, and for hardware and software support. Crucially, through its RAMDAC and 15-pin D-Sub connector, it established how the PC could convert digital instructions into a 256-colour analogue video signal, setting the stage for the 16-bit and 24-bit colour standards to come.

Instead of sending six colour signals from the graphics card to the monitor, like the older EGA chipsets, the VGA chipset and its RAMDAC sent only three signals – red, green and blue, with a potential 64 different levels for each. For VGA, this resulted in an 18-bit palette of up to 262,144 colours, 256 of which could appear simultaneously in Mode 13h. Once adopted, this same core technology gave scope for 16-bit and 24-bit colour in later graphics chips, with up to 65,536 colours or 16.7 million colours on the screen at once.

Resolution wasn't the base level VGA spec's strength. In fact, PC journalists of the time pondered why it was stuck at 320 x 200 in Mode 13h. However, programmers found workarounds. A handful of games, such as the legendary horror game Dark Seed, opted to work with a reduced 16-colour palette in order to use the full 640 x 480 resolution. Meanwhile, Michael Abrash, who would later work with id Software on Quake, worked out an approach that enabled programmers to use 256 colours at a slightly higher resolution of 640 x 240, which he dubbed Mode X.

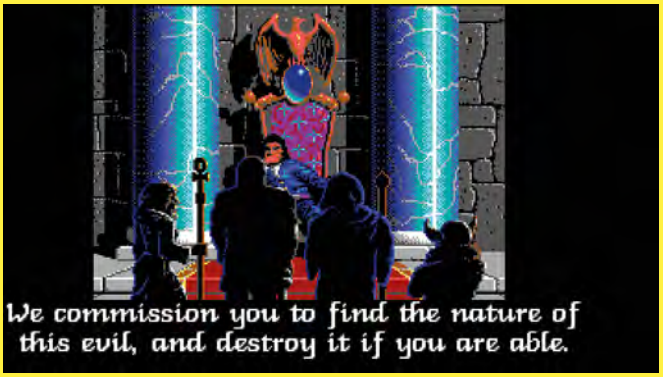
Meanwhile, Windows 2.0 moved to adopt the 640 x 480 mode with 16 colours, bringing the interface closer to what we expect from a GUI today. However, many of the applications and games we think of as belonging to the VGA era stuck to Mode 13h and its 320 x 200 resolution. What's more, with the CPU performing most of what we'd now call the GPU's legwork, this was arguably for the best – until the Intel 486 appeared in 1989, there wasn't any really CPU powerful enough to handle gaming at higher resolutions.

THE IMPACT OF VGA

Luckily, those colours alone had a huge impact. The ZSoft Corporation's PC Paintbrush and Electronic Arts' Deluxe Paint II revolutionised professional graphics and computer art on the PC, thanks to 256-colour support. VGA also made CorelDRAW, launched in January 1989, a realistic alternative to the digital design packages appearing on Apple's computers.

Meanwhile, for PC games, VGA was nothing short of transformative. Sure, the 64,000 pixels on your monitor looked a little chunky; however, with 256 colours, the artists working at leading developers, such as LucasArts, Sierra Online, Microprose, Electronic Arts and Origin Systems, were able to produce sprites that looked more like recognisably human (or inhuman) characters, and background scenery that could bring their game worlds to life. Plus, while the PC couldn't pull off the same smooth scrolling, sprite-scaling tricks as the Commodore Amiga or 8-bit consoles, its best games were developing a visual richness of their own. As the PC moved into the 386 era, it was beginning to be taken seriously as a gaming machine.

Taken on its own, the first VGA chipset wouldn't have made such an impact. After all, you only got it to use it if you bought a pricey IBM PS/2 machine. Instead, it really only gained momentum once it began to appear in add-in cards.



Eye of the Beholder – VGA's larger colour palette (right) gave artists the chance to use more realistic shading compared with EGA (left)

The Secret of Monkey Island – moving to VGA (right) enabled PC developers to create more human-like characters compared with EGA (left)

IBM was first out of the gate with its PS/2 Display Adapter, a card that gave any reasonably modern IBM-compatible PC with ISA slots a VGA chipset for the princely sum of $599 US (about £420 inc VAT then and £1,200 inc VAT in today's money).

