BUDGET GPUs WE TEST 7 NEW AND OLD CARDS TO FIND THE SWEET SPOT

CUSTOM PC

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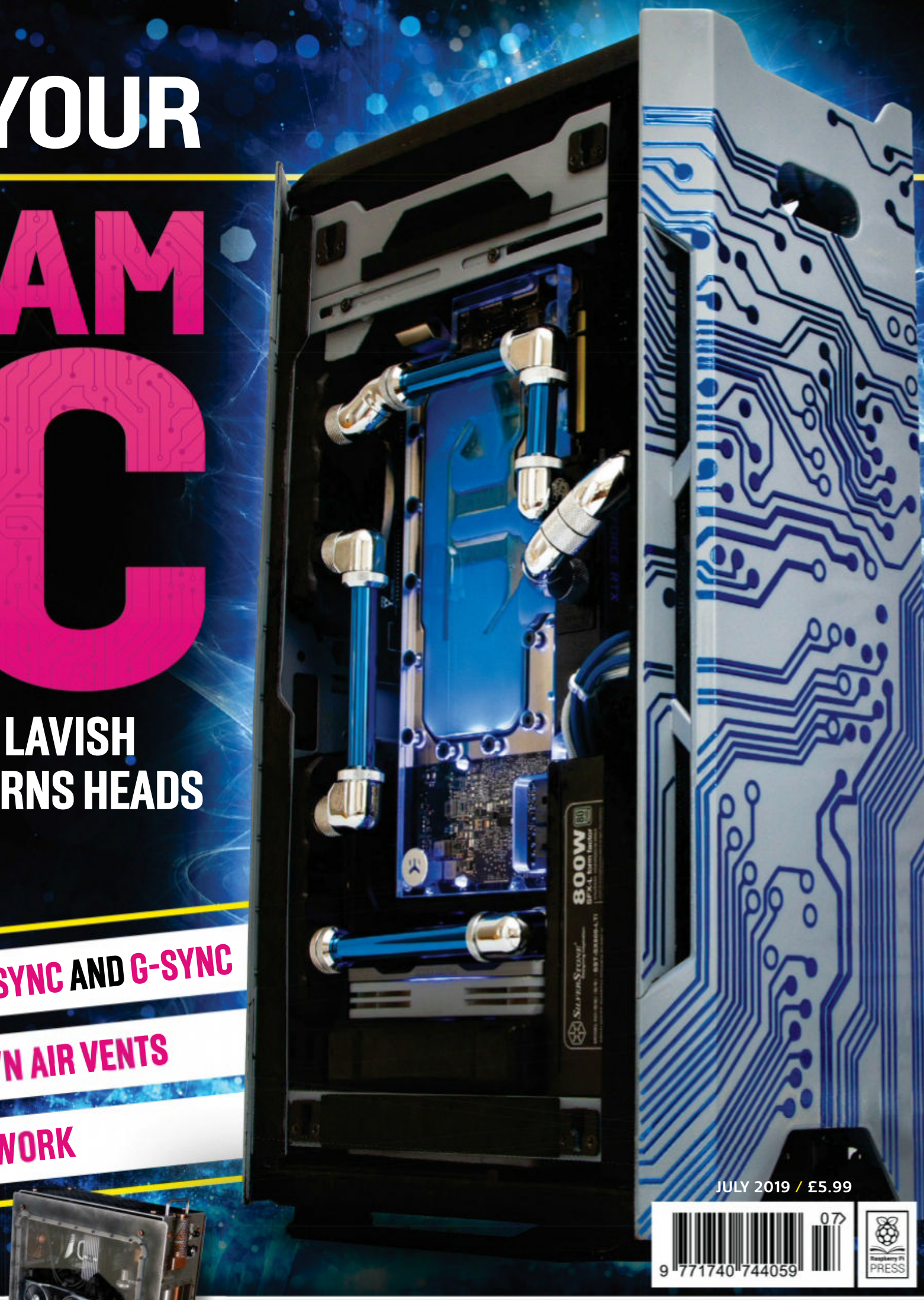

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Welcome

Custom PC Issue 190

/ FROM THE EDITOR

Sweet dreams

Just look at that cover. In fact, don't just look at it, run your fingers over it and feel it. Isn't that spot gloss exquisite? More to the point, isn't Antony Leather's dream PC build a beauty? If you fancy having a go at building your own dream PC, then turn to p76 to find out what's involved, from inspiration and planning through to cutting and painting.

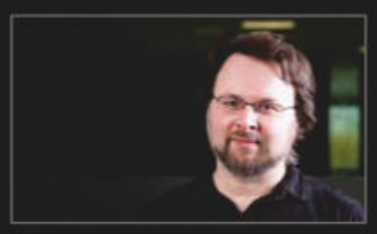
Other highlights in this issue include a dive into the technology that makes LCD monitors tick (see p88), as well as a full exploration of the £200-£300 graphics card market (see p42), comparing old and new GPUs to find the sweet spots.

This issue also sees us introducing a few changes to **Custom PC**. Firstly, you'll no doubt have noticed that, in addition to the fancy cover finish, we've changed the paper size. However, we've been very careful not to reduce the number of words on each page in the process.

We've also cut down a fair bit of the 'filler' from the past design. The Elite list (see p62) has been condensed down to six pages, for example, and now features bundles of core components for assembling a number of builds for different budgets. We've removed a few other superfluous pages as well, and expanded the number of pages for features, reviews and Labs tests.

The core focus of this design refresh hasn't been so much 'revamping' **Custom PC** as making it work better, while retaining the core focus. We've paid attention to the feedback received in our recent reader survey, as well as correspondence from our readers, and made a few tweaks to bring back some of the classic **Custom PC** magic.

The Readers' drives section (see p111) is now focused on readers of the mag again, rather than professional modders, for example – send us photos of your rig if you'd like to be involved! You'll notice a few other tweaks too. Next month, we'll also be bringing back the Retro tech section due to popular demand We're really pleased with what we've done with this issue, and we hope you enjoy reading it as much as we enjoyed making it. CPC



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CUSTOM PC

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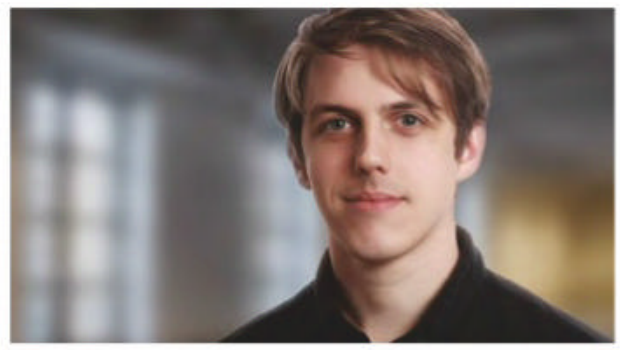

RICHARD SWINBURNE / VIEW FROM TAIWAN

WHAT GOOGLE STADIA GOT WRONG

A bad launch could earmark yet another Google product for the bin, argues Richard Swinburne

What started out as Project Stream became Google Stadia at GDC 2019. This game streaming service is a bit like Netflix for games, meaning you only need an app and a controller to play, and the game itself is rendered and streamed from a Cloud server. Rather than launching the service, the big reveal actually turned out to be a teaser ahead of the real launch later this year. While regular readers of my column will know I expect to see several game streaming services arriving over time, Google Stadia probably won't last the course.

At the launch, Google compared Stadia to the PS4 Pro and Xbox One, claiming a performance leadership with '10.7 TFLOPs of GPU performance', while also ignoring PC gamers in the process. The problem began here: Google has no brand currency among gamers, and to poke them in the ribs and say 'we're better than your favourite platform' only provokes a territorial reaction of 'no thank you'.

When the demo system tried to play Assassin's Creed Odyssey, the people watching the feed could see the input-to-action latency. For me, this latency cemented Stadia's downfall, because this game needs precise timing to execute some moves and counterattacks, especially when you get to the legendary enemies deeper in the game.

Maybe the demo exacerbated some underlying feelings about streaming, but I'm confident that there's no need for PC gamers to get stressed. Since the PC ecosystem isn't controlled by one company, its experience is difficult to replicate. The PC also has a huge user base; publishers aren't going stop selling through Steam, GOG or other stores.

Since the PC ecosystem isn't controlled by one company, its experience is difficult to replicate

What amazes me, though, is that Google didn't address its huge Android gaming ecosystem. Not only would doing so potentially bring PC-quality graphics to smartphones, but it could also greatly increase the quality and diversity of titles. There are plenty of popular genres that aren't latency-crucial – sims, city builders, puzzle and strategy games are solid potential streaming candidates.

At around the same time as the Stadia reveal, Valve launched Steam Link Anywhere. It's an Android app that basically offers the equivalent of Valve's Steam Link device. It lets you stream any game from your Steam library to your Android phone or tablet, over Wi-Fi or 4G. The app basically just streams Big Picture mode to your phone, with the addition of virtualised inputs for mouse or gamepad via touch-screen controls.

Sadly, after some testing using a touch-screen with fat thumbs on games designed for use with a mouse, the experience ranges from frustrating to unplayable. I couldn't get a connection over 4G at all, which is a shame, as I'm dying to play full-fat Civilization VI while I'm on the train, but even on Wi-Fi (it only needs 100Mb/sec), I still experienced over 100ms of latency and frequent performance blips from my PC.

The app is only in beta, so it's expected to a bit rough around the edges, but Valve hasn't yet publicly committed to developing it further. If its previous projects are a reliable gauge, though, I'm not holding my breath. That would be a crying shame, because Valve would sell more PC games if this app worked properly – it gives gamers more options for games they already own, and more of an excuse to upgrade their rig rather than their phone. CPC

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @Bindibadgi

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TRACY KING / SCEPTICAL ANALYSIS

DUBIOUS AUTHORITY

Tracy King pulls apart Prince Harry's latest comments about Fortnite and game addiction

Authority is strange. There's a common perception that one sort of authority equals another (for example, a doctor might be considered an authority in their field of medicine, and also a moral authority because they've dedicated their lives to helping people). It can hold true – although there are plenty of exceptions – but what happens when someone has authority that they didn't get by being an expert on anything? In this case, I'm talking specifically about Prince Harry.

Harry used to be the rebellious royal, dressing as a Nazi for one private party, playing strip billiards at another. He was a kind of fond tabloid joke, but then he grew up and beardy, and became a serious royal who spends his days advocating for various charities and good causes. He's great PR for that sort of thing, not because of any particular expertise, but because he's royalty, and to many people, royalty equals authority.

But that's precisely why he's made it into this column. It's bad enough when academic or political authorities make unfounded, fearmongering claims about video games and technology, but at least the public is justified in thinking they might know what they're talking about. When Prince Harry does it, he's speaking from no higher authority than his own backside. According to the BBC, at a recent speech in London, he said about Fortnite:

'That game shouldn't be allowed. Where is the benefit of having it in your household? It's created to addict, an addiction to keep you in front of a computer for as long as possible. It's so irresponsible. It's like waiting for the damage to be done and kids turning up on your doorsteps and families being broken down. He also said social media was 'more addictive than alcohol and drugs'.

When Prince Harry does it, he's speaking from no higher authority than his own backside

This is all tosh of the highest royal order. There's more evidence for the existence of ghosts in Windsor Castle than there is to back up Prince Harry's claims. But – putting aside the democratic nightmare of royal family member suggesting something perfectly legal should be banned – it's easy to see why he believes this stuff. Fuelled by media reporting and often dodgy science, lots of people think games and smartphones are bad for us. In his new book, Lost in a Good Game, psychologist Dr Pete Etchells explains:

'For as long as video games have existed, there have been questions about their addictive properties. In a letter to the Journal of the American Medical Association in 1982, researchers at Duke University Medical Centre reported three cases of men ... who they claimed had "Space Invaders" obsession.' Prince Harry's remarks about Fortnite will seem just as silly in years to come. Dr Etchells goes on to explain why it's not straightforward to claim games are addictive:

'Games are, by their very nature, hobbies designed to be immersive and interactive – therefore, standard criteria for addiction, such as being preoccupied with them, or playing them instead of engaging in other hobbies, doesn't really sit well as a benchmark for "harmful engagement.""

As we've seen in previous columns detailing the government's, and even medical science's, premature acceptance of gaming addiction, it really matters when authorities say this stuff. It opens the doors to unproven and potentially harmful treatments (such as the 'gaming addiction boot camps' in China), and can rob kids of their right to access the same culture and technology as everyone else. It also makes me very cross. Next time a prince wants to wade in on the video game debate, he'll have to get past this King. CPC

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

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PHILIPS

Incoming

We take a look at the latest newly announced products

New budget Nvidia GPU

Nvidia has unveiled the GTX 1650, a new budget option for both its desktop and laptop GPU ranges, with prices for desktop cards starting from £138 inc VAT at **scan.co.uk**

It's based on Nvidia's new TU117 GPU, and includes 14 Turing streaming multiprocessors, giving it a total of 896 stream processors. Memory support tops out at 4GB of GDDR5, connected to a 128-bit bus, resulting in total memory bandwidth of 128GB/sec. Meanwhile, the stock GPU base clock sits at 1485MHz, with a 1665MHz boost clock.

In comparison, Nvidia's GTX 1050 includes 640 stream processors, and has a 1354MHz base clock and 1455MHz boost frequency, along with the same 128-bit memory interface. Meanwhile, the laptop GTX 1650 actually includes more stream processors (1,024) and texture units (64) than the desktop part, but Nvidia has reduced its clock speeds. We'll be taking a look at the desktop GTX 1650 next issue.

Fractal Design goes all out on glass

If you like tempered glass, Fractal's new Define S2 Vision case should be right up your street. It's fully wrapped in dark tempered glass panels, for a see-through but smoky look that's ideal for showing off the bits you want visible while hiding the darker, untidier depths of your PC. Available in two variants, the S2 Vision RGB (pictured) includes four of the company's Prisma ARGB fans, and additional RGB lighting strips. Alternatively, you can opt for the Blackout edition, which ditches the RGB lighting and uses Fractal's Dynamic X2 PWM Black fans.

Elsewhere, the case offers the usual Define S2 features, including a USB 3.1 Type-C connection on the front panel, a full-length ventilated PSU shroud, capacity for up to 420mm radiators and a total of nine fan mounts. The downside to the new S2 Vision is a price that reflects the use of so much of a premium, heavy, material. The RGB version has a pre-order price of £225 inc VAT at **scan.co.uk**, while the Blackout costs £180 inc VAT.

AOC launches 200Hz HDR ultrawide monitor

AOC has announced the AG353UCG, a new ultrawide 35in monitor that combines a 200Hz refresh rate with a full array local dimming (FALD) backlight. That's where the display uses several LEDs – 512 of them in this case – to individually control the backlight brightness of different areas of the screen. It enables the AG353UCG to conform to the top-tier DisplayHDR 1000 standard, which requires a display to produce a dazzling 10,000:1 contrast ratio.

Elsewhere, the AG353UCG includes a 3,440 x 1,440 resolution and supports a wide colour gamut, while the housing incorporates RGB lighting, four USB 3.1 ports, speakers, and both DisplayPort and HDMI video inputs. Like its direct competitors, the forthcoming Acer X35 and Asus PG35VQ, the AG353UCG uses a VA-type LCD panel rather than IPS. Pricing is expected to be around the £2,000 mark.

Corsair updates gaming mice

Corsair has introduced a new wireless mouse that the company claims has a sub-1ms latency and a range of up to 33ft, thanks to Corsair's own Slipstream wireless technology. The new Ironclaw RGB Wireless also supports Bluetooth, has a battery life of up to 50 hours and can be connected directly via USB so that you can charge it while it's in use. With an 18,000dpi PMW3391 optical sensor, gaming performance is sure to be impressive, and you get ten fully programmable buttons as well. The Ironclaw has a price of £70 inc VAT, and it has a hefty weight of 130g.

Also new to the company's line-up is the Glaive RGB Pro (pictured), which takes the original Glaive's modular design with interchangeable side grips, but adds RGB lighting and the same 18,000dpi sensor as in the Ironclaw wireless.

Intel laptop CPU hits 5GHz

Intel has announced six new laptop CPUs, with the new flagship Core i9-9980HK offering eight cores (and 16 threads via Hyper-Threading), along with a 5GHz maximum turbo speed frequency. That K on the end of the name also denotes an unlocked multiplier.

Elsewhere, the range includes another CPU with eight cores and 16 threads, but a locked multiplier (the Core i9-9880H), and two 6-core chips with 12 threads (the Core i7-9850H and 9750H). There are also two quad-core models with eight threads (the Core i5-9400H and 9300H). Surprisingly, the whole range has the same thermal design power (TDP) rating of 45W TDP.

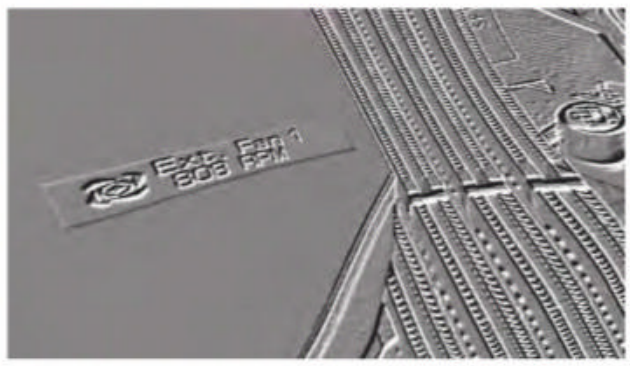
All the processors will also support Intel Optane memory and Wi-Fi 6 (802.11ax), but will still use the same HD graphics 630 of previous-generation chips. The company has also broadened its desktop CPU line-up, with a range of processors that fill some existing gaps, such as the Core i9-9900, which is essentially a non-overclockable version of the Core i9 9900K.

WIN

A be quiet! DARK BASE PRO 900 CASE!

What's that?

Our pals at be quiet! are offering a Dark Base Pro 900 Rev. 2 Silver case to one **Custom PC** reader. The image below is a distorted close-up of a piece of hardware in this issue. If you identify it, email the name and page number of the product to competition@custompcmag.org.uk, with 'What's that? 190' in the Subject field.



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Driver watch

Nvidia enables ray tracing on GTX GPUs

Nvidia has released a new driver that enables some GTX-branded GPUs to run real-time ray tracing. The list of supported GPUs includes the Turing-based GeForce GTX 1660 and 1660 Ti, as well as older Pascal-based GPUs, from the GTX 1060 6GB to the GTX 1080 Ti. However, these GPUs don't have the dedicated RT cores found in Nvidia's RTX GPUs.

We tried it out in Battlefield V on a GeForce GTX 1070 and it does indeed work. However, there's a severe performance hit from not having the RT hardware. Even at 1080p, the GTX 1070 dropped down to 27fps with High DXR, compared to 41fps on the RTX 2060. Likewise, with Low DXR enabled the RTX 2060 never dropped below 60fps, while the GTX 1070 lagged behind with a minimum of 40fps.

Letters

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

Realistic SSD testing

I read your roundup of the latest NVMe SSDs with interest last month. However, your testing methodology got me thinking. The headline drive speeds and IOPS results are way in excess of what a 'normal' consumer is likely to need. Also, these figures are only really achievable at high queue depths, typically QD32, which isn't representative of consumer PC use.

Would you consider adjusting your SSD testing methodology to include more tests that are representative of what consumers are actually likely to encounter?

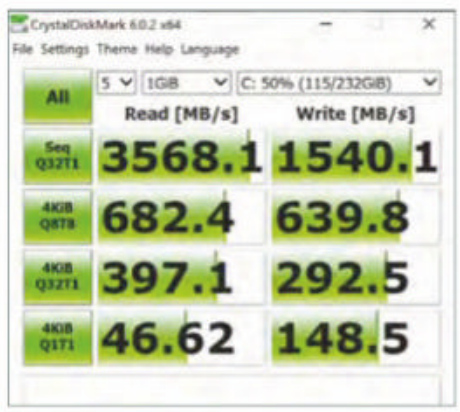
GEORGE POWELL
(subscriber for many years now)

Edward: This concern has been at the back of my mind for a while too, and we'll certainly consider tweaking our SSD tests in the future. While these extreme synthetic tests are useful, more meaningful real-world tests are always preferable.

That said, there are two key problems. The first is that there simply aren't many real-world tests that can challenge these drives. Where we used to be able to test areas such as Windows boot and game loading times, the storage is now so fast that the difference between drives in these tests can be fractions of a second.

Likewise, file transfer tests are meaningless if your source drive isn't fast enough to keep up with the drive you're testing.

One compromise might be to more extensively test with IOmeter. It's still a synthetic test, but by tailoring its access patterns to be more reflective of real-world access patterns, we might be able to eke out some more meaningful results. We'll try a few out a few ideas over the coming months to see what's best for showing meaningful differences between drives, as well as relatable results.



Synthetic tests help to show the performance difference between drives, but the big numbers are rarely indicative of real-world use

Balance of power

Just a thought, but why don't you have PSUs on your Elite list? I assume you don't test them as they're not the sexiest pieces of kit. As you well know, though, a good PSU is essential to builders who want to overclock or build a high-end gaming PC.

ANDREW SHORTHOUSE

Ben: We stopped reviewing PSUs a couple of years ago, not because they're not sexy enough, but because the strict requirements of the 80 Plus scheme now effectively cleans out the dregs. In the past, we used to see cheap PSUs actually exploding in the lab when put under their supposedly rated load, and we also saw huge differences in efficiency. However, our last few PSU Labs tests showed that you now only need to look at a PSU's 80 Plus rating and you'll get an accurate reflection of its maximum load and efficiency – you then just need to make a decision about what sort of cabling and connectors you want. It's been a long time since we've tested a genuinely unstable PSU – they're basically commodities now. CPC

Twitter highlights

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@adzgaming Chilling in Ibiza with a copy of **@CustomPCMag**

@KdePeteb Are there any irresistible subscription offers?
Ben: *There are indeed – you can get your first three issues for a fiver! See p40.*

@ChrisGomez37 It seems that something has gone a bit wrong as @zinio is still showing issue 187 as the latest one. Would you be able to look into it? I'd like to catch up with 188 & 189!
Ben: *Thanks to everyone who brought this to our attention, and sorry for the delay here. It's been a licensing spaghetti junction getting the digital issues sorted out after the transition to a new publisher, but I think we're there now. All the latest issues are now available to download on Zinio.*

Correction In our Issue 189 interview with Andrew Back about the RISC-V PC, we mistakenly listed Andrew's name as Andrew 'Black' rather than 'Back'. We apologise for this mix-up.

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Fans
2 x 140mm

Stated noise
Up to 31dBA

Alphacool's new all-in-one liquid cooler, the Eisbaer Extreme 280, seeks to build on previous models with a larger, more attractive radiator, a more powerful pump and the use of a proper DIY water-cooling CPU waterblock, complete with snazzy lighting.

The Eisbaer Extreme 28's price reflects the fact that it comprises a bunch of water-cooling components plucked from Alphacool's high-end DIY parts range. Thankfully, though, unlike many of its previous efforts at making combined pumps and radiators, this time Alphacool has gone with its own version of the Laing D5 pump, instead of the whiny DC-LT pump used in the Alphacool Eissturm Gaming Copper (see Issue 188, p41).

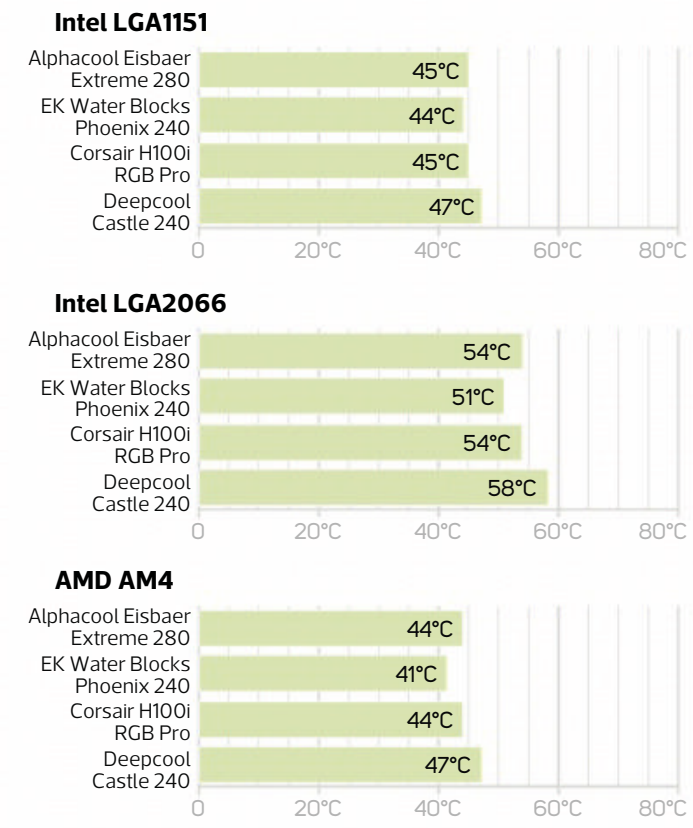
Normally, the D5 is rated at over 1,000 litres an hour, but it's also quite noisy at this speed, so most owners opt for a PWM-controlled version, or the Vario model with its built-in speed controller, to rein in the pump and drastically cut noise levels with little impact on cooling. The VPP755 pump used in the Eisbaer Extreme 280 looks like a D5, but it's only rated at up to 340 litres an hour. That figure is at the lower end of speeds at which you'd want to run the D5, but it's still far more powerful than the pumps in most all-in-one liquid coolers.

The pump is practically inaudible at full speed, but on performing a teardown of the unit and removing the metal radiator cover, we spotted that the pump has the same control dial as the D5 Vario, offering full control over its speed range. Alphacool claims the speed can be adjusted down to 120 litres an hour, but unless you're extremely sensitive to noise and the rest of your system is super-quiet, you likely won't need to tweak this dial.

Strangely, there's no cut-out to access the control dial, which is a shame given it's a useful feature, and reassembling the housing is extremely fiddly – you won't want to do it regularly. It's next to impossible to access the dial once the radiator is installed and the rest of the system is running, which is when you'd actually want to be tweaking the fan speed.

Another issue is the size of the housing. It looks fantastic, but at nearly 160mm wide, 64mm deep and 385mm long, it may not fit into cases that can accommodate other 280mm all-in-one liquid coolers, especially if you plan on installing it

TEMPERATURE (DELTA T)



	LGA1151	LGA2066	AM4
COOLING	38/40	36/40	36/40
FEATURES	17/20	17/20	17/20
DESIGN	19/20	19/20	19/20
VALUE	18/20	17/20	15/20
OVERALL SCORE	92%	89%	87%

in the roof – measure your case first. However, the reason for its girth is that all of the water-cooling components are housed inside the radiator unit. The pump, refillable reservoir, radiator and fans all reside inside the housing with just the cables, tubes and waterblock protruding, meaning you don't need to find space for reservoirs or pumps.

The pump is powered by a 4-pin Molex connector, while the fans are wired to a single 4-pin PWM cable, allowing you to control their speed using your motherboard's BIOS or software. This setup also means there's no software with the Eisbaer Extreme 280, not least because it doesn't have RGB lighting either, but the simple approach is quite refreshing – as long as you don't mind heading into the BIOS to fine-tune the fans. Alphacool has opted to include be quiet! Silent Wings 3 140mm fans, which can spin at up to 1,300rpm and top out at a noise level of 31dBA.

Meanwhile, the Eisblock XPX CPU waterblock is compatible with all current CPU sockets out of the box, including AM4. However, the mounting kit is quite fiddly, with the need to install nuts, washers and springs. You also need to pay careful attention to how far the mounting screws protrude into certain CPU sockets. It's certainly not as easy to fit as many other all-in-one liquid coolers we've tested.

With the pump being more than powerful enough to push coolant around the Eisbaer Extreme 280's own loop, Alphacool has also added quick-release fittings to both tubes, allowing you to quickly and easily add components to the loop.

A graphics card waterblock would be first on our list, since the large 280mm radiator has plenty of headroom if you're just cooling a mainstream CPU. You would just need to add quick-release fittings to plug into the existing ones, although both the CPU waterblock and radiator use standard G1/4in fittings, so you have all sorts of other options here.

PERFORMANCE

The slow-spinning fans made a pleasant change from the monstrous blades on recent all-in-one liquid coolers we've tested, such as the Corsair H100i RGB Pro, yet the Eisbaer Extreme 280 managed to match that cooler on all sockets, and do much better than the Deepcool Castle 240, too.

The EK Water Blocks Phoenix managed noticeably better results on our AM4 test rig, though, despite having a smaller radiator, trimming 3°C from the delta T of the Eisbaer Extreme 280, and the same again when dealing with our Core i9-7900X. However, the Phoenix was much louder at full speed than the Eisbaer Extreme 280, with the Alphacool unit's fans likely limiting its performance.

CONCLUSION

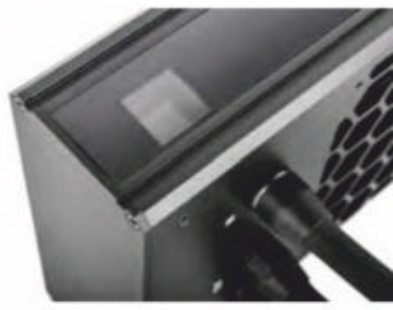
You essentially get a DIY water-cooling loop with the Eisbaer Extreme 280, and its price reflects this situation, as does the ability to add other components. It's also supremely quiet, and none of the other coolers we've tested recently get close to its level of cooling at the same noise levels.

The radiator is a monster, though, and the large shroud and integrated pump, reservoir and fans mean you'll need to check carefully if it will fit in your case. It's cheaper than the EK Water Blocks Phoenix, but it's also much quieter. If noise isn't an issue, of course, there are plenty of cheaper, sealed-loop alternatives, but if you want a combination of low noise and powerful, expandable cooling, the Eisbaer Extreme 280 is worth every penny.

ANTONY LEATHER

VERDICT

A supremely quiet, powerful and expandable CPU cooler.



POLAR BEAR

- \+ Expandable
- \+ Quiet 140mm fans
- \+ Powerful pump

TEDDY BEAR

- – Huge radiator shroud
- – Fiddly mounting mechanism
- – High price

E-ATX X299 MOTHERBOARD

Asus ROG Rampage VI Extreme Omega

/ £588 inc VAT

SUPPLIER scan.co.uk

SPEC

Chipset
Intel X299

CPU socket
Intel LGA2066

Memory support
8 slots: max 128GB DDR4 SODIMM (up to 4266MHz)

Expansion slots
Three 16x PCI-E 3, 1x PCI-E 3

Sound
8-channel SupremeFX S1220

Networking
1x 10 Gigabit LAN, 1x Gigabit LAN, 802.11ac Wi-Fi

Overclocking
Base clock 80-300MHz, CPU multiplier 7-83x; max voltages, CPU 1.92V, RAM 2.4V

Ports
6 x SATA 6Gbps (X299), 4 x M.2, 1x USB 3.1 Type-A, 1x USB 3.1 Gen 2 Type-C, 10 x USB 3, 2 x LAN, 5 x surround audio out, S/PDIF out

Dimensions (mm)
305 x 277

Even though Intel's X299 chipset launched two years ago, Asus has seen fit to revamp its flagship offering, as with the ROG Zenith Extreme Alpha (see Issue 189, p30). In fact, the two boards share a few similarities, but the latter sports AMD's Socket TR4 for Threadripper CPUs, whereas the former is designed to handle the worst that Intel's 18-core CPUs can throw at it.

Intel's decision to increase its core count from ten to 18 in a single generation did, according to Asus, cause problems for motherboard manufacturers that had already nailed down their designs for X299. Then Intel rebranded a bunch of Xeon CPUs to combat AMD's WX-series Threadripper CPUs and, all of a sudden, X299 boards were having to deal with nearly double the core counts. Thankfully, most X299 boards fared well, but even Asus admits that the Rampage VI Extreme didn't have the ideal power circuitry to deal with Intel's monstrous 18-core CPUs.

Both the Zenith Extreme Alpha and Rampage VI Extreme Omega employ similar power delivery, with 16 phases in eight teamed pairs, which Asus claims can better adapt quickly to the huge and sudden power demands of an overclocked 18-core CPU. The result is a monster motherboard, with an enormous fan-assisted cooling array that has to include a tool so you can get at the DIMM slot latches at the top of the slots – they're unreachable when memory is installed due to the proximity of the VRM heatsink.

That's the only niggle with the board, though, which is unlikely to worry anyone unless you regularly swap out memory modules. The rest of the features and layout are exceptional. Again, Asus' new DIMM.2 module is included so you can fit additional PCI-E M.2 SSDs, and it includes two large heatsinks to keep them cool – they reduced the load temperature of our Samsung 960 Evo by 16°C. There are two additional M.2 ports under the large heatsink on the lower half of the board too, as well as a U.2 port. There are only six SATA ports, but that's more than plenty for most people's needs these days.

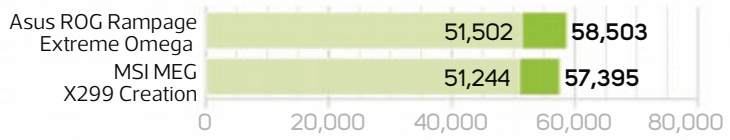
Meanwhile, you get the full array of overclocking and testing tools from Probelt voltage readout points, and an LN2 mode for extreme overclockers. You also get power, reset and clear-CMOS buttons, plus two headers for thermal probes and monitoring water-flow rates. You also get a 36W header dedicated to powering water-cooling pumps – there's plenty for enthusiasts. In addition to the six 4-pin fan headers on the PCB, Asus also includes a fan expansion card that connects to the motherboard using a proprietary cable and offers an additional six 4-pin headers, and three more thermal probe headers, with the card able to sit in a 2.5in bay.

There's plenty of futureproofing here too, with an Aquantia 10Gb on-board network controller in addition to the usual Intel Gigabit LAN, plus a USB 3.1 Type-C port on the rear I/O panel and header on the PCB. We doubt you'll run out of USB ports either, because you get ten USB 3 ports on the I/O panel in addition to USB 3.1 Type-A and Type-C ports.

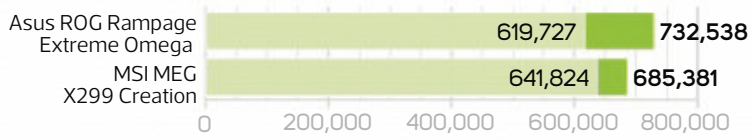
As you'd expect, there's Realtek ALC1220-based audio, with Asus including an ESS Sabre9018Q2C amplifier and

BENCHMARK RESULTS

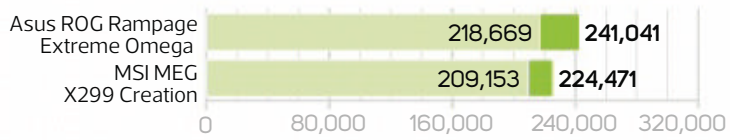
GIMP IMAGE EDITING



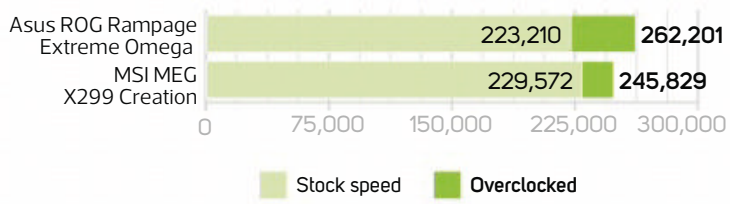
HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTI-TASKING

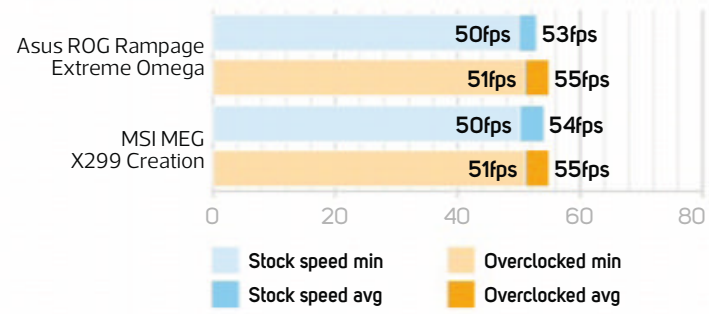


SYSTEM SCORE



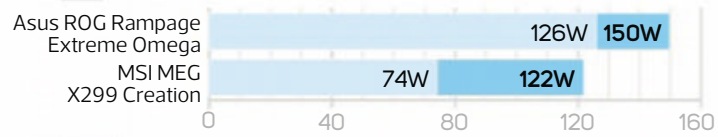
ASHES OF THE SINGULARITY

DX12 CPU benchmark, 1,920 x 1,080, High settings

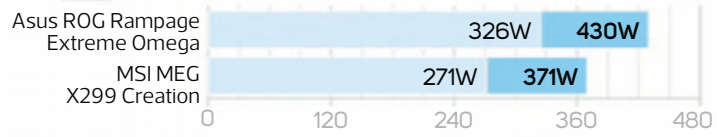


TOTAL SYSTEM POWER CONSUMPTION

Idle



Load



snazzy illuminated audio jacks too. The board looks fantastic on its own, but the aesthetics are backed up by some subtle digital RGB lighting on the PCH heatsink, underside of the PCB and I/O shroud. The latter also sports a LiveDash OLED display, which can be customised to show data such as system temperatures or images.

Performance

Asus' EFI hasn't changed much, which is good, because it's well laid out, although we'd like to see more granularity with fan control – an area where Gigabyte offers more tweaking options. We managed to get our Core i9-7900X to 4.6GHz using a vcore of just 1.16V. Comparatively, MSI's MEG X299 Creation required 1.23V.

The overclock saw the system score rise from 223,210 to 262,201, with the video encoding score rising massively from 619,727 to 732,538. The MSI board was faster and less power-hungry at stock speed, but while it was a little slower when overclocked to the same frequency, it drew 59W less power under load. SSD performance was good too, with our Samsung 960 Evo reading at 3,398MB/sec and writing at 1,875MB/sec.

Meanwhile, audio performance was excellent, with a dynamic range of 114.1dBA, noise level of -114.2dBA and one of the lowest THDs we've seen from a Realtek ALC1220-based audio codec of 0.0019 per cent.

Conclusion

Aside from slightly high power consumption, the Asus ROG Rampage VI Extreme Omega has practically every feature you could possibly want bolted to its E-ATX-sized PCB. It handles hefty overclocks with ease, and is especially well suited to an all-singing, all-dancing liquid-cooled PC with plenty of speedy M.2 SSDs.

The downside, as always with a ROG flagship board, is the price; at nearly £600, it's noticeably more expensive than the competition, and more than double the cost of some X299 boards. However, if you pair its balanced, extensive and futureproofed set of features with a Core i9-9980XE, you won't need to upgrade again for a very long time.

ANTONY LEATHER

OMEGA

- + Overclocks 18-core CPUs with ease
- + Excellent for exotic cooling
- + Masses of expansion possibilities

CASIO

- – High power consumption
- – Extremely high price
- – Fiddly memory slots

VERDICT

A monumental motherboard that brings back the Rampage name with a bang and plenty more besides.

PERFORMANCE **32/35**

DESIGN **33/35**

VALUE **22/30**

OVERALL SCORE **87%**

Z390 MOTHERBOARD

MSI MPG Z390 Gaming Pro Carbon AC / £180 inc VAT

SUPPLIER cclonline.com

MSI's MAG Z390 Tomahawk (see Issue 188, p26) has already made an impact in the land of sub-£200 Z390 motherboards, including plenty of premium features for under £160. However, there were a few notable omissions and cut-backs, some of which are addressed by the MPG Z390 Gaming Pro Carbon AC, which still costs well under £200.

It has more visual pizzazz than the Tomahawk, with chrome surrounds on the DIMM slots, as well as splashes of tasteful RGB lighting on the I/O shroud, and on the underside of the right of the PCB. These lights all sport individually controllable LEDs, plus you get two 4-pin RGB headers and one 3-pin connector if you want to add more lighting strips.

