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CUSTOM PC

THE BEST-SELLING MAG FOR PC HARDWARE, OVERCLOCKING, GAMING & MODDING / ISSUE 206

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Welcome

Custom PC Issue 206

/ FROM THE EDITOR

Load the shrink ray

In our last issue, we had great fun knocking together a retro gaming PC using 1990s hardware. Our archaic yellow ATX motherboard sported a stack of seven PCI and ISA expansion slots, and back then you really needed them. Once you'd added a sound card, graphics card, 3D accelerator, modem and network card, there wouldn't be much room to swing a ribbon cable in your cramped beige case's dusty innards.

Compare that with today, when all the basics are already integrated onto your motherboard. I have one PCI-E card in my ATX PC – my graphics card, and I know I'm not alone. I could easily downsize the whole caboodle into a tiny box, and I wouldn't lose features or performance. I could have a 16-core CPU, super-fast PCI-E 4 storage, a full-fat graphics card and decent-quality sound too.

Of course, some people still need expansion cards for various tasks, such as video capture and music production. Some PC enthusiasts also like to have loads of room for complex water-cooling loops. Mini-ITX isn't for these folks, although you can water-cool a mini-ITX PC if you don't mind putting in the planning work. For the average PC gamer, a mini PC will do it all.

It's not as simple as just buying smaller components though. As our modding editor Antony Leather has said before, the mini-ITX world is chock-full of innovation. That's great, as it drives progress, with great-looking systems that take up hardly any desk space. However, it also means there are lots of very different ideas when it comes to case and component design, resulting in compatibility problems.

That's why a large focus of this issue is traversing the mini-ITX obstacle course. On p74, our lead feature takes you through all the considerations, from case styles to components and cooling, with tips for planning a mini system that's right for you. There's also a mini-ITX motherboard Labs test on p38, covering boards for both Intel and AMD CPUs. We've put a couple of new mini-ITX cases through their paces at the front of our reviews section on p16 as well. If you're thinking of building a new PC, and don't use any specialist PCI-E cards, then why not downsize this time? **CPC**

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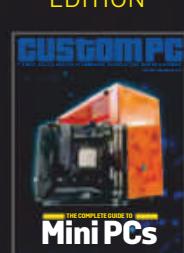
ISSUE 206



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

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

ISSUE 206 SUBSCRIBERS EDITION



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RICHARD SWINBURNE / VIEW FROM TAIWAN

INTEL GOES BIG ON LITTLE

Intel looks set to mix Core and Atom CPU cores on its 12th-gen CPUs.
Richard Swinburne takes a look at the implications

Inside Intel's latest Linux patch notes is a specific line that says 'Hybrid Core/Atom Processors'. It looks as though next year's Alder Lake (12th-gen) CPUs are set to introduce the first heterogeneous x86 CPU design, a combination of 'big' Golden Cove (Core) and 'little' Gracemont (Atom) cores.

ARM introduced heterogeneous CPUs to the consumer market with its own 'big.LITTLE' design in 2012, mixing two types of its Cortex-A cores together in a single chip – high-performance 'big' cores and power efficiency-focused 'little' cores. The design switched between either cluster of four cores depending on performance demands.

This original 'clustered switching' wasn't that elegant and has evolved to become much more fine-grained, where any core can be assigned work at any time. ARM's recent DynamIQ design even allows companies to mix any number of 'big' and 'little' cores within a single octa-core cluster, meeting a huge variety of design demands from its customers.

Following its first attempt at mixing one 'big' and four 'little' cores with its Lakefield SoC, Intel is looking for the same opportunity to target multiple price/performance brackets, while effectively upping the number of cores, making it more competitive against AMD. Many online stores offer 'sort by core count' as a search filter, and selecting an '8-core' box could offer 8+0, 6+2, 4+4 configurations, all at slightly different prices.

This may seem silly, but not everyone is technical enough to know the real deal. In the mobile world, practically all smartphones, from entry-level to flagship models, are all sold as being 'octa-core' and it's up to the buyer to know

what's inside. Smartphone chip naming schemes hide the CPU architecture, fabrication node and the count of 'big' and 'little' cores. Both Intel and AMD have already unaligned their product names with the first two features, so it's no stretch of the imagination to think that future product naming be opaquer.

Intel is fighting against AMD at 7nm while languishing at 14nm, and by the time it rolls out 10nm chips, AMD will probably be at 5nm. As such, I expect Alder Lake to adopt a chiplet design, where its 'little' efficiency-focused Atom cores are put on a 10nm die, and its 'big' cores are put on a separate die fabricated on a mature 14nm process.

This approach would smooth the roll-out of Intel's 10nm process, because a cluster of 'little' Atom cores is smaller and simpler than a cluster of 'big' cores, and the former won't need a high clock speed. Even if the 10nm Atom yield isn't terribly good, Intel can still make plenty of chips per wafer to satisfy demand.

Where the rest of the CPU parts, such as the integrated graphics processor (IGP), memory controller and PCI-E lanes, will go also remains to be seen. However, since the IGP-less F-suffix CPUs are a persistent feature of the market now, Intel could save a lot of hassle by separating the IGP onto its own die as well, and simply omitting it for those F-suffix products.

Intel knows AMD doesn't have the benefit of a 'little' core any more, since it stopped developing its 'small cat' cores – Bobcat, Jaguar and Puma – several years ago in favour of one Zen to rule them all. Unless AMD revives this idea, or forks Zen into a power efficiency-focused design, Intel will have the benefits of 'little' cores all to itself. **EPC**

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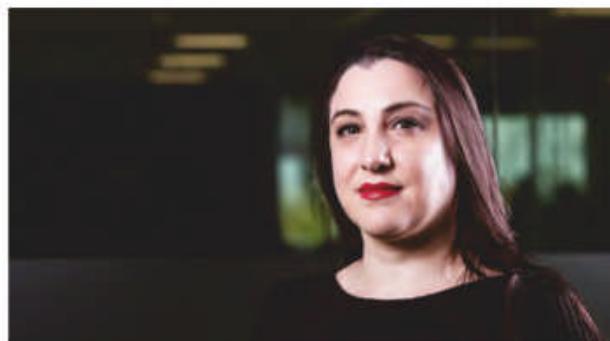
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TRACY KING / SCEPTICAL ANALYSIS

EPIC BATTLES

Google and Apple have removed Fortnite from their app stores, but Tracy King isn't taking any sides

Fight! Specifically, a battle royale between the giant armies of tech and gaming. It's Epic, maker of Fortnite, vs Apple. However, it's also Epic vs Google, Epic vs Valve and, if you believe the rhetoric, in some ways Epic vs the entire concept of monopolies and profit. It's tempting to pick a side, and many gamers jumped on board the #FreeFortnite hashtag on social media, referring to a Fortnite tournament where you could win prizes that mock Apple.

If you don't already know, Apple removed Fortnite from the iOS app store, because Epic was selling add-ons directly to players, thereby depriving Apple of its 30 per cent cut. Google did the same with the Google Play Store. The most simplistic argument around this situation is that Epic signed up for Apple's terms, in return for access to a lucrative and essential mobile gaming audience, and vital support from Apple. Epic knew the terms and has no right to start demanding special treatment.

In this scenario, Apple is Goliath and Epic is David, bringing down the giant with just a pebble. But of course, this is nonsense. While Apple may be one of the biggest tech companies in the world, Epic is no child. Fortnite alone generates over a billion dollars in revenue every year. Epic has access to lawyers just as expensive and effective as those of Apple, Google or anyone else it cares to legally battle.

Equally though, Apple absolutely doles out special treatment when it suits the company. Amazon, for example, negotiated more favourable terms than 30 per cent for the Prime video streaming service.

Epic has access to lawyers just as expensive and effective as those of Apple and Google

On PC, the situation is a little more complicated, in that Epic has its own PC games store, which 'only' takes a 12 per cent cut of game revenue, rather than the industry standard 30 per cent. This takes the argument away from Fortnite and who gets a slice of those billions of dollars, and into Epic's own entry into the digital high street as a storefront.

While this may lend some credibility to Epic's argument that it's an anti-monopoly organisation, companies gain a monopoly through being profitable, and profits are what Epic wants. It's not possible that the Epic Game Store would exist were it not profitable. The very fact that Epic offers store exclusives makes it clear that it wants money that would otherwise go to its competitors.

Monopolies emerge from precisely this situation. In one of its court documents, Epic cited Google's old motto of 'don't be evil', but as far as I know, it has no plans to ease Epic Game Store user licences so that libraries become transferable.

The lower fees attract developers and therefore exclusives, which lock gamers into Epic's platform. Do this well enough to become dominant and bam, you have yourself a monopoly to protect, and some smaller tech player will come along and launch a legal challenge.

And ultimately this is why any claim on Epic's part to be the good-guy David against the evil giants of Apple and Google should be ignored. The innocent party here is the end user, the gamer who is giving all of them – David and Goliath alike – our money. Epic can claim the 30 per cent fees are unfair as a principle, but if Epic wins this battle, will its increased profits go to charity, or does the principle of 'too much profit' only extend to everyone else? **EPC**



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Incoming

HYPERX LAUNCHES LIGHTWEIGHT WIRELESS HEADSET

HyperX has expanded its line-up of Cloud headsets with a lightweight wireless model for PC and PS4 owners. The Cloud Stinger Core weighs 275g and has 40mm drivers.

HyperX says its 2.4GHz wireless connection has a range of 12m, and claims it has a 17-hour battery life. Hyper X also claims that its soft,

breathable earcup cushions will remain comfortable during long gaming sessions. Other features include volume controls on the earcup, and a swivel-to-mute noise-cancelling microphone. The Cloud Stinger Core Wireless is available in an all-white design from argos.co.uk for £75 inc VAT.



NEW NVIDIA GPUs INCOMING

By the time you read this magazine, Nvidia will have officially announced some details of its forthcoming Ampere-based GeForce GPUs, presumably with RTX 3000-series model numbers.

However, in a very irritating twist of fate, the announcement by Nvidia CEO Jen-Hsun Huang was on 5pm on 1 September, just after this issue had gone to press but before it went on sale, and Nvidia was keeping tightly schtum on the subject with no pre-briefings for the press.

The new graphics cards look set to be the first ones to feature a new 12-pin

power connector, which should be compatible with some existing PSUs via an adaptor.

The company recently released a YouTube video called The Remarkable Art & Science of Modern Graphics Card Design, which showed a diagram of the new 12-pin connector on a strangely shaped PCB with a large cut-out in it, which we're assuming is one of the new Founders Edition cards.

We should have all the details in our next issue, and hopefully some reviews too. Watch this space.



ALPHACOOL SHRINKS LIQUID COOLER

Water-cooling specialist Alphacool has released a new all-in-one liquid cooler designed specifically for small form factor systems. The Eisbaer LT 92 CPU has a 92mm copper radiator, and features short 25cm tubing, enabling it to be squeezed into the tight confines of a mini case with a 92mm fan mount.

The radiator measures 30mm thick, and has an overall height of 130mm, so it's still best to measure up the area around your fan mount before purchasing. You'll also need to supply your own 92mm fan, as no fans are included in the box. The Eisbaer LT 92 is available to buy now for £68 inc VAT from aquatuning.co.uk, and is compatible with AM4, LGA2066, LGA115x and LGA1200 sockets, as well as others.



ZEN 2 GETS BUDGET MOTHERBOARDS

AMD has finally filled out its 3rd-gen Ryzen chipset line-up, with the release of the budget-focused A520 chipset. A520 will support AMD's forthcoming CPUs based on the Zen 3 architecture as well as 3rd-gen Ryzen CPUs, but there's no support for older 2nd-gen or 1st-gen Ryzen chips.

Although the A520 chipset will play host to AMD's latest CPUs, however, there's no PCI-E 4 support, with just 26 PCI-E 3 lanes available with a 3rd-gen Ryzen chip, and you won't be able to overclock your CPU via the multiplier either.

No motherboards have yet been released to retail, but ASRock's A520M HVS (pictured) is currently available for pre-order from scan.co.uk for £52 inc VAT, making it a massively cheaper option than any boards based on AMD's B550 chipset, or even the older B450 chipset for that matter.



CORSAIR INTRODUCES HARD-TUBE STARTER KITS

Corsair hopes to make it easier for beginners to get to grips with hard water-cooling tubing, by introducing starter kits. The Hydro X HX305iRGB (pictured) and XH303iRGB feature all the gear you need, including a Corsair XC7 RGB CPU waterblock, a 360mm radiator, three RGB fans, fittings, adaptors, clear hard tubing and coolant.

In addition, you get the tools to cut and bend the tubing, including a saw, tube holder, bending mandrel and silicone insert. The difference between the two kits is the pump/reservoir combo unit. The XH303i has an XD3 RGB for compact systems, and the XH305i comes with Corsair's XD5 RGB.

The XH305iRGB and XH303iRGB are available from overclockers.co.uk for £520 and £450 inc VAT respectively.



ASUS UNLEASHES 360Hz MONITOR



If you're a competitive gamer who is lucky enough to have a GPU system capable of maintaining 360fps then Asus has the display for you. The company's new ROG Swift PG259QN touts a super-fast 360Hz refresh rate, and it also has full Nvidia G-Sync hardware to eliminate tearing artefacts at this speed.

Asus has even had to design a custom heatsink for the monitor, which the company says will ensure 'efficient cooling during marathon gaming sessions'. The PG259QN has a 24.5in



AOC RELEASES 165Hz VA GAMING SCREENS

AOC has expanded its line-up of gaming monitors further, with the release of four new curved displays. All the monitors have 1,920 x 1,080 VA panels with FreeSync Premium support, with AOC claiming a 1ms (MPRT) response time.

Thanks to the use of VA panels, AOC is also claiming some high contrast ratios for the screens, with the 24in models having a stated 3,000:1 contrast ratio, which steps up to 4,000:1 on the 27in models.

Prices start from £169 inc VAT for the C24G2AE, which has a 24in screen and a tiltable stand, with the C24G2U offering the same panel on a height-adjustable stand with a 4-port USB hub for an extra £20. There are two 27in models with the same stand options too, priced at £229 and £249 inc VAT respectively.



IPS panel with a resolution of 1,920 x 1,080, and Asus claims it has a 1ms GTG response time, and a 1,000:1 contrast ratio. There's no word on UK pricing yet, but Asus says the ROG Swift PG259QN will be available later in September, with a price of \$699 US ex tax, which works out at around £627 inc VAT.

Letters

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



Rate my rig

After over a decade since my last build, I've caught the bug again thanks to reconnecting with your magazine. I even subscribed again! My first (recent) attempt is based on the entry-level RTX gaming system on your Elite list, with a few modifications. I replaced the Antec Neptune 240 with a Noctua NH-U12S SE-AM4, and I used a Corsair RM650x PSU and a be quiet! Pure Base 500DX case. I welcome your thoughts.

MAURICE HAYEK

Ben: Thanks for your subscription, Maurice, and I'm glad to hear you're back into PC building after all this time – your new build must be a significant upgrade on your old machine! That's an excellent choice of case for the entry-level RTX gaming system on our Elite list. The Pure Base 500DX came out of our last case Labs test with an award, thanks to its snazzy looks and great cooling. That's a superb PSU too, with full modular cables and 80 Plus Gold certification. It's arguably overkill for your spec, but it's always good to have a bit of headroom.

The be quiet! Pure Base 500DX is an excellent choice of case

When's the next issue out?
CUSTOMPC
 OCT 08
 Issue 207
 On sale on Thursday, 8 October

We haven't tested the Noctua NH-U12S, but Noctua generally has a great reputation for high-performance, well-built and quiet coolers, although they're not cheap. The NH-U12S has a maximum rated TDP of 140W, which will be more than enough to cool your 65W Ryzen 5 3600 – you can probably even squeeze a bit more clock speed out of it. Nice work – enjoy your new system.

Type-C is my type

I agree with Anthony Leather regarding USB Type-C ports (see Issue 205, p94). I'm looking at getting a new laptop within the next year, and I'd be happy if it didn't have any Type-A ports at all. I've even bought a USB Type-C-to-Type-B cable, so I can continue using my external hard drive once I switch machines. Type-C is better in every way.

ANDREW LEVICK

Ben: I think the only reason Type-A refuses to die is simply because it's been

the standard for over two decades, and there's so much kit that uses it. I also love the Type-C connector – it's compact and it doesn't matter which way round you plug it in. It's just a shame that the names of the USB standards it accompanies have become such a confusing jumble of nonsense.

Retro power

In your retro DOS build in Issue 205, I'm interested to see how the -5V line is generated from that PSU for the ISA card.

MARK SIMPSON

Ben: Indeed, this is well worth bringing up, as it's not mentioned in the feature, for which I apologise. Old PC power supplies, including AT ones and the 1st-gen ATX ones, had a -5V line, which was required by some ISA cards. The latest ATX standards (from version 2.01 onwards) have no requirement for a -5V line, so new PSUs generally don't have them, including the Corsair PSU in our build.

That's not a problem for the ISA Sound Blaster 16 in our build, as it doesn't need it, and neither do most ISA cards, to be fair. However, there's a few cards that need it, including some early Sound Blaster models. If you're building a retro machine like ours, it's worth Googling your chosen ISA cards' power requirements first.

Our ISA Sound Blaster 16 worked fine with a new Corsair PSU, but some old ISA cards require a -5V line, which isn't found on most new PSUs



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Reviews

MINI-ITX CASE

RAIJINTEK METIS EVO TGS / £120 inc VAT

SUPPLIER overclockers.co.uk

ALIEN

- + Aluminium exterior
- + Good GPU clearance
- + Expandable cooling

PROMETHEUS

- Large
- Poor stock cooling
- No audio ports

SPEC

Dimensions (mm)
293 x 290 x 263 (W x D x H)

Material
Steel, aluminium, glass

Available colours
Black, red, pink, blue, silver, grey

Weight
4.35kg

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

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

Form factor(s)
Mini-ITX

Cooling
1x 120mm/140mm/200mm front fan mount (fan not included), 2x 92mm rear fan mounts (fan not included), 1x 120mm base fan mount (fan not included)

CPU cooler clearance
135mm

Maximum graphics card length
280mm

The original Raijintek Metis and Metis Plus were supremely small, thanks to good use of interior space that allowed for reasonably long graphics cards and ATX PSUs, as well as 120mm all-in-one liquid coolers. It was a little limited on airflow, though, but that's true of many small cases. Raijintek has decided to do something about that, though, and the Metis Evo is the result. Available in a range of colours, it's available with vented or tempered glass side panels, with our sample sporting the latter.

The roof is also perforated, allowing the roof-mounted graphics card to breathe. That said, the graphics card mount is off-centre, and the cooler of our model didn't line up, with half its fan obscured, so you'll want to check the design of your GPU cooler first.

There's also space for 135mm CPU air coolers and graphics cards up to 280mm. The latter is a big upgrade from the original's 170mm, and even using a 220mm-long graphics card will still leave enough space for a 30mm radiator and fan. However, the CPU cooler height is a downgrade, despite the Metis Evo being a much larger case than its predecessor. That's because it adopts a dual-chamber design, with the PSU now sitting behind the motherboard rather than in front of it.

That's a shame, as it means there's quite a bit of wasted interior space, so you'll need either a low-profile air cooler or an AIO liquid cooler. However, not all the extra volume has been squandered. There's now space for a pair of hard disks and 2.5in SSDs, which is double

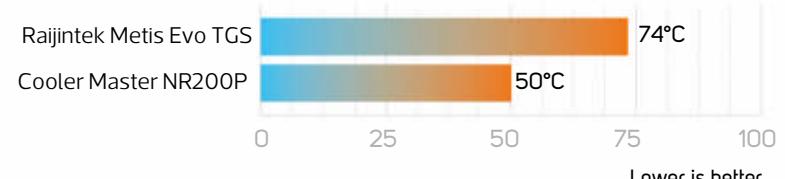


what its predecessor could house, and there's much more space for PSU cables too. Plus, while the case touts ATX PSU compatibility, Raijintek includes an SFX PSU mount, enabling you to install smaller PSUs.

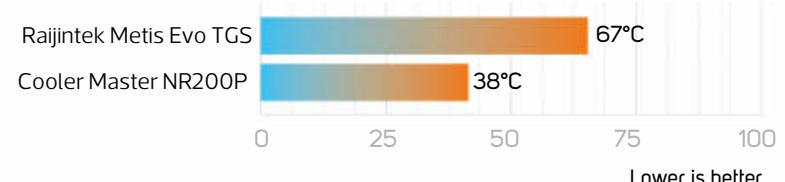
The biggest boost, though, is the fan and radiator support. The old case was limited to 120mm all-in-one liquid coolers, but the Metis Evo's added girth sees the front offering a home for up to 200mm radiators, with a 120mm fan mount in the base and two 92mm fans in the rear. There's a 70mm gap between the front fan mount and internal supports too, so it's possible to use a 45mm-thick radiator and a single row of fans.

TEMPERATURE RESULTS

CPU DELTA T



GPU DELTA T



Sadly, out of the box, there are no fans included, with Raijintek pitching the Metis Evo as a blank canvas, especially where CPU cooling is concerned. Even if you opt for the glass panel version, as with our sample, the Metis Evo is still able to sit in the high-airflow camp, as the entire front of the case sports mesh and acts like a dust filter.

There's a removable filter in the base too, but the roof vent lacks one, relying on the holes to be small enough to trap any detritus. The mesh panel has the front panel ports embedded into it as well, although you don't get any audio ports and the Type-C port here is powered by a USB 3 header, so it's not full-fat USB 3.1 Gen 2.

The tempered glass version includes two glass panels, which are held in place using thumbscrews, attaching to a large U-shaped aluminium enclosure. The latter can also be removed separately, leaving a gaping opening that makes installing your hardware much easier.

That said, you'll have to deal with 16 screws to get there, so this isn't a case for regular upgraders. The panels sit nearly a centimetre away from the enclosure, with large gaps around them, but Raijintek also includes neoprene strips you can install to make them dustproof.

Performance

With no fans as standard, the Metis Evo TGS didn't fare well with our new mini-ITX test system, with our single-fan GeForce GTX 1660 hitting a hefty 67°C delta T, and MSI Afterburner indicating an actual temperature of 90°C. The CPU was even worse – the delta T hit 74°C, with our low-profile cooler being denied a side intake through which to draw cool air.

Adding a 140mm fan to the front panel saw that figure fall by a massive 15°C, but the GPU temperature remained stubbornly high at a delta T of 63°C, although this was at least below the temperature limit we'd set in Afterburner, so the GPU wouldn't be throttling. We suspect there's some recirculation going on, as the cooler on our test graphics card does dump warm air back into the case, and part of the fan is also obscured by the top panel. Either way, the Metis' cooling prowess was certainly given a bloody nose by the Cooler Master NR200P (see p18).

Conclusion

The Metis Evo isn't particularly small, even for a cube-style mini-ITX case, and it doesn't optimise its interior space as well as the original Metis either. The dual-chamber design



with the motherboard in the middle of the case, and the PSU behind it, means the case is much wider than necessary.

On the plus side, you gain options for storage and a larger graphics card, but there's wasted space in front of the PSU. Small form factor purists will likely scoff at this inefficiency, and the company's Ophion mini-ITX cases are certainly more in line here, offering water-cooling support and space for large graphics cards in a significantly smaller volume.

However, as we've already mentioned, the Metis Evo is a blank canvas, so out-of-the-box cooling is never going to be a strong point. Filling all its fan mounts will take advantage of that massive front mesh, and even adding a single 140mm front fan saw a huge drop in CPU temperature and a small fall in GPU temperature too. There's room for water-cooling gear too, with plenty of space for mounting pumps and reservoirs, as well as a 200mm radiator in the front.

Out of the box, the Metis Evo is bit of a mess, and we doubt the vented side panel version will improve that situation much. However, with the right cooling gear added, the Metis Evo TGS has huge potential as a high-airflow or water-cooled chassis that's still compact compared with micro-ATX and ATX cases. At £120 inc VAT, though, the base package needs to be better.

ANTONY LEATHER

VERDICT

Some worthwhile improvements over its predecessor, but the new Metis uses its interior space inefficiently, and requires additional cooling hardware to shine.

COOLING	20 / 30
FEATURES	17 / 20
DESIGN	24 / 30
VALUE	15 / 20

OVERALL SCORE
76%

MINI-ITX CASE

COOLER MASTER MASTERBOX NR200P / £90 inc VAT

SUPPLIER overclockers.co.uk**MASTER BOX**

- + Flexible cooling
- + Decent graphics card and CPU cooler clearance
- + Innovative design

CARDBOARD BOX

- No USB Type-C port
- Hard disks limit cooling options
- No roof radiator mount

SPEC**Dimensions (mm)**

185 x 360 x 274 (W x D x H)

Material

Steel, plastic, glass

Available colours

Black, white

Weight

5.1kg

Front panel

Power, 2 x USB 3, 1x audio headphone/mic

Drive bays

1x 3.5in, 1x 2.5/3.5in, 2 x 2.5in

Form factor(s)

Mini-ITX, mini-DTX

Cooling

2 x 120mm roof fan mounts (fans included), 1x 92mm rear fan mount (fan not included), 2 x 120mm base fan mount (fan not included), 2 x 120/140mm side fan mounts (fan not included)

CPU cooler clearance

155mm (vented side panel), 153mm (glass side panel), 76mm (vertical GPU)

Maximum graphics card length

330mm

Externally, Cooler Master's new £90 mini-ITX case looks similar to a number of others on the market, but the MasterBox NR200P is hiding a treasure trove of features and customisation inside it, and we're sure other companies will soon be scrambling to try to match it. The NR200 range comes in two guises, with the NR200P flagship we're reviewing offering two 120mm fans, the option of a perforated or glass side panel and a PCI-E riser cable. The NR200 lacks those features, and has 120mm and 90mm fans instead.

Despite costing under £100, the MasterBox NR200P feels very solid and weighs over 5kg. It's reasonably compact, with a width of under 20cm, and it only stands 27cm tall. However,

its footprint is certainly a lot larger than cases such as the NZXT H1 or Phanteks Evolv Shift.

Unlike Raijintek's Metis Evo (see p16), the MasterBox NR200P is designed with SFX PSUs in mind, supporting both SFX and longer SFX-L PSUs, housed in a movable bracket that sports integrated Velcro cable ties. This bracket can be relocated to the front of the case to boost airflow through the side panels, or to house slim micro-ATX motherboards with a maximum size of 244 x 226mm. The case can also accommodate Asus' Crosshair XIII Impact mini-DTX motherboard.

The front panel, roof, base and both side panels are all held in place using pins, with just a single screw holding the base panel in place – the only place where you'll need a screwdriver. As a bonus, the beam running from front to back in front of the motherboard is also removable so, as with Fractal Design's



Define 7, you get a wide-open chassis with which to play, which makes installing your hardware much easier.

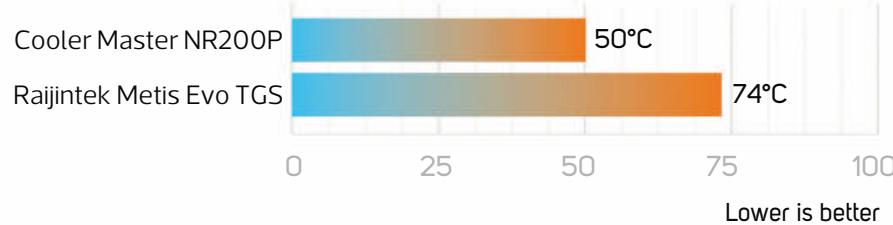
Cooler Master has even cut out a large hole in the front of the chassis to allow you to manoeuvre long graphics cards into place, with clearance for up to cards up to 330mm long, and with triple-slot coolers too. The 155mm of CPU cooler clearance is reasonable as well – that's more than enough for the ARCTIC Freezer 7 X and plenty of smaller 120mm-fan coolers. Cooler Master has uploaded 3D-printable case feet files too, should you wish to print some alternative ones.

Two fans are included in the box, which sport mounting pins that press into the roof fan mounts, removing the need for a screwdriver, although you can install them elsewhere with fan screws. They're not installed as standard – instead, you can place them into two of six 120mm fan mounts, with a pair each in the base, roof and side mounts, and the latter mounts also support 140mm fans.

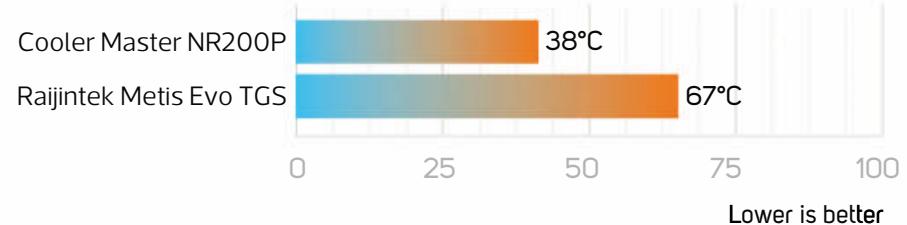
The base and side mounts can also house 240mm radiators, with the option of a 280mm radiator in the side mount. The case sports a dedicated pump mount as well, so custom water-cooling gear is a definite possibility. That's a lot of cooling potential for such a small case, but with two powerful 1,800mm fans included, it won't be a slouch out of the box for air-cooled systems either. What's more, there's even a 92mm fan mount in the rear should you wish to maximise cooling or balance the airflow further. A 3-way 4-pin splitter cable is also included, enabling you to power a trio of fans from one motherboard header.

TEMPERATURE RESULTS

CPU DELTA T



GPU DELTA T



Bear in mind that if you decide to use the vertical GPU mount and included riser cable, that will render the side fan mounts unusable. However, with a large vented panel in the base, your system may well look more attractive with an air-cooled card in the usual horizontal position anyway.

Meanwhile, the base is covered with a large magnetic mesh to stop dust ingress, as are the vented side panels, while the roof sports a clean fixed mesh. The low price has resulted in one casualty, though, which is a Type-C USB port and there are just two USB 3 ports on the front panel.

Storage stands at a maximum of two 3.5in mounts, with one located in the side fan mounts, removing the possibility of housing a radiator there. A second is located on top of the PSU, but this is shared with one of three 2.5in mounts. The other two are located behind the front panel, but as this panel pops off easily, installing an SSD here isn't as tricky as it sounds.

Overall, it's a brilliantly well thought-out case that has a mostly tool-free design, excellent water-cooling support for its size and plenty of flexibility when it comes to making use of the limited space.

Performance

As the fans aren't installed out of the box, we placed them where we saw fit to cool our specific hardware most effectively, placing one in the base blowing air at our GPU and into the case, and the other one exhausting air directly above our low-profile CPU cooler in the roof. This setup did the trick, keeping the GPU temperature nearly 30°C cooler than the fanless Raijintek Metis Evo TGS, admittedly while making a lot more noise. Cooler Master recommends using these mounts to cool your GPU too, with slim models from the likes of Noctua able to help with triple-slot graphics cards.



The CPU delta T of 50°C was a massive 24°C cooler than the Metis Evo TGS too, and even adding an intake fan to the latter still saw the MasterBox NR200P lead by 9°C. Switching to the glass side panel saw this figure rise by just 2°C, although the impact will likely be much higher if you mount your GPU vertically.

Conclusion

The Cooler Master MasterBox NR200P is without doubt the best mini-ITX case we've ever reviewed. It's not the smallest chassis, but it's still very compact and it can switch between being optimised for air cooling, liquid cooling, style or storage space. This flexibility is unparalleled in the mini-ITX world, as is its lift-away construction, where you peel off layers until you're left with an open frame with which to work. You can easily build a high-end mini-ITX or mini-DTX PC in this case, and it costs under £100 too. It's not just highly droolworthy, but it's also a bargain.

ANTONY LEATHER

VERDICT

A brilliantly well thought-out, flexible case that's good out of the box, but also has huge potential for water cooling.

COOLING
29/30

FEATURES
18/20

DESIGN
29/30

VALUE
19/20

OVERALL SCORE

95%



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280MM AIO LIQUID CPU COOLER**FRACTAL DESIGN CELSIUS+ S28 PRISMA / £156 inc VAT**SUPPLIER scan.co.uk**30° CELSIUS**

- + Fan and lighting hub included
- + Tidy cabling
- + Easy to install

30° FAHRENHEIT

- Pricier models can offer better cooling with lower noise
- No software control or extra fan screws
- Expensive

SPEC**Compatibility**

Intel: LGA1200, LGA115x, LGA2066, LGA2011, LGA1366; AMD: Socket AM4, AM3+, AM2+, FM2+, FM1, TR4

Radiator size with fans (mm)

143 x 324 x 55 (W x D x H)

Fans

2 x 140mm Fractal Design Prisma AL-14 PWM ARGB

Stated noise

34.1dBA

If you have your heart set on a powerful dual-fan all-in-one liquid cooler, then you currently have quite a few excellent models from which to choose.

However, when Antec's sub-£100 gets you decent cooling and RGB lighting, there's no need to spend much more unless you're looking for more advanced lighting or more cooling power. Stepping up to a 280mm radiator will offer more cooling capacity and allow fans to spin at lower speeds for similar heat dissipation, though, and this is where Fractal Design's Celsius+ S28 Prisma comes in.

It offers some familiar features to the original Celsius series, such as a handy hub based on the radiator for connecting your fans, meaning there's no need for cables to trail from them to your motherboard or pump. The tubes themselves house the cables attaching the pump, and the hub also has the 3-pin digital RGB connectors for the fans. The only parts you need to connect to your PC are the single RGB and PWM connectors from the pump. Full marks for avoiding spaghetti so far.

Price-wise, it's very similar to other RGB-equipped

280mm liquid coolers, such as Corsair's H115i RGB Platinum, except there's no software control with the Fractal. Instead, the Celsius+ S28 Prisma offers an automatic control mode, which reins in noise at the expense of cooling for quieter, less cooling-focused performance.

This can be enabled by twisting the pump housing, as can a PWM mode that allows your motherboard to take control. The hub includes a quartet of 4-pin fan headers too, so you can add an additional row of fans and control them, although only enough screws are included for two fans.

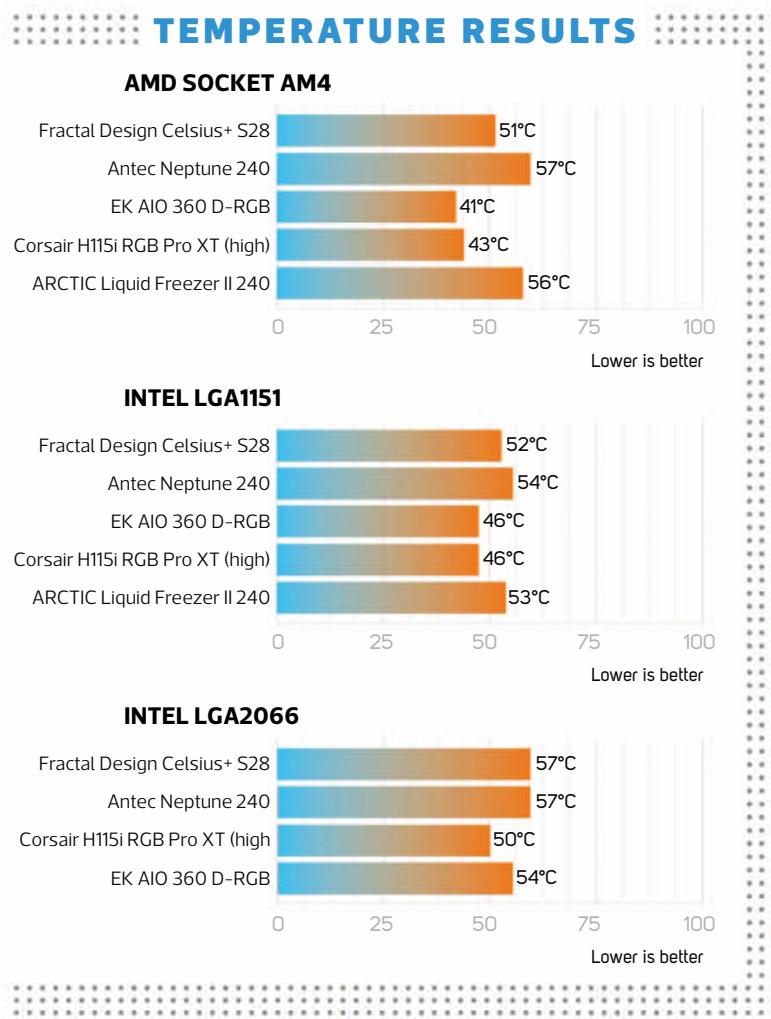
The pump can spin at up to 2,800rpm and has a claimed head pressure of 1.46mm H₂O, which is

reasonably powerful, and the speed falls back to a minimum of around 600rpm at a fan duty cycle of 15 per cent or below. In PWM mode, your motherboard will have control until the coolant temperature reaches 55°C, after which the fans and pump will ramp up to maximum speed.

The auto control mode will also use coolant temperature to control the pump and fan speeds, ramping up gradually. However, the fact that the pump is much less powerful than a DIY water-cooling pump means that, below a certain speed, performance will also be affected here, as we regularly see on other AIO liquid coolers with pump speed control.

The Celsius+ S28 Prisma includes a pair of Prisma AL-14 PWM fans, which retail for £30 each, with a triple pack costing £70. They can spin at up to 1,700rpm, so remain reasonably quiet at full speed, with the fans on the 240mm and 360mm





models of this cooler reaching a higher speed of 2,000rpm. The claimed static pressure is 2.38mm H₂O, which is very good for a fan that tops out well south of 2,000rpm.

Their RGB lighting is certainly more vivid than that on Antec's Neptune 240, although maybe not quite as intense as Corsair's latest models. The pump section also features digital RGB lighting, and looks extremely smart when illuminated. There's a glowing ring around the pump housing, with a deep black void in the centre, plus a small Fractal logo.

The cooler is an Asetek design and uses familiar mounting mechanisms, with plates securing to the pump for Intel sockets and AMD Socket AM4. The pump can also play host to the Asetek adaptor that comes with Threadripper CPUs. However, the latter's heatspreader isn't entirely covered by its contact plate.

Meanwhile, the large radiator measures 324mm long, 30mm deep and 143mm wide, which is a sizeable beast to house in any case, but it's certainly not oversized – if your case specifies 280mm radiator compatibility, it will almost certainly fit. The tubing is also flexible, and the sealed fittings rotate at the pump base, allowing you to point them in the right direction. They're braided too, which we think is more attractive than bare rubber.

Performance

In PWM mode, the Celsius+ S28 Prisma managed a delta T of 51°C in our overclocked Ryzen 7 1700 AM4 system, which was a couple of degrees warmer than the Corsair H115i RGB Pro XT on its balanced cooling profile, but a

significant 6°C cooler than the Antec Neptune 240 and 5°C cooler than ARCTIC's Liquid Freezer II 240.

When dealing with our overclocked Core i5-9600K, it managed a delta T of 52°C, which was just one degree behind the Corsair cooler in its balanced mode, although the latter did knock off an additional 5°C in its maximum speed mode. Finally, our Core i9-9980XE CPU ran at a delta T of 57°C, where only the monstrous EK AIO 360 D-RGB and Corsair H115i RGB Pro XT on its maximum setting performed significantly cooler.

The fans were certainly audible at maximum speed, but the noise isn't unpleasant and the pump remained quiet throughout, with just a low hum at full speed, but no unpleasant whine. Meanwhile, at lower speeds, the Fractal was inaudible from outside out test case. Switching to Auto mode resulted in quiet operation for longer, but temperatures quickly rose four or five degrees higher as a result.

Conclusion

In spite of its lofty price tag, the Fractal Design Celsius+ S28 Prisma's ease of installation and lack of cable spaghetti really count in its favour, as does the crisp and vivid lighting. Cooling is on par, rather than exceptional, in PWM mode at full speed, and you don't get much more here for the extra cash compared with the Antec Neptune 240, for example. However, you get that extra cooling power with lower noise levels, and that helps to justify the price. All in all, the Celsius+ S28 is an attractive, well-designed and powerful cooler from Fractal Design, although Corsair's Corsair H115i RGB Pro XT can offer better cooling at lower noise levels.

ANTONY LEATHER

VERDICT

Tidy, smart and cool, and the noise levels are reasonable too.

Intel LGA115x

COOLING
35/40

FEATURES
16/20

DESIGN
17/20

VALUE
16/20

FITTING
Easy

OVERALL SCORE

84%

AMD AM4

COOLING
35/40

FEATURES
16/20

DESIGN
17/20

VALUE
16/20

FITTING
Easy

Intel LGA2066

COOLING
36/40

FEATURES
16/20

DESIGN
17/20

VALUE
16/20

FITTING
Easy

OVERALL SCORE

84%

OVERALL SCORE

85%

FAN CONTROLLER

CORSAIR iCUE COMMANDER PRO / £60 inc VAT

SUPPLIER scan.co.uk

CHOCOLATE BISCUIT

- + Excellent control over cooling and lighting
- + Thermal sensor-based fan and pump control
- + Compact

TAKE THE BISCUIT

- iCUE software can be finicky
- Noticeable CPU load
- Not compatible with other lighting systems out of the box



While a PWM fan hub can allow your case's fans to tap into your motherboard's cooling software, it can be tricky to control an entire case and water-cooling system's worth of fans.

Similarly, adding all your lighting into the equation – both inside your PC and from any external sources you have in your gaming den – often means you run out of ports on your motherboard. Many motherboards also lack the ability to control your radiator fans based on coolant temperature and thermal probes, never mind having all of the above work together via a single piece of software. Enter the Corsair iCUE Commander Pro, which does all this and more.

It can be installed anywhere in your case using adhesive pads, so there's no need for a drive bay. It's powered by a SATA power connector and uses a single USB 3 header to connect with your PC and sync with Corsair's iCUE software.

However, if you need to connect your case's USB 3 ports too, the iCUE Commander Pro sports a pair of USB 3 header passthroughs, so it can sit between your motherboard and case. There are six fan channels on the device itself, but these can be expanded using standard fan splitters and support either 3-pin or 4-pin fans too.

Next to these are two RGB LED channels, which can connect to Corsair's RGB fan hubs such as the Lighting Node Pro, and daisy chaining means you can connect numerous RGB devices to either channel. Corsair's RGB connectors aren't directly compatible with other manufacturers out of the box, but if you search Google for Corsair RGB adaptor cable, you'll likely find some cunning devices that will allow you to connect other RGB devices to the iCUE. Corsair's own ecosystem is quite wide-ranging, though, and includes pumps, waterblocks and a variety of external RGB components too.

Critically, the iCUE Commander Pro also sports thermal probe headers, and these can be used to control your fans and pumps, making them react to coolant temperature as any good water-cooling setup should. This means it has an advantage over EK Water Blocks' Loop Connect, which we were told will receive thermal sensor fan control in a future update.

SPEC

Connections

2x USB 2 downlink headers (USB 3 uplink header required), 2x RGB LED channels, 6x 3-pin/4-pin fan headers, 4x temperature sensors

Software

Corsair iCUE

Accessories

Mounting pads, 2x RGB hub cables, 4x thermal sensors, 4x fan extension cables



Corsair's iCUE software is very easy to use as far as cooling goes and it's simple to create your own custom fan profiles. The iCUE Commander Pro is also able to recognise individual components from its RGB and Hydro X water cooling component ranges, giving you specific control over them and making complicated setups easier to manage.