Yet by this point, the older EGA standard had spawned a growing industry of third-party manufacturers, adept at mimicking or reverse-engineering IBM's technology and spawning their own versions. What's more, these guys didn't stop at simply replicating IBM's latest standards; they wanted to add a little extra sauce to their cards by actively enhancing them.

As a result, October 1987 saw the launch of the first VGA-compatible third-party graphics card, the STB VGA Extra. It did everything VGA did, albeit with a few foibles here and there, with some optimisations that made it slightly faster. By mid-1988 to 1989, the likes of Tseng Labs, Cirrus Logic, Chips and Technologies and ATi were entering the fray, and not only were they driving prices down to $339 US, but they were also adding new capabilities. These enhanced VGA cards added features to accelerate video, or increased the RAM to 512KB, and tinkered with the BIOS to cover more advanced resolutions, such as 800 x 600 in 16 colours or 640 x 480 with 256 colours.

Developers were able to produce sprites that looked more recognisably human

Dark Seed sacrificed colour depth for resolution, in order to do justice to H.R. Giger's artwork

This in turn put pressure on the system bus. The original VGA controllers were so undemanding that they couldn't exhaust the miserable bandwidth of the 8-bit ISA bus, but as these new chipsets emerged, they required more bandwidth and a spot on the wider 16-bit ISA bus.

As time went on and Intel's CPUs grew faster, demands would grow accordingly, resulting in the development of the Extended ISA (EISA) bus and VESA Local Bus. However, this complicated the situation further, with the fastest enhanced VGA cards, based on Tseng Labs or Cirrus Logic tech, performing best in 16-bit versions running on the 16-bit ISA bus, although this wasn't always the case with every chipset.

By 1989, NEC would lead the early graphics chipset manufacturers in the creation of the Video Electronics Standards Association and the Super VGA BIOS, opening up support for higher resolutions and colour depths across the PC industry. Windows acceleration became the new battleground and video acceleration became the next cutting-edge technology.

Yet all these new cards and advanced feature sets still had the VGA standard at their core. VGA became the base requirement for new PCs running later versions of Windows or IBM's OS/2. In many respects, IBM had built the foundation of PC graphics for the next ten to 15 years. In fact, you could argue that VGA is still the foundation.

If so, it probably wasn't a whole lot of comfort to IBM. While VGA was the last graphics standard IBM managed to establish, it wasn't for the want of trying. Even as it launched VGA, it was preparing its 8514 graphics adaptor, with fixed functions to accelerate common 2D drawing processes, such as drawing lines or filling shapes with colour. In 1990, it hoped to supersede VGA with its new 1,024 x 768, 256-colour standard, XGA.

Both these new standards floundered because they were designed to run on IBM's MCA bus, while IBM's clone-making rivals focused on getting the most out of the existing 16-bit ISA bus, before working on the proposed EISA replacement. The result? Super VGA became the new de facto standard, while IBM lost its domination of the PC industry. Bad news for Big Blue, but good news for those of us who enjoyed the more cost-conscious, game-focused machines in the years that followed.

THE VERY BEST OF EARLY VGA

Coming at you in 256 glorious colours at 320 x 200

WING COMMANDER

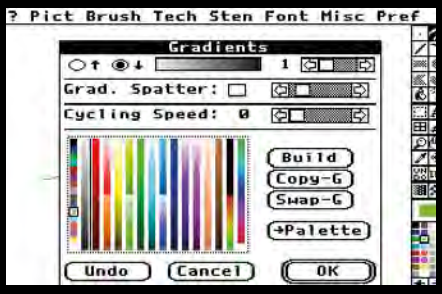
By 1990, VGA was well established, the 386 had become the mainstream PC CPU and the 486 had just appeared. All three technologies found their perfect showcase in Wing Commander. Chris Roberts' dazzling space combat game offered stunning scaling and rotating sprite spaceships, Star Wars-inspired cinematic cutscenes and thrilling mission design. It paved the way for LucasArts's X-Wing games and the Elite revival, while showing the way forward for a new breed of Hollywood-influenced, story-driven games.