The MAG Z390 Tomahawk lacked Wi-Fi, and included a rather pointless Key E M.2 slot for adding your own Wi-Fi module. However, Wi-Fi is included on the MPG Z390 Gaming Pro Carbon AC, courtesy of an Intel Wireless-AC 9560 controller with bundled aerials. Justifying our comments about the questionable second LAN port on the MAG Z390 Tomahawk, MSI's more expensive MPG Z390 Gaming Pro Carbon AC also has just the single, Intel-controlled port – a more logical choice.

The cheaper board had no internal USB 3.1 Type-C header either, but it's on the Tomahawk. Meanwhile, the I/O panel reveals a trio of USB 3.1 Type-A ports plus a Type-C port, so you won't be left wanting for the latest USB standards. However, the board could do with more than just five Type-A USB ports on the rear panel – they can get quickly occupied by headsets, external storage and other USB peripherals, in addition to your keyboard and mouse.

Another benefit of this board over the Tomahawk is audio. The latter only has Realtek ALC892 audio, while the MPG Z390 Gaming Pro Carbon AC goes all-out with a tweaked version of the great-sounding Realtek ALC1220 codec.

SPEC

Chipset
Intel Z390

CPU socket
Intel LGA1151 (Coffee Lake refresh)

Memory support
2 slots: max 64GB DDR4 (up to 4400MHz)

Expansion slots
Three 16x PCI-E, three 4x PCI-E

Sound
8-channel Realtek ALC1220

Networking
1 x Intel Gigabit LAN, 802.11ac Wi-Fi

Overclocking
Base clock 100-538MHz, CPU multiplier 8-120x; max voltages: CPU 1.72V, RAM 2.2V

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

Dimensions (mm)
304 x 243

Surprisingly, MSI was able to include two M.2 ports with the MAG Z390 Tomahawk, with both catering for SATA and PCI-E SSDs, and there was a heatsink too. It's a similar setup with the MPG Z390 Gaming Pro Carbon AC, although its heatsink is larger. Due to its size, one of its mounting screws sits under your graphics card, meaning you'll need to remove the latter to access that lower M.2 slot.

Sadly, the heatsink can't be transplanted to the top slot either. We'd persevere with the bottom slot, though, since the heatsink dropped the load temperature of our Samsung 960 Evo SSD by 20°C, a result likely helped by the SSD not being sandwiched between the graphics card and CPU socket.

There isn't much in the way of overclocking and testing tools though – you'll need to step up to MSI's MEG Z390 Ace to get on-board power buttons, clear-CMOS buttons and LED POST code displays, but that's the same with other manufacturers too. Meanwhile, the power circuitry is substantial, with 11 phases in total from five doubled phases, plus another phase for the CPU's integrated graphics. That's more power phases than the MAG Z390 Tomahawk, plus the heatsinks for the power circuitry are slightly larger. It's great to see another integrated I/O shield on a sub-£200 board too, saving your fingers from the sharp edges of your case's I/O panel hole.

Performance

MSI hasn't changed much of its EFI for a couple of generations of its Intel boards now, but the design is still fresh, lag-free and easy to navigate. The fan control section lacks a couple of options compared with Gigabyte's EFI –

18+

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Cheap constant access to piping hot media
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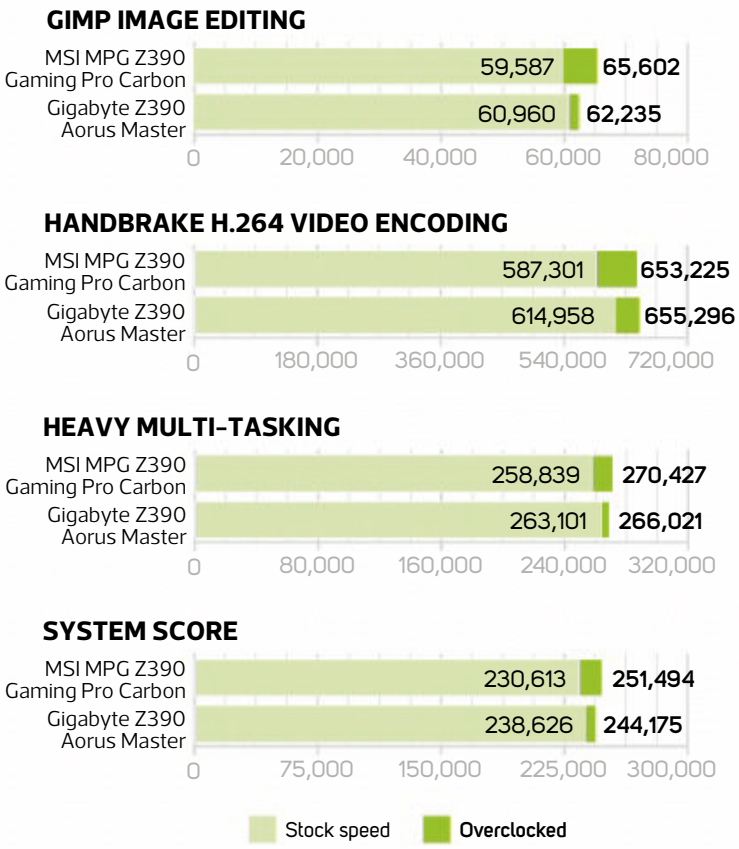
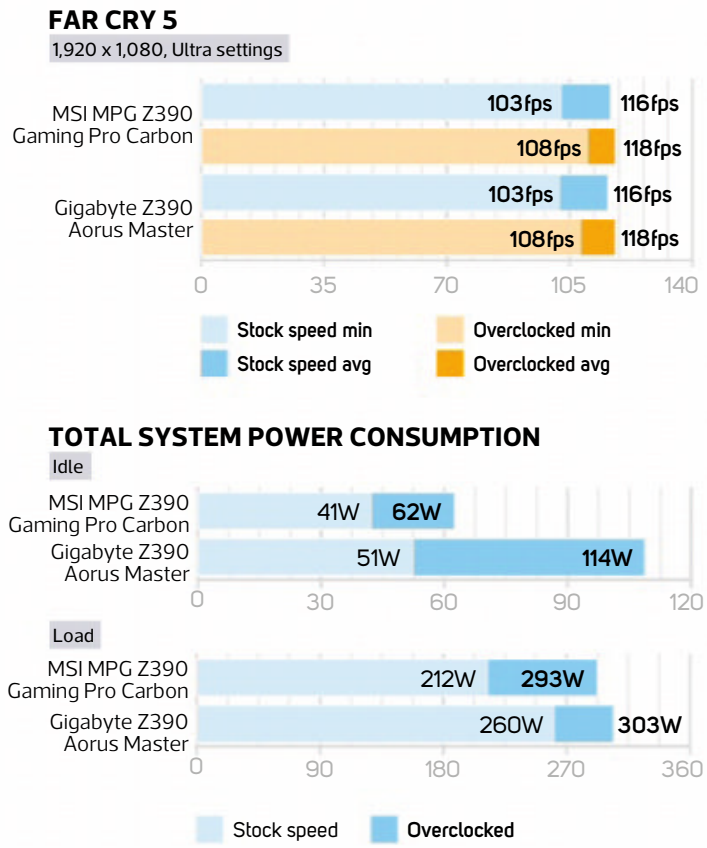
AvaxHome - Your End Place

We have everything for all of your needs. Just open https://avxlive.icu

BENCHMARK RESULTS





namely, the ability to switch off fans at low temperatures, and pick from more temperature inputs to control fan speed – but there are enough options to gain decent control over your system's fans.

We managed to hit our usual 5GHz clock speed on our Core i9-9900K, but it wasn't as easy as with many boards we've tested, requiring us to apply loadline calibration in addition to a 1.24V vcore. Otherwise, any vcore below 1.28V was unstable.

MSI has tuned the board well for power consumption, however, with our system drawing just 41W from the mains when idle (before our EFI tinkering) and drawing 212W under load – some of the lowest figures we've seen. The overclocked power draw was much higher, naturally, but not much higher than most other boards. Performance was on the money at stock speed and when overclocked, with system scores of 230,613 and 251,494 respectively - the biggest gain was seen in the video encoding test, which rose from 587,301 points to 653,225.

Audio performance was also excellent, with a dynamic range of 113.5dBA and noise level of -113.4dBA, which are again among the best results we've seen. We also saw M.2 read and write speeds of 3,385MB/sec and 1,870MB/sec using our Samsung 960 Evo SSD, which are equally chart-topping, although only marginally.

Conclusion

The obvious competition for the MSI MPG Z390 Gaming Pro Carbon AC is Gigabyte's Z390 Aorus Pro, which costs around the same money. The latter has more USB ports and fan headers, but lacks Wi-Fi and its USB Type-C header only supports USB 3, so your choice largely comes down to how you'll be connecting to the Internet and if you have a USB 3.1-enabled case. The Gigabyte board is a slightly better choice if Wi-Fi isn't essential, but the MSI MPG Z390 Gaming Pro Carbon AC remains an excellent Z390 motherboard if Wi-Fi is a priority.

ANTONY LEATHER

VERDICT

Plenty of premium features and solid overclocking for under £200.

CARBON FIBRE

+ Decent overclocker
+ Wi-Fi and plenty of premium features
+ Good EFI

CARBON MONOXIDE

- Overclocking needs more tweaking than usual
- No on-board overclocking and testing tools
- M.2 heatsink sits under graphics card

PERFORMANCE 32/35

FEATURES 31/35

VALUE 24/30

OVERALL SCORE 87%

M.2 SOLID STATE DRIVE

WD Blue SN500 NVMe 500GB

/ £69 inc VAT

SUPPLIER overclockers.co.uk

Up to this point, M.2 SSDs have tended to be in one of two categories: expensive NVMe models or cheaper SATA ones. The WD Blue SN500, though, is a genuine halfway house. It offers a meaningful upgrade over SATA drives but is only a little more expensive.

This 500GB version offers sequential read speeds of up to 1,700MB/sec, which certainly isn't breaking any records, but is still over three times faster than a SATA drive. Meanwhile, its sequential write speed is rated at a far more impressive 1,450MB/sec – plenty of more expensive drives don't offer much more – and its random performance is equally good, rated at 275K IOPs for reads and 300K IOPs for writes.

The big downside is that the SN500 range tops out at just 500GB, with a 250GB model also available (with the same claimed sequential read speed but a slightly slower 1,300MB/sec write speed), so anyone requiring a larger drive won't have access to the same great price/performance balance.

Western Digital hasn't scrimped on the endurance rating of these drives either. The 250GB model is rated to 150 total terabytes written (TBW) while the 500GB version is rated to 300TBW, both of which are typical for drives this size. A five-year warranty is likewise to be expected.

As with most M.2 SSDs, the drive is physically a tiny PCB with some chips on it, although the number of chips is astonishingly low. There are just two of note: the larger module that's a single stack of 64-layer SanDisk 3D TLC NAND, and the smaller controller module, which is an in-house WD design. The rest of the PCB is left to stickers and other bumf – a shorter 42mm version of the drive will also be available.

This sparsity of components can in part be explained by the density that NAND manufacturers can now achieve, along with the relatively small capacity of these drives, but it's also down to what WD has cut from these drives. Most obviously, there's the lack of DRAM, with WD completely removing the 1GB module used on its higher-end drives. There's still some memory inside WD's controller, but the company hasn't revealed how much it uses.

WD has also halved the number of lanes between the controller and the NAND, moving from a four-lane to a two-lane design. The upshot is performance that's notably behind higher-end NVMe drives in more ways than just the headline sequential and random speeds. It's unlikely the drive will be slower than any SATA ones, but it's not going to be suited to seriously heavy workloads either.

All of which brings us to our testing, where the WD Blue SN500 delivered just the performance we expected. In CrystalDiskMark, it hit its rated sequential read and write speeds almost exactly. It was similarly exacting in its random read speed performance, though random write speeds were a little below the expected 300K IOPs figure.

In PCMark 8's storage test, this drive's total bandwidth rating was also in the expected ballpark. Faster NVMe drives hold a clear lead, but the SN500 is well ahead of SATA models. The only fly in the ointment is that you only need to spend a little more money to get a notably faster drive. The 480GB Corsair MP510, for instance, is just £14 (20 per cent) more expensive yet has nearly double the performance.

Conclusion

The WD Blue SN500 is an ideal SSD upgrade for people who don't require a particularly large or blisteringly fast boot drive. It's cheap and its performance offers a solid upgrade over SATA drives while not breaking the bank. It's certainly not the fastest drive going, but it's great for the money.

EDWARD CHESTER

PERFORMANCE 36/50

FEATURES 16/20

VALUE 30/30

OVERALL SCORE 82%

VERDICT

We have a new budget M.2 SSD king, even if it isn't going to break any performance records.

NEW

Wireframe

Join us as we lift the lid
on video games

Visit **wfmag.cc** to learn more

GAMING CHAIR

Nitro Concepts S300 EX / £240 inc VAT

SUPPLIER overclockers.co.uk

NITRO

- \+ Sturdy and well-made
- \+ Comfortable seat and cushions

NIGHT ROBE

- – Overly firm armrests
- – Relies on cushions for lumbar support
- – Not for small people

With gaming chairs still trending in the PC gaming hardware market, it's no surprise to see manufacturers tweaking their designs to grab market share and tempt gamers away from their £30 generic office chairs. We've already put some Nitro Concepts chairs through their paces here at Custom PC, courtesy of the E200 and S300, with the latter gaining an Approved award last year. The new S300 EX is similar, but the company has switched materials, while keeping costs around the same.

The S300 had a dense mesh material, on which it was comfortable to sit, and it stayed at the same temperature all year round, while making none of the squeaks associated with leather or faux leather chairs. However, the mesh can also snag and absorb liquid spills, while faux leather usually wipes clean. With the S300 EX, Nitro Concepts has gone back to faux leather, which is a good move overall. It's available in plain black, or in black with either red or white details, with the colour options extending to the sides, headrest and five-pointed star base.

Like the S300, you get both lumbar and headrest cushion supports, and both are handy depending on your default sitting position. Unlike noblechairs' latest efforts, there's no specific lumbar support, so the cushion is important for proper back support. If you have a slightly tilted backrest, then the second cushion comes into play, supporting your head while keeping your body mostly upright. Adjustment and dimensions are exactly the same as the S300, with backrest tilt, chair tilt and height adjustment – the latter goes even higher than the hefty noblechairs Hero, with a maximum height of 61cm off the floor.

Like the Hero, the S300 EX is definitely made for medium-to-large people, and that target extends to the arm rests too. They lack the ability to move laterally themselves, unlike noblechairs' models and GT Omega's Pro Racing, but you can at least move each support arm in and out by loosening screws underneath.

The armrests do move back and forth, and rotate too, allowing them to reach inwards a little further than the noblechairs Hero, although the GT Omega Pro Racing is still the best option for smaller people. Also, while the armrests are padded and not solid plastic, they're not particularly soft and comfortable either. Meanwhile, the seat cushion comprises cold-cured foam and feels springy and comfortable, with a little more give compared with most noblechairs models we've tried, although it's not for people who prefer a particularly soft seat cushion.

Assembling the S300 EX is also straightforward, and won't pose too many issues. However, due to its weight, which sits at around 25kg, we advise you to unbox the components and take them individually to where you'll be sitting, rather than trying to haul the completed chair to your office, especially if it needs to go upstairs.

Conclusion

While there are pros and cons to faux leather materials, it's preferable overall to the mesh material of the S300 EX's predecessor. However, there's otherwise not much that's new here, apart from some new aesthetic touches. If you're on a tight budget, we'd still recommend the GT Omega Racing Pro chair, which will save you around £40, while the noblechairs Epic and Icon models can be had for around £50 more, and offer more adjustment. However, for the price, the S300 EX is a decent, if not spectacular, gaming chair.

ANTONY LEATHER

VERDICT

A solid effort that justifies its asking price, although it could do with softer armrests and the ability to adjust them properly.

COMFORT 45/50

FEATURES 20/25

VALUE 18/25

OVERALL SCORE 83%

RAZER

BLADE STEALTH 13

MOVE WITH POWER

The Razer Blade Stealth 13" laptop is available with a more powerful 25W NVIDIA® GeForce® MX150 4GB graphics for gaming and content creation. Featuring a visually stunning thin bezel display, and Razer Chroma™ keyboard, it combines mobility and style with power that's perfect for work and play.

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- Up to 512GB PCIe M.2 SSD
- Stunning thin bezel display, up to 4K resolution
- Long battery life, up to 13 hours*
- Responsive keyboard, powered by Razer Chroma™
- Incredibly thin and compact (21 x 30.5 x 1.5 cm)

*depends on configuration

AVAILABLE FROM

Available at amazon · Currys PC World · RAZERSTORE razer.com · SCAN

GAMING KEYBOARD

Thermaltake Level 20 RGB / £155 inc VAT

SUPPLIER scan.co.uk

SPEC

Connection
Wired, USB

Cable
1.8m, braided

Material
Aluminium

Switch type
CherryMX Blue or Speed Silver

Backlighting
RGB

Extras
USB and audio pass-through, replacement key set, volume wheel, key puller

With a price of £155, Thermaltake's Level 20 RGB competes with the best names in gaming keyboards and, like its competitors, it offers extensive media controls, RGB lighting, control software and premium construction. The latter is evident across most of the unit too, with a huge piece of aluminium sitting under the keys, which plants the Level 20 RGB firmly on your desk, and results in a weight of over 1.4kg.

You get a standard full key set, plus a generous helping of media controls, including dedicated playback and audio mute buttons, plus a volume wheel for fine adjustment – the latter is much more useful than having this feature as the second function of other keys. However, the quality isn't quite on a par with Corsair's K70 keyboards, with the media keys feeling a little loose. On occasions, even some of the main keys exhibit a slight rattle too, plus there's no wrist rest included.

The Level 20 RGB is available with two types of switch - CherryMX Speed Silver and standard Blue, with our sample using the former. They're akin to CherryMX Red switches, except they've had 0.8mm cut off their 2mm actuation point, resulting in a quicker response. Like the Red switches, they also have a linear, non-clicky action, which is pleasant to use in games and for long periods of typing.

Thermaltake includes a set of 11 red replacement keys as well, should you wish to highlight the WASD area, with a key-puller included. Meanwhile, there's a trio of connectors bundled into a braided cable, which include an audio pass-through for the on-board mini-jack, and a pass-through for the USB 2 port located at the top of the keyboard.

There's loads of lighting too. The RGB lighting extends to the Thermaltake logo and opaque strips next to the Return key, as well as the keyboard's sides and the keys themselves. The key sockets also illuminate, meaning the keyboard does glow quite profusely in low light. Thermaltake's iTake software is meant to allow you to customise the lighting on a per-key basis, as well as enabling you to change key assignments and record and execute macros. The lighting controls are fairly detailed and you're able to drag a selection tool over keys you want to group, altering their lighting colour or effects.

However, changing key assignments didn't seem to work – whether we were assigning media functions or executing macros, the key would refuse to do any task other than its original function. We updated the keyboard's firmware, but still had the same issue.

Conclusion

The Thermaltake Level 20 RGB is a decent effort at competing with the big guns in the £150 price bracket, but some areas need work if it's going to truly compete with the likes of the Corsair K70 range. The software has some gremlins, and a quick Google shows our experience isn't unique here, plus some areas of the keyboard don't feel as premium as the competition.

If the Level 20 were cheaper and those issues were ironed out, Thermaltake would be onto a winner, but at the moment, we recommend giving it a miss.

ANTONY LEATHER

LEVEL 20

- \+ Solid construction
- \+ Full media controls
- \+ Software-controlled lighting

LEVEL 42

- – Software gremlins
- – Some keys rattle or feel loose
- – No wrist rest

VERDICT

A good effort at a premium mechanical gaming keyboard, but there are a few too many gremlins.

DESIGN 25/40

FEATURES 32/35

VALUE 15/25

OVERALL SCORE 72%

WIRELESS KEYBOARD

Corsair K83 Wireless / £110 inc VAT

SUPPLIER scan.co.uk

The Corsair K83 Wireless is designed to handle gaming, media and living-room duties without any wires cluttering up the couch. The main keyboard is a tenkeyless unit, with a circular touchpad on its right, along with mouse buttons, a volume roller and buttons to alter the backlight brightness and lock the function keys. It's a setup that can handle full OS navigation on the sofa, which is great for controlling media, web browsing and basic work tasks. Then, above the touchpad, there's a joystick and two shoulder buttons that enable the K83 to be used for living-room gaming.

It's a hefty slate of features inside a pleasingly svelte frame. The K83 only weighs 0.48kg – half the weight of many gaming keyboards – and it's just 380mm wide and 125mm deep. It's easy to carry the Corsair between rooms, or balance it on your lap. The K83 feels solid, despite those dimensions, and it looks the part: the top is made from brushed aluminium, while the underside uses subtle plastic.

There are plenty of connection options too. The K83 supports 2.4GHz wireless, Bluetooth 4.2 and USB, and it has a 1,000Hz polling rate and 20-key rollover. Meanwhile, the wireless connection has 128-bit AES encryption and a 1ms response time, although the Bluetooth connection slumps to a 7.5ms response time.

However, hands-on use reveals several key limitations. The keys, for example, use low-profile scissor hardware reminiscent of the chiclet buttons on most laptops. The keys have a solid base, reasonable speed and consistent, comfortable action – but they don't have the travel, weight or speed of proper mechanical switches. They're fine for web browsing and casual gaming, but you expect better from a keyboard costing over £100.

The vertical cursor keys are also tiny, and the Delete key has gone, with that feature banished to the Backspace button. Meanwhile, the joystick is a little top-heavy and doesn't have the range of movement of usual gamepad equivalents. Plus, if you want to hold the keyboard like a gamepad to use the shoulder buttons, the bottom-right corner cuts uncomfortably into your palm. And, of course, you only get one joystick – so you can't truly replicate a two-stick gamepad.

Likewise, while the touchpad has full Microsoft gesture support, the pad is a little too small to support four-finger movements or the rapid movements that gaming often requires. The volume roller is grippy, but also wobbly – so pushing it to mute audio is awkward. At least the two touchpad buttons are good, although not as responsive as those on a proper mouse.

On the plus side, we had no connection issues – the K83 easily hooked up to Windows and Android hardware. You also get status lights in between the function keys, and a power button at the rear, which is handy to avoid accidentally running down the battery. The battery lasts for around 18 hours with low backlighting and 40 hours with the backlighting deactivated. The lighting is white, rather than RGB, but it does look good.

Conclusion

We like the idea of a cable-free gaming and multimedia keyboard, but Corsair's K83 wireless is too compromised. Its scissor keys have disappointing travel, the touchpad is small and the joystick can't match proper gamepads. It's not always comfortable to hold either, and its £110 inc VAT price is expensive. Corsair's K83 Wireless is a brave attempt to cover lots of bases, but it can't handle much beyond basic use. If you want an all-in-one device to control a PC from your sofa, we'd wait until Corsair has refined the design.

MIKE JENNINGS

SPEC

Connection
1ms 2.4GHz wireless, Bluetooth 4.2, USB

Cable
2m

Material
Aluminium, plastic

Switch type
Corsair ultra-low-profile scissor

Backlighting
White

Extras
Trackpad, joystick

VERDICT

A reasonable idea with plenty of potential, but there are too many compromises to justify the price.

DESIGN **26/40**

FEATURES **28/35**

VALUE **18/25**

OVERALL SCORE **72%**

GAMING LAPTOP

Asus ROG Zephyrus S GX701GX / £3,199 inc VAT

SUPPLIER amazon.co.uk

SPEC

CPU
2.2GHz Intel Core i7-8750H

Memory
16GB 2666MHz DDR4

Graphics
Nvidia GeForce RTX 2080 8GB Max-Q

Screen
17.3in 1,920 x 1,080 IPS 144Hz G-Sync

Networking
Dual-band 802.11ac Wi-Fi

Storage
1TB Samsung PM981 SSD

Ports
3 x USB 3.1, 2 x USB 3.1 Type-C, 1 x audio jack, 1 x HDMI

Dimensions (mm)
399 x 272 x 19 (W x D x H)

Weight
2.7kg

Operating system
Windows 10 Home 64-bit

Warranty
Two years parts and labour return to base

Asus' Zephyrus laptops have hugely powerful components and a keen sense of style, and the GX701GX doesn't disappoint. It looks superb. It's made from black magnesium alloy with bronze edges, and the Republic of Gamers logos have a stylish chrome effect. It's eye-catching without being garish.

It's not too hefty either. Its 2.7kg weight is normal for a 17.3in laptop, and it's only 19mm thick. It's too big for regular moving, but it's easier to sling the Zephyrus in a backpack than many other laptops with this level of power. You get three full-sized USB 3.1 ports and two Type-C connectors, with Gen 2 supported on three of those ports. However, there's a notable lack of a wired Ethernet port, or a card reader for that matter. Plus, while the screen is sturdy, the metal above the keyboard is flimsy.

Opening the lid activates a secondary mechanism to push the machine's base panel away from the body, opening a small gap to aid heat dissipation. It's a great idea, but the base panel is flimsy and can snag cables for any peripherals you might be using.

Asus has also gambled on the ergonomics, which isn't entirely successful. The keyboard and touchpad sit alongside each other at the front edge, mimicking a desktop setup and allowing for more venting above them. However, the keyboard has no numberpad, and the cursor keys are small. Plus, while the buttons have decent speed, they have little travel and their action is muddy. It's fine for most games, but no better than the typing gear on cheaper laptops. On the plus side, there's per-key RGB lighting and n-key rollover, plus a separate volume roller.

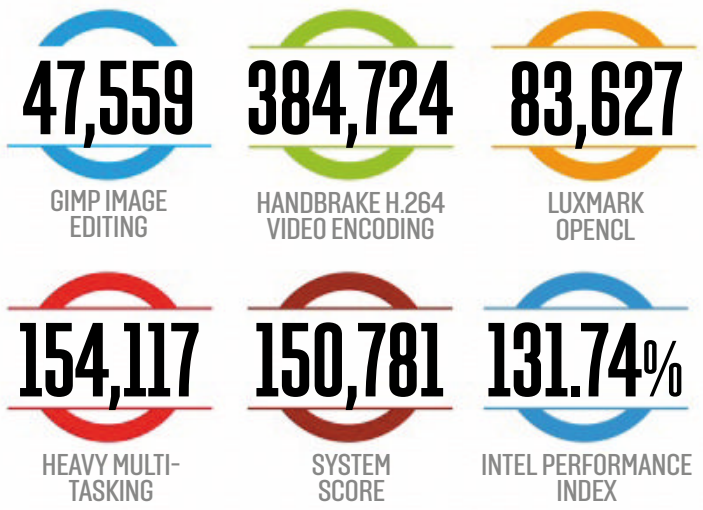
Likewise, positioning the touchpad to the right makes sense, but it's small. The buttons are reasonable, but they're missing the speed and snap of proper gaming mice. Plus, while you can turn the pad into a virtual numberpad, using this feature prevents the touchpad from working.

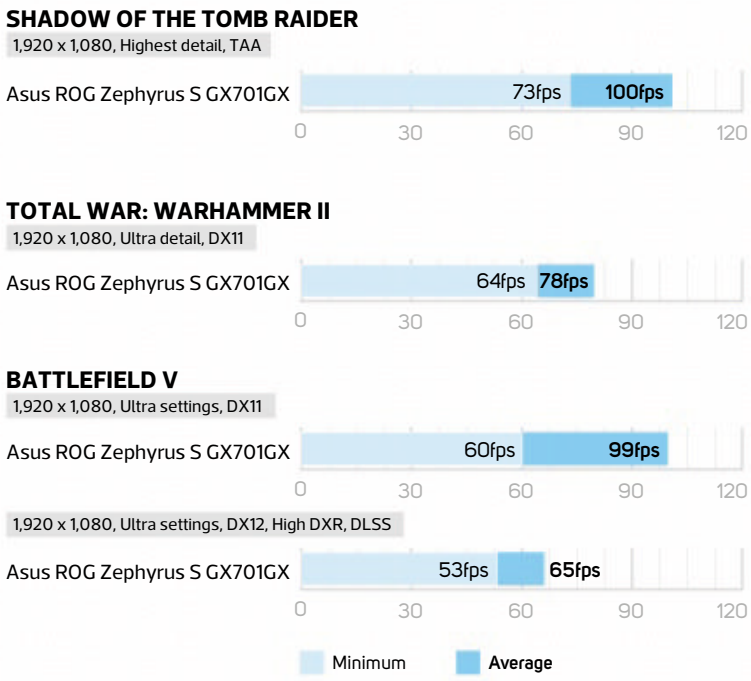
The core spec is solid though. The RTX 2080 Max-Q GPU is the star. Nvidia has used the more powerful variant, which means a base clock of 990MHz and a boost peak of 1230MHz. Plus, by default, Asus' Turbo mode adds an extra 100MHz to both figures. Meanwhile, the 6-core Intel Core i7-8750H CPU runs at 2.2GHz with a boost peak of 4.1GHz, and it's used in most high-end gaming machines. It's great for work and play, and there's 16GB of DDR4 memory, although it runs at a middling 2666MHz. You get a 1TB M.2 NVMe SSD as well, although it's an older Samsung PM981 model.

Performance

The RTX 2080 played all our test games at 60fps and beyond at the screen's native 1,920 x 1,080 resolution. It also handled Battlefield V with ray tracing set to High without dropping below 53fps. Those figures ensure that the Asus will play any triple-A release smoothly, and you can use G-Sync effectively, as well as the screen's 144Hz refresh rate – many games will get beyond 100fps without any major tweaking.

BENCHMARK RESULTS





Meanwhile, the Core i7 CPU's single and multi-threaded results draw it level with similar rival laptops, and its overall result of 150,781 is fine. Asus' Armoury Crate software also enables you to switch between this machine's Turbo, Windows and Balanced performance modes. In Windows mode, the Tomb Raider minimum declined to 40fps, and it goes down by another couple of frames per second in Balanced mode.

The Asus is near-silent when idle in Turbo mode, though, and the CPU and GPU delta Ts of 64°C and 41°C are solid. It starts to make some noise during gaming, but it's still quieter than most RTX 2080 and 2070 laptops. During games, the CPU and GPU ran at solid speeds of 3.9GHz and 1700MHz, so there are no throttling problems. In a full-system stress test, the noise increased, but the CPU and GPU still ran at 3.1GHz and 1500MHz and the noise was still fine compared with rival machines.

The base and area above the keyboard can get too hot to touch though. Plus, while the noise is reduced in the Windows and Balanced modes, it's still present. If you're getting good frame rates in these modes then use them, but don't expect silence.

The screen's Full HD resolution and 144Hz G-Sync are well balanced for games, and quality is excellent. The brightness of 287cd/m^2 is fine, and the black level of 0.20cd/m^2 is terrific. The contrast ratio of 1,420:1 produces punchy, vivid images with loads of depth and subtlety. Meanwhile, the delta E of 2.09 and colour temperature of 6,267K are good, and the panel displays a solid 90 per cent of the sRGB gamut. Uniformity is great – the Asus' backlight strength only deviated by 6 per cent, which is extremely low.

The speakers are good too, with decent high-end clarity, although the bass is muddy. Don't expect much from the battery though. A gaming test with reduced screen brightness saw the Asus last for nearly 100 minutes, and that figure will plummet with a brighter screen.

Conclusion

At its core, this Asus is excellent. The RTX 2080 runs games fast enough to sate the superb screen, and there's a decent CPU. The exterior looks stylish, and while the thermal performance isn't perfect, it's better than most stylish high-spec gaming laptops. On the downside, the keyboard is shallow and lacks a numberpad, and the touchpad is small. The cooling panel is flimsy, and some areas get very hot too. If you can cope with those issues, though, the Asus has lots to offer – not least its vast power, great screen and good thermals. It's expensive and not as good as it thinks it is, but the Zephyrus motors through demanding games.

MIKE JENNINGS

VERDICT

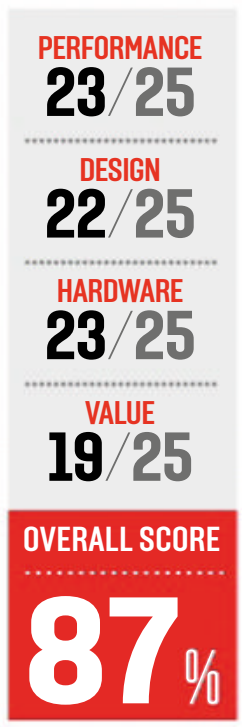
Huge power, a great screen and solid thermals all impress, despite a couple of suspect design decisions.

ZEPHYR

- + Superb screen
- + Great gaming performance
- + Stylish chassis

HURRICANE

- – Can get too hot to touch
- – No numberpad
- – Shallow keyboard



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MINI-ITX GAMING PC

Corsair One i160

/ £3,399 inc VAT

SUPPLIER corsair.com

The Corsair One has been around for a couple of years, but this machine never fails to impress thanks to stunning design and performance. There are no huge design changes in this updated version – instead, Corsair has enhanced its existing design with small, impactful improvements. The exterior, for instance, is still hewn from rock-solid, aircraft-grade aluminium, and it's still a small, monolithic machine with a height of 380mm and a weight of 7.38kg. It's still smaller than a conventional tower, and its size and subtle design mean that it still works equally well in an office, living room or LAN party.

The subtle alterations start at the side panels, where there are more air vents. The front I/O panel has been moved and improved: it's now at the bottom, and you get HDMI and audio outputs alongside two USB 3.1 ports. The slats at the bottom are more prominent now, and the front has strips of RGB lighting – not just plain blue LEDs. Meanwhile, the top still houses heat-dissipating aluminium slats, and it can still be removed by a single button press. The exterior changes are subtle, because most of the changes are on the inside.

Last year's machine installed the motherboard and GPU at the bottom, which led to cramped internals. Now, the GPU core and PSU stay at the bottom, but the motherboard moves to the top. It's a simple, effective change.

The motherboard isn't covered by PSU cables, so the CPU and memory are more accessible, and the GPU power cables are discreetly routed through the side of the system. It's an obvious change to improve navigation and airflow, and the PSU itself impresses: the Corsair SF600 is tiny, modular and 80 Plus Gold-rated.

Elsewhere, Corsair has reduced the size of the CPU cooler, which now means the PSU its own source of cool air – that's important, because air is pulled through the bulk of the PC by the sole 140mm fan in the roof. The One remains an amazing piece of design and build quality – both the CPU and GPU are liquid-cooled, with radiators built into the side panels – it's an amazing achievement for a mass-produced mini machine.

This year's machine has upgraded internals too. There's an RTX 2080 Ti, for starters, and it's an MSI Ventus OC model – which means the original boost clock of 1545MHz has been improved to 1635MHz. Meanwhile, the Intel Core i9-9900K CPU runs at its 3.6GHz stock speed, with a turbo peak of 5GHz, and it's joined by 32GB of 2666MHz DDR4, a 512GB Samsung PM961 SSD and a 2TB hard disk. The memory and hard disk could be faster, and the SSD won't match up to Samsung's latest drives, but it's otherwise a barnstorming spec for a machine of this size.

It's all installed in a modified MSI Z370I Gaming Pro Carbon AC motherboard. As with most mini-ITX boards, there's not much upgrade room, but it already has good audio and dual-band 802.11ac Wi-Fi. It also has three USB 3.1 ports and a Type-C connector. The specification compares well with last year's Corsair, which had the same memory and storage alongside a GTX 1080 Ti and a 6-core i7-8700K.

The cost of all this design work and hardware, though, is a monster £3,399 inc VAT. You can buy mini-ITX machines with the same core spec for under £3,000 elsewhere, so you're paying a hefty premium for Corsair's design work and the compact chassis.

SPEC

CPU
3.6GHz Intel Core i9-9900K

Motherboard
MSI Z370I Gaming Pro Carbon AC

Memory
32GB Corsair Vengeance 2666MHz DDR4

Graphics
MSI GeForce RTX 2080 Ti 11GB

Storage
512GB Samsung PM961 M.2 SSD, 2TB Seagate Barracuda hard disk

Case Corsair One

Cooling
CPU: custom 200mm radiator; GPU: custom 260mm radiator with 80mm fan; top: 140mm fan

PSU
Corsair SF600 600W

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

Ports
2 x USB 3.1, 1 x audio, 1 x HDMI; rear: 3 x USB 3.1, 1 x USB 3.1 Type-C, 2 x USB 2, 1 x PS/2, 1 x optical S/PDIF, 5 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
Two years parts and labour return to base

1 The MSI GeForce RTX 2080 Ti card is fitted with a Corsair waterblock and fan

2 A radiator sits in each side panel to cool the CPU and GPU respectively

3 Moving the motherboard to the top gives room for the PSU to breathe

Performance

Price issues aside, there's no denying the Corsair's fearsome performance. Its single-threaded image editing score is barely distinguishable from chips with huge overclocks, thanks to the 5GHz turbo speed. The Corsair also delivered an excellent result in our heavily multi-threaded Handbrake test. The SSD isn't bad either – its respective read and write speeds of 3,059MB/sec and 1,456MB/sec can't match Samsung's best drives, but they're still really fast.

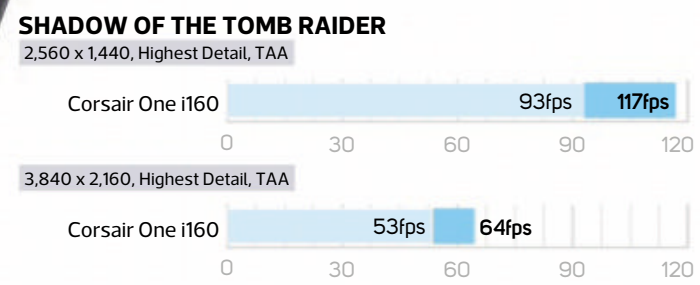
The Corsair's overall RealBench score of 224,646 was barely behind full-sized, overclocked machines with the Core i9-9900K, and it opened up significant leads over machines with 6-core i7-8700K chips – including last year's Corsair One. The Corsair's gaming ability is similarly impressive. It can handle any game at 2,560 x 1,440, and it handled our 4K test games with minimums of 47fps or better, including a solid minimum of 53fps in Battlefield V with High DXR and DLSS enabled.

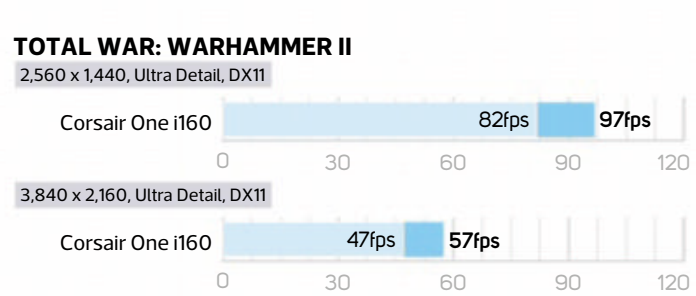
Corsair's latest PC delivered this performance alongside superb thermal results, which is testament to Corsair's compact cooling design. The CPU and GPU delta Ts of 49°C and 41°C are fantastic. Clock speeds weren't problematic either. The CPU run at 4.7GHz during games and a rock-solid 4.2GHz with all cores stressed. The RTX 2080 Ti ran at around 1870MHz during 4K games tests too.

The Corsair didn't have noise trouble either. During easier tasks and games, the system is near-silent, and during tougher games, there's low, subtle fan noise that's barely noticeable. The noise didn't increase during a full-system stress test either. The Corsair is much quieter than most full-sized, equivalent PCs we've tested.

BENCHMARK RESULTS

61,810	561,104	155,809
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	LUXMARK OPENCL
244,512	**224,646**	**196.28%**
HEAVY MULTI-TASKING	SYSTEM SCORE	INTEL PERFORMANCE INDEX





Conclusion

The One was already fantastic, and Corsair's design tweaks make it even better. The interior is more accessible and has better cooling than last year's PC, and the outside has RGB LEDs and more ports. On the inside, Corsair delivers a huge performance boost without extra noise or heat. Corsair's PC offers incredible performance inside a brilliant, subtle chassis, but the price remains high. If you want a super-powerful, quiet and compact PC in a well-built chassis then don't hesitate, but bear in mind that you can get similar computing power for much less money elsewhere.