We did, however, notice the iCUE software used between 1-3 per cent of CPU load despite running in the background, showing that all this clever software control doesn't come without some overhead, but this should seldom be noticeable in terms of performance or heat in most systems.

Conclusion

While opting for a product like the iCUE Commander Pro means you're tied to Corsair's own ecosystem for RGB lighting out of the box, there are ways around this, and it doesn't impact the device's ability to control your fans and pumps or use thermal sensors.

We'd like to see a few more fan headers, but for automatic control of your PC's cooling, especially if your motherboard lacks thermal sensors or sufficient RGB lighting control, the iCUE Commander Pro represents an easy way to control everything from one piece of software. It certainly has its quirks, but it's otherwise a great all-in-one solution for controlling your PC's cooling and lighting.

ANTONY LEATHER

DESIGN
26/30

FEATURES
28/30

VALUE
31/40

OVERALL SCORE

85%

VERDICT

Limited to Corsair's lighting ecosystem without adaptors, but it's otherwise a great fan and lighting controller.



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**iCUE**

- + Standalone option
- + Real-time CPU, GPU and fan information
- + Game screens allow in-game controls

iQUEUE

- Limited customisation
- Poor viewing angles
- Expensive

SPEC

Connections
USB

Display
640 x 48, 5in
touch-screen

Accessories
Desk stand,
keyboard adaptors

Keyboards with displays have been around for a long time, even predating the current trend for mechanical gaming keyboards. For example, Logitech's old G-series membrane keyboards offered fancy customisable LCDs. Fast forward to 2020 and Corsair clearly feels these screens need to be introduced again, and the company's iCUE Nexus is designed to integrate onto the company's own keyboards, although it can also sit on your desk as a standalone unit.

You'll need to check compatibility with your existing Corsair keyboard, though, as not all models are supported. However, the box includes several adaptors, so you can clip it to most models, making use of the USB pass-through to connect both your keyboard and the iCUE Nexus to your PC. For those without a Corsair keyboard, a neat and surprisingly large stand holds the iCUE Nexus so that it sits securely and is at a readable angle when placed on your desk.

The 5in touch-screen can be configured in Corsair's iCUE software, and it offers a resolution of 640 x 48. However, while it's reasonably bright, viewing angles are quite poor – even when you view it head-on, some outer sections of the display lose clarity. The screen can be split into five sections called buttons, onto which functions can be assigned. There are also widgets linked to inputs, such as CPU temperature, CPU load and fan speeds. You can create up to 256 custom screens too, swiping between each option using the touch-screen.

Pre-configured screens are loaded for many of Corsair's own peripherals and RGB hardware, including options for enabling 7.1 surround sound, bass boost or microphone mute. However, there's limited control over RGB lighting, other than the ability to enable Lighting Link, which synchronises all of Corsair's connected lighting components to a rainbow colour mode.

Even products such as Corsair's LS and LT LED kits didn't have their own profiles on the screen, and there was no way to change the colour of lighting on

any components either, which would be very useful.

For instance, there should be the option to add Corsair lighting components to the iCUE Nexus, and control them individually, perhaps with a selection of colours and effects assigned to buttons. At the very least, controls that are available in iCUE should be selectable.

On the plus side, you can create and assign macros to the Nexus' buttons using iCUE, and Corsair also offers pre-configured game screens for a number of titles, with more in the works, which allow you to assign specific game commands to the screen's buttons. You can also launch applications from the Nexus, but you'll need to upload your own thumbnail images. Another issue we spotted was high CPU load, with iCUE doubling from up to 2 per cent CPU utilisation to 4 per cent or more with the Nexus plugged in.

Conclusion

The surprisingly high CPU load, lack of presets and customisation are problems for the iCUE Nexus, especially when it costs nearly £100. Corsair's iCUE software gives you huge control over your peripherals, lighting and cooling, but you can only tap into a fraction of those features using the iCUE Nexus. Corsair itself has admitted that support and features will grow over time, but at the moment, unless you can make real use of the Nexus in one of the supported games, we suggest waiting to see how it develops before splashing out.

ANTONY LEATHER

DESIGN
22/35

FEATURES
21/35

VALUE
27/30

OVERALL SCORE

70%

VERDICT

A lot of potential, but the Nexus lacks easy customisation, as well as control over Corsair's lighting peripherals.

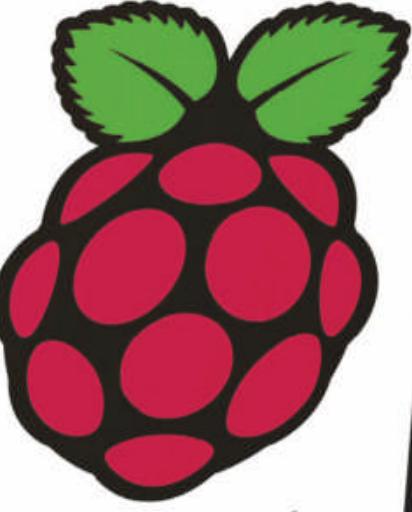
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GAMING LAPTOP

ASUS ROG ZEPHYRUS DUO 15 / £4,000 inc VAT

SUPPLIER scan.co.uk

Asus' ROG Zephyrus Duo 15 is one of the most outrageous gaming portables around – a dual-screen machine packed with top-tier components. It comes with what Asus calls a 'ScreenPad' – a 14.1in screen that sits above the keyboard designed to hold chat tools, browsers and other secondary software during gameplay.

Its own launcher can group frequently used apps together, and snap windows around, which is useful. However, game support is thin on the ground; the ScreenPad adds features in Dying Light II, League of Legends, Dota 2, Fortnite and CS:GO, but no other game support is currently available.

The ScreenPad has a resolution of 3,840 x 1,100, which means a density level of 283ppi, matching the pixel density of the main 15.6in 4K panel. The latter has a 60Hz refresh rate and Nvidia G-Sync, which means it's better suited to cinematic single-player experiences and productivity applications than fast-paced multiplayer gaming.

Indeed, the Duo's screen is Pantone-validated and can display 100 per cent of the sRGB and Adobe RGB gamuts for colour-sensitive workloads. Alternatively, you can pick up the Duo with a 1080p 300Hz G-Sync panel. That's better for esports, and it's a full £1,000 cheaper, as it uses a Core i7 CPU and an RTX 2070 Super GPU.

This pricier model deploys an RTX 2080 Super Max-Q GPU, which has



3,072 stream processors and 8GB of memory. Meanwhile, the Intel Core i9-10980HK CPU has eight Hyper-Threaded cores and a peak Turbo speed of 5.1GHz. The supporting spec is all top gear too. There's 32GB of 3200MHz memory, Wi-Fi 6 and 2.5Gbps Ethernet, and storage comes from two 1TB PCI-E 3 NVMe Samsung SSDs in RAID 0 that deliver great read and write speeds of 3,463MB/sec and 3,246MB/sec, although you'll lose all your data if one drive goes down.

On the outside, the Duo is subtle and sturdy, with a 2.4kg weight and 21mm thickness. That's larger than most laptops, but not too bulky considering the hardware. Connection options are reasonable too, with one USB 3.2 Gen 2 port and a Type-C port that supports DisplayPort, power delivery and Thunderbolt 3. There are also two USB 3.2 Gen 1 connections and an HDMI output, but no webcam or card reader.

The large second screen means the keyboard is punted to the front edge, though, which doesn't make for comfortable typing, and Asus' bundled wrist rest is a heavy rubber unit that isn't particularly well cushioned – it's not useful if you have large hands. The keys themselves have a moderate 1.4mm of travel, and the buttons are fast and responsive, although they feel soft rather than crisp and weighty. They're fine for gaming and typing, but they lack the satisfying tactile experience of mechanical keyboards. The cursor keys are also tiny, and the RGB LED backlighting is patchy and inconsistent.

Meanwhile, the touchpad is narrow and positioned in an unusual location on the right. Cleverly, you can also use it as a light-up numeric keypad, which works surprisingly well, although it's not as good as using physical keys.

BENCHMARK RESULTS

SHADOW OF THE TOMB RAIDER

3,840 x 2,160, Highest Detail, TAA



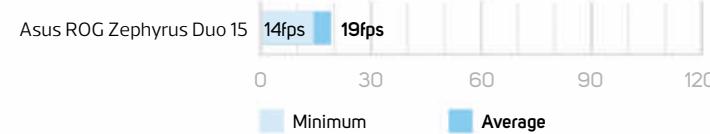
TOTAL WAR: WARHAMMER II

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



BATTLEFIELD V

3,840 x 2,160, Ultra settings, DX12, High DXR, TAA



50,223

GIMP IMAGE
EDITING

532,090

HANDBRAKE H.264
VIDEO ENCODING

168,220

HEAVY MULTI-
TASKING

193,127

SYSTEM
SCORE

Performance

The RTX 2080 Super struggles at the screen's native 4K resolution. Its Shadow of the Tomb Raider and Total War: Warhammer II minimum framerates sat just below 30fps, and it couldn't get beyond 28fps in Battlefield V with ray tracing on High, even with DLSS enabled.

We only achieved playable frame rates by dialling down the graphics – with those three titles at High, the minimums sat between 30fps and 33fps, and at Medium, those figures improved to 34fps and 40fps. It's difficult to get the most intensive games to run smoothly without graphical compromises, and the Asus' Turbo mode doesn't make a huge difference either.

The Asus' 1080p minimum frame rates are good though. It ran Shadow of the Tomb Raider at 81fps, Total War: Warhammer II at 60fps and Battlefield V at 51fps with ray tracing on High – you'll be better off running your games below the screen's native 4K resolution.

Meanwhile, the 8-core Intel CPU will handle any CPU-intensive game and almost any content-creation task. Its Handbrake score of 532,090 is a highlight, showing great multi-threaded performance, although AMD's 8-core Ryzen 9 4900HS is even quicker here.

The Asus' thermal performance is mixed though. Its CPU and GPU delta Ts of 63°C and 42°C are fine, and the Asus is no louder than any other laptop when gaming at normal settings. However, the Turbo mode is loud, and it's noisy when tasked with tough workloads. The base panel became extremely hot during gaming and system tests as well.

The CPU struggles to attain its stated speeds too. During all-core benchmarks, the i9-10980HK did occasionally meet its top-rated 4.3GHz turbo speed, but it usually ran at 3.9GHz or below. Likewise, in single-core tests, the chip usually ran at 4.8GHz or below.

On the plus side, the primary display has a great contrast ratio of 1,290:1, which makes for ample depth and vibrancy. Its average delta E of 3.29 is decent, and the colour temperature of 7,234K is fine – a little cool, but not ruinous. The display lived up to Asus' Adobe and sRGB gamut coverage claims as well.

The only issue came in the uniformity test, where the screen lost 16 per cent of its backlight strength in the corners. That's mediocre, but it won't affect gaming. In short, the display is easily good enough for gaming and for most workloads. You'll only need more accuracy for pro-level graphics work. The ScreenPad is dimmer, but its 1,000:1 contrast ratio is fine for secondary use, although it has shallow viewing angles and can look washed out.

Meanwhile, the 4W speakers deliver loads of volume and crisp, clear mid-range sounds, but the top end is slightly tinny and bass is weak. Not surprisingly, battery life is disappointing. The Asus lasted for just under an hour when gaming, and using the battery restricts GPU speeds as well.

Conclusion

The Asus Duo has a versatile specification, solid screen quality and that second display, which is an innovative feature that could be useful. The ScreenPad currently lacks game support, though, and it contributes to compromised ergonomics. The Asus also has a stratospheric price, and its GPU can't play games at the native 4K resolution. Ditch the ScreenPad and you'll get a laptop with the same CPU and GPU for much less money. It's great to see some innovation in the world of gaming laptops, but despite its frills, the Duo has too many niggles to justify its high price.

MIKE JENNINGS

VERDICT

It's innovative and fast, but this laptop is too expensive and inconsistent.



DUO

- + Solid performance
- + Innovative second screen
- + Versatile spec

DOA

- Very expensive
- GPU can't always handle 4K
- Design compromises

PERFORMANCE

23/25

DESIGN

19/25

HARDWARE

21/25

VALUE

15/25

OVERALL SCORE

78%

AMD B550 GAMING PC**CCL SHADOW HAWK XT / £1,489 inc VAT**SUPPLIER cclonline.com

CL's Shadow Hawk XT is a rare beast when it comes to gaming PCs in 2020 – a rig that relies entirely on AMD for its both its CPU and GPU. Ryzen CPUs aren't unusual, of course. This PC relies on the new Ryzen 5 3600XT, a modest refresh of the Ryzen 5 3600X – the base clock remains at 3.8GHz and the boost speed improves by 100MHz to 4.5GHz, but the rest of the 6-core design remains unchanged, and CCL runs it at stock speeds.

The rarer part in this PC is the AMD Radeon RX 5700 XT

GPU. AMD's GPUs have faced an uphill battle against Nvidia, and the card in this PC is an overclocked model from Asus. It has a boost clock that peaks at 2010MHz rather than 1905MHz, and an optional overclocked mode adds an extra 25MHz.

Meanwhile, the 1TB XPC SSD is capacious and supports PCI-E 4, although its read and write speeds of 3,170MB/sec and 3,123MB/sec are no faster than a decent PCI-E 3 SSD. We have no complaints about the memory though – the 16GB of XPG DDR4 RAM canters along at 3600MHz.

The Asus B550 motherboard is a solid option too. It has three spare 1x PCI-E sockets, two vacant memory slots and an empty M.2 connector, and decent S1220 audio, along with extra lighting headers and a Thunderbolt header. At the rear there are fast USB 3.2 Gen 2x2 Type-A and Type-C ports, alongside a BIOS Flashback button. You even get both 2.5Gbps Ethernet and dual-band Wi-Fi 6. The only notable missing features are on-board buttons and displays for testing, and SLI support, but these aren't dealbreakers.

The components are packed into a white version of Cooler Master's



MasterBox TD500 Mesh chassis. The white finish isn't the only bold aesthetic choice on this case either – the front panel is covered with angled mesh and the four case fans are all illuminated with RGB LEDs.

The top of the chassis has two USB 3.2 Gen 1 ports, but no USB Type-C, and the side panel is made from tempered glass. On the inside, the layout is good and conventional, with a PSU shroud at the bottom and neat building throughout, even though the 80 Plus Gold power supply isn't modular. It's very neat around the rear too, and there's room for pairs of 2.5in and 3.5in hard disks.

Some areas of the case are tricky to reach though. The be quiet! CPU cooler is huge, blocking a memory slot and making the top half of the board hard to access, and the hefty Asus graphics card blocks one 1x PCI-E slot and several SATA ports.

There's a modest gulf between this machine and last month's £1,199 PC Specialist (see Issue 205, p30), which also deployed the Ryzen 5 3600XT. That rig had an Nvidia GeForce RTX 2060 Super graphics card, which isn't as fast as the Radeon RX 5700XT, but does support real-time ray tracing, which looks amazing in games that support it. The PC Specialist also had slower memory, poorer connection options and fewer motherboard features than the CCL though.

The CCL faces tougher competition from the wider market – because this £1,489 rig comes up against PCs with the RTX 2070 Super. At this price you may have to compromise on CPU power and motherboard features, but it's easy to find a PC containing one of these Nvidia GPUs.

- SONIC**
- + Great frame rates
 - + Fast, versatile AMD CPU
 - + Solid motherboard features
 - + Good-looking and robust case

- ROBOTNIK**
- Expensive
 - Loud when playing games
 - No ray tracing



Regardless of the CCL's price, it's protected by a good warranty. The three year collect and return service covers parts and labour for the duration, which is great to see at this price.

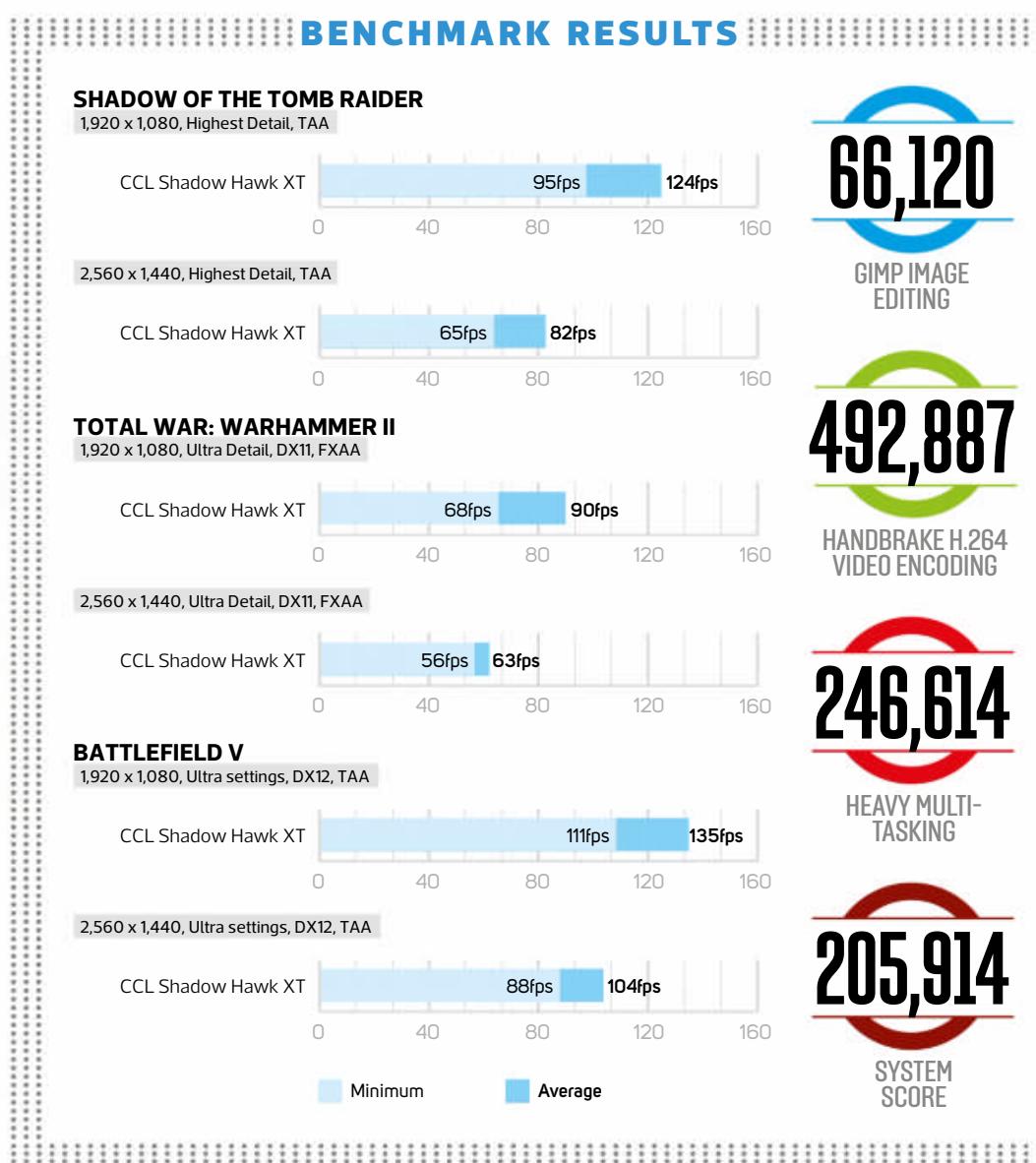
Performance

AMD's new processor is excellent. In our single-threaded image editing test, it scored 66,120, and in our heavily multi-threaded Handbrake test, the CCL scored 492,887. This chip tackles photo work, light video processing, everyday computing and multi-tasking with more speed than its predecessor, and the new Intel Core i5-10600K for that matter, although Ryzen 7 parts remain quicker still.

The Radeon RX 5700 XT is fast too. At 1080p, its gaming minimums ranged between 68fps and 111fps, and at 2,560 x 1,440, those figures sat between 56fps and 88fps – all superb results.

At both resolutions, this GPU will run tough single-player games without complaint. The Radeon card beats the RTX 2060 Super in terms of raw frame rates too, but the RTX 2070 Super is a tougher test. When stacked up against the beefier Nvidia GPU, the AMD part is a few frames slower and lacks ray tracing too.

The CCL doesn't get a clean bill of health in thermal tests either. While its CPU and GPU delta Ts of 58°C and 51°C are



good, there's noticeable fan noise when the system is idle. It's no louder when gaming, but the fan rumble is audible – it's certainly noisier than most mid-range PCs that we review.

Conclusion

The Shadow Hawk finds itself in a tough spot. The new AMD CPU provides ample power for everyday tasks, and the Radeon GPU can handle 1080p and 2,560 x 1,440 gaming brilliantly, but you can't enable the top ray-tracing eye candy, which you're going to want when CyberPunk 2077 is released later this year.

On the plus side, the case looks good, the build quality is tidy and the motherboard has a solid range of features. The main problem for the CCL, though, is its price. When you're paying nearly £1,500 for a PC, it should really support real-time ray tracing now, and you shouldn't have to put up with irritating fan noise either.

MIKE JENNINGS

PERFORMANCE	21/25
DESIGN	20/25
HARDWARE	18/25
VALUE	17/25
OVERALL SCORE	76%

VERDICT

A great-looking system with fast frame rates, but it's pricey for a PC without ray tracing, and the fans make a racket too.

AMD X570 GAMING PC**CHILLBLAST FUSION
RYZEN 7 3800XT
GAMING PC / £2,349 incVAT**SUPPLIER chillblast.com

This PC's prosaic name gets straight to the point, emphasising its new AMD processor. The Ryzen 7 3800XT is part of AMD's Zen 2 refresh, and it has a top boost speed of 4.7GHz, compared to the 3800X's 4.5GHz peak. It's not a big difference, but this minor change should give AMD a leg up against Intel's Comet Lake CPUs, and its base speed of 3.9GHz and 8-core Zen 2 design are perennially impressive.

It's backed by 32GB of 3200MHz Corsair Vengeance LPC memory, and storage comes from two SSDs rather than an SSD and a hard disk. The Corsair RM650x PSU is modular and has an 80 Plus efficiency rating, so we have no concerns there. You also get an MSI GeForce RTX 2080 Super card, which runs at stock speeds and gives you 3,072 stream processors, 48 RT cores and 8GB of memory. There's not much in the way of fancy lighting, though, with no LEDs on the memory or graphics card.

The motherboard is modest too. The Asus TUF Gaming X570-Plus covers the basics, with two vacant memory slots, several free SATA ports and one free M.2 connector. There's a spare 16x PCI-E slot and two 1x PCI-E slots. The board also has decent Realtek S1200A audio, along with two full-sized USB 3.2 Gen 2 ports and a Type-C connection at the rear.

Drill down into the spec, though, and there are omissions. At this price we'd expect 2.5Gbps Ethernet, rather than Gigabit, and the Wi-Fi is dual-band 802.11ac – not Wi-Fi 6. The motherboard has no on-board displays or buttons either, and no SLI support.

The components sit inside a Fractal Design Define 7 Compact. This chassis has the classic Fractal aesthetic of clean lines and brushed metal, which means it's equally at home in a gaming den or office. Build quality is superb, and the interior is neat, with tidy cabling, rubber grommets and a PSU shroud. At the rear, there are two free hard disk bays and a spare SSD cage between smart cable-routing channels and Velcro ties. The side and front panels have sound-dampening material, and the side panels use neat buttons, rather than thumbscrews. Helpfully, the chassis also has a USB 3.2 Gen 2 Type-C port and four full-sized USB connectors on the front.

There aren't many downsides. It's heavy, and you can't open the front door – that feature is only included on the full-sized version. The Noctua CPU cooler and 265mm graphics card also make the middle of the build a little cramped.

As usual, this PC is protected by Chillblast's excellent warranty. It's a five year labour deal, which is two years more than most manufacturers provide, and this PC also comes with two years of parts coverage with collect and return service. The Chillblast is a tad expensive compared with the market though. It's possible to find this specification for under £2,300 elsewhere, and if you're willing to compromise on memory and storage then it could cost under £2,000.

Performance

At retail, the Ryzen 7 3800XT doesn't offer the same level of value as the other XT CPUs (see Issue 205, p17), but it's still a formidable component in this PC. Its single-threaded image

SPEC

CPU
3.9GHz AMD Ryzen 7 3800XT

Motherboard
Asus TUF Gaming X570-Plus (Wi-Fi)

Memory
32GB Corsair Vengeance LPX
Black 3200MHz DDR4

Graphics
MSI GeForce RTX 2080 Super 8GB

Storage
500GB Seagate FireCuda 520
PCI-E 4 M.2 SSD, 2TB Seagate
Barracuda 120 SATA SSD

Networking
Gigabit Ethernet, dual-band 802.11ac Wi-Fi

Case
Fractal Design Define 7 Compact

Cooling
CPU: Noctua NH-U12S chromax.black,
1x 120mm fan; GPU: 1x 90mm fan;
front: 1x 140mm fan; rear: 1x 120mm fan

PSU
Corsair RM650x 650W

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

Operating system
Microsoft Windows 10 Home 64-bit

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

editing score of 61,062 is barely slower than Intel's best chips, and its Handbrake result of 646,811 is another stellar result. The Chillblast is a great choice for content creation and productivity apps alongside gaming. That said, though, the 12-core Ryzen 9 3900XT offers much more in terms of bang per buck.

Meanwhile, the primary Seagate PCI-E 4 SSD delivered a great read speed of 4,878MB/sec and a solid write pace of 2,499MB/sec, and the secondary 2TB SATA SSD returned speeds of 417MB/sec and 493MB/sec – moderate for SATA drives, but far better than any hard disk and fine for bulk data storage.

The RTX 2080 Super is reliably fast too. At 2,560 x 1,440, its minimums of 60fps in Battlefield V with ray tracing and DLSS is great, and that dropped to a still playable 40fps at 4K. Our other game tests were also solid, never dropping below 67fps at 2,560 x 1,440 and 37fps at 4K. You really need an RTX 2080 Ti for 4K gaming, but the Super will be able to handle it if you dial down the settings a bit.

The Chillblast's CPU and GPU delta Ts of 63°C and 61°C are also fine, and the machine is quiet when idle. When gaming and running productivity applications, the system produces a subtle rumble, which is also fine. The Chillblast only produced an uncomfortably high noise level when every component was stressed, and that kind of workload is rare.



RISING

- + Fast in games and apps
- + Smart, neat and quiet
- + Great memory and storage
- + Generous warranty

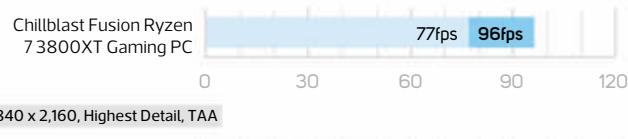
FALLING

- Mid-range motherboard
- No GPU overclock
- A little expensive

BENCHMARK RESULTS

SHADOW OF THE TOMB RAIDER

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



61,062

GIMP IMAGE EDITING

TOTAL WAR: WARHAMMER II

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

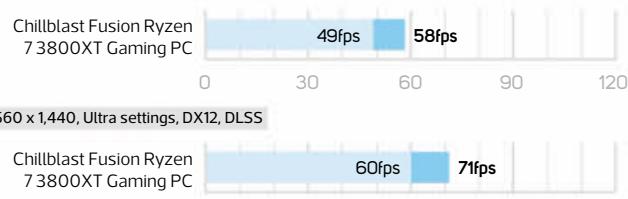


646,811

HANDBRAKE H.264 VIDEO ENCODING

BATTLEFIELD V

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



272,582

HEAVY MULTI-TASKING

2,560 x 1,440, Ultra settings, DX12, DLSS



252,248

SYSTEM SCORE

Conclusion

Chillblast's Fusion Ryzen 7 3800XT impresses in plenty of key departments. The CPU is fast and versatile, the GPU is reliably quick and the storage and memory are great. The case is smart and sturdy, the build is tidy and the rig is quiet. There aren't many downsides – the motherboard is a mid-range option that lacks high-end features, and there's no GPU overclock. It's a little expensive for the spec on offer too. If you need a well-rounded, powerful PC for work and play that isn't loud or extravagant, though, this is an excellent choice.

MIKE JENNINGS

PERFORMANCE

22/25

DESIGN

22/25

HARDWARE

22/25

VALUE

21/25

OVERALL SCORE

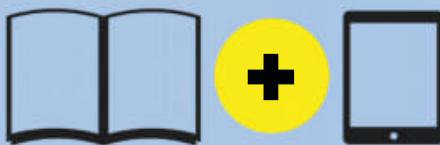
87 %

VERDICT

Fast, well built and well rounded. The Chillblast is quite expensive but it's worth the money.

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Custom kit

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

SCREEN MOM SCREEN CLEANER KIT

/ £15.99 inc VAT

SUPPLIER [amazon.co.uk](#)

Cleaning a screen can sometimes feel like you're just swapping dust, fingerprint powder and blood spatters for a bunch of streaks. The Screen Mom Screen Cleaner Kit thankfully doesn't go that way with it. Consisting of a 40 x 40cm microfibre cloth and an impressively hefty bottle of cleaner, the Screen Mom manages to avoid causing streaks and does a great job of cleaning ordinary household mess off a monitor.



The bottle contains 16 fluid ounces because of American exceptionalism, or 473ml to everybody else. This is just about enough screen cleaner to keep a large monitor in reasonably good nick for a long time. The cleaner works very well, the cloth is fine for the job and there's enough of both to last ages.

Soccer Mom Screen Mom

KALIBRI OMEGA

/ £25.99 inc VAT

SUPPLIER [amazon.co.uk](#)

The Kalibri Omega is an on-desk headphone stand that departs from the usual gaming PC aesthetic of angles, lights and unnecessary plastic corners. The Omega is, as the name implies, an omega shape made out of wood. You sit it on the desk, plonk your headphones on it when you're not using them and that's almost all there is to it. The Omega includes four small grippy feet that you can attach to the bottom to give it some extra traction, and most of the weight is at the bottom, which helps to keep it in place.

There's a whole raft of reasons why wood isn't usually part of a PC's aesthetic – the cost, the difficulties it brings to manufacturing and the simple fact that RGB lighting doesn't improve the look of it (Christmas trees notwithstanding), but there's a lot to be said for a low-key rustic style. In short, the Omega does its job well and it looks good too.



Alpha Omega

VKUSRA USB HUB

/ £20.99 inc VAT

SUPPLIER [amazon.co.uk](#)

The Vkusra is a 7-port USB 3 hub, and there are no fancy new connectors such as Type-C ports. Each port has its own power switch and a light indicating if it's activated, which is a neat touch. Thanks to an uncluttered design, the Vkusra also gives you a lot of room between ports, so it's ideal for devices that maybe use non-standard plugs or cables. Meanwhile, the cable is 1.2m long, which is plenty if you're plugging it into the back of a PC, or even if you're just using it as a charger and plugging it into a USB power socket.

One significant oversight with the Vkusra, though, is that while it includes a 5V power socket, into which you can plug a mains adaptor to give you more stable power, this isn't included with the hub. So it's a hub that has to come with the caveat that you probably can't use all the ports at once without an additional piece of equipment, which puts it on shaky ground. With that in mind, while the Vkusra USB hub is neatly designed and well put together, it falls short.



Unpowered Powered

SPEEDLINK CRIPT

/ £8.99 inc VAT

SUPPLIER overclockers.co.uk

Somewhere amid the mousepads that cover most of the desk, the mousepads that have lighting, firmware and a unified lighting software lies that curious breed – the ultra-thin sticky mousepad, and the Speedlink Cript is just such a pad. The Cript is a normal-sized mousepad, measuring 380 x 280mm, but it's less than a millimetre thick and adheres to the desktop with its reusable adhesive coating on the back.

This coating isn't particularly strong, and it takes a little bit of use for it to really settle, but once it's in place, the low friction on the surface and the flatness of the pad mean you're unlikely to knock it free by accident. It also doesn't mark the desk to which it's attached. The top surface is good enough too – it's not amazing, but it's also not underwhelming, plus it's lightly textured and easy to clean.



While the thin profile makes the Cript extremely light, however, it's also thin and folds easily, with potentially fatal results for itself, so it's not particularly portable. That said, the Cript is a decent choice for a low-profile desktop set up where you just need a mousepad to do its thing, rather than be the centre of attention.

Cropped ●●●○○ Cript

ORETECH PHONE MAGNIFIER

/ £14.99 inc VAT

SUPPLIER amazon.co.uk

Phone projectors that blow up a smartphone display onto a bigger screen are relatively common and equally, due to the nature of the job, relatively big. The Oretech Phone Magnifier, by contrast, folds down into just a couple of thin sheets of wood, and it can still blow up your smartphone display to a 12in diagonal.

The top piece of wood is foldable, rolling back on itself into a heptagonal tube that provides the backrest for the smartphone. Underneath this top piece is a sticky pad to hold the phone in place against the backrest, the screen and a brace for the screen, which is again bolstered by a sticky pad. Once it's unfolded, you prop up the phone and watch it through the screen, and sure enough, the phone screen is blown up to the size of the Oretech's screen. The screen itself is fine – it won't amaze anybody, but it gets the job done, providing a big, clear, zoomed-in view of what's on the smartphone display.



The benefits to this system are its compact nature of the device and the lack of additional parts, but the shortcomings are more nuanced. There's no easy way to properly position the smartphone – you'll have to aim it and then position the Oretech, based precisely on where you're planning to sit to watch it, and this will likely vary each time.

Even when you've done this, it can still wobble and you'll have to set it up again. Top points to the Oretech for portability, but setting up is enough of a pain to be a legitimate problem.

Big screen ●●●○○ Silver screen

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

LABS TEST

Mini games

Antony Leather lines up eight mini-ITX motherboards, with both B550 and Z490 chipsets, to find the best ones

How we test

This month we're taking a look at the latest mini-ITX motherboards that use Intel's Z490 chipset and AMD's B550 chipset. We've worked with their layouts, probed their EFIs and bombarded them with our usual performance benchmarks, as well as tests for audio quality, storage performance and cooling, to see which ones are worth your cash.

We use an Intel Core i9-10900K for our Intel motherboards and a Ryzen 9 3900XT for AMD motherboards. We use the latest BIOS versions, as well as an Nvidia GeForce RTX 2070 Super graphics card and 16GB of 3466MHz Corsair Vengeance RGB Pro RAM.

Our new motherboard and CPU cooling test rigs also sport a Barrow Rhopilema test bench and full custom water-cooling systems. These setups include two 240mm radiators and a Laing DDC pump, to eliminate any cooling bottlenecks.

We have a Windows 10 installation on a 2TB Samsung 970 Pro SSD, along with a Samsung 960 Evo (for Intel motherboards) and a Corsair MP600 PCI-E 4 SSD (for AMD motherboards), to test the speed of M.2 ports. We also tap into the SSDs' internal temperature sensors to see how well any M.2 heatsinks perform under load, using back-to-back runs of CrystalDiskMark's entire battery of tests.

In addition, we use RightMark's Audio Analyzer software to measure the dynamic range, noise level and total harmonic distortion of the on-board audio. Other tests include our RealBench suite of benchmarks, Far Cry New Dawn and Cinebench R20's single and multi-threaded tests. Finally, we measure the total system power consumption at the mains at both stock and overclocked speeds. Our scores are based on a weighted calculation, including performance, features and value, and the overall score is the sum of those three values.

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Z490 MINI-ITX MOTHERBOARD

ASROCK Z490 PHANTOM GAMING-ITX/TB3 / £281 inc VAT

SUPPLIER novatech.co.uk

ASRock's Z490 Phantom Gaming-ITX/TB3 is a beast that looks like it means business. While it will just about leave you with change from £300, the company has certainly gone to town to justify the comparatively high asking price. It offers full Thunderbolt 3 support for starters, and it has two VRM fans.

One of these fans is exposed and cools the tall heatsink at the top of the board. Another fan sits on a second heatsink under the I/O shroud, cooling the total of nine power phases beneath. The fans only spin up under certain conditions according to ASRock, but the top fan was spinning as soon as we turned on the system. We couldn't control its speed either, but thankfully it was inaudible from a few feet away.

PHANTOM OF THE OPERA

- + Excellent VRM and M.2 cooling
- + Attractive design
- + Thunderbolt 3 support

THE PHANTOM MENACE

- No thermal probe headers
- Only three fan headers
- No Type-C USB header

SPEC

Chipset Intel Z490

CPU socket Intel LGA1200

Memory support 2 slots: max 64GB DDR4 (up to 4666MHz)

Expansion slots One 16x PCI-E 3

Sound 8-channel Realtek ALC1220

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

Cooling Three 4-pin fan headers, VRM heatsink, M.2 heatsink, 2 x VRM fans

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 3, 3 x USB 3.1 Gen 2 Type-A, 1 x USB 3.1 Gen 2 Type-C Thunderbolt 3, 2 x USB 3 Type-A, 3 x surround audio out, line in, mic, optical S/PDIF output, 1 x HDMI 2, 1 x DisplayPort 1.4

Dimensions (mm) 170 x 170

The cooling system extends down to the PCH heatsink by way of a heatpipe to spread the load, and this heatsink then attaches loosely (without thermal pads) to a heatsink on a vertically mounted daughterboard. The latter heatsink cools one of the two M.2 ports, but it's quite fiddly to remove, requiring you to take the entire daughterboard off the PCB. However, this raised heatsink cooled down our M.2 SSD to a super-low temperature of just 55°C – the lowest result on test.

The daughterboard also offers two SATA 6Gbps ports and a USB 2 header, but sadly, the main reason for including it seems to be to make way for the cooling system rather than adding more features. You still only get three fan headers and four SATA 6Gbps ports in total, as well as the two M.2 ports. Sadly, ASRock didn't find a way to include a Type-C header either – it's the only Z490 board on test to lack one, and strangely, even its far cheaper B550 sibling has one too.

Meanwhile, the rear I/O panel offers a reasonable array of options, with the full complement of audio ports, a total of five Type-A USB ports, a Thunderbolt 3 Type-C port and even a clear-CMOS button. There's an antenna for the integrated 802.11ac Wi-Fi too and the integrated I/O shield has been shrunk a little to allow for easier installation.

Firing up the board saw the VRMs kept below 52°C under load, although that's not surprising with the massive heatsinks and two fans. Overclocking was trying, though, and the board required a hefty 1.36V to get



our Core i9-10900K stable at 5.1GHz. It was nippy at stock speed, with a Cinebench single-threaded score of 524, but the power draw of 360W proved that, despite using default BIOS settings, ASRock is enabling some aggressive turbo boosting by default. Audio performance was excellent compared with the rest of the field, with the lowest THD we've ever seen of just 0.0017 per cent, and a dynamic range of 105dBA.

Conclusion

The ASRock Z490 Phantom Gaming-ITX/TB3 has an attractive design but, apart from the extra cooling power, Thunderbolt 3 support and great audio performance, there's very little else to set it apart from the competition. Both Asus and Gigabyte's Z490 options offer more for similar or less cash, but it's still a decent option if you want Thunderbolt 3 support.

VERDICT

Big cooling and Thunderbolt 3 support, but not much else to excite.

PERFORMANCE

33/35

FEATURES

27/35

OVERALL SCORE

84%



Z490 MINI-ITX MOTHERBOARD**ASUS ROG STRIX Z490-I GAMING / £298 inc VAT**

SUPPLIER novatech.co.uk

While there's currently no Asus Impact board available for Intel's LGA1200 socket, the Asus ROG Strix Z490-I Gaming is close to being worthy of the Impact name. It has a deliciously complicated PCB, with a triple stack of heatsinks and PCBs hiding both M.2 ports, and unlike every other board on test this month, both these ports are equipped with heatsinks. Our Samsung 960 Evo SSD peaked at 60°C under load, which was the second coolest result.

That ROG logo has full RGB backlighting too, with the only downside of this contraption being that it makes installing your SSDs very fiddly indeed. The PCB is otherwise suitably equipped. You get a Type-C USB 3.1 Gen 2 header, four SATA 6Gbps ports and Asus has even shoehorned a thermal probe header into the design, so you can hook it up to your water-cooling system to have your fans respond to coolant temperature. It's a shame, then, that Asus hasn't found a way to include more

**SPEC****Chipset** Intel Z490**CPU socket** Intel LGA1200**Memory support** 2 slots: max 64GB DDR4 (up to 5000MHz)**Expansion slots** One 16x PCI-E 3**Sound** 8-channel SupremeFX S1220A**Networking** 1x 2.5 Gigabit LAN, Intel 802.11ax Wi-Fi**Cooling** Three 4-pin fan headers, VRM heatsinks, VRM fan, M.2 heatsink**Ports** 4 x SATA 6Gbps 2 x M.2 PCI-E 3, 3 x USB 3.1 Gen 2 Type-A, 1 x USB 3.1 Type-C, 2 x USB 3 Type-A, 2 x USB 2, line in, mic, line out, 1 x HDMI 2, 1 x DisplayPort 1.4**Dimensions (mm)** 170 x 170

than the usual three fan headers, which is a feat the Gigabyte board in this test has managed.

However, the Asus does include a Delta-made VRM fan to cool the 8+2 phase power delivery, which can be controlled in the EFI should you wish to turn it off. The heatsinks are large and connected by a heatpipe to spread the load, so the fan can help cool a large portion of the PCB. The VRMs hit 56°C under load, which isn't quite as cool as the ASRock Z490 Phantom Gaming-ITX/TB3, but it's still an excellent result.

With seven Type-A USB ports on the rear I/O panel, it has the joint highest number of USB ports, although there's no Thunderbolt 3 support like the ASRock board. You get USB BIOS FlashBack too, enabling you to drop in an 11th-gen CPU at some point without needing to own a 10th-gen CPU to update the BIOS, although it would have been good to see some additional on-board overclocking and testing tools. Audiophiles should note there are just three audio jacks too, so as well as lacking an optical port, you'll need to hook up some multi-channel speaker systems to your case's front panel audio port too.

We didn't enable Asus' 10th-gen enhanced power limits for our stock speed tests, but doing so will see boosted performance compared with our results here, as well as significantly higher power consumption. Even so, the Asus' performance was on par with the

ROG

- + Twin M.2 heatsinks
- + Thermal probe header
- + Type-C USB header

RAG

- Only three fan headers
- Just three audio ports
- Voltage droop when overclocking



other boards and had the best audio results on test too.

Overclocking proved a little tricky, though, with the vcore seeming to drop significantly under load, eventually requiring 1.4V to maintain 1.32V under load, with loadline calibration not able to deal with this on its own. This resulted in higher than average power consumption when overclocked.

Conclusion

Asus has mostly hit the nail on the head with the Asus ROG Strix Z490-I Gaming. It's dripping with high-end features and, compared with the competition, it's by far the best board for a 10th-gen Intel system, especially one that's water-cooled. For this price we'd like to see a few extra features, but it's a stunning and droolworthy piece of PCB real estate nonetheless.

VERDICT

The best Z490 mini-ITX board available, although it's not perfect.