THE SECRET OF MONKEY ISLAND

It's a toss-up which was more influential – the first of Ron Gilbert's beloved pirate series or the awesome Indiana Jones and the Fate of Atlantis. Either way, these two titles used VGA's capabilities to full effect, with impressive sprite characters and glorious backdrops that made the most of the larger colour palette. You no longer had to use your imagination to visualise locations, because the artists had done the hard work for you. The Secret of Monkey Island II: Le Chuck's Revenge went even further, with graphics that embraced a stunning, hand-painted look.

WOLFENSTEIN 3D

This pioneering Nazi-blasting FPS from id Software was originally designed to run with EGA graphics, but that became unthinkable once John Carmack and his crew were unleashed on VGA. The texture-mapped walls made the most of simple bitmapped textures, but the sprites for the Nazis, zombies and Hitler-loving hounds looked dazzling in 256 colours, as id pushed the 386 CPUs of the era to their limits. Doom would push 3D realism further still, but even that relied on the limited capabilities of the humble VGA card.



DELUXE PAINT

By 1987, PC users were already getting sick of Commodore Amiga users rubbing their face in the dirt with Deluxe Paint. With advanced drawing tools, fills and scaling capabilities, these smug gits could create images as cool-looking as the legendary King Tut mask or Birth of Venus. When Deluxe Paint II was ported to the PC in 1988, PC users were invited to the party, helping to establish the PC as the graphics powerhouse it would become with the arrival of Adobe Photoshop, Paint Shop Pro and CorelDRAW.

EYE OF THE BEHOLDER

Before The Elder Scrolls, Lands of Lore and Ultima Underworld redefined the RPG genre, Eye of the Beholder set a new benchmark for the expected standard of graphics.

With its graphics built in Deluxe Paint II and powered by 256-colour VGA, it updated the 'Dungeon Master' tile-based dungeon crawler genre, adding customisable characters, an engaging story, and the kind of D&D lore we've come to know and love. People tend to remember the excellent Amiga port of this game, but the PC version was the original, and in many ways the best.

DARK SEED

Combining a point-and-click adventure with psychological horror and the art of Alien maestro, H.R. Giger, Dark Seed used VGA in an unusual way, dropping down to 16 colours in order to hit the maximum 640 x 480 resolution (apparently, Giger made this a condition of the team using his art). In any case, it worked, mixing sequences set in an American town setting with scenes straight from one of Giger's dark sci-fi body horror netherworlds. Even now, it's one weird-looking game. CPC

Readers' drives

Intel Gamer Days

Kris Butterill bolted together two modded Raijintek Enyo cases to create this monster dual-system build, featuring hand-bent tubing, custom 3D-printed parts and four reservoirs

Photography by Andre Pattenden – andrepattenden.com

CPC: How did this Intel dual-PC project start?
Kris: Intel had seen a build I did for MSI, a project for a YouTuber called Mumbo Jumbo, and really loved the final aesthetic. It contacted me to ask if I could put something together as a prize for its 2021 Intel Gamer Days campaign. The brief was to create something really over the top, a dual system with one side dedicated to gaming and one side dedicated to streaming.

This meant the winner would get a rig that could handle pretty much anything they could throw at it, plus it had to look pretty! The focus was celebrating the Intel Gamer Days campaign, so it had to stand out and be themed around Intel's branding, hence the yellow and blue colour scheme. It needed to look as clean and unique as possible, while retaining the core Intel branding elements to make it instantly recognisable.