MIKE JENNINGS

VERDICT

World-beating design and improved performance create an incredible PC, but you have to pay for it.

MINI COOPER

+ Sensational, upgraded design
+ Lashings of all-round power
+ Consistently cool and quiet

MINIDISC

− Very expensive
− Memory could be faster
− SSD has been superseded

PERFORMANCE	23/25
DESIGN	24/25
HARDWARE	23/25
VALUE	18/25
OVERALL SCORE	**88%**

GAMING PC

PC Specialist Velocity S1 / £2,699 inc VAT

SUPPLIER pcspecialist.co.uk

The Velocity S1 is a mid-range system in PC Specialist's Liquid Series water-cooled line-up, but is still costs a pricey £2,699 inc VAT. It's packed with great EKWB hardware, including an EX 150 reservoir, a Revo D5 pump and a CoolStream PE 360 radiator in the roof.

The CPU is topped by a Supremacy Evo waterblock that allows the coolant to be seen, and this machine also has a GPU waterblock. The whole system has chrome-effect fittings that look excellent. The Velocity's CPU and GPU waterblocks look great with the blue coolant, and the motherboard lighting and strips of RGB LEDs are synchronised to transition between different colours. It looks stunning, and it has hard tubing as well.

The front is decorated with gunmetal steel, and you can choose from two interchangeable front panels – one meshed, and another with tempered glass. The roof and both side panels are also made from tempered glass. You get good connections at the front as well, with four USB 3.1 ports and a Type-C connection.

The interior has solid design and welcome extra details. Cables are covered by a sturdy PSU shroud and routed neatly through holes with rubber grommets. The graphics card and its waterblock are suspended with a bracket, and another bracket secures the pump and reservoir. At the rear, all the cables are covered and there's room for three 2.5in drives and one 3.5in hard disk. It's a massive system, though, measuring 546mm tall and 544mm long.

The CPU is a Core i7-9700K, which has been overclocked from 3.6GHz to a beefier 4.9GHz. That's good, but its eight cores don't have Hyper-Threading. The CPU is paired with an RTX 2080 GPU, which has 2,944 stream processors and 8GB of GDDR6 memory, but it runs at its stock base and boost speeds of 1515MHz and 1710MHz. That's disappointing given the cooling hardware in this machine.

Elsewhere, there's 16GB of 3000MHz RAM, a Samsung 970 Evo Plus SSD and a 2TB hard disk. There's also a modular Corsair PSU with an 80 Plus Gold rating. The motherboard impresses too; the Asus ROG Strix Z390-E Gaming has loads of spare SATA, M.2 and PCI-E connectors, alongside 802.11ac Wi-Fi and decent S1220A audio, plus five USB 3.1 connectors and a Type-C port at the rear.

You get a three year warranty as well, although disappointingly, parts are included only for the first year, and there's only a solitary month of collect and return cover.

The Velocity has excellent design, but its price bears examination. You could replicate the Velocity on PC Specialist's website, using standard GPU cooling and a Corsair Hydro H115i CPU cooler, and the price drops to £2,282. There's nothing wrong with paying more money for the spectacle and thermal advantages of water cooling, of course, and the Velocity S1 does look fantastic, but it's also important to be aware of where you're spending your budget.

SPEC

CPU
3.6GHz Intel Core i7-9700K overclocked to 4.9GHz

Motherboard
Asus ROG Strix Z390-E Gaming

Memory
16GB Corsair Vengeance 3000MHz DDR4

Graphics
Nvidia GeForce RTX 2080 8GB

Storage
500GB Samsung 970 Evo Plus M.2 SSD, 2TB Seagate Barracuda hard disk

Case
Cooler Master MasterCase H500M

Cooling
CPU: EKWB EK-RES X3 150 LITE reservoir, EKWB EK-XTOP Revo D5 pump, EKWB EK-CoolStream PE 360 radiator with 3 x 120mm fans, EKWB EK-Supremacy EVO waterblock GPU: EKWB EK-FC waterblock; front: 2 x 200mm fans

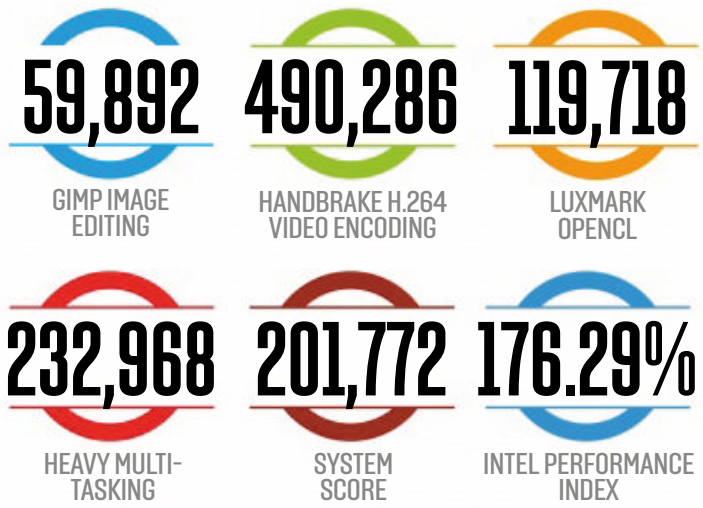
PSU
Corsair RM650x 650W

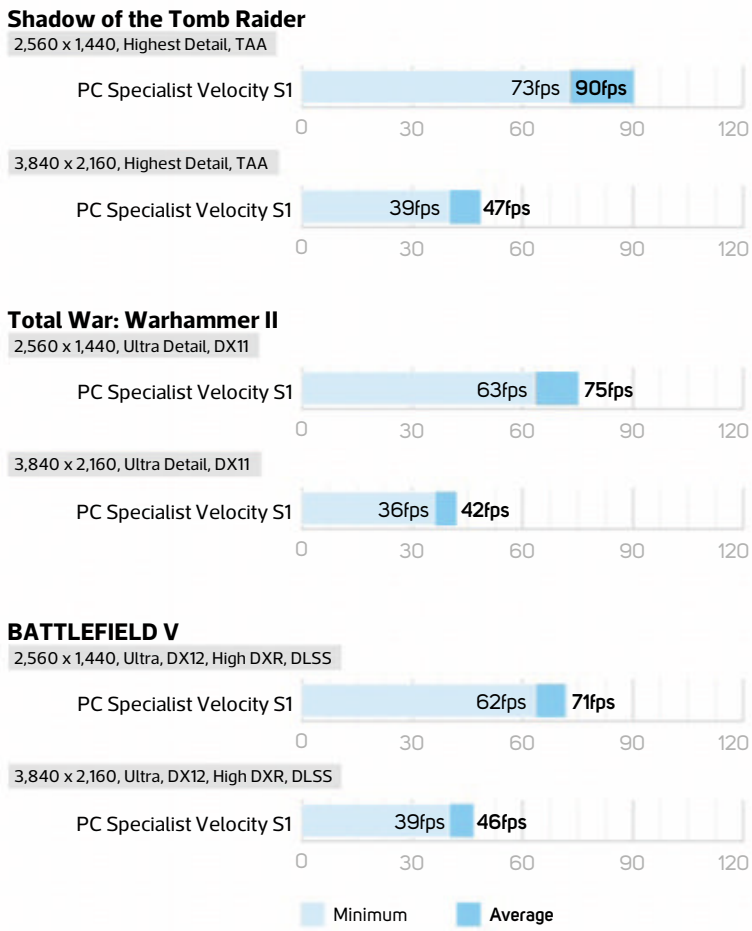
Ports
Front: 4 x USB 3.1, 1 x USB 3.1 Type-C, 2 x audio; rear: 5 x USB 3.1, 1 x USB 3.1 Type-C, 2 x USB 2, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
One year parts and labour plus two years labour only, first month collect and return

CPC REALBENCH





LIQUID LUNCH

- \+ Stunning water-cooling loop
- \+ Great gaming speed
- \+ Feature-packed motherboard

LIQUIDATED

- – High price for the spec
- – CPU doesn't have Hyper-Threading
- – Noisy when CPU is stressed

PERFORMANCE

The Velocity is a great machine for gaming, delivering playable 39fps and 36fps minimums in Tomb Raider and Warhammer II at 4K, and even managing a solid 39fps minimum in Battlefield V at 4K with High DXR and DLSS enabled. Where this PC really shines, though, is at 2,560 x 1,440, where it never dropped below 60fps in any of our demanding game tests.

It's a good bill of health for gaming, but the overclocked CPU could be more competitive in applications, especially given the price of this system. Its Handbrake video encoding score of 490,286 is reasonable, but around 100,000 points behind Core i9-9900K systems with Hyper-Threading. The Velocity's lesser application score doesn't mean this machine is slow, of course – it won't bottleneck games and it will handle almost any CPU-dependent task, you just expect a little more from a water-cooled machine costing £2,699 inc VAT.

Speaking of cooling, the PC Specialist's CPU and GPU delta Ts of 53°C and 38°C are great, but noise levels are inconsistent. The Velocity produced a noticeable rumble when idle, which didn't get louder during gaming. When compared with the rest of the market, this machine is actually reasonably quiet during gameplay. Stress the overclocked CPU, though, and the noise becomes loud and irritating. The racket comes from the radiator's fans, and it makes this PC one of the noisiest we've tested during CPU-intensive tasks. It precludes the Velocity from being maxed out in heavily multi-threaded CPU workloads unless you're willing to cope with the noise.

CONCLUSION

The PC Specialist Velocity S1 offers stunning design and build quality – it's a tidy build inside a premium case with a gorgeous water-cooling system. If you want your rig to be as much about spectacle as computing power then it delivers the goods. Plus, while it doesn't have the very fastest components available, its Core i7 CPU and GTX 1080 GPU are still a potent combination for 2,560 x 1,440 gaming.

This machine gets noisy during CPU-intensive workloads, though, and the cost of the water-cooling gear adds a considerable premium to the price. If you have the money, though, and you want a well-built water-cooled gaming PC in a gorgeous package, the Velocity S1 is a great system, as long as your priority is gaming rather than heavily multi-threaded CPU work.

MIKE JENNINGS

VERDICT

Solid gaming performance in a stunning build, but it gets noisy when the CPU is stressed, and the water-cooling gear adds a hefty premium.

PERFORMANCE	20/25
DESIGN	24/25
HARDWARE	22/25
VALUE	19/25
OVERALL SCORE	85%

GAMING PC

Scan 3XS Gamer RTX

/ £1,399 inc VAT

SUPPLIER scan.co.uk

Amazingly, Scan's latest 3XS Gamer RTX system costs just £1,399 inc VAT, but still includes a GeForce RTX 2070. The basic EVGA card has no RGB LEDs, and its core runs at the stock 1620MHz boost clock. Importantly, though, you get the full power of 2,304 stream processors in an affordable package.

It's a decent step up from the RTX 2060, which we've seen in recent PCs around the £1,299 mark. Scan has paired the RTX 2070 with an Intel Core i5-9400F – a Coffee Lake refresh CPU without integrated graphics. It has six cores but no Hyper-Threading, and its 2.9GHz base clock hits a turbo peak of 4.1GHz. The multiplier is locked, though, so you can't push it further.

Scan has filled out the rest of the rig with reasonable, affordable components. There's 16GB of memory clocked to a middling speed of 2666MHz, while a mid-range Intel 660p NVMe SSD sits alongside a 2TB hard disk. It's powered by a semi-modular Corsair CM550M PSU with an 80 Plus Bronze rating, which is fine for this spec and price.

There's also an Asus ROG Strix B360-H Gaming motherboard – an affordable board based on Intel's B360 chipset. It has two M.2 slots, although one of them only has access to two PCI-E 3 lanes rather than four, as well as two USB 3.1 Gen 2 ports. Its heatsinks are simple, with red LEDs rather than RGB LEDs. Meanwhile, there are two spare memory slots that only support up to 2666MHz DDR4 memory, and a second 16x PCI-E slot, although it only runs at 4x speed. There's no Wi-Fi or USB Type-C either – it's a basic motherboard designed to get the job done and not much else.

It's all housed in a good-looking Corsair Carbide 275R chassis, with a tempered glass side panel and a matt steel front. It has reasonable features. There's the usual PSU shroud, rubber-grommeted cable holes and white LEDs, and Scan has done its usual good job of keeping the interior neat, and also installed its own M.2 heatsink on the Intel SSD. Likewise, the front of the case houses Scan's own-brand 240mm water-cooling radiator, and there's room for four 2.5in drives at the rear. On the downside, the Corsair's PSU shroud and front panel are a little flimsy.

As usual, Scan's warranty covers labour and parts for three years, with the added bonus of a year of on site service.

SPEC

CPU
2.9GHz Intel Core i5-9400F

Motherboard
Asus ROG Strix B360-H Gaming

Memory
16GB Corsair Vengeance 2666MHz DDR4

Graphics
EVGA GeForce RTX 2070 8GB

Storage
500GB Intel 660p M.2 SSD, 2TB Seagate Barracuda hard disk

Case Corsair Carbide 275R

Cooling CPU: Scan 3XS 240mm water cooler with 2 x 120mm fans; GPU: 2 x 100mm fans; rear: 1 x 120mm

PSU
Corsair CX550M 550W

Ports Front: 2 x USB 3, 2 x audio; rear: 4 x USB 3.1, 2 x USB 2, 1 x Gigabit Ethernet, 1 x PS/2, 1 x optical S/PDIF, 5 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
Three years parts and labour with first year on site

Performance

The RTX 2070 handled our test games comfortably at both 1080p and 2,560 x 1,440, staying well above 60fps at the former and never dropping below 52fps at the latter, even when running Battlefield V with DXR set to High – you can comfortably play games with real-time ray tracing at decent settings on this budget rig.

We even managed to run Battlefield V at 4K with Low DXR, and the frame rate didn't drop below a minimum of 43fps. The frame rate started to drop below 30fps in other games at 4K though.

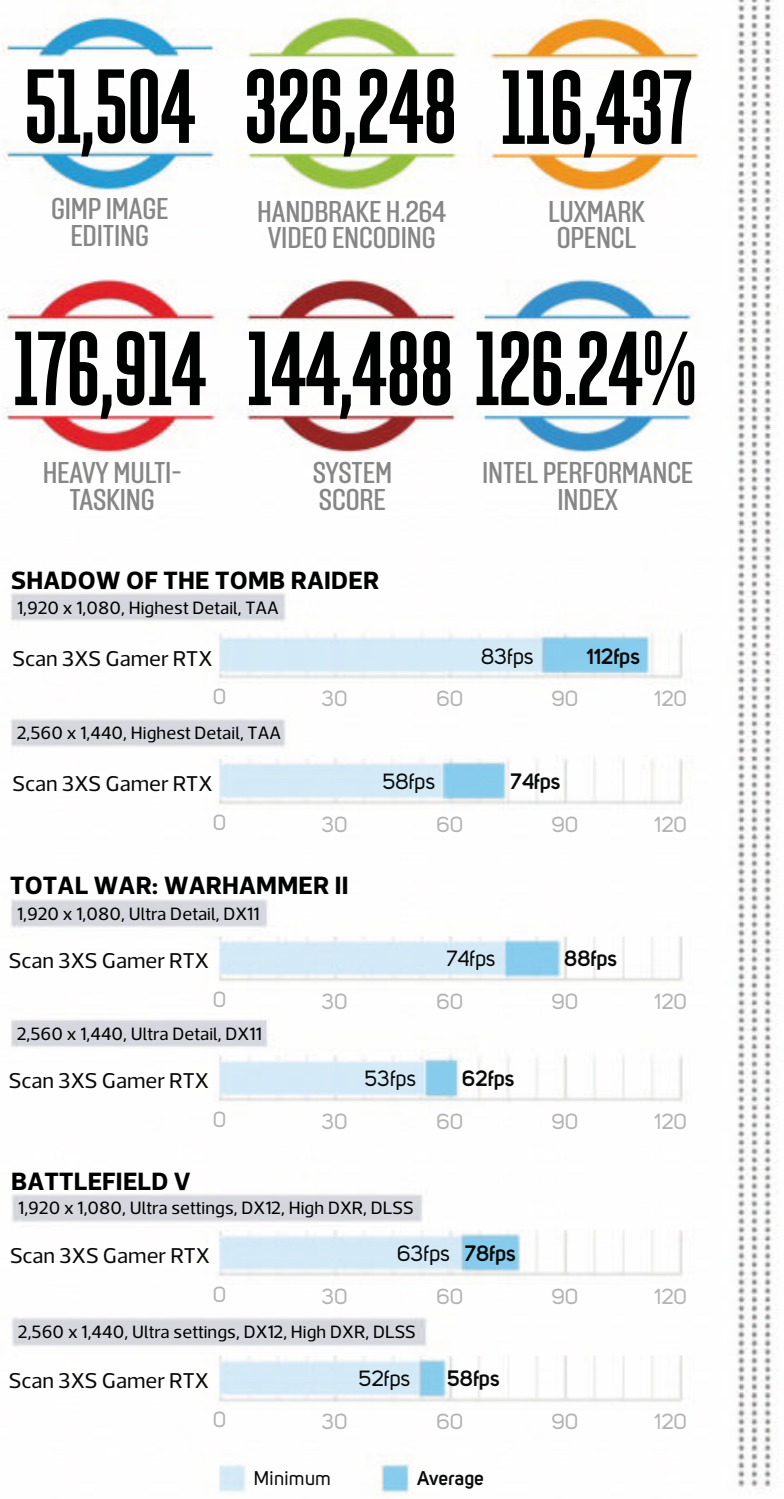
Meanwhile, the Core i5-9400F is a solid CPU. Its single-threaded Gimp image editing score is fine – not as quick as overclocked chips, but good enough for general-purpose computing, and single-threaded performance is what you really need for gaming. Its six cores and lack of Hyper-Threading saw it return middling scores in the Handbrake test, but none of the results is ruinous.

HOW WE TEST
PAGE 60

BENCHMARK RESULTS

51,504	326,248	116,437
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	LUXMARK OPENCL

176,914	144,488	126.24%
HEAVY MULTI-TASKING	SYSTEM SCORE	INTEL PERFORMANCE INDEX



Ultimately, the Scan delivered an overall result of 144,488. It's not an astoundingly good result by any stretch, but in truth, it's ample power to run any game, any everyday application and plenty of productivity tools. Scan's machine might slow down when faced with complex video editing, streaming or content-creation work, but it gets the job done for a low price.

Don't expect a huge amount from the affordable Intel SSD either. Its read and write speeds of 1,566MB/sec and 983MB/sec are fine, and much quicker than a SATA drive, but they're a long way behind top-tier Samsung silicon.

On the plus side, the lack of overclocking results in good thermal performance. The Scan's CPU and GPU delta Ts of 38°C and 42°C are fine, and the machine consistently produces a low, quiet rumble. It's marginally louder during gaming and CPU-intensive workloads, but it remains quieter than many gaming rivals.

1. **The EVGA GeForce RTX 2070 card offers great gaming speed for this price**
2. **A Scan-branded heatsink sits on top of the Intel 660p NVMe SSD**
3. **The 240mm all-in-one liquid cooler seems wasted on a stock speed Core i5**

Conclusion

Scan's £1,399 system isn't flashy, but it offers excellent gaming ability for its price. The RTX 2070 plays any game at 1080p or 1440p, even with ray tracing enabled. If gaming performance is your top priority, but you have a tight budget, then the 3XS Gamer RTX offers a huge improvement over the RTX 2060 systems we usually see in this price league.

Elsewhere, Scan's machine has a reasonable CPU, a basic motherboard and a smart, unfussy case. There's no overclocking, but the specification is quiet and capable. However, in this price league, we can't help wondering why Scan didn't use an overclocked Ryzen 5 2600 with a decent B450 motherboard instead. The CPU would be quicker across the board, and the 240mm liquid cooler could certainly cope – it seems wasted on a stock speed Core i5.

As it is, the upgrade path is limited, and you can't overclock the CPU. If you want a fast gaming PC for this price, though, the Scan provides solid power inside a smart, quiet build.

MIKE JENNINGS

VERDICT

Amazing gaming performance for the price, although the rest of the specification is unremarkable.

RTX

- \+ Fast RTX 2070 GPU
- \+ Amazingly low price
- \+ Clean, sensible build

ARTIE FUFKIN

- – Basic motherboard
- – Limited upgrade paths
- – No overclocking

PERFORMANCE	DESIGN	HARDWARE	VALUE
21/25	22/25	18/25	22/25

OVERALL SCORE

83%

Custom Kit

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

Tablecoaster / £11.99 inc VAT

SUPPLIER amazon.co.uk

The Tablecoaster is a cup holder crossed with a coaster, which apparently shares some of its DNA with limpet mines. You affix it to your desk or table, put your drinking vessel on it, and in theory it's then almost impossible to spill your drink. In practice, the success of the device varies with the receptacle. A pint glass will fit but has some wobble because of the height, and a wine glass is a dead loss. However, a mug or can works perfectly.

A removable inner layer allows cans to fit snugly, and there's a slot to accommodate handles for mugs. The adhesion is extremely strong, to the point where you sometimes need to pry the Tablecoaster off its surface once it's attached. If you're a bit of a klutz and don't want to spill yet another Coke into yet another keyboard, the Tablecoaster is an ideal fix.

Coaster ●●●●○ **Rollercoaster**

Razer Sphex V2 / £14.99 inc VAT

SUPPLIER overclockers.co.uk

The Razer Sphex V2 is an ultra-thin gaming mousepad. The surface is polycarbonate with a slight grainy texture, which is fine for any modern gaming mouse. The biggest variant of the pad measures 355 x 254mm, which is too small for a low-sensitivity setup, but fine for anyone else. The most surprising dimension of the Sphex V2 is the height; at 1mm, it's amazingly thin.

The space is saved by the Sphex V2 not having a rubbery base or feet to prevent it from slipping. Instead, the entire bottom of the pad is coated in a sticky multi-use adhesive that will stick repeatedly, as long as you to clean it every so often.

There's a little cloth tab on the side to lift up the pad when it's time to relocate it too, which is handy, because otherwise it would be a nightmare to shift without damaging it.

Despite the reusable base and light weight, however, the Sphex V2 isn't ideal for travel. Once the plastic cover is off the adhesive, there's no putting it back on, and although the polycarbonate has some flex, it will be easy to damage in transit. It's a great low-profile option for a home system, however.

Grazer ●●●●○ **Razer**

GameSir X1 Battledock / **£27.99** inc VAT

SUPPLIER amazon.co.uk

The X1 Battledock is an oddity that connects to your phone via Bluetooth, and you can then plug a keyboard and mouse into it, allowing you to play games on your phone using a keyboard and mouse. The X1 Battledock also acts as an adjustable stand for the phone, and it does this job well.

It's intended to be used in Playerunknown's Battlegrounds, and the benefits to playing such a game in this way over using the phone controls are significant, but the justification for using it is sketchy. You can't just really set it up without a tabletop, and you're in effect turning a phone into a tiny laptop. The X1 Battledock is neatly designed, and it does the limited job it attempts to perform, but it doesn't do any other useful jobs, such as letting you use your keyboard for typing. It's hard to justify it unless you're really into the mobile version of Playerunknown's Battlegrounds and don't like playing it with the same controls as everybody else.

Battlebus ●●○○○ Battledock

NEWYES Reusable Smart Notebook / **£17.80** inc VAT

SUPPLIER amazon.co.uk

The NEWYES Reusable Smart Notebook is a reusable pad that gets worryingly close to feeling like an ordinary paper pad. Close enough, in fact, that somebody might destroy it with a Biro if you leave it lying around. The paper quality feels good, the ring binding is solid and it would make a decent notebook on its own, albeit an expensive one. The pen that comes with the pad uses erasable gel and operates like a standard ballpoint pen. To erase your words, or incriminating cobweb doodles, you have to use a wet cloth, like the one supplied, or the eraser on the back of the pen.

The smart element of the NEWYES comes from the companion CamScanner smartphone software, which allows you to take pictures of your notes, clean them up visually and store them or share them in different formats as needed. It's a handy application, but not a revolutionary one. The Smart Notebook is neat and tidy, and takes up a lot less space than the big pile of notebooks you could get for the same price.

Not ●●●●○ Note

Karrong Headlamp / **£17.99** inc VAT

SUPPLIER amazon.co.uk

Attaching a light to your head so you can conduct activities in the dark isn't a remotely new concept, but a device that lets you wear a lighting array that wouldn't look out of place on the front of a rally car is another situation altogether. The Karrong features a cluster of five white lights on the front, as well as a couple of smaller lights that can be red or white. There's also a red light on the back, making the back of your head look like a tiny floating car in the dark, in a good way.

The two sets of frontal lights have several modes. The full beam is extremely powerful and best used in the middle of nowhere, while the progressively less powerful modes go down to a fairly restrained red light that's fine for reading and rummaging, and less likely to dazzle people. There's also an emergency strobe function, and the beam can be tilted, which is helpful with close-up tasks.

The Karrong is adjustable to fit and fairly comfortable with the batteries at the back to keep down the weight at the front. You get around two hours from the batteries and it can be recharged via a supplied micro-USB cable.

All in all, it's an extremely useful gadget that's ideal for jogging anywhere you can get away with looking like a Subaru Impreza, while also being ideal for use in power cuts, rummaging around in dark places or constructing tunnel networks at home.

Improper ●●●●○ Impreza

Seen something worthy of appearing in Custom Kit? Send your suggestions to editor@custompcmag.org.uk

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LABS TEST

Graphic violence

With new GPUs and massive price drops, the £200–£300 graphics card market looks confusing. Ben Hardwidge looks for the sweet spots

How we test

We tested all these graphics cards at 1,920 x 1,080 and 2,560 x 1,440, using four test games – Battlefield V, Shadow of the Tomb Raider, Total War: Warhammer II and Deus Ex: Mankind Divided. You can see more details about our game tests on p60. We haven't performed ray-tracing tests in this group test, as only one GPU has the ability to do it properly.

For this specific Labs test, we've also built a spreadsheet to work out the scores mathematically. We feed all the frame rates for each GPU into the spreadsheet and it allocates points when the minimum frame rate hits certain milestones. We work on the basis that 30fps is the bare minimum you should expect from a graphics card, so a GPU receives three points if it never drops below 30fps in each game.

In this price range, we think that 60fps is the ultimate goal for running games at demanding settings, so cards receive six points if they never drop below this level. Points are also awarded between this level – for example, a card gets 4.5 points for a minimum of 45fps. These points are then indexed comparatively, with the spreadsheet working out a final performance score for each graphics card at each resolution. We run Unigine Superposition as well, for comparative purposes, but this test isn't used in the performance score calculations.

We've taken a similar approach to calculating power efficiency. We calculate the average frame rate over all four test games, and then divide this figure by the peak wattage recorded at the wall. This figure is then indexed comparatively, with the spreadsheet working out a final score out of ten, based on the average frame rate per watt. Meanwhile, the value score is worked out by adding up the final performance scores and dividing them by the price.

Contents

AMD Radeon RX 590 / From £200 inc VAT

SUPPLIER overclockers.co.uk

The fact that AMD's Radeon RX 590 is now the lowest-scoring card on test shows just how much chaos has recently been created in this pocket of the GPU market. When we first reviewed it five months ago, it was an obvious victor over the GTX 1060 in an otherwise uncrowded arena. Now it's up against several other contenders and finding it hard to counter-attack.

That's not to say the RX 590 is a bad GPU. In fact, it's testament to the current competition in this price bracket that not a single card on test dropped below 30fps in any of our game tests. There are no terrible cards here, it's just that some of them offer more performance for your buck than others.

Unlike Nvidia's new GeForce GXT 1660 and 1660 Ti, the Radeon RX 590 isn't really a new GPU – it's basically an RX 580 GPU but with a die shrink, going from the RX 580's 14nm FinFET process to a new 12nm FinFET process. The result is a GPU with the same count of 5.7 billion transistors, and the same basic architecture, but with a bit more room to tweak the clock speed, with the boost clock going from the RX 580's 1340MHz to 1545MHz in the RX 590 – an increase of over 200MHz.

It's otherwise the same GPU, with 36 compute units containing 2,304 stream processors, as well as the same count of 32 ROPs. It's accompanied by 8GB of 8000MHz (effective) GDDR5 memory too, just like the top-end RX 580 cards, giving it 2GB more than the GTX 1660.

That aforementioned clock boost provides a welcome speed bump over the RX 580 in games, and puts the RX 590 well above Nvidia's aging GeForce GTX 1060 6GB as well. The problem is that the GTX 1060 is no longer the RX 590's prime opponent. It's now also up against the GeForce GTX 1660, with cards such as the Zotac model over the page costing just £6 more.

It's not a complete trouncing – there are some games, such as Battlefield V and Deus Ex: Mankind Divided, where the RX 590 is slightly quicker, while the latter has the upper hand in our other two tests. The Radeon RX 590's performance is still competitive, and it easily handles all our test games at 1,920 x 1,080. The performance differences are minimal – it's really six of one and half a dozen of the other compared with the GTX 1660 when it comes to frame rates.

Where the GTX 1660 roundly beats the RX 590, however, is power efficiency. The AMD GPU requires both a 6-pin and an 8-pin PCI-E power connector on the card, while the Zotac GTX 1660 only has a single 8-pin connector. The power draw results speak for themselves, with our test system drawing 314W from the mains under load with the RX 590 installed, compared to just 181W with the Zotac GTX 1660 card – a massive difference of 133W. The Zotac also has much more overclocking headroom than the Radeon RX 590 if you're happy to get your hands dirty.

SPEC

Graphics processor AMD Radeon RX 590

Base clock 1469MHz

Boost clock 1545MHz

Pipeline 2,304 stream processors, 32 ROPs

Memory 8GB GDDR5, 8GHz effective

Memory interface 256-bit

Bandwidth 256GB/sec

Power connections 1 x 6-pin, 1 x 8-pin

RAD

+ Decent 1080p performance
+ Low price
+ 8GB of memory

SAD

- High power draw
- Little overclocking headroom

Conclusion

Don't worry if you bought an AMD Radeon RX 590 card recently. Just a few months ago, it was definitely the best buy in this price league, and it's still a competitive GPU that can handle 1080p gaming at top settings without any trouble. However, if you're looking at buying a new graphics card, and only have around £200 to spend, the Zotac Gaming GeForce GTX 1660 is now the obvious contender, offering slightly faster performance in some games, as well as much lower power consumption.

VERDICT

Still a competitive performer, but the GTX 1660 is much more power-efficient.

1920 PERFORMANCE	EFFICIENCY	OVERALL SCORE
26/35	5/10	77%
2560 PERFORMANCE	**VALUE**	
21/30	25/25	

Zotac Gaming GeForce GTX 1660 / £206 inc VAT

SUPPLIER cclonline.com

At the cheaper end of the GTX 1660 price scale is Zotac's Gaming card, while MSI's Gaming X model (see p48) provides a more premium package. With a price of £206 inc VAT, the Zotac gives AMD's Radeon RX 590 a serious run for its money.

Unlike the RX 590, the GTX 1660 is also a new GPU, based on the Turing architecture also used in Nvidia's top-line RTX chips. With these cheaper GTX-branded GPUs, however, Nvidia has removed the advanced features such as RT cores and Tensor cores, and instead focused on maximising rasterisation performance for the lowest price possible. The result is the streamlined TU116 GPU, which is used in both the GTX 1660 and 1660 Ti, but with one texture processor cluster (TPC) disabled on the former, giving you a total of 1,408 stream processors.

Some other notable improvements come with the Turing architecture, though, including a massive increase in FP16 floating point performance (with 128 FP16 stream processors in each streaming multiprocessor), and some tweaks to the cache system, effectively tripling the L1 cache from the GTX 1060 6GB's 480KB to 1,536KB. It also has the ability to execute integer and floating point instructions concurrently, reducing the number of instruction slots needed to execute operations that use both types.

In terms of performance, the Zotac Gaming GeForce GTX 1660 is a long way in front of its predecessor, the GTX 1060 6GB. In Shadow of the Tomb Raider and Total War: Warhammer II, it's quicker than the Radeon RX 590 too. That said, the AMD chip performs much better than the GTX 1660 in the latter game in DX12 mode, due to Nvidia driver issues.

There's little separating the Radeon RX 590's performance from that of the Zotac Gaming GeForce GTX 1660 – the two cards exchange blows depending on the game thrown– they're both fine for 1080p gaming and some 2,560 x 1,440 gaming. Where the Zotac has the upper hand is power efficiency, with our test system drawing just 181W from the mains with this card installed.

It's also massively overclockable. Our sample was happy to have another 210MHz added to its 1785MHz GPU boost clock, and another 400MHz (1.6GHz effective) to its GDDR5 memory frequency. It's a tweak that gives a serious boost, with the 1080p Shadow of the Tomb Raider minimum frame rate leaping from 54fps to 63fps. Comparatively, we could only push the Radeon RX 590's boost clock from 1560MHz to 1617MHz, giving us a small speed increase of 1-2fps.

Of course, overclocking headroom is variable between cards, but the Zotac proves that a stronger cooler and backplate won't help here – the pricier MSI card has both those features, but it still wouldn't overclock as far as the Zotac. Amazingly, the Zotac is also very quiet. The one area where the RX 590 potentially beats it is in having 2GB more memory, but that's not currently an issue for gaming at these resolutions.

SPEC

Graphics processor Nvidia GeForce GTX 1660

Base clock 1530MHz

Boost clock 1785MHz

Pipeline 1,408 stream processors, 48 ROPs

RT Cores 0

Tensor Cores 0

Memory 6GB GDDR5, 8GHz effective

Memory interface 192-bit

Bandwidth 192GB/sec

Outputs/inputs 3 x DisplayPort 1.4, 1 x HDMI 2b

Power connections 1 x 8-pin

TURING CARD

+ Low power draw
+ Massively overclockable
+ Quiet cooler
+ Low price

TURIN SHROUD

- RX 590 faster in some games
- Only 6GB of memory

Conclusion

Zotac's budget GTX 1660 performs similarly to the Radeon RX 590, but with loads of overclocking headroom and great power efficiency. You can pick up a better card for an extra £50, but if your budget limits you to around the £200 mark, this is the best buy.

VERDICT

The card to buy if you can't go much beyond £200, with decent speed, overclocking headroom and power efficiency.

1920 PERFORMANCE 28/35	EFFICIENCY 9/10	OVERALL SCORE 83%
2560 PERFORMANCE 21/30	VALUE 25/25	

Nvidia GeForce GTX 1070 / From £230 inc VAT

SUPPLIER scan.co.uk

The grizzled veteran of this Labs test is Nvidia's GeForce GTX 1070. First launched in the middle of 2016 for around £400, this aging GPU is still managing to duel competitively thanks to a massive price cut. It's uncertain how long stock of the GTX 1070 will be available, but there were still plenty of them on the shelves as this issue went to press, with prices as low as £230 inc VAT.

Like the AMD Radeon RX Vega 56 (see p47), its price cut has created a fair bit of confusion. The first reviews of these aging GPUs were based on old games, leaving people uncertain whether they should buy a new GTX 1660, or an older GPU with a price cut now. It's a question we aim to answer with this Labs test, by testing both old and new GPUs on the same test rig with our current games suite.

Based on Nvidia's previous-generation Pascal architecture, the GTX 1070 is quite a different beast from the other Nvidia GPUs on test. It's built on a 16nm process, compared with the 12nm transistors used in today's chips, and it also doesn't have any of the advanced features of Nvidia's RTX 2060, such as RT and Tensor cores, for real-time ray tracing and AI learning features.

What it does have is a large bank of 1,920 stream processors spread over 15 streaming multiprocessors, as well as 8GB of GDDR5 memory connected to a comparatively wide 256-bit memory interface, and 64 ROPs. Comparatively, the GeForce GTX 1660 Ti has 6GB connected to a 192-bit memory interface, with 48 ROPs.

SPEC

Graphics processor Nvidia GeForce GTX 1070

Base clock 1506MHz

Boost clock 1683MHz boost clock

Pipeline 1,920 stream processors, 64 ROPs

RT Cores 0

Tensor Cores 0

Memory 8GB GDDR5, 8GHz effective

Memory interface 256-bit

Bandwidth 256GB/sec

Power connections 1x 8-pin

On the face of it, the GTX 1070 should have better parallel performance than the GTX 1660 Ti from its extra stream processors, as well as faster performance at higher resolutions with anti-aliasing, where the extra memory and bandwidth comes into play. In practice, though, it's not quite so simple. The GTX 1660 Ti has other improvements, such as a new cache system, as well as the ability to execute concurrent integer and floating point instructions. It also has a higher boost clock of 1770MHz, compared to the GTX 1070's 1683MHz boost frequency.

The only way to find out which GPU is faster is to put them to the test, where it's a close-run competition. The GTX 1070 has the upper hand in Total War: Warhammer II, and Deus Ex: Mankind Divided, while the GTX 1660 Ti is quicker in Battlefield V and Shadow of the Tomb Raider. None of the differences is massive though.

The bigger problem for both GPUs is AMD's Radeon RX Vega56, which beats both GPUs in nearly every game test – only Total War: Warhammer II was quicker on the GTX 1070. The GTX 1070 is less power-hungry than the Vega 56, but the GTX 1660 Ti is even better in this respect.

Conclusion

Thanks to a chunky price cut, Nvidia's GeForce GTX 1070 still holds up well against the competition despite its age. It offers great performance at 1080p, and can cope with some 2,560 x 1,440 gaming too. Its only problem is that the Radeon RX Vega 56 only costs £20 more and is significantly quicker in most games, even if it does draw more power. The GTX 1070 justifies its current price by occupying a happy middle ground between the GTX 1660 and Vega 56, but we recommend finding the extra £20 for the latter if you can do it.

PASCAL

+ Good power efficiency
+ New low price
+ Still competitive performance

FERMI

− No Turing features
− Slower than Vega 56

VERDICT

Still a competitive GPU despite its age, although the Radeon RX Vega 56 is quicker for not much more money.

1920 PERFORMANCE	EFFICIENCY	OVERALL SCORE
28/35	9/10	82%
2560 PERFORMANCE	**VALUE**	
23/30	22/25	

MSI GeForce GTX 1660 Gaming X / **£240** inc VAT

SUPPLIER scan.co.uk

MSI's GeForce GTX 1660 Gaming X goes all out on features, surrounding this budget GPU with a full metal backplate on the rear of the PCB, as well as the company's Twin Frozr 7 cooler, complete with RGB lighting around the fans, and illuminating the MSI logo on the top edge. It looks great in your case, but the extra features push up the price to £240 inc VAT.

That's a good £34 more than Zotac's Gaming GeForce GTX 1660, which is based on the same GPU, and it pushes the price into the same territory as GeForce GTX 1070 and AMD Radeon RX Vega 56 cards. MSI has also applied a decent overclock to the GPU, with the boost clock sitting at 1860MHz, compared to just 1785MHz on the Zotac card. Meanwhile, the 6GB of GDDR5 memory sits at the same stock speed of 8GHz (effective).

You certainly feel like you've got a lot of graphics card for your money when you take it out of the box, with the chunky backplate and cooler adding extra weight. The cooler is also very quiet, even when running games at full pelt. The question is whether it's worth paying the extra money for this premium package, when it has the same basic underlying tech as the cheaper Zotac card – a TU116 GPU with one texture processor cluster (TPC) disabled, giving you a total of 1,408 stream processors.

The GPU core overclock certainly improves performance, but not hugely. We generally observed a difference of 1-2fps across our tests compared with the Zotac card – it's a welcome boost, but it doesn't provide a meaningful difference between the two cards. The MSI is also a fair way behind GTX 1070 and Radeon RX Vega 56 cards in game tests.

We hoped that the extra cooling headroom would enable the MSI card to overclock higher than the Zotac card too, but that sadly wasn't the case with our sample. We managed to add an extra 380MHz to the memory clock, and another 120MHz to the GPU core clock, but experienced instability at higher settings. The end result is a GPU boost clock of 1980MHz, compared to 1995MHz on the Zotac card.

It's still a great result, which pushed the minimum Shadow of the Tomb Raider frame rate up to 59fps (from 55fps) at 1080p, and overclocking headroom can of course vary between different samples.