PERFORMANCE**33/35****FEATURES****32/35****OVERALL SCORE****89%****VALUE**
24/30

Z490 MINI-ITX MOTHERBOARD

GIGABYTE Z490I AORUS ULTRA / £250 incVAT

SUPPLIER scan.co.uk

With some excellent mini-ITX boards to its name over the years, Gigabyte's Z490I Aorus Ultra has a reputation to manage, and from looks alone it appears to mean business. Its trio of heatpipe-linked heatsinks are chunky and help cool the 8-phase power delivery feeding the CPU, with no fans in sight. Thankfully, with a VRM temperature measured with our IR probe of 58°C, it's more than able to cope with Intel's mighty Core i9-10900K.

The M.2 and PCH heatsink, on the other hand, sports the same confused design as Gigabyte's AMD-based counterparts, with a

large slab of metal enclosing the actual M.2 heatsink underneath. While our M.2 SSD was still cooler with this than with no heatsink, it was cooler still if that top heatsink was removed, allowing the one below to breathe. Still, it's a minor issue given that this won't affect the performance of your SSD.

Meanwhile, the Gigabyte includes a Type-C USB port as well as the usual four SATA 6Gbps ports and two PCI-E M.2 slots, with the top port, Gigabyte claims, being able to support PCI-E 4 SSDs with future CPUs, with the 16x PCI-E slot also reportedly getting future PCI-E 4 support. However, Gigabyte has switched to tiny ports for most of the fan headers, with adaptor cables included in the box to convert them to 4-pin fan headers. Amazingly, this setup enables the board to offer four fan headers on the PCB, which is one more than every mini-ITX board on test this month, so well done Gigabyte.

There's no Thunderbolt 3 support, though, and more disappointingly, no thermal probe headers either. That's a real shame, because Gigabyte's EFI and software offer excellent fan control, and the thermal probe input is great for controlling your water-cooling system. This omission surprised us given Gigabyte's inclusion of them on other premium boards.

The rear I/O panel does have an impressive tally of seven Type-A USB ports, though, which is more than many ATX boards we've seen, although there are only three audio jacks. There are precious few overclocking and testing tools too, with the most noteworthy being the inclusion of Q-Flash Plus, which will enable you to update the BIOS without a compatible CPU, although this will only be useful with future Intel CPUs.

The Gigabyte board put in a solid if not inspiring performance in our benchmarks,



with average scores in RealBench, Far Cry New Dawn and Cinebench's multi-threaded test, but the single-threaded test was a little low at 503 points. The audio performance was average too, with the Asus board outperforming it comfortably.

However, it managed lower power draw at stock speed and when overclocked, and it matched the other boards' performance when overclocked too.

Conclusion

We'd have liked to see a little more from the Gigabyte Z490I Aorus Ultra, but in the end it costs much less than the other Z490 boards, while offering more fan headers and USB ports than any of them. If you can't quite stretch your budget to the Asus ROG Strix Z490-I Gaming, it's our next favourite option for a mini-ITX system.

VERDICT

Despite a few oddities, the Gigabyte is still a great choice if you can't afford to go over £250.

PERFORMANCE

32/35

FEATURES

29/35

OVERALL SCORE

88%

27/30

SPEC

Chipset Intel Z490

CPU socket Intel LGA1200

Memory support 2 slots: max 64GB DDR4 (up to 5000MHz)

Expansion slots One 16x PCI-E 3

Sound 8-channel Realtek ALC1220

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

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

Ports 4 x SATA 6Gbps, 1x M.2 PCI-E 3, 4 x USB 3 Type-A, 1x USB 3.1 Gen 2 Type-C, 1x USB 3.1 Gen 2 Type-A, 2 x USB 2 Type-A, line in, mic, line out, 1x HDMI 2, 1x DisplayPort 1.4

Dimensions (mm) 170 x 170



Z490 MINI-ITX MOTHERBOARD**MSI MEG Z490I UNIFY / £280 inc VAT**SUPPLIER ebuyer.com

Rather than drop its Z490 offering into one of its middling product ranges, MSI has launched the Z490I Unify into its prestigious MEG range of motherboards. This means you get beefed-up power circuitry and active cooling, although the price sits close to £300 inc VAT as a result.

The 8-phase power delivery with 90A stages is cooled by two massive heatsinks linked with a heatpipe, and cooled by a small fan embedded within the I/O shroud. The VRMs did top 60°C under load, but this was accurately measured using software, which most other boards on test lacked, plus it's tens of degrees lower than the danger zone, so nothing serious to worry about. Meanwhile, the large M.2 heatsink saw our SSD sit at 62°C under load, which was over 10°C cooler than

without it, while a second M.2 slot resides on the underside of the PCB as usual.

The jet-black design is certainly menacing, but that's all you get in terms of visual frills. There's no active RGB lighting, and MSI has ditched 4-pin RGB headers in favour of 3-pin digital headers, so you'll need to plan your lighting setup accordingly.

We were pleased to see a USB 3.1 Gen 2 Type-C header, though, and the rear I/O panel offers five Type-A USB ports plus a Type-C port too, but the features are otherwise a tad unremarkable. There's just the usual count of three fan headers and four SATA 6Gbps ports, but no thermal probe headers. The rear I/O panel does offer the full complement of audio outputs, though, as well as a clear-CMOS button and antenna connectors for the 802.11ax Wi-Fi.

The MEG Z490I Unify got our CPU up to its usual 5.1GHz maximum with a minimum of fuss, needing 1.32V to get a stable overclock, which is better than the ASRock Z490 Phantom Gaming-ITX/TB3 managed. MSI's EFI is excellent too, so it's just a shame it doesn't include thermal probes for controlling fans in water-cooling systems.

Stock speed performance was reasonable, with good results in Cinebench, and the RealBench results were either on par or slightly ahead of the competition. However, we were disappointed with the audio performance, which sat below 100dBA and -100dBA for the dynamic range and noise



levels respectively, which are low for the Realtek ALC1220 codec. On the plus side, the power consumption is low.

Conclusion

The MSI MEG Z490I Unify has a great-looking, moody design, as well as decent cooling and an excellent EFI. However, other boards on test offer more in some areas for a similar or lower price, and the MSI's lack of standout features let it down here.

The fan-assisted cooling is great, but it's matched elsewhere, as is the M.2 cooling, overclocking and features, with some of the latter bettered by other boards too, albeit not by much. With the Gigabyte Z490I Aorus Ultra costing £30 less, and the fantastic Asus ROG Strix Z490-I Gaming only retailing for £18 more, the MSI's price is its biggest enemy.

VERDICT

A good-looking moody design and plenty of features, but there's not enough wow factor to justify the price.

PERFORMANCE**33/35****FEATURES****26/35****OVERALL SCORE****83%****MEGALODON**

- + All-black design
- + Full set of audio ports
- + Excellent EFI
- No standout features
- Competition is similarly priced or cheaper
- No 4-pin RGB headers

SPEC**Chipset** Intel Z490**CPU socket** Intel LGA1200**Memory support** 2 slots: max 64GB DDR4 (up to 5000MHz)**Expansion slots** One 16x PCI-E 3**Sound** 8-channel Realtek ALC1220**Networking** 1x 2.5 Gigabit LAN, Intel 802.11ax Wi-Fi**Cooling** Three 4-pin fan headers, VRM heatsink, M.2 heatsink, VRM fan**Ports** 4 x SATA 6Gbps, 2 x M.2 PCI-E 3.1 x USB 3.1 Gen 2 Type-A, 1 x USB 3.1 Gen 2 Type-C, 2 x USB 3 Type-A, 2 x USB 2 Type-A, 3 x surround audio out, line in, mic, optical S/PDIF output, 1 x HDMI 2, 1 x DisplayPort 1.4**Dimensions (mm)** 170 x 170

B550 MINI-ITX MOTHERBOARD

ASROCK B550 PHANTOM GAMING-ITX/AX / £215 inc VAT

SUPPLIER overclockers.co.uk

The ASRock B550 Phantom Gaming-ITX/ax isn't quite as lavish as its Z490 counterpart, and at £215 inc VAT, it's also the most expensive B550 board on test. Its silver cladding does look very smart, though, even if the PCB is a little bare compared with other boards on test.

You get an easily accessible M.2 port on the top side, which offers PCI-E 4 compatibility and is equipped with a large, flat heatsink that kept our SSD at a peak of 62°C in our back-to-back CrystalDiskMark runs. The second port is located on the rear of the PCB as usual, but is limited to PCI-E 3 SSDs as well as SATA M.2 SSDs.

You get the typical four SATA 6Gbps ports, and they're handily angled too for easier cable routing. There's a Type-C header on the PCB as well, so you can hook up compatible cases. However, despite the ample free PCB real estate provided by having the power circuitry on one side of the PCB, ASRock hasn't added any more fan headers than the usual three, nor extra RGB headers, with the typical 3-pin and 4-pin headers included there too.

SPEC

Chipset AMD B550

CPU socket AMD Socket AM4 (Zen+, Zen 2)

Memory support 2 slots: max 64GB

DDR4 (up to 5400MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek S1220

Networking 1x Intel 2.5 Gigabit

LAN, Intel 802.11ax Wi-Fi

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

Ports Three 4-pin fan headers, VRM heatsink, M.2 heatsink, Ports 4 x SATA 6Gbps, 1x M.2 PCI-E 4, 1x M.2 PCI-E 3, 1x USB 3.1 Gen 2 Type-A, 1x USB 3.1 Gen 2 Type-C, 4x USB 3 Type-A, line in, mic, line out, 1x HDMI 2.1, 1x DisplayPort 1.4

Dimensions (mm) 170 x 170

The 8-phase power delivery has a relatively small passive heatsink compared with the rest of the field this month – backed up by a second heatsink underneath – but despite that, we measured a VRM temperature of just over 50°C, so there's plenty of headroom. Meanwhile, the integrated I/O shield offers five Type-A USB ports, which is reasonable and you get a full-fat USB 3.1 Gen 2 Type-C port too.

There's integrated 802.11ax Wi-Fi like the other B550 boards on test, as well as Realtek ALC1220 audio, but yet again, despite having the room for it, ASRock has only included three audio outputs in the form of 3.5mm mini-jacks instead of the full complement on MSI's option, which includes an optical out too. We wouldn't mind if there had been a price saving, but that's not the case with the B550 Phantom Gaming-ITX/ax.

There wasn't really much difference in terms of performance among the B550 boards, and the B550 Phantom Gaming-ITX/ax didn't leap out anywhere as a result. Despite a rather basic EFI, it managed to hit our usual 4.3GHz all-core overclock with our Ryzen 9 3900XT easily with 1.4V, and this saw the video encoding score rise from 782,047 to 836,917.

At stock speed, the single-thread performance was a little low at 511 points, but that was the only test where it was noticeably



slower than other boards. It also exhibited the lowest idle power draw at stock speed and when overclocked, and the lowest overclocked power draw at load too.

Conclusion

Had the ASRock B550 Phantom Gaming-ITX/ax cost £40 less, it would have provided some stiff competition this month. It performs well and it handled our Ryzen 9 3900X with ease, so it has got the basics right. However, while it's not hideously more expensive than the other boards on test, unless you're completely sold on its looks, it doesn't warrant any extra outlay. It's also missing a few features that would otherwise help to justify its slightly higher price.

VERDICT

A solid effort, but it lacks the feature set needed to justify its price.

PERFORMANCE

32/35

FEATURES

28/35

VALUE

24/30

OVERALL SCORE

84%



B550 MINI-ITX MOTHERBOARD

ASUS ROG STRIX B550-I GAMING / £200 incVAT

SUPPLIER overclockers.co.uk

Asus has a trio of small motherboards for AMD's X570 and B550 chipsets, with both the X570 version of the ROG Strix B550-I Gaming we're looking at here, as well as the mighty Crosshair VIII Impact. At £200, it's significantly cheaper than the X570 version, which costs closer to £300.

At first glance, the two boards seem very similar. Both have fan-assisted VRM heatsinks, which in this case kept the VRMs below 60°C according to our IR probe (the VRM phase design is 8+2). They both also share the same aesthetics, with an all-black theme and stacked components rising off the 170 x 170mm PCB.

However, there are some subtle differences. The ROG Strix B550-I Gaming lacks the snazzy RGB lighting on the M.2 heatsink. It also has just one small fan cooling

the chipset and VRMs, while the X570 board has two. The latter has three more Type-A USB ports than the B550 board's sub-par four, and both its M.2 ports support PCI-E 4 SSDs as well.

However, the ROG Strix B550-I Gaming also sports a Type-C USB header, which is strangely missing from its more expensive sibling. In addition, it has USB BIOS FlashBack, and has the same trio of fan headers

and RGB headers. So, in many ways the ROG Strix B550-I Gaming is a match for the more expensive board, and actually has one or two extra features. The main difference, then, is VRM cooling and the added bandwidth on offer from the X570 chipset.

Compared with the rest of the boards this month, Asus has a very strong offering here, except for the lack of USB ports. It had the lowest M.2 SSD temperature on test at just 56°C, thanks to the raised M.2 port, as well as audio that pipped the rest of the field to the post.

Its real trump card, though, is its set of thermal probe headers. If you're using it for a water-cooled system, it's the best board here, as you can control your radiator fans and pump based on the coolant temperature. It has the best EFI too, bettering both Gigabyte and ASRock's efforts, although MSI's B550 board this month is on par in this regard. The MSI board also sports a greater number of audio outputs, while the Asus board has only three.

Overclocking was simple, with our usual 1.4V seeing a maximum CPU frequency of 4.3GHz with our Ryzen 9 3900X, although you'll likely want to use 1.3V or less for a long-



term overclock. This saw the system score rise from 332,819 to 351,258, with 500 points added to the Cinebench score and the highest single-threaded result as well.

Conclusion

As the basis for a high-end mini-ITX system, perhaps with some custom water-cooling gear, the Asus ROG Strix B550-I Gaming is without doubt the best B550 board on test, and arguably a better choice than its pricier X570 sibling too. It's great in all areas, except if you need more than four USB ports or the full six audio outputs. Best of all, it doesn't come equipped with the usual Asus price premium.

VERDICT

An excellent B550 board that ticks nearly every box, and the price is reasonable too.

PERFORMANCE

31/35

FEATURES

32/35

OVERALL SCORE

89%

SPEC**Chipset** AMD B550**CPU socket** AMD Socket AM4 (Zen+, Zen 2)**Memory support** 2 slots: max 64GB DDR4 (up to 5100MHz)**Expansion slots** One 16x PCI-E 4**Sound** 8-channel SupremeFX S1220A**Networking** 1x Intel 2.5 Gigabit LAN, Intel 802.11ax Wi-Fi**Cooling** Three 4-pin fan headers, VRM heatsink, M.2 heatsink, one heatsink fan**Ports** 4 x SATA 6Gbps, 1x M.2 PCI-E 4, 1x M.2 PCI-E 3, 3 x USB 3.1 Gen 2 Type-A, 1x USB 3.1 Gen 2 Type-C, 1x USB 2 Type-A, line in, mic, line out, 1x HDMI 2.1, 1x DisplayPort 1.4**Dimensions (mm)** 170 x 170

B550 MINI-ITX MOTHERBOARD

GIGABYTE B550I AORUS PRO AX / £190 inc VAT

SUPPLIER scan.co.uk

As the only B550 mini-ITX motherboard we'd reviewed up until this month's Labs test, we didn't have much with which to compare the Gigabyte B550I Aorus Pro AX. However, now we have a pretty good idea about where it sits among the other baby boards sporting AMD's new chipset.

It's good-looking, if chunky, and it sports a large heatpipe-linked pair of heatsinks that cool an 8-phase power delivery and the top M.2 slot. There are essentially two heatsinks – a small one that sits on the SSD and then a massive, thick one that only makes slight contact with it. The big one blocks airflow to the SSD heatsink, though, so if you remove the big one, the SSD temperature drops by a few degrees, which isn't a great piece of design. That said, either setup is still cooler than using no SSD heatsink at all.

STRAWBERRY JAM

- + Great VRM cooling
- + Good software
- + Cheaper than X570 model

TRAFFIC JAM

- Questionable heatsink design
- No thermal probe header
- No USB Type-C header

SPEC

Chipset AMD B550

CPU socket AMD Socket AM4 (Zen+, Zen 2)

Memory support 2 slots: max 64GB DDR4 (up to 4800MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1220

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

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

Ports 4 x SATA 6Gbps 1x M.2 PCI-E 4, 1x M.3 PCI-E 3, 1x USB 3.1 Type-A, 1x USB 3.1 Type-C, 4 x USB 3 Type-A, line in, mic, line out, 2 x HDMI 2.1, 1 x DisplayPort 1.4

Dimensions (mm) 170 x 170

At £190, this board is significantly cheaper than its Z490 sibling, but the latter does sport several extra features. It has a USB Type-C header, which is becoming popular with many mini-ITX cases these days, so the lack of one is annoying at this price; this feature is found on every other B550 board on test too.

It also lacks the quartet of fan headers on the Z490 model, which really helped to set that board apart, making do with a more typical three. Meanwhile, the five Type-A USB ports on the back are usual for a mini-ITX board.

However, we'd rather Gigabyte ditched one of the three display outputs, which will only be useful for APU support, and two is arguably enough here.

It's good to see Q-Flash Plus is included, though, which allows you to update the BIOS without a compatible CPU. Plus, if you want to add RGB lighting components, there are both 3-pin and 4-pin headers on the PCB.

As with all the boards on test this month, overclocking and testing tools are otherwise non-existent, but you do get Realtek ALC1220 audio, 802.11ax Wi-Fi and a PCI-E 4 M.2 port, with a PCI-E 3 M.2 port on the underside of the PCB for good measure. However, one glaring omission is a thermal probe header, which is a shame given that Gigabyte's EFIs and software are geared towards detailed fan control.

We didn't quite hit the usual 4.3GHz with our Ryzen 9 3900X, but came close at 4.25GHz. However, even pushing the vcore up to 1.4V didn't see us get a stable benchmark run above this figure. The overclock saw the system score rise from 325,498 to 339,577, and the Cinebench score go from 6,983 to 7,463, but its general performance was



slightly behind the other boards in most tests. Meanwhile, the VRMs ran at a cool 51°C under load, which was the lowest temperature on test, and there's no fan noise either. Audio performance was also on par with the other boards on test, with a dynamic range of 102dBA.

Conclusion

The Gigabyte B550I Aorus Pro AX isn't perfect, but it does only cost £190 inc VAT. The VRM cooling is superb, despite the lack of fans, and the audio performance is solid too. However, you only need to spend an extra £10 to get the Asus ROG Strix B550-I Gaming, which has a better balance of design and features.

VERDICT

Decent VRM cooling and a fair price, but the Gigabyte has too many niggles for us to recommend it.

PERFORMANCE

31/35

FEATURES

27/35

OVERALL SCORE

84%

VALUE
26/30



B550 MINI-ITX MOTHERBOARD**MSI MPG B550I GAMING EDGE WiFi / £190 inc VAT**SUPPLIER ebuyer.com

MSI decided to leave X570 to other manufacturers when it came to mini-ITX, but with the arrival of B550, the company has finally dished out some PCI-E 4, small form factor love to 3rd-gen Ryzen owners. The MSI MPG B550I Gaming Edge WiFi is one of the cheapest boards on test, leaving you with change from £200, but it doesn't skimp on features.

There's a USB Type-C header, which is absent on the Gigabyte B550I Aorus Pro AX, and you even get a fan-assisted M.2 SSD and chipset cooler too. You can control the fan in the EFI or software, but it only powers up under high chipset temperatures. If you want to boost M.2 cooling, it's best to set it to a fixed speed, so it's on all the time.

It's easy to remove the cooler to access the PCI-E 4 M.2 port beneath it, and there's a second slot on the underside of the PCB, which is limited to PCI-E 3 SSDs. If you have a SATA M.2 SSD, though, you'll need to use it in the top slot, which means you'll lose the only slot compatible with PCI-E 4 SSDs.

The power delivery comes from eight CPU power phases, rated at 60A, and it's all cooled by a large topside heatsink and

smaller metal plate on the underside. It would have been good to see the cooling setups linked, so the fan could assist the VRMs, as we've seen on other MSI boards recently, but with a peak load temperature of just 54°C, it's not really necessary.

Meanwhile, the colour scheme is jet black, and if you want to add some RGB lighting, be aware there's only a single 3-pin header for digital lighting and no 4-pin headers. The MSI is also the only B550 board on test to offer six audio outputs, including an optical port.

However, while the overall layout is generally excellent, there's one mind-boggling oversight. The clear-CMOS jumper's location evaded us until we turned to the manual, only to find it embedded under the I/O shield and VRM heatsink. This required removing the I/O shield and dealing with four screws, which wouldn't be possible if you'd already built your PC.

Proving just how inconvenient this setup is, we actually needed to use the jumper, as overclocking saw the board refuse to boot when we pushed it too far. Thankfully, it managed to hit the usual 4.3GHz with a 1.4V vcore, as with the other boards on test. What's more, it was quite speedy at stock



speed, managing the highest RealBench system score and Cinebench scores without drawing significantly more power.

Conclusion

MSI's MPG B550I Gaming Edge Wi-Fi offers good performance, an excellent EFI and plenty of other features – it would have picked up an award were it not for its hidden CMOS jumper. This should always be easily accessible and not require disassembling your PC to access it. If you'll be running at stock speed, though, and have never needed to reset the BIOS, then it's a better buy than Gigabyte's offering at the same price, plus it offers fan-assisted cooling and a USB Type-C header. **EPC**

SPEC**Chipset** AMD B550**CPU socket** AMD Socket AM4 (Zen+, Zen 2)**Memory support** 2 slots: max 64GB DDR4 (up to 4600MHz)**Expansion slots** One 16x PCI-E 4**Sound** 8-channel Realtek S1220**Networking** 1x Intel 2.5 Gigabit LAN, Intel 802.11ax Wi-Fi**Cooling** Three 4-pin fan headers, VRM heatsink, M.2 heatsink**Ports** 4x SATA 6Gbps, 1x M.2 PCI-E 4, 1x M.2 PCI-E 3, 1x USB 3.1 Gen 2 Type-C, 1x USB 3.1 Gen 2 Type-A, 2x USB 3 Type-A, 2x USB 2, line in, mic, 3x surround audio out, 1x optical S/PDIF, 1x HDMI 2.1**Dimensions (mm)** 170 x 170**CUTTING EDGE**

- + Good M.2 and VRM cooling
- + USB Type-C header
- + Full audio outputs

CUTTING HEDGE

- Hidden clear-CMOS jumper
- Only top M.2 port supports SATA M.2 SSDs

PERFORMANCE**32/35****FEATURES****27/35****OVERALL SCORE****86%****VALUE**
27/30

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ISSUE #34

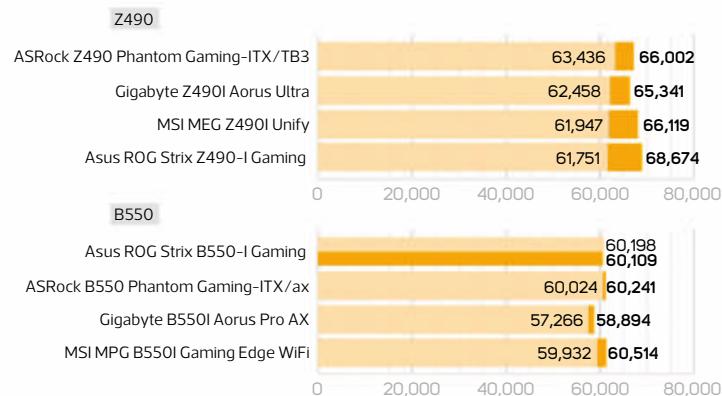
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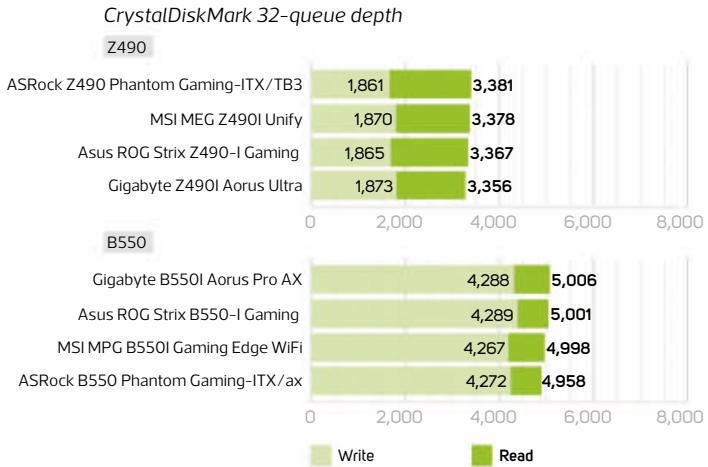


MINI-ITX MOTHERBOARDS LABS RESULTS

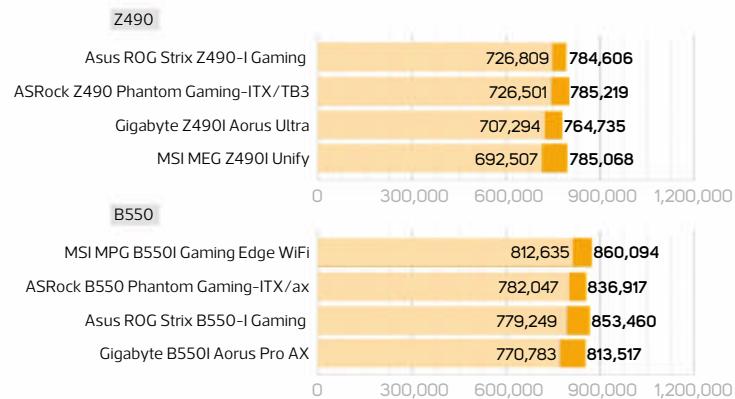
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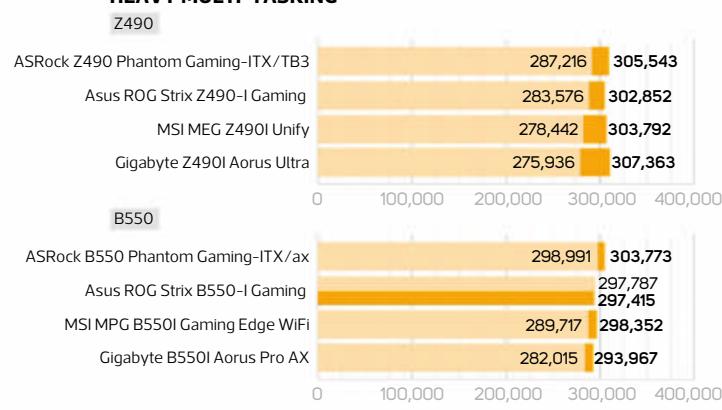
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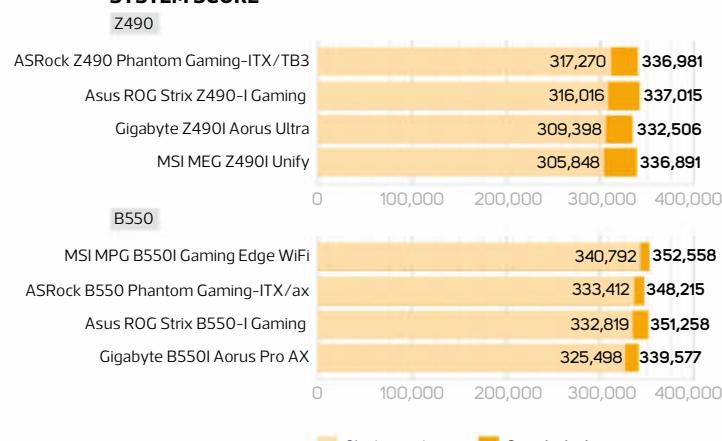
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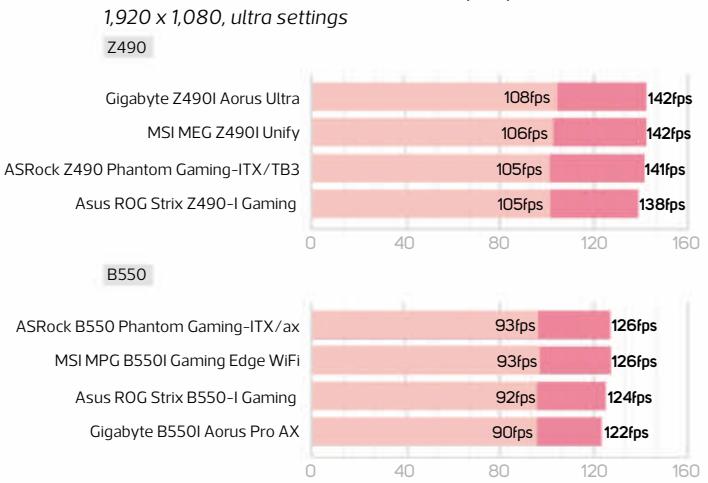


SYSTEM SCORE

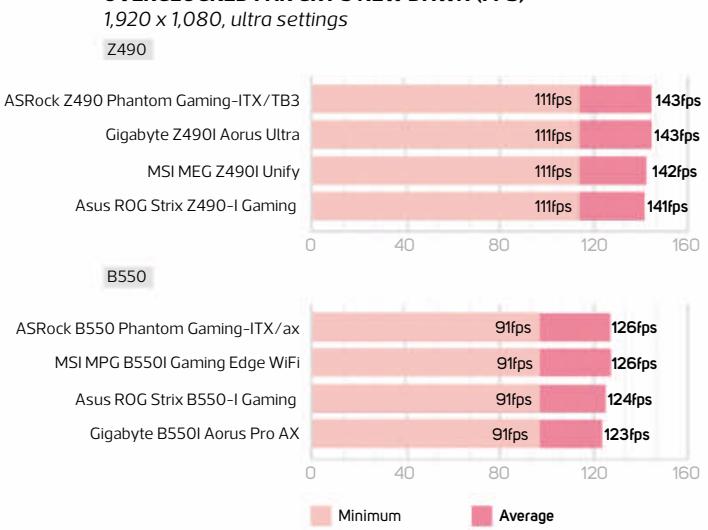


Stock speed Osclocked

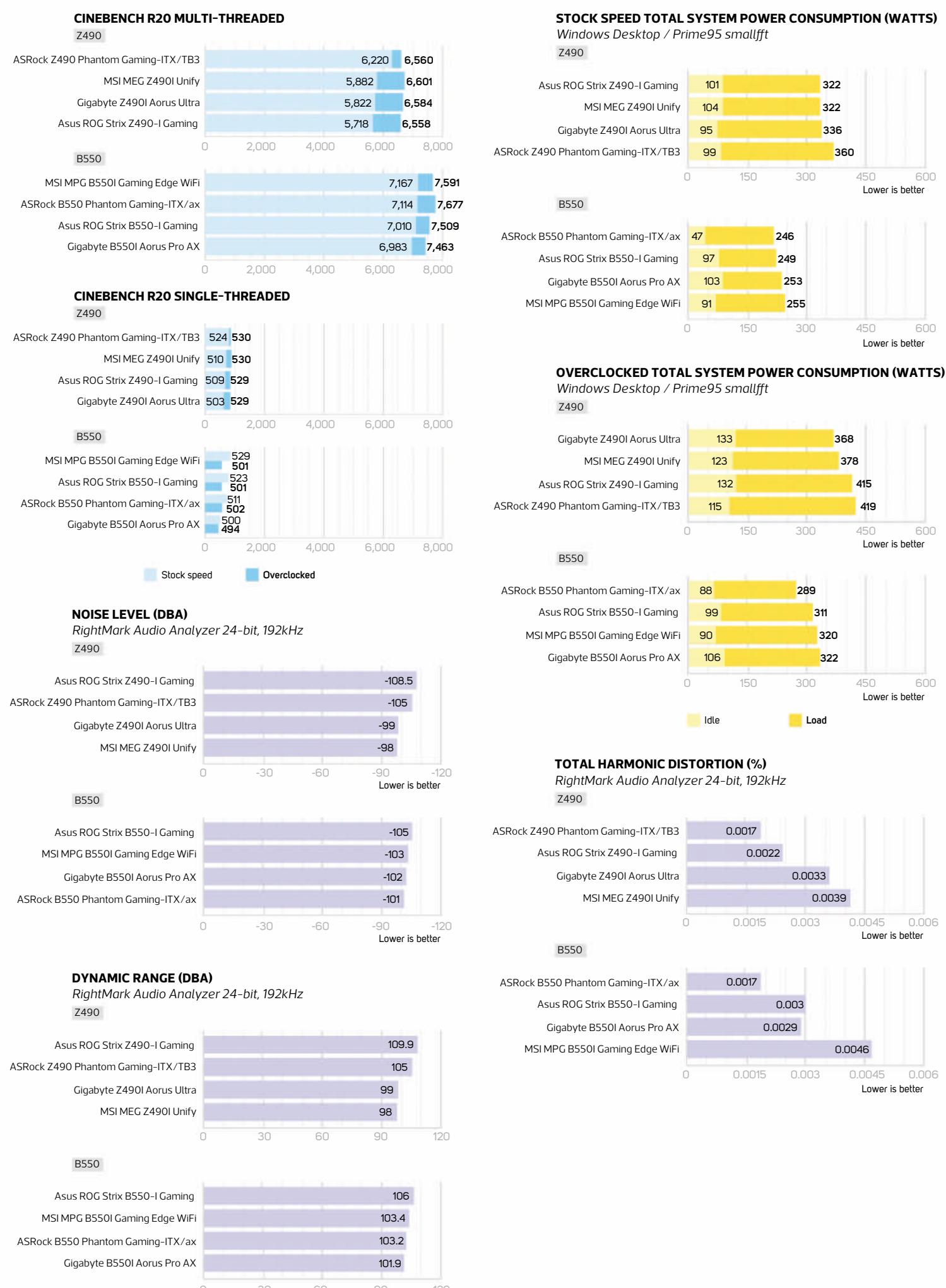
STOCK SPEED FAR CRY 5 NEW DAWN (FPS)



OVERCLOCKED FAR CRY 5 NEW DAWN (FPS)



MINI-ITX MOTHERBOARDS LABS RESULTS



LABS TEST

Longview

Often considered the ultimate gaming monitor upgrade, Edward Chester puts five of the latest 34in ultrawide gaming screens to the test

How we test

Outside of the few monstrous 49in megawide monitors and TV-sized console gaming monitors available, 34in, ultrawide gaming monitors are the top option for most buyers. They're a great compromise between sheer screen size, resolution and game compatibility.

What's more, the latest models are cheaper and more capable than ever, with the cheapest model on test coming in at under £400. All five of the displays we're testing also have a maximum refresh rate of 144Hz or higher, which is a marked upgrade on the 100-120Hz of most previous top-spec ultrawide screens.

Most also sport a claimed 1ms response time, although you'll seldom see this figure in real-world use. Nonetheless, the average response time of these latest panels is a step up from older models. All of them also support both FreeSync and G-Sync (sometimes in an unofficial capacity, but we've tested each one and they all work), so you can eliminate tearing and stuttering in your games, whether you have an AMD or Nvidia GPU.

To test the screens, we first assess their design and build quality and tot up any extra physical features, such as extra video connections, a USB hub, headphone holder and RGB lighting. We also

check the versatility of the stand: whether it offers height, rotation, pivot and tilt adjustment.

Next up we test image quality with an X-Rite i1Display Pro colorimeter and DisplayCal software, gauging aspects such as the colour balance and gamma, all with the brightness of the display set to a standard 150nits (generally around 25/100 on a display's brightness scale). We also check the maximum brightness of the display.

For displays with an extended colour gamut, as used for HDR, we then check to see if there's a way to reduce this gamut down to normal sRGB levels – most displays have a dedicated sRGB mode – and assess its image quality.

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

Finally, we turn to gaming. Here, we mainly concentrate on FPS games, where fast response times, high refresh rates and adaptive sync features are most crucial. We test subjectively and then also use Blur Buster's excellent ghosting UFO test to check the sharpness of the display in high-speed motion.

Contents

- › Acer Nitro XV340CKP / p51
- › AOC CU34G2X / p52
- › iiyama G-Master GB3461WQSU / p53
- › iiyama G-Master GB3466WQSU / p54
- › LG UltraGear 34GN850 / p55
- › Image quality graphs / p56

ACER NITRO XV340CKP / £635 inc VAT

SUPPLIER laptopsdirect.co.uk

The Nitro XV340CKP doesn't sport Acer's top-of-the-line Predator gaming branding, but it's still a very capable gaming display, as you'd hope given its relatively premium price. While most of the screens on test cost under £500, the Acer costs well over £600.

The price is matched with a premium design, with the Nitro sporting a very elegant, narrow, cylindrical stand with a matching circular base. Combined with an all-black colour scheme, it's a clear cut above all the other displays on test for sheer desk appeal. You don't get any fancy extras such as RGB lighting or a headphone stand though.

You do get a largely typical selection of connections, with two DisplayPort 1.2 inputs, two HDMI 1.4 ports, a 4-port USB 3 hub, a headphone jack and an internal power supply, so there's no power brick. All the connections are on the underside of the bump in the back of the display, so there are no USB ports on the edges, for instance.

SPEC

Screen size 34in

Resolution 3,440 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync,
unofficial G-Sync support

Display inputs 2 x DisplayPort 1.2, 2 x HDMI 1.4

Audio 2 x 3W speakers, line in, headphone out

Stand adjustment Height, rotation, tilt

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

We're used to Acer providing excellent menu systems with its displays, but the first clear misstep of this monitor is its OSD controls. Rather than a mini joystick, you get four buttons on the back of the display, and while they're easy to locate, they correspond clearly with the options shown on screen, and the menus themselves follow a logical navigation pattern, the actual buttons are too stiff so they regularly don't register presses, making navigating the OSD a slow, button-bashing affair.

Meanwhile, the LCD panel has the same 3,440 x 1,440 resolution and 34in diagonal as all the other displays on test. However, while some panels on test are curved or based on VA-type LCD tech, the Acer has a flat IPS-type LCD panel. This is our preferred panel type (of these two) for gaming and desktop duties, thanks to its excellent viewing angles, colour accuracy and faster response time – benefits that are all clear to see in this excellent display.

Out of the box, colour balance is fairly good (6,775K) and contrast (859:1) is okay for an IPS-type panel. However, colours look a little washed out, which is down to the gamma level of 2.06 being a little lower than the ideal of 2.2. Switch the display to its 2.4 gamma option, though, and the gamma hits 2.25, so we ran the display in this mode.

What you don't get here, though, is a truly wide colour gamut, as we've tended to see with recent displays. It hits just 113 per cent of the sRGB colour space, compared to the 140 per cent that proper HDR standards require. That's still more than enough for normal use, but this monitor's HDR pretensions are completely unfounded.

When it comes to gaming, this screen put in a solid performance. The 1ms response



ACE OF SPADES

- + Elegant design
- + Good overall image quality
- + Decent gaming performance

ACE OF BASE

- Low maximum brightness
- Slightly grainy screen surface
- Unresponsive OSD buttons
- No proper sRGB mode

time claim of its IPS panel is as far-fetched as ever, but it's still noticeably quicker than previous generation ~4ms panels, and the 144Hz refresh rate further pushes its gaming advantage over previous 120Hz screens.

Conclusion

The Acer Nitro XV340CKP is a good monitor that delivers on much of what you'd hope for from its spec sheet. It also easily has the most attractive design of all the display's on test. However, it lacks a few features here and there, and isn't without issues, so doesn't do enough to justify its relatively high price.

VERDICT

A very good ultrawide display but one that feels a bit pricey right now.

IMAGE QUALITY

23/30

FEATURES

15/20

GAMING

23/30

VALUE

13/20

OVERALL SCORE

74%



AOC CU34G2X / £499 inc VAT

SUPPLIER laptopsdirect.co.uk

If the Acer Nitro XV340CKP typifies one type of ultrawide gaming monitor configuration, the AOC CU34G2X represents the main other type of ultrawide gaming monitor you can buy at the moment. Instead of a flat IPS-type LCD panel, it sports a curved VA-type LCD panel.

It's an interesting divide that's common throughout different sizes of monitor, and it's one that primarily seems to come from the need to address one of the downsides of VA-type panels. While they have much better viewing angles than TN-type LCD panels, they're not as good as IPS. As such, on flat screens, you can notice the slight shift in colour that happens from the changing angle of view from the centre to the edge of the screen. By curving the display, this effect is minimised.

I SEE YOU

- + Great out-of-the-box image quality
- + High contrast
- + Good value

ICU

- OSD is tricky to use
- Sluggish response time
- Relatively low contrast for VA panel
- Low maximum brightness

SPEC

Screen size 34in

Resolution 3,440 x 1,440

Panel technology VA

Maximum refresh rate 144Hz

Response time 1ms

Contrast 3,000:1

Adaptive sync FreeSync, unofficial G-Sync support

Display inputs 1x DisplayPort 1.2, 2 x HDMI 1.4

Audio Headphone out

Stand adjustment Height, rotation, tilt

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

Conversely, the big advantage of VA panels is their high contrast. Thanks to being much better than other LCD types at blocking the light from their backlights, they can produce much deeper black levels. This is why they tend to be used for TVs, and they're ideal for watching movies or playing dark, atmospheric games.

At least that's the theory, but while the AOC CU34G2X's measured contrast level of 2,220:1 comfortably doubles that of any of the IPS displays on test, it's actually on the low side for a VA panel. The iiyama G-Master GB3466WQSU's measured contrast ratio is over 60 per cent higher.

Nonetheless, right out of the box, the AOC's image quality is great, with decent colour balance (6,961K), near-perfect gamma (2.19) and, yes, a contrast level that's noticeably high. Fire up the new The Batman trailer and it really pops in a way that IPS (and TN) panels just can't rival.

However, with a maximum colour gamut of 120 per cent sRGB, it doesn't achieve the full colour range required for proper HDR standards, and its contrast still isn't really sufficient for the full impact. As such, HDR content seldom looks meaningfully better than SDR, especially as this display's maximum measured brightness is a modest 244 nits.

Meanwhile, the downside of VA panels is their slow response time. While this screen has a 144Hz refresh rate and rated 1ms response time, it doesn't feel anywhere near as snappy as the 1ms IPS displays on test. That said, this display copes better than the iiyama G-Master GB3466WQSU, which felt sluggish enough to affect our performance in fast-paced first-person shooters. Like most of the other displays on test, you can also turn on a backlight-strobing blur reduction mode that



further improves the response time, although it can't close the gap on those IPS rivals.

Elsewhere, the CU34G2X's feature set is in line with most of the other displays on test, although it only has one DisplayPort input, rather than two, and you don't get speakers. It also has awkward buttons for navigating its on-screen display menus; however, the menus themselves are sufficiently comprehensive.

Conclusion

The AOC CU34G2X is great for people who like to sit back, and enjoy movies and atmospheric, slower-paced games on their PC. It will still do faster-paced gaming, but just not as well as IPS alternatives. The iiyama GB3466WQSU is a little cheaper and has higher contrast, but gaming is better on the AOC. If deep blacks and high contrast are your priorities then this is a decent display, but the IPS panels on test are better for fast-paced gaming.