/MEET THY MAKER

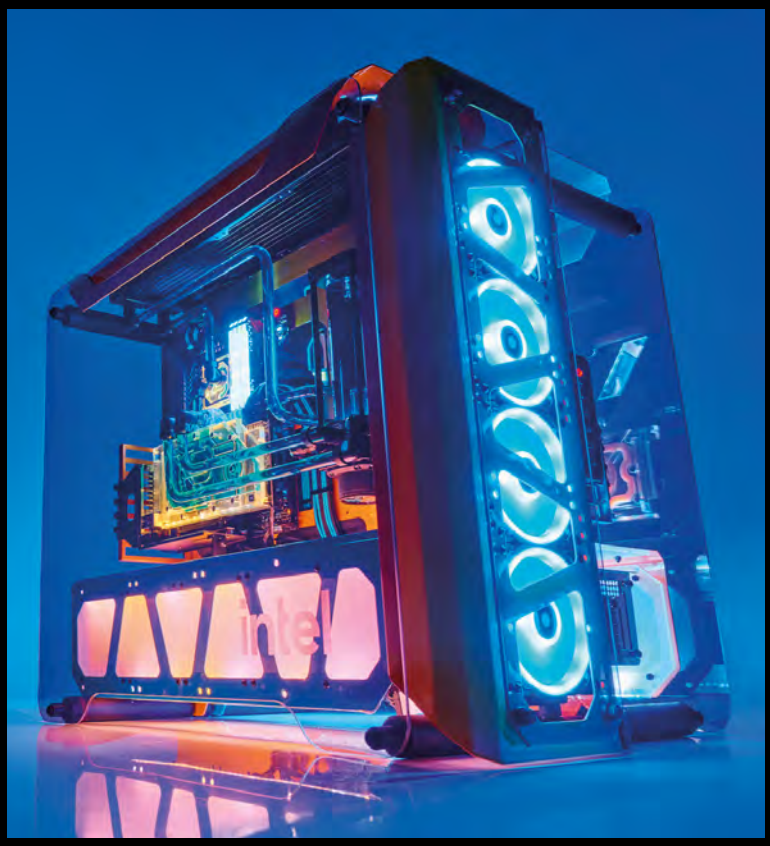
Name Kris Butterill
Age 30-something
Occupation Water Fairy
Location Grimsby, UK
Main uses for PC The winner decides!
Likes Food
Dislikes Diets

CPC: Are the two chassis basically identical but with the yellow and blue swapped around?
Kris: They're close to identical, although each side of the chassis has some subtle changes to elements, such as the fan colours and layout of the water-cooling loop. I wanted to create a system that wrapped around itself, so you could see that it's something special and view all the key details from any viewing angle.

CPC: Are the two systems fixed together?
Kris: It's designed to be one complete build with both sides permanently attached to each other. The only downside is the weight of it when you want to move it around. It separates into its two sides for easier maintenance and positioning, though, and each side is totally independent.

My original plan was to run the coolant from the pumps on one side to cool the components on the other system. However, that meant really overcomplicating the build, and would result in such a mash-up of colour on each side that it wouldn't look right. It also needs to be hand-delivered to Intel UK, and to some extent, it needed to be reasonably practical to ship out to the winner.

CPC: It's difficult to tell, but is this a scratch build or did you use an existing case?
Kris: Thanks for the kudos, but



no, this is based on an off-the-shelf chassis, believe it or not! The whole project needed to be based around a chassis that could offer mounting for dual ATX-sized systems, and to be honest, there aren't any off-the-shelf single cases that do that out of the box. However, the Raijintek Enyo is a modular chassis that had potential to use two of them together. I had to modify the mounting system and essentially bolt them back to back, using just the front-facing sides of each chassis kit.

When in discussion, neither Intel nor myself could be 100 per cent sure that the concept and idea would work until the cases were ordered and landed with me. Once they were with me, though, it soon became clear that our aim was achievable, albeit with some tinkering here and there.

The modular design of the Enyo made it fairly easy to put it all together. I had to drill and modify some small aspects of the cases in order to get the motherboard mounting correct. There was also some customisation involved when moving the mounting locations of the power supplies and top radiator panels.