However, the fact that the Zotac can overclock slightly higher without a backplate, and with a comparatively basic cooler, means the benefit of the MSI's cooling package is largely aesthetic with this GPU.

We've had to adjust our scoring system for this review, as it only accounts for performance, efficiency and value, and not extra cooling and lighting features. We've accounted for these features by bumping up the value score appropriately, but even then the MSI card can't quite justify its price.

SPEC

Graphics processor Nvidia GeForce GTX 1660

Base clock 1530MHz

Boost clock 1860MHz

Pipeline 1,408 stream processors, 48 ROPs

RT Cores 0

Tensor Cores 0

Memory 6GB GDDR5, 8GHz effective

Memory interface 192-bit

Bandwidth 192GB/sec

Outputs/inputs 3 x DisplayPort 1.4, 1 x HDMI 2b

Power connections 1 x 8-pin

X-FILES

+ RGB lighting
+ Backplate
+ Quiet cooler

X FACTOR

− Expensive for budget GPU
− Can't compete with Vega 56

Conclusion

You can make a good argument for paying more money for a premium cooler, as well as RGB lighting, when you get into the realms of powerful GPUs that benefit from it, but they're wasted on the GTX 1660. This part of the graphics card market is now crowded and fiercely competitive, and there's simply no room for superfluous extras bumping up the price. We recommend either buying a cheaper GTX 1660 model, or a card with a more powerful GPU instead.

VERDICT

A lovely graphics card package with a decent cooler and attractive lighting, but it's overkill for a budget GPU.

1920 PERFORMANCE	EFFICIENCY	OVERALL SCORE
28/35	9/10	81%
2560 PERFORMANCE	**VALUE**	
21/30	23/25	

AMD Radeon RX Vega 56 / From £248 inc VAT

SUPPLIER scan.co.uk

AMD's Radeon RX Vega chips might have originally landed with an uninspiring fart noise, but a huge price cut to just under £250 has made the Vega 56 seriously competitive in this Labs test. In Deus Ex: Mankind Divided at 1080p, it even beat Nvidia's GeForce RTX 2060.

Rather than using GDDR5 or GDDR6 memory, with chips spread over the front and back of the PCB, AMD's Vega 56 and 64 use HBM2 (high-bandwidth memory), which is integrated into the same package as the GPU. The close proximity of the memory to the GPU reduces latency, and there's a super-wide 2,048-bit memory interface connecting the GPU to the 8GB of memory, along with 64 ROPS.

The memory is only clocked at 1.6GHz (effective), but the massive memory interface compensates for the clock frequency. The result is a fat total memory bandwidth of 410GB/sec, compared to 336GB/sec for the RTX 2060, despite the latter's faster effective memory clock. Meanwhile, the GPU contains 56 Vega compute units (CUs), which are divided into a total of 3,584 stream processors.

VEGA BUS

- \+ Huge price cut
- \+ Great performance
- \+ 8GB of HBM2

VENGABUS

- – Cheaper cards are noisy
- – High power draw
- – No ray-tracing support

In terms of performance, the Vega 56 isn't as fast as the RTX 2060, but it's significantly faster than every other card on test. It stayed above 60fps in three of our game tests at 1080p, and only came third in Total War: Warhammer II, slightly behind the GTX 1070. Impressively, it also never dropped below 66fps in Battlefield V at 2,560 x 1,440, and its minimums were well above 40fps in Shadow of the Tomb Raider and Deus Ex at this resolution too.

There are two flies in the ointment. The first is the power draw. Radeon RX Vega 56 cards have two 8-pin PCI-E power connectors, and our test system drew 278W from the wall with the Vega 56 installed at load, compared to 192W with the GeForce GTX 1660 Ti. The efficiency isn't terrible, though, as you still get a lot of performance for that power draw. It can't match Nvidia's chips for efficiency, but it's much more power-efficient than the clocked up Radeon RX 590.

The other issue is cooling. These chips require a fair amount of airflow, and the cheaper cards in the range come with single-fan blower-style coolers, which make a horrible amount of noise at full load. That said, paying an extra £30 for a Sapphire model from **overclockers.co.uk** with a custom, quieter cooler still results in a total score of 87 per cent in our spreadsheet.

SPEC

Graphics processor AMD Radeon RX Vega 56

Base clock 1156MHz

Boost clock 1471MHz

Pipeline 3,584 stream processors, 64 ROPs

Memory 8GB HBM2, 1.6GHz effective

Memory interface 2,048-bit

Bandwidth 410GB/sec

Power connections 2 x 8-pin

It's even overclockable – we pushed the Radeon RX Vega 56's GPU core boost clock all the way up to 1650MHz, and added another 880MHz (effective) to the memory clock too, and it was still stable.

This tweak boosted performance massively, with the 1080p Shadow of the Tomb Raider minimum frame rate jumping from 63fps to 70fps. It hits power draw hard, though, with our system drawing a colossal 379W from the mains.

Conclusion

If you're not bothered about cooler noise – it won't be so much of an issue if your PC sits under your desk, or if you wear a headset when gaming – the Radeon RX Vega 56's performance simply can't be beaten at this price. Even paying more money for a better cooler still results in a good deal here, although you're then arguably better off spending the extra money needed for an Nvidia GeForce RTX 2060 card. If getting the fastest frame rate for the least amount of cash is your top priority, however, the Vega 56 is the GPU to buy.

VERDICT

Fantastic performance for under £250, although the cheaper cards have noisy coolers.

1920 PERFORMANCE 33/35	EFFICIENCY 7/10	OVERALL SCORE 90%
2560 PERFORMANCE 25/30	VALUE 25/25	

Nvidia GeForce GTX 1660 Ti / £260 inc VAT

SUPPLIER scan.co.uk

The Titanium flavour of Nvidia's new GTX-branded Turing GPUs impressed us last month, with an MSI Gaming X card coming in at just £250 inc VAT. A month later, the price has gone up everywhere, with even the cheapest cards costing £260 inc VAT. That's a problem when there's competition from so many other GPUs, old and new, in the same price league and it puts the GTX 1660 Ti in a difficult position.

It's still a great GPU, hence the total score of 86 per cent, but the cheaper Radeon RX Vega 56 is faster, and just another £39 would net you an RTX 2060. Meanwhile, cheaper GTX 1660 cards, such as the Zotac on p44, might not offer as much bang for your buck, but are great if you only have around £200 to spend. It all puts the GTX 1660 Ti in a position where, despite being a decent GPU, there's currently no point in buying it, as there are better products for every budget surrounding it.

Graphics card prices are volatile, though, and it's still worth taking a look at what makes the GTX 1660 Ti tick. It's based on the same TU116 GPU as the GTX 1660, but with all of its texture processor clusters (TPCs) enabled, giving it the full count of 1,536 stream processors. It also has 6GB of GDDR6 memory, with an effective frequency of 12GHz, as opposed to the 8GHz (effective) GDDR5 memory with the vanilla GTX 1660. The latter gives it a good boost in memory bandwidth, with a total of 288GB/sec compared to the GTX 1660's 192GB/sec.

With the extra stream processors and faster memory, the GTX 1660 Ti pulls out in front of the GTX 1660, adding an extra 10fps to the minimum frame rate in Battlefield V at both our test resolutions. Its minimums are 4–7fps quicker than those of the GTX 1660 in our other game tests too. The problem is that AMD's Radeon RX Vega 56 can be bought for £11 less money, and it outpaces the GTX 1660 Ti across the board in terms of frame rates.

In its favour, the GTX 1660 is much more power-efficient than the Vega 56. Our system drew just 192W from the mains with the GTX 1660 Ti installed, compared to 278W with the Vega 56 fitted. The GTX 1660 Ti is also easier to cool, so there's a greater variety of cards with quiet coolers available than with the Vega 56.

TITANIUM

- \+ Low power draw
- \+ Overclockable
- \+ Decent gaming performance

TIN

- – Can't keep up with Vega 56
- – Priced slightly too high

SPEC

Graphics processor Nvidia GeForce GTX 1660 Ti

Base clock 1500MHz

Boost clock 1770MHz

Pipeline 1,536 stream processors, 48 ROPs

RT Cores 0

Tensor Cores 0

Memory 6GB GDDR6, 12GHz effective

Memory interface 192-bit

Bandwidth 288GB/sec

Power connections 1 x 8-pin

As with the GTX 1660, there's a decent amount of overclocking headroom with the GTX 1660 TI too. We were able to overclock the memory on our sample to 14GHz (effective), and we took the GPU boost clock all the way up to 2GHz, which took the Shadow of the Tomb Raider minimum frame rate at 2,560 x 1,440 from 43fps to 47fps.

Conclusion

With a slight price rise since launch, and fierce competition from the cut-price Radeon RX Vega 56, the GTX 1660 Ti has its work cut out. In terms of bang per buck, the Radeon RX Vega 56 is the clear winner. However, the GTX 1660 Ti has low power consumption and a greater range of quiet coolers in its favour. If these are bigger priorities than getting the fastest frame rates, the GTX 1660 Ti remains a solid choice. It's just a shame it's currently priced too high to be truly competitive.

VERDICT

Solid performance, plenty of overclocking headroom and low power consumption, but it's priced too high to stand out in this crowded market.

1920 PERFORMANCE	EFFICIENCY	OVERALL SCORE
31/35	10/10	86%
2560 PERFORMANCE	VALUE	
23/30	22/25	

CCL COMPUTERS

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Nvidia GeForce RTX 2060 / From £299 inc VAT

SUPPLIER scan.co.uk

Graphics cards featuring Nvidia's latest RTX tech have now dropped below the £300 mark, with Palit RTX 2060 cards now going for £299 inc VAT. That means you get access to Nvidia's dedicated RT cores for real-time ray tracing, as well as the Tensor cores, which can improve anti-aliased performance using Nvidia's custom DLSS (deep learning super-sampling). These features aren't featured in many games yet, but real-time ray tracing (see Issue 186, p92) does look fantastic in the games that support it.

In our initial review (see Issue 187, p20), the RTX 2060 coped with real-time ray tracing in Battlefield V with a solid minimum of 60fps at 1080p in Low DXR mode. This figure then increased to dropped to 41fps in High DXR mode. Since then, however, the game has introduced DLSS support, which will improve performance even further. We haven't tested DXR in this Labs test, seeing as only one GPU has the official hardware to support it, but it's a definite bonus.

Even without the RT and Tensor cores, however, the RTX 2060 is by far the best card on test. Of course, you'd expect the most expensive card to be the fastest, but the performance margins are large for a comparatively modest increase in outlay. The card didn't drop below 60fps in any of our demanding test games at 1,920 x 1,080, which is a superb result. It also stayed above 45fps in all our games at 2,560 x 1,440, making this resolution a solid proposition, even when running demanding titles.

SPEC

Graphics processor Nvidia GeForce RTX 2060

Base clock 1365MHz

Boost clock 1680MHz

Pipeline 1,920 stream processors, 48 ROPs

RT Cores 30

Tensor Cores 240

Memory 6GB GDDR6, 14GHz effective

Memory interface 192-bit

Bandwidth 336GB/sec

Power connections 1 x 8-pin

In terms of specs, the RTX 2060 is based on the same 12nm TU106 GPU found in Nvidia's pricier RTX 2070 (see Issue 184, p28), but with six of the streaming multiprocessors (SMs) switched off, giving you a total of 30. That's still a powerful chip for under £300, though, giving you 1,920 Turing stream processors, compared to the 2,304 in the RTX 2070.

However, reducing the number of SMs also reduces the number of memory controllers, so you only get 6GB of memory with the RTX 2060, connected to a 192-bit memory interface. Nvidia gets around that limited interface by using high-speed GDDR6 memory, though, running at an effective frequency of 14GHz, giving you a total bandwidth of 336GB/sec. The Radeon RX Vega 56 is technically better in this respect, but it's still slower in the vast majority of tests. Basically, the memory currently isn't a limiting factor in current games running at these resolutions.

Despite all the extra RTX hardware, the RTX 2060 still doesn't draw that much power either. Our test system drew 244W from the mains with the 2060 installed, which is a fair bit more than the other Nvidia GPUs but still well behind the AMD GPUs. When you compare that figure to the frame rates you get, however, the big picture shows the RTX 2060 to be extraordinarily power-efficient.

TRACING RAYS

+ Superb gaming performance
+ Very power-efficient
+ Real-time ray-tracing support

TRACING PAPER

– Comparatively expensive
– Only 6GB of memory

Conclusion

Pricier GPUs are usually faster than cheaper ones, but the RTX 2060's performance jump is huge. There's only £40 separating the RTX 2060 from the GTX 1660 Ti now, but the RTX chip is significantly quicker across the board. Add the great power efficiency, as well as hardware for real-time ray tracing and deep learning features such as DLSS, and the RTX 2060 is a long way in front of every other card on test. If you can stretch your budget far enough to buy an RTX 2060 then do it. CPC

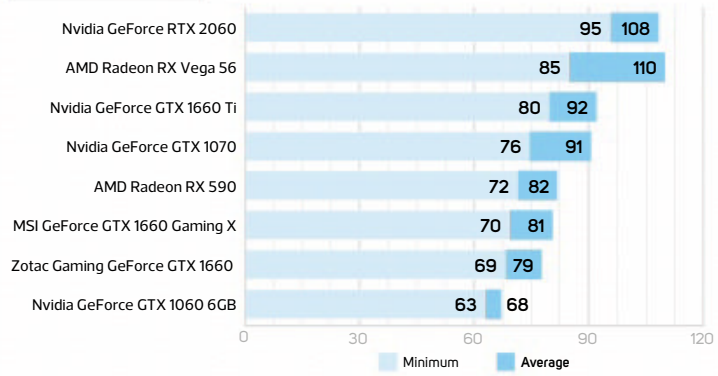
VERDICT

Well worth the extra money, the RTX 2060 is a long way in front of every other card on test.

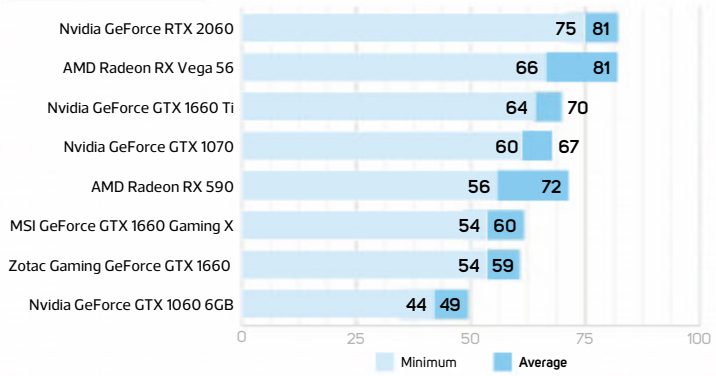
1920 PERFORMANCE	EFFICIENCY	OVERALL SCORE
35/35	10/10	96%
2560 PERFORMANCE	VALUE	
28/30	23/25	

GRAPHICS CARD RESULTS

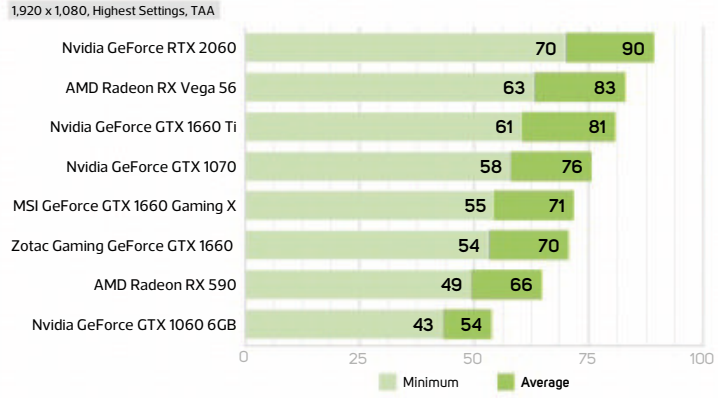
BATTLEFIELD V (FPS)
1,920 x 1,080, DX11, Ultra settings



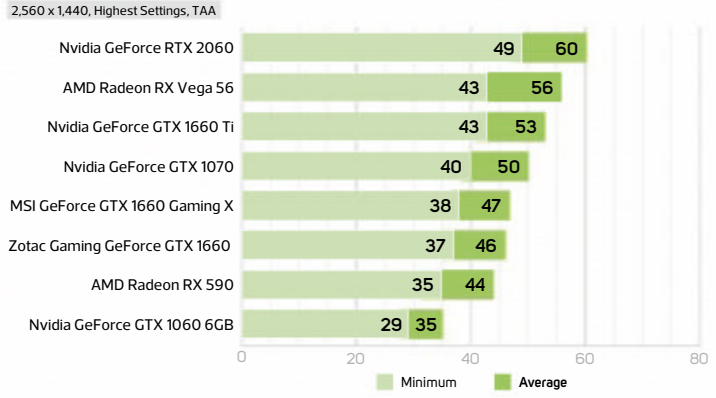
BATTLEFIELD V (FPS)
2,560 x 1,440, DX11, Ultra settings



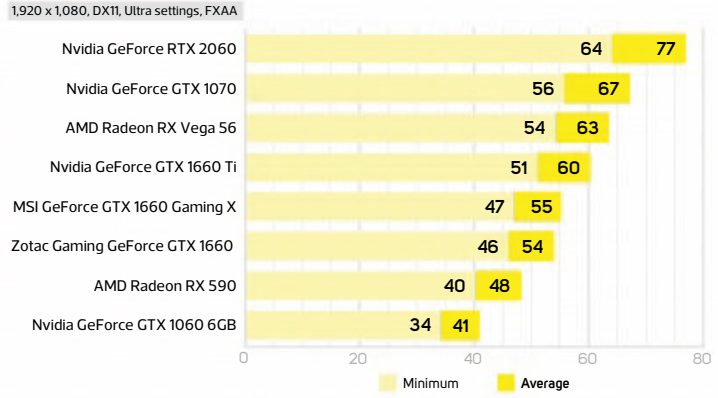
SHADOW OF THE TOMB RAIDER (FPS)
1,920 x 1,080, Highest Settings, TAA



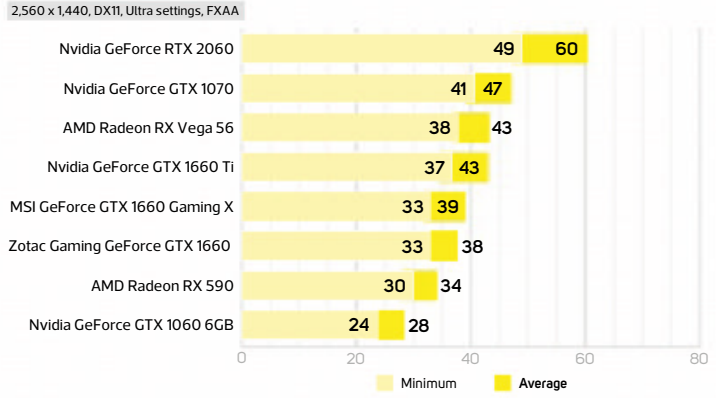
SHADOW OF THE TOMB RAIDER (FPS)
2,560 x 1,440, Highest Settings, TAA



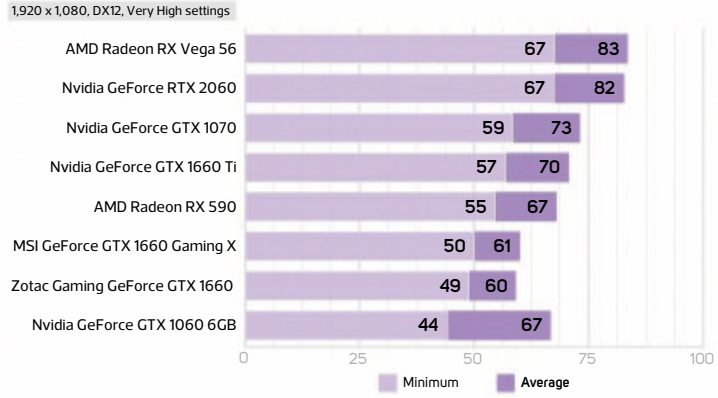
TOTAL WAR: WARHAMMER II (FPS)
1,920 x 1,080, DX11, Ultra settings, FXAA



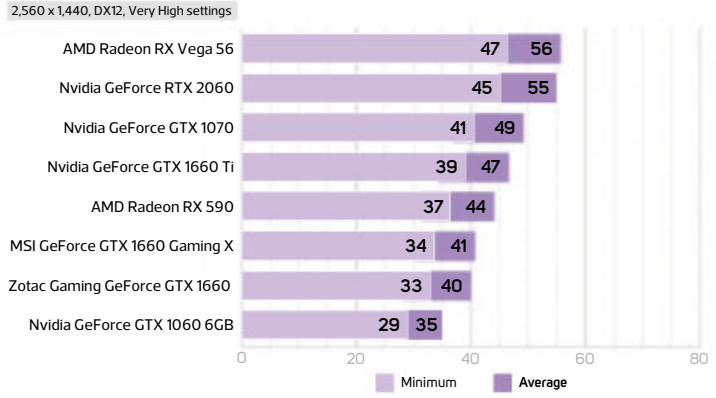
TOTAL WAR: WARHAMMER II (FPS)
2,560 x 1,440, DX11, Ultra settings, FXAA



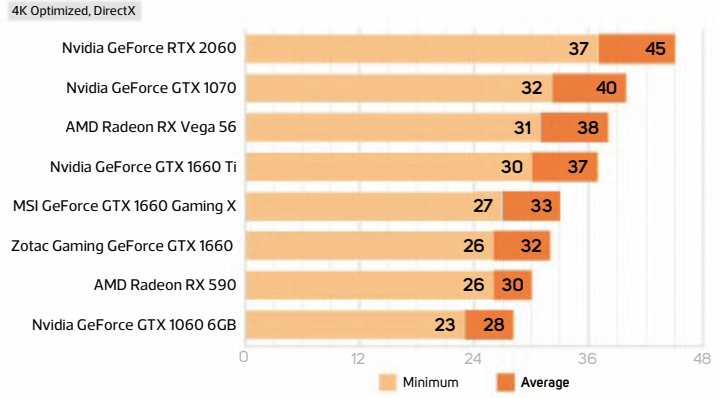
DEUS EX: MANKIND DIVIDED (FPS)
1,920 x 1,080, DX12, Very High settings



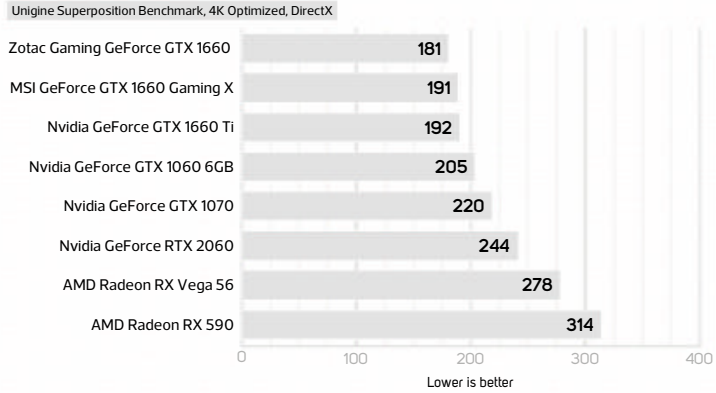
DEUS EX: MANKIND DIVIDED (FPS)
2,560 x 1,440, DX12, Very High settings



UNIGINE SUPERPOSITION (FPS)
4K Optimized, DirectX



TOTAL SYSTEM LOAD POWER CONSUMPTION (WATTS)
Unigine Superposition Benchmark, 4K Optimized, DirectX



LABS TEST

FreeSync goes G-Sync

Nvidia recently added G-Sync support to some FreeSync monitors, making them far more tempting. Edward Chester takes a look at five examples

How we test

The arrival of Nvidia's G-Sync technology was one of the most exciting PC gaming developments in years. In one fell stroke, it improved your gaming experience in two clear and profound ways. Like V-Sync, it eliminated image-tearing, but by syncing the refresh rate of the monitor to the frame rate of your graphics card, it also removed the stutter associated with V-Sync. The result was a smoother, better-looking gaming experience regardless of the frame rate your PC could muster.

The problems with G-Sync, though, have been just as numerous. Support is exclusive to use with Nvidia graphics cards – it uses a functionally limited custom processor inside the monitor and it's also expensive. At least, that was the situation until recently. Nvidia has now opened up G-Sync support to some displays that use AMD's rival FreeSync technology, enabling you to buy a cheaper FreeSync display and still get smooth gaming with your Nvidia graphics card. We've grabbed five such displays to see if we've finally found gaming monitor perfection.

To test the monitors, we first look at the design, build quality and other physical features, including areas such as ergonomics and connections. We then assess image quality using a combination of subjective tests, gauging aspects such as viewing angles and gaming performance, as well as objective tests for image quality with an Xrite iDisplay Pro colorimeter and DisplayCal software. We test the display both in its out-of-the-box state, and when it's set up to our liking, we also perform a test after full calibration.

Crucial to this Labs test, we'll also be testing some games, looking at how well G-Sync works and its impact on the value and appeal of these displays.

Contents

AOC G2590FX / £200 inc VAT

SUPPLIER overclockers.co.uk

The AOC G2590FX typifies the benefits of buying a FreeSync monitor with G-Sync support. It costs just £200 yet still delivers a 144Hz refresh rate and 1ms response time, while also providing the benefits of adaptive sync on both AMD and Nvidia graphics cards. In comparison, you can't buy a true G-Sync display for under £400 inc VAT.

As such, the AOC G2590FX hardly has to do more than deliver a usable level of image quality and gaming performance to be worth considering. Thankfully, though, it delivers a lot more than that. For a start, it's very stylish. The screen is surrounded on three sides by a slim, low-profile bezel that gives the whole display a light, modern feel. A simple round base with a concentric circle pattern and a muted red plastic trim along the bottom of the display further add to the simple but effective vibe.

What you don't get is much in the way of extras. The stand is a very basic, all-plastic affair that only offers tilt adjustment, while there's no USB hub or pop-out headphone stand. You don't even get any speakers. Input options are better, with one each of DisplayPort, HDMI and VGA sockets, but its feature set is otherwise sparse.

Around the back, you'll find a single mini-joystick for navigating the OSD menus. This system works superbly in conjunction with the menus, making it quick and intuitive to change settings. The menus aren't the prettiest we've seen, and they aren't exactly festooned with extra options, but all the essentials are there.

SPEC

Screen size 24.5in

Resolution 1,920 x 1,080

Panel technology TN

Maximum refresh rate 144Hz

Stated response time 1ms

Contrast 1,000:1

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

Audio 3.5mm audio in, 3.5mm audio out (no volume control)

Stand adjustment Tilt

Extras None

What's more, there won't be much need to venture into the menus anyway, as the display arrives with its image properly configured – only the brightness level really needed to be adjusted. Indeed, for a TN display, overall image quality is excellent across the board.

In its default mode, the display delivers a plentiful 901:1 contrast ratio, a colour temperature of 6,673K (very close to the ideal of 6,500K) and its gamma reading is 2.18 – just a smidge short of the ideal of 2.2. Subjectively too, this display delivers the goods. Viewing angles are reasonable for a TN display, colours all look natural and there's none of the fuzziness or shimmer that can affect some cheap displays.

When it comes to gaming, the 144Hz refresh rate, 1ms response time and G-Sync support work superbly. While 240Hz screens do provide an even more responsive feel, you're still getting a very snappy, yet smooth, experience that's great for a wide variety of genres, including first-person shooters.

The size and resolution is well balanced too. With 1,920 x 1,080 pixels stretched over a 24.5in screen, you get a pixel density of 90ppi. It's better to have a higher pixel density for a monitor dedicated to desktop work, but for gaming, it's a great balance between having a sharp image while also making it easy to aim.

FREESYNC

- \+ Fantastic value
- \+ Good gaming performance
- \+ Decent image quality

FREE SINK

- − Basic plastic stand
- − No USB hub or other extras
- − Goes no higher than 144Hz

Conclusion

A bargain price, an attractive design, good overall image quality and great gaming performance combine to make the AOC G2590FX a superb value monitor. It really shows the benefit of adding G-Sync support to a FreeSync display. If your budget can't go beyond £200 inc VAT, this display should to go right to the top of your gaming monitor shortlist, whether you use an AMD or Nvidia GPU.

VERDICT

Embodies the benefit of adding G-Sync support to FreeSync monitors. A bargain.

IMAGE QUALITY	FEATURES	OVERALL SCORE
24/30	13/20	82%
GAMING PERFORMANCE	VALUE	
25/30	20/20	

Asus VG258QR / £280 inc VAT

SUPPLIER overclockers.co.uk

The Asus VG258QR is on the pricier side of the scale for a 1080p G-Sync 24in/25in monitor without the official hardware. However, it delivers the premium touches you expect from a slightly more expensive monitor.

It gets off to a good start with the build quality and styling. Surrounding the display is a narrow, low-profile bezel, providing a compact, modern look, while the rest of the monitor has a simple, understated feel with its muted, dark grey plastic finish. There's none of the RGB lights of the Asus XG248Q, but that's precisely why this display is much more affordable.

The stand also offers a full set of ergonomic adjustments, and provides a solid platform for the display. Connection options aren't this display's strongest suit though. There's no USB hub and, instead of the two HDMI video inputs on some of the other displays on test, the third input is a less useful DVI-D port.

Back to the good stuff though, the screen steps up from the 144Hz refresh rate of more basic gaming screens to 165Hz. The difference is subtle rather than groundbreaking, but it's a neat feature, especially as there's no need to overclock the display to obtain it.

Another positive feature is the on-screen display menu system. It's controlled by a mini-joystick and four buttons on the back of the display. They all work superbly together, making setup quick and easy. There's a few settings that are a little tricky to find, and quite a few that are locked out unless you switch to the right gaming profile, but by and large, it's easy to get this monitor set to your liking.

The Asus strikes a good balance between resolution and screen size too. The panel size of 25in, along with a 1,920 x 1,080 resolution, makes for a slightly blocky image that may not be ideal for desktop work, but it's great for gaming. The slightly larger pixels make it easy to aim precisely without compromising sharpness, and you also don't need a monster GPU to churn out the necessary frame rates.

DISPLAYPORT

- \+ Premium look and feel
- \+ Decent value
- \+ Great gaming performance

DVI

- – No USB hub
- – Who uses DVI now?

SPEC

Screen size 25in

Resolution 1,920 x 1,080

Panel technology TN

Maximum refresh rate 165Hz

Response time 1ms

Contrast 1,000:1

Display inputs 1 x DisplayPort, 1 x HDMI, 1 x DVI-D

Audio 2 x 4W speakers, 3.5mm audio in, 3.5mm audio out

Stand adjustment Height, pivot, rotation, tilt

Extras None

Overall image quality impresses too. Right out of the box, the display is set up well, with colour balance and gamma all being very close to ideal figures. The native contrast is very good too. The net result is an image that's rich, colourful and accurate. The usual caveats of using a TN-type display apply, so viewing angles aren't amazing, and the image isn't as stable and clear as IPS screens, but it's great for a TN display.

Gaming performance is excellent too. The extra 21Hz isn't the most obvious upgrade over other gaming screens, but the image is otherwise very quick to respond and the display kept up with our fast movements perfectly. G-Sync also worked as expected, with no problems and a smooth, tear-free gaming experience.

Conclusion

The Asus VG258Q isn't the cheapest, fastest or most feature-rich 1080p gaming display, but it does strike a great balance between all these factors. It's not too pricey, yet has some premium touches, without going overboard on unnecessary extras. With excellent image quality and gaming performance, this monitor is easy to recommend.

VERDICT

Stylish, responsive and capable. A premium gaming monitor for an affordable price.

IMAGE QUALITY	FEATURES	OVERALL SCORE
24/30	16/20	84%
GAMING PERFORMANCE	**VALUE**	
26/30	18/20	

Acer ZX321Q / £300 inc VAT

SUPPLIER box.co.uk

Measuring 31.5in from corner to corner, Acer's ZX321Q has a huge screen yet it still only sports a resolution of 1,920 x 1,080 pixels, meaning you get a bit of a chunky image when you're up close to it. The Acer also uses a VA-type panel, which generally provides a better image than the TN panels on test.

In particular, it has far wider viewing angles; along with its low pixel density, this mean it's better suited as a hybrid TV/monitor than a straight desktop monitor – it's ideal if several people are viewing the screen while playing games, or while sitting to the side on a bed or sofa. Where the XZ321Q regains its PC gaming credentials is with its 144Hz refresh rate and, of course, FreeSync and G-Sync support.

The upshot is a display that won't be an obvious upgrade for many PC gamers, but it's potentially be ideal in some scenarios. It was this potential that the XZ321Q showed when it was first released back in 2016, but a high price of around £500 inc VAT made it unconvincing. However, a price drop in many shops to as little as £300, and the addition of G-Sync support, has given it a new lease of life.

Meanwhile, styling and build quality are excellent. The display has low-profile, hidden bezels around the top and sides, and the whole screen has a slight curve. A matt black and silver colour scheme is used throughout the design, with a general feeling of quality in all areas. The same goes for the hefty stand, which has height, rotation and tilt adjustment.

SPEC

Screen size 31.5in

Resolution 1,920 x 1,080

Panel technology VA

Maximum refresh rate 144Hz

Response time 4ms

Contrast 3,000:1

Display inputs 1 x DisplayPort 1.2, 1 x HDMI 1.4

Audio 2 x 7W speakers, 3.5mm audio in, 3.5mm audio out (no volume control)

Stand adjustment Tilt

Extras 4-port USB 3 hub

The connection options also hint at the potential to use this display for a more varied role, including four video inputs – HDMI 1.2, HDMI 2, DisplayPort 1.2 and mini-DisplayPort 1.2. There's also a 4-port USB 3 hub on the rear and a pair of 7W speakers, which offer more power and clarity than most monitor speakers. The OSD also impresses, with an easy-to-use mini-joystick and four buttons, plus an intuitive and responsive set of menus.

As for the screen itself, the huge size and low resolution mean it's not ideal for work and other desktop duties, but overall image quality is very good. Viewing angles, colour balance and gamma are all excellent right out of the box, while the whopping 3,000:1 contrast ratio gives the display a real depth and punch that's great for watching video and playing games.

VA-type LCDs are not known for their responsiveness, and are generally considered the worst for competitive PC gaming. Surprisingly, however, we found the overall gaming experience to be excellent on the Acer. The slow response time wasn't too egregious, and the vast screen size makes it easy to see and target your enemies. The low resolution also means you can get high frame rates at the native resolution without an overly expensive GPU.

HD SCREEN

+ Huge screen
+ Good gaming performance
+ Decent image quality

HD FLOPPY DISK

- Low pixel density
- Relatively slow response time
- Niche appeal

Conclusion

With a price drop and the addition of G-Sync support, the Acer ZX321Q makes a lot more sense now than when it first launched. The chunky pixel density means it's not ideal for everyone, especially as a general desktop monitor. However, it's a solid option as a crossover TV/monitor hybrid for gaming and movies.

VERDICT

A big screen with great gaming performance, although the low pixel density means it's not ideal for general work.

IMAGE QUALITY	FEATURES	OVERALL SCORE
25/30	17/20	81%
GAMING PERFORMANCE	VALUE	
23/30	16/20	

Asus ROG Strix XG248Q / **£420** inc VAT

SUPPLIER overclockers.co.uk

Sitting under Asus' Republic of Gamers umbrella, the XG248Q sits at the premium end of the FreeSync monitor market, with a price that's nearly double that of some 1080p, 144Hz gaming monitors. Its headline feature is a 240Hz refresh rate. While some 240Hz screens have dropped to as low as £350 inc VAT, most still demand a similar outlay to this display. In other areas, it delivers the sort of premium touches you'd expect for the money as well.

As with other Asus Strix products, there's a strong focus on RGB lighting. Around the back of the display you'll find a ring of multi-coloured light that you can set to all manner of colours and lighting patterns. It's about as pointless as RGB lighting gets for most people, as you can't see it at all from the front – it's hardly bright enough to illuminate the space behind – but it does look attractive from the back.

There's also a downward-firing red light on the underside of the stand. You can use this light to project an Asus ROG logo or, via an included blank plastic disc, a design of your own choice, onto the surface below – like a Batman signal. Unfortunately, we found that, even on its lowest brightness, this light was a bit too distracting to switch on while using the monitor.

Elsewhere, the design has plenty of quality touches. A low-profile bezel surrounds the panel, while the back of the display is adorned with a fetching PCB-like pattern. The stand also offers a full set of ergonomic adjustments and sits on three elegant metal legs.

SPEC

Screen size 24in

Resolution 1,920 x 1,080

Panel technology TN

Maximum refresh rate 240Hz

Response time 1ms

Contrast 1,000:1

Display inputs 1 x DisplayPort, 1 x HDMI, 1 x DVI-D

Audio 2 x 4W speakers, 3.5mm audio in, 3.5mm audio out

Stand adjustment Height, pivot, rotation, tilt

Extras 2-port USB 3 hub

There aren't many practical extras though. While there's a USB hub, it only has two ports on the back, with none on the side. There's also a headphone jack but no built-in speakers, and no stand for your headphones either. It does a little better when it comes to video inputs. You get the obligatory DisplayPort socket, and not one but two HDMI ports, which is more than any true G-Sync display can provide.

Meanwhile, the menu controls consist of a mini-joystick and four buttons on the back of the display. They work superbly in conjunction with the excellent on-screen display (OSD) menu system. The menu system is quick and easy to navigate and has a plethora of options.

What's more, the display arrives properly set up, so you won't have to change much anyway – just drop the brightness and you're ready to go. A little bit of fine tuning of the colour balance can get you even closer to perfection, but by and large, the XG248Q is as good as TN displays can get right off the bat, with excellent contrast, colour balance and gamma.

As you'd expect, gaming performance is superb too. G-Sync works flawlessly and the responsiveness of the screen is exceptional – 240Hz is worth it for competitive gaming, if you're good enough. The balance of display size and resolution is spot on too.

REPUBLIC

+ Stylish design
+ Great 240Hz gaming performance
+ Good image quality

DESPOTISM

- Expensive
- Not outstanding value

Conclusion

The Asus ROG Strix XG248Q delivers great image quality for a TN monitor, as well as exceptional gaming performance and premium design. However, the price is high for what's on offer, and some of the extra features are largely superficial, so it's not a standout bargain.

VERDICT

A fantastic, high-end gaming screen, but it's up against stiff competition at this price.

IMAGE QUALITY	FEATURES	OVERALL SCORE
25/30	16/20	81%
GAMING PERFORMANCE	**VALUE**	
28/30	12/20	

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BenQ Zowie XL2740 / £479 inc VAT

SUPPLIER overclockers.co.uk

BenQ's Zowie XL2740 has a comparatively utilitarian design, despite its premium price tag and high-end specification, which includes a 240Hz refresh rate.

You won't find slim, low-profile bezels or RGB lighting here, just a solid mass of hefty matt black plastic with the merest hints of red paint or plastic here and there. We're all for keeping design simple, but it's all a bit stark. On the plus side, there's plenty of handy little extras, although quite frankly, you'd expect them given the price of this display.

The stand, for instance, offers a full complement of ergonomic adjustments, including the ability to pivot the display into a portrait mode. The top of the stand also includes a carry handle. On the screen's left-hand side there's also a pop-out headphone stand, a couple of USB 3 ports, and audio in and out sockets, while the base of the stand has a circular recess to hold the wired OSD remote. The remote includes three buttons for instantly recalling a preset, as well as a couple of other buttons and a scroll wheel for navigating the menus. It's not an essential addition but it can be useful.

Less useful for most people is the Shield. It comprises two side wings that are supposed to help you concentrate when gaming, but we found their benefit to be dubious. If BenQ had included a top piece, like you get with standard anti-glare hoods, then it would have been a bit more viable for that use. More impressive is the selection of connections. On the back you'll find a DisplayPort 1.2 port, an HDMI 1.4 input, an HDMI 1 socket and even a DVI-D port. There's also a second 3.5mm audio input and the USB uplink port for the hub.