VERDICT

The IPS vs VA debate rages on, and the AOC CU34G2X makes a strong argument for the latter, but it can't compete with more responsive panels in games.

IMAGE QUALITY

24/30

FEATURES

16/20

GAMING

22/30

VALUE

16/20

OVERALL SCORE

78%

IIYAMA G-MASTER GB3461WQSU / £399 incVAT

SUPPLIER cclonline.com

We're looking at a couple of brand-new iiyama ultrawide gaming monitors in this test, each of which represents the IPS/VA divide. Given the fairly fundamental differences in such displays, it's intriguing to see that iiyama has opted for such similar and impenetrable model names for these two displays. While over the page we have the VA-equipped G-Master GB3466WQSU, here we're looking at the IPS-sporting GB3461WQSU.

This IPS model has a couple of key advantages going for it. The first is that, along with height, rotation and tilt adjustment, the stand includes a pivoting motion. There's a prominent sticker on the base of the stand telling you not to pivot the display – the display is so wide, it would hit the desk in portrait mode. However, there's enough movement room to make reaching around the back to plug in cables much easier than with all the other displays on test.

You also get the addition of both picture-in-picture and picture-by-picture modes, allowing you to view two video sources at once. It's a niche, more business-centric,

feature but one that most gaming displays omit, so it's a neat bonus here.

Likewise, the physical design is a little more on the business-focused side than the other displays on test this month.

It's quite a dull, boxy-looking display, with none of the minimalist chic of the Acer, for instance. Still, you get an integrated carry handle, which is useful on a screen this size, and the simple rectangular foot is compact and practical.

Connection options are the same as several other displays on test this month, with two DisplayPort 1.2 inputs and two HDMI 1.4 ports, but you only get two USB 3 ports. These sit on the underside of the back of the display, along with the headphone socket, internal power supply and surprisingly reasonable-sounding stereo 3W speakers.

Default image quality initially looks very good, with a reasonably balanced-looking colour response, and seemingly decent contrast ratio and gamma level. However, on testing, the default colour balance is actually quite far off ideal, coming in with a warm and yellow hue.

Unfortunately, this can't quickly be fixed by opting for a different colour mode; instead you'll have to tweak the RGB balance (we settled on 96 x 96 x 100). With this tweak performed, though, the monitor delivers very good image quality across the board.

That said, there's no sign of any significant extended colour gamut for HDR. It stretches



to just 112 per cent of the sRGB colour space, which is well short of meaningful HDR colour ranges. The sRGB mode also doesn't reduce this to 100 per cent, but it's a small enough increase to not be a concern anyway.

As for gaming performance, the GB3461WQSU put in a similar showing to the Acer XV340CKP, with a surprisingly snappy overall response that feels like a noticeable upgrade over older 34in IPS screens. The LG 34GN850 is a little faster, but this is still a very capable gaming screen. The iiyama doesn't have the LG's official G-Sync support, but it still worked fine with G-Sync in our tests.

Conclusion

The G-Master GB3461WQSU isn't perfect, with less than ideal colour balance out of the box, and a rather staid frame and stand design. However, it otherwise delivers great image quality and fantastic gaming performance, all for an astonishingly low price. If you're short on cash, but want a big gaming monitor upgrade, this is the one to buy.

VERDICT

A very low price makes the GB3461WQSU a fantastic-value ultrawide gaming display, despite its few flaws.

SPEC

Screen size 34in

Resolution 3,440 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync,
unofficial G-Sync support

Display inputs 2 x DisplayPort 1.2, 2 x HDMI 1.4

Audio 2 x 5W speakers, line in, headphone out

Stand adjustment Height, rotation, pivot, tilt

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

LLAMA

- + Fantastic value
- + Great image quality
- + Good gaming performance

DRAMA

- Poor default colour balance
- Lacks colour gamut for HDR
- Staid design

IMAGE QUALITY

24/30

GAMING

24/30

OVERALL SCORE

83%

FEATURES

16/20

VALUE

19/20



If high contrast is the calling card of VA-type LCD panels, then the iiyama G-Master GB3466WQSU certainly fits the bill. It's rated to the same 3,000:1 contrast level as the AOC CU34G2X, but while the AOC came up well short of that figure during testing, the GB3466WQSU hits a lofty 3,542:1. That's more than triple the contrast ratio that any of the IPS displays on test can deliver.

This high contrast lends itself well to both games and watching video, with the deeper black levels providing a real depth that adds extra atmosphere and makes colours stand out even more. While we're fans of the generally natural-looking colour, high response time and image stability of IPS screens – and their

readability for desktop use, precisely because of their lower contrast – they pale in comparison to good VA panels for that visual impact. It's a shame, then, that this screen's gamma setting is a bit low. We tried the standard 2.2 gamma, but measured it at just 1.95 during testing, which results in a noticeably grey, washed-out quality to the whole image. Instead, we tried the 2.6 setting; according to our measurements, this resulted in a reading of 2.32 – much closer to the ideal of 2.2.

What's more, the default colour balance is poor. Out of the box, the GB3466WQSU's colour temperature was 7,278K, which is miles off the ideal of 6,500K, resulting in a noticeably cold, blue tinge to the image. Thankfully, switching to the Warm colour preset pulled the temperature closer into line, with a reading of 6,786K.

All that contrast should also lend itself to better HDR reproduction than most displays. However, we weren't convinced in this case. This display has a slightly extended colour gamut (which annoyingly can't be disabled using the sRGB colour mode) of 129 per cent of sRGB, but it has no backlight trickery going on, so it can't really compete with proper HDR displays. It's certainly not good enough to be a significant selling point.

Elsewhere, the display has a similar curved profile to the AOC panel, and a slightly more fetching design than its IPS cousin, the GB3461WQSU. However, the stand doesn't offer any rotation, which is a pain when you're trying to position it in front of you. It offers the same connections and half-decent speakers as its siblings, though, and its menu system is similarly adequate but certainly not a joy to use.

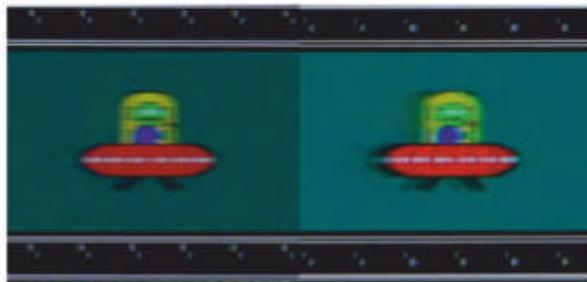
When it comes to gaming, however, the slower response time of VA panels is strongly in evidence here. This was the only panel on test

HIGH CONTRAST

- + Deep contrast ratio
- + Great for dark movies and atmospheric games
- + Good value

HIGH CHOLESTEROL

- VA panel comparatively slow for gaming
- Poor default colour balance
- sRGB mode doesn't reduce gamut



The Blur Busters ghosting test clearly shows how the GB3461WQSU's IPS panel (left) responds quicker than the GB3466WQSU's VA panel (right), making for a sharper image

IIYAMA G-MASTER GB3466WQSU / £440 inc VAT

SUPPLIER cclonline.com

SPEC

Screen size 34in

Resolution 3,440 x 1,440

Panel technology VA

Maximum refresh rate 144Hz

Response time 1ms

Contrast 3,000:1

Adaptive sync FreeSync, unofficial G-Sync support

Display inputs 2 x DisplayPort 1.2, 2 x HDMI 1.4

Audio 2 x 3W speakers, line in, headphone out

Stand adjustment Height, rotation, tilt

Extras 100 x 100mm VESA mount

where the screen impacted our ability to hit our shots in first-person shooters. It would be fine for single-player games, but comparatively, it feels a little sluggish in competitive multiplayer games, where split seconds count.

Conclusion

With a little setup tweaking, this is a decent display for people who want a big, bold, high-contrast screen for watching movies and playing slightly slower-paced, atmospheric games. The price is reasonable too. However, it's a touch sluggish for faster games, and its lack of a proper sRGB mode isn't ideal for desktop work either.

VERDICT

A decent-value display with plenty of good qualities, but there are caveats to its gaming performance.

IMAGE QUALITY

22/30

FEATURES

16/20

GAMING

19/30

VALUE

17/20

OVERALL SCORE

74%

LG ULTRAGEAR 34GN850 / £970 incVAT

SUPPLIER overclockers.co.uk

Costing more than double the other displays on test (apart from the Acer), you'd be forgiven for thinking the LG UltraGear 34GN850 can claim some significantly greater performance abilities than the other displays on test. However, while it does have several advantages, they're subtler than you might expect.

The most obvious win for this monitor is its maximum refresh rate of 160Hz. It's a small jump over 144Hz, but every little helps for fast-paced competitive gaming, especially if you're considering upgrading from a 100-120Hz ultrawide display. However, this is an overclocked figure, so you'll have to jump into the display's OSD to stretch its maximum from 144Hz.

Another small advantage here is official G-Sync support. In many instances, official support isn't necessary, but sometimes

there can be some performance issues with displays that don't have official support, so it's good to have the guarantee.

The single most important feature for which you're paying, though, is the response time. While plenty of competitors now claim a 1ms response time, LG has been leading the way for the last couple of years with the real-world response times of its displays. As ever, the 1ms claim is only viable in its 'fastest' overdrive setting, which produces terrible image quality, but in the more sensible 'faster' overdrive setting, this display still delivers a class-leading response time.

The end result is noticeably superior gaming performance to even the other IPS displays on test. Whether it's truly a 'double-the-money' improvement is a tougher call, but the LG's other class-leading features help to make that decision a little easier. For a start, this display arrives with near-perfect image quality straight out of the box – just turn down the brightness and you're good to go. It also has 140 per cent sRGB (98 per cent DCI-P3) colour space coverage, so it's the only display on test that can deliver the full range of colours for even the most demanding HDR specs.

Sadly, with a relatively modest contrast ratio of 939:1 and no clever backlighting control, it lacks the contrast to provide a particularly impactful HDR image – you'll have to double your money again to get true HDR on a display this size. Crucially, though, this display also offers a proper sRGB mode that pulls that colour space coverage down to 96 per cent sRGB. Plus, unlike many displays, it allows you to adjust the brightness in this mode too.

So far so impressive, but the UltraGear 34GN850 bizarrely looks among the cheapest and more obviously plasticky of the displays on test. It also uses an external power



brick, it has no speakers, its stand can't rotate or pivot and all its connections jut directly out the back of the display – that's convenient for plugging and unplugging cables, but it looks a bit messy.

Thankfully, the on-screen display menu system is excellent, with a comprehensive range of options and an easy to use joystick control system, rather than the clunky separate buttons of the other displays.

Conclusion

Just a year ago this display would have been a steal, but now prices for 34in monitors with high refresh rates have plummeted, and demanding over double the price of the likes of the iiyama G-Master GB3461WQSU is a tough ask. That said, the superb gaming and colour performance comfortably make this display stand out as the best in its class. It's expensive but worth it if you have the money. **CPC**

VERDICT

A higher refresh rate, faster response time and better default image quality than the competition make the LG a fantastic monitor, although it's not cheap.

IMAGE QUALITY

28/30

GAMING

28/30

OVERALL SCORE

84%

FEATURES

14/20

VALUE

14/20

GOLD STAR

- + Class-leading responsiveness in games
- + High colour gamut
- + Very good default image quality

PARTICIPATION MEDAL

- Contrast not high enough for HDR
- Expensive

SPEC

Screen size 34in

Resolution 3,440 x 1,440

Panel technology IPS

Maximum refresh rate 144Hz

Response time 1ms

Contrast 1,000:1

Adaptive sync FreeSync and G-Sync

Display inputs 2 x DisplayPort 1.2, 2 x HDMI 1.4

Audio 2 x 3W speakers, line in, headphone out

Stand adjustment Height, rotation, tilt

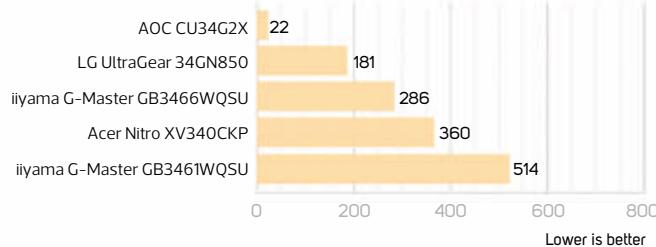
Extras 100 x 100mm VESA mount

ULTRAWIDE GAMING MONITOR LABS RESULTS

DEFAULT / HDR MODE

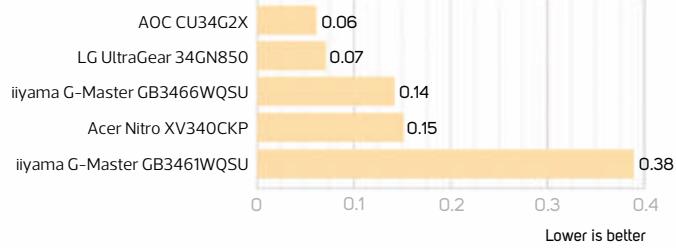
COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



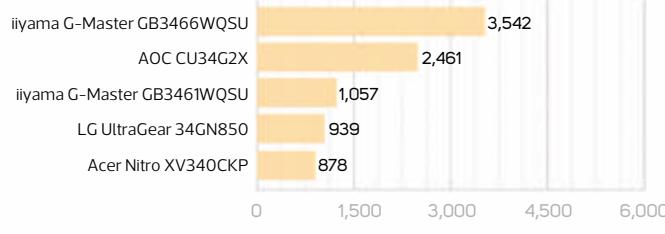
AVERAGE GAMMA

Deviation from ideal result (2.2)



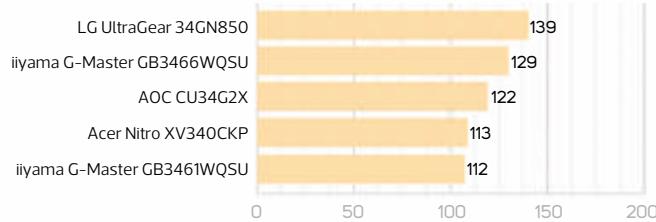
CONTRAST RATIO

Ratio of white-to-black luminance



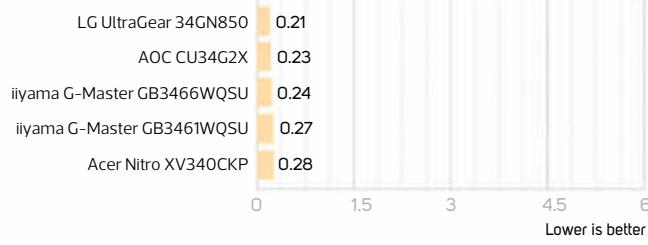
sRGB COLOUR SPACE*

Percentage of sRGB colour space covered



COLOUR ACCURACY

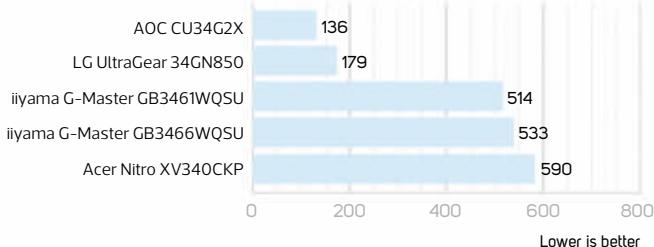
Average delta E 2000



sRGB MODE

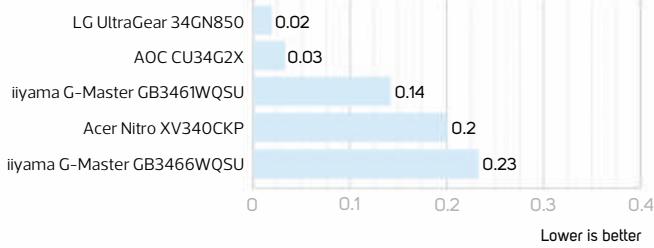
COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



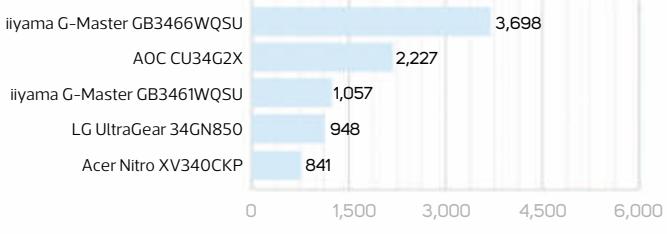
AVERAGE GAMMA

Deviation from ideal result (2.2)



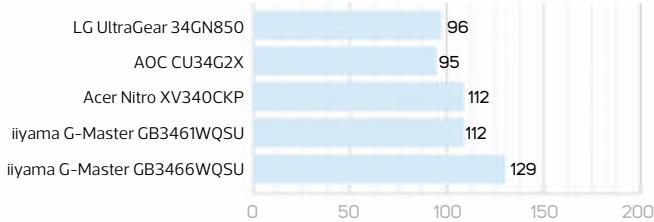
CONTRAST RATIO

Ratio of white-to-black luminance



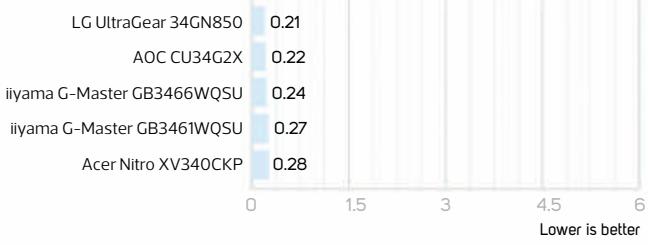
sRGB COLOUR SPACE*

Percentage of sRGB colour space covered

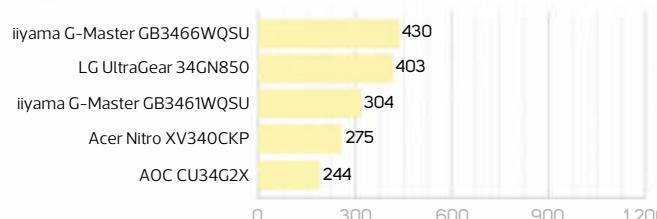


COLOUR ACCURACY

Average delta E 2000



MAXIMUM BRIGHTNESS

Brightness in cd/m² (nits)

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

NEW

Wireframe

Join us as we lift the lid
on video games



Visit wfmag.cc to learn more

How we test

MOTHERBOARDS

TEST PROCESSORS

- › **Intel LGA1200** Intel Core i9-10900K
- › **Intel LGA2066** Intel Core i9-7900X
- › **AMD AM4** AMD Ryzen 9 3900X
- › **AMD TRX4** AMD Threadripper 3970X



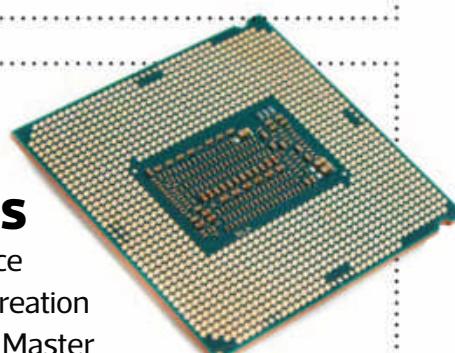
Our test gear comprises a GeForce RTX 2070 Super Founders Edition and a 2TB Samsung 970 Pro SSD (or a PCI-E 4 1TB Corsair MP600 SSD on X570 and TRX40 boards). We also use Corsair Vengeance RGB 3466MHz DDR4 RAM – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems. 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 New Dawn on Windows 10 Home 64-bit. We also test the board's M.2 ports, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer. Where possible, CPUs are overclocked and benchmarked again.

PROCESSORS

TEST MOTHERBOARDS

- › **Intel LGA1200** MSI MEG Z490 Ace
- › **Intel LGA2066** MSI MEG X299 Creation
- › **AMD AM4** Gigabyte X570 Aorus Master
- › **AMD AM4 (APU)** MSI X470 Gaming Pro Carbon
- › **AMD TRX4** Asus ROG Zenith II Extreme



Our CPU test setup comprises a GeForce RTX 2070 Super Founders Edition (or an APU's integrated GPU), a 2TB Samsung 970 Pro SSD, and Corsair Vengeance RGB 3466MHz DDR4 memory – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems. A Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock is also used.

We use Windows 10 Home 64-bit, and test with our RealBench suite, as well as Cinebench for 3D rendering and Adobe Premiere Pro for video export times. Far Cry New Dawn and Metro Exodus test gaming performance. Finally, we record the total power draw of the test PC. We run all tests at stock speed and at the highest stable overclocked frequency.

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

TEST KIT

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

INTEL LGA1151

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

INTEL LGA2066

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

AMD AM4

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

AMD TR4

AMD Threadripper 2950X overclocked to 4.1GHz with 1.425V vcore, AMD Threadripper 2990WX overclocked to 4GHz with 1.3375V vcore, ASRock X399M motherboard.

GRAPHICS CARDS

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

We test graphics cards at 1,920 x 1,080, 2,560 x 1,440 and 3,840 x 2,160, although we omit the latter resolution on cheaper cards that can't produce playable frame rates at this setting.

TEST KIT

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

GAME TESTS

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

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

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

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



POWER CONSUMPTION

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

CUSTOM PC AWARDS



EXTREME ULTRA

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



PREMIUM GRADE

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



PROFESSIONAL

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



APPROVED

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



CUSTOM KIT

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

CUSTOM PC REAL BENCH

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.

Core component bundles

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

Budget system with integrated graphics

Quad-core CPU, basic gaming

Needs a micro-ATX or ATX case.

We recommend a 350W 80 Plus power supply.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3400G	scan.co.uk	#194 p20	£130
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	#194 p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 11 integrated into CPU	N/A	#194 p20	£0
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2Z 3200C16)	scan.co.uk	#204 p74	£67
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	cclonline.com	#204 p74	£80
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	#204 p24	£66

Total £343

Budget gaming system

Quad-core CPU, 1080p gaming

Needs a micro-ATX or ATX case. We recommend a 450W 80 Plus power supply. See Issue 204, p74 for an example build guide.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 3 3300X	ebuyer.com	#203 p28	£120
CPU COOLER	ARCTIC Freezer 7X	scan.co.uk	#202 p20	£18
GRAPHICS CARD	PowerColor Radeon RX 5600 XT	ebuyer.com	#204 p74	£255
MEMORY	16GB (2 x 8GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2Z 3200C16)	scan.co.uk	#204 p74	£67
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	cclonline.com	#204 p74	£80
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	#204 p24	£66

Total £606

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 2060 (1080p gaming with ray tracing and some 2,560 x 1,440 gaming)	ebuyer.com	#199 p50	£276
SWAP STORAGE	1TB WD Blue SN550 (M.2 NVMe)	scan.co.uk	#204 p24	£108

Entry-level RTX gaming system

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

Needs a micro-ATX or ATX case. We recommend a 550W 80 Plus Bronze power supply. See Issue 201, p76 for an example build guide.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3600	scan.co.uk	#195 p16	£174
CPU COOLER	Antec Neptune 240	scan.co.uk	#204 p16	£80
GRAPHICS CARD	Zotac GeForce RTX 2060 Super Mini	ebuyer.com	#199 p53	£365
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3466MHz (CMW16GX4 M2C3466C16)	scan.co.uk	#201 p76	£124
MOTHERBOARD	MSI MAG B550M Mortar (micro-ATX)	ebuyer.com	#204 p42	£150
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	#204 p24	£66

Total £959

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 Super (2,560 x 1,440 gaming with real-time ray tracing)	scan.co.uk	#193 p16	£470
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	#166 p54	£95
SWAP STORAGE	1TB WD Blue SN550 (M.2 NVMe)	scan.co.uk	#204 p24	£108

Mid-range gaming system

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

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



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 3700X	scan.co.uk	#200 p51	£299
CPU COOLER	Antec Neptune 240	scan.co.uk	#204 p16	£80
GRAPHICS CARD	Nvidia GeForce RTX 2070 Super	scan.co.uk	#193 p16	£470
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U3600 38G17-DT60)	amazon.co.uk	#199 p57	£140
MOTHERBOARD	Asus ROG Strix X570-E Gaming (ATX)	overclockers.co.uk	#193 p44	£290
STORAGE	1TB Corsair MP600	scan.co.uk	#193 p26	£204

Total £1,483

UPGRADES

ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	#166 p54	£95
SWAP CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	#185 p82	£125



Core component bundles cont ...

4K gaming system

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



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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 9 3900XT	overclockers.co.uk	#205 p18	£500
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	#175 p20	£125
GRAPHICS CARD	Nvidia GeForce RTX 2080 Ti	scan.co.uk	#189 p20	£1,175
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U3600 38G17-DT60)	amazon.co.uk	#199 p57	£140
MOTHERBOARD	MSI Prestige X570 Creation (E-ATX)	overclockers.co.uk	#193 p48	£440
STORAGE	1TB Corsair MP600	scan.co.uk	#193 p26	£204

Total £2,584

UPGRADES

ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	#166 p54	£95
SWAP CPU	AMD Ryzen 9 3950X (16 cores)	scan.co.uk	#197 p24	£690

Heavy multi-threading workstation

**Serious multi-threaded power,
1080p gaming**



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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Threadripper 3960X	scan.co.uk	#197 p18	£1,240
CPU COOLER	Enermax Liqtech II TR4 240 (240mm AIO liquid cooler)	amazon.co.uk	#186 p44	£160
GRAPHICS CARD	Nvidia GeForce GTX 1660 Super	ebuyer.com	#199 p46	£207
MEMORY	32GB (4 x 8GB) Corsair Dominator Platinum RGB 3600MHz	scan.co.uk	#197 p20	£277
MOTHERBOARD	ASRock TRX40 Taichi (E-ATX)	overclockers.co.uk	#198 p44	£470
STORAGE	1TB Corsair MP600	scan.co.uk	#193 p26	£204

Total £2,558

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 Super (2,560 x 1,440 gaming with ray tracing, and some 4K gaming)	scan.co.uk	#193 p16	£490
SWAP CPU	AMD Threadripper 3970X (32 cores – massive multi-threaded power)	scan.co.uk	#197 p19	£1,980
ADD SECONDARY STORAGE	6TB Seagate BarraCuda Pro	cclonline.com	#166 p50	£192

Mini PCs

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

Mini-ITX



Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z490 (LGA1200)	Asus ROG Strix Z490-I Gaming	novatech.co.uk	#206 p40	£298
AMD B550 (AM4 budget)	Asus ROG Strix B550-I Gaming	overclockers.co.uk	#206 p44	£200
AMD X570 (AM4 mid-range)	Asus ROG Strix X570-I Gaming	overclockers.co.uk	#198 p20	£290

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	overclockers.co.uk	#206 p18	£90
MID-RANGE	Phanteks Enthoo Evolv Shift Air	overclockers.co.uk	#195 p49	£95
PREMIUM	NZXT H1	scan.co.uk	#201 p24	£299

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	#143 p17	£53

ATX cases



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	#176 p28	£55
BUDGET QUIET	be quiet! Pure Base 500	scan.co.uk	#196 p24	£70
SUB-£100	be quiet! Pure Base 500DX	overclockers.co.uk	#202 p39	£99
COMPACT	Fractal Design Define 7 Compact	scan.co.uk	#203 p32	£100
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	#202 p44	£128
SUB-£150	Fractal Design Define 7	overclockers.co.uk	#204 p18	£145
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	#187 p24	£200

Micro-ATX



Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	Asus ROG Maximus XI Gene	novatech.co.uk	#189 p28	£306
AMD X399 (TR4)	ASRock X399M Taichi	scan.co.uk	#179 p28	£329
AMD B550 (AM4)	MSI MAG B550M Mortar	ebuyer.com	#204 p42	£150

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	scan.co.uk	#180 p46	£47
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	#161 p26	£80

Networking



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER (WI-FI 6)	TP-Link Archer AX6000	overclockers.co.uk	#196 p57	£280
MESH ROUTER (WI-FI 6)	Asus AiMesh AX6100	amazon.co.uk	#196 p54	£349
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	#196 p58	£50
SINGLE-BAY NAS BOX	Synology DS118	box.co.uk	#174 p34	£159
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	#200 p22	£153
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	#174 p34	£214

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

Monitors



Up to 24in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144Hz, TN, 1,920 x 1,080, F, G	AOC G2590FX	overclockers.co.uk	#190 p53	£170
24IN, 144Hz, VA, 1,920 x 1,080, F	AOC C24G1	cclonline.com	#191 p28	£187
24IN, 165Hz, TN, 2,560 x 1,440, G	AOC AGON AG241QG	amazon.co.uk	#169 p55	£480

Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60Hz, VA, 4K, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£350
34IN, 144Hz, IPS, 3,440 x 1,440, W, F	iiyama G-Master GB3461WQSU	cclonline.com	#206 p53	£399
34IN, 144Hz, IPS, 3,440 x 1,440, W, F, G	LG UltraGear 34GN850	overclockers.co.uk	#206 p55	£970
35IN, 200Hz, VA, 3,440 x 1,440, W, G, HDR	Asus ROG Swift PG35VQ	scan.co.uk	#198 p58	£2,350
43IN, 120Hz, VA, 4K, F, G	Asus ROG Strix XG438Q	amazon.co.uk	#205 p39	£1,003

Up to 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 144Hz, IPS, 1,920 x 1,080, F, G	AOC 27G2U	box.co.uk	#201 p53	£232
27IN, 165Hz, VA, 2,560 x 1,440, F	MSI Optix MAG272CQR	box.co.uk	#201 p28	£400
27IN, 240Hz, IPS, 1,920 x 1,080, F, G	Acer Nitro XV273	alza.co.uk	#204 p25	£432
27IN, 144Hz, IPS, 2,560 x 1,440, F, G	Asus TUF Gaming VG27AQ	overclockers.co.uk	#201 p54	£480
27IN, 165Hz, IPS, 2,560 x 1,440, F, G	Gigabyte Aorus FI27Q	overclockers.co.uk	#201 p55	£450
27IN, 240Hz, TN, 2,560 x 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£590
27IN, 144Hz, IPS, 4K, G, HDR	Asus ROG Swift PG27UQ	amazon.co.uk	#181 p31	£1,849

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 60Hz, IPS, 4K	AOC U2790PQU	amazon.co.uk	#194 p30	£319

Peripherals and audio

Gaming keyboards



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
MEMBRANE	Corsair K55 RGB	amazon.co.uk	#201 p45	£49
BUDGET MECHANICAL TENKEYLESS	HyperX Alloy FPS Pro	amazon.co.uk	#201 p46	£70
MECHANICAL	Corsair K68 RGB	overclockers.co.uk	#181 p53	£100
MECHANICAL MMO	Corsair K95 RGB Platinum	overclockers.co.uk	#164 p26	£150
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	#193 p56	£160
PREMIUM MECHANICAL TENKEYLESS	Asus ROG Strix Scope TKL Deluxe	scan.co.uk	#202 p24	£140
LUXURY MECHANICAL	Razer Huntsman Elite	box.co.uk	#193 p59	£185

Gaming mice



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Corsair M55 RGB Pro	amazon.co.uk	#200 p24	£28
FIRST-PERSON SHOOTER	SteelSeries Rival 600	box.co.uk	#184 p59	£55
MMO	Razer Naga Trinity	scan.co.uk	#186 p52	£90
WIRELESS	Corsair Dark Core RGB Pro	amazon.co.uk	#202 p25	£90
AMBIDEXTROUS	Razer Lancehead Tournament Edition	amazon.co.uk	#177 p53	£75
ULTRA LIGHTWEIGHT	Glorious PC Gaming Race Model O	overclockers.co.uk	#195 p58	£53

Peripherals and audio cont...



Game controllers

Category	Name	Supplier	Issue	Price (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	argos.co.uk	#202 p50	£230
PREMIUM RACING WHEEL	Fanatec CSL Elite PS4 Starter Kit	fanatec.com	#202 p49	~£485
GAMEPAD	Microsoft Xbox One Wireless Controller	argos.co.uk	#191 p56	£45



Gaming headsets

Category	Name	Supplier	Issue	Price (inc VAT)
STEREO	Sennheiser GSP 300	amazon.co.uk	#194 p56	£89
SURROUND	Asus ROG Centurion	cclonline.com	#163 p49	£209
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£160

Speakers

Category	Name	Supplier	Issue	Price (inc VAT)
STEREO	Edifier R1280DB	amazon.co.uk	#192 p57	£120

Non-gaming keyboards

Category	Name	Supplier	Issue	Price (inc VAT)
WIRELESS MULTI-DEVICE	Logitech K780	ebuyer.com	#203 p58	£62
TENKEYLESS MECHANICAL	Majestouch Convertible 2 Tenkeyless	keyboardco.com	#203 p55	£140

PCs and laptops



Pre-built PC systems

Category	Name	CPU	GPU	Supplier	Issue	Price (inc VAT)
ENTRY-LEVEL RTX GAMING	PC Specialist Magma R2	AMD Ryzen 5 3600XT stock speed	Nvidia GeForce RTX 2060 Super	pcspecialist.co.uk	#205 p30	£1,324
8-CORE GAMING	Wired2Fire Predator	AMD Ryzen 7 3700X stock speed	Nvidia GeForce RTX 2060 Super	wired2fire.co.uk	#196 p40	£1,411
MID-RANGE RTX GAMING	Chillblast Fusion Ryzen 7 3800XT Gaming PC	AMD Ryzen 7 3800XT stock speed	GeForce RTX 2080 Super	chillblast.com	#206 p32	£2,349
PREMIUM MINI-ITX	Corsair One i160	Intel Core i9-9900K stock speed	Nvidia GeForce RTX 2080 Ti	corsair.com	#190 p32	£3,250
PREMIUM GAMING PC	Scan 3XS Vengeance XTi iCUE	Intel Core i9-10900K stock speed	Nvidia GeForce RTX 2080 Ti	scan.co.uk	#203 p36	£3,300
WATER-COOLED 16-CORE GAMING	CyberPower Hyper Liquid Ultra 9 RTX	AMD Ryzen 9 3950X stock speed	Nvidia GeForce RTX 2080 Ti	cyberpowersystem.co.uk	#203 p38	£3,916
THEADRIPPER PC	Chillblast Fusion Conqueror	AMD Ryzen Threadripper 3970X stock speed	Nvidia GeForce RTX 2080 Ti	chillblast.com	#199 p32	£7,000
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	2 x Nvidia GeForce RTX 2080 Ti	scan.co.uk	#145 p58	£12,964

Laptops



Category	Name	CPU	GPU	Screen	Supplier	Issue	Price (inc VAT)
THIN AND LIGHT GAMING	Asus ROG Zephyrus G14 GA401IV	AMD Ryzen 9 4900HS stock speed	Nvidia GeForce RTX 2060 Max-Q	14in 2,450 x 1,440 IPS 60Hz	overclockers.co.uk	#202 p28	£1,800
GAMING	Chillblast Phantom 17	Intel Core i7-9750H stock speed	Nvidia GeForce RTX 2070	17.3in 1,920 x 1,080 IPS 144Hz	chillblast.com	#197 p53	£1,949

Games



RICK LANE / INVERSE LOOK

A WORTHY ADVERSARY

Rick Lane explores what makes a good enemy in a game

Enemy design is one of the most complicated areas of game development. It requires the involvement of almost every studio discipline, the combined effort of artists, modellers, animators, sound designers, writers and AI programmers. Even environment designers don't get away from enemy design scot-free, because enemies need a place in which to fight and the ability to traverse that environment effectively.

This complexity, combined with the variety of enemies most games feel obliged to include, means games often get enemy design wrong. It doesn't help that the difference between good and bad enemies is often subtle. Enemies need to challenge the player without annoying them, a distinction many games often fail to make. Enemies also need to be satisfying to defeat, because there's no point in putting the player to all that trouble if the payoff isn't worth it.

While there's no right or wrong way to approach enemy design, there are certain types of enemies that are best avoided unless the designers know what they're doing. The most obvious examples are flying enemies. Being able to move in three dimensions makes flying enemies much harder to hit than terrestrial equivalents. Consequently, developers can't make them too powerful because they'll be impossible to kill. The result is always like trying to swat a housefly buzzing around your living room. It poses little threat, but it's also a nuisance that's impossible to ignore.

Indeed, bugs of all stripes tend to underwhelm in-game opponents. Whether it's giant spiders terrifying people with arachnophobia, or swarms of pixels through which you have to

hack or shoot with no skill or emotional investment, encounters with virtual bugs are either repulsive or simply hollow.

Finally, there are enemies that employ cheap tricks to damage the player, ones that are invisible, poison you or explode when they get into close range. These enemies aren't challenging to fight. Instead, they have one gimmick intended to catch you out, which is boring when it fails and only serves to make the player feel foolish when it succeeds.

Good enemies, by comparison, tend to be bipedal, roughly humanoid, and fight you directly. It's possible there are complex psychological reasons for this, but a simple explanation is that enemies capable of falling over offer an easy and satisfying

way to communicate defeat. The best enemies, meanwhile, are those that appear intelligent, as if they're making decisions and responding dynamically to a fight.

This is why Half-Life's marines, Halo's Elites, and FEAR's clones are iconic adversaries, because they feel like they're trying to outwit you, rather than simply outgunning or overpowering you. That doesn't mean every enemy has to look and behave in a human way – Alien: Isolation's Xenomorph is an 'intelligent' yet distinctly nonhuman adversary. However, enemies that are closer to humans seem to be on safer ground than others.

All of this may sound petty, but it's important to highlight what does and doesn't work in enemy design, for the sake of both developers making games and the people playing them. I'd rather have one less enemy in a game than face another giant rat, or some flying bug that spits poisonous green goo. Give me a worthy adversary, an encounter that has the potential to be surprising, dynamic and memorable. **CPC**

It's like trying to swat a housefly buzzing around your living room



5/8

SHORT / NODE 3A
Studio

Superhot: Mind Control Delete / £19.99 incVAT

DEVELOPER Superhot Team / **PUBLISHER** Superhot Team

Officially Superhot: Mind Control Delete is an expansion pack. But in practice this superb follow-up to Superhot walks, talks, and shoots like a sequel. MCD radically expands upon the Superhot's time-manipulating action, adding new weapons, new enemies, and a whole new, randomly generated structure. The result is a relentless tirade of action that will eat up your evenings more efficiently than a toddler full of sugar.

Importantly, the basic premise remains the same – time only moves when you do. The world exists in a base state of Max Payne-like slow motion, and it's only when you move that the game speeds up to normal timeflow. This gives you the ability to choreograph your own action-movie sequences on the fly, letting you pull off John Wick-like stunts without needing annoying things such as skill or talent.

MCD dedicates itself to making the most of this core idea in two ways. Firstly, it massively expands the potential of the core combat. There's a substantial roster of new weapons, ranging from assault rifles and katanas to railguns and hypodermic needles. You can kill enemies with a well-aimed pencil and throw a CD with such force, it will embed in an opponent's head. MCD also broadens the range of its orange-glass enemies, including a spiky variant that explodes into shrapnel when killed, and a terrifying dog-like creature that can't be stopped, and must be evaded for the duration of the fight.

The most significant change to MCD's combat is the introduction of special abilities. These come in two forms.

Hacks are minor upgrades ranging from simple health boosts to modifiers such as turning thrown objects into grenades. Then there are cores, more substantial powers that include a powerful charge attack and switching bodies with enemies. The best of these is the Recall core, which lets you throw your katana like a spear and then magically call it back to your hand, slicing through anything it touches on the backswing.

All of these changes are packaged into a newly structured campaign. MCD no longer has a linear story. Instead, you explore an open-ended computer maze via connected nodes. Each node comprises a randomly assorted set of combat arenas that must be progressed through without dying to complete it. If you die, you go back to the start and the levels are rearranged.

MCD flirts with repetition in ways most games would desperately try to avoid. Yet it's important to stress that, although levels repeat often (a few more arena types would not go amiss), enemies are always arranged differently, which means that no two fights are ever identical. As such, MCD becomes hypnotic, as you glide seamlessly from level to level, each one an action sequence acted and directed by you simultaneously.

MCD's only significant issue is the story. While interesting, it's too focused on being vague and aloof in a misguided attempt to seem clever. Aside from that, Superhot: Mind Control Delete is a stylish, spectacular, and utterly engrossing FPS.

RICK LANE**SUPERHOT**

- + Great core concept
- + More weapons and abilities
- + New structure rocks

SUPER-NOT

- Story could be better
- Not enough levels

/ VERDICT

Iffy story aside, Superhot: Mind Control Delete is a superb evolution over the original.

OVERALL SCORE**82%**



Death Stranding / £54.99 inc VAT

DEVELOPER Kojima Productions / **PUBLISHER** 505 Games

EXPRESS SERVICE

- + Gorgeous world
- + Deep, innovative mechanics
- + Great story generator

LOST IN THE POST

- Actual story is mediocre
- Messy menus
- Too many superfluous gadgets

Death Stranding is possibly the most indulgent game ever made, a pompous, meandering, and ridiculous experience with an overlong story, boring characters, and no ability whatsoever to retrain its own excesses. At the same time, it's one of the most interesting open-world games we've played in ages, one that thinks differently about how open worlds can be interacted with and used as a foundation for producing unique, player-driven stories.

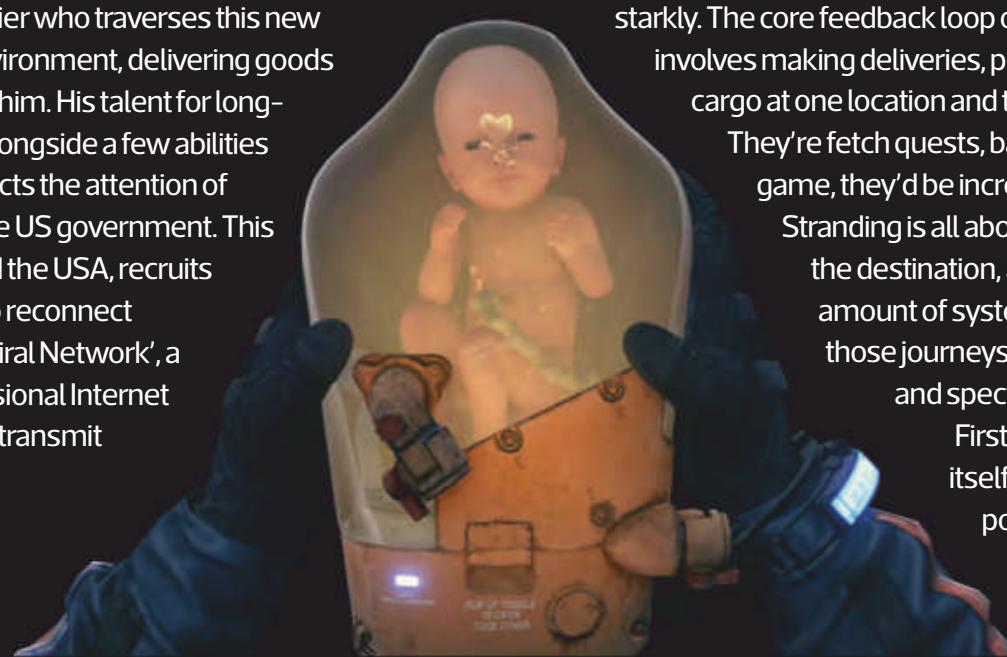
The game takes place in the United States in the near future, after an event known as the Death Stranding has rendered it unrecognisable. Only a handful of cities remain habitable, and the infrastructure that once connected them has been utterly destroyed. You play as Sam Porter Bridges, a professional courier who traverses this new and dangerous environment, delivering goods to those who need him. His talent for long-distance hauling, alongside a few abilities unique to him, attracts the attention of what remains of the US government. This organisation, called the USA, recruits him for a mission to reconnect America via the 'Chiral Network', a sort of extradimensional Internet that can be used to transmit holographic data.