> I had to drill and modify some small aspects of the cases in order to get the motherboard mounting correct

In its final configuration, the case is simply huge! Once the modular panels had been modified, it was then time to build it up for test fitting and making sure that all the parts connected perfectly. The Enyo does have some sway in it though – if Raijintek ever makes a V2 edition of this open-air case then it would be nice to have a little more rigidity with thicker panels. Overall, though, it's sturdy enough once it's all built up.

CPC: Those are some strikingly bold and bright colours. What paints did you use?

Kris: Every modder had a weakness, whether they like to admit it or not, and paint is one of those areas for me. Given the sheer size of this project, and the need for the best possible longevity, I decided to outsource the paint job. It's powder-coated for additional durability and the colours were RAL-matched to Intel's branding. Originally, the idea was to keep the colours completely separate, but after getting the parts back, swapping over the power supply shrouds really added some extra contrast to the theme.

CPC: How did you create the diffuse lighting effect? Is that translucent acrylic?

FRONT PC SPECS

CPU Intel Core i9-11900K

Motherboard Asus ROG Maximus XIII Extreme Glacial

Case Raijintek Enyo

Storage 3 x 2TB WD Black PCI-E 4

Graphics card Asus TUF GeForce RTX 3090

Memory 64GB Corsair Dominator

Cooling Full custom water-cooling loop, with 2 x Alphacool Eisbecher Aurora reservoirs, 2 x Alphacool VPP655 pumps, 2 x Alphacool ST30 480mm radiators, 1 x Alphacool GPU waterblock. 8 x Corsair LL120 fans