Meanwhile, the on-screen display is controlled by five buttons that run along the bottom bezel of the screen. The button layout is logical and the menus are fast. There's a few settings that have obscure names – most notably overdrive, which is called AMA (Advanced Motino Acceleration) – but it's easy enough to set up this display. That's just as well, as the out-of-the-box image quality of this display is awful. It came set to its FPS1 preset as standard, where the picture was washed out and the colour was poor.

However, switching to the Standard picture mode, and changing the gamma setting from 3 to 5, results in a normal-looking display.

Once we made these tweaks, the colour balance is fine, contrast is excellent for a TN display and the gamma reading – the setting that was causing the display to look so washed out in its default mode – is near perfect at 2.25. What's more, the gaming performance of this display is superb. That 240Hz refresh rate combined with G-Sync makes for a crystal-clear, lightning-quick gaming experience.

SPEC

Screen size 27in

Resolution 1,920 x 1,080

Panel technology TN

Maximum refresh rate 240Hz

Response time 1ms

Contrast 1,000:1

Display inputs 1 x DisplayPort, 2 x HDMI, 1 x DVI-D

Audio 3.5mm audio in, 3.5mm audio out

Stand adjustment Height, pivot, rotation, tilt

Extras 2-port USB 3 hub, pop-out headphone stand, wired OSD remote

DAVID BOWIE

+ Fantastic gaming performance
+ Loads of features
+ Robust build quality

DAVID BRENT

– Expensive
– Uninspired appearance
– Poor out-of-the-box image quality

Conclusion

A high price means the XL2740 doesn't feel like quite the bargain offered by some of the other G-Sync-capable FreeSync monitors on test. In fact, you can get 240Hz true G-Sync monitors for less money. The larger screen size, extra features and fantastic gaming performance certainly make this display a contender, but it's simply too expensive at the moment.

VERDICT

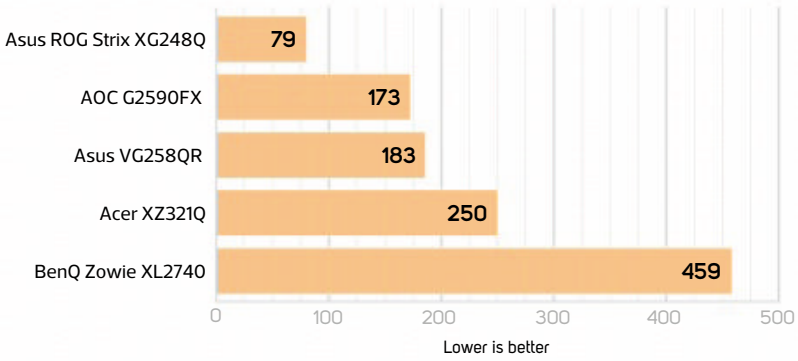
A pricey but very capable gaming monitor, once you've got it running in Standard mode and adjust the gamma.

IMAGE QUALITY	FEATURES	OVERALL SCORE
22/30	18/20	79%
GAMING PERFORMANCE	**VALUE**	
28/30	11/20	

MONITOR IMAGE QUALITY RESULTS

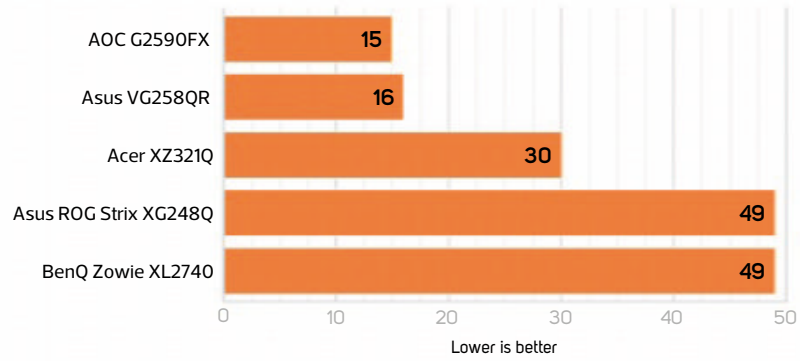
UNCALIBRATED COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



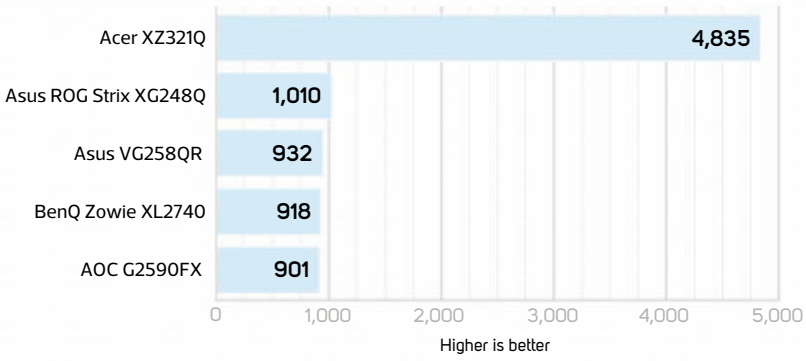
CALIBRATED COLOUR TEMPERATURE (KELVIN)

Deviation from ideal result (6,500K)



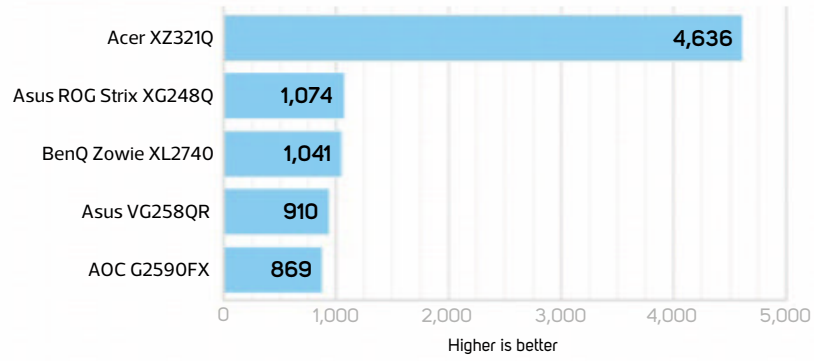
UNCALIBRATED CONTRAST RATIO

Ratio of white-to-black luminance



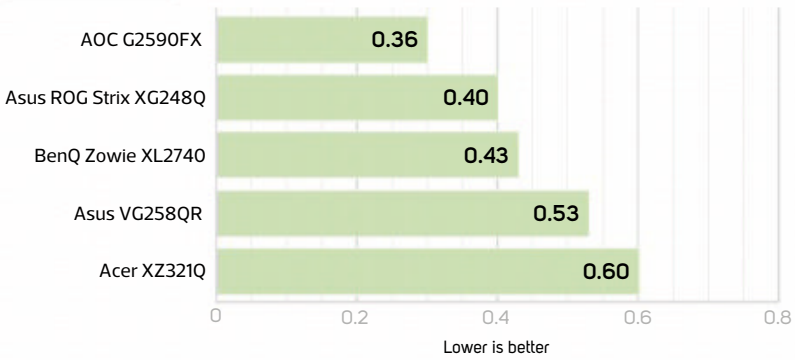
CALIBRATED CONTRAST RATIO

Ratio of white-to-black luminance



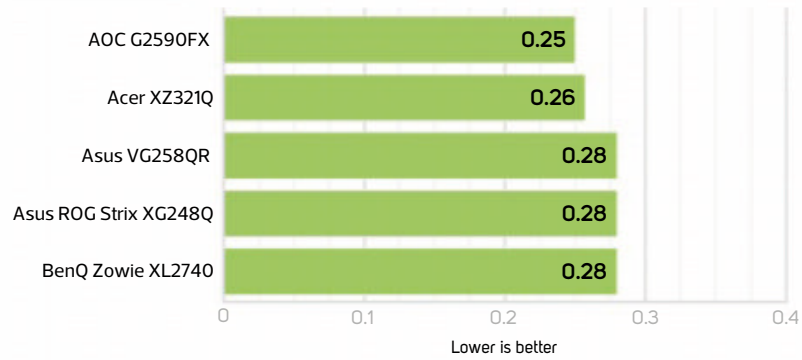
UNCALIBRATED COLOUR ACCURACY

Average delta-E 2000



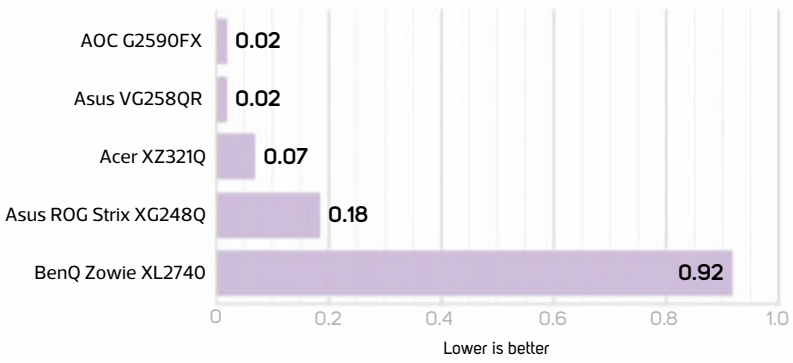
CALIBRATED COLOUR ACCURACY

Average delta-E 2000



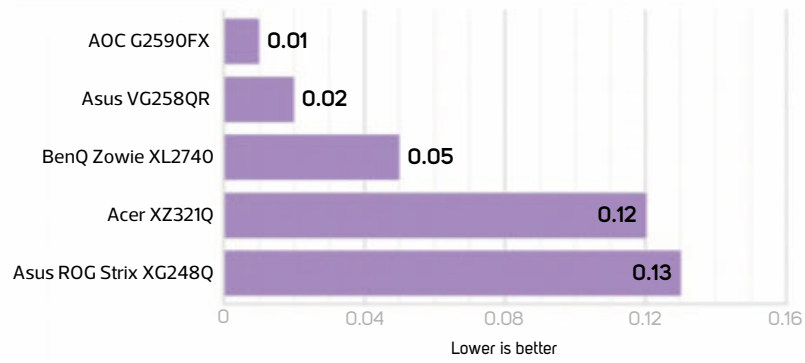
UNCALIBRATED AVERAGE GAMMA

Deviation from ideal result (2.2)



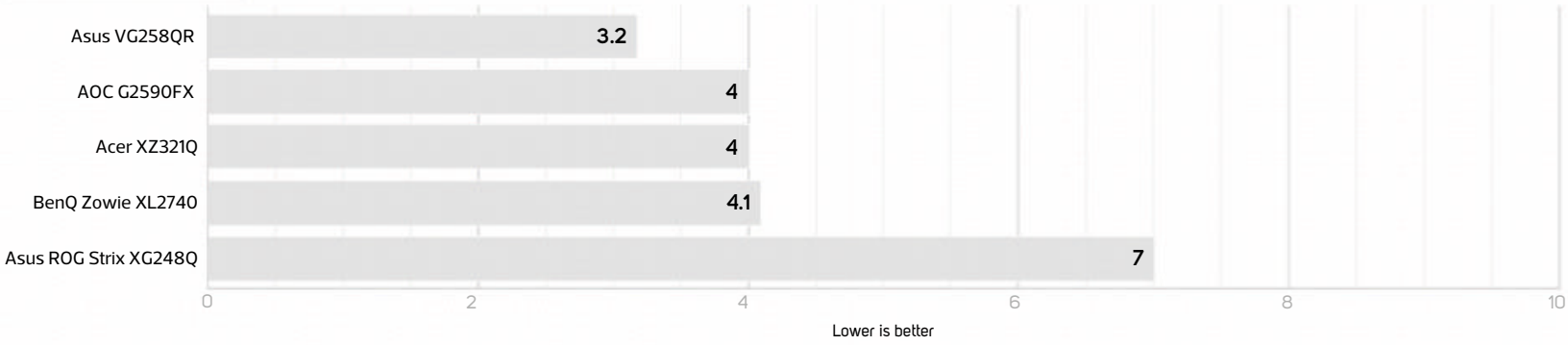
CALIBRATED AVERAGE GAMMA

Deviation from ideal result (2.2)



BRIGHTNESS UNIFORMITY

Average deviation from centre (%)



How we test

MOTHERBOARDS

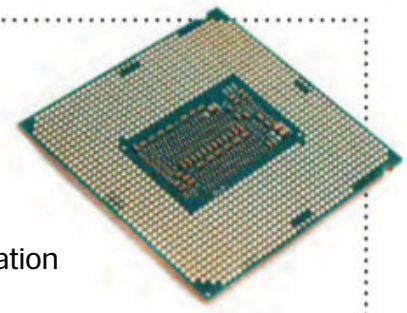
TEST PROCESSORS

- **Intel LGA1151** Intel Core i9-9900K
- **Intel LGA2066** Intel Core i9-7900X
- **AMD AM4** AMD Ryzen 7 2700X
- **AMD TR4** AMD Threadripper 2950X

We otherwise use the same core spec to test each motherboard. Our test gear comprises a Zotac AMP! GeForce GTX 1080 graphics card and a 512GB Samsung 960 Pro SSD. We also use Corsair Vengeance RGB 3000MHz DDR4 memory – a 16GB dual-channel kit for mainstream desktop systems, and a 32GB quad-channel kit for HEDT systems.

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

PROCESSORS



TEST MOTHERBOARDS

- **Intel LGA1151** MSI MEG Z90 ACE
- **Intel LGA2066** MSI MEG X299 Creation
- **AMD AM4** MSI X470 Gaming AC
- **AMD TR4** MSI MEG X399 Creation

We otherwise use the same core spec to test each CPU. Our test gear comprises a Zotac AMP! GeForce GTX 1080 graphics card and a 512GB Samsung 960 Pro SSD. We also use Corsair Vengeance RGB 3000MHz DDR4 memory – a 16GB dual-channel kit for mainstream desktop systems, and a 32GB quad-channel kit for HEDT systems.

We use **Custom PC**'s own RealBench suite, Cinebench and Far Cry 5, installed on Windows 10 Home 64-bit, and record the power draw of the test PC. These tests cover a broad range of performance characteristics, including image editing, gaming, video encoding and 3D rendering. We run all tests at stock speed and at the CPU's highest overclocked frequency.

MONITORS

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

CPU COOLERS

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

TEST KIT

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

INTEL LGA1151

Intel Core i5-9600K CPU overclocked to 4.6GHz with 1.2V vcore, MSI Z370 PC Pro 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, Asus ROG Strix B350-F Gaming 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 real-time ray tracing. Every graphics card is tested in the same PC, so all 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 are unable to produce playable frame rates at this setting. We also try to overclock every graphics card we test to assess the performance impact.

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

Battlefield V Tested in DirectX 11 at Ultra settings on every card. If a GPU also supports real-time ray tracing, we then test it in DirectX 12 with DXR enabled on Low and High settings. We run through a one-minute custom benchmark in the 'Under No Flag' War Story, recording the frame rate with Fraps.

Shadow of the Tomb Raider Tested at the Highest settings preset, with TAA. We run the built-in benchmark, and record the frame rate from the GPU test.

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.

Deus Ex: Mankind Divided Tested at the Very High preset in DirectX 12, running the built-in benchmark.

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. Bear in mind that this result is for the whole system, not the graphics card alone.

CUSTOM PC AWARDS

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

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

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

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

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

CUSTOM PC REALBENCH

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

GIMP IMAGE EDITING

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

HANDBRAKE H.264 VIDEO ENCODING

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

LUXMARK OPENCL

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

HEAVY MULTI-TASKING

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

Elite

Our choice of the best hardware available

Core component bundles

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

Budget system with integrated graphics

Quad-core CPU, basic gaming

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 3 2200G	scan.co.uk	**#176** p22	£85
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#176** p80	£0
GRAPHICS CARD	AMD Radeon RX Vega 8 integrated into CPU	N/A	**#176** p22	£0
MEMORY	8GB (2 x 4GB) Corsair Vengeance LPX 3000MHz (CMK8GX4M2A 3000C16)	scan.co.uk	**#176** p80	£48
MOTHERBOARD	MSI B450M Mortar (micro-ATX)	scan.co.uk	**#182** p50	£88
STORAGE	500GB Crucial MX500 (SATA 2.5in)	ebuyer.com	**#176** p43	£63
	Total £284			
UPGRADES				
SWAP CPU	AMD Ryzen 5 2400G (slightly faster CPU and GPU performance)	scan.co.uk	**#189** p45	£135

Budget gaming system

6-core CPU, 1080p gaming

Needs an ATX case with room for a 150mm-tall air cooler. We recommend a 450W 80 Plus Bronze power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 2600	scan.co.uk	**#189** p20	£145
CPU COOLER	ARCTIC Freezer 33 eSports One (air cooler)	amazon.co.uk	**#175** p20	£33
GRAPHICS CARD	Zotac Gaming GeForce GTX 1660 6GB	cclonline.com	**#190** p44	£206
MEMORY	8GB (2 x 4GB) Corsair Vengeance LPX 3000MHz (CMK8GX4M2A 3000C16)	scan.co.uk	**#176** p20	£48
MOTHERBOARD	MSI B450 Tomahawk (ATX)	overclockers.co.uk	**#182** p20	£100
STORAGE	WD Blue SN500 NVMe 500GB (M.2 NVMe)	overclockers.co.uk	**#190** p22	£69
	Total £601			
UPGRADES				
SWAP GRAPHICS CARD	AMD Radeon RX Vega 56 (smooth 1080p and some 2,560 x 1,440 gaming)	cclonline.com	**#190** p47	£248
SWAP MEMORY	16GB (2x 8GB) Corsair Vengeance LPX 3200MHz (CMK16GX4M2B 3200C16)	scan.co.uk	N/A	£96
SWAP STORAGE	500GB Samsung 970 Evo Plus (M.2 NVMe)	ebuyer.com	**#188** p51	£108

Mid-range all-purpose system

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

Needs an ATX case with room for a 120mm all-in-one liquid cooler. We recommend a 550W 80 Plus Bronze power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 2700X	overclockers.co.uk	**#189** p52	£290
CPU COOLER	Alphacool Eisbaer LT 120 (120mm AIO liquid cooler)	aquatuning.co.uk	**#178** p49	£77
GRAPHICS CARD	AMD Radeon RX Vega 56	cclonline.com	**#190** p47	£248
MEMORY	16GB (2 x 8GB) Corsair Dominator Platinum RGB 3200MHz (CMT16GX4M2C 3200C16)	scan.co.uk	**#188** p19	£143
MOTHERBOARD	Gigabyte X470 Aorus Ultra Gaming (ATX)	box.co.uk	**#176** p48	£134
STORAGE	500GB Samsung 970 Evo Plus (M.2 NVMe)	ebuyer.com	**#188** p51	£108
	Total £1,000			

UPGRADES

SWAP MEMORY	16GB (2 x 8GB) Corsair Dominator Platinum RGB 3466MHz (CMT16GX4M2C 3466C16)	scan.co.uk	**#188** p19	£179
SWAP GRAPHICS CARD	Nvidia GeForce RTX 2060 (smooth 2,560 x 1,440 gaming, and real-time ray tracing at 1080p)	scan.co.uk	**#190** p50	£299
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£100

Mid-range gaming system

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

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	Intel Core i7-9700K	cclonline.com	**#189** p53	£389
CPU COOLER	Corsair H100i Pro RGB (240mm AIO liquid cooler)	scan.co.uk	**#183** p50	£77
GRAPHICS CARD	Nvidia GeForce RTX 2070	scan.co.uk	**#184** p28	£470
MEMORY	16GB (2 x 8GB) Corsair Dominator Platinum RGB 3200MHz (CMT16GX4M2 C3200C16)	scan.co.uk	**#188** p19	£143
MOTHERBOARD	Gigabyte Z390 Aorus Pro (ATX)	cclonline.com	**#189** p32	£168
STORAGE	500GB Samsung 970 Evo Plus (M.2 NVMe)	ebuyer.com	**#188** p51	£108
	Total £1,355			

UPGRADES

ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£100

Core component bundles cont ...

4K gaming system

Very fast 8-core CPU, 4K gaming with real-time ray tracing

Needs an 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	Intel Core i9-9900K	overclockers.co.uk	**#189** p20	£470
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	**#175** p20	£110
GRAPHICS CARD	Nvidia GeForce RTX 2080 Ti	scan.co.uk	**#189** p20	£1,000
MEMORY	16GB (2 x 8GB) Corsair Dominator Platinum RGB 3200MHz (CMT16GX4M2C 3200C16)	scan.co.uk	**#176** p20	£143
MOTHERBOARD	Asus Maximus XI Hero (ATX)	scan.co.uk	**#182** p20	£260
STORAGE	500GB Samsung 970 Evo Plus (M.2 NVMe)	ebuyer.com	**#176** p20	£108
	Total £2,091			
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	**#166** p54	£100

Heavy multi-threading workstation

Serious multi-threaded power, 1080p gaming

Needs an ATX case with room for a 240mm all-in-one liquid cooler. We recommend a 700W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Threadripper 2950X	overclockers.co.uk	**#182** p23	£800
CPU COOLER	Enermax Liqtech II TR4 240 (240mm AIO liquid cooler)	overclockers.co.uk	**#186** p44	£130
GRAPHICS CARD	Zotac Gaming GeForce GTX 1660 6GB	cclonline.com	**#190** p44	£206
MEMORY	32GB Corsair Dominator Platinum RGB 3200MHz (CMT32GX 4M4C3200C16)	scan.co.uk	**#188** p19	£286
MOTHERBOARD	MSI X399 Gaming Pro Carbon AC (ATX)	amazon.co.uk	**#170** p50	£355
STORAGE	1TB Samsung 970 Evo Plus (M.2 NVMe)	ebuyer.com	**#188** p51	£213
	Total £1,990			
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 (2,560 x 1,440 gaming with real-time ray tracing)	scan.co.uk	**#184** p28	£470
SWAP CPU	AMD Threadripper 2990WX (faster in some heavily multi-threaded software, not recommended for gaming)	scan.co.uk	**#182** p24	£1,628
ADD SECONDARY STORAGE	6TB Seagate BarraCuda Pro	overclockers.co.uk	**#166** p50	£200

Mini PCs

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

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	ASRock Z390 Phantom Gaming-ITX/ac	scan.co.uk	**#185** p50	£198
Intel X299 (LGA2066)	ASRock X299E-ITX/ac	scan.co.uk	**#174** p26	£396
AMD X470 (AM4)	Asus ROG Strix X470-i Gaming	scan.co.uk	**#181** p22	£182

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Define Nano S	scan.co.uk	**#153** p22	£60
PREMIUM	NZXT H200i	scan.co.uk	**#187** p41	£120

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	**#143** p17	£43

Power supplies

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
800W SFX	SilverStone Strider SST-SX800-LTI	scan.co.uk	**#185** p82	£161

ATX Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	**#176** p28	£55
SUB-£75	NZXT H500	scan.co.uk	**#178** p26	£70
SUB-£100	Lian Li Lancool One Digital	overclockers.co.uk	**#184** p32	£95
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	**#187** p24	£128
HIGH-END	Phanteks Enthoo Evolv X	overclockers.co.uk	**#187** p24	£200
LUXURY	Cooler Master Cosmos C700M	scan.co.uk	**#183** p28	£400

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	Asus ROG Maximus XI Gene	overclockers.co.uk	**#189** p28	£309
Intel X299 (LGA2066)	MSI X299M Gaming Pro Carbon AC	cclonline.com	**#174** p24	£255
AMD X399 (TR4)	ASRock X399M Taichi	scan.co.uk	**#179** p28	£330
AMD B450 (AM4)	MSI B450M Mortar	scan.co.uk	**#182** p50	£88

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	overclockers.co.uk	**#180** p46	£50
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	**#161** p26	£70
PREMIUM	NZXT H400i	overclockers.co.uk	**#175** p32	£90

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER	Linksys EA9500 Max-Stream	amazon.co.uk	**#182** p58	£232
PREMIUM ROUTER	Asus ROG Rapture GT-AC5300	overclockers.co.uk	**#170** p35	£340
MESH NETWORK (requires existing router)	BT Whole Home Wi-Fi Triple Pack	currys.co.uk	**#172** p54	£180
PREMIUM MESH ROUTER	Netgear Orbi 2-Pack (RBK50)	amazon.co.uk	**#172** p57	£295
WI-FI ADAPTOR	Asus PCE-AC68	scan.co.uk	**#128** p88	£58
SINGLE-BAY NAS BOX	Synology DS118	box.co.uk	**#174** p34	£148
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£204

Monitors

AMD FreeSync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN BUDGET 1,920 X 1,080	AOC G2460VQ6	amazon.co.uk	**#174** p52	£125
24IN MID-RANGE 1,920 X 1,080	ViewSonic XG2401	amazon.co.uk	**#167** p52	£200
24IN 240Hz ESPORTS 1,920 X 1,080	AOC AGON AG251FZ	overclockers.co.uk	**#187** p48	£290
27IN 2,560 X 1,440	Samsung C27HG70	ebuyer.com	**#171** p28	£474

Nvidia G-Sync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN 2,560 X 1,440	AOC AGON AG241QG	box.co.uk	**#169** p55	£400
27IN 2,560 X 1,440	Asus ROG Swift PG279Q	scan.co.uk	**#155** p48	£672
35IN ULTRA-WIDE 3,440 X 1,440	AOC AGON AG352UCG6	box.co.uk	**#180** p52	£730
27IN 4K PREMIUM	Asus ROG Swift PG27UQ	scan.co.uk	**#181** p31	£1,799

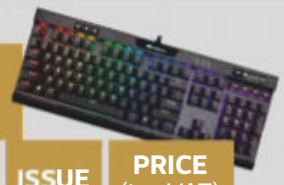
AMD FreeSync and Nvidia G-Sync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN BUDGET 1,920 X 1,080	AOC G2590FX	overclockers.co.uk	**#190** p53	£200
25IN MID-RANGE 1,920 X 1,080	Asus VG258QR	overclockers.co.uk	**#190** p54	£280

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN 5,120 X 2,880	Iiyama ProLite XB2779QQS	scan.co.uk	**#179** p34	£695

Peripherals and audio



Gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
MEMBRANE	Corsair K55 RGB	overclockers.co.uk	**#176** p52	£50
MECHANICAL	Corsair K68	ebuyer.com	**#181** p53	£83
MECHANICAL MMO	Corsair K95 RGB Platinum	ebuyer.com	**#164** p26	£170
PREMIUM MECHANICAL	Corsair K70 RGB MK.2	overclockers.co.uk	**#187** p30	£160

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
FIRST-PERSON SHOOTER	SteelSeries Rival 600	scan.co.uk	**#184** p59	£74
MMO	Roccat Nyth	amazon.co.uk	**#186** p53	£67
AMBIDEXTROUS	Razer Lancehead Tournament Edition	scan.co.uk	**#177** p53	£65
WIRELESS	Logitech G Pro Wireless	currys.co.uk	**#187** p19	£130

Peripherals and audio cont ...

Game controllers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEERING WHEEL AND PEDALS	Logitech G920 Driving Force	currys.co.uk	**#159** p55	£200

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
2.1	Acoustic Energy Aego^3	amazon.co.uk	**#164** p49	£219

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	HyperX Cloud Alpha	currys.co.uk	**#173** p50	£70
SURROUND	Asus ROG Centurion	ccdonline.com	**#163** p49	£209
WIRELESS	SteelSeries Arctis 7	amazon.co.uk	**#178** p58	£114
PREMIUM WIRELESS	SteelSeries Arctis Pro + GameDAC	scan.co.uk	**#179** p31	£213

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET PC WITH INTEGRATED GRAPHICS	Falcon Raptor RX	AMD Ryzen 5 2400G stock speed	AMD Radeon RX Vega 11	falconcomputers.co.uk	**#176** p52	£470
SUB-£1,000 GAMING	Chillblast Fusion Ryzen 5 GTX 1660 Ti	AMD Ryzen 5 2600 stock speed	Nvidia GeForce GTX 1660 Ti	chillblast.com	**#189** p58	£999
ENTRY-LEVEL GEFORCE RTX GAMING	PC Specialist Magma RTX	AMD Ryzen 7 2700X OC to 4.1GHz	Nvidia GeForce RTX 2060	pcspecialist.com	**#187** p58	£1,305
GEFORCE RTX 2080 GAMING	Chillblast Fusion Juggernaut 2080	Intel Core i5-9600K OC to 4.6GHz	Nvidia GeForce RTX 2080	chillblast.com	**#183** p62	£2,100
PREMIUM MINI-ITX	Corsair One i160	Intel Core i9-9900K stock speed	Nvidia GeForce RTX 2080 Ti	corsair.com	**#190** p32	£3,399
PREMIUM GEFORCE RTX 2080 TI GAMING	CyberPower Infinity X99 Hyper Liquid II	Intel Core i9-9900K OC to 4.6GHz	Nvidia GeForce RTX 2080 Ti	cyberpowersystem.co.uk	**#187** p56	£3,586
DREAM PC	Scan 3XS Barracuda	Intel Core i9-9900X OC to 4.4GHz	2 x Nvidia GeForce RTX 2080 Tiw	scan.co.uk	**#145** p58	£9,788

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
GAMING	PC Specialist Recoil II RTX 17.3in	Intel Core i7-8750H stock speed	Nvidia GeForce RTX 2070	17.3in 1,920 x 1,080 IPS 144Hz	pcspecialist.com	**#188** p32	£1,696
THIN AND LIGHT GAMING	Chillblast Fusion Ryzen 5 GTX 1660 Ti	AMD Ryzen 5 2600 stock speed	Nvidia GeForce GTX 1660 Ti	Nvidia GeForce RTX 2070	scan.co.uk	**#189** p34	£1,750
PREMIUM GAMING	Asus ROG Zephyrus S GX701GX	Intel Core i7-8750H stock speed	Nvidia GeForce RTX 2080 Max-Q	17.3in 1,920 x 1,080 IPS 144Hz G-Sync	amazon.co.uk	**#190** p28	£3,199

RICK LANE / INVERSE LOOK

BRING BACK GIBS!

Rick Lane wants first-person shooters to be more honest about violence

Pardon me for turning into your grandad, but when I was a lad and first-person shooters were fast, blocky and entirely inappropriate for me to be playing, enemies wouldn't simply crumple to the ground like a rubber lamppost when shot. Instead, when struck by a rocket or a shotgun blast, they would explode in a shower of meaty giblets (hence 'gibs').

In the 1990s, if an FPS didn't let you gib an opponent in at least two different ways, it probably wasn't worth playing. But gibs fell out of favour after the turn of the millennium. There wasn't any obvious cause, although there's a couple of possible culprits. The first is technological. Gibs disappeared around the advent of ragdoll physics, which quickly became the de facto end state of dead virtual enemies. Also, trying to render the trajectories of all those flying chunks would have killed most PCs of the time.

In the 2000s, first-person shooters also moved away from the fantasy and sci-fi settings of Quake and Unreal, and embraced real-world scenarios such as WWII and modern theatres of conflict, emphasising authenticity. Developers such as Infinity Ward wanted to portray the battlefields believably. These games wanted to be taken *seriously*.

As such, they didn't want to accidentally glorify the violence of these wars, so the emphasis on gore was reduced. Given that the inspiration for many of these games was Spielberg's horrifically grisly Saving Private Ryan, this may appear an odd decision.

But at the time, games didn't enjoy the same respect as film as art forms, hence this weird drive to represent war tastefully. That's been the standard for the best part of 20 years, but I'm increasingly of the opinion that gibs ought to make a comeback. It's not about virtual bloodlust (although a good gibbing is undeniably satisfying); it's because I believe we've moved too far in the other direction.

For example, The Division 2 (see opposite) is a robust if unimaginative shooter in which you're a special forces agent restoring order to a destroyed Washington DC. At least, that's the premise, but really you're just using real-world guns to shoot numbers out of people in order to unlock a slightly better gun, like the world's worst pinata party.

> Rendering the trajectories of all those flying chunks would have killed most PCs of the time

I find this approach to representing violence insidious. I can understand Infinity Ward wanting to avoid glorifying historical violence out of respect for the (relatively recently) deceased.

However, The Division is set in a contemporary America, which has massive and well-documented problems with gun violence. With its guns and soldiers, The Division 2 is highly realistic, yet its treatment of violence isn't just minimised but euphemised. It really is one step away from shooting candy out of your enemies.

To me, that's more disturbing than any meat that fell out of the guts of even the most gratuitous 1990s shooter. I'm not saying that The Division 2 should feature explosive gibs (although grenades are kind of designed to make a mess). However, games that portray real-world military violence shouldn't shy away from the results of said violence. Better yet, I'd love shooters to avoid realism altogether, and instead focus on being stylish, thrilling, imaginative and utterly gib-tastic. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

The Division 2 / £41.99 inc VAT

DEVELOPER Massive Entertainment / **PUBLISHER** Ubisoft

Tom Clancy's The Division was like a digestive biscuit, a derivative multiplayer cover shooter that provided a certain level of sustenance but wasn't remotely exciting. By comparison, The Division 2 is more like a chocolate digestive. It's still the largely the same derivative experience, but improved by a layer of fat and sugar. Set six months after the first game, The Division 2 takes place in Washington DC. The US capital is an overgrown ruin controlled by three different gangs, and your job is to wrest back control of the city from them.

The original game was criticised for refusing to engage with its own story about a group of heavily armed militia suppressing a civilian uprising with extreme violence. The Division 2 responds by offering almost no story whatsoever. The game may feature plentiful quests and reams of dialogue, but all of it has about as much substance as your average breakfast talk show. You're a good man who shoots bad people for ostensibly justified reasons, but really, your goal is to acquire a slightly better gun.

However, in terms of play, there are improvements over the first game. Most notably, the mission designs are far more interesting. Your main objectives will see you fight through a TV broadcasting station lit up with hundreds of screens, and battle through the exhibits of the American History Museum. Even the side missions, while smaller, are given bespoke locations that are distinct from one another, including knotty fights through bookstores, research centres and across the rooftops of an apartment complex.

Combat is also more engaging and tactical then beforehand. While you're still shooting numbers out of people, the game's RPG elements are less prominent, and each weapon is markedly different in terms of looks, sound and feel. Each of the three gangs you face also fight in distinct ways. The Hyenas, for example, seem to have adopted their tactics and dress sense from Mad Max, using narcotics to send themselves into a frenzy before sprinting directly at you. The True Sons, on the other hand, deploy proper military strategies, with heavy machine gunners laying down covering fire as their squadmates attempt to flank you.

The Division 2 is unquestionably better than the original, but it still does little that genuinely innovates or impresses. The cover shooting, while entertaining, remains only slightly more evolved from the days of Gears of War, and you're otherwise ultimately only playing to grab that slightly better gun, or a more robust set of kneepads. If you like your games straightforward with plenty of content, you'll enjoy The Division 2. Just don't expect to be blown away by it.

RICK LANE

JOY DIVISION

- \+ More interesting missions
- \+ Improved combat
- \+ Distinctive opponents

LONG DIVISION

- – Basic motherboard
- – Limited upgrade paths
- – No overclocking

/VERDICT

The Division 2 won't offend your senses, but it won't delight them either.

OVERALL SCORE

65%

Sekiro: Shadows Die Twice / **£49.99** inc VAT

DEVELOPER From Software / **PUBLISHER** Activision

POSTURE

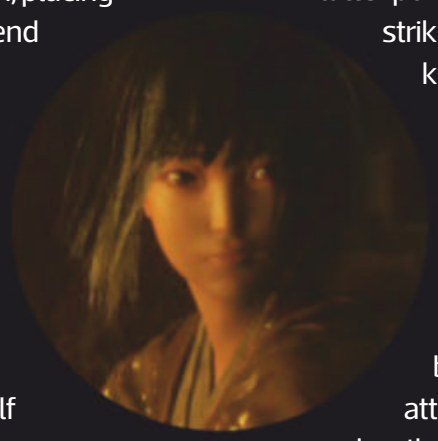
- \+ Exhilarating duels
- \+ Superb combat mechanics
- \+ Great world building

PASTURE

- – No multiplayer component
- – Spirit Emblems offer unnecessary challenge

How could From Software follow up Dark Souls, a game that radically changed notions about how games can present storytelling, environment design and challenge? Its mysterious world, punishing combat and gargantuan monsters made it hugely influential. From Software has grudgingly developed two sequels, but in many ways, Sekiro: Shadows Die Twice is Dark Souls' true spiritual successor, as it tears up the rulebook again.

Sekiro is set in a mythologised feudal Japan, placing you in the role of Wolf, who is a Shinobi – a blend of ninja and warrior who is honour-bound to protect the juvenile Lord Kuro. The game begins with Wolf failing in this duty, bested in battle by another warlord, resulting in the kidnapping of Kuro and the loss of Wolf's left arm. He awakes in a dilapidated temple overseen by an elderly sculptor, who provides him with an intricate prosthetic to replace his missing arm, at which point Wolf departs on a quest to rescue his missing liege.

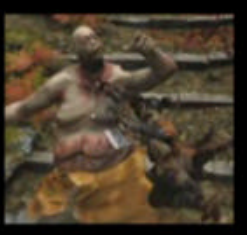


Structurally, Sekiro bears some obvious resemblances to From Software's previous games. The game world, which surrounds a huge fortress named Ashina Castle, is expansive both horizontally and vertically, with many interconnecting pathways that gradually unlock as you explore. You progress through this world by moving between Sculpted Idols, Sekiro's equivalent of Dark Souls' bonfires, which allow you to rest and upgrade your abilities (at the cost of respawning all enemies you've killed up to that point).

Yet while Dark Souls let you create your own character, Sekiro has you playing a specific individual who wields a specific weapon, a katana. Wolf is a master of the shinobi combat style, which blends stealth and ninjutsu techniques with a highly aggressive form of sword fighting. It's in this latter point where fans of Dark Souls will find the most striking difference to From Software's best-known game. Whereas Dark Souls' combat placed a heavy emphasis on evading enemy attacks, Sekiro's combat is all about squaring up to your opponent.

At the centre of combat is the Posture system. Replacing the stamina bar in previous From games, Posture represents both Wolf and his opponents' ability to block attacks. Although enemies still have a health bar, the quickest way to defeat them is to break their guard by overwhelming their posture, which enables Wolf to inflict a single, devastating Deathblow attack. Posture damage is achieved by attacking your enemy, deflecting their blows by timing your blocks precisely, and performing satisfying counters to your enemy's special moves.

Through this system, Sekiro encourages players to face opponents directly, whether they're low-level samurai,



master swordsmen or giant bulls with flaming horns. Facing some of these enemies is an intimidating prospect, and it takes a while to overcome your instinct to flee. Once you learn the nuances of the Posture system, however, these encounters look less like insurmountable obstacles, and more like opportunities to hone your skills.

The result is some of the most exhilarating duels seen in any game. Highlights include a rooftop encounter with a samurai who rapidly switches between sword and bow to throw you off your guard, and the showdown with the almighty Guardian Ape, whose ferocious, earth-shaking attacks are merely the beginning of this incredible fight. These enemies move fast, hit hard and deceive you with clever feints and tricky timings. Battling them will make you course with adrenaline, and overcoming them feels like an enormous achievement.

And that's merely Sekiro's surface, mechanically and thematically. There's a host of sword skills to unlock, while your Shinobi prosthetic provides a wide array of equipment to give your combat an edge. The latter range from shuriken launchers that interrupt enemy attacks, to a telescopic spear than can pull armour pieces off an opponent.

There's also a full stealth system that lets you sneak up on opponents and instantly kill them, or with certain bosses, halve their health to make the fight easier. In the game's latter half, you also unlock ninjutsu skills, which allow you to disappear in a cloud of smoke made with an enemy's blood, or turn an enemy into your puppet, fighting at your side.

Sekiro is more than a combat engine, however. Thematically, it ponders Buddhist notions of immortality and reincarnation in various ways, not least in your own character. If killed in combat, Wolf is capable of resurrecting himself during a fight, lessening the burden of death on the player, and encouraging them to be more aggressive in combat. Such resurrection comes at a cost, though, drawing life from the game world around you, with consequences at both a mechanical and narrative level.

Intriguingly, Sekiro's storytelling is much more direct than Dark Souls, although the many side quests are typically obscure, overlapping with different rewards depending on how you approach them. It's difficult to judge the depth of Sekiro's worldbuilding without experiencing the game multiple times. One noticeable aspect, though, is that, while Sekiro's world is elegantly interconnected, those connections are less significant than in previous From games, as the ability to teleport between idols means you rarely need to backtrack or deploy useful shortcuts.