If all this sounds like hot nonsense, wait until you find out about

the baby-in-a-jar who helps you to detect invisible monsters from another dimension. Death Stranding is directed by Hideo Kojima, famous for his long-running Metal Gear Solid series. But even by Kojima's standards, Death Stranding is an extremely weird game. The broader ideas are pretty interesting and unusually wholesome for a big-budget action game, all about reconnecting and rebuilding society in a way that's explored meaningfully. Unfortunately, the script is dire, with one-dimensional characters exhaustively explaining every facet of the world to you in agonisingly long cutscenes. It honestly makes you wonder how Kojima has become lauded as one of gaming's greatest storytellers.

The truth is Kojima has always been a much better game designer than a writer. Death Stranding highlights this contrast starkly. The core feedback loop of Death Stranding involves making deliveries, picking up large orders of cargo at one location and transporting it to another. They're fetch quests, basically, and in any other game, they'd be incredibly boring. But Death Stranding is all about the journey, rather than the destination, and dedicates a huge amount of systems and ideas to making those journeys engaging, dramatic, and spectacular.

First off, there's the landscape itself. Death Stranding's post-apocalyptic vision of America is based on hyper-detailed photogrammetric





captures of Iceland. It's a landscape of intense relief, all volcanic mountainsides and glacial scree. Simply walking across this terrain is a treacherous business. The game simulates Sam's balance, so moving fast down a slope or over rocky terrain will cause him to stumble. Fail to correct your balance and you'll fall over, damaging both yourself and any cargo you might be carrying.

At its core, Death Stranding is a hiking simulator, and an engrossing one at that. You need to plot your routes carefully, looking at the satellite map and figuring out how to navigate around impossibly steep cliffs, ravines, and fast-flowing rivers that can sweep you away. As well as being an absolutely stunning place to inhabit, the world is also one giant, natural puzzle.

And this is merely the tip of Death Stranding's systemic iceberg. The game isn't simply about getting from A to B, it's about establishing pathways that can be used over and over again. What's more, these pathways aren't purely for yourself. You also make them for other players.

There are a couple of layers to this. Firstly, Death Stranding gradually makes exploration and traversal easier through new gadgets and equipment. These start off small, with items such as climbing ropes and extendable ladders. These let you abseil down cliffs, and create makeshift bridges across ravines and rivers. Later on, you unlock a 'PCC', a nanobot assembly kit that lets you construct more elaborate structures such as arched bridges and ziplines. You can even construct roads, and travel using vehicles such as bikes and delivery vans, although roadbuilding takes quite a long time, requiring a heavy investment of resources.



This is where the multiplayer component of Death Stranding comes in. Despite appearances, you're not alone in Death Stranding's world. While you'll never see other players in your game directly, many of their structures will appear in your world, while your structures can appear in theirs. This lends a wonderful sense of cooperation to the experience. You'll struggle halfway up a hillside to discover a climbing rope planted by someone else, making the rest of the ascent easier. Or you might stumble across a half-finished road-paving project, and decide to add the remaining resources to complete that segment both for yourself and everyone else.

As you become more proficient at navigation, so too Death Stranding makes the world more hazardous. Certain sectors of the map are patrolled by MULES – cargo-obsessed bandits who chase you with electrified spears and attempt to strip your gear from your back. A bigger threat still is the rain. One of Death Stranding's quirkiest ideas is that it doesn't rain water, it rains time. With the exception of Sam's clothing, these droplets age any surface that they touch, causing plants to grow and wither, skin to age, and cargo to rust.

As if that wasn't bad enough, timefall also heralds the arrival of Death Stranding's most dangerous adversaries – BTs. These are extradimensional ghosts that are invisible unless you stand right next to them. If you get caught by a BT, you're in for a spectacular and terrifying fight for survival. Hence, navigating through a BT-infested area is Death Stranding at its most tense, as you watch the angle of your special Odalrek scanner to pinpoint the creatures' approximate locations, weaving around them while the persistent rain threatens to ruin your cargo.

In this way, each mission you take on becomes its own miniature adventure story, whether it's the time you crashed your bike into a ravine and had to climb out, or the time you were swept downstream by a river into a BT-infested area. It isn't a perfect experience, menus are overwrought, and of all the gadgets that become available to you, you'll probably only use half of them on a regular basis. Yet none of that changes the fact that, from a mechanical point of view, Death Stranding is exceptionally well designed.

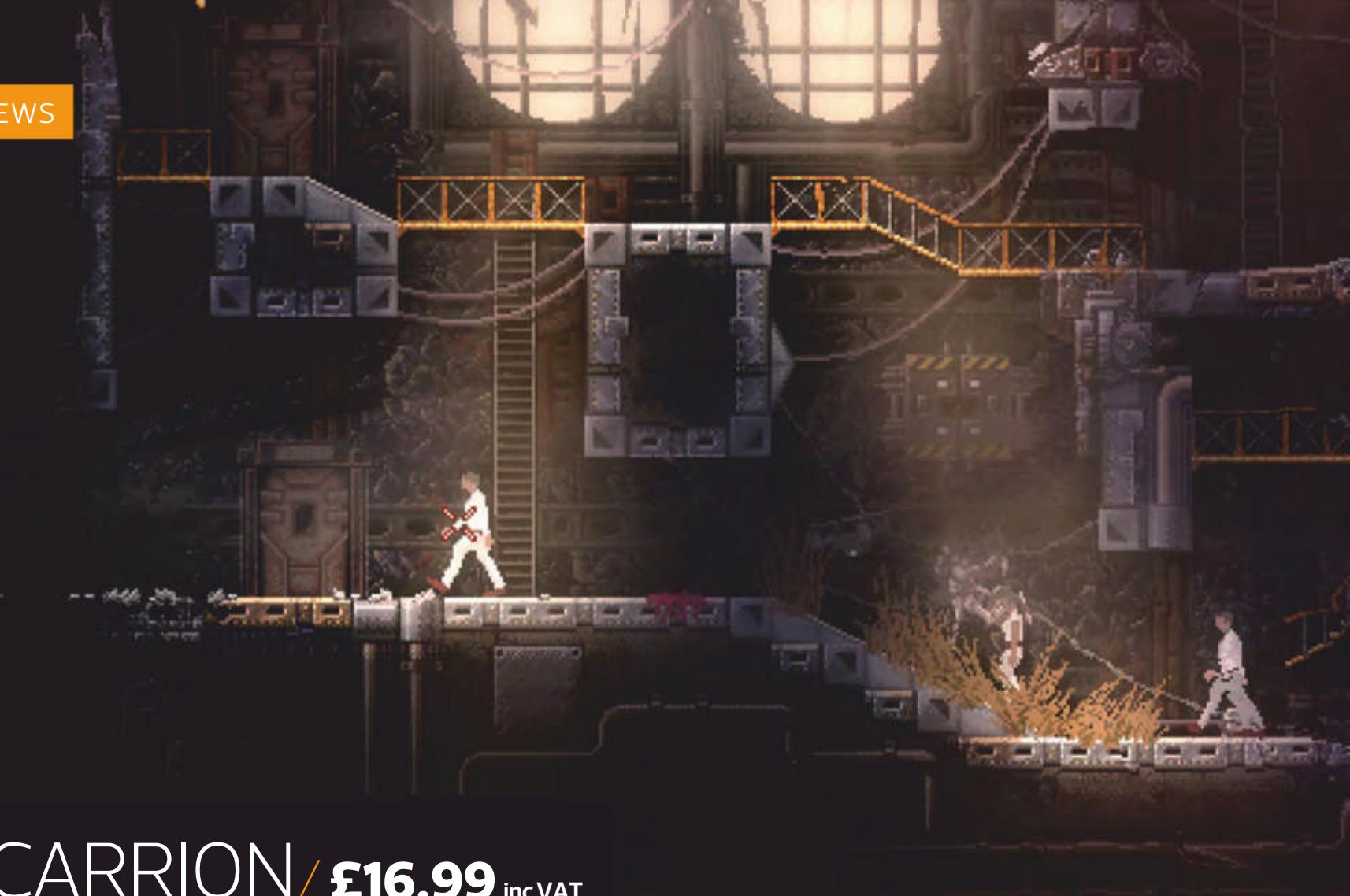
It's unfortunate that Death Stranding's compelling exploration is often buried beneath Kojima's middling cinematic aspirations. Despite hiring some of the best actors and directors in the world (one character is played by Pan's Labyrinth director Guillermo del Toro), there's only so much they can do with Kojima's plodding script. Nonetheless, the personal stories generated by Death Stranding's deep and lovingly crafted systems make it worth putting up with the game's less likeable indulgences.

RICK LANE

/ VERDICT
Death Stranding's narrative is tedious and overlong, but its opportunities for player-driven storytelling are original and engrossing.

OVERALL SCORE

80%



CARRION / £16.99 inc VAT

DEVELOPER Phobia Game Studio / **PUBLISHER** Devolver Digital

CARRION

- + Monster looks (horribly) great
- + Movement is fantastic
- + Tactical element to combat is interesting

CARRY ON

- Combat areas too small
- Limited abilities
- Oddly human puzzling

/ VERDICT

Carrion captures the splattery vibe of 1980s monster movies, but cramped combat areas and limited abilities result in a slightly squandered premise.

OVERALL SCORE

65%

Heavily inspired by films such as *The Blob* and John Carpenter's *The Thing*, Carrion is a 'reverse-horror-experience' that puts you in control of a monster and challenges you with escaping from a secretive, subterranean research complex. Short, sharp, and stupendously violent, it's an entertaining premise delivered with grisly style, although it doesn't dig into its concept as much as we would like.

By far the biggest draw of Carrion is the monster itself, a nameless, formless mound of meat and teeth that terrifies despite the fact you control it. While not a true shapeshifter like Carpenter's *Thing*, Carrion's creature is constantly in a state of physical flux. You start out as little more than mouth with a bit of muscle attached, but after chowing down on a couple of scientists, you'll quickly grow in both size and power, gaining new abilities at each key stage of growth.

Although Carrion's monster certainly looks the part, what really makes it frightening is the speed of its movement. Controlled like a mouse cursor, Carrion's monster propels itself through caverns and ventilation ducts like a fleshy missile, firing out sticky tendrils at all angles to support its seething central biomass. Yet while powerful and

intimidating, Carrion's monster is something of a glass cannon. A few shots from a pistol will quickly whittle your health down, so you must be cautious when approaching human encounters. You can squeeze through ventilation shafts to ambush enemies from behind, or grab and throw objects to stun opponents before killing them.

This tactical underlayer to Carrion is probably the most interesting aspect of its play. Unfortunately, it's also underbaked. Most areas you explore are cramped, so there's usually only one 'correct' strategy for dealing with enemies. Your combat abilities are also limited. Aside from eating and grabbing things, you can spit a sticky web that traps your prey and slam opponents with your massive bulk. Eventually you unlock the ability to control enemy minds, but this power comes late in the game and doesn't get the airtime it deserves.

Outside of combat, Carrion is a simple, Metroid-style puzzler. Again, its functionally sound. The navigational puzzles are well constructed, with many requiring you to be the right 'size', so you can utilise the appropriate abilities that come with that specific form. But there's something distinctly off about this unimaginable horror spending so much time finding different ways to flip switches. It's like waking up to find Alien's Xenomorph in your house, only it's stooped over your kitchen counter trying to use the espresso machine.

This, ultimately, is Carrion's key flaw. It puts you in the role of the monster, but mechanically the game retains a very human perspective. Gulping down scientists and tearing guards to shreds is gruesomely entertaining, but while you'll often act like a monster in Carrion, you'll rarely find yourself thinking like one.

RICK LANE





CREAKS / £17.99 inc VAT

DEVELOPER Amanita Design / PUBLISHER Amanita Design



Czech studio Amanita Design is one of the most consistently brilliant indie developers around. From its atmospheric point-and-clickers, Samorost and Machinarium, to madcap comedies such as Botanicula and Chuchel, Amanita's games are always strange, surprising and joyous experiences. With the spooky puzzler Creaks, Amanita upholds this reputation, delivering one of its most ambitious and accomplished games yet.

Creaks puts you in control of a charmingly nervous fellow who is simply trying to read his favourite book when his bedroom light begins to flicker. Investigating the problem, he discovers a secret tunnel built into his wall leading to a vast underground city, a city under threat of destruction from a gigantic monster.

Creaks' audio and visual design is spellbinding. The world sports Tim-Burton-like aesthetics – teetering gothic architecture that's all crooked angles and cluttered rooms. Like much of Burton's work, the tone walks a line between comedy and horror. Levity is provided by a tribe of affable bird-people who you come to know throughout the game, while the horror element derives from the bizarre creatures lurking within the city.



These creatures are also the keystone of Creaks' puzzling. See, all of Creaks' monsters are actually inanimate objects, transmogrified into living beings in the subterranean gloom of Creaks' rickety metropolis. In the absence of light, a chest of drawers turns into a squat, bulldog-like creature, while a coat stand morphs into a skittering tree-person that cackles menacingly. Each of these creatures has a unique movement pattern that forms the foundation of every puzzle. The dogs, for example, will chase you if you get too close, while the tree-people copy your own movements.

Taking advantage of these movement patterns is crucial to solving Creaks' puzzles. For example, you might get a dog to chase you beneath a lamp, then switch that lamp on, turning the dog back into a chest of drawers that can be stood on to access a ladder. Puzzles often involve several different creatures at once. A dog will only chase you if there's a clear path between you and it. If you can get a tree-person to stand in front of you then the dog will leave you alone.

Aside from a couple of finicky late-game puzzles, Creaks' conundrums are beautifully balanced. One of the game's smartest ideas is to bake dynamic audio cues into the soundtrack that play whenever you complete a segment of a puzzle, which gradually layer up to form a full melody. It's a superb way to communicate to the player that they're on the right track, alleviating much of the frustration that comes with getting stuck on a puzzle game.

Creaks' gothic fairytale could have delved deeper into the core theme of materialism, and the problems acquiring too much stuff can create. Yet despite being lightweight, it's never less than entertaining. Combined with superb art, wonderful music and perfectly pitched puzzling, Creaks is another splendidly bizarre creation from Amanita Design.

RICK LANE

CREAKS

- + Fantastic art
- + Even better audio
- + Clever, neatly balanced puzzles

CRACKS

- Story is overly simple
- Some later puzzles can frustrate

/ VERDICT

Beautiful, clever, and wonderfully strange, Creaks is a delight from start to finish.

OVERALL SCORE

90%

REALITY CHECK

Rick Lane explores the latest in VR games, including the new Microsoft Flight Simulator and yet more Star Wars VR content



NEWS

STAR WARS: TALES FROM THE GALAXY'S EDGE

Between Vader Immortal and Star Wars: Squadrons, Disney and LucasFilm have been pumping out the VR Star Wars experiences lately. Now there's another name to add to the growing pile – Star Wars: Tales from the Galaxy's Edge.

Tales from the Galaxy's Edge is a slightly unusual premise. Developed by ILMxLAB (the creators of Vader Immortal), it's a new story experience that's based on Galaxy's Edge – the theme park worlds at Disney's resorts in California and Florida. Specifically, the game takes place on the planet of Batuu, centring around a location known as the Black Spire Outpost, between the events of The Last Jedi and the Rise of Skywalker.

While the specifics of the experience remain largely under wraps (the game is still very early in development), what's clear is



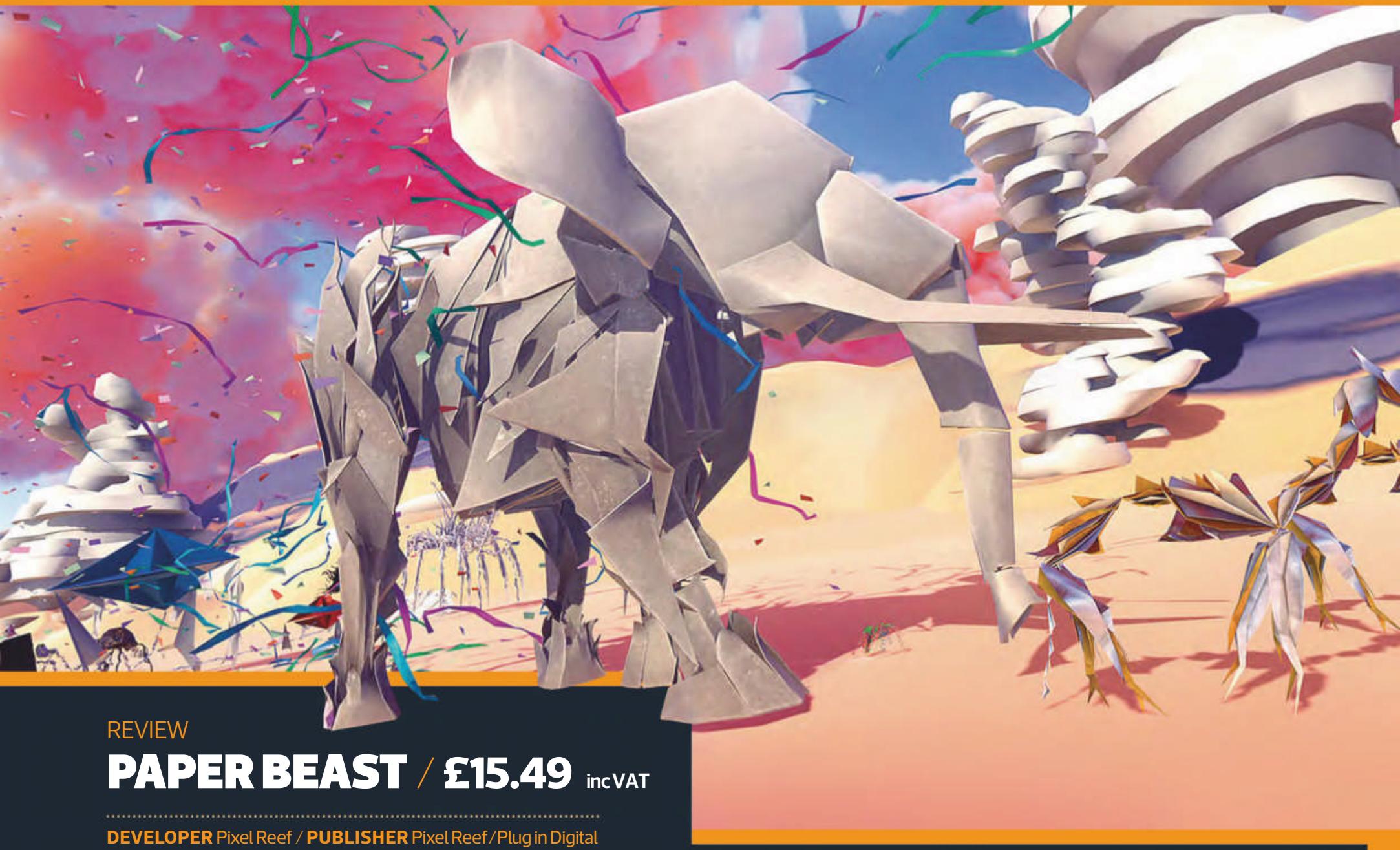
NEWS

MICROSOFT FLIGHT SIMULATOR

It's been over ten years since Microsoft published a new Flight Simulator, and even longer since it released a good version. But if it plays anything like it looks, the reboot of the venerable series could be the best version ever. Microsoft Flight Simulator uses a combination of real-world satellite data (updated in real time via your Internet connection) and advanced AI algorithms to recreate a stunningly accurate version of the entire globe. It's so detailed that you can fly among weather patterns based upon current real-world meteorology, and in some major cities, fly over your own house.

Flight Simulator is a natural home for VR, perhaps more so than any other game. So it isn't surprising to hear that the new version will offer support for VR headsets. What is surprising, however, is how that support will be offered. VR support won't be available on launch; instead, a VR update is loosely scheduled for 'autumn' this year. Moreover, initially the game will only support the HP Reverb G2, an upcoming headset co-developed between HP, Microsoft and Valve. Support for 'other headsets' will follow, although Microsoft has yet to announce which.

It's a shame that Flight Simulator's VR mode will be initially restricted by ownership of a fairly oblique (albeit admittedly powerful) VR headset. Let's hope broader support isn't too far away, as Flight Sim looks likely to be a heck of a VR experience.



REVIEW

PAPER BEAST / £15.49 inc VAT

DEVELOPER Pixel Reef / PUBLISHER Pixel Reef/Plug in Digital

Paper Beast is the most unusual VR game we've encountered yet, an interactive wildlife simulation that's evenly split between god-game and 3D puzzler. It's fascinating, extremely weird, and surprisingly emotional, although the way it's structured makes it feel like two separate halves of a more complete experience.

Paper Beast's core mechanics revolve around its origami animals. From ribbon-backed porcupines and spindly horses to a bizarre cross between a giraffe and a table, Paper Beast's animals are as strange as they are lovable. But there's more to these creatures than their curious looks.

Each beast has its own unique set of AI behaviours that enable it to interact with the world around it. There are insectoid animals that roll up sand like dung-beetles, herbivores that eat crumpled bits of paper and predatory creatures that hunt other animals.

How you interact with these creatures depends on which mode you're playing. The story mode is a linear sequence of puzzle vignettes that all involve helping different beasts to get from one location to another.

Sometimes you need to manipulate their behaviour, such as picking up a beast's favourite snack to guide it across hazardous terrain. Other times, it involves altering the

terrain itself, sculpting sand bridges so that animals can navigate a fast-flowing river, or using a paper chain to attach lightweight animals to heavier creatures, so they don't blow away in the wind.

Paper Beast's story is supposedly about mass data collection, although it's so vague and ambiguous that you'd be forgiven for not noticing. Regardless, Paper Beast has a powerful sense of mood. Watching its various animals struggle against the elements and predators is surprisingly moving. There are moments of celebration, such as colourful animal parades, and moments of tragedy, witnessed in one creature's attempt to cross an arid desert.

Well crafted though it is, Paper Beast's story mode nonetheless feels constrained. The way you can interact with both the animals in the environment is fascinating, but it all takes place in small environmental boxes that only offer a handful of mechanics at any one time. This is where Sandbox mode comes into play. Here, you're given a square of desert that you can shape however you like. You can sculpt the landscape, populate it with animals, and even trigger different kinds of storms.

Sandbox mode demonstrates just how intricate Paper Beast's simulation is. You'll see plant life spread naturally across the

landscape, watch the interplay between herbivores and carnivores, and see how each animal reacts to different weather conditions. It's incredible to watch, but it's also little more than an elaborate tech demo. There's no real objective or overarching structure. It's just an opportunity to play with the tools.

There's a sense that a bigger experience was planned here, a dedicated god-game that for some reason was split down the middle. Both function well enough. The story is interesting and the sandbox fun to mess with. But each side also feels like it would be better if it could somehow integrate the other half. All that said, if you're after a VR experience that's different from the usual fare, Paper Beast is certainly that. **CPC**

PAPER BEAST

- + Great concept
- + Interesting systems
- + Enjoyable puzzles

REGULAR BEAST

- Feels like two halves of a better game

VERDICT

Paper Beast's origami animals are as captivating as they are unusual, but the way the game is structured limits the overall potential.

OVERALL SCORE

70%

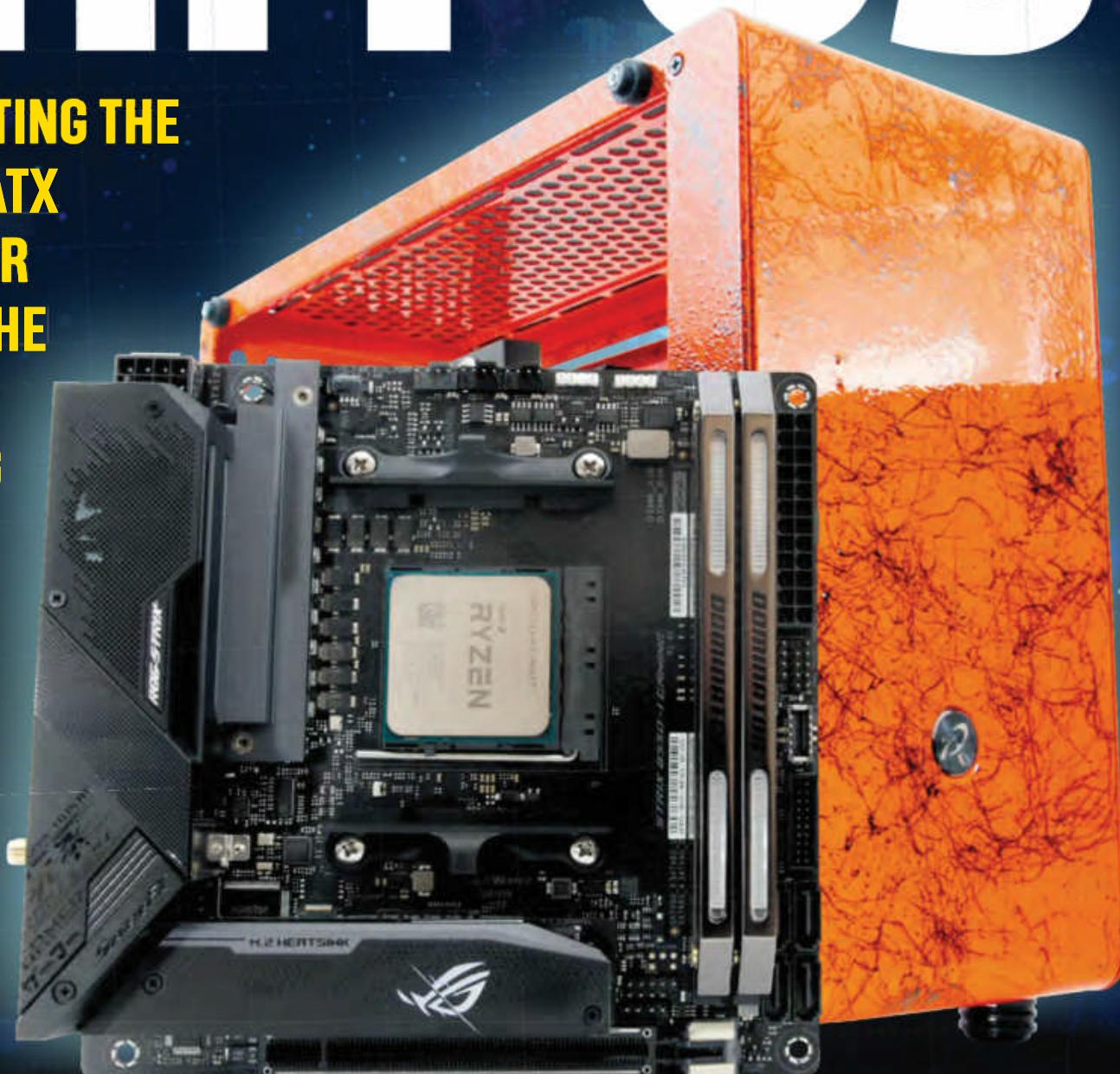
THE COMPLETE GUIDE TO MINI PCS

FEEL LIKE YOU'RE WASTING THE SPACE IN YOUR GIANT ATX CASE? ANTONY LEATHER TAKES YOU THROUGH THE VARIOUS HARDWARE OPTIONS FOR BUILDING A SMALL AND POWERFUL MINI PC

If your only PCI-E card is a graphics card, and you only have a smattering of storage drives, have you ever considered downsizing? It's not a question many have asked, and most of us carry on using space-wasting, desk-hogging ATX systems, even though you can build PCs that are just as powerful and quiet, but take up a fraction of the space.

The amount of desktop real estate you can claw back with a mini-ITX system can be considerable, and it will be much more portable too. There are plenty of affordable ways to go about building a PC pocket rocket and plenty of exciting hardware choices too. In fact, mini-ITX cases and motherboards are even more varied than other form factors, making choosing your hardware fun – manufacturers take very different approaches to solving the hurdles of small form factor PCs.

Mini systems can also be water-cooled and modded. In fact, water cooling really comes



into its own with small PCs, as you need to deal with heat in small places. It can be easier to mod small systems than large ones too. You need less space to work on them, they require fewer materials such as paint or vinyl to cover the panels, and adding a side window or radiator blowhole is easier too, because everything is smaller.

However, cramming high-end hardware into a tiny case doesn't come without its

problems. Cable tidying can be a challenge, and both cooling and noise can pose sizeable obstacles that, if left unchecked, can result in a PC that runs hot and makes an unpleasant sound. In worst-case scenarios, it could even overheat and become unstable. This feature is designed to help you overcome all these issues, so you can build an efficient, powerful mini PC that packs a punch and is just as powerful and quiet as an ATX equivalent.



From left to right: ATX, micro-ATX and mini-ITX

WHAT IS MINI-ITX?

If you're not familiar with mini-ITX or motherboard form factors, then the first thing you need to know is that motherboards aren't all the same size. There are four common sizes when it comes to PCs, and some cases are limited to specific sizes. This feature is all about mini-ITX, which is the smallest size that's commonly available.

Mini-ITX motherboards measure 170 x 170mm, so they're considerably smaller than typical ATX motherboards, which measure 305 x 244mm. This small size allows case manufacturers to reduce the size of cases, shrinking them to fit and even juggling different designs in a way that's just not possible with ATX motherboards. So, while mini-ITX is just a motherboard form factor, the name is also synonymous with cases limited to this size, as well as graphics cards and CPU coolers specifically designed for these types of systems.

BENEFITS AND DRAWBACKS

The ability to build a supremely small PC while still using high-end hardware is the main attraction of mini-ITX. The space savings will mean your PC is more portable – great for LAN parties or travelling to and from university, and you'll gain more desk or floor space, which is a real boon if you have a small room or desk.

You can use top components too, including a Core i9-10900K or Ryzen 9 3950X CPU, along with a GeForce RTX 2080 Ti graphics card, and get similar

temperatures and identical performance to what you'd see on a desktop PC. You can water-cool your hardware too. Multiple 420mm radiators and a dozen slow-spinning fans might not be on the cards, but you can build a PC that will eat many ATX systems for breakfast.

Small PCs do come with drawbacks though. As well as being trickier to build and keep tidy, your motherboard will have fewer ports and, apart from one or two exceptions, you'll only get two memory slots. You'll be limited to one PCI-E card too, so if you're planning on using a graphics card, you won't be able to use a PCI-E sound or network card.

On-board overclocking and testing tools, such as power and reset buttons, are rare too, as are more than four SATA ports. Some boards only have three audio outputs due to space constraints as well, so hooking up 8-channel speakers can be a challenge. You'll also have less airflow to help cool your hardware, and most mini-ITX cases have severely restricted clearance for tall CPU coolers or long graphics cards.

THE BEST MINI-ITX CASE FOR YOU

Unlike ATX cases, choosing a mini-ITX case isn't just a question of looking at cooling and features. There are far more considerations, such as whether it uses small SFX PSUs, hardware clearances and the actual layout and design of the case itself. We'll talk about



THE ASUS CROSSHAIR VIII IMPACT

Asus' Crosshair VIII Impact is a rare alternative to mini-ITX boards in the miniPC space. It's supported by many mini-ITX cases, but it's actually a mini-DTX motherboard, which is slightly longer, measuring 170 x 203mm instead of 170 x 170mm. As a result, there are numerous mini-ITX cases available that don't have the space for it, so double-check your chosen case's motherboard support before buying this board.



Mini-ITX motherboards have fewer PCI-E slots, memory slots and SATA ports than most larger motherboards

PSUs and hardware later on, but this section is all about the cases and their differences.

Mini-ITX cases have existed for decades, but they've only recently been focused on enthusiasts wanting to use hefty cooling systems and discrete graphics cards. Since then, a few case designs have carved out niches for themselves, and each has its benefits and drawbacks. This isn't an exhaustive list, and there are plenty of other weird and wonderful designs out there, but this section covers the majority of them.

TRADITIONAL TOWERS

Mini-ITX tower cases are essentially miniaturised versions of ATX towers, with similar layouts and features. As their design doesn't generally require the manufacturer to invest in loads of extra research and development time, they're often some of the more affordable mini-ITX options.

These cases usually offer excellent water-cooling support, easy cable tidying and great storage options as a result. The downside is that they're quite inefficient in terms of making the most of the small motherboards housed inside them, or indeed other space-saving components such as SFX PSUs. They offer an easy way into the world of small form factor PCs, though, and they still save valuable desk or floor space.

CUBES

There have been a number of cube case designs over the years, and most of them focus on keeping height and volume to a minimum, while still maintaining good support for storage and liquid cooling. They're often very reasonably-priced too but, as with most small cases, they have compromises.

If you want to use an air cooler, they're usually extremely restricted in terms of height limits, for example.

The PSU can often sit above the motherboard in these cases too, which not only makes cable tidying difficult, but in some circumstances, also means the PSU will compete for air with the CPU cooler. General cable-tidying features are often non-existent in these cases too, as there's no traditional motherboard



NZXT's H200 is an example of a tower mini-ITX case

WHILE MINI-ITX IS JUST A MOTHERBOARD FORM FACTOR, THE NAME IS ALSO SYNONYMOUS WITH CASES LIMITED TO THIS SIZE

tray behind which you can route the cables. This layout also means you often don't get a great view of your hardware through any windowed panels.

The NZXT H1's footprint is barely any bigger than a mini-ITX board itself, but its cooling and hardware support are limited

ULTRA-LOW FOOTPRINT

SilverStone's FT03 Mini set the scene for this class of cases a while ago, with a compact tower design and a super-low footprint that beat many cube designs in terms of features. Later, the likes of the NZXT H1 and Phanteks Shift took this approach even further, with footprints barely bigger than a mini-ITX motherboard itself.

If desk space is at a premium, and you want to focus on reducing how much room your PC requires, these cases are your best bet, and they're also eye-catching and distinctive. You'll need to be aware of several issues though.



Fractal Design's Core 500 is compact and short, but its width enables it to house large graphics cards and liquid-cooling hardware



Firstly, water-cooling support can be non-existent in these cases without extensive modding, or at the very least, you'll be limited to single-fan all-in-one liquid coolers. Just like cube cases, the proximity of the case panels to the motherboard means there's limited scope for using CPU air coolers too. Most of these cases are also extremely limited when it comes to housing hard disks but, due to their height, they do at least offer support for high-end graphics cards.

DUAL-CHAMBER

With the motherboard situated on one side of the case, the graphics card on the other, and often using a small PSU, dual-chamber cases have sprung up as a popular new mini-ITX chassis design, in part thanks to their supremely small size and decent GPU cooling; they often have room for liquid cooling too. They're frequently quite expensive, and some models fetch upwards of £200. However, given their niche, low-volume nature, use of premium materials such as aluminium, as well as the need to include a PCI-E riser cable, we can forgive this pricing to some extent.

As usual, clearance for tall CPU coolers isn't great, and cable-tidying features are nearly non-existent. These cases are also best used with some form of liquid cooling and, if possible, with short PSU cables too.



Cases such as Kolink's Rocket split the interior in two, and position the graphics card back to back with the motherboard to save space



Dual-chamber cases use a PCI-E riser cable to connect the motherboard to the graphics card

GPU cooling is often reasonable if a vented side panel is used. However, beware of cases that use glass or unvented metal panels if you're using an air-cooled graphics card, as cooling can be severely hampered due to the close proximity of the card's cooling fans to the side panel.

CHIPSET CHOICES

When it comes to choosing between AMD and Intel, the situation changed dramatically with the launch of AMD's X570 chipset last year. Finally, motherboard manufacturers saw fit to offer high-end mini-ITX boards for an AMD chipset, and we even saw the resurrection of the Impact range from Asus, albeit in the slightly longer mini-DTX format, although it's still compatible with many mini-ITX cases.

There were also some excellent mini-ITX offerings for AMD's previous X470 chipset, but prior to this, Intel was your only realistic option.

There's no mini-ITX option for AMD's fabulous Threadripper CPUs. In fact, there's not even a micro-ATX option for TRX40 CPUs. This leaves us with just four chipsets from which to choose, and your options mainly come down to your choice of CPU.

With Intel, assuming we're talking overclockable options, you have its Z490 chipset for LGA1200 CPUs and the X299 chipset for LGA2066 CPUs. The former has options from most major manufacturers, so there's plenty of choice, and such a system makes an excellent choice for a compact gaming PC with a CPU such as the Core i5-10600K.

Intel's high-end desktop (HEDT) X299 chipset, though, has just one option, which is the ASRock X299E-ITX/ac. It's become quite tricky to find, and it's also expensive, but Bitspower still offers funky full-cover water blocks for it. This board also has the advantage of offering more ports and PCI-E lanes, as well as memory channels, than any other mini-ITX board, although it does lack the PCI-E 4 support of AMD's X570 and B550 chipsets.

However, if you want to build the most powerful mini-ITX system possible, this ASRock board is the way to go. The Core i9-10980XE and Core i9-10940X CPUs it supports are both overclockable, and make for superb gaming and content creation CPUs once they're overclocked. The downside, of course, is their price, and they offer far lower value for money than AMD's Ryzen 9 3950X.

With the ASRock board, you'll also need to factor quad-channel SODIMMs into your budget, which can be expensive. There's not much room around the CPU socket for a wide cooler either. It's a board with extremely niche appeal, but it's still the only option if you want to build the most powerful mini-ITX PC possible.

Each mini-ITX platform has its pros and cons, but there's currently a great choice of mini-ITX boards for both AMD and Intel systems



ASRock's X299E-ITX/ac is the only enthusiast mini-ITX board that can house a high-end desktop CPU. It even supports quad-channel memory

With AMD, you have the choice of the X570 and B550 chipsets, with very little difference between the two where mini-ITX is concerned. Both chipsets support PCI-E 4, meaning you can push the latest supporting NVMe SSDs to their limit. In terms of layout, B550 mini-ITX boards are often identical to the equivalent X570 boards made by the same manufacturer.

The main difference between the two chipsets is the bandwidth available for multiple PCI-E 4 devices, so if you plan on using multiple PCI-E 4 M.2 SSDs, X570 is your best bet. Otherwise, B550 boards can save you some money, but check the feature set to see if there are any other differences between your chosen board and its X570 equivalent.

AMD has some fantastic CPUs too, and the 16-core Ryzen 9 3950X makes for a supremely powerful option for a mini-ITX PC, plus it's much easier to cool and overclock than Intel's HEDT options. It's also worth considering older B450 and X470 mini-ITX options, especially the latter. They might not support PCI-E 4 SSDs, but they're much cheaper and more than capable of handling AMD's 3rd-gen Ryzen CPUs.

WHICH GRAPHICS CARD?

If your main priority is gaming then the graphics card should be your main component choice, but bear in mind that your choice of graphics card will impact on your choice of cases too. Using an air-cooled graphics card can pose problems from an airflow point of view in some cases, where the cooler faces an unvented side panel, and there's generally less air available in smaller cases than larger ones, plus fewer fans working pushing air across the chassis.

Short cards in both air and water-cooled flavours are available for numerous Nvidia and AMD GPUs



For this reason, using an air-cooled graphics card with a large cooler is a good idea, as it will mean your card is more self-sufficient at cooling itself. Restrictions you might encounter are length and depth, depending on your case, but not all GPUs use the same PCB, so you have some options here. For example, there are short-PCB cards with many GPUs, so if your dream case has tight graphics card clearance in terms of length, a card such as the Asus GeForce RTX 2070 Dual Mini may well do the job, as it only measures 200mm long.

Water-cooling your graphics card can also be a great way to shave inches off your card's length (and width for that matter), and manufacturers such as Zotac have even offered extra-short PCB water-cooled cards for this reason.

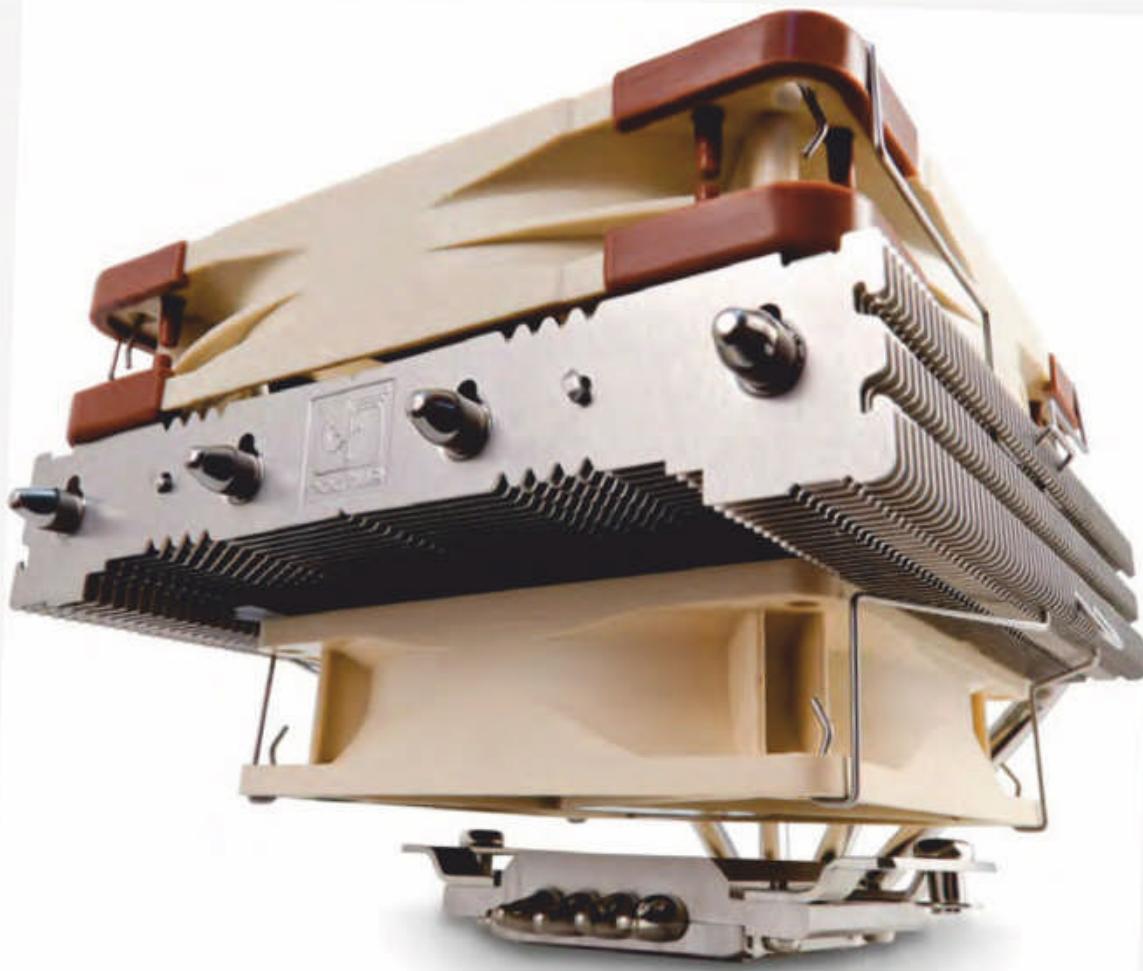
One word of warning if you're thinking of opting for any of AMD's PCI-E 4 graphics cards and an X570 or B550 motherboard, though, is that some riser cables don't support PCI-E 4. If you combine a motherboard and graphics card with the new PCI-E standard, but use a PCI-E 3 riser cable, your system will go haywire.