REAR PC SPECS

CPU Intel Core i7-11700K

Motherboard Asus ROG Maximus XIII Hero

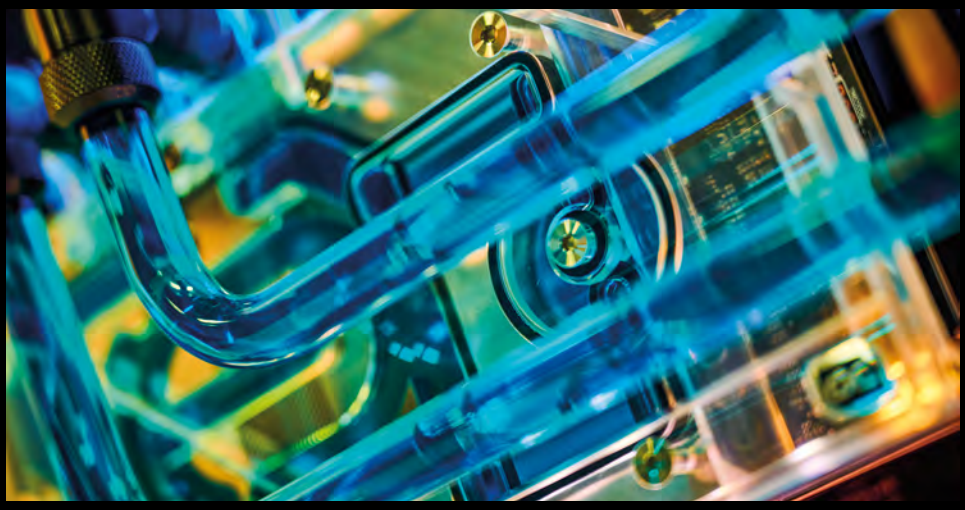
Case Raijintek Enyo

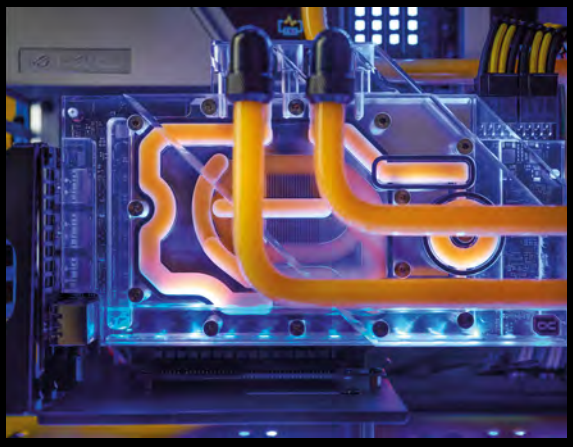
Storage 2 x 2TB WD Black PCI-E 4

Graphics card Asus TUF GeForce RTX 3080

Memory 64GB Corsair Dominator

Cooling Full custom water-cooling loop, with 2 x Alphacool Eisbecher Aurora reservoirs, 2 x Alphacool VPP655 pumps, 2 x Alphacool ST30 480mm radiators, 1 x Alphacool GPU waterblock. 8 x Corsair LL120 fans





Kris: Indeed, I designed up the panels in CAD to match up with the mounting holes for the fan placement in the bottom shrouds. They were then laser-cut, with RGB strips added to the edges to allow the light to diffuse through them. All the RGB lighting is controlled by a rather in-depth Corsair iCUE-based system running two Corsair Commander Pro units per side.

CPC: Take us through the water-cooling systems.

Kris: There are two 480mm Alphacool radiators per system. Alphacool is my go-to cooling partner, as it gives me peace of mind when it comes to reliability and quality. I didn't go for 45mm-thick rads, as the Enyo case's weight-bearing capacity isn't perfect, so I used 30mm-thick radiators.

I designed and 3D-printed some custom mounts for the reservoirs, as the Enyo's standard mounting pattern didn't match up to the Alphacool mounting brackets. Despite the two reservoirs in each system, the loops aren't split either – each system has one big elaborate run, rather than two separate loops.

I could have made two separate water-cooling loops for the CPU and GPU in each system, but this setup helps to bulk out the system, adds a unique feature and builds in some redundancy should a pump fail at some point.

It's very rare that I pre-plan tubing runs, as what you have in mind might not actually be physically possible. All the tubes were bent by me, and some of them required four or five attempts to ensure they were absolutely perfect. I used Alphacool 13/10mm PMMA tubing – I prefer it to PETG – and used the integrated tubing pass-through on the chassis.

CPC: Where are all the cables hidden?

Kris: The cables are predominantly hidden behind the power supply shrouds. There's all the Corsair iCUE wiring that goes to the fans and lighting, with custom-length cables from the SFX 1000W PSUs to the motherboards and GPUs.

There's a small gap between each side of the system that's used for some of the cable runs. Planning this included measuring up for the custom cables – I didn't want any excess because that would just give me another tidying problem down the line.

There's a lot of room under the bottom shrouds, and I designed and 3D-printed some custom brackets for the Commander Pro units to sit inside them.

I love using my 3D printer – it's such a great tool to use when I want to overcome little problems, such as these. I didn't want to use 3M pads, as they might fail six months down the line.

CPC: What specs did you choose and why?
Kris: I love Asus hardware, so it wasn't hard for me to figure out what I wanted to use for the core of each system. Intel wanted to go over the top, essentially handing me (with certain terms) an unlimited budget for hardware. For gaming, I think what we used was over the top.

The Asus Glacial is simply a gorgeous motherboard, with its built-in water-cooling support and extensive features, while Asus' Hero range is one of my all-time favourites. It's all based on Intel 11th-gen hardware, so there's a Core i9-11900K and Core i7-11700K, plus Asus TUF RTX 3090 and RTX 3080 graphics cards, 10TB of PCI-E 4 storage from WD and Corsair Dominator RAM. All in, I think there's over £15K worth of gear sat here, just in hardware, so it's not like we skimped anywhere!

CPC: Did you come across any difficulties?
Kris: Loads of them! The biggest, though, was accommodating the sheer size and weight of this thing in its entirety. It's a little easier to handle when it's separated into single entities, but it requires two people to lift it when it's all bolted together, and I wouldn't recommend trying to move it as a whole unit. Whoever ends up with this machine needs to choose where it's going to live wisely, because it isn't going anywhere once it's in place!

The top of the Enyo case also sags a little with the weight of the 30mm-thick rads. I could have added supports, but that would have taken away some of the overall look of the build, plus it's certainly not a major factor as it stands.