There's a couple of other issues too. Using your Shinobi prosthetic costs Spirit Emblems, essentially a form of ammo. Learning to deploy your prosthetic abilities effectively is a big enough challenge itself, and Spirit Emblems are an unnecessary restriction that discourage experimentation. Moreover, the game features no multiplayer component. No invasions, no summoning, no messages written on the ground to help reassure and sometimes deceive players. It isn't a flaw as such, as Sekiro is clearly about making *you* face and overcome its challenges. But it's a notable absence that makes Sekiro's world feel a little less strange and alive.

That's a small price to pay for the best action game in years though. Sekiro might well be From's most challenging game, but it's also the best at instructing you how to master that challenge, and getting schooled by its many deadly instructors is always thrilling.

RICK LANE

/VERDICT

From Software delivers another harsh, mysterious and enthralling world, and the best swordfights ever committed to code.

OVERALL SCORE

94%

Ape Out / **£10.99** inc VAT

DEVELOPER Gabe Cuzillo / **PUBLISHER** Devolver Digital

The basic premise of Ape Out is 'Hotline Miami, but with a killer gorilla'. Viewed from a top-down perspective, you assume the role of the titular simian, and are tasked with escaping a series of increasingly complex and challenging urban environments, basically by smashing everything in sight.

Mechanically, Ape Out is simple and elegant. Your Ape can perform two actions; shoving and grabbing, but these actions can be combined in imaginative ways. You can shove an enemy into a wall, for example, but you can also shove them into other enemies, knocking them down like skittles.

Grabbing, meanwhile, gives you de facto access to a range of power-ups, all of which are related to whatever you've grabbed. Grabbing any enemy will cause them to discharge their gun, meaning you can effectively wield enemies as weapons. You can also rip huge metal doors from their hinges, essentially giving you a bulletproof shield.

What results is a fast and frenetic action game that, considered from a purely mechanical perspective, is pretty entertaining. What makes Ape Out special, however, is how it weaves style through these systems. Most notably, there's the brilliant jazz percussion soundtrack. Every movement and action is linked to a unique drumbeat or cymbal crash, and it all flows dynamically together to form the game's soundtrack. As your actions intensify, the soundtrack turns into riotous noise, while in quieter moments, it fades naturally into the background. The improvisational nature of jazz makes it a perfect accompaniment to an action game. It's amazing nobody thought of it sooner.

That's not the only area where Ape Out oozes style. While the game's block colours and rough-hewn polygons may look basic, they're deployed to superb effect. In the first of the game's four stages, which takes place in a research centre, the colour scheme alters along with the action. As alarms blare through the facility, the palette switches from neutral blue to vivid orange. Then, later, the game suddenly turns black as you manage to cut the power, and navigate a maze of enemy torch beams.

The first half of Ape Out is perfectly paced. Your ape can take two wounds before dying, while levels are just the right length to be challenging without becoming frustrating. The latter two stages, however, are longer and feature much larger clusters of enemies, which tips the scale too far towards irritation. It doesn't help that the controls are slightly too slippery, and you can easily be killed because you were at slightly the wrong angle to perform a successful shove or grab.

Nonetheless, Ape Out is remains a marvellous example of interweaving style and systems, while the dynamic soundtrack is worth the price of entry itself.

RICK LANE

KING KONG

+ Fast, frenetic action
+ Dynamic jazz percussion soundtrack
+ Stylish use of colour palettes

KING JOFFREY

– Frustrating later levels
– Controls can be slippery

/VERDICT

Forget King Louie, Ape Out's jazzy violence makes it the real King of the Swingers.

OVERALL SCORE

80%

The Occupation / £19.99 inc VAT

DEVELOPER White Paper Games / **PUBLISHER** Sold Out

The Occupation is a bite-sized stealth adventure that stands on the precipice between broken and brilliant. It takes place in the fictional British town of Turing in an alternate 1980s timeline, and places you in the role of Harvey Miller, a renowned journalist. Miller is investigating the recent bombing of the Bowman-Carson facility, a private corporation that's working on behalf of the government on the creation and implementation of the Union Act, a highly controversial anti-immigration bill.

It's a fixed-time game lasting four and a half hours across four acts. The first two chapters culminate in interviews with key Bowman-Carson employees, where you can ask questions about bombing and the Union Act. Your starter questions aren't particularly incisive, however. To get to the root of the mystery, you'll need to pursue several distinct leads, by sneaking into restricted areas and evading the watchful eyes of Bowman-Carson's security guards.

What results is a fascinating combination of stealth and first-person adventure, wrapped in a sumptuously detailed and highly interactive world. There's so much happening in the Occupation's relatively small levels that you're unlikely to see it all first time. Each lead is an intricate puzzle that may involve eavesdropping on conversations, breaking into offices, rifling through drawers, hacking computer terminals and printing out documents to present as evidence.

Compounding the challenge is some of the most convincing stealth AI this side of Alien Isolation. There may only be two guards in the Bowman-Carson facility, but they're brilliantly conceived. If you're spotted in a restricted area by a guard and run away, they won't forget they have seen you, and will give you a warning if they catch up with you later. Do it multiple times and you may be taken to the security office for chastisement. Guards will also hunt for you with torches, follow you around like a chaperone, and even search under desks beneath which you might happen to be hiding. It's enormously clever.

Add some exceptional storytelling, first-rate voice acting and some stunningly beautiful visuals for a game designed by just nine people, and The Occupation is a surefire winner, right? Alas, no. This superbly designed game is beset by some serious bugs. Some leads simply can't be followed because of broken event triggers or missing items, while the guards have a tendency to get stuck on environmental objects, rendering all the fantastic AI work moot.

Perhaps these issues will have been resolved by the time you read this review. We certainly hope so, because The Occupation is otherwise a superbly designed game, and comfortably the most detailed and interactive narrative adventure ever designed.

RICK LANE

OCCUPATION

- \+ Exceptional storytelling
- \+ Beautiful visuals
- \+ Highly convincing AI

MENIAL ROLE

- – Buggier than a bug barn
- – Broken event triggers and missing items
- – No overclocking

/ VERDICT

A taut political thriller with some incredible stealth AI, the Occupation is a stunning game let down by a handful of nasty bugs.

OVERALL SCORE

75%

REALITY CHECK

In this new monthly section, Rick Lane takes a look at the latest developments in VR

Into the cosmos

At CES this year, HTC announced the Vive Cosmos; like the Rift S and the Oculus Quest, it switches out external sensors for on-board camera tracking. However, it also features a new screen that minimises the pixelly 'screen door' effect that was the bane of first-generation headsets. Oh, and it includes a couple of nifty light-up controllers.

Alongside the Cosmos, HTC also announced a new version of the Vive Pro called the Vive Pro Eye. This headset includes an advanced eye-tracking system that lets you aim at an object simply by looking at it. There's no word on pricing, although we expect the Cosmos to be the more affordable headset by some margin. The Cosmos is due for launch in the first half of 2019, while the Vive Pro Eye is scheduled for launch towards the end of the year.

OCULUS DRIFT

Oculus is gearing up for not one but *two* headset launches this spring. Both headsets build on the technology established by the Oculus Go. First up is the Oculus Rift S, a direct successor to the original Rift. Most notably, it requires no external sensors. Instead, it's equipped with Oculus' new Insight tracking system – five cameras housed in the headset itself, so you no longer need to faff around finding the right areas to place sensors.

In addition, the Rift S includes Passthrough, which lets users paint room boundaries through a 'mixed-reality' system enabled by the on-board cameras. It also comes with a higher resolution than the original Rift – 1,280 x 1,440 pixels per eye – alongside a slightly expanded field of view.

The second headset is the Oculus Quest, which like the Go, is an all-in-one headset that requires no connection to a PC. The difference is that the Quest is a proper gaming platform, essentially the VR equivalent of a handheld console. Using just the headset, a pair of Touch controllers and an accompanying mobile app, users can access and play games from their library anywhere they want.

Weirdly, the Quest is both more and less advanced than the Rift S. It has an even higher resolution than its PC-based counterpart, at 1,600 x 1,440 pixels per eye, and requires no cabling, whereas the Rift S still tethers you to your PC. On the flip side, it has four on-board cameras compared to the five on the Rift S, and includes a relatively measly 64GB worth of on-board storage. Both headsets will work with existing Oculus game libraries, but only around 50 games on the Oculus store are currently compatible with the Quest (which still isn't a bad start).

Both headsets launch this spring for £399 inc VAT, an odd decision by Oculus, as it's quite easy to get the headsets confused. Neither device should be considered the Rift 2, as they're more evolutionary than revolutionary, but the lack of external sensors is undoubtedly a significant improvement.

INDEX FINGERS

As if new hardware from both Oculus and HTC weren't enough, Valve has confirmed it's developing its own VR headset, named the Valve Index. Information about the Index is currently limited, as most of it stems from a leak of the Index's Steam store page (which Valve has confirmed is real). Images of the headset reveal two front-facing cameras and integrated headphones, while the specs list also mentions a power adaptor and USB connectors. There's no reference to external sensors, suggesting that the Index will follow Oculus and HTC in integrating sensors directly inside the headset.

The Index will also have two 'Knuckles' controllers. They're similarly sized to the Vive controllers, but have a wraparound band designed to prevent you from accidentally throwing the controller while playing. Valve suggests minimum PC specs of a dual-core CPU with Hyper-Threading, 8GB of RAM and a GeForce GTX 970. No doubt we'll hear much more about the Index in the coming months.

SPATIAL AWARENESS

In its continuing effort to make No Man's Sky the game everybody wanted on launch, Hello Games has announced a new VR update and, quite frankly, it looks incredible. It's a complete overhaul of the original game to make it VR-compatible. Tools and weapons can be wielded in your virtual hands using the relevant controllers for the Oculus or Vive, while you can scroll through game's menus with a flick of your fingers.

Perhaps most excitingly, you fly your spacecraft through hand-based interactions, physically pushing forward a throttle lever with one hand while steering with a flight-stick in the other. Oh, and you even exit your spacecraft by physically pushing up the cockpit canopy up with your hands! The VR update will be bundled as part of the Beyond update. All told, it's shaping up to be a big year for Hello Games, and No Man's Sky VR could well be this year's killer VR title.

SKELETON DANCE

VR's immersive quality is a fundamental part of what makes it so compelling, but it's also tough to feel immersed when your in-game character is usually represented as a pair of floating hands. It's a situation that Stress Level Zero hopes to address with Boneworks, an ambitious VR shooter built around an experimental physics engine that aims to replicate realistic full-body movement and interactions.

At the core is an advanced procedural animation system, which tries to replicate full body motion based on the position and movements of your head and arms. As a simple example, if the game notices your headset lowering in a downwards motion, it will make your character bend their knees and crouch. The same goes for walking, jumping, running and climbing.

The other key element of Boneworks, however, is imbuing the game world around with a sense of weight and solidity. As suggested by the title, your character has virtual bones and muscles that respond to external stresses. Picking up heavy items will put stress on your virtual limbs, forcing you to move slower. On the flip side, you can also use this system to navigate the environment in different ways, such as using a crowbar to dangle precariously from a ledge. It looks highly convincing in motion, but it's the feel of Boneworks that will ultimately determine whether it succeeds in its ambitions or fails. We'll find out later this year.

HOW TO BUILD YOUR DREAM PC

ANTONY LEATHER

SHOWS YOU HOW TO MAKE A STUNNING BUILD WITH YOUR OWN PERSONAL STAMP

Building a PC is a rewarding but often challenging experience, so it always helps to plan your build and pay careful attention to the hardware you'll be using. However, if you intend on going the extra mile to build the PC of your dreams, there's a whole new set of criteria. We're sure that most people's idea of a dream PC would include a case that's been customised to some degree and there's plenty of examples of unique dream PCs, using heavily modified cases or even custom-made ones.

Hardware priorities will often change too. If you're even considering building a dream PC, you'll likely already know your way around normal PCs and have some idea of what a typical, well-balanced build might entail. However, as you leave the realms of standard PCs behind, the lines between value and extravagance begin to blur. In fact, it's perfectly acceptable in the world of PC modding to choose aesthetics over performance, or to choose hardware that doesn't score highly in reviews, as long as it's the best choice for your project as you imagine it. All that matters is that it's stable, performs well enough for your needs and fits with what you envisaged.

So, over the next few pages we'll be showing you some of the ways you can turn a standard PC into something special, guiding you through all the above considerations and more, including planning, modding techniques, cooling and choosing your hardware. Along the way, I'll also be showing you how I went about building my own dream PC so you can get a real sense of the work involved.


800W
ST-XL form factor

IT STARTS WITH A VISION

It probably sounds terribly self-indulgent but having a clear idea about how your dream PC should look and how it should come together is absolutely essential, for a number of reasons. Winging it can result in a PC that runs hot and noisy, or that simply isn't as polished as it might otherwise have been.

Unlike a traditional PC, you're not constrained by value or choosing the best hardware. However, that doesn't mean you shouldn't consider important factors such as cooling. You can build the most amazing-looking PC ever, but if it overheats after five minutes in your favourite game, you've gone too far. Even PC modding has its limits, as you can never completely ignore your hardware's needs.

HAVING THE CASE TO HAND MEANT I COULD STRIP IT DOWN, REMOVING UNNECESSARY FIXTURES AND FITTINGS

At the start, you'll likely have a particular hardware setup in mind, and its cooling requirements can often dictate or even drive the customisation required to make it over the finishing line.

The opposite is true too. You might have your heart set on making your own case, or modding an existing one, perhaps with plans to drastically alter it and its cooling arrangement. These decisions will in turn dictate the hardware you can install inside, whether it's due to space limitations introduced in the modding process, or because its resulting cooling potential has changed for better or worse.

You'll also want to have a good idea about how else to modify your case, such as painting, machining or adding vinyl logos or patterns and, just as importantly, the order in which to do these jobs. For example, paints can easily be scratched, so if you plan to modify your case and test-fit a bunch of hardware, the painting process should be left until the very end once you know exactly what's going where.

PC Building Simulator allows you to build a virtual PC including water-cooling components

It can help to look at manufacturers' case images to see how your project might come together, and how you might modify the case

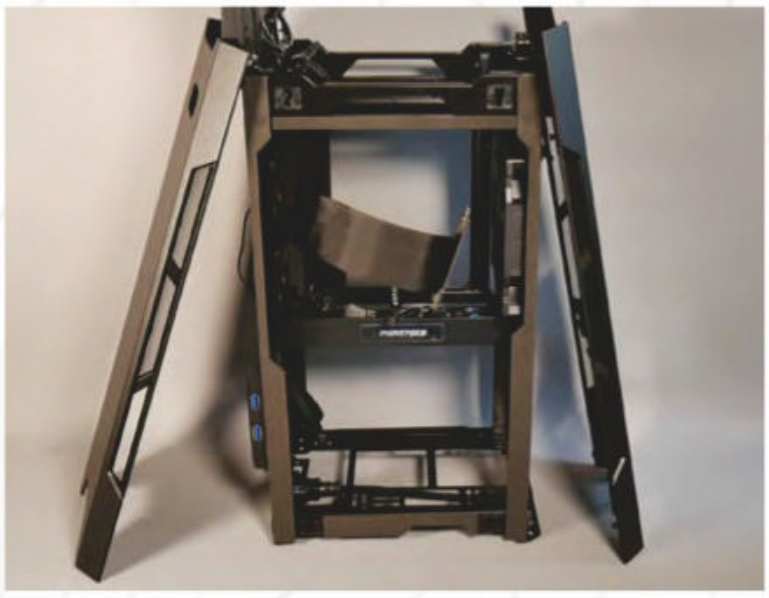
For my own dream PC, I planned to use Phanteks' Shift mini-ITX case. I wanted to spray-paint the side panels, as well as investigate the feasibility of modifying them to improve airflow, while also adding some custom water-cooling hardware.

PLANNING: VIRTUAL VS PHYSICAL

There are plenty of ways to get a more concrete version of your vision and plan your dream PC. You can search online forums for similar projects to see what others have done, and once you've got an idea, you can use one of several 3D modelling programs, such as SketchUp (formerly Google SketchUp). These programs allow you to mix and match components, and then create a 3D model of your case so that you can tinker with it, be it test-fitting various radiators, creating a custom water-cooling loop, or trying out different colour schemes.

A simpler but easier to use program is PC Building Simulator (**pcbuildingsim.com**). This software doesn't allow you to physically modify cases available in the pre-modelled inventory, but you can test-fit hardware and water-cooling components, and you can tweak aspects such as rigid tubing, coolant colour and lighting. Being able to plan your lighting and water-cooling loop in real time this accurately is very handy indeed, although if you're planning some involved modding, you may find it's not quite flexible enough.

However, these virtual methods don't compare with having your PC case in front of you when it comes to visualising your project, generating ideas and even spotting potential problems. Such issues could include knowing how a case comes apart if you want to spray it, or whether you can remove certain sections without compromising structural stability. As a result, if your heart is set on using



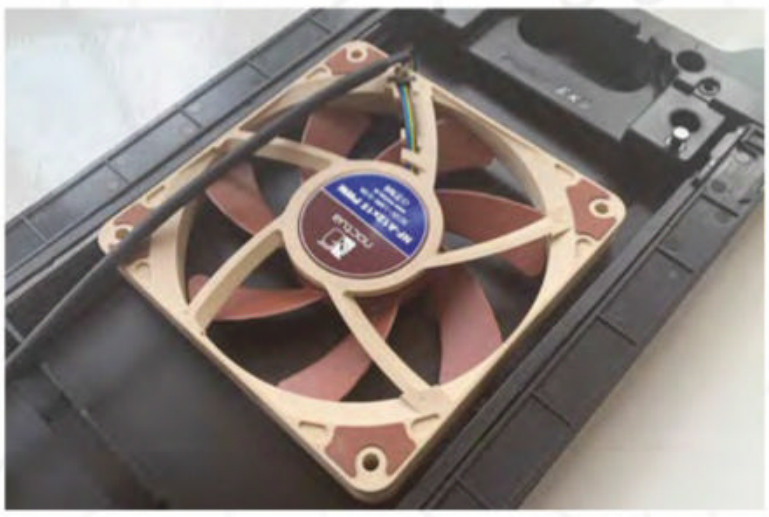
I dismantled my Phanteks Evolv Shift to get a better idea of how I could modify the case to improve water-cooling component support

a particular case, it's a very good idea to buy it and take a good look at it. You can then mull over ideas for a few weeks, and take accurate measurements, which will all pay dividends in helping you to create a better dream PC.

With my own project, I wanted to use Phanteks' Evolv Shift case. At the start, I wasn't entirely sure what kind of cooling system I could install. However, having the case to hand meant I could strip it down, removing unnecessary fixtures and fittings, and I found that a specific model of 120mm radiator made by Bitspower was small enough to sit in the case's inner recesses, where most other radiators would be too big.

I also found that the front and rear panels were large enough to house Noctua's new half-height NF A12x15 fans, paving the way for me to cut vents into the panels and house a more potent cooling system, and use more powerful hardware as a result. If you're pushing the limits of what's possible with a particular case in this way then it's likely you'll want to account for every millimetre of space, and this simply can't be done using the case's basic dimensions or even an accurate 3D render.

With the case on hand, I discovered that Noctua's new half-height fans could sit inside the side panel, allowing me to use more powerful components



5 Handy PC modding tools

DRILL AND DRILL BIT SET

If you buy one tool for your modding project, make it a drill. It will allow you to fully dismantle a case by drilling out the rivets that hold it together, separating the panels to make your life easier when cutting and painting them. Adding water-cooling fill ports, fan blowholes and mounting holes for reservoirs are just some of the other tasks that require a drill.

DREMEL

As an all-in-one tool for precision sanding and cutting, a Dremel is unbeatable. Whether it's cutting away some sections of steel in your chassis to make way for radiators or reservoirs, or sanding freshly cut sections, just a few accessories paired with one of these popular rotary tools (or an alternative equivalent) will allow you to modify your case quickly and easily.

RIVET GUN

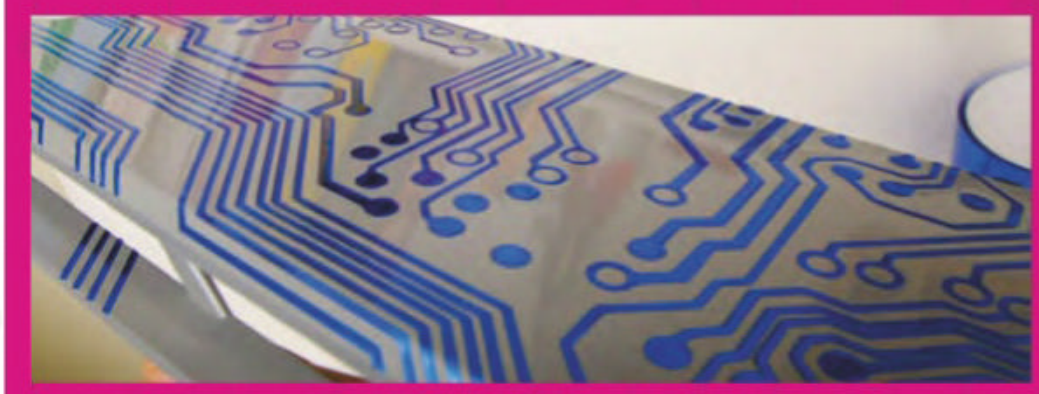
This is likely to be a one-time use tool, but thankfully they can be bought for under £15, and the rivets themselves are very cheap. Once you've drilled the rivets out of your case to dismantle it, you'll need a rivet gun to secure it back together again. You can even buy coloured rivets to match your case's colour scheme.

CUTTING MACHINE

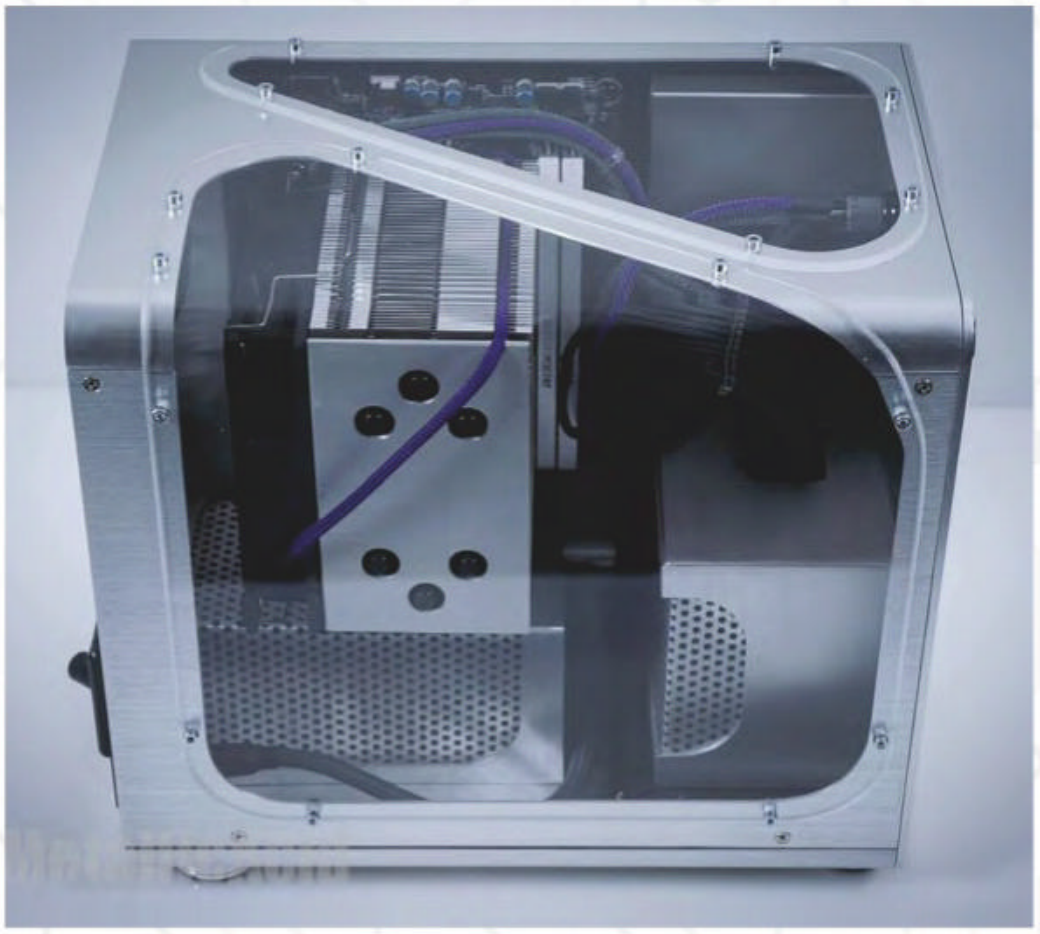
A cutting machine or vinyl cutter can cut a variety of soft sheet materials, such as cardboard and paper, but it's vinyl that's most useful with PC modding. You can create precise patterns and logos in a huge range of colours in adhesive vinyl, which you can then transfer directly to your case. Just as useful is the ability to use vinyl to mask paint and create super-detailed designs in minutes. Doing the same job by hand would take hours.

DIGITAL VERNIER CALLIPER

If you're making precise measurements of your case to customise it, a Digital Vernier calliper is essential. You can measure the inner or outer diameter of objects down to the sub-millimetre scale, allowing you create custom parts that fit perfectly, or measure the exact size of holes required to fit components into your case.



The blue circuit pattern on our front panel was made with as vinyl cutter. The panel was sprayed grey, and then we cut the blue vinyl with our cutting machine



Acrylic is soft, making it easy to machine, and it can be bent to shape when heated, as shown here in Justin Ohlsen's Elegance case mod

PC MODDING MATERIALS

While you can easily mod a PC by just cutting vents and holes, or adding paint or vinyl, extensive customisation often requires the use of sheet materials. Aluminium is useful for covering over unsightly areas of your case, such as the motherboard tray or unused mounting points. It can also be used to create shrouds for radiators or custom mounts for your hardware. Aluminium is much easier to cut than steel, and it's bendable too, making it a popular material for creating components or even entire scratch-built cases.

Acrylic is another hugely popular material, largely thanks to the fact it comes in a variety of colours and can be opaque or transparent. As a result, it's ideal for creating windows and other see-through features, plus the fact it can be illuminated makes it ideal for playing around with different lighting effects.

It's even easier to work with acrylic than aluminium too, although that's also one of its downsides: it scratches easily, so isn't ideal for use as a structural material. One of acrylic's best attributes is that it's easily bent by heating it with a heat gun, making it easy to match the curves of a case or create your own custom shapes.

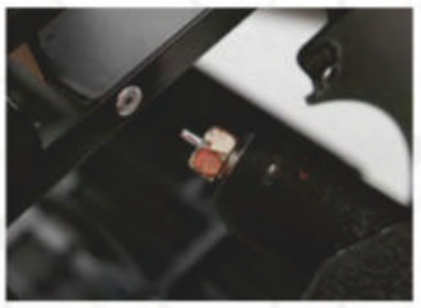
Dismantling your case into sections can make it easier to spray-paint

DISMANTLING YOUR CASE

Taking apart your case and drilling out rivets might sound like a scary prospect, but it's actually one of the most fundamental parts of modding and is fairly straightforward. There's a number of reasons you'll likely need to do it. For one, spraying your case inside and out when it's fully assembled is much more difficult, often resulting in bare patches or paint runs, whereas dealing with sections separately will make your life a lot easier.

Use a drill to remove rivets that hold the case together, using masking tape to prevent the drill slipping and scratching the metal

Replacement rivets are readily available, and in a variety of colours too



Assembling the case requires new rivets and a rivet gun to secure the loose panels back together

What's more, to spray a whole case, you'll likely need an entire room or garage in which to work. However, if you're dealing with smaller sections, you can quite easily create a small spray booth or suspend the sections while you paint them. The latter approach will mean you can cover the entire section in one go for a better finish. If you want to send your panels to a professional machining company or painter then they nearly always require the case to be dismantled too.

Drilling rivets can be a bit of a fiddly process, but it doesn't require much effort. For most cases, you'll need to use a 4mm drill bit, and the idea is that you drill through the head of the rivet, separating it from the tail on the other side of the join. Use a low to medium drill speed and proceed with caution. Eventually the rivet will separate, leaving a hole. Moving the drill slightly off-centre can help if you feel like it's not making progress.

It's likely a lot of sharp metal shavings will be created in the process, so be sure to have a vacuum cleaner to hand to clean up regularly. Remove all the rivets from any given section and it should just fall apart, ready for the next stage of your modding project.

To reassemble the case, you'll need rivets with heads just small enough to fit through the existing holes. You don't need to make do with standard silver rivets either – black and a variety of other colours are available too. Simply insert the rivet tail into the gun, push the head through the two sections of your case and squeeze the gun to lock the rivet in place.

Installing rivets doesn't require too many large, sharp tools, so it's fairly easy to avoid scratches. As ever, though, a bit of care is required, especially if you've just given your case a fresh coat of paint. One way to minimise scratches is to add some protective layers of sticky tape around the area you're riveting. However, make sure you leave several days for any fresh paint to cure properly before affixing any tape to it. Until it's properly hardened, new paint can easily be lifted even by masking tape.

ALTERING THE CASE

Whether you're modifying an existing case or building your own one, any structural changes will always need to be your first priority, as you won't easily be able to drill holes or cut fan holes ones you've painted the case or installed any hardware. You have plenty of factors to consider here too. Do you want to add air vents, radiator holes or fan blowholes? Do you want to create a custom mount for your graphics card using a PCI-E riser cable? Do you want to rotate the motherboard or shift the motherboard tray to make space for other components?

All these alterations will need to be completed prior to painting. They'll likely require the case to be dismantled and, most importantly, they need to actually work and allow your hardware to be installed afterwards. It helps to draw up a list of all the modifications you'll need to perform in order to get an idea of how long it's all going to take, and whether you have the tools and expertise required.

PAINTING

If you want to paint your case, bear in mind that it's not for the fainthearted. You'll need plenty of preparation time, space and, as with most handiwork, practice – you're not likely to finish it perfectly on your first try in a few hours. You'll want to have a few trial runs first to get the hang of the various techniques involved. Plus, in the UK, you'll be at the mercy of the weather too as cold, damp days aren't ideal for spray painting. We'll be taking an in-depth look at spray painting in next month's 'How to' section, but we'll take you through the basics here.

Apply primer to create a light, smooth undercoat for the colour coat

If you decide to give it a go, once you've dismantled your case, you'll need to sand all the parts you'll be painting with 800-grit sandpaper, and plenty of water, to remove any imperfections in the existing paint. Rattle can spray paints will usually work fine over the top of existing case paint, so there's no need to strip or sand off all the paint first, but smoothing the surface will provide a good layer to which your primer can adhere.

Use a face mask when using rattle cans, whether you're spraying outside or indoors in a garage. If you have access to the latter, remember that the spray can reach several metres away, so take precautions to cover other objects in the room. Outdoors, it's a good idea to use a booth to provide shelter from wind, contain the paint particles, protect the drying paint from dust and allow you to leave objects in place should it rain. Plastic greenhouses are great for this work and can be purchased for under £20.

WHETHER YOU'RE MODIFYING A CASE OR BUILDING YOUR OWN ONE, STRUCTURAL CHANGES WILL NEED TO BE YOUR FIRST PRIORITY

Primer provides a smooth layer on which the colour coat can sit and irons out any minor scratches and imperfections in the material. Start by applying a generous coat of primer before allowing it to dry and then adding a second coat. Once this coat is dry, which takes ten to 15 minutes (double-check the cure time, as you don't want to be sanding uncured paint), use 800-grit sandpaper to gently smooth over the finish, using water as a lubricant. You can then flush

Sand the factory-applied paint to create a smooth surface for the primer

Allow each colour coat to dry for 30 minutes, applying at least three light coats in order to cover the primer

Apply lacquer generously and use at least three coats, or maybe more if you use effect sprays such as the marble we used here

After a couple of days of drying time, you can use automotive polish to lightly buff the finish and make it shine

it with water again and allow it to dry naturally. Give it another two or three coats, with light sanding after every other coat, and you'll completely cover the object, meaning you're ready for the colour coat.

Apply the colour coat in light layers, covering the entire object each time. If you spot imperfections from the paint nozzle spitting, or from foreign objects, allow the paint to dry thoroughly before sanding it down using 800-grit sandpaper, cleaning it down and continuing – don't poke at the paint when it's wet.

Finally, the clear coat or lacquer gives an object's colour coat a glossy sheen, but also helps to protect it. As such, aim to apply several coats to boost the shine and protection of your paint job. Clear coat can also be applied over vinyl. However, bear in mind that standard clear coat isn't particularly hardy, and professional clear coats used by professional painting companies will be more resistant to scratches. You can consider using 2K clear coat too, which is harder once dry, but it can be quite expensive and its hazardous fumes require proper face protection. Whatever clear coat you use, allow it at least two days of drying time to fully cure. You can then use automotive polish to lightly buff the finish.

FOR UNDER £200, THIS FIRM DID IN 15 MINUTES WHAT WOULD HAVE TAKEN ME SEVERAL WEEKENDS OF PAINSTAKING FILING

3D printed objects aren't limited to case components – you can print items such as motherboard shrouds too

Professional services using machines such as waterjet cutters can be pricey, but the end results are fantastic and can save a huge amount of time

CALLING THE PROS

While the process of modding and learning new skills and techniques along the way can be enormously rewarding, getting someone else to do your modifications – specifically a professional outfit that does similar jobs day in, day out – is sometimes the best option.

There are some tasks or techniques that it's either not practical to do yourself, or would simply take too long to learn or be too costly to get all the required tools. Plus, if you're inexperienced, there's a good chance the end result could be better anyway. Opting for the professional option will demand a fee, of course, and it most likely won't be cheap, but if you're just after that perfect result for a one-off project, it's very much an option worth considering.

My own PC was a classic example. I wanted to cut vents in the front panel using the same pattern as those in the roof of the case, which comprised a number of slim rectangles for each of the two radiator exhaust holes located there. The trouble was that the panel is made from thick aluminium, and cutting intricate rectangular holes into it neatly and accurately would have taken weeks using files, and I couldn't afford the required expensive machine tools to do it quicker.

In the end, I decided to investigate how to get the design cut into the panel professionally, which wasn't entirely straightforward. Some services demand a huge amount of money, as they usually deal with companies and large volumes rather than an individual and a single small sheet of aluminium. The fact the Phanteks Evolv Shift's metal panels aren't flat also meant I was turned down by several companies on my shortlist.

However, my persistence paid off, as I discovered a waterjet cutting service locally that was helpful in getting my design drawn up in CAD software, just requiring a high-resolution JPEG file of the design to be sent by email. The firm transferred the design to its waterjet cutter's software

and scaled it to the right size using the dimensions I'd provided. For under £200, this firm did in 15 minutes what would have taken me several weekends of painstaking filing, and the result was perfect too.

Another very useful service for PC modding is 3D printing. It can be used to craft whole case sections, make elaborate decorative items or just provide support and mounting points for other components. Websites such as **3dhubs.com** allow you to upload your designs – whether it's a custom component or an entire PC case – and print it in a variety of materials and colours. To create your own virtual objects to 3D print, check out **tinkercad.com**, which is easy to use and can output STL files to upload to 3D printing services.

GOING FULLY CUSTOMISED

Building your own case can solve a lot of problems, as it allows you to fully tailor your chassis to your specific needs. Have no need for storage mounts or a full-sized ATX PSU? Then don't add them. Maybe you want to create a super-slim case with room just for your hand-picked hardware, or you've dreamed of owning a desk PC. Making a case from scratch means you can avoid wasting space and remove unwanted features. You can also construct your case using your preferred materials and stick to specific dimensions.

While it can take a while to get used to SketchUp, in the absence of having an off-the-shelf case to examine, it can be invaluable when designing your own case, as it allows you to add 3D models of your intended hardware to the mix. You can play around with designs and layouts, and visualising your future case in this way can help to finalise your design before you start ordering materials. It can help you identify potential issues before the build process too.

If you want a unique case that's tailor-made to your own requirements, there's also a way to get one without making the entire case from scratch yourself. Companies such as Parvum Systems (**parvumsystems.com**) create acrylic

Companies, such as Parvum, can do some of the hard work for you. This mod is Violet Reality by Snef Computer Design

TOP TIPS for using pro services

RESEARCH

Asking for advice on PC modding forums can reveal previously used companies or point you in the right direction, especially where machining is concerned, as there's several ways to go about cutting holes in case panels.

Most towns will have paint shops and machining services, so Google is definitely your friend too. Be sure to shop around for the best quotes and, if possible, visit the company with your case or send photos to explain exactly what you need.

DOUBLE-CHECK YOUR NEEDS

Professional machining and painting can be expensive, and you only get one shot at it. As a result, be very sure of your requirements in terms of measurements or colours, and make sure the company has fully understood your instructions.

TEST COLOURS FIRST

If you're getting your panel sprayed, don't be afraid to try out different colours yourself first before sending it to be sprayed professionally. This step can also help if you're not entirely sure about which colour to choose.

YOU DON'T NEED CAD SOFTWARE

For a one-off dream PC, it makes little sense spending thousands of pounds on buying expensive machines such as laser cutters. Similarly, there's not much point spending months learning how to use CAD software, especially when most professional services can create 3D models or machining-compatible files for you too. As long as you provide accurate measurements, most services can do the rest.

PREPPING CAN SAVE MONEY

For professional painting services, you can save money by preparing the pieces yourself before you send them away. Most cases are powder-coated these days, but this coating needs to be removed before professional painters will work their magic – they can remove this coat themselves, of course, but for an extra fee. You can sand the panel to remove any pre-applied paint or use paint stripper, but it's worth asking the company first to check if this is okay.

REMOVE FIXTURES AND FITTINGS

Any separate components need to be removed from your case first, and you'll likely need to dismantle your case too. These components might include drive cages, dust filters and case feet – they all need to come off prior to shipping your components.

Creating a case from scratch is a huge amount of work, but it's often the only way to create truly unique designs, such as Wilhelm Bäckman's Husky Bongs mahogany desk PC

cases that can be customised to cater for water-cooling components, such as pass-through plates and reservoirs, or simply to add aesthetic elements.

Creating your own case is challenging. You'll need to do every part of the process, from drilling the correct holes for mounting your motherboard to working out ways to secure the various sections of the case together, as well as deciding where to mount fans and other hardware. It's the ultimate creative approach but don't underestimate the amount of effort that's required.

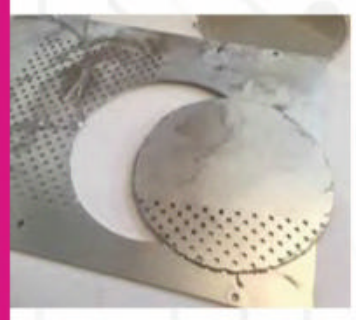
COOLING

Making sure your PC won't overheat is important, so nailing down your hardware and cooling requirements is vital. If you're not planning on modifying your case too much, in terms of its physical layout or altering its cooling arrangement, you basically just need to balance your hardware with the cooling system. However, optimising your dream PC's cooling will need careful consideration if you're tweaking the case's layout or replacing panels, as airflow and, in turn, cooling ability, can be affected.

Modding, though, can often be about form over function, so don't be afraid to close off that unattractive mesh front panel with illuminated acrylic or a sheet of aluminium. Just be sure to balance this lack of ventilation with added airflow elsewhere (for air-cooled systems, anyway), whether it's with extra ventilation holes or using more powerful fans. A popular modification is to add a fan blowhole, which can be done in a range of materials and not only boosts cooling, but can also act as a centrepiece of a project, perhaps with an RGB fan.

The same is true with water-cooling hardware. It's pointless installing a radiator inside a case with no way to draw air into it, or to expel it out of the case. However, adding a new radiator mount to a case is one of the most popular ways to modify a PC case, and manufacturers offer ways to make your life easier here, such as offering radiator grilles.