However, there are two ways around this problem. Firstly, you can switch the 16x PCI-E slot to PCI-E 3 mode in your motherboard's BIOS. This will have a negligible impact on game performance and will solve the problem. Alternatively, if you must have PCI-E 4 support, then PCI-E 4 riser cables have started to appear online, but they're very rare and you'll likely have to buy one from overseas.

AIR COOLING

As with graphics cards, bigger is better when it comes to your CPU cooler and mini-ITX PCs. This will mean it's less reliant on your case's cooling, which can often be limited compared with a big ATX case with more volume and twice the number of fans. Many mini-ITX cases are limited to low-profile coolers, but there are plenty of meaty options here, such as the Noctua NH-L12 (pictured), and you should aim to get the biggest cooler your case and wallet can manage.

Use the biggest cooler you can fit in your case, such as this Noctua NH-L12, as most mini-ITX cases run hotter than larger, better-ventilated cases



Doing so will mean your PC runs cooler and quieter. It's always important to remember that, typically, mini-ITX PCs can run warmer than their larger siblings, which can lead to higher noise levels, so it's important to minimise this noise (and heat) by maximising your component cooling. If your case supports tower CPU coolers, then again, get the most powerful model possible, even if it looks out of place and is maybe pricier than one you would buy for a larger PC.

IT'S HARD TO GET RID OF ANY WARM AIR SPILLING BACK INTO YOUR CASE FROM YOUR GRAPHICS CARD OR CPU COOLER

WATER COOLING

The main issue when using air-cooled components in a mini-ITX PC is that it's hard to get rid of any warm air spilling back into your case from your graphics card or CPU cooler, simply because there are fewer fans than you'll get in a large PC, and space is more confined too. However, this is one area that water cooling comes into its own.

Rather than dumping hot air back into the PC and relying on often modest airflow, water-cooling radiators can be placed in the

An all-in-one liquid cooler, or a custom water-cooling loop, can help get the heat out of small cases quickly and efficiently

exhaust fan mounts of your case, expelling any heat gathered from your CPU and GPU straight out of your case. This kind of efficient cooling can be very beneficial to mini-ITX cases, so using an all-in-one liquid cooler or a custom water-cooling loop will help your system cope with high-end overclocked hardware in small cases.

You don't have to avoid high-end features such as rigid tubing either, although dealing with it will obviously be much harder (and very fiddly) in the tight confines of a



Compact combined pump/reservoir units can help you squeeze custom water-cooling systems into mini-ITX cases



Extra-slim radiators and fans can make all the difference when you're trying to fit water-cooling systems into small cases

WATER-COOLING TIPS

There's now a huge range of water-cooling hardware available, and it's usually possible to water-cool even the smallest mini-

ITX PC. Water cooling always adds work when it comes to maintenance and troubleshooting, making it more time-consuming, and this is compounded with mini-ITX cases, as some systems will need to be completely stripped down. However, the benefits still far outweigh the drawbacks here, and water-cooling systems can be even more beneficial with mini-ITX PCs than in larger systems.

ITX cases. Combined pump/reservoir units are excellent here, and some recent additions from manufacturers such as EK Waterblocks, Corsair and Phanteks combine compact reservoirs with powerful pumps that are perfect for squeezing into tight spaces.

In extreme situations, you can also consider Alphacool's GPX cooling systems, which combine a pump with a GPU waterblock. Also, if you pre-fill your loop with coolant, it's possible to do without a reservoir entirely, saving even more space. If your case doesn't have room for thin radiators, which are typically around 30mm thick, then there are still ways to water-cool your PC.

XSPC offers a super-slim range of TX radiators, for example, which measure just 20mm thick, so you can often install them in places not designed for usual radiators. The fact that they're thinner doesn't always mean they offer poor cooling capacity either.

They sport 22 fins per inch, and the core itself has a similar size to those in normal radiators. Thinner radiators also have



less airflow restriction than their larger counterparts, meaning they're easier to get working efficiently at lower fan speeds.

In addition, we can highly recommend Noctua's NF-A12x15 fans. Like the XSPC radiators, these fans are thinner than your typical 120mm fan, being just 15mm thick, rather than 25mm. As a result, you can fit them to XSPC's TX radiators and they take up little more space than a standard 30mm radiator with no fans.

MOST SFX PSUs COME WITH BRACKETS, SO YOU CAN THEM INSTALL IN ATX PSU MOUNTS AND FREE UP SOME SPACE

Again, such a setup may well make the difference between being able to water-cool your mini-ITX PC and having to stick with air cooling, or it might enable you expand your cooling system with additional radiators or another row of fans. Just like air coolers, aim to add as many radiators as possible in your mini-ITX system.

MEMORY CHOICES

Usually, your choice of memory is the same as for an ATX system, but once again, your choice of case might impact on the size of modules you can use. For example, NZXT's

It's worth checking if tall memory will interfere with your CPU cooler, and some cases even have memory height limits too

H1 mini-ITX case has a memory height limit of just 45mm, which restricts you to very short modules. Thankfully, your motherboard will be hidden within the depths of this case, so memory isn't going to impact on aesthetics.

WHAT IS AN SFX PSU?

ATX-size PSUs are by far the most popular ones used in PCs, but smaller PSUs have existed for a while, usually

SFX PSUs are slimmer and narrower than ATX PSUs



Cases such as Fractal Design's Era ITX support both SFX and ATX PSUs, but using the former means there's space for liquid cooling

with loud, tiny fans and limited power ratings. There's been a lot of change on that front in the past couple of years though. SFX PSUs are smaller in all dimensions than ATX models, enabling manufacturers to reduce their cases' dimensions or offer more room for other components such as radiators.

While SFX PSUs initially had quite limited power ratings, they can now reach 800W, and are therefore able to power any system you could feasibly install into a mini-ITX case. Meanwhile, the slightly longer SFX-L PSUs have recently hit 1000W and often come with larger, quieter fans.

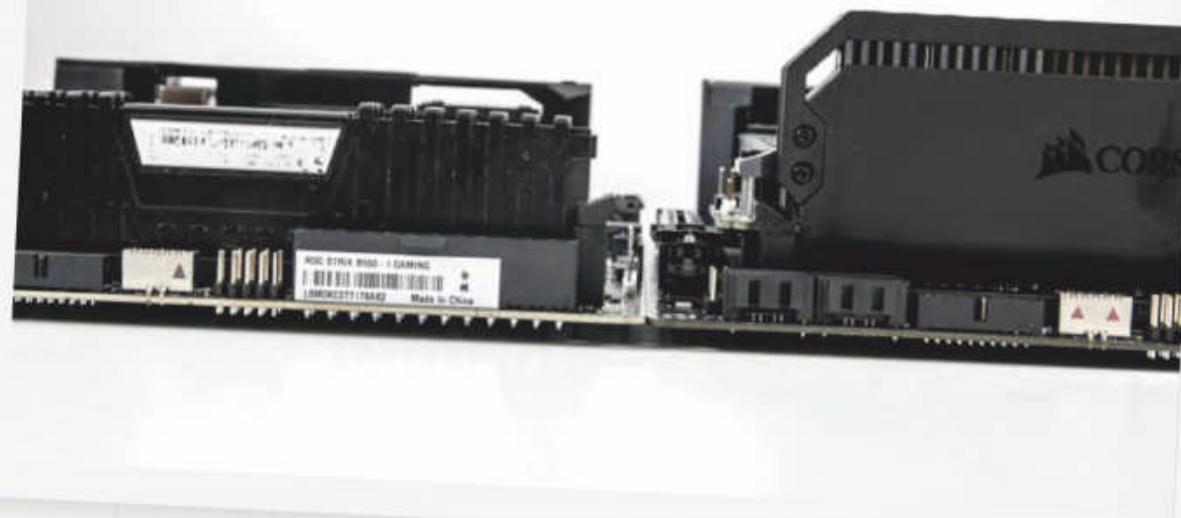
You don't need a case that's limited to SFX PSUs to warrant owning one though. Most SFX PSUs come with brackets, so you can them install in ATX PSU mounts and free

up some space, perhaps for water-cooling gear. Whatever PSU you use, it's highly advisable to use a modular one. Being able to cut cable clutter to a minimum is extremely useful in a small case.

ARE YOUR PSU CABLES TOO LONG?

SFX PSUs often come with (or have available) shorter cable sets than those with ATX PSUs, which can be hugely beneficial with small systems, as the standard cables with ATX PSUs are often far too long for mini-ITX systems, so you just end up wasting space stowing them. However, there is a way around this, which is to make

ATX PSUs often come with unnecessarily long cables





Many modding tasks can be easier with mini-ITX PCs than ATX ones, and you can water-cool them too your own cables, or use a custom cable service such as the one from [cablemod.com](#), where you can specify cable lengths for individual cables, such as the 24-pin ATX cable or 8-pin EPS 12V cable.

WHY YOU WANT M.2 SSDs

M.2 SSDs are great for mini-ITX systems, and it's little wonder that motherboard manufacturers have tried to include at least two ports on their recent mini-ITX motherboards, with some even managing

M.2 SSDs can save significant cable clutter in mini-ITX PCs



three. Every 2.5in SSD or 3.5in hard disk you can banish from your case means more space, better airflow and two fewer cables.

Using an M.2 SSD for mass storage of your data isn't being particularly value-conscious in larger PCs, but with mini-ITX, it can often be useful and in some cases essential, where storage options are limited. The prices of M.2 SSDs have come down a lot too, and owning a 2TB model won't set you back much more than £250 inc VAT now, with a 1TB WD Blue SN550 PCI-E costing only just over £100 inc VAT.

USE A NAS BOX

If you need more than a few terabytes of storage space, but your dream mini-ITX case lacks sufficient space for your needs, then consider using a NAS box or even just an external USB hard disk.

The former will allow you to add numerous hard disks together for more storage, and it can also be placed remotely. They have other perks too, such as remote

access over the Internet, creating your own cloud storage, redundancy through RAID arrays and media server support.

MINI MODDING

Modding can be just as rewarding with mini-ITX cases as with larger ones, and it can even turn a dysfunctional case into a unique and water cooling-friendly chassis if you're prepared to pick up some power tools. Thanks to their smaller size, they're often easier to modify too, especially if you have limited work space.

Spray painting is one task that's much less work with smaller cases, as you'll be covering a smaller total area. Your preparation time will be shorter as well, you'll spend less time masking up areas and the spraying process will require a smaller work area. Mini-ITX cases are far easier to spray inside and out than ATX ones if you're going all out with your paint job. And if you're sending panels away to be machined or painted by a third party, this will cost you less for a mini-ITX case than an ATX one. **CPC**





SMOOTH OPERATOR

MUCH DISCUSSED AND MUCH MISUNDERSTOOD, VRMS ARE CRUCIAL TO THE OPERATION OF YOUR PC, BUT WHAT EXACTLY ARE THEY AND HOW DO THEY WORK?

EDWARD CHESTER EXPLAINS ALL

If you've ever been interested in dabbling in overclocking, one of the terms you'll see discussed a great deal is 'VRM'. The term stands for voltage regulator module, and it describes an electronic circuit that regulates and converts the main output voltages of a PC's power supply to the voltages required for integrated circuits (ICs), such as your CPU, memory and GPU. On current systems, that means taking the 12V output of a power supply and converting it to typically around 1V for a GPU or 1.4V for a CPU.

It's a simple task, but an essential one, as ICs of this complexity require very stable input voltages to operate reliably, and to ensure stable overclocking. If they don't get quite enough voltage at just the right time, it might result in an error in operation, while an unwanted high blip in the voltage could cause damage. In other words, it's well worth knowing a little more about VRMs and how they operate.

Single-phase VRM

The key principle on which voltage regulation circuits rely is the ability to reduce the average output voltage of a circuit by switching an input voltage on and off. So, if you have a 12V DC input and you switch it on and off for equal periods of time, the average output voltage is 6V DC. This switching can be easily achieved via a relatively simple metal oxide semiconductor field effect transistor (MOSFET) circuit that, because the switching is so rapid and absolute (it's either fully conducting or fully off), can be very efficient.

That's the theory, but in practice, just switching a signal on and off doesn't net you a steady 6V. Instead, you need a way of smoothing out those transitions so that you don't just get a theoretical average 6V, but an actual 6V. This is achieved with a combination of an inductor (often called a 'choke') and a capacitor, creating a complete circuit whose most basic form is known as a buck converter.



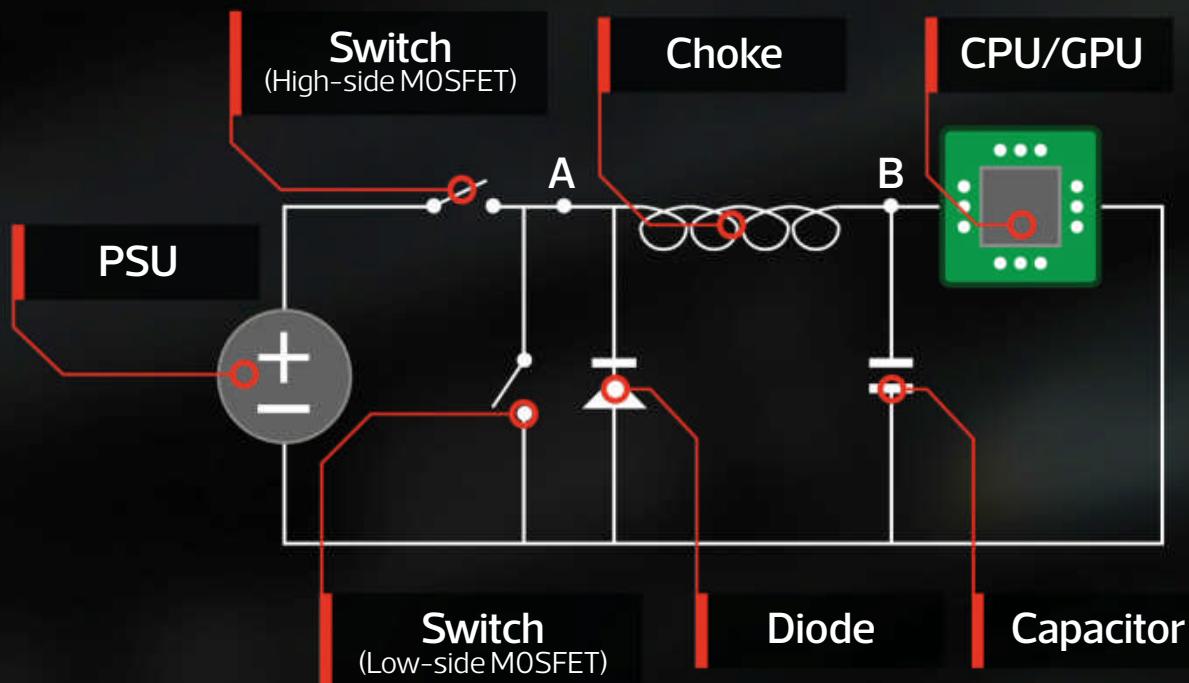


Fig 1: In principle, a VRM is a very simple circuit consisting of a couple of switches, a diode, an inductor and a capacitor

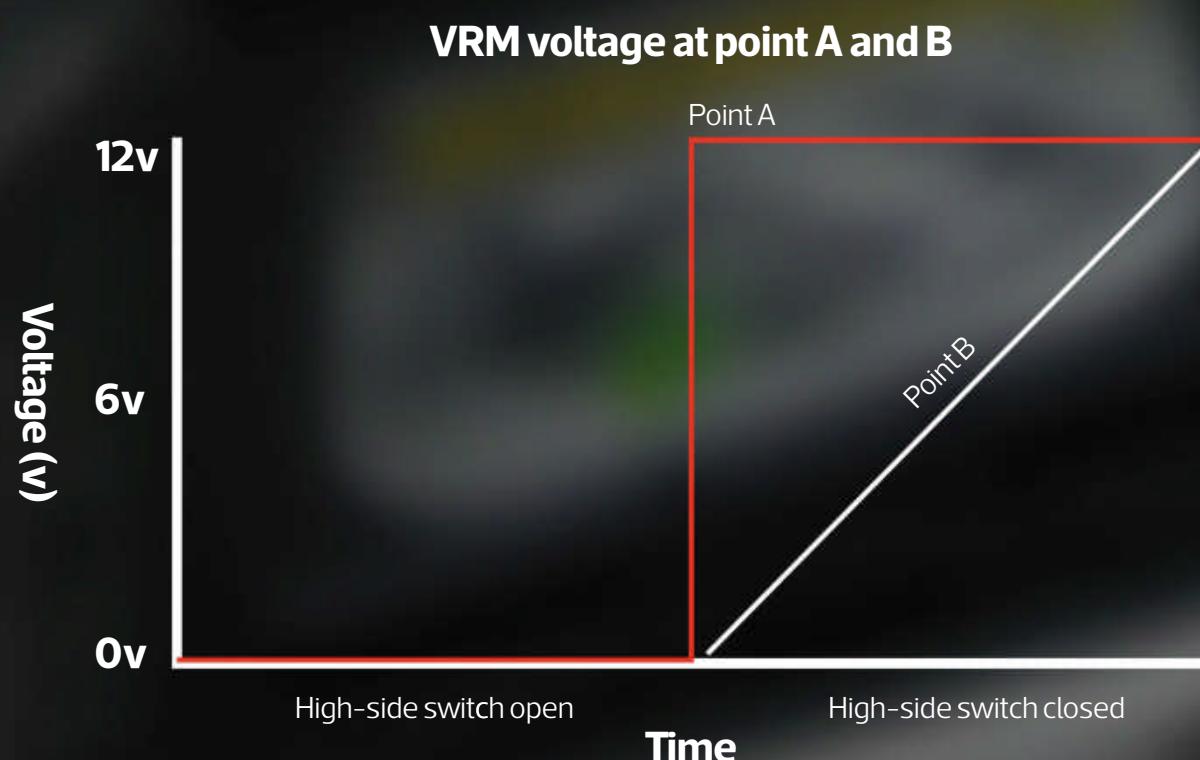


Fig 2: The inductor in a VRM slows the rate of change of voltage at its output

If we look at Fig 1, we can see two MOSFET switches, marked high-side and low-side. To start, we'll only be paying attention to the high-side switch. When the high-side switch is closed, the voltage at the input of the inductor (point A), becomes 12V. This causes current to begin flowing through the inductor – which is essentially a coil of wire around a magnetic core – which in turn causes the inductor to start creating a magnetic field around itself.

However, as this field is building up, it induces a voltage in the wire that resists the current flow from the input. This results in a voltage drop at the output terminal, which is effectively equal and opposite to that of the

input. In other words, while we get 12V in, initially we don't get anything out.

As the magnetic field builds up, however, the negative voltage it's inducing lessens over time, until the field strength reaches a stable maximum where it's no longer charging up. At this point, it no longer induces a reverse voltage, so current can flow freely and we finally have our 12V at the output of the inductor. Plot this effect on a graph, as in Fig 2, and we can see that, as the 12V pulses come into the inductor, the voltage increases relatively steadily at its output.

When the switch is then closed, we get 0V at the input to the inductor and, essentially,

it works in reverse. The magnetic charge around the inductor dissipates, inducing a voltage in the opposite direction (so it's adding to the output voltage rather than cancelling it), which slowly drops off over time. This now gives us a relatively steady increase and decrease in voltage (Fig 3).

That's an improvement, but it's still not smooth enough, which is where the capacitor comes in. This component temporarily stores electrical charge, so as the voltage it receives rises, it gets charged up, and as the voltage it receives drops, it discharges. The net result is that the voltage across it remains relatively steady, giving us our cleaner, steadier voltage to supply to the CPU or other component.

As for the rest of the circuit shown in Fig 1, because of the way inductors work, the initial spike of voltage it produces when the input voltage is switched off can be very high, so the circuit includes a diode to eliminate this and prevent it from causing any harm. However, because diodes are quite inefficient compared with transistors, when the high-side switch opens, the low-side switch closes. This allows that surge to flow through both the diode and low-side MOSFET, greatly increasing the efficiency of the circuit.

Repeat this on/off cycle with a 50 per cent duty cycle, and you should get a steady 6V. However, that's still too high for a CPU, so instead, the pulse width is changed so that the resultant output voltage is lower. With a duty cycle of 10–15 per cent, we get the 1.4V or so that a CPU needs. This pulse width change, and the overall control of VRM circuits, is performed by an IC called the pulse width modulator (PWM) controller.

Multi-phase VRMs

A single VRM circuit can be effective enough for certain applications, but to ensure as smooth a voltage as possible, you can combine multiple VRMs in parallel, creating a multi-phase VRM. The trick here is that the phases (the timing of each 12V pulse from the PWM) of each circuit are offset in a way that means the high-side switch is only closed and building charge on the inductor for one circuit at a time. During this time, the rest of the phases are discharging.

It's easy to see that having multiple phases in a VRM circuit is beneficial for smoother power, but this isn't the only benefit. Because each phase is only handling a portion of the current flowing through the whole VRM

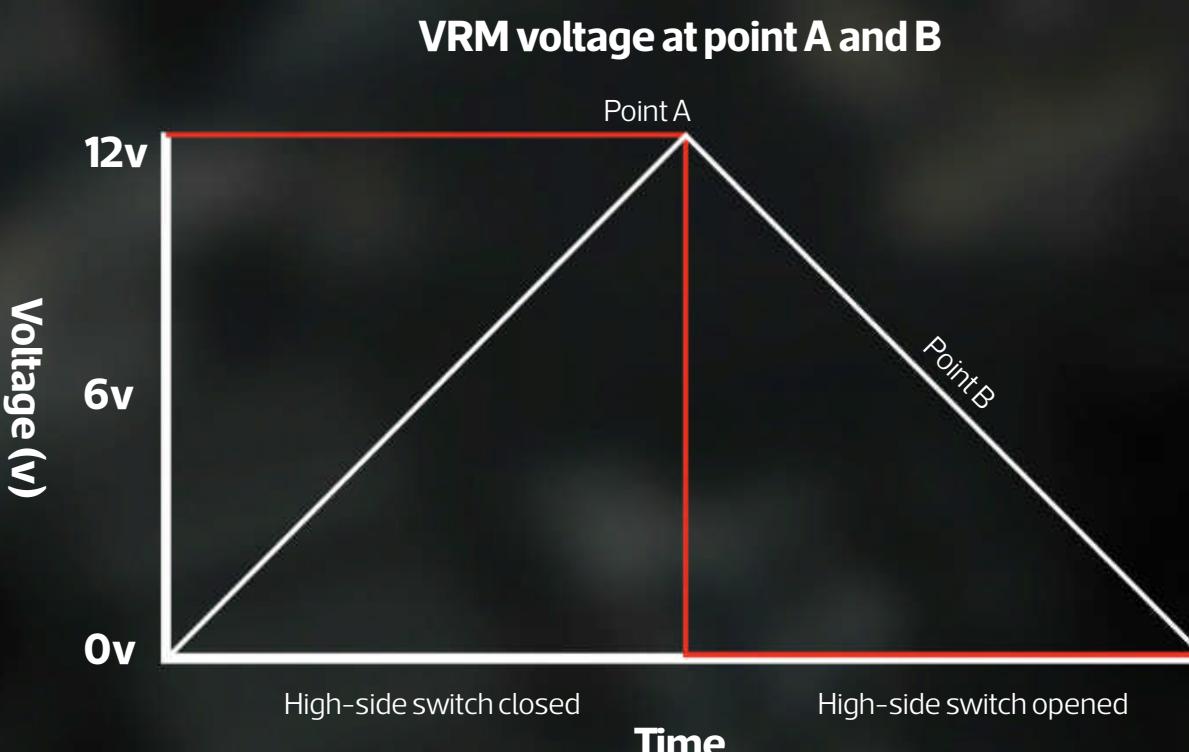


Fig 3: With our input voltage off, the output voltage of the inductor slowly drops

To ensure as smooth a voltage as possible, you can combine multiple VRMs in parallel, creating a multi-phase VRM

setup, each phase is put under much less strain than the same current passing through a single phase. As a result, they don't get as hot and don't have to be rated to such high currents, making the components potentially cheaper and more reliable.

That said, though, the overall benefit of ever greater numbers of phases is diminishing. Beyond a certain point, heat and current load concerns are minimal, while the improvement in overall voltage ripple-reducing effect becomes negligible.

Doublers

One of the reasons why VRMs have had so much attention is because motherboard and GPU manufacturers have caught on to several tricks for making VRM setups appear as, say, true 8-phase setups, when in fact they're only 4-phase. These arrangements aren't necessarily bad, but they have some downsides.

The first arrangement is known as a doubler. This is where you have the extra VRM circuitry, but each phase is only activated half as frequently as in a normal setup. So, where a true multi-phase setup would fire up all its phases in quick succession for every pulse from the PWM controller, a doubler fires up each phase only on every other pulse.

results in benefits from the reduced load on the VRM components, but you still don't get the voltage regulation benefits of a true multi-phase setup. You can also get hybrid versions of all the above options, such as a true 4-phase setup with a doubler for a 'virtual' 8-phase system.

Analogue vs digital PWMS

As we've already discussed, there are two main parts to a VRM circuit. There's the largely analogue part of the circuit that does the voltage smoothing, and there's the controller chip, which provides the PWM pulses that are fed into the analogue part of the circuit. However, these PWM controllers aren't just simple devices that fire out a fixed pulse – they're rather complex integrated circuits themselves. Sophisticated ones will have multiple phase control, and they also take care of another crucial function – monitoring.

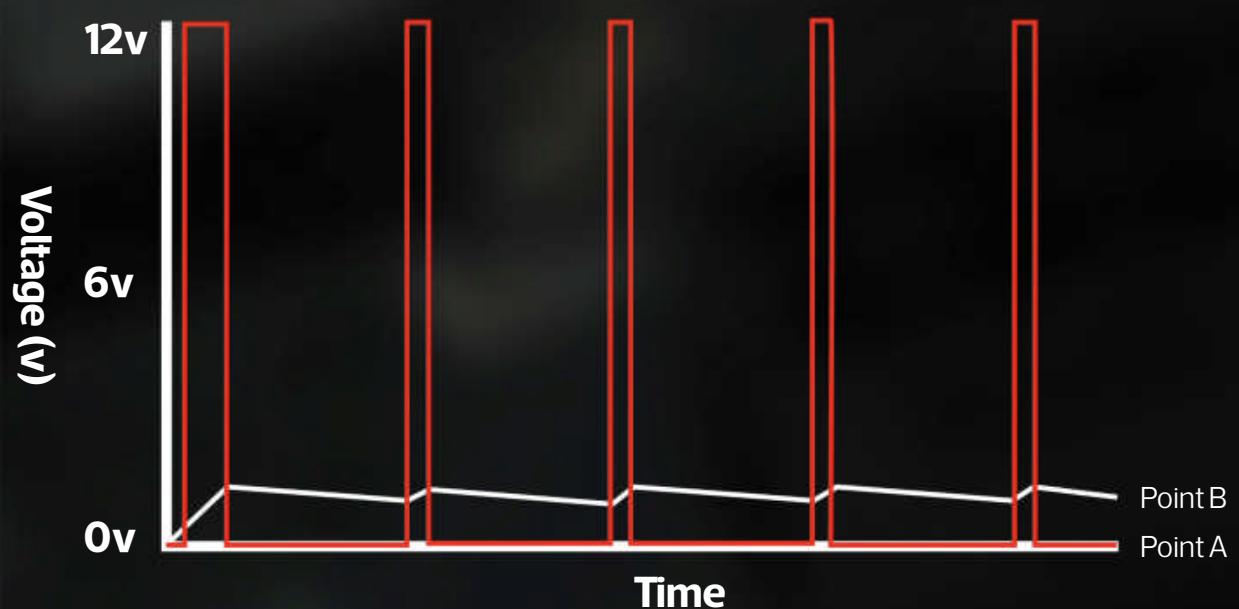
The voltage of a CPU or GPU is never truly constant; in order to be more efficient, the chip will regularly reduce or increase the power it requires. The problem for VRMs is that these constantly changing power requirements put a different load on the VRM, altering its ability to precisely meet the needs of the processor. So, in order to ensure the VRM is always delivering what the processor needs, a feedback loop is needed from the CPU to the PWM.

The feedback method is simple in principle. A reference voltage (V_{ref}), such as the CPU voltage you input into a BIOS, is constantly fed into the VRM, and then compared with the current monitored voltage. The difference

The net result is a similar reduction in overall load and heat generation as a normal multi-phase circuit, but with only the voltage ripple-reduction of a circuit with half the phases. So you'll get a more reliable motherboard but probably one that doesn't overclock as well.

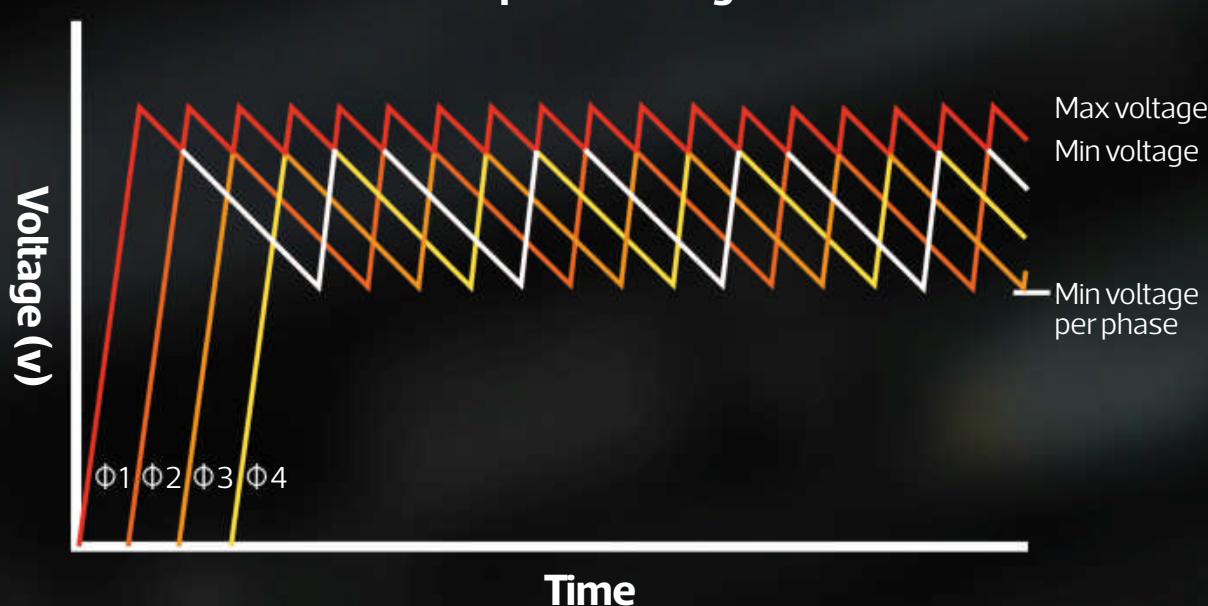
There are also configurations that duplicate the VRM hardware, but this time they're wired so that each phase is driven simultaneously by the same pulse, with no offset. This again

VRM voltage at point A and B



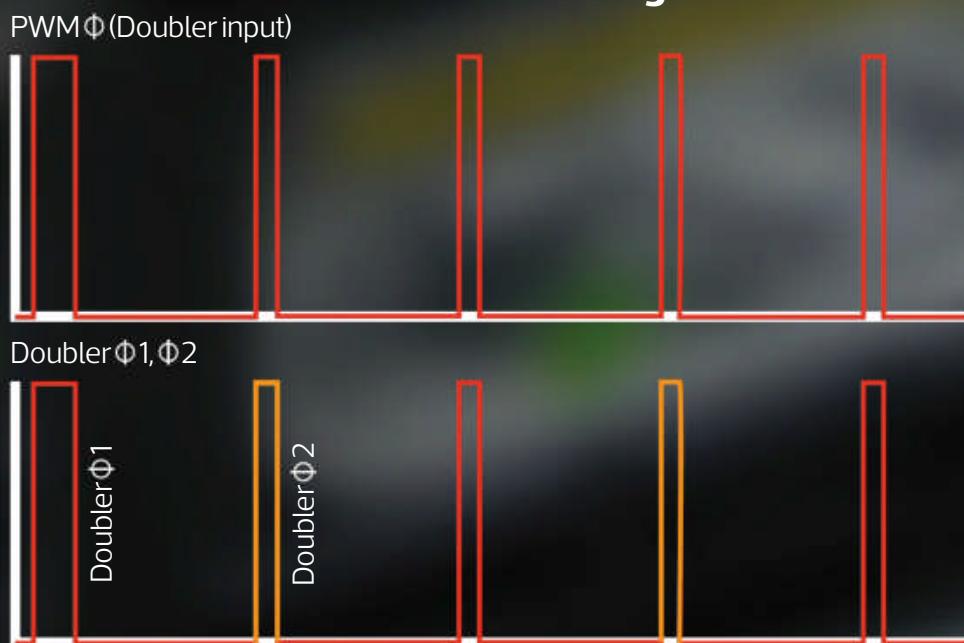
Thanks to the inductor and capacitor, the VRM produces a relatively steady output voltage from the 12V pulses it receives

VRM phase voltages



With multiple VRM phases, the output voltage is topped up more regularly than with a single phase, resulting in smoother power delivery

PWM-Doubler signal



A doubler VRM arrangement reduces VRM load, but doesn't increase the smoothness of the voltage

If you're looking for a serious competitive advantage in overclocking, a robust VRM setup is a crucial consideration

between the Vref and actual voltage fed to the CPU or GPU is then used to modify the PWM signal to try to bring the output voltage back into line.

There are generally two different approaches to achieving this feedback loop. The first uses an analogue comparison. In this system, a digital signal representing the reference voltage is fed into the PWM controller, where it's converted into an analogue voltage. This signal is then compared

with the feedback voltage and an analogue error signal is created from this comparison. This information is then fed back to the PWM controller, where it directly alters the PWM output.

This technique is robust, relatively easy to implement and it reacts very quickly. However, it's not particularly sophisticated, which is where digital PWMs come in. Here, instead of converting the reference voltage to an analogue signal, the feedback voltage is

converted into a digital signal and compared with the digital reference voltage.

The advantage of this approach is that it opens up the PWM microcontroller to consider a much greater range of other variables and parameters in its voltage correction calculations. These could be temperature sensors, BIOS settings and other stored values. This extra information, and the general digital nature of the controller, can make for even tighter voltage control, and also makes it easier to allow overclockers access to fine-tune exactly how the power delivery system works.

The downside to digital PWM controllers is they're more expensive and complex to configure. Modern motherboards almost exclusively use digital PWMs for CPU and memory power delivery, but analogue PWMs may be used for less critical parts of a board.

Terminology

The final piece of the puzzle is explaining just what's meant by the terminology you'll see used to describe the power delivery on a motherboard. You'll often see motherboard manufacturers advertise very high numbers of phases in an A+B format.

In theory it's simple enough. The first number is the number of phases dedicated to the CPU, while the second is the number of phases for the memory. You'll see the MOSFETs, diodes, chokes (inductors) and capacitors of the VRMs for the CPU phases strewn around the edges of the CPU socket, and often covered by heatsinks (which are generally cooling the MOSFETs), while those for the memory will generally be off to one side of the memory slots.

Where it gets complicated is when motherboard manufacturers say a board has, for instance, a 16+2 design, but it may in fact be using doublers and only have a true 8-phase setup. Finding out the exact setup can take a bit of sleuthing, either searching online sources that have already done the digging, or looking up the PWM chips themselves and finding out how many phases they're actually rated to handle.

If the chip only has four or eight phases, and the board claims 16, clearly some doubling is going on. For most people, it won't be a concern one way or the other, but if you're looking for a serious competitive advantage in overclocking, a robust VRM setup is a crucial consideration. **CPC**

CUSTOM PC AWARDS

Back at the beginning of 2020, when everyday life was rather different to life under the COVID-19 pandemic, we got our heads together to decide which of the products and companies from the past year had really blown us away. Longlists were whittled down to shortlists, and then to nominations of just four products, before we eventually (with much discussion!) agreed on the winners.

It's been a while since we last did the Custom PC awards, and we had grand plans for an awards ceremony in Cambridge – we even had fancy trophies made up for the winners. Then we had lockdown and it all had to be put on hold. With no end in sight now, though, we thought it was now high time we revealed the winners of the awards, particularly as some of them were decided by you, Custom PC's readers, rather than the editorial team.

As a result, bear in mind that these are the award winners we picked (and you voted for) in March this year, so they don't include any products we've reviewed in the past six months. Even so, there isn't a single award winner here that we wouldn't recommend now – every single one is still brilliant.



EDITORIAL VOTED AWARDS

DECIDED BY BEN HARDWIDGE, EDWARD CHESTER,
ANTONY LEATHER AND MIKE JENNINGS

LIFETIME ACHIEVEMENT

CORSAIR

The clever folks at Corsair have been answering the needs of PC hardware enthusiasts for decades, making memory with amazing heatsinks, and even incorporating LEDs into them, well before the current trend. Corsair still makes superb memory today, and it's since diversified into DIY water cooling, cases, SSDs, fans, system monitors, all-in-one liquid coolers and even air coolers. Offering a huge range of quality enthusiast products, and constantly investing in research and development, Corsair has been a mainstay of Custom PC since the very beginning.



CORSAIR

Other nominees
AMD / Asus / Nvidia

BEST VALUE COMPONENT

AMD: RYZEN 5 3600

AMD's 3rd-gen Ryzen line-up hasn't just changed expectations at the top end of the scale, but at the sub-£200 level too. With six cores, 12 threads and the Zen 2 microarchitecture under its heatspreader, the Ryzen 5 3600 offers incredible multi-threaded power for its price, and its 4.2GHz single-core boost clock means it can cope with gaming demands too. It's an incredible CPU for the price.

Other nominees

AMD Ryzen 5 3400G / Sapphire Pulse Radeon RX 5600 XT / WD Blue SN550



AMD

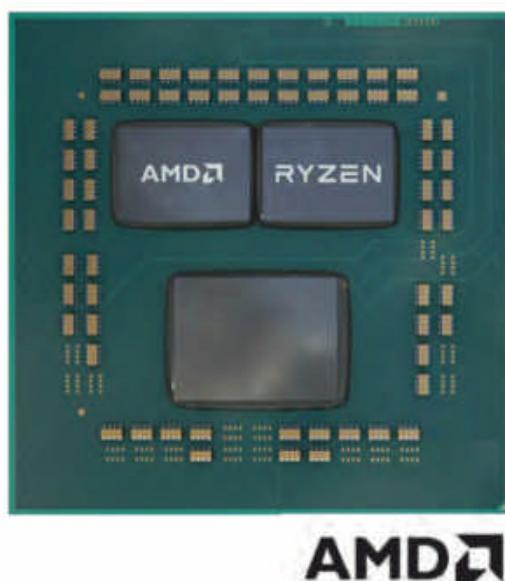
TECHNICAL INNOVATION

AMD: 7NM CHIPLET PROCESSOR DESIGN

AMD had already turned the CPU market on its head when it launched its first two generations of Ryzen CPUs, but the chiplet approach to making its 3rd-gen Ryzen CPUs has completely changed the game. While Intel is still languishing on its 14nm process, AMD has made a scalable 7nm chiplet system, enabling the company to make AM4 CPUs with anywhere between four and 16 cores, while the I/O chip is built on a larger process.

Other nominees

Oculus (Quest VR) / Asus (Crosshair VIII Impact) / Corsair (One i160)



EXTREME ULTRA

AMD: THREADRIPPER 3960X

With its new 7nm chiplet design under its belt, AMD went all out with its 3rd-gen Threadripper line-up, which even goes up to the flagship 64-core 3990X. Most importantly, though, AMD learned some hard lessons about latency and clock-speed boosting from the 2nd-gen Threadripper line-up, with the latest chips handling any job from gaming to massively multi-threaded rendering. It's the 24-core 3960X that hits the sweet spot for most enthusiast needs, though, costing £1,240 inc VAT and coping with pretty much any computing job you can throw at it.



Other nominees

Gigabyte TRX40 Aorus Extreme / Asus ROG Swift PG35VQ / Thermaltake WaterRAM

COMPONENT MANUFACTURER

ZOTAC

There's a lot more to making a quality component than cramming it full of LEDs, and Zotac's approach to graphics cards has really impressed us over the past year. Of course, like any other graphics card maker, Zotac has plenty of top-end overclocked models with bells and whistles, but it's the company's 'Mini' graphics cards that have earned the company this award.

We've tested many of them over the past couple of years, and they've consistently been well priced, quiet, small and overclockable. Comparatively, many other budget graphics offerings have horrible blower coolers, but these Mini cards offer an affordable way to get the latest GPU tech without making significant sacrifices.

Other nominees

Asus / Corsair / AMD



BEST SMALL FORM FACTOR PRODUCT

PHANTEKS: ENTHOO EVOLV SHIFT AIR

A year or so ago, most mini-ITX cases were either mini versions of ATX cases, or cube-shaped boxes, but Phanteks had other ideas when it was developing the Enthoo Evolv Shift Air. Taking its design cue from skyscrapers, the Shift Air starts with a tiny footprint and builds up, meaning there's room for liquid cooling and plenty of airflow in a case that measures just 186mm wide. To top it all off, you can pick up one for under £100 inc VAT.

Other nominees

Asus ROG Strix X570-I Gaming / Asus Crosshair VIII Impact / Lian Li PC-Q37WX



PHANTEKS

BEST CASE

PHANTEKS: ECLIPSE P600S

Phanteks' Eclipse P600S is an amazing chassis for the money, with features designed with PC builders in mind. From its replaceable front and roof panels, to its superb cable-tidying system, this mammoth case has it all. You can even install ten hard drives in it, and it can accommodate a mighty 420mm radiator as well. Cooling is superb as well, and there's the option to mount your GPU vertically without being right next to the side panel.



PHANTEKS

Other nominees

NZXT H700i / be quiet! Pure Base 500 / Lian Li PC-011Dynamic Razer Edition

BEST COOLING PRODUCT**ALPHACOOL: EISBAER EXTREME 280**

Alphacool took the concept of the all-in-one liquid cooler about as far as it can go with the Eisbaer Extreme 280. This awesome CPU cooler combines the convenience of an all-in-one liquid cooler with the performance of a full custom water-cooling loop, and you can even expand it, adding other components to the loop. The integrated pump, which is Alphacool's spin on the classic Laing D5, is supremely quiet, as are the fans, and the cooling power is phenomenal. It's not cheap, and you'll need to measure up your case to make sure it fits, but this is a cracking CPU cooler.