CPC: How long did it take you to complete this build?
Kris: I'd say around eight to ten weeks, but a lot of that time was down to the paint job and waiting for arts. The wait feels like forever on a project such as this one when you just want to crack on with it.

CPC: Is there anything else you want to add about the build process?
Kris: Probably the most important thing about this whole project is that Intel is giving it away! Entering to win this system will truly help a non-profit organisation, Technovation, which empowers girls to become leaders through tech education. The Technovation Girls program equips young women (aged eight-18), with the support of volunteer mentors and parents, working in teams to code mobile apps that address real-world problems. You can enter to win this system by donating $10 US or more at **prizeo.com/mod83**. If you want to give more, you'll earn more entries to win. You can use the promo code MOD83 and get 200 bonus entries when you make a donation.

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?
Kris: No modder is every truly happy with a build! There's always something you would change, try differently and so on. Overall, though, I don't think it turned out too bad, eh? CPC

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

GPU SALES STORY

James Gorbold takes a look at how sales of GeForce cards compare with Radeon cards at Scan, and it's not good news for AMD

While **Custom PC**'s Labs tests and reviews can tell you which GPUs you should buy, based on their performance in games and whatever prices they're fetching at the moment, I thought it might be interesting to provide my own commentary on the current state of the graphics card market and where it's headed. Reviews can tell you which products offer the best bang per buck, but that doesn't always reflect people's buying habits.

While I can't provide any specific numbers, as they're commercially sensitive, this column is based on information available to me working for Scan, the largest graphics card retailer in the UK – in other words, I'm basing it on real supply and demand data, not just speculation.

For instance, while it probably won't come as a surprise to many of you that Nvidia is still dominating the gaming GPU market, with an overwhelming proportion of market share, it's still quite shocking to see just how badly the Radeon RX 6000 series is performing. When I talk about performance here, I don't mean frames per second – that's a separate topic entirely, and one that's covered by this month's Labs test (see p44) – but market performance.

> It's quite shocking to see how badly the Radeon RX 6000 series is performing

The sad truth is that, even with competitive performance in rasterised games, Radeon is continuing to take a beating from GeForce. This is true across the whole landscape of GPUs, none more evident at the high-end, with sales at Scan dominated by the GeForce RTX 3080, closely followed by the GeForce RTX 3080 Ti. Then, a fair way behind, but still in third place, is the GeForce RTX 3090 and fourth is the GeForce RTX 3070 Ti, which was covered in last month's Labs test.

That's zero places among the top four big hitters for a single Radeon GPU. That's not to say they aren't selling – they are, but sales are comparatively tiny. What should be particularly worrying for AMD, apart from the fact that it has reasonably competitive products that aren't selling, at least not at Scan, is that even when there are shortages of particular GeForce GPUs, gamers don't switch over to buying Radeon GPUs instead.

For example, we recently experienced an even more acute shortage than usual of GeForce RTX 3080 cards, but when faced with this shortage, gamers chose to upgrade to the RTX 3080 Ti instead of an AMD Radeon card. This behaviour, incidentally, is a large part of the reason why we chose the combination of a GeForce RTX 3080 Ti and Core i9 12900K in our system that's reviewed in **Custom PC** this month (see p34).

While this certainly isn't terminal news for AMD's GPU division, especially as the company's consumer and enterprise CPU divisions have been performing extremely well in recent years, it's not a good sign when you have supply and your products still aren't selling.

The sad fact of the matter is that, despite having reasonably competitive GPUs and a slew of game giveaways, Radeon simply doesn't have the same brand recognition as GeForce. Nvidia's GeForce division truly excels at marketing, which is always important. This is particularly the case when you have supply challenges, while also simultaneously having opportunities to exploit, such as so many new gamers entering the market since the start of the pandemic.