Adding a fan blowhole can boost cooling if you need to steal some of your case's ventilation for other features



Water-cooling is usually the centre of attention in a modded PC, such as Odyssey by Nenad Djordjevic

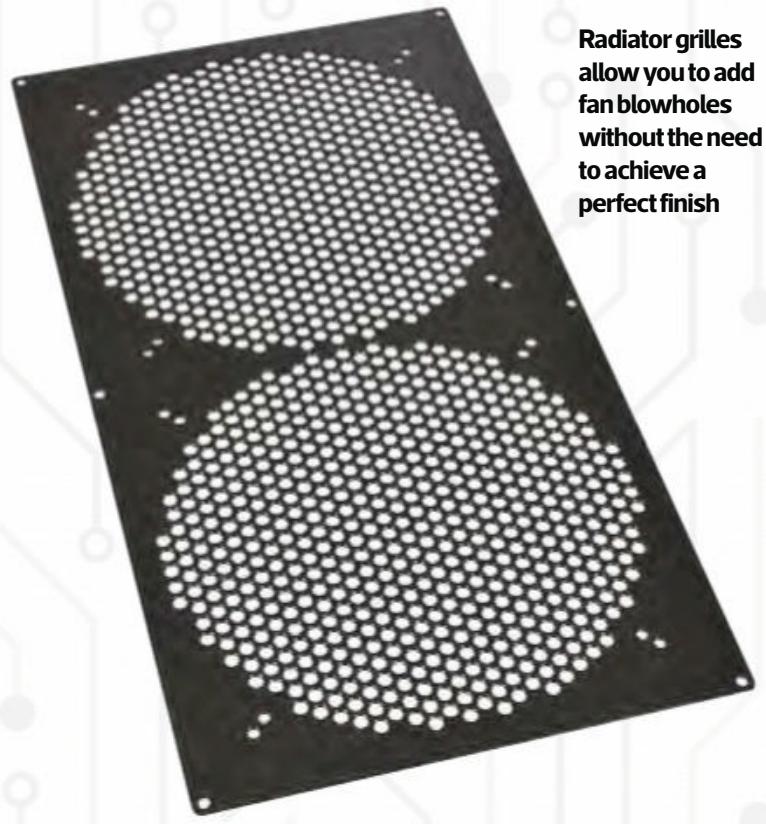
These grilles allow you to cut a large vent in your case without needing to be too accurate. They simply screw into place over the hole you've cut and provide all the neat grilles and mounting holes you need.

One of the best things about water cooling is that it's supremely flexible and you can adapt your water-cooling components to suit almost any case, maximising the heat dissipation and, as a result, your hardware options. For example, in my Phanteks Evolv Shift project, I didn't have room for any large radiators, but still had to water-cool some serious hardware. However, I had room for three 120mm radiators including space for one to have a pair of fans in push-pull mode to maximise cooling.

A water-cooling loop is often the centrepiece of a modded PC, and rigid tubing now plays a huge role here, thanks to its clean lines and professional look. Rather than routing the tubing out of the way as efficiently as possible, the latest PC mods often use it as the main feature above the rest of the hardware. However, it's worth remembering that, if you plan on using your dream PC as your main system, water-cooling gear, and especially rigid tubing, can make it tricky and time-consuming to replace hardware and diagnose problems.

CUSTOM PSU CABLES

One of the key finishing touches to a truly special dream PC is a good-looking set of cables. While many modders will choose to hide away as many cables as possible, with the



Radiator grilles allow you to add fan blowholes without the need to achieve a perfect finish

right approach, cables can be just as much a feature as any other part of your build.

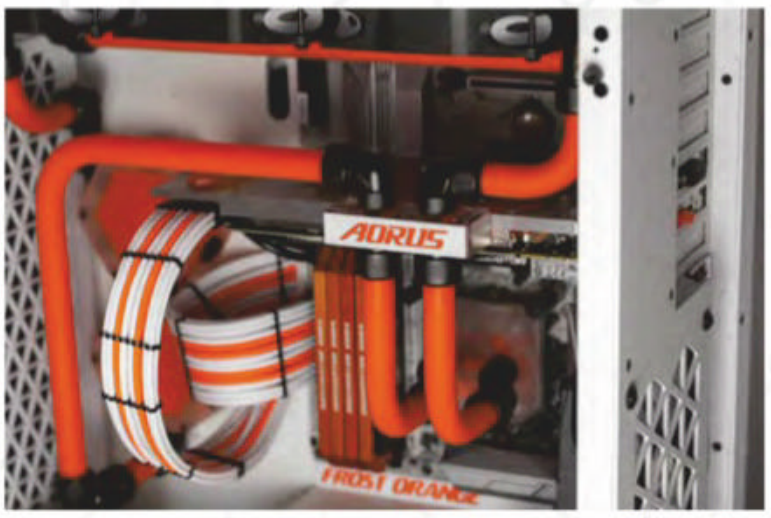
Cable modding tools and braiding kits allow you to create cables with a custom length and style, so you can tidy up and colour-match your cables to your PC's theme, while well-organised cable routing can provide a clean and tidy look. A proper cable job can make all the difference between a good PC and a great one, and thankfully, there's several companies that can make them for you, and in a huge variety of colours.

In the UK, **pexonpcs.co.uk** offers premium components for making your own cables, extensions for your existing PSU and a custom cable-making service. Another excellent manufacturer is cablemod.com, which offers a huge range of pre-made cable kits for a variety of PSUs. Cablemod also has an online configurator, which allows you to create your own cables and even has the option to include cable combs. The latter are handy for keeping your individual PSU cables running in straight lines, without getting tangled, too.

LIGHTING

The icing on the cake of most PC mods is lighting, but it doesn't have to be the latest garish RGB technology. Just subtle lighting that matches your coolant and case's colour scheme can look fantastic. However, you can use

You can create your own custom PSU cables, or use one of several online services to do it for you. Pictured: Frost Orange by ML MODS



Black Mirror, by Snef Computer Design, goes big on RGB lighting, but you can achieve great effects with static colours too

RGB lighting to your advantage here too. You probably won't find a coloured LED strip in exactly the right shade to match your components or coolant, but RGB lighting gives you the ability to fine-tune the lighting colour to your precise requirements.

It's worth checking in advance whether your case has built-in RGB lighting, and if so, whether it's compatible with your motherboard, as there are some slightly different standards and software. However, it's usually possible to use adaptors or your own lighting kit. Don't forget about RGB memory too, which can be tuned to a specific colour, to provide more full-on RGB lighting effects.

YOU SHOULD BUILD THE RIG OF YOUR DREAMS AND NOT DOGGEDLY ADHERE TO BEST-BUY LISTS OR BOW TO OTHERS' CRITICISM

IT'S YOUR DREAM

In the end, PC modding isn't about competitions and having the best hardware, even if lots of the PC mods you'll see at large events and online are built to show off the latest and greatest components. Whether or not you have a serious amount of cash to spend on your PC, you should build the rig of your dreams and not doggedly adhere to best-buy lists or bow to others' criticism.

By all means, it can help to take some advice on board, and one of the best ways of finding this advice is to become a member of an online forum that has experienced modders in its community. Their wisdom can save a lot of time and hassle, as well as help you achieve the best result.

Ultimately, though, if you know your PC will be cool enough and perform as you need it, the rest is up to you, so get out there and give it a go. **CPC**

THE LIGHT CRYSTAL

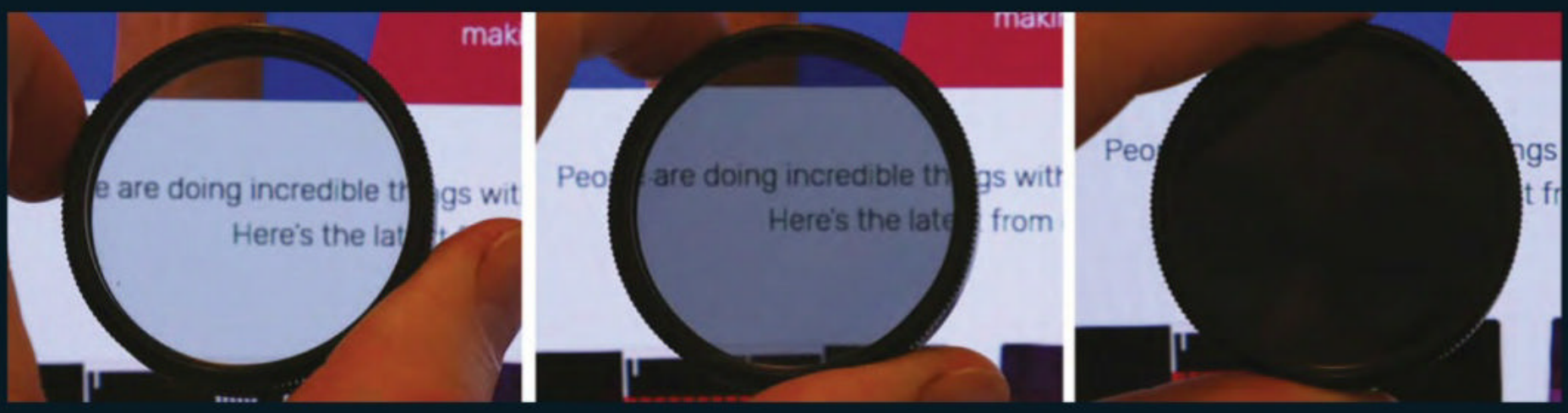
EDWARD CHESTER

EXPLORES THE INNER WORKINGS OF MODERN LCD MONITORS

Not so long ago, your choices when it came to PC monitors were simple. If you wanted a fast gaming screen, you opted for a TN LCD with a fast refresh rate and low response time, which invariably meant a big compromise when it came to image quality. Meanwhile, if image quality was a key concern, you could stick to slower screens that used higher-quality IPS or VA LCD panels.

However, in recent years, LCD monitors have improved across the board. You can now find a wide range of displays that provide both good image quality and gaming performance. This variety is great, but it does make choosing just the right monitor for your needs that much more complicated. So, to help you make sense of it all, over the next few pages we're going to take you through the differences between the various LCD panel types and their key benefits and downsides.

HOW LCDs WORK



From left to right: A polariser in front of an LCD at 0 degrees, 45 degrees and 90 degrees

The principles of how an LCD works are the same regardless of what type of LCD technology a panel uses. At its most basic level, you have a source of light (the backlight) then a layer of liquid crystal and various other filters that manipulate the light, blocking it off or altering its colour, to produce the final image. More specifically, the key principle is the ability to polarise light. That's where the randomly oscillating waves produced by a light source are filtered, so only those waves oscillating in line with the gaps in a polarising filter (polariser) are allowed to pass through it.

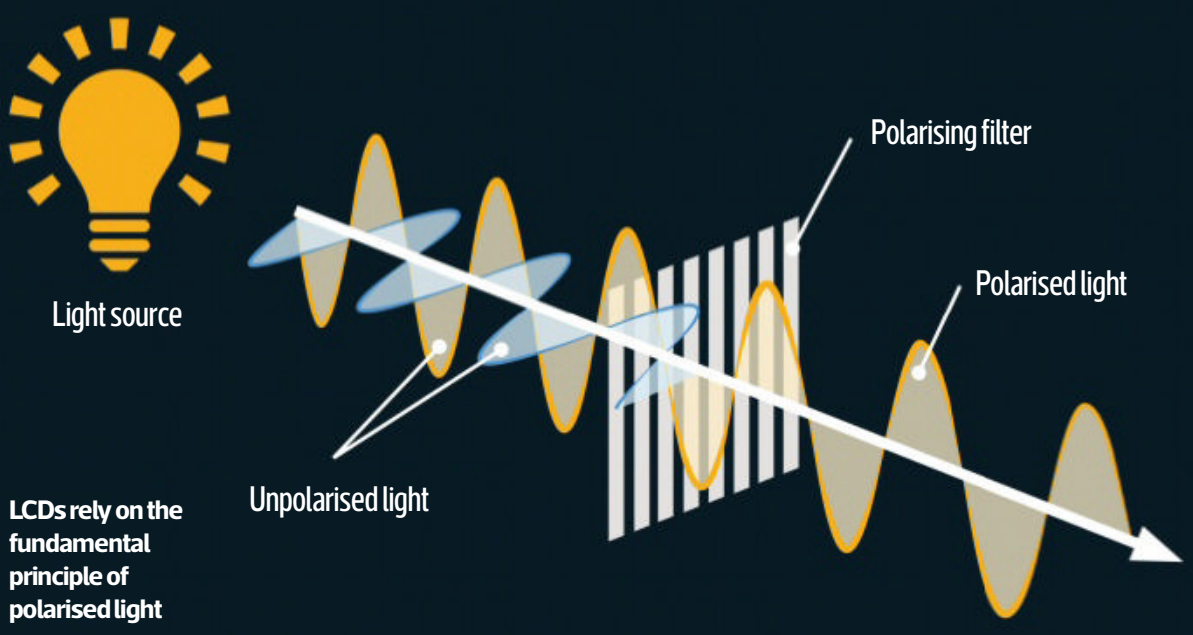
Put another polariser in the way and the light will continue to pass through it, as long as the orientation of the second polariser is the same as the first. However, rotate the second polariser and it blocks the light. Only once the waves from the light source are twisted round, so they're in line with the second polariser, can the light once again pass through, which is where those liquid crystals come into play.

LIQUID CRYSTALS

Liquid crystals are exactly what their name suggests. They're a liquid but they also have some of the ordered structural properties of a crystal. More specifically, the molecules of a liquid crystal can be in one of several states or phases somewhere between the two extremes of being a crystal and a liquid.

One such state is known as smetic, where the molecules form complete layers but each layer can move easily over another one. However, the state that's of interest here is nematic. That's where the molecules can move freely but will tend to want to stay pointed in the same direction – a little like how the matches in a box can move around each other but still all face the same direction.

Crucially, liquid crystals can also diffract light, just like many conventional crystals. As an unordered pool, liquid crystals will form into semi-structured patterns, which create pretty diffraction patterns when polarised light is passed through them.



LCDs rely on the fundamental principle of polarised light

However, arrange them into a grid of pixels, while carefully controlling them, and they can be used to twist the light in order to get it through that second polariser.

DO THE TWIST

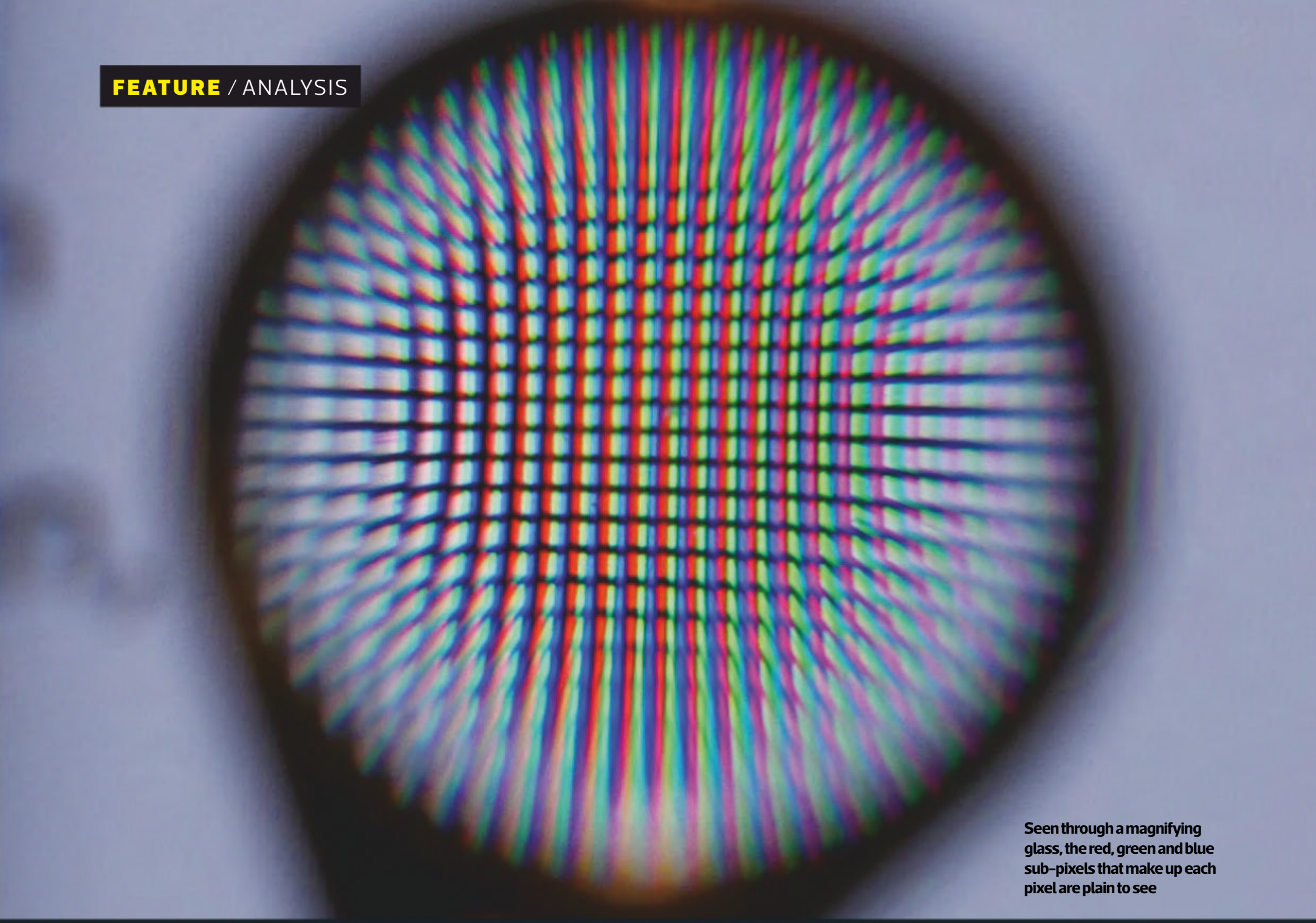
A TN LCD is the most basic form of LCD panel. In it, two polarising filters are arranged at 90 degrees from each other, and a thin layer of liquid crystal sits between them. By having a surface that seeds the crystals to form in a certain direction in line with the polarisers, the liquid crystal naturally forms a twisted pattern between the two polarisers, giving the technology its name: twisted nematic (TN).

In this state, light can pass through the overall setup. However, by applying a voltage to the crystals, they can be forced to point straight towards the light source, so they no longer twist the light, so it's blocked. Alter the amount of de-twisting and you can alter the brightness of the pixel.

The principle of twisting liquid crystals is used to power all LCDs, with different types of panels employing different crystal and polariser arrangements to improve some of the shortcomings of TN LCDs. Before we delve into those differences, though, it's worth establishing some of the finer details of how the whole picture is formed.

SUB-PIXELS AND RGB FILTERS

We've now established how an LCD pixel can be formed, but there's a little more to making a full colour monitor. For a start,



Seen through a magnifying glass, the red, green and blue sub-pixels that make up each pixel are plain to see

there's the idea that all colour images on computers are formed from the combination of red, green and blue light. So, to create a coloured pixel, you need three smaller sub-pixels that combine to create the 16.7 million colours produced by a typical 8-bit colour depth display. Displays that use 6-bit colour use techniques akin to anti-aliasing (dithering and FRC) to provide the appearance of 8-bit colour.

How an LCD actually works, then, is by having a single source of white light that's polarised and then separated into a grid of tiny sub-pixels. The brightness of the light is then manipulated by the liquid crystals (as controlled by a thin-film transistor layer, hence the term TFT) and passed through one of three red, green or blue filters before being fired out through the final polariser.

COLOUR GAMUTS AND BACKLIGHTS

Where monitor tech starts to get more complex is when you consider the different types of backlights that can be employed. Most LCDs now use a single row of white LEDs, which sit along the bottom of the screen. Through a series of reflective and diffusive surfaces, the light is evenly spread out over the whole back surface of the screen, where it's then reflected through the LCD.

However, there's a few other variations on LCD backlights. For one, you can get screens that use three different colours of LED to create a wider range of colours than a single white LED. This approach was traditionally how professional wide colour gamut displays were created. There are also displays where LEDs are placed directly behind the LCD, rather than just along one edge below it. Such a setup can potentially allow for a more uniformly backlit display, which is again particularly desired for professional users.

What's more, directly backlit displays can allow you to individually control the brightness of different areas of the backlight. That ability is beneficial because all LCD panels fail to completely block all the light from getting through them, even when a pixel is off. By having the backlight itself turn off, you can create true darkness, for a higher contrast display. Monitors that use a grid of many backlights in this way are known as full array local dimming (FALD) displays, and recent examples include the Asus ROG Swift PG27UQ (see Issue 181, p31). Such monitors currently offer the pinnacle of image quality for LCDs.

TN LCDs

Having established the role played by the liquid crystal panel in an LCD, we can now explore the different types of LCD, starting with the original and most basic variant, TN. This technology has remained largely unchanged since its inception. It still uses those two 90-degree filters and a twisted crystal structure that's de-twisted when the pixel is activated.

The main area where we've seen improvements, other than screen size and resolution, is the refresh rate. TN LCDs are inherently very quick at changing from an on to an off state, with pixel response times as small as 1ms. This speed led to them being the first LCD types to be used

at higher refresh rates, with 144Hz screens now widely and cheaply available. Recently, we've even seen the introduction of 240Hz screens. This fast response is the key upside of TN LCDs, but they also have downsides.

The first one is viewing angles. Because the twisted liquid crystal molecules are inherently positioned at a variety of different angles to the plane of the screen, there's more variation in the polarisation angle of the light, and the path it takes before it hits the second polarising filter. As a result, the image you see varies considerably as you move around the area in front of the screen.

There's also a knock-on effect when it comes to colour accuracy and contrast, with the more variably scattered light reducing the ability to accurately isolate both the brightness and colour of a pixel.

Modern TN panels have improved all these factors, and the higher-quality 8-bit colour (rather than 6-bit) panels used in the likes of the AOC AG273QCG are adequate for most uses.

LCDs

The first alternative LCD technology to be developed was IPS, made by LG. It takes a radically different approach to TN by mounting the electrodes that control the crystal orientation on the same surface, rather than across opposing sides of the liquid crystal layer. As such, when a voltage is applied across the electrodes, the crystals turn from their resting vertical position to a horizontal position, like a clock dial going from 12 o'clock to 3 o'clock.

Because the crystals are always parallel to the plane of the screen, rather than turning perpendicular to it (as with TN LCDs), they're named in-plane switching (IPS) LCDs. This greater control over the orientation of the crystals (and the subsequent light paths) leads to IPS LCDs having much better viewing angles than TN LCDs, along with better colour accuracy.

TN LCDs are inherently very quick at changing from an on to an off state, with pixel response times as small as 1ms

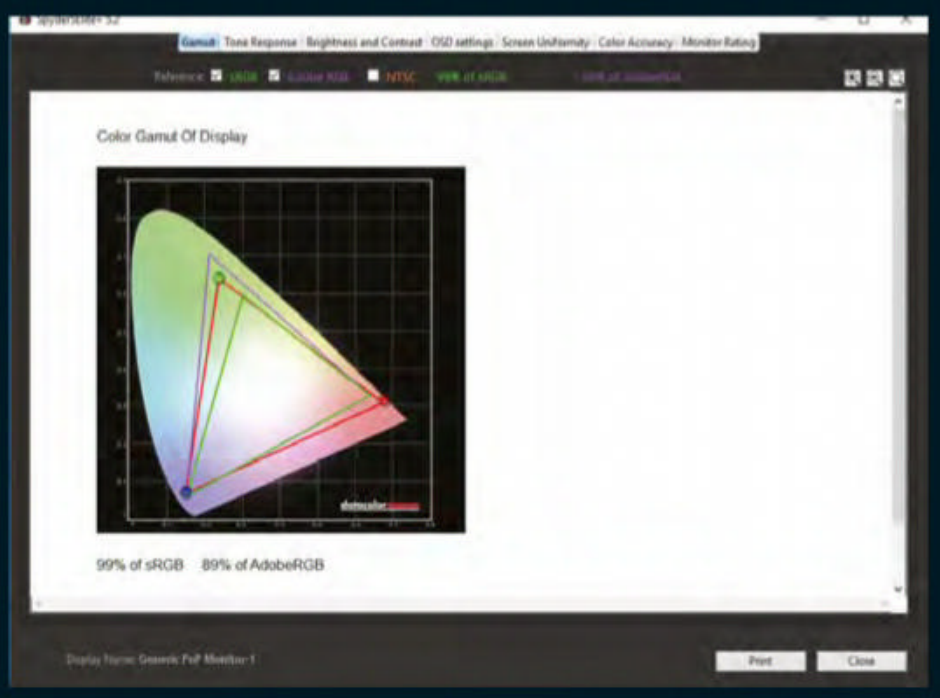
The main downside to IPS LCDs is their response time, with early models having response times as slow as 60ms. These days, this figure has dropped as low as 4ms on some variants, which is still well above the 1ms of TN but good enough for respectable gaming performance. Consequently, 144Hz and even 165Hz IPS gaming screens are now commonplace.

The second problem with IPS screens is what's known as 'IPS glow', where light leaks from behind the LCD to form a lighter patch on the screen when viewed at an angle. You'll seldom notice it in normal use on good-quality screens, but it can be more obvious on poorer-quality screens and can be distracting when the screen is showing a dark image. It's the latter problem that means IPS isn't necessarily the best choice for watching video.

Notably, though, if IPS is combined with FALD technology, IPS glow is all but eliminated, putting it among the best technologies for video.

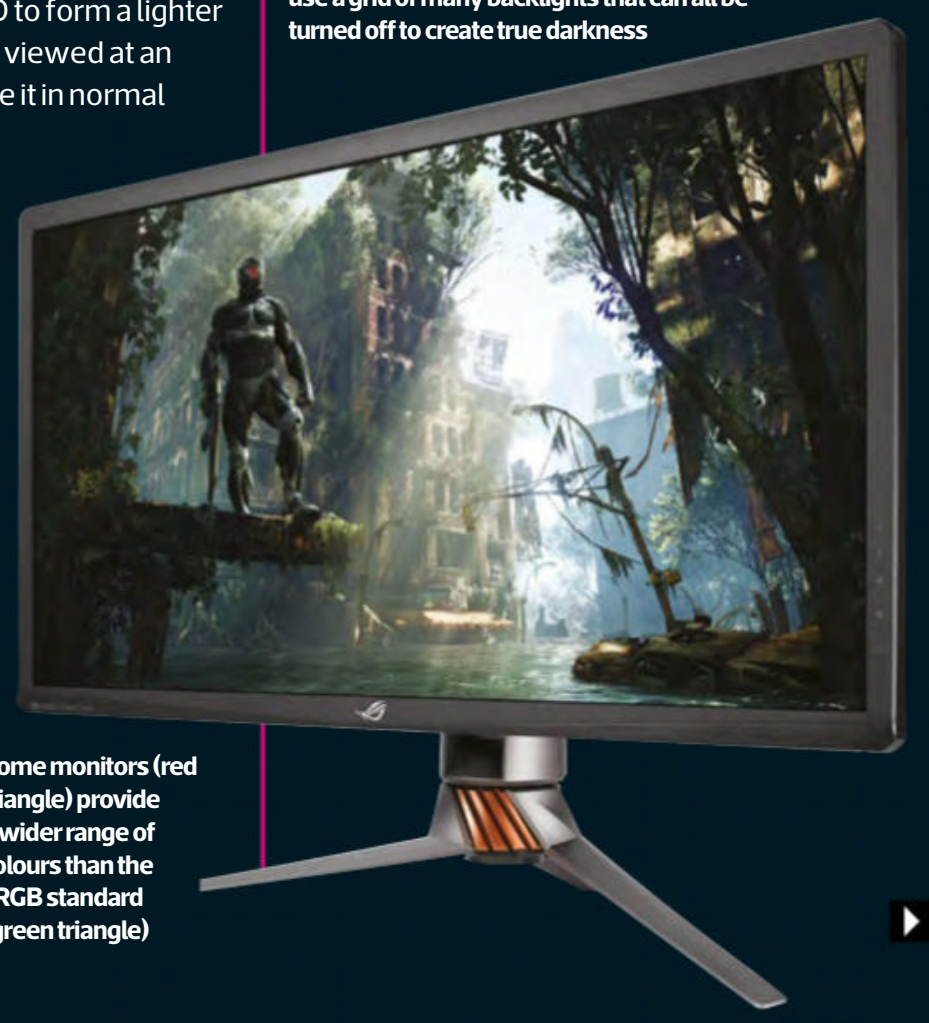
As well as the original IPS specification, there have been many refinements and alternative takes on the basic idea of IPS screens over the years. One of the most common variations is LG's own Advanced High-performance IPS (AH-IPS), which includes a transparent electrode for higher light transmittance and improved power consumption. Another common variation is e-IPS, which is generally considered a budget variation with slightly worse viewing angles than IPS – it tends to be used in 6-bit colour panels.

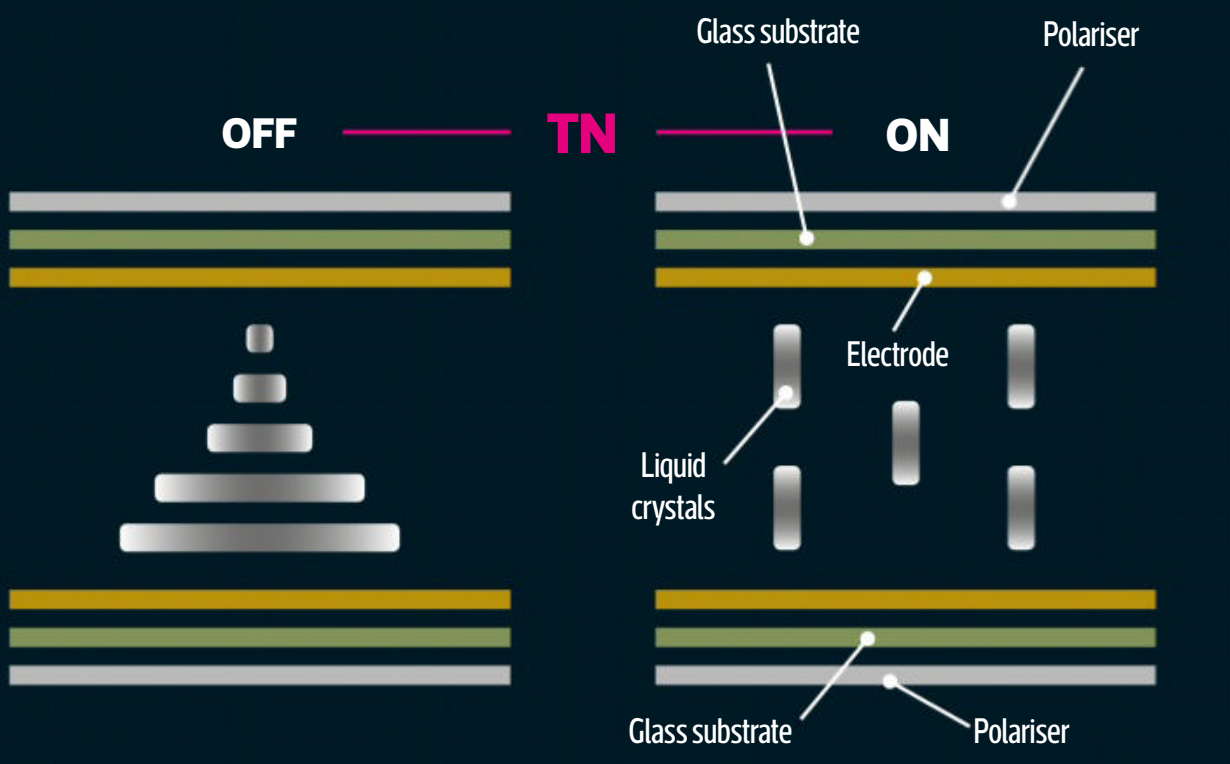
There's also Samsung's Plane to Line Switching (PLS) technology, which is functionally identical to IPS, and Advanced Hyper-Viewing Angle (AHVA), which is made by AU Optronics. AHVA is one of the most popular IPS-type variants available at the moment, as it's the only one readily made with refresh rates in excess of 120Hz. If you're buying a fast-



Some monitors (red triangle) provide a wider range of colours than the sRGB standard (green triangle)

FALD displays, such as Asus' ROG Swift PG27UQ, use a grid of many backlights that can all be turned off to create true darkness





TN, IPS and VA LCDs all use fundamentally different structures to create their image

refresh gaming monitor with an IPS-type panel, it's almost certainly AHVA. As with PLS, its characteristics are essentially identical to IPS.

VA LCDs

The final main variant you'll find for LCD monitors is VA or vertical alignment, so named because the liquid crystals normally sit vertically (perpendicular) with respect to the screen's surface, and then twist round when a voltage is applied.

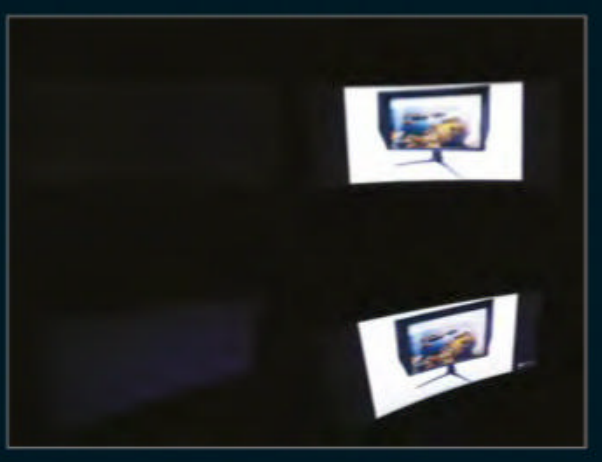
Like TN-type LCDs, the two electrodes that apply voltage to the liquid crystal sit either side of the crystal layer. However, unlike with TN, the electrodes are offset in such a way that the crystals don't point directly forwards but tilt to the side.

As such, the pixels are off by default, and it's only when a voltage is applied that the crystals align in a way that allows light to twist and pass through the second polariser.

It's this 'off by default' state and crystal pattern that allows for the main advantage of VA displays, which is their exceptional contrast. While IPS and TN displays typically deliver contrast ratios of around 1,000:1, VA displays regularly have a contrast ratio of 3,000:1 and can even hit 5,000:1. This high contrast ratio is fantastic for watching video, as it adds a real depth to the image.

High contrast is generally desirable elsewhere as well, although technically, PCs are designed to work with a 1,000:1 contrast ratio, as that's the standard for the sRGB colour space. Also, while high contrast is desirable for games where you want to immerse yourself in the visuals of the world, for competitive gaming, it can

IPS glow occurs when light leaks from behind the LCD to form a lighter patch on the screen when it's viewed at an angle



make it more challenging to see objects in darker parts of an image.

There are other downsides to VA LCD technology too. The first is an oddity in its viewing angles. Because the technology tips over the liquid crystals sideways, you'd normally have to view such a panel from a 45-degree angle to make it usable. To get around this issue, VA LCDs have multiple domains within each sub-pixel, each of which directs its liquid crystals in alternating directions. It's the net combination of the two directions that results in the good overall viewing angles.

However, while the combined image is good, it's not perfect. If you look at the screen, and move your head from a perfectly perpendicular angle to slightly off-axis, you'll see a change in the image, with contrast actually improving. This subtle alteration of the image as you move in and out of perpendicular means that, in practical terms, VA displays can't really compete with IPS displays for viewing angles, especially when it comes to colour critical work.

The other key problem is that VA technology has a slow response time. While the latest versions claim response times as low as 4ms (and you can get 200Hz displays), the real-world experience is noticeably worse than IPS, which itself is worse than TN. The slow pixel response manifests as a smearing, ghosting effect when the on-screen image is moving. You can see it best using BlurBusters' UFO motion test.

As with IPS screens, there's a number of different variants of VA LCDs, many of which have come and gone.

However, the two main variants that are readily available are MVA, developed by Fujitsu, and PVA, developed by Samsung. While they're different in some areas, they both essentially deliver the same performance characteristics and use the same core principles – as such, they can be considered equivalent.

CRYSTAL CLEAR CONSEQUENCES

The upshot of having three different types of LCD panel in regular use today is that buyers now have a meaningful choice to make, and while we've highlighted some of the general differences between these panel types, what you no doubt really want to know is just which is best for what and which should you buy.

GAMING

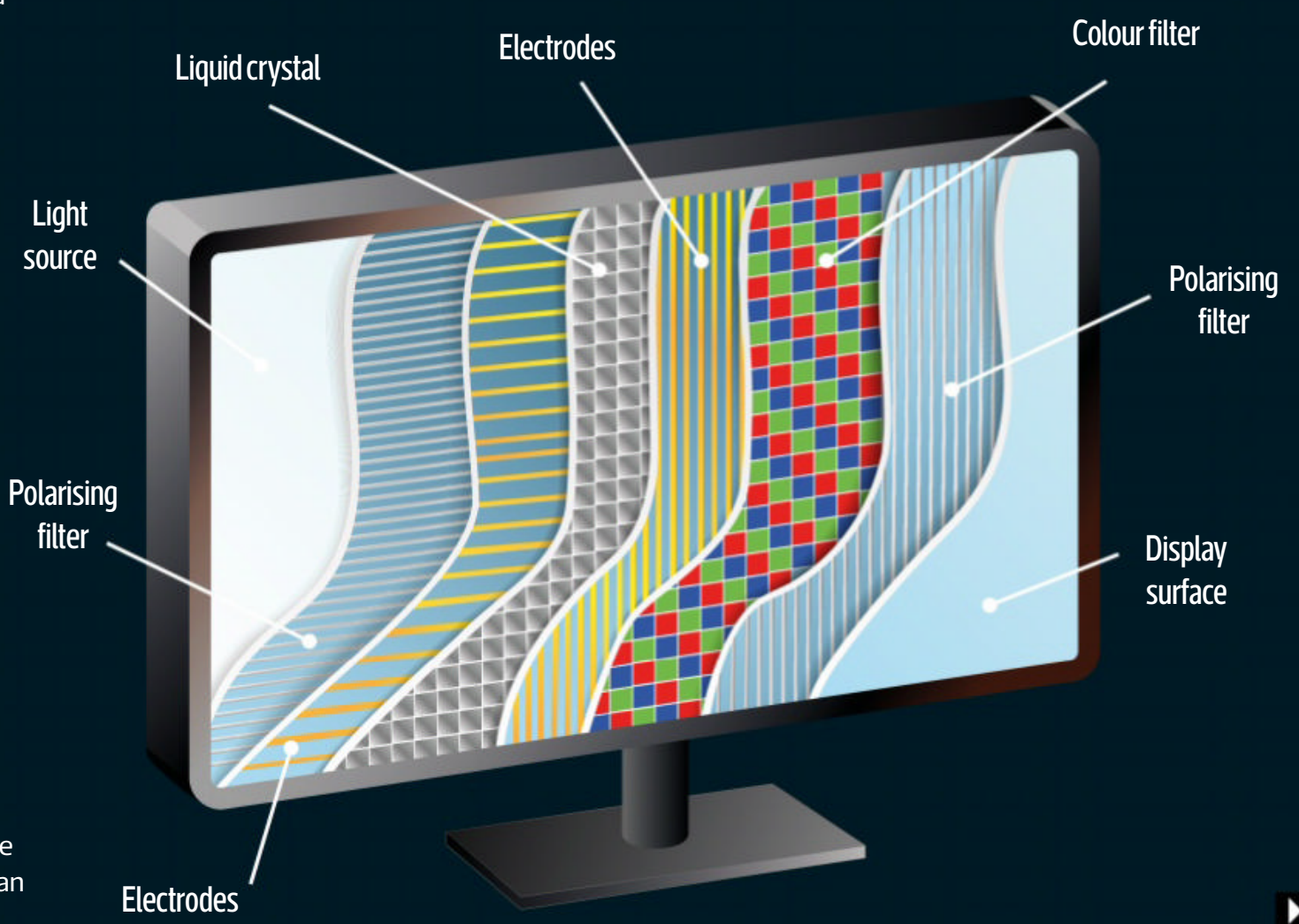
The single biggest factor in improving your gaming experience is getting a higher frame rate, and that applies to the refresh rate of monitors too. However, the importance of this factor varies depending on the types of games you play.