Other nominees

ARCTIC Liquid Freezer II 240 / Deepcool Gammaxx GT / EKWB EK-Kit Performance 240



OCOOL

BEST MONITOR**ASUS: ROG SWIFT PG35VQ**

Asus' massive ROG Swift PG35VQ might have an eye-watering price tag, but it's one of few gaming monitors we've tested that can deliver the HDR goods, largely thanks to its count of 512 (32 x 16) backlights. Add in G-Sync support and a 200Hz refresh rate, and you get a top-notch gaming monitor. Its 3,440 x 1,440 resolution is ideal for the 35in diagonal, meaning you don't have to mess around with Windows scaling, and you don't need as much GPU power as you do for 4K gaming.

Other nominees

Acer Predator CG437K / AOC C24G1 / AOC U2790PQU



ASUS

BEST MOTHERBOARD**ASROCK: TRX40 TAICHI**

There were a load of contenders for this category, based on various chipsets, but ASRock's TRX40 Taichi is the one that really wowed us. Despite having a much lower price than its competitors, the TRX40 Taichi stormed our Threadripper motherboard Labs (see Issue 98, p42), with quiet fans, decent VRM cooling, a well thought-out layout, a hefty backplate and an M.2 expansion card, giving you loads of options for high-speed storage.



ASRock

Other nominees

Asus ROG Strix X570-E Gaming / MSI Prestige X570 Creation / Gigabyte Z390 Aorus Pro

BEST LAPTOP**CHILLBLAST: PHANTOM 17**

Proving that you don't need an outrageously angled design to make a great gaming laptop, Chillblast's Phantom 17 goes all out on quality but keeps 'gamer' frills to a minimum. Its superb 17.3in screen has a 144Hz refresh rate and you can spec up the Phantom 17 with a variety of GeForce RTX GPUs, from the RTX 2060 to the 2080 Max-Q. What's more, you even get a mechanical keyboard inside this portable machine, and its operation is cool and quiet. With prices starting from £1,560 inc VAT for a machine with a GeForce RTX 2060 and a Core i7-10875H CPU, it's keenly priced too.



Chillblast

BEST NETWORKING PRODUCT**ASUS: AIMESH AX6100**

Buying a new router can make a massive difference to your online experience at home, whether you're looking for more bandwidth or better range, and the AiMesh AX6100 delivers on both fronts. It conforms to the latest Wi-Fi 6 standard, and you get two units in the box, which form a mesh to cover your whole home, resulting in incredible long-range performance.



ASUS

Other nominees

TP-Link Archer AX6000 / TP-Link Archer TX3000E / Synology DS220J

BEST GRAPHICS CARD

NVIDIA: GEFORCE RTX 2070 SUPER FOUNDERS EDITION

Nvidia's reference cooler design has gone from strength to strength, and the company can now manufacture its own cards under the Founders Edition moniker. The GeForce RTX 2070 Super Founders Edition is well built and well designed, with quiet operation and a two-slot form factor.

It doesn't have RGB LEDs, but it looks so classy that it hardly matters. At just £489 inc VAT, it also offers a sub-£500 route into ray tracing at 2,560 x 1,440. You get diminishing returns after this point, with the RTX 2070 Super sitting firmly in the performance/value sweet spot.

Other nominees

Sapphire Radeon RX 5600 XT Pulse /
Sapphire Radeon RX 5700 XT Nitro+ /
Zotac GeForce RTX 2060 Super Mini



BEST CPU

AMD: RYZEN 9 3900X

AMD is killing it in CPU land at the moment, and making our choice in this category was more a case of choosing between AMD CPUs than choosing between Intel and AMD. Intel's Core i9-9900KF still had the upper hand in terms of raw clock speed and games performance when we were deciding these awards, but AMD's 3rd-gen Ryzen CPUs were ruling everywhere else.

Our pick of the bunch was (and still is) the 12-core (24-thread) Ryzen 9 3900X, which is a killer CPU in every respect. You can pick up one for under £400 inc VAT, and its 12 cores rip through heavily multi-threaded tasks, while its 4.6GHz turbo clock makes it a formidable gaming chip.

Other nominees

AMD Ryzen 9 3950X / AMD Threadripper 3960X / Intel Core i9-9900KF



BEST PERIPHERAL

CORSAIR: K70 MK.2 LOW PROFILE

You'd have to go a long way to better Corsair's classic K70 design. It has superb build quality, with a classy brushed aluminium top plate, and the layout is spot on, with volume roller and dedicated media controls above the numberpad.

Corsair makes the most of the low-profile Cherry MX switches in this version, which measures just 22mm to the top of the front keys, allowing your wrists to rest at a low angle. Add full key illumination for the RGB lighting, which is customisable in Corsair's software, and you have a superb, thoroughly gorgeous keyboard.

Other nominees

Corsair Virtuoso RGB Wireless SE /
Glorious PC Gaming Model O /
Logitech MX Master 3



READER VOTED AWARDS

BEST ONLINE RETAILER

SCAN

Runners-up

Amazon / Overclockers UK / Ebuyer

BEST INDEPENDENT SYSTEM BUILDER

SCAN

Runners-up

Chillblast / Overclockers UK / PC Specialist

We wanted to give our readers a voice when it came to assessing system builders and retailers, as well as service and support – an area that can be tough for us to gauge as journalists. You voted in your hundreds, and some brands

were consistently ahead, with Chillblast, Overclockers UK and PC Specialist getting regular nominations. However, Scan was the overall winner of every award – an amazing feat for the Bolton firm. Well done, Scan. **GPC**

SCANS

BEST SERVICE AND SUPPORT

SCAN

Runners-up

Chillblast / Overclockers UK / PC Specialist

iPREDATOR POWDER

BJÖRN HÖJING BURLE SHOWS US HIS iMAC-INSPIRED MOD

SYSTEM SPECS

Weight	26kg
Size (mm)	830x170x380 (WxDxH)
Build time	~250 hours
Sponsors	Cablemod, MSI, Thermal Grizzly
Case	Scratch built 5mm thick aluminum plate + Acer Predator X34P monitor stand and monitor
PSU	Corsair SF750 Platinum
Motherboard	MSI MEG Z490-I Unify
GPU	Nvidia Palit RTX 2080 Ti ProGaming OC at 2135Mhz
CPU	Intel Core i9 10900k at 5.2Ghz all cores at 1.34V
Memory	G.Skill Trident Z 3600MHz CL16 at 4000MHz CL14 (Samsung B-Die)
SSD	2x Samsung 960 EVO 500GB, Samsung 850 EVO 250GB
Cables	CableMod Pro sleeves Black/white PSU/SATA cables
Cooling	Phobya Nickel 150ml reservoir, Thermaltake Pacific W5 CPU block, EK Velocity copper GPU block, EK D5 pump, Revo Plexitop RGB sleeved cables, 2x EK Coolstream 240mm PE radiators, Phanteks PWM fan controller, Bykski RGB Plexi flow indicator, Bykski hardline gunmetal fittings, 4x Corsair ML120 Pro white LED
Lighting	Asus ROG controller, 4x 300mm and 2x 600mm Asus lighting strips

It was an innocent enough request: 'I want an iMac'. My wife uttered these words to me just after I returned from Dreamhack Jönköping where I'd hoped to exhibit my first attempt at a proper mod.

However, a blown motherboard the day before the competition scuppered my chances, so instead I was looking for a new project.

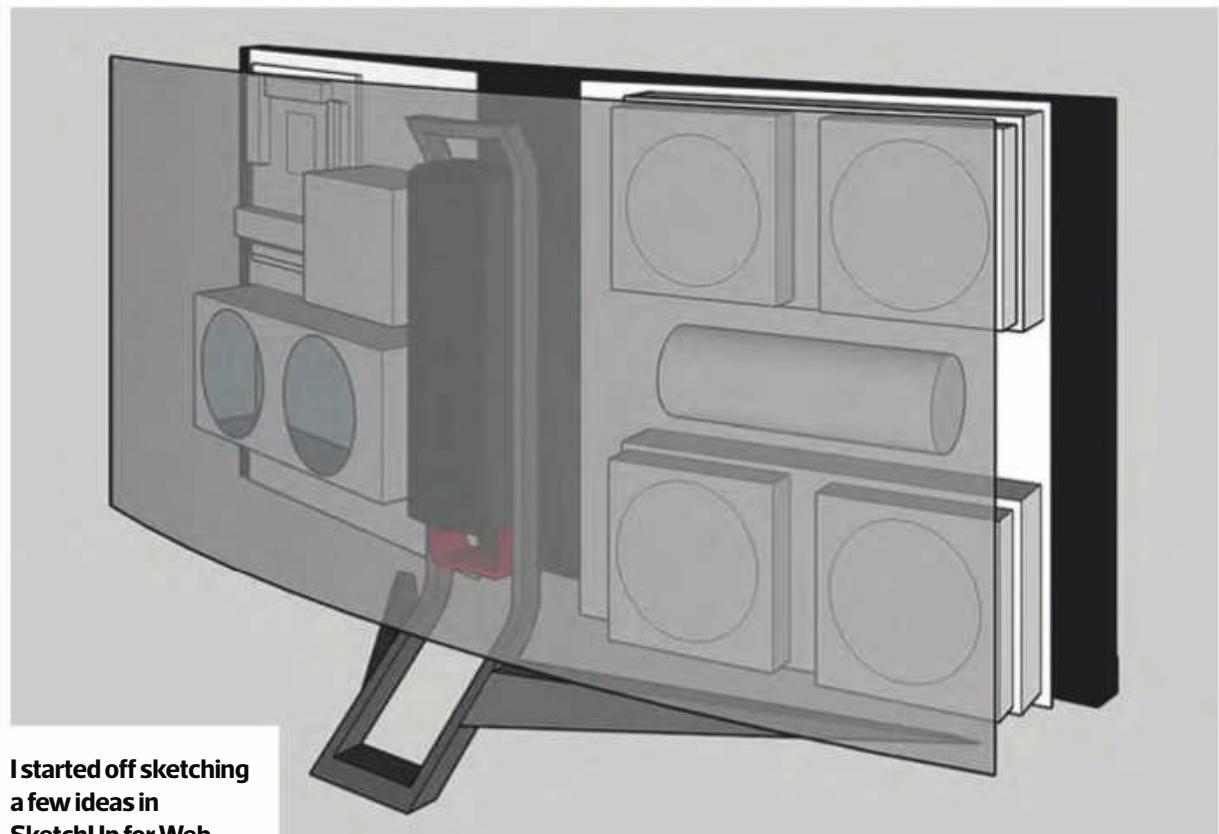
As you can imagine, I panicked a bit upon hearing these words but soon realised that maybe this iMac thing wasn't such a bad idea. Of course, no actual Mac would ever cross my doorstep, but the idea of building

a computer in or on a screen? That I could get behind. After all, there's plenty of space on ultrawide monitors.

From idea to concept

Once the thought had taken hold, I started drawing up ideas in SketchUp for Web. In the meantime I kept my eyes open for suitable monitors with sturdy enough stands, and eventually settled on the Acer Predator X34P, a 34in, IPS screen with a 3,440 x 1,440 resolution.

I decided to go with a design in keeping with our home decoration, which is rather industrial but still minimalist and white.





The colours I went for were black and white paired with brushed aluminium. Even though I'd rarely see the backside of the monitor, the geek in me decided to go with an inside-out design. I had to know that all those beautiful components, pipes and lights are out in the open.

Hardware choices

At heart I'm a gamer. My PC is used 50 per cent for gaming, 2-3 per cent for photo editing, video rendering and office work, and the other 47-48 per cent of the time I spend rebuilding and upgrading it! Thus, I wanted high-end gaming components.

I realised that even the backside of a 34in monitor wouldn't fit an entire ATX system, so smaller form factor components were the clear choice. I already had the motherboard and CPU – a Ryzen 7 2700 and Asus B450-I from my previous PC – but still needed the PSU. I also needed all the

parts for a complete custom water-cooling loop, a GPU riser, sleeved cables, some thick aluminium sheeting on which to mount the PC, and of course an Acer Predator X34P.

Bits and pieces begin to trickle in

With the various components I needed starting to arrive, it was time to order the aluminium plate on which everything would be mounted. I wasn't sure how thick it needed to be, so I discussed it quite a bit with a friend and fellow modder, Laine, who told me that it didn't need to be thicker than

I REALISED THAT EVEN THE BACKSIDE OF A 34IN MONITOR WOULDN'T FIT AN ENTIRE ATX SYSTEM

3mm. Somehow I misread this and ended up ordering a 1000x500x5mm aluminium plate. Not only would this make machining the metal more difficult, it was more expensive too. Perfect!

Right after that I found the monitor I wanted, used, for a decent price. With some of the key components at hand I began measuring and designing. I planned to make a CAD file of the aluminium plate, with the idea to send it off to get laser-cut or CNCed for a perfect finish. However, I overestimated my 15-year-old CAD skills and after a four-month struggle, I opted for a more hands-on solution. I summoned all the components I had, put them down on the slab of metal and got out a whiteboard marker.



As components and the metal plate started to arrive, I was able to begin testing component positions



Drilling, cutting and bending 5mm aluminium is not easy!

From here I just drew out each component on the plate, marked out the screw holes I needed, et voila! The downside to this approach is that I now had to make every single hole and cut myself, which also meant that all the cut edges would be jagged and need a lot of cleaning up. I also realised it would be some time before I'd get to make another attempt if I failed, as I had already blown my budget.

Deep cuts

I spent another month revising my plan before I finally found the guts to start cutting. I used a drill, jigsaw and a handsaw, and it took a good five or six hours just sawing out the larger holes, and another ten to 12 hours to drill and tap all the screw holes.

Quite a few saw blades and drills went to their graves during this process and all of this work had given me even more work. I had taped over where I was sawing, to protect the surface, but apparently I didn't do a good enough job, as once I removed the tape, it revealed scratches all over the surface.



By removing the VESA mount, the aluminum plate could be attached directly to the stand and the monitor can fit on the mount as usual

The legs of the stand were stripped of their paint and sanded back to give a nice brushed finish, to match the rest of the PC



The only option was to set to with my beltsander. A lot of elbow grease and time later, the plate had a lovely brushed finish.

In many ways, all of the above was the easy bit, as I still had two big problems to solve. The first is how would I be able to bend 5mm thick aluminium? The second, how on earth would I manage to fit the plate to the monitor and stand?

The first was the quickest to solve, though it took some research. The local sheet metal company didn't have the tools to bend a 5mm-thick plate but it pointed me in the direction of those who could. I'd calculated the required angle to be six degrees and, as luck would have it, that was the biggest bend they could do with such a thick plate.

The second problem took more time. I wanted to make use of the VESA mount on the monitor stand, but there's only one mount, and both the plate and the monitor to attach to it. After a few months of sketches, I decided the best solution was to detach the VESA mount from the stand and attach the aluminium plate behind it. The monitor then attaches to the VESA mount as normal.



During the months it had already taken to get to this point, I befriended a guy working at Trigono AB, a Swedish PC components distributor. This friendship got me my first sponsors, in the form of CableMod and Thermal Grizzly. A sweet set of sleeved cables and a wide range of thermal pastes and thermal pads showed up at my door not long after.

Going with the flow

I still lacked quite a few components for the water cooling, and I had to cough up the cash and order fittings and a flow indicator from Bykski. Luckily it wasn't that expensive and the financial pain was lessened by a modder friend selling me a brand-new Thermaltake Pacific W5 CPU block on the cheap.

I added in the new components and, to my surprise, it went very smoothly, the entire process taking less than 30 minutes. Now, for the first time in over a year, I was 100 per cent certain this would work.

I still thought something was missing on the build though. It was all black, white and brushed aluminium, as I'd planned, so I couldn't put my finger on it. I asked my wife, who of course has impeccable taste when it comes to home decoration, and she took a quick look and said, 'You need another material somewhere, perhaps leather, and the monitor's colour doesn't match the rest'.

She was right, as ever – leather would be perfect for breaking up the cold look of the build. But where to add it? I pulled out a few old belts and toyed around with them (but back to the modding – Ed), placing them all over the place to figure out what might work. Eventually, I realised that I could solve my PSU-mounting issue as well by using the leather to strap the PSU in place.

As to the monitor, I quickly tore it to pieces using pliers, razors and screwdrivers. I then ground down the plastic with 80-grit then

120-grit sandpaper then sprayed on a layer of undercoat followed by three layers of white top coat. To finish, the surface was knocked back with 1200-grit sandpaper

A couple of brown leather straps were the perfect finishing touch and mounting option for the PSU



Plenty of help was needed to achieve some of the more difficult pipe bends

before sealing it with clear coat. For the stand, I stripped off the paint with paint remover then I used 80-grit paper to give it a brushed look.

As soon as the last parts for water cooling arrived at my door, I went off to the local hardware store to pick up some chromed copper pipes. Then I made the 100km drive to my friend EGXI-Modified who had promised to give me a crash course in pipe bending. EGXI has been a modder for almost 15 years and his day job is plumbing – I know none as good as him at bending pipes, that's for certain.

Fifteen beers apiece later, I had built my first custom loop, on the backside of my 34in monitor. I would never have figured out some of those bends had it not been for EGXI. Especially the one you can see going from the flow indicator, behind the monitor stand to the GPU.

Spreading the word

During this project my wife suggested I start a Facebook and Instagram page for my hobby, instead of littering my non-modding



The finished PC fits in perfectly with our preferred black and white theme

friends' feed with pictures of my progress. So that I did.

When I drove home from EGXI I had 80 followers on my Facebook page, which I was quite happy with. The day after, I took

At this point I got in touch with MSI about a future project, and they quickly decided that I couldn't have an AMD CPU and B-450 board for a high-end gaming rig, and that a switch to the blue team was required. So, a week

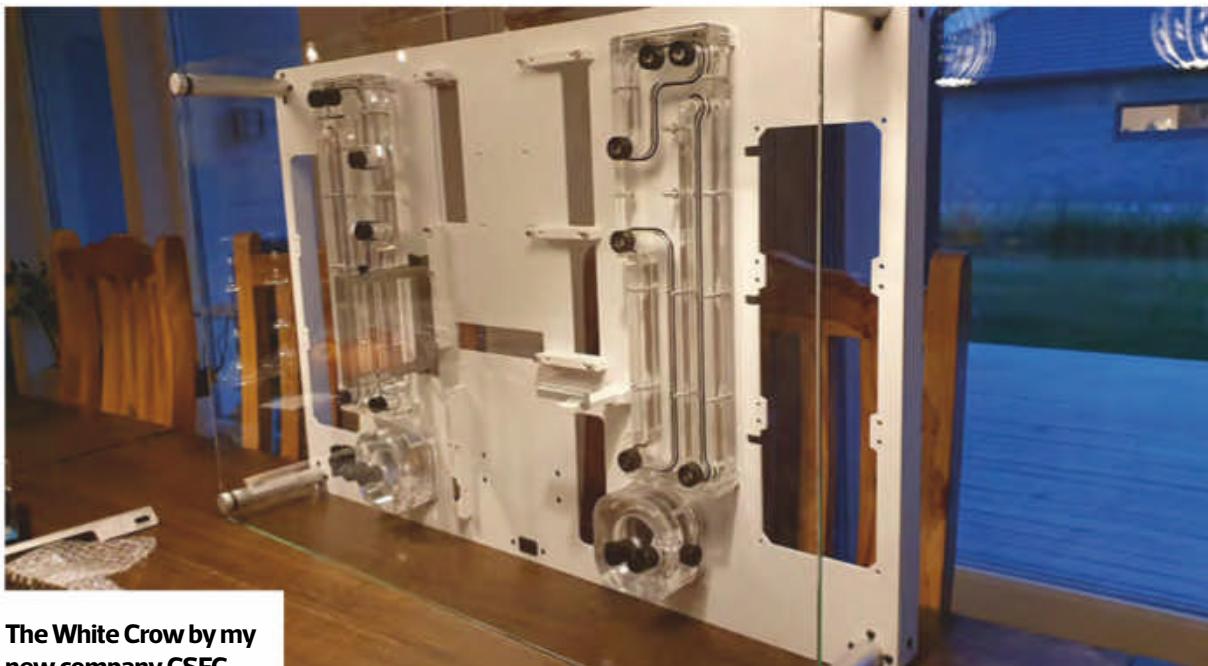
before its public release, the most beautiful motherboard I've owned arrived at my door. The MSI MEG Z490-I Unify was the perfect black heart for my build. I quickly sold my old motherboard and Ryzen CPU, using that money to get my hands on an Intel i9 10900K.

Lessons learned

I'm very proud of what I accomplished with this build. In hindsight, I wish I'd planned even better for cable management and chosen a thinner plate, but I love the result.

This build has done a lot for me. I have learned how to make custom-loops, build a 'case' from scratch and work with metal. It also led me to start up my own company, Creative Solutions For Gamers (CSFG), together with three other tech enthusiasts. We're trying to bring new types of chassis to the market through crowdfunding.

My next two projects are sponsored by MSI, the first is in CSFG's second prototype chassis, the White Crow, which is a wall-mount design featuring custom distribution plates and pump tops. The second one is for the streamer GhazzyTV, a Path of Exile-themed build with a Kolink chassis. **CPC**



The White Crow by my new company CSFG



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

ANALYSIS

Nine Tiles Prototype ZX Spectrum ROM

Blue's ZX Spectrum Next (reviewed in board-only form in Issue 176 and in retail-release guise in Issue 202) isn't your average microcomputer. It's designed to take on different 'personalities', ranging from ZX Spectrum variants with custom read-only memory (ROM) contents, to entirely different machines loaded onto the field-programmable gate array (FPGA) as a soft core.

The ability to load custom ROMs offers a key opportunity in the field of electronic

archaeology too – restoring the Nine Times prototype ROM to fully functional status.

Nine Tiles is a Cambridge-based software development house, chosen by Sinclair to develop the BASIC ROM needed for its ZX80, ZX81 and ZX Spectrum microcomputers in the 1980s.

Last year, Nine Tiles emptied out a storage space and donated a wealth of hardware, software and documentation to The Centre

for Computing History, including a never-before-seen prototype ZX Spectrum.

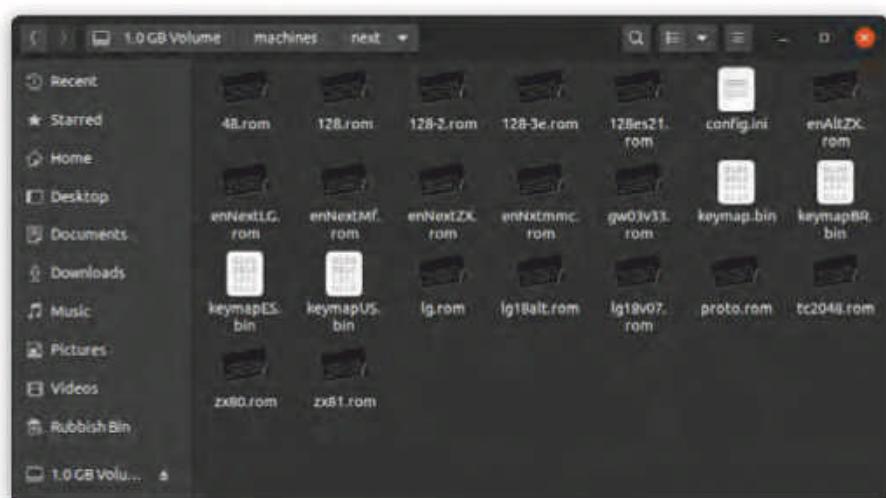
The prototype is particularly interesting, as

With a little work, the ZX Spectrum Next can run a rare pre-release prototype ROM

development of the ROM continued for a full three months post-launch. However, the resulting enhanced ROM was never publicly released, as Sinclair opted to standardise on the unfinished launch ROM instead.

Aware of the history of the system, Nine Tiles allowed the Centre to dump the contents of the ROM and make it available to download for educational and historical purposes. What's more, that ROM file is, in theory at least, compatible with the ZX Spectrum Next.

Loading a new machine definition into the ZX Spectrum Next is simple. The bundled SD card includes a 'machines' folder with all the standard ROM files, plus a configuration file. Opening this file in a text editor reveals the machine definitions themselves, and simply adding a new line at the bottom and copying



A folder on the bundled SD card includes all the ROM files, plus a configuration file for machine 'personalities'



The Nine Tiles prototype system predates the launch of the ZX Spectrum, and its ROM is unique (Image courtesy of The Centre for Computing History)

the prototype ROM into the folder is enough to create a new definition.

Each definition includes a name, the filename of the ROM image and two numbers. The first number selects the type of machine, from a traditional 48k Spectrum to the 128k/+2, the +2A/+3, and Soviet clones with custom timings. The latter number sets the default video output.

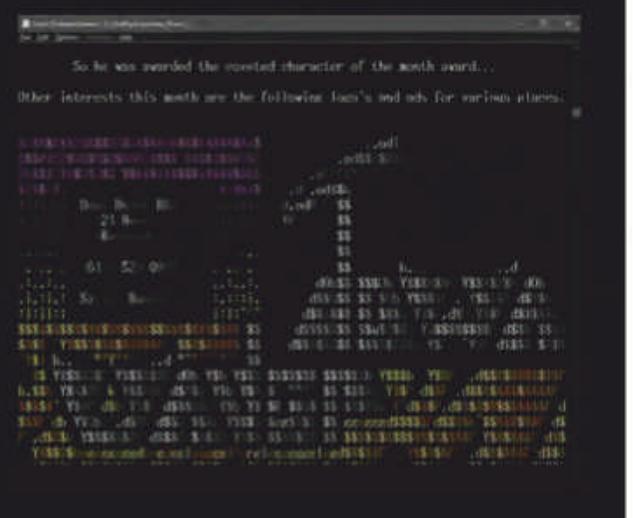
Putting the SD card back into the ZX Spectrum Next and powering it up offers the chance to press the spacebar at boot, loading the 'personalities' menu with a list of machines – including the prototype ROM. Selecting the new entry will load the ROM and boot the machine, but with one problem: any attempt to store information in memory will fail with the error message 'RAMTOP no good.'

NEWS IN BRIEF

The Oldschool PC Font Pack 2 released

The Oldschool PC Font Pack, a collected recreation of classic computer typefaces, has hit release 2, and now includes bitmap-format, web-format, TrueType and aspect-corrected versions of the font files. Based on text-mode and system fonts, the downloadable Creative Commons-licensed font pack includes modern pixel-accurate recreations of the typefaces used on systems ranging from the Apricot Xen family to IBMs, Amstrads, Wyse terminals, and even AmiBIOS and Phoenix BIOS interfaces.

The new release offers over 130 additional fonts, aspect-ratio-corrected versions of existing fonts and remains free to download from int10h.org/oldschool-pc-fonts



Like other machines of the era, the ZX Spectrum Next had no concept of protected memory: the PEEK and POKE commands could be used at any time to read from and, crucially, write to any section of memory, including those parts populated from the ROM. Using the POKE function, you can reconfigure various ROM-loaded settings – including RAMTOP, a setting that tells the ZX Spectrum where the upper limit of fitted RAM is located.

To make the prototype ROM function, several ROM settings need to be changed. To do this, in the BASIC interpreter type:

```
POKE 23653, 219
POKE 23732, 255
POKE 23733, 255
POKE 23734, 244
POKE 23735, 9
```

These commands take one-byte memory locations (the first number) and write reconfiguring settings (the second number), including RAMTOP, STKEND and P-RAMT, which would ordinarily be set by the ROM.

Adding a new personality is as easy as finding a ROM and placing a fresh configuration line at the bottom of the file

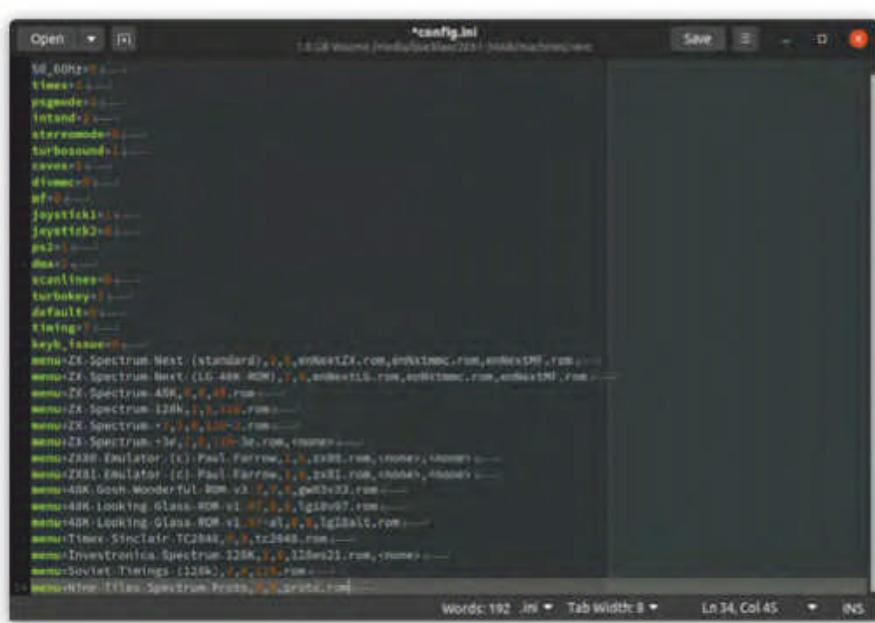
To make sure the values are correct, a comparison to a working machine is required. Each memory location is read using PEEK on the launch-day ROM, then the value noted and written into the prototype ROM's running memory using POKE. With these inserted, it's possible to use the prototype ROM to run any program that can run on a standard Spectrum with a launch ROM.

Functionally, the ROM is identical to any other 48k Spectrum, with one key difference – it includes the missing ROM sections for peripheral control. These weren't finished in time for the original ZX Spectrum launch, and Sinclair opted for a different approach to solving the problem – each peripheral device had its own shadow ROM, filling the gap in the system ROM without requiring the company to replace physical ROM chips in the thousands of machines that had shipped at the time.

In theory, then, the prototype ROM allows for peripherals to run without this shadow ROM, which would have made them cheaper to produce. In practice, you won't find any peripherals lacking shadow ROM with which to test the theory, so running the prototype ROM is more of an exercise in bragging rights than really enhancing the ZX Spectrum experience.

ZX Spectrum Next owners looking to try the ROM themselves can download it from custompc.co.uk/SpectrumPrototype

It can also be used with emulators, or with an original ZX Spectrum 48k when burned to a suitable EPROM.





TUTORIAL

FLIR ETS320 variable focus hack

Thermographic analysis of electronics can reveal a lot of information, from which components require additional cooling to impending failure, and the FLIR ETS320 (see Issue 201) is a fantastic tool for the electronics lab or particularly well-heeled hobbyist.

It has one particular flaw, however. As demonstrated in our earlier review, it's designed to focus on a very small area measuring just 49 x 37.5mm. Moving the camera further than 70mm from the object being tested enlarges the view, naturally, but passes outside the focus point, meaning the pin-sharp 320 x 240-resolution thermal imagery becomes blurred and defocused to the point of uselessness.

There are very few interesting devices worth analysing with a smaller area than 50

A 3D-printed tool allows the fixed-focus lens to be adjusted at will



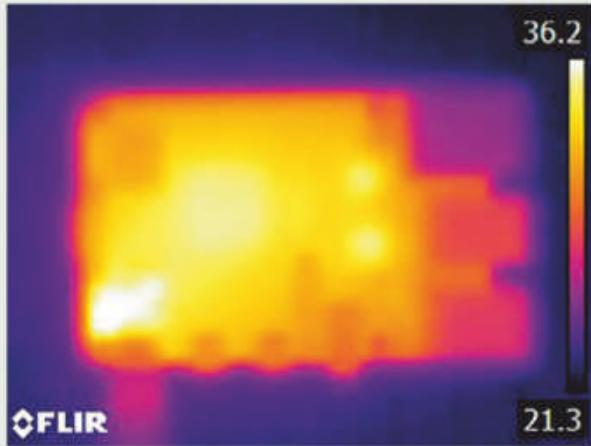
x 38mm; any larger device, from a compact Raspberry Pi Zero to an ATX motherboard, either needs to be analysed section by section, or you need to replace the ETS320 with a different thermal camera. You're then left with a trade-off between price and resolution, with the handheld cameras of equal resolution being considerably more expensive than the ETS320, while the cheaper handheld cameras such as the C2 drop the resolution as low as 80 x 60.

Officially, the ETS320 is a fixed-focus thermal camera. The focal point of the camera is set at the factory, and there's no mention of adjusting it in any of the documentation. Unofficially, however, it is adjustable, as long as you have a particular tool.

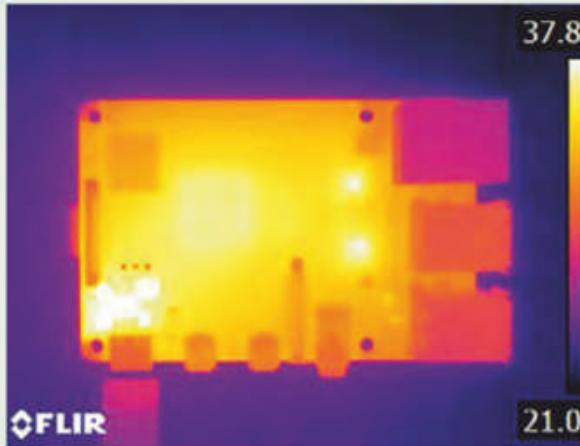
Lining up the tool with the indentations in the lens housing is a little awkward, but worth the effort

A look at the underside of the camera unit itself reveals a single lens set in a housing surrounded by a strange star pattern – the ETS320 lacks a visible-light camera, which is used on many FLIR thermal camera models to create a blended, edge-enhanced image known as multi-spectrum imaging (MSX). It's the star pattern that allows the lens assembly, floating in front of the thermal sensor itself, to be screwed inwards and outwards, adjusting the focal point away from the factory-set 70mm distance.

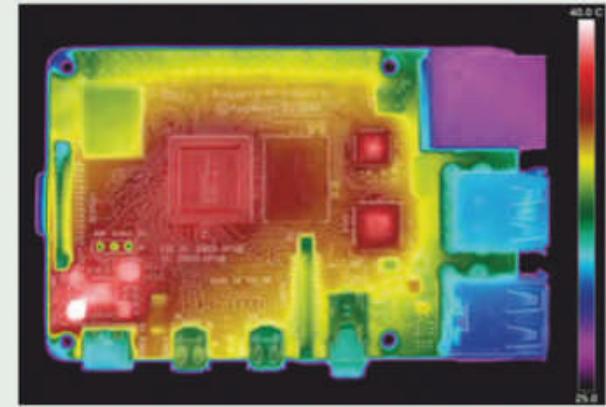
While FLIR, presumably, has the tool required to fit the lens housing in its factories, it won't sell you one, which is where the hobbyist community comes to the rescue. All FLIR E-series cameras use the same lens system



Without adjustment, capturing the entirety of even a small board, such as the Raspberry Pi 4, is impossible



After adjustment, the thermal image comes through pin-sharp and with much more useful data



The thermal data can be extracted and overlaid on a visible-light image, mapping perfectly to the curves of the board

for the thermal sensor, and it wasn't long after their launch that a reverse-engineered tool became available to download from 3D printer file-sharing service Thingiverse at thingiverse.com/thing:188896

The small tool, which can be printed on any hobbyist-grade 3D printer, has a smaller star-pattern end that fits into the lens assembly. The larger end is designed to be gripped in order to twist and turn the lens assembly – you screw clockwise to move the focal point one way, or anticlockwise to move it the other way.

The hole in the middle isn't just there to reduce the material needed to print the tool either. It also allows for a partial view through the tool, meaning it's possible to watch the

screen – or a larger external display (the E-series cameras act as webcams when connected to a host machine via USB) – as the focus is adjusted, just as you would with a manual-focus visible-light camera.

The difference is stark. Prior to adjustment, moving the camera higher on its mount would create a blurry, useless image, but it's now possible to shift it right to the top for a wide-angle view and still capture useful data. It's even possible to rotate the camera assembly to shoot in a semi-handheld mode, extending the flexibility further.

There are, naturally, caveats to this trick. The first is that, in theory at least, it's possible to completely unscrew the lens assembly

or tighten it enough to strip its threads, either of which stands a very good chance of damaging both the lens and the sensor behind it. The second is that this method is very much unsupported by FLIR, and could cause problems if you send off your camera for warranty repair or calibration without adjusting the lens back to the factory-set focal distance. Third, as the lens assembly isn't designed to be regularly adjusted, it will likely be quite susceptible to wear and tear, so it's a good idea to be sparing on just how much you do move it.

For the ETS320, it's also slightly trickier to use than handheld cameras. The tool has a tendency to skip out of the lens assembly if it's not held completely flat, and having to do so from underneath the camera is awkward at best.

These are relatively minor points, however, when compared with the benefits offered by the hack. The ability to switch the focus on demand makes it possible to use the ETS320 for high-resolution overview thermography, whereas out of the box, it's only usable for close-up work where you need to concentrate on one particular area of a board on test.

This wider view also allows for an easy way to overcome the lack of MSX capabilities. The raw thermal data can be extracted from the JPEG files the ETS320 saves. It can then be processed, upscaled and overlaid on an edge-enhanced visible-light image of the board on test. This will provide a highly detailed, at-a-glance look of heat distribution that simply can't be offered by a stock ETS320.

The FLIR ETS320 remains available from custompc.co.uk/ETS320 priced at £3,118.80 inc VAT.

NEWS IN BRIEF

Cooler Master launches Raspberry Pi case crowdfunder

Enthusiast PC brand Cooler Master has launched a crowdfunding campaign for the Pi Case 40, an aluminium chassis for the Raspberry Pi 4. 'Pi Case 40 is the result of an intense co-working between our engineers and key community ambassadors, from computer scientists, to musicians, to gamers,' claims Cooler Master's Matteo Stracciari. 'Pi Case 40 sports a unique features set and a cooling solution worthy of Cooler Master's name.'

The aluminium case includes a TPU rubber bumper, VESA-compatible mounting brackets, and a 90-degree GPIO header with silkscreened labelling. The case is scheduled for delivery in September from kickstarter.com, priced at €23 (around £21 ex VAT).



REVIEW

Do You Compute?

Ryan Mungia and Steve Heller's *Do You Compute?* has the tagline 'Selling Tech from the Atomic Age to the Y2K', and it's a nostalgia-grab coffee-table tome with a difference. There's no shortage of books filled with screenshots of classic games now, and even books capturing imagery of the hardware are catching up now too. However, *Do You Compute?* doesn't look at the software and the hardware per se, but instead looks at how companies advertised them, reaching all the way back to the 1950s and stopping just short of the millennium.

The book opens, and closes, with full-page, full-colour prints of James Balls' iconic vintage computer photography, followed by introductions by the book's co-creators. These are short essays that concentrate on advertising and appearance, rather than technical details or even commercial success.

The meat of the book is split decade by decade, and places advertising brochures, photographs and other ephemera on the page, usually with little more than a company

name and a date. A few notable launches get a paragraph or so of text for context, such as the Captain Zilog comic brochures of the 1970s, but the collected imagery is the focus.

All the imagery is presented in high-quality, full-colour print on glossy paper, and is properly credited to its parent company. It's clear that Mungia and Heller took the proper route, seeking copyright clearance from each of the companies featured. It's the right, and legal, approach, but it has left an unfortunate hole in the book. Page 157 is almost entirely blank, bar a short paragraph captioning an image that isn't there: an advertising poster for the Apple II microcomputer.

'Apple,' the accompanying note reads, 'respectfully declined to be included in the book.' It's a major blow – Apple's advertising, from the iconic Big Brother Superbowl advert through to 'Think Different' and 'Rip, Mix, Burn', has long been a leader in advertising technology to the masses, and you won't find any of that between the covers of *Do You Compute?*



A coffee-table book with a difference, *Do You Compute?* looks at how computers have been advertised

It's a loss, but not a fatal one to the book. There are plenty of companies who were happy to cooperate with Mungia and Heller, and with nearly 50 years of material to cover, readers won't feel shortchanged.

There's delight to be found in the opening spread for each chapter too – a timeline, with one small image for each entry, covering the biggest technological advances and product highlights of the decade covered.

Flicking through *Do You Compute?* is an undeniable delight. Those of a certain vintage themselves will find the later chapters filled with familiarity, although it's surprising to see Microsoft's advertising ignored until the era of Windows 98. Meanwhile, more experienced readers will likely find long-dormant neurons firing at the sight of posters advertising the Remington Rand UNIVAC II, or the IBM 702 Electronic Data Processing Machine.

Do You Compute? is available under ISBN 978-0-9916198-2-5 for a recommended retail price of £40 (VAT exempt). At the time of writing, **Blackwells.co.uk** had the book on offer for a bargain price of £18.70. **CPC**



The book is well presented and packed with imagery, although Apple's absence is a definite loss

WIN —

A BE QUIET! 1,500W DARK POWER PRO 12 PSU

We have a truly amazing PSU up for grabs this month, courtesy of the kind folks at be quiet! The be quiet! Dark Power Pro 12 not only has 1,500W of power on tap, but it also has 80 Plus Titanium efficiency certification. This PSU offers world-class performance and virtually inaudible operation, thanks to its full digital control and frameless fan concept.



- 80 Plus Titanium efficiency (up to 94.9 per cent)
- Full digital control (PFC, LLC, SR/12V) and full bridge topology
- Patented frameless Silent Wings fan for virtually inaudible operation at ordinary load
- Full mesh PSU front with redesigned funnel-shape opening
- Overclocking key switches between six 12V rails and one massive 12V rail
- Japanese 105°C capacitors ensure highest stability and reliability
- Aluminum case and modular, individually sleeved cables
- Ten-year manufacturer's warranty

WORTH
£420

SUBMIT YOUR ENTRY AT
CUSTOMPC.CO.UK/WIN

DARK POWER 12
NO COMPROMISE SILENCE AND PERFORMANCE

be quiet!



Competition closes on Friday, 9 October. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation and Raspberry Pi Trading, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from Custom PC magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked.



ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

My case wish list

If you're an old-timer like myself, and you've seen the transition from beige boxes devoid of decent features, to fantastic models such as the Fractal Design Define 7 and Phanteks Eclipse P600, you'll know just how far PC cases have come. There have been lulls to be sure. It wasn't that long ago that I was complaining that all PC cases had started to look the same, with front mesh panels, black exteriors and a modicum of cable-tidying features.

Then it was all change with the move to tempered glass panels, closed front panels and RGB lighting. I'm not really complaining about these features either. RGB lighting can look great when it's used tastefully, and tempered glass panels also add to the aesthetic prowess of your PC. However, the case features that improve cooling or really make it easier to build a better PC are what interest me.

I'm the first to admit that in the past, for example, I've raved about

**PWM fan hubs
enable you to
control multiple
fans from one
motherboard
fan header**

fan controllers being included with cases. However, if a case now turned up with manual dials, buttons or sliders to control the fans, I'd be appalled. Motherboard fan control is no longer a massive pain to set up, and manufacturers now include fully customisable fan response graphs that give you easy, detailed control over each fan header.