What's more, with a newly confident Intel about to enter the gaming GPU market, AMD's standing looks set to become rockier. Still, out of the flames of intense competition sometimes, just sometimes, truly astonishing technology emerges. Here's hoping. 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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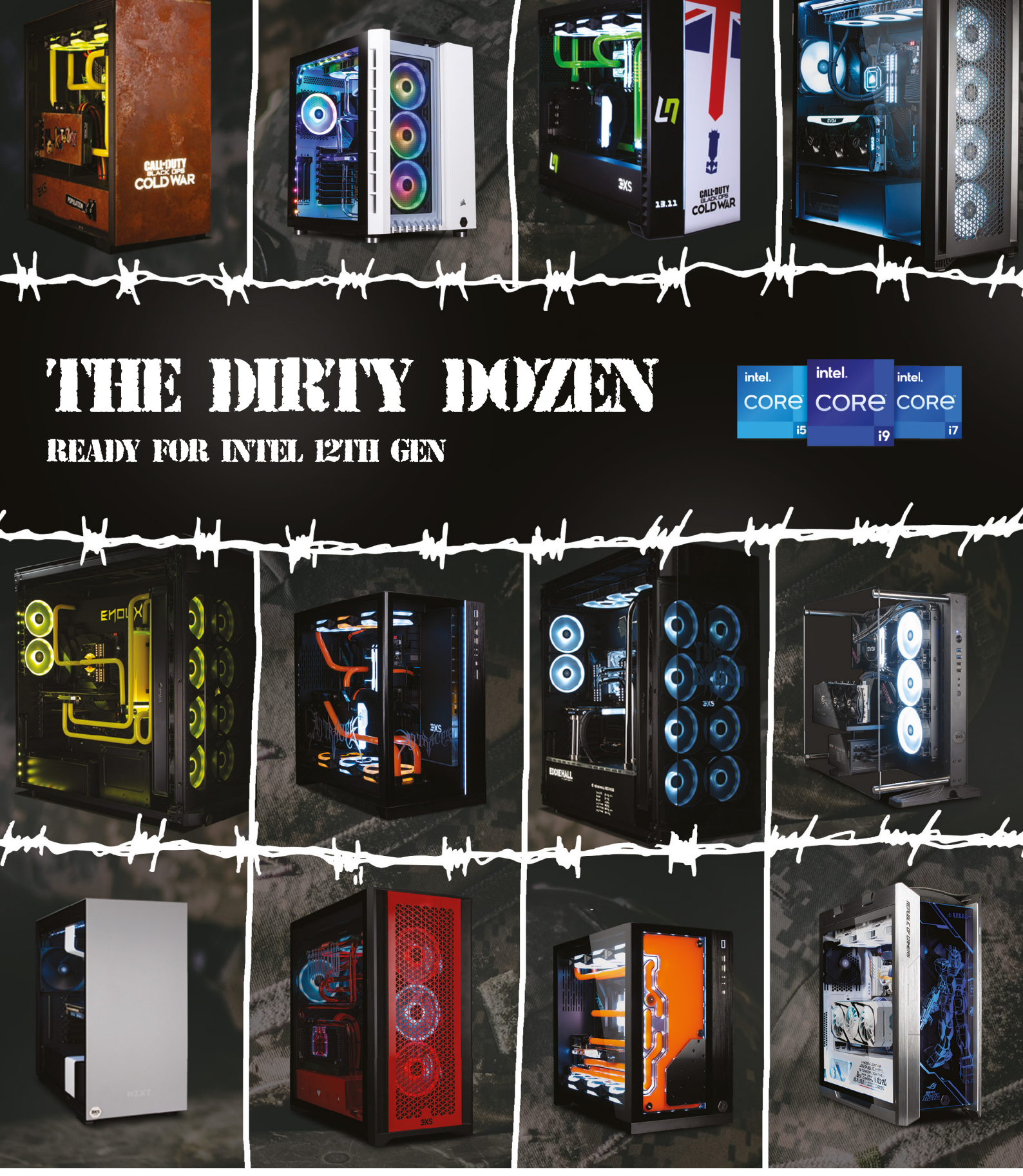

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