This means I'd much rather have a case with a PWM fan hub that can connect to a motherboard. These hubs allow you to tap into your motherboard's fan control system, but have just one



cable running from your motherboard to the hub, before splitting out of sight to all your fans. I'd like to see this feature in more cases, as it makes it much easier to set up both air and water-cooled PCs, and more ports on existing cases would be useful too.

Fractal Design has wowed me over the past month or two with its Define 7 and Define 7 Compact. We've seen removable fan mounts on cases from other manufacturers, such as Phanteks – the roof fan mounts in the Eclipse P600S and Evolv X can be lifted out, which makes installing fans and radiators far easier in this location.

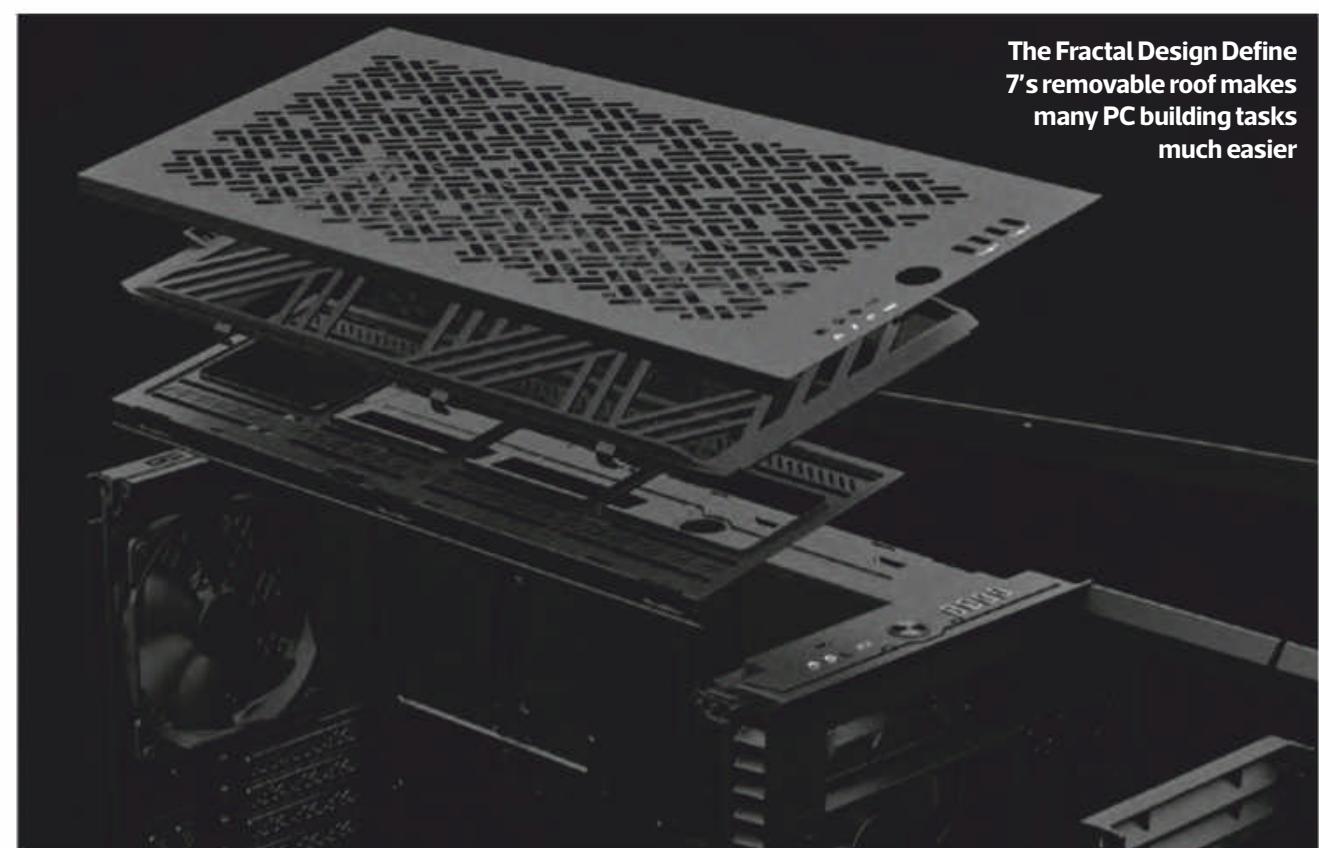
However, Fractal Design's new cases go one step further and make it easy to remove the entire roof section – frame and all. As we saw in last month's Dream PC feature, this makes installing a high-end water-cooled PC so much easier. The only time I found it easier to install a water-cooling system was when I'd removed a case's rivets and fully dismantled it.

While some new case features may only save a few minutes of your time, and could well be used just once, the removable roof is absolutely a feature I'd want if I intended to build a water-cooled PC. In fact, I'd find it very hard not to pick the Define 7 for this feature alone.

Fractal Design has also been at the forefront of cable-tidying improvements. Its simple large Velcro ties have made cable-tidying much easier on several PCs I've built using its cases, and they inspired a recent modding guide of mine, where I showed how to add them to your own case.

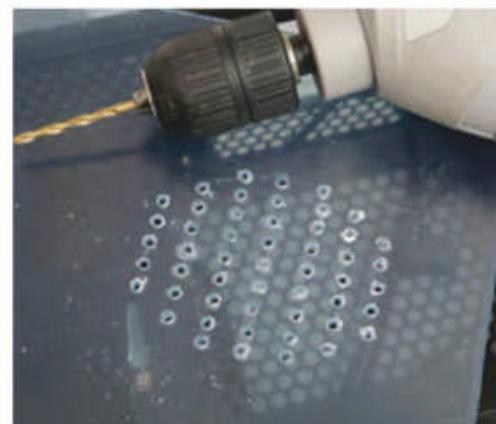
In my view, it's not just tricky to deal with standard cable ties, but they're also not reusable and you never get enough in the box. I would like to see more cases coming equipped with Velcro ties, even in budget cases, but especially in models costing upwards of £100. And not just a few of them, but enough to properly build a whole tidy PC – even the Define 7 could have done with a few more in the box.

It's Fractal Design to the rescue again with its swap-out roof panels too. Aside from giving any buyer a good deal of excitement when they see the size of the accessory box, being able to alternate between a clean exterior and a well-vented roof just adds further to a case's flexibility. Phanteks has also provided similar features on its cases.



The Fractal Design Define 7's removable roof makes many PC building tasks much easier

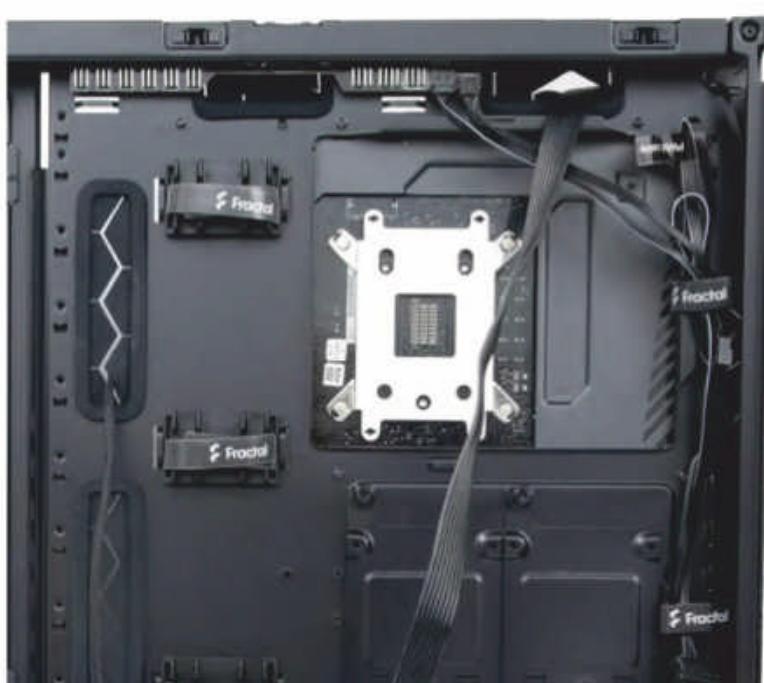
Case manufacturers could offer clear vented panels to reduce GPU temperatures



If it isn't possible with glass, then using high-quality acrylic would solve that problem. Plus, unless you're up close, you can't easily tell the difference between tempered glass and decent-quality acrylic anyway – at least I can't. Even a small ring of vents near the GPU fan can dramatically drop GPU thermals, meaning owners of high-end systems could use the second panel, while those who prefer glass or use cooler-running systems could use the glass panel.

Fractal Design may be at the forefront of case design right now, but one company rarely stays at the top for long and there are clearly plenty more features I'd like to see included with future cases. Other manufacturers will likely catch up quickly too – whenever you think you've reached the peak of case design, several new killer features will suddenly come along.

That said, PC cases have never been better than the ones available right now, and while they've historically been stuck with similarly lengthy upgrade cycles to PSUs, cases are quickly latching on to the same sort of upgrade desire from enthusiasts as graphics cards and motherboards, so the next 12 months could prove interesting. **CPC**



Velcro ties are so much better than standard plastic cable ties

The idea of replaceable panels got me thinking about other cases too. I've seen a lot of cases struggle when the graphics card is placed vertically and sat next to the side panel. The close proximity next to an unvented surface doesn't give the cooler enough room for proper airflow, leading to higher GPU temperatures – significantly higher in some cases.

Modifying a side panel to include vents can dramatically improve GPU temperatures, and while doing this with a glass panel could prove tricky, manufacturers could consider offering alternative panels. These panels would be especially useful for mini-ITX cases, as many mini-ITX cases have airflow arrangements where the graphics card sits next to a side panel, but not all of them include vents to aid airflow.

How to Use glass and metal tubing

Often seen as the pinnacle of hard tubing materials, **Antony Leather** shows you how to cut and prepare glass and metal tubing

 **TOTAL PROJECT TIME** / 2 HOURS

Metal and glass tubes look great in a custom water-cooling loop, yet it's surprisingly easy to work with these materials compared with acrylic and PETG (see p102). You can't bend the tubes yourself, but pre-bent sections are available for most types of bends, meaning a lot of the hard work is already done for you. However, these tubes are expensive, meaning mistakes will cost you dearly. In this guide we'll take you through the best tools to cut and prepare your glass and metal tubing for use in your water-cooling system.

TOOLS YOU'LL NEED



Rothenberger
tube cutter
wickes.co.uk



Masking tape
Most hardware
stores



Glass or metal tube
overclockers.co.uk



Mini blow torch
Most hardware stores



Sandpaper
Most hardware stores



Glass cutter
amazon.co.uk



1 / BENEFITS OF GLASS AND METAL TUBING

Glass tubing is an alternative to acrylic and PETG, while metal tubing comes in a range of colours. Glass offers exceptional clarity, and it generally isn't susceptible to staining. Unlike PETG tubing, both glass and metal will never get hot enough to deform either.



2 / CONSIDER PRE-BENT TUBING

If you'd rather not use fittings to join your lengths of metal or glass tubing at bends, you can buy pre-bent sections. You can't bend them at home unless you use copper pipes, but even then you'll need special tools, such as a pipe bender, and you'll also need to get the copper plated, which can be expensive.



3 / USE ANGLED JOINTS

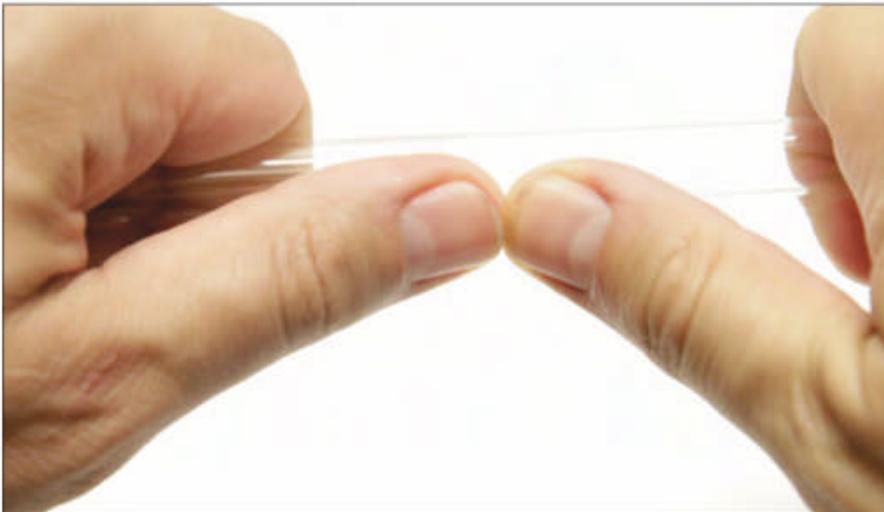
Using a 90-degree fitting is the easiest way to join two lengths of rigid tubing, and is much quicker and cheaper than making bends at other angles when it comes to building your loop.

GLASS TUBING



1 / SCORE GLASS TUBE

The simplest way to cut glass tube is to snap it, which isn't as scary as it sounds at first. Start by scoring the tube all the way around it using a glass tube cutter. Once you can feel the score in the tube with your finger, it's ready to be cut.



2 / SNAP TO CUT

Place your thumbs behind the score, and have the rest of your fingers at the front. Press firmly with your thumbs on the score and the tube should snap with a clean cut at that point.



3 / FLAME-POLISH EDGES

Use a mini blow torch to lightly melt the edges, so they become rounded. This will allow the tube to slide into the fittings. Also, make sure there are no sharp edges, as these can damage the O-rings in your fittings. You can also use 400-grit sandpaper for this job, but be sure to use goggles and a mask to protect yourself against glass dust.

METAL TUBING



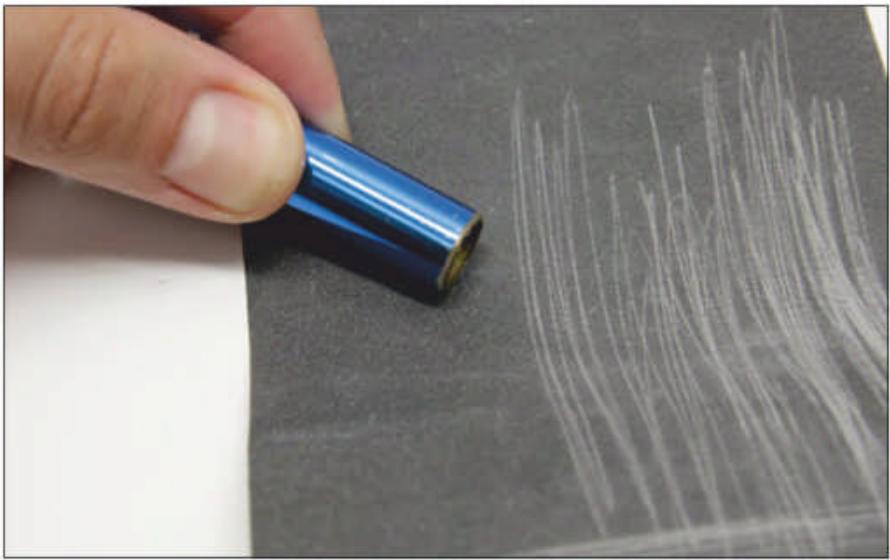
1 / APPLY MASKING TO METAL TUBING

With metal tubing, you'll need to take care of the exterior, as the plating can be delicate. Apply masking tape to the areas on which you'll be working, and mark up the point you need to cut.



2 / USE A TUBE CUTTER

Use a tube cutter to gradually eat into the tube. Rotate it slowly and, when it becomes easier, tighten the tool a little and continue rotating the tube. Repeat this process until the tube separates into two pieces.



3 / FILE EDGES

The edges will likely have shards on them, and will be very sharp, so use sandpaper to get rid of these hazards on the outer edge, and use a tube reamer to work the inside if necessary.

How to Use acrylic and PETG tubing

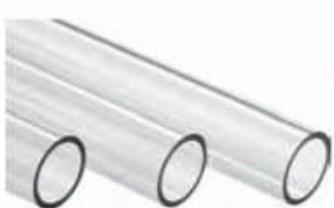
Antony Leather shows you how to cut and bend hard tubing made from PETG and acrylic

& **TOTAL PROJECT TIME** / 2 HOURS

Acrylic is by far the most popular material used for rigid tubing in water-cooling systems, but polyethylene terephthalate glycol (PETG) serves a similar purpose, allowing you show off your coloured coolant and offering the ability to include clean bends and a super-snazzy look with your PC.

The bending process can be a challenge, though, and creating your loop will be much more time-consuming than flexible tubing, so this guide is for enthusiasts who want to play with bends and create a unique water-cooled PC. The two materials need slightly different methods, but we've explained the steps for both acrylic and PETG, so you know which one to choose and how to work with it.

TOOLS YOU'LL NEED



Acrylic or PETG tubing
watercoolinguk.co.uk



Pipe cleaner or metal rod
Most hardware stores



Tube bending tools
watercoolinguk.co.uk



Hacksaw with
fine-tooth blade
Most hardware stores



Tube insert
watercoolinguk.co.uk



Tube reamer
watercoolinguk.co.uk



Washing-up liquid
watercoolinguk.co.uk Supermarket



1 / PETG VS ACRYLIC

Acrylic tubing is favoured for its higher melting point, meaning it's less susceptible to higher coolant temperatures, but is trickier to heat and bend. Conversely, it's much quicker to work with PETG, but it can deform if your coolant gets too warm and it occasionally suffers from kinks when bending.



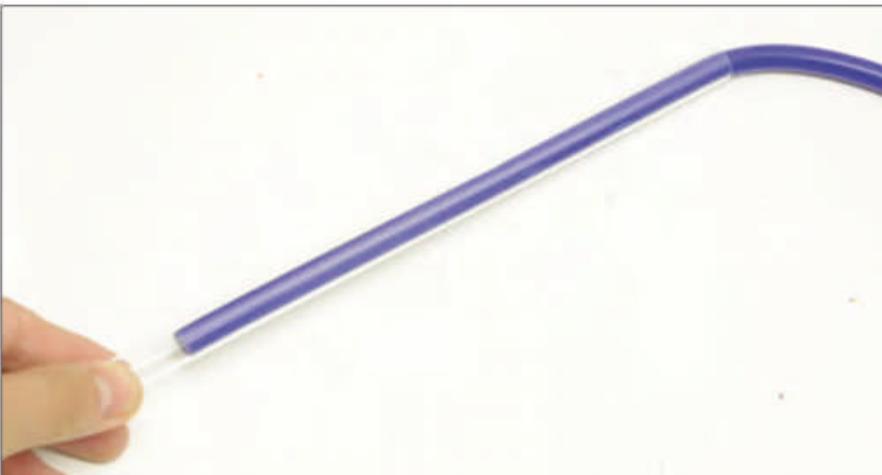
2 / WORK OUT LENGTHS AND BENDS

Pipe cleaners or thin metal rods are ideal for working out the lengths and locations of bends in your tubing. Place one end resting on the tube support inside your tube fitting, and bend the pipe cleaner to the required angle. You can now use it as a template.



3 / USE LUBRICANT

The anti-kinking insert can become lodged inside the tube once it's bent, so it's important to use lubricant. Washing-up liquid works well for this purpose, but be sure to rinse the tube thoroughly afterwards.



4 / INSTALL INSERT

The insert prevents the tube from kinking when you bend it, which will happen instantly without it. Place it so that there's at least four inches on either side of your bend location.



7 / ALLOW TUBE TO COOL

With the tubing fed into the bending tool, if you're happy with your work and the tube looks to be free of bubbles and deformities, allow it to cool for 30 seconds, by which time it will be strong enough to handle.



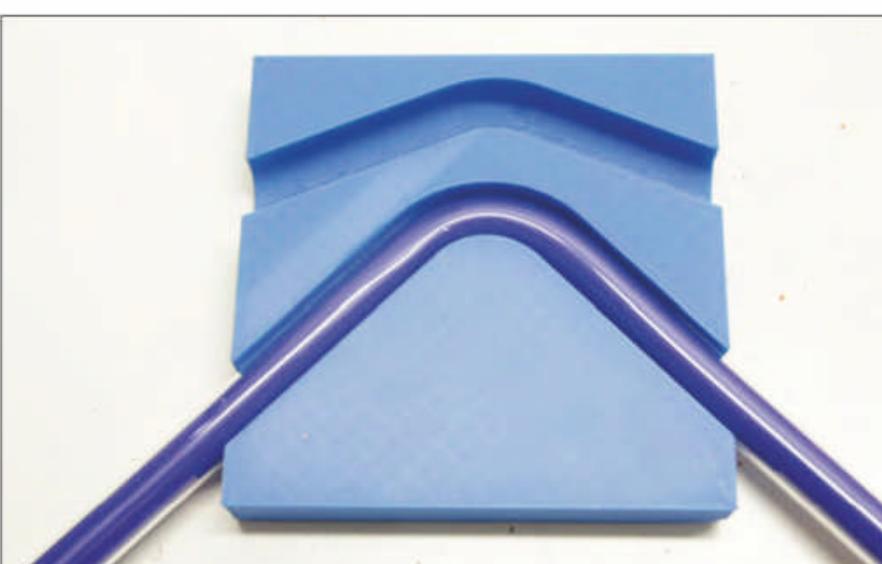
5 / HEAT TUBING

Use a heavy-duty heat gun to warm the tubing evenly from 2in away, going back and forth quickly across either side of your bend point. PETG tubing takes least 15 seconds to become malleable, while acrylic takes longer. Too much heat will cause bubbles to form, so practise on a spare section first to find the right balance.



8 / CUT TO SIZE

To cut PETG or acrylic tubing, use a hacksaw with a fine-tooth blade, and gently allow the weight of the saw to cut through the tube at your desired location. Too much pressure can crack the tube, so take it easy.



6 / USE TUBE BENDER

Once your tubing is heated correctly, feed it gently into your tube bender with the corner of the bend aligned with the centre of the section you just heated. If it doesn't bend enough, try warming the tubing for a few more seconds.



9 / USE A TUBE REAMER

Finally, a tube reamer is required to chamfer the outer edge, so the tube slides into the fittings more easily. The reamer also has a tool for scraping the inside of the tube to remove any debris from cutting.



How to Measure and cut soft tubing

Making a water-cooling loop with soft tubing is much less hassle than doing it with hard tubing, and it still does the job fine. **Antony Leather** shows you how to use it properly

 **TOTAL PROJECT TIME** / 2 HOURS

Hard acrylic and metal tube might be all the rage, but it's blissfully simple to work with soft flexible tubing by comparison, and it's much cheaper too. Used correctly, every water-cooling tube and fitting will be leakproof, but even traditional flexible tubing can cause leaks if it isn't cut properly, so in this guide we'll show you what you need to create super-straight cuts in any tube size. We'll also talk about the different types and sizes of tubing available, as well as how to accurately measure the tubing in order to link the components in your loop.

TOOLS YOU'LL NEED



Tube cutter
watercoolinguk.co.uk

Flexible tubing
watercoolinguk.co.uk



1 / CHOOSE THE RIGHT FLEXIBLE TUBE

There are various sizes and types of flexible tubing available, depending on the diameter of tubing you want to use. It's available in a variety of colours, as well as clear PVC for showing off your coolant, and matt black rubber. Thicker tubing will also be more resilient against kinking in tight spots than thinner tubing.



2 / MEASURE TUBE TO FIT

It's easy to measure the lengths of flexible tubing needed between components. Attach one end of the tubing to a component, and run the tubing to the next part. Don't add so much that the tube sags, while too little means it needs to stretch – both situations can lead to kinking.



3 / USE TUBE-CUTTING TOOL

The most important advice for dealing with flexible tubing is to invest in a tube-cutting tool. Don't use a knife or scissors, as they can result in uneven edges, which can cause leaks. Place the tubing into the cutter support and slowly close the blade. The tool can be used with any thickness of tubing too. **CPC**

Folding@home

Join our folding team and help medical research

ACTIVE USER MILESTONES

USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE
PC_Rich	6,000,000,000	Jim	3,000,000
Dave_Goodchild	800,000,000	leeoliver24	2,000,000
tarka_dahl	500,000,000	Peanut.Rec.	2,000,000
GWallace	200,000,000	Benharvey1985	2,000,000
Aardwork	200,000,000	Mabinogion	2,000,000
1car1_Garforth	100,000,000	jettison_theory	2,000,000
pcchameleon	100,000,000	Andy_Mclean	2,000,000
NoizDaemon666	90,000,000	Dodge1990	2,000,000
Teq554	70,000,000	Mabinogion	2,000,000
jonesd98	70,000,000	Lightning	1,000,000
Macrosb	60,000,000	markdiss	1,000,000
teens:)unite	60,000,000	PendragonOrion	1,000,000
dis80786	60,000,000	Sonic67	900,000
Garry_Rees	40,000,000	Matt_Livermore	900,000
40138	40,000,000	Sidog21	900,000
SgtDunk	40,000,000	Trotski	700,000
Count_Stex	40,000,000	Jim	500,000
dmackey828	30,000,000	IanPocock	400,000
GreenPig	30,000,000	yonedafolding	400,000
Chaplain-Brawl	30,000,000	MDT	300,000
YCDCN22	20,000,000	Cole	300,000
jvbrugger	20,000,000	Jared18639	300,000
Manda_Chuva	20,000,000	Wenna	200,000
Sypei	10,000,000	JRJE	200,000
Liaw_Jun_Xian	10,000,000		
MEH/Desktop	10,000,000		
gKitchen	10,000,000		
kim	9,000,000		
Maleor	8,000,000		
marcostheblack	8,000,000		
GJBriggs	7,000,000		
Will_Walton	4,000,000		
TheLimey	4,000,000		
Howard	3,000,000		

WHAT IS FOLDING?

Folding@home uses the spare CPU and GPU cycles for medical research, with a current focus on COVID-19. You can get the client from foldingathome.org/start-folding and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag – we'll print all the milestones we can fit on the page. You can discuss folding with us and other readers online at the bit-tech forums (custompc.co.uk/FoldingForum).

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	Shirty	21,313,154	4,715,397,464
2	DocJonz	13,086,367	12,137,743,944
3	Dave_Goodchild	7,966,437	838,758,320
4	tarka_dahl	7,006,996	514,701,351
5	Desertbaker	6,038,254	2,394,731,179
6	PC_Rich	5,734,496	6,096,080,404
7	Lordsoth	5,653,296	4,282,301,179
8	Slavcho	3,494,778	2,875,826,450
9	pcchameleon	1,666,141	109,236,237
10	MEH/Desktop	1,661,784	11,786,144
11	rjcmn	1,558,852	179,536,708
12	sonic_vortex	1,448,723	488,695,976
13	Allan_Smith	1,319,675	687,479,634
14	dis80786	1,220,504	63,547,452
15	Bloo_Toon	1,131,102	274,855,018
16	gKitchen	1,127,233	14,712,913
17	BurnedFastfood	1,124,807	134,121,066
18	Simlec	1,099,637	177,817,486
19	Little_Willie	1,071,476	250,310,526
20	Chaplain-Brawl	1,061,320	38,606,051

TOP 15 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	DocJonz	12,137,743,944	322,643
2	PC_Rich	6,096,080,404	161,944
3	Shirty	4,715,397,464	36,560
4	Nelio	4,638,586,520	523,610
5	Lordsoth	4,282,301,179	172,723
6	HHComputers	3,544,050,839	85,007
7	Slavcho	2,875,826,450	67,241
8	piers_newbold	2,703,256,197	107,638
9	Scorpuk	2,544,487,884	57,720
10	Desertbaker	2,394,731,179	58,685
11	clanseven	2,223,720,446	33,156
12	Unicorn	1,753,462,654	57,079
13	daxchaos	1,637,104,710	41,302
14	Laguna2012	1,527,029,380	51,930
15	apeman556	1,473,567,286	52,001

Readers' Drives

Cesar

Taking design cues from various guises of Batman's flamboyant nemesis, Tom Keen set about making twisted tubing bends and having custom parts made for this Joker-themed build



CPC: How did this project start? What inspired you to build a PC based on The Joker?

Tom: The build originally started as a form of rehabilitation, where I was trying to help with my brain condition and it snowballed from there. Originally, I was trying to improve my short-term and multitasking memory and it sort of went from there. Comics inspire me more than anything when building a PC. I've had an interest in comics for decades now, especially when it comes to the villains and anti-heroes.

I feel like I relate to The Joker in a way, and I love his over-the-top nature, not to mention the colours. This PC also contained my first real attempt at

a proper custom loop, so I wanted to do it justice. I have other projects down the line waiting to become a reality as well.

CPC: What distribution plate is that at the front?

Tom: The distro plate was supplied by Barrow, and it's not the best example of that company's work, as it didn't fit well. It was being used with components that weren't compatible with it, and it had no instructions, so it took a while to work out the flow paths.

Not many distro plates were around when I was building this PC, although I now own my own CNC machine, as well as a lot more tools and parts that I couldn't access at the time. I now mainly focus on making my own parts where possible.

CPC: Those are some tight bends and turns in the tubing – why did you go for this look?

Tom: When I think of The Joker, the first word I think of is 'twisted', so I tried to incorporate twists in various places – I hadn't tried doing

this before, so I was glad it worked. Also, if The Joker built anything, I thought it was probably going to look industrial and built to serve its purpose, rather than looking clean and structured, so I tried to incorporate that look into it.

CPC: What material did you use for the tubing, and how did you go about measuring, cutting and making those bends?

Tom: I tend to stick with 16mm PETG tubing, usually from Thermaltake, although I'm starting to look more into using glass in the future. For cutting, I use my trusty little pipe cutter, but I tend to gauge measuring and bending with my eyes and do it freehand, which I find a lot easier. On this particular occasion, the tubing was finished with a satin spray to give it a frosted effect.

CPC: How did you make the custom Joker fan grille?

Tom: The design was my own, and it was manufactured by Gorilla Gaming in Gateshead. The laughter was probably the hardest factor to



/MEET THY MAKER

Name Tom Keen

Age 36

Occupation

Modder/parent

Location Co Durham

Main uses for PC Gaming, design work and running machinery (CNC)

Likes Family, hoodies, comics and any form of electronics

Dislikes Bananas, needles and feet



design, because I wanted it to look a certain way, but the end result turned out amazing.

GPC: Where did you get the custom purple and green PSU cables?

Tom: The cables were custom-made by Adam at Simple Sleeving. At the time, I believe this was one of his first sets of cables. I'm quite lucky in a way, because there are

GPC: Take us through the water-cooling loop. Is it just the one radiator?

Tom: It is one radiator. It wasn't originally supposed to be a single radiator, but it just ended up that way due to various factors. The performance was still impressive, so I stuck with it. Pretty much every cooling component used is made by either Bykski (GPU block) or Barrow

When I think of The Joker, the first word I think of is 'twisted', so I tried to incorporate twists in various places

quite a few PC modders and builders in my local area, as well as businesses that have helped a lot as I've been learning. I would have been lost without some of them.

GPC: How did you plan the cable routing?

Tom: I have a thing about being able to see cables, so I hide them wherever and however possible! I had very few issues keeping all the cables neat in the Lian Li case – if anything, I had room to spare. Routing the cables for the Corsair fans was probably the most tedious job, due to the amount of wires, but even then, I managed to get them all neatly tucked away.

(fittings, distribution plate, pump and tubing), and I still use both companies' kit. I can't fault them for their price-to-performance ratio, and they offer some designs you don't tend to see normally. I'm a sucker for anything that's out of the ordinary and eye-catching.

GPC: What's the picture on the GPU waterblock?

Tom: It's actually Joker art I came across quite a while before I started the build, and I loved it. The picture is based on Jack Nicholson's Joker, and he was the first Joker I ever knew so it holds nostalgic memories for me. It was difficult to make this choice, as I have a few favourite





variations, but I love the circus-orientated and flamboyant side to The Joker more than anything else.

CPC: Does the water-cooling system allow a decent overclock, or is it more optimised for quiet operation?

Tom: It's actually more geared towards quiet operation than overclocking, and the ML fans definitely help. At that time, I was more interested in gaming than other software, although that has changed dramatically and I now spend more time designing and planning on my PC.

CPC: What's the bright green coolant?

Tom: It's a mix of XSPC UV green dye and white coolant – it was a fantastic colour, until around three days after the pictures were taken

and then it separated, which wasn't pretty. I tend to stick to Mayhems Pastel UV Green now, which has no issues.

CPC: What specs did you choose and why?

Tom: I went purely for gaming-orientated specs, and I already owned some parts, such as the Core i7-7700K CPU, which I had previously delidded, as well as the MSI GeForce GTX 1080 Ti Gaming X Trio graphics card and Corsair ML Pro fans. I was lucky enough to find the Asus Maximus board while I was looking for a completely different board, and it more than ticked the boxes I needed. It has built-in water-cooling support as well as a monoblock and fantastic overclocking abilities – it was really a no-brainer and it's still one of my favourite boards.

SYSTEM SPECS

CPU Intel Core i7-7700K (delidded and overclocked to 4.8GHz)

Case Lian Li PC-011 Dynamic

GPU MSI GeForce GTX 1080 Ti Gaming X Trio

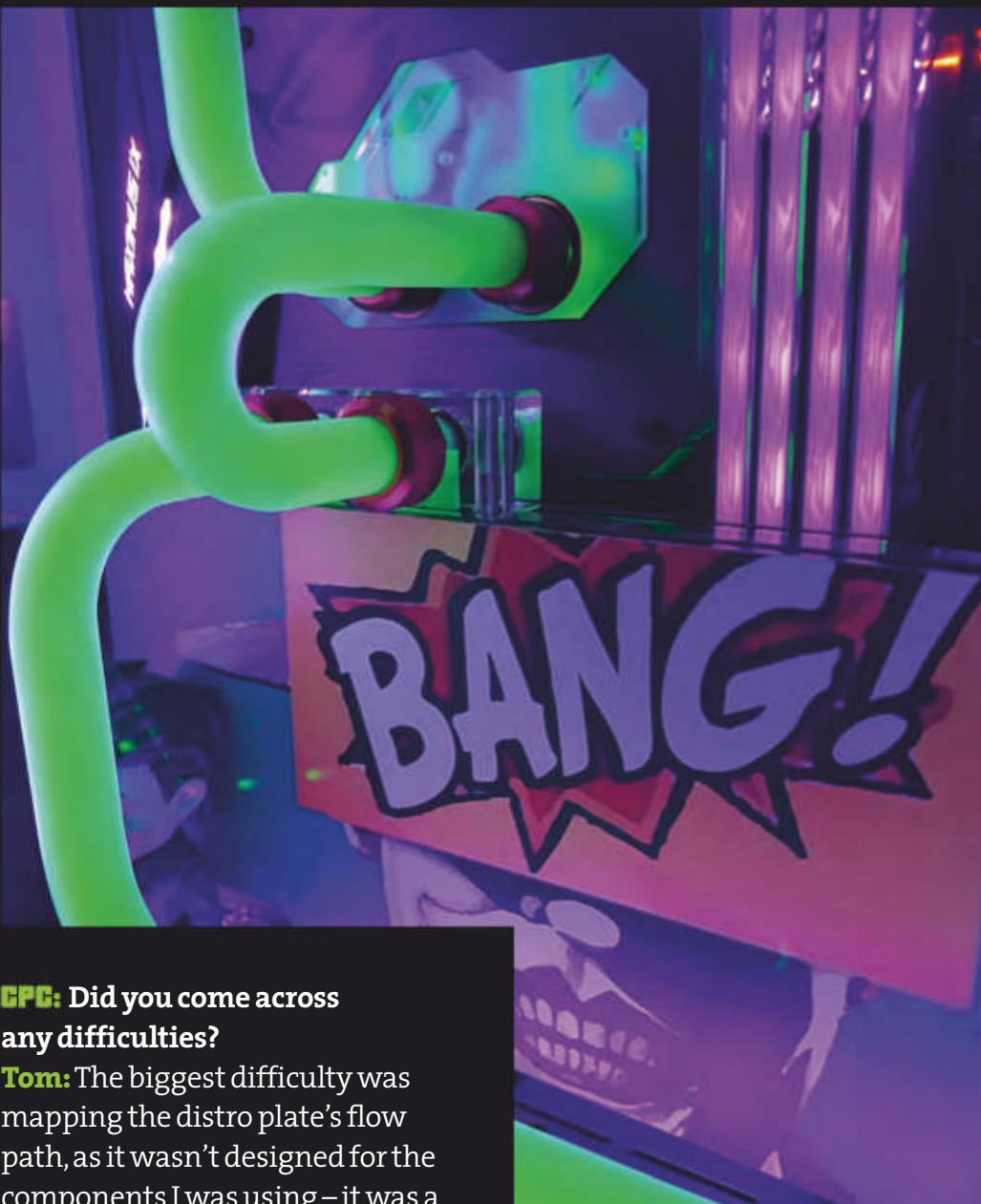
Storage 512GB Aorus 512 M.2 NVMe SSD, 500GB Samsung Evo 840 SSD, 500GB Samsung Evo SSD

Memory 16GB (2 x 8GB) Aorus 3200MHz DDR4

Motherboard Asus ROG Maximus XI Code

PSU EVGA Supernova 750W G2

Cooling Barrow 240mm radiator with 2 x Corsair ML120 Pro fans in push configuration, 3 x Corsair ML120 Pro fans on back intake, 20 x Barrow Hard Tube Fittings (10 x red, 10 x white), Barrow DDC PWM pump, Barrow distribution plate with Alphacool and Phanteks 90-degree fittings



CPC: Did you come across any difficulties?

Tom: The biggest difficulty was mapping the distro plate's flow path, as it wasn't designed for the components I was using – it was a completely different model from the one I ordered. That sounds simple enough, but it took me a while with my memory loss. There was also nearly a major issue when test-filling the loop, as the radiator that was installed at the start had some unseen manufacturing damage.

After filling the loop, I could hear a faint hiss of air from above the 8-pin CPU socket on the motherboard, and I just managed to get my hand underneath the radiator in time to stop the liquid hitting the motherboard. That was pretty nerve-wracking, especially when you consider that this was my first main modding project.

CPC: How long did it take you to complete this build, from start to finish?

Tom: From design to the end product, I would say a few months, mainly due to having custom work

made and waiting for parts. The physical building took around two days, including leak testing. I have a habit of not stopping unless I absolutely have to.

CPC: Have you got any tips for people who are interested in building a system with hard-tube water cooling?

Tom: Research, don't be afraid to make mistakes, don't try to please everyone and enjoy it!

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?

Tom: Overall, it's one of the nicest builds I've done, and I've come much further since, thanks to this great end result. If I had the knowledge and tools I have now when I started, it would have looked very different. **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



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



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 the AM4/LGA1151 or LGA2066 version.

Corsair Hydro X Series XR5 240mm Radiator



The Corsair Hydro X Series XR5 240mm Water Cooling Radiator delivers extreme custom cooling performance, with a 30mm radiator thickness and premium copper core. Its dual 120mm fan mounts on each side are ready for your most ambitious custom cooling build, and its 25 micron-thick cooling fins offer a high thermal transfer rate.



JAMES GORBOLD / HARDWARE ACCELERATED

OPTIMISING THE ULTIMATE JACK-OF-ALL-TRADES

James Gorbolt considers how to spec up optimum PCs for different purposes

Just like one my other hobbies, target shooting, specing a PC is a complex and ongoing process of refinement. For target shooting, you start with deciding the distance(s) at which you're going to shoot, which leads onto calibre, the type of gun, ammunition load, optic and gun rest. As with many hobbies, you repeat that cycle, tweaking and upgrading your loadout, and adding aftermarket parts.

The process for building and upgrading PCs is equally complex, with a multitude of interlinked decisions that have an impact on one another. Just like target shooting, you first need to decide what types of games and software you're going to run the most. This is critical, because despite the PC being a decent jack-of-all-trades, you'll have a far better experience if your PC is speced for its purpose.

For instance, the three main types of content creation software all have quite different hardware priorities. When specging up an audio PC, your highest priority should be latency and I/O, which means not just picking the right CPU, but also the right audio devices and motherboard, so it has the right combination of USB, Thunderbolt, storage and network controllers.

You also need to be very careful about graphics cards, as many drivers increase latency to an unacceptable level. In addition, you need to extensively tweak the EFI and Windows to ensure your music doesn't suffer from any artefacts caused by a lag in processing. Ultimately, it may even mean you need to invest in a second PC if you also want to play games.

In contrast, building a PC for video processing means striking the right balance between CPU and GPU performance, while keeping enough budget aside for high-performance and

You may need to invest in a second PC if you also want to play games

spacious storage. Until recently, the CPU was king for video work, and indeed, it's still critical for many applications, but an increasing number of workflows now run far faster on a GPU, so it's important to research which applications and codecs you'll be using.

Graphics and visualisation applications are also sensitive to your hardware configuration. For instance, AutoCAD is still stubbornly single-threaded, so you should choose the CPU with the highest clock speed and instructions-per-clock possible.

In contrast, many rendering and computational fluid dynamics (CFD) applications favour the number of CPU cores as opposed to CPU core throughput. You need to be careful with choosing a GPU as well – unlike gaming, where you not only need to consider a graphics card's number of stream processors and its amount of VRAM, some graphics applications also run at different levels of floating point precision, and not every graphics card is equal in this regard. For instance, despite being two generations old, Nvidia's Quadro GV100 is still the fastest GPU in double-precision floating point maths.

While specging up a gaming PC is generally easier than a content creation system, it's still worth thinking about the sort of games you play the most. For instance, many online competitive games, such as MOBAs, are deliberately programmed to be playable on basic hardware configurations, so you may be wasting cash if you splash out on a ray-tracing GPU, a tonne of CPU cores and a glorious ultra-wide display.

In contrast, single-player-focused high-fidelity games have higher hardware requirements and will run best on a carefully balanced combination of a powerful GPU, CPU, RAM and SSD. **OPC**

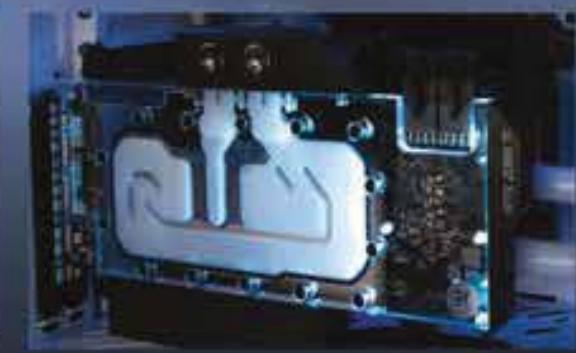
James Gorbolt has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

3XS SYSTEMS ePRO GAMING

Every 3XS PC is a Dream PC



Scan recommends
 Windows 10



Spec up your perfect PC today

 scan.co.uk/3XS • 01204 47 47 47

SCAN 



G-MASTER™
#MONITORS 4 GAMERS
by iiyama

RED EAGLE™



Immerse yourself in the game with the curved
GB3466WQSU Red Eagle with FreeSync Premium Pro



Inspired by the curve of the human eye, the 1500R curved VA panel with 144Hz refresh rate, 1ms MPRT and the 3440x1440 resolution, guarantees superb image quality and a comfortable and very realistic viewing experience.