While 60Hz is fine for slow-paced games, any game where there's a lot of movement on screen – such as racing games or first-person shooters – benefits from a faster frame rate. Even a bump up to 75Hz is worthwhile and 100Hz gives you a noticeable boost. As such, even if you don't consider yourself a hardcore competitive gamer, opting for a screen with a refresh rate higher than 60Hz is worthwhile.

The key factor is that, in this instance, you don't need to compromise so much on image quality by going for a TN panel with a fast response time. There are many IPS and VA-based screens with a fast refresh rate, providing a great compromise between smooth gaming and great image quality.

If, however, you're *really* into competitive FPS gaming, a fast response time is a must-have feature. We've yet to find a VA-based gaming monitor that fits the bill for this type of gaming: the image they produce is just too smeared and blurry. Some IPS-based screens fare a little better. The likes of the Asus ROG Swift PG279Q, with its 165Hz refresh rate and 4ms response time, are just

INSIDE AN LCD MONITOR



LCD COMPARISONS

VIEWING ANGLES

The excellent viewing angles of IPS screens means you get almost no image distortion when they're viewed off-axis, although they do suffer from IPS glow. VA screens show a little more colour variance (see the white background), while TN screens suffer from significant changes if you don't view the screen head-on.

IPS

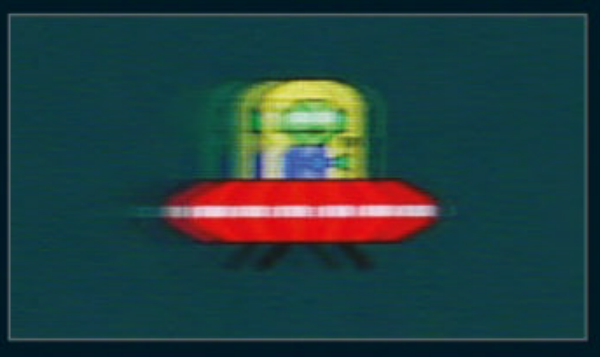
TN

VA

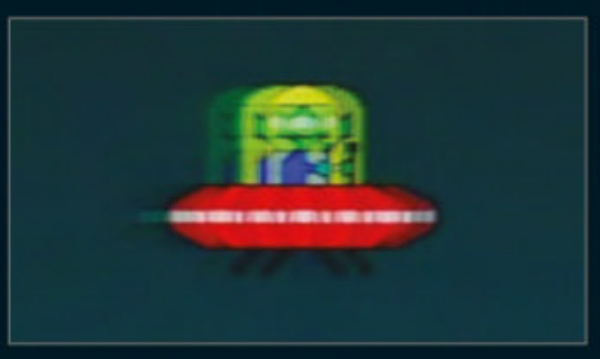
RESPONSE TIME

The slow pixel response time of VA screens results in a long trail of ghost images on moving objects. The trailing images have more colour variation too, making the ghosting more distracting. IPS has shorter trails and no colour distortion, while TN panels are much quicker to respond, resulting in a far clearer image.

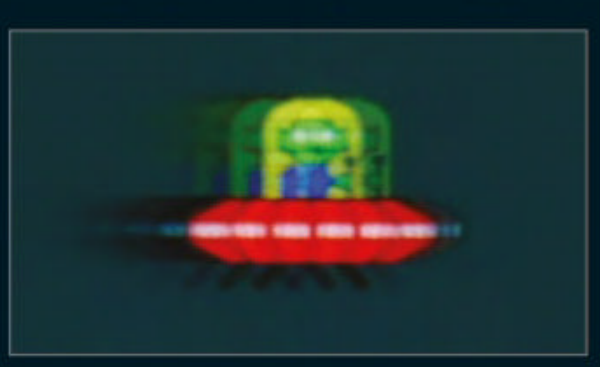
IPS



TN



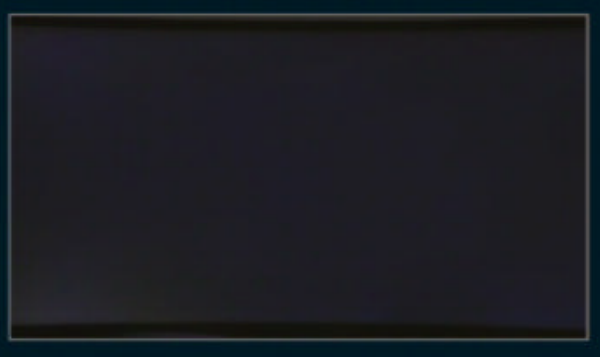
VA



CONTRAST

The lower black level of VA screens allows for them to provide a higher-contrast image (~3,000:1), which makes them particularly good for watching movies. IPS and TN screens have a higher black level for a given screen brightness, resulting in a lower contrast (~1,000:1). The image brightness is falsely high in these photos to demonstrate the effect.

IPS



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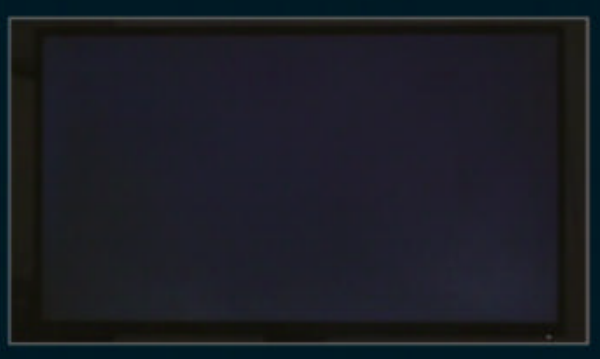

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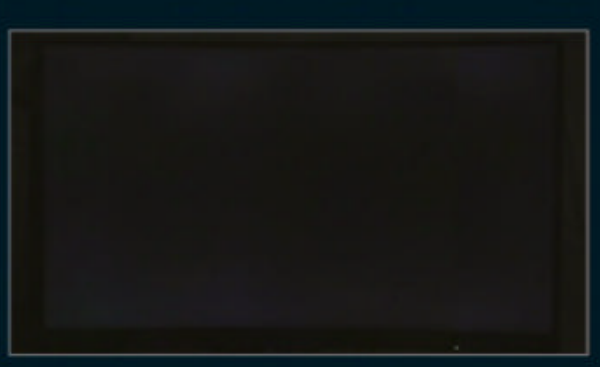


WE STRONGLY RECOMMEND OPTING FOR A 1MS, 144HZ (OR HIGHER) TN-BASED PANEL FOR COMPETITIVE GAMING

about good enough for staying competitive in online shooters.

Otherwise, we recommend a 1ms, 144Hz (or higher) TN-based panel for competitive gaming. The step up in sharpness and responsiveness is clear even compared with 144Hz IPS screens. If you have the money, there's also a strong argument for getting two screens – one for competitive gaming and one for everything else.

DESKTOP WORK AND IMAGE EDITING

When it comes to the more mundane computing tasks, the main factor is having a comfortable, sharp, stable image that's easy to view for many hours at a time. It's for this reason that TN displays are generally best avoided. The relatively poor viewing angles and often lower-quality colour reproduction of TN screens means they can be harder on the eyes when trying to focus on text and other fine details.

They're also not ideal for any work that requires particularly accurate colour reproduction, such as image and video editing. Again, the poor viewing angles can affect how colours are perceived by the viewer, plus TN screens often have a lower colour depth and hence poor colour accuracy. It can result in you missing some fine details in your image, or seeing colours differently to how they should appear.

It's a similar situation with VA panels. The slight difference in image performance when viewed on and off-axis means the image isn't quite as stable as on IPS displays. Plus, the slight compression of colours, particularly in the darker end of the spectrum, can make it a little harder to spot fine differences in colour.

As such, our go-to recommendation for general desktop work and tasks where colour accuracy are paramount is an IPS screen. Cheaper screens that use a 6-bit e-IPS panel still have good viewing angles but aren't quite so good on colour accuracy, but otherwise (calibration aside), almost any good-quality IPS display is the way to go here.

VIDEO

If you regularly like to sit back and watch video on your PC's monitor, then we'd recommend a VA display. Contrast is king when it comes to movies, and VA is the clear leader here – FALD displays and OLED aside – giving you the best black levels and most engaging image of any LCD technology. The generally good viewing angles of VA also makes it far superior to TN displays, and the lack of IPS glow further enhances its credentials, especially if several people are sitting round the screen, or if you sit and watch from an awkward angle such as a nearby sofa or bed.

Ultimately, in an ideal world, a monitor should excel at all the above tasks, and in theory, the likes of OLED and micro-LED displays could hit that goal. However, until we see widespread adoption of those technologies, LCD is the standard, so you'll have to be honest with yourself when thinking about your next monitor purchase. There may not yet be the perfect monitor for everyone, but there's probably one that suits your most important needs. GPG

Some IPS screens, such as the Asus ROG Swift PG279Q, still offer a 165Hz refresh rate and 4ms response time

NEXT STOP, DESOLATION

Bill Owen takes us on a ride with his Metro Exodus themed mod

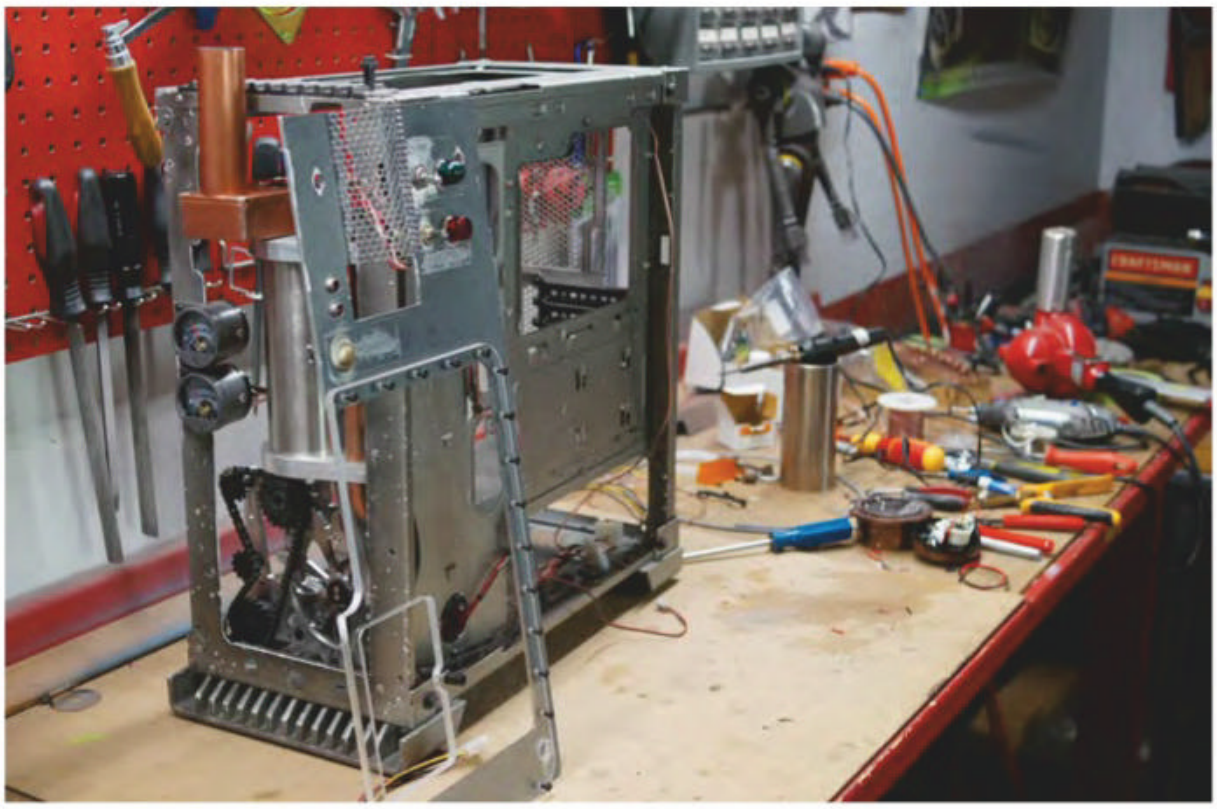
Creating dystopian themed PC mods has long been a passion of mine, so receiving an invitation from Deep Silver to create a Metro Exodus themed PC was a dream come true. The Metro game (and book) series is set in a post-apocalyptic Russia, where the fallout from nuclear war has left the world ruined and humanity has to survive on the scraps left over from its previously peaceful age.

The main character, Artyom, must eke out a living, scavenging what he can find, while taking on hazards both human and mutant with his cobbled-together arsenal of handmade weapons. Rendered in gorgeous detail by the 4A Game development team in Ukraine and Malta, there could hardly be a more inspiring world on which to base a PC mod.

Raising steam

A steam-powered locomotive plays a large role in the game and, since there are no electrical power sources in this world, I imagined the PC as being independently powered by a small single-piston steam engine.

A remote-controlled smoke machine gives the faux steam engine its puff



Creating a working piston assembly in the front of the case was the biggest challenge of this PC

One month to develop a working engine from scratch wasn't realistic, but creating a contraption that looked like one might be doable. However, such a task would require some extra engineering expertise and there was only one person I knew who could do it: the modding genius known in the bit-tech online mod community as 'Cheapskate'. My thanks go out to him for his help.

We already knew we'd be using an Nvidia RTX 2080 and Corsair 570X Crystal mid-tower chassis as the foundation for our build. As such, space was limited to the front of the chassis for creating the faux single-piston engine. While it restricted our options, this location did ultimately make sense, as it best presented the piston rod and gears.

Not surprisingly, it was this piston/gear assembly that was the most time-consuming feature of the PC. It consists of a large stainless-steel tube with a working piston inside it, along with a gear and chain assembly for keeping the machine moving. Everything other than the chain had to be created from scratch.

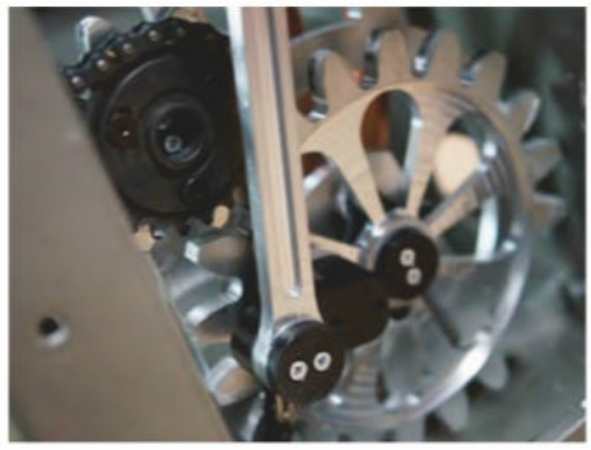
The piston engine was made from a variety of machined and laser-cut parts. Materials included black acetal, and 6061 aluminium for the frame work and gears. The piston and crankshaft were made from grey Delrin and they actually pump inside the cylinder. Meanwhile, the smoke stack is one designed for scale-model steamboats made by 'RC Smokers' in Australia.

Even in post-apocalyptic Russia, you have to think about safety

ONE MONTH TO DEVELOP A **WORKING ENGINE FROM SCRATCH** WASN'T REALISTIC

The smoker is based on similar technology to vape pens and can be refilled with the same liquid. So not only does the PC provide a fun visual effect, but you can even use it as an air freshener of sorts.

Before the smoke generator arrived, we had designed the piston cylinder to be connected to the smoker box with a tube, so the piston would produce a realistic steam train chugging effect. However, the piston didn't produce enough air pressure, so we had to abandon this idea. Luckily, the RC Smoker produced its own effect, so we could rely on that. I also added a keychain remote control for the smoker, just to mess with people.



The piston's gears and crank were machined from aluminium and Delrin

Crank it up

To drive the piston assembly, we used a gear and chain system, with the chain coming from Cheapskate's bicycle. Power comes from an IG32 12V DC 197rpm motor, which is controlled by a wireless RF remote control switch transmitter and receiver (single channel, relay, 12V DC, 10A). The speed of the piston gear assembly is controlled by a vintage rheostat dial on the front panel.

Tuning the gears to turn and operate effortlessly took a great deal of development time. I believe it went through three design revisions until we nailed it. Incidentally, if you've ever wondered where to find parts for future PC mods, recycle bins are a good place to start. Putting myself in the role of the game's protagonist, I climbed over a fence to scavenge parts from my local bins and returned triumphant with a nice steel handle and some vintage incandescent table lights to illuminate the PC's interior. Score!

The light fixtures were a particularly lucky find, as they look like the sort of thing you might encounter near an abandoned Russian factory. Well, to my mind, at least. If you fancy a bit of dumpster diving, though, do proceed with caution. There's loads of inspiration to be found in those bins but plenty of nasty stuff too. Bring gloves and a filtered mask.

Post-apocalyptic PC

The world of the Metro games has always been a harsh place, so it was important that the exterior of the Metro Exodus PC reflected

Mini light fixtures salvaged from a bin were just the right style for this build

this hardship. You can't be lugging around a PC with tempered glass panels in this wasteland. As such, I outfitted the Corsair 570X case with a battle-hardened exterior.

The tempered glass panels were replaced by 5mm thick machined aluminium plates. All of the exterior panels were also given suitably steamy circular ventilation holes.

The left side also has a large cast acrylic window fastened to it with countersunk machine screws. Below the window are air vents for the vertically mounted RTX 2080 graphics card.

Plenty of scuffing and scouring gave the Metro Exodus PC a suitably weathered look

Several antique dials add an ideal analogue feel

The corner of the window also has a voltmeter that mirrors the Geiger counter gauge on the 'Bracer' wristband of main character, Artyom. To create it, I modified an Uxcell AC 0-300V analogue-dial voltmeter with a new face and Russian text that reads 'индикдтор' (indikdtor, or indicator).

The gauge is backlit with a 12V incandescent light bulb from a Triumph motorcycle taillight. I distressed its bezel with a barrel sander attachment on my Dremel and bent the edge with a heat gun. Its surface was given a faux rust effect with the Triangle Coatings Sophisticated Finishes Rust Antiquing Set.

Meanwhile, the right side panel was milled with the game's logo. Behind the cut-out we fitted a 3D version of the Metro Exodus logo made from 12.7mm thick clear acrylic. The panel was backlit with white LEDs sourced from Darkside Mods, and the acrylic was scuffed with 500-grit sandpaper to disperse the lighting.

The front panel was machined from 5mm-thick aluminium with a clear acrylic window at the bottom. We engraved the Russian words двигатель (motor) and Начните (start) underneath the dials.

Only belatedly did I realise that Начните doesn't quite mean 'start' but rather 'beginning'. It still sort of works but clearly trusting in Google Translate alone wasn't the best approach.

The bezel was finished with Rust-Oleum Hammered hammer-effect paint and primer. This provided the sort of beaten, industrial look that would be at home in the world of Metro Exodus. To further the rugged look, I scuffed the paint around the switches and dials with medium-grit sandpaper.

TRUSTING IN **GOOGLE TRANSLATE ALONE** WASN'T THE BEST APPROACH

The front panel provided space for the basic controls of the PC. I reached out to three individuals in Russia who collect and sell these parts on eBay. They helped me to get an authentic Russian military transmitter dial switch and control panel lights. I also salvaged some vintage gumdrop-style red and green incandescent light bulbs from the control panel of a diesel locomotive. The lights indicate when the piston and smoker are turned on by the remote control.

The top and side panels were aged and weathered to give the impression that this machine had survived many years of abuse. This process began with airbrushing on a flat black base coat, which was then scuffed with

a medium (red) Scotch-Brite pad around high-usage areas, such as access screws, switches and buttons. The final touch was the lower front grille, which was laser-cut from acrylic and bent with a heat gun.

What's that burning smell, Bill?

Upon completing the build, I invited some friends into my workshop to gauge their reactions, and what amazed me was how few people were bothered by the smoke billowing from the PC. Clearly, the lack of an unpleasant odour accompanying the smoke – if you're ever had any electronics go up in smoke, you'll know what I mean – was enough to reassure them it wouldn't do any harm. It was fun to set off the smoker by remote when they had their faces up close though!

Only RGB lights and cockroaches will survive the apocalypse

After posting images of this build on Instagram, someone asked, 'What's with the RGB lights on the CPU and memory, they don't fit the theme'. It's a reasonable question and one that's worth addressing when it comes to PC modding in general.

For a start, giveaway builds such as this one are sponsored, so hardware partners provide the components to build the systems and, accordingly, they often want their wares to be displayed in all their glory.

As a result, you do sometimes need to compromise the aesthetics, but that's the balance you need to strike when building these sorts of systems.

The second reason also answers another question that I'm often asked, which is why I don't implement custom liquid cooling for these builds. The answer is that I believe in keeping these types of builds simple. The machine's new owner may never be inclined to do proper maintenance and clean the liquid loop, or they may want an easy path to upgrading hardware at a later date.

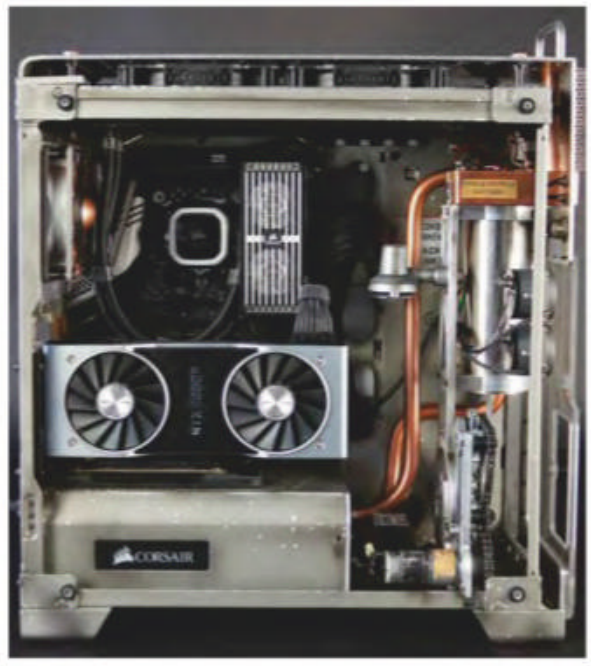
Also, shipping anything with a water-cooling loop is a major hazard. If you send it filled, there's a very high chance of the competition winner receiving a rather damp and unusable PC. And even if you send it empty, you're relying on the winner to properly fill it themselves, and there's still the high chance of a leak having developed en route.

The smoking PC leaves Mnpctech for Corsair giveaway

All told, I was very pleased with the final results. As with any mod, I hated to see it leave after putting in all that work, but I'm glad to hear that the individual who won is very satisfied with it. I also couldn't be happier to see that Corsair's competition for the case received 130,000 entries. **CPC**

You can see videos of my build on my YouTube channel:
youtube.com/user/MonsterMawd

The internals of the PC were kept quite simple, for reliability and easy upgrades



The Metro Exodus PC in all its glory

GARETH HALFACREE'S

Hobby tech

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

REVIEW

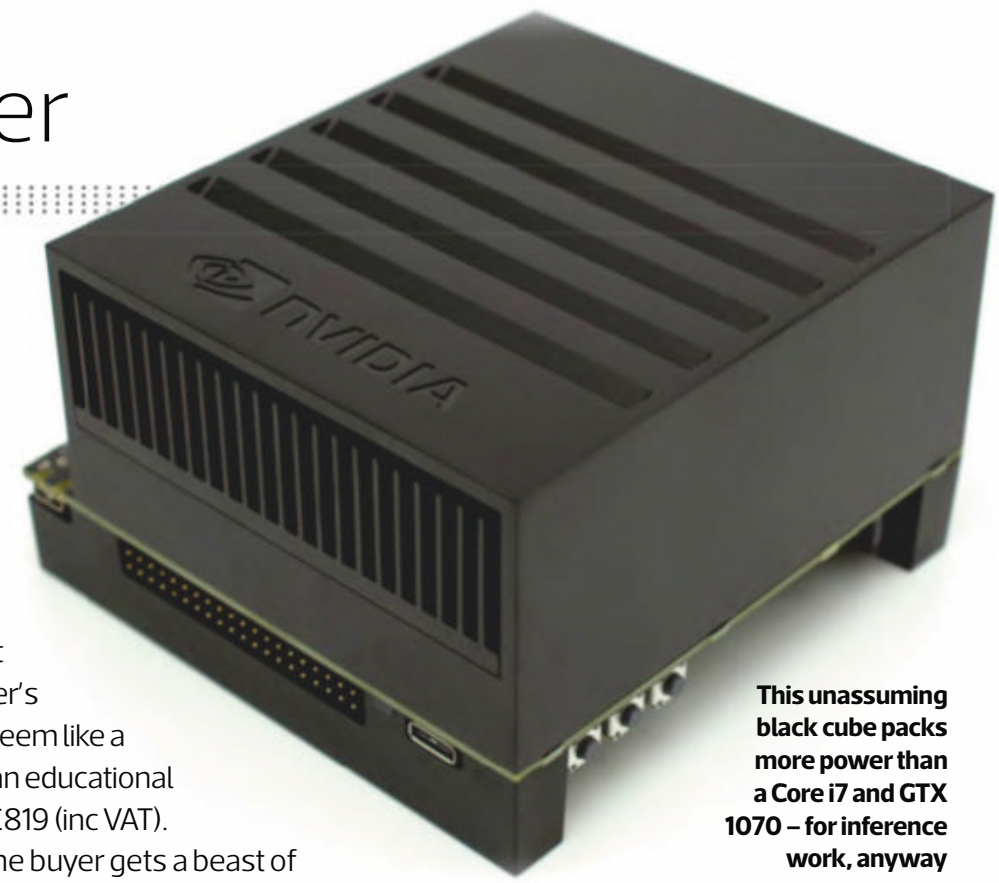
Nvidia Jetson AGX Xavier

Back in 2014, Nvidia surprised the tech industry by seeming to jump on the Raspberry Pi bandwagon – and missing by a mile. The Jetson TK1 (reviewed in Issue 133) was a monstrously powerful single-board computer, but the £200 inc VAT price tag jarred badly with the decision to make Maplin the sole UK stockist. Not surprisingly, the Jetson TK1 wasn't a commercial success. It did, however, give rise to an entire family of more sensibly targeted embedded devices, which retain their predecessor's name: the Jetson TX1 and TX2, and now the Jetson AGX Xavier.

There's an even newer member of the family too, unveiled at the company's 2019 Graphics Technology Conference (GTC) – the Jetson Nano, an attempt to correct the mistakes of the past and bring Jetson back to the hobbyist market with a sub-£100 (inc VAT) price tag and cutting-edge hardware. With a review sample still en route at the time of writing, though, a look at the Jetson AGX Xavier offers a fair view of what's happened since the launch of the original TK1.

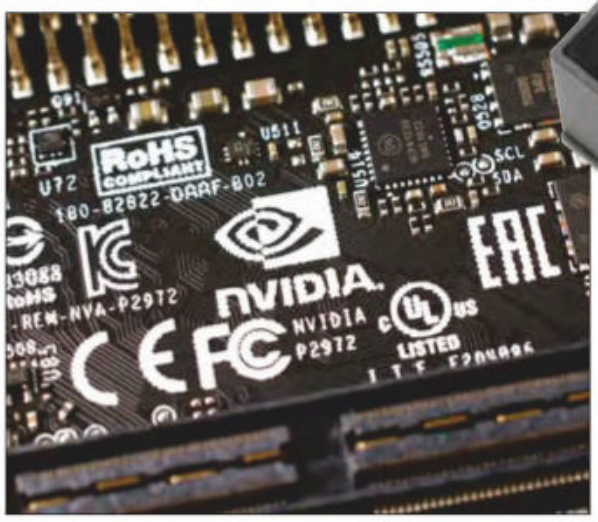
The biggest difference between the TK1 and the AGX Xavier is pricing. The TK1's £200 inc VAT launch price pushed it out of the reach of most hobbyists, but it makes the AGX Xavier's £1,199 inc VAT price seem like a bargain, even when an educational discount brings it to £819 (inc VAT).

For that, though, the buyer gets a beast of a system. Measuring just 105 x 105 x 65mm, the Developer Kit variant – which turns the AGX Xavier's usual system-on-module (SOM) format into a plug-and-play device – includes a 64-bit 2.265GHz 8-core CPU based on Nvidia's in-house Carmel ARMv8.2 cores. There's also a Volta GPU with a 1366MHz core clock, 512 stream processors, plus 64 Tensor cores and two Nvidia Deep Learning Accelerators (DLAs), alongside a seven-way Vision Processor (VP), all hooked into 16GB of LPDDR4X RAM.



This unassuming black cube packs more power than a Core i7 and GTX 1070 – for inference work, anyway

It's the accelerator cores that reveal the target market for the Jetson AGX Xavier: artificial intelligence and other deep learning platforms. Nvidia's vision for the Jetson family, the education- and hobbyist-focused Nano notwithstanding, is to sit at the heart of all sorts of devices, from industrial robots to autonomous vehicles. The result is a lot of computing power in a tiny form factor, and a surprisingly small power envelope of just 30W.



If Nvidia has its way, that logo will be found inside our future robot overlords

That claimed thermal profile, though, doesn't tell the whole story. In order to avoid the need to design multiple SOMs for different-use cases, Nvidia has made the Jetson AGX Xavier's thermal profile software-adjustable. The Developer Kit comes with preconfigured settings to run at 10W, 15W and a full 30W, plus an 'unrestricted' profile, which the company recommends using for benchmarking purposes.

That 'unrestricted' profile provides the best performance, but at an undeniable cost. Power draw, as measured from the wall, hit 52W during benchmarking – approaching double the headline TDP. Meanwhile, a separate tool that pegs the CPU cores at their top speeds makes the internal and surprisingly loud fan run at full tilt until the system is rebooted.

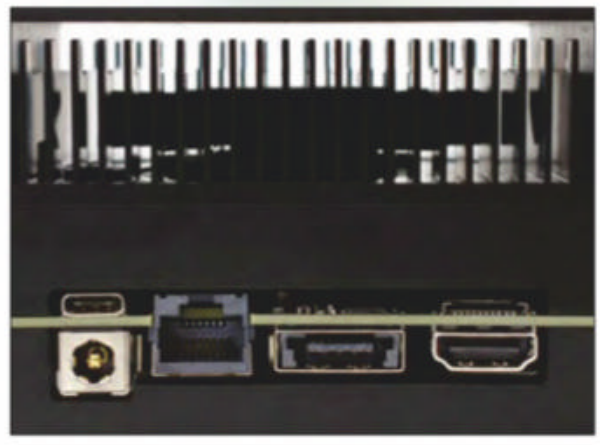
While 52W is significantly more than 30W, there's no denying that the Jetson AGX Xavier is still hitting well above its weight. When combining the compute power available on both the GPU and the dedicated DLAs, the Jetson AGX Xavier beats an Intel Core i7 and Nvidia GTX 1070 workstation for raw performance, while drawing around a tenth of the power at the wall.

Sadly, however, actually getting this performance out of the system isn't exactly straightforward. Running an inference network on the GPU is the work of a single command, but the DLAs – which account for 10 trillion operations per second (TOPS) of the Jetson AGX Xavier's claimed 32 TOPS INT8 compute performance – need special handling to run concurrently with the GPU. Worse, they're currently limited to FP16 operation, with INT8 promised from a future but as yet unavailable update to the Ubuntu-based Linux4Tegra operating system.

The bad news continues if you hoped to use the Vision Processor for computer vision projects. While the DLAs will, at least, run FP16 workloads, the Vision Processor is entirely unavailable to the user. Again, Nvidia has promised to resolve this problem in future software updates, but the latest release – part of the JetPack 4.2 toolchain – still has it marked on the road map with no launch date in sight.

The Jetson AGX Xavier isn't for hobbyists or tinkerers though: the Jetson Nano is set to take care of that market. For AI developers looking to put considerable power into as small a space and power envelope as possible, there's little to match the Jetson AGX Xavier. Nvidia, judging by the price point and the sweet time it's taking to unlock all its hardware features, knows that only too well. The Jetson AGX Xavier is available now from developer.nvidia.com for £1,199 inc VAT.

There's room for expansion on the AGX Xavier, including an optional camera daughterboard



The Developer Kit version of the AGX Xavier is a fully functional standalone computer, complete with Ethernet and HDMI

NEWS IN BRIEF

Museum gets prototype ZX Spectrum

Not-for-profit educational venture, the Centre for Computing History, has received an original ZX Spectrum prototype from Nine Tiles. 'The prototype machine itself has a full travel keyboard with the commands handwritten on the top,' says the museum. 'All the chips are labelled, and the underside of the board is all hand-wrap wiring.' The prototype came alongside a wealth of other machines and documentation from the company, including a workstation known to house the original design files for the ZX81 and Spectrum uncommitted logic arrays (ULAs). For more information, please visit **computinghistory.org.uk**

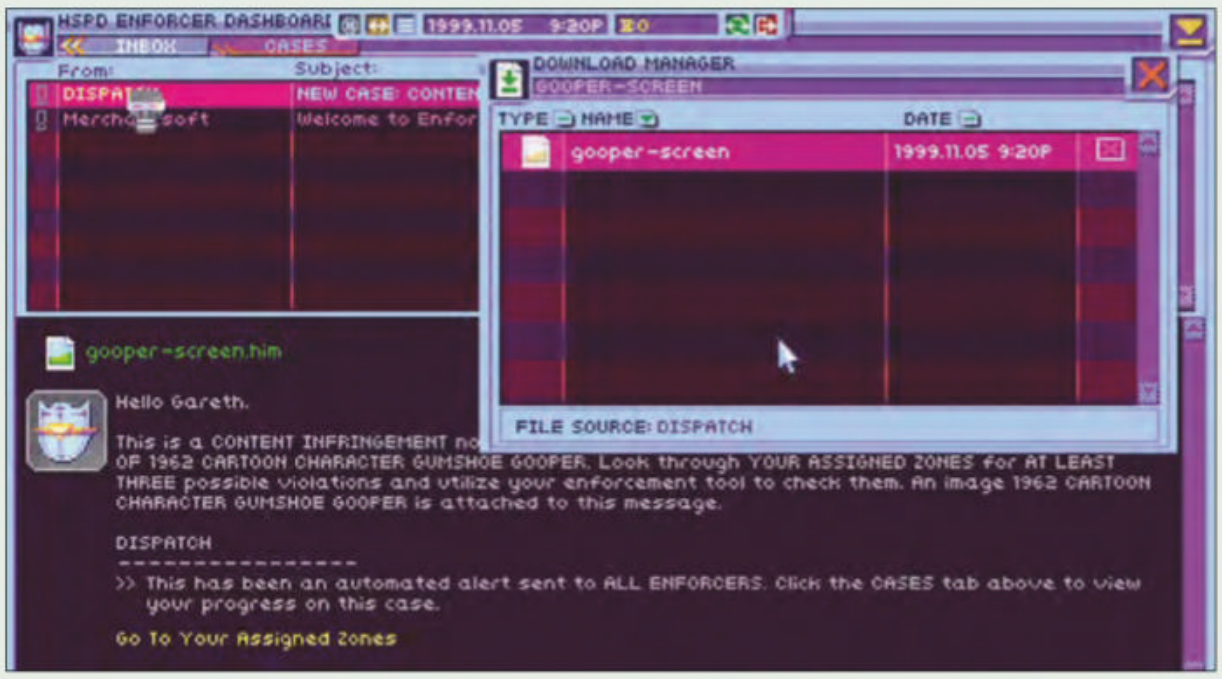
The entire game is played inside this fake operating system, HypnOS

REVIEW

Hypnospace Outlaw

Hypnospace Outlaw is a game that took an abrupt shift partway through its development process, but in an unusual twist to the norm, feels so much better for it.

Its origins trace back to Hypnospace Enforcer, a 2014 release from Jay Tholen, who also developed the point-and-click adventure Dropsy. Tholen describes Hypnospace Enforcer as 'a side project I took on while developing Dropsy to prevent burnout'. In it, the player drives an angular vehicle across a colourful track in order to chase down criminals in Hypnospace – a persistent online world inhabited by people wearing electronic headbands to enter a collaborative electronic dream state in 2114.

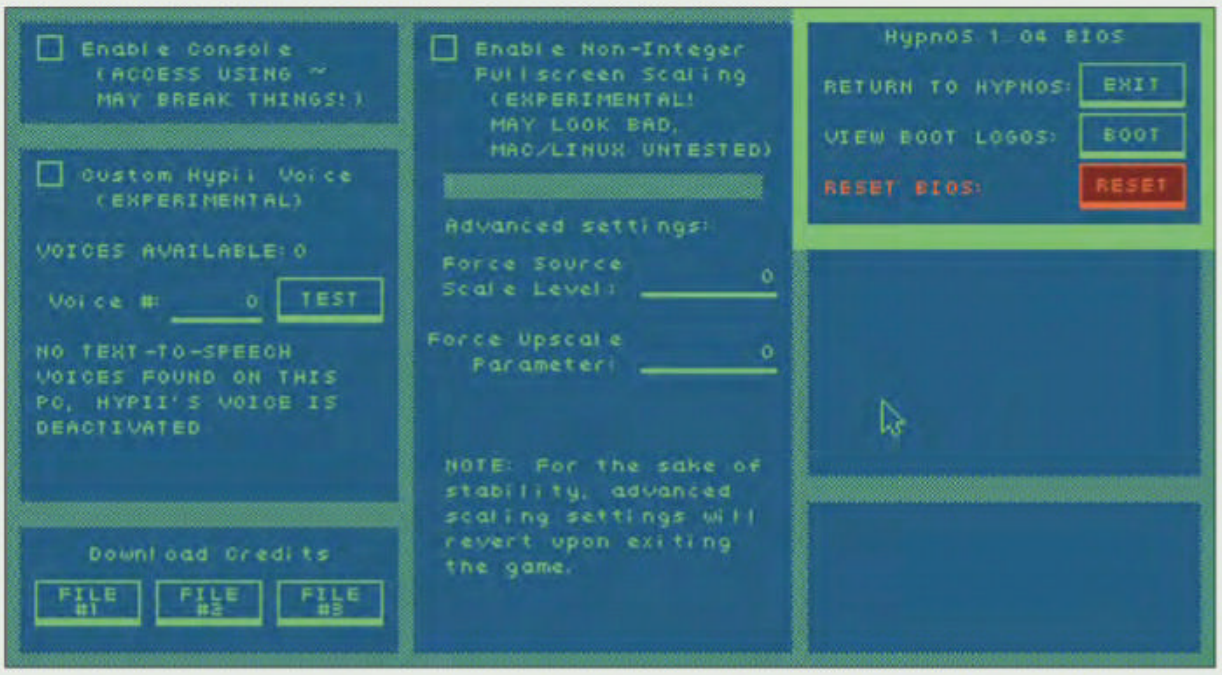


Juggling windows in such a small resolution feels very Windows 3.1

It's not a big game, it's not a complex game, and it's not even a particularly clever game, but the core concept – a separate internet inhabited entirely by people who would prefer browsing to dreaming – prepared the ground for Hypnospace Outlaw. First publicly announced when the Kickstarter crowdfunding campaign launched in September 2016, Outlaw takes the setting of Enforcer and builds significantly more of a game around it.

The original concept, as described on Kickstarter, was to keep the car-smashing, high-speed, high-colour chase aspects of the original Enforcer, but include more of a functional Hypnospace in the background. Players would be given the job of tracking down trouble, including 'adware, toolbars, hackers, infected GIFs and MIDI files', as well as 'a rogue AI' – on GeoCities-inspired amateur websites.

You would be reporting infractions of the CHIME laws – content infringement, harassment, illegal activity, malicious



As the game progresses, multiple themed areas become unlocked

software and extralegal commerce – to the Hypnospace Police Department, in exchange for a cryptocurrency-like token to spend on all sorts of goodies, from antivirus software and music downloads to virtual pets.

Over time, the GeoCities-style browser side took the bulk of the developers' focus, and the car-smashing race-'em-up slipped down the priority list. Now, it's present only as an aside, and as a way of earning additional coins in the late game, when infringements aren't so easy to find.

It's not a bad move though. The world Hypnospace Outlaw conjures through its fake web browser is pixel-perfect convincing for its shifted 1999 setting – the game's default mode is to run in a tiny 480 x 270-pixel window at 1:1 scaling, although the player is free to make it bigger if a magnifying glass isn't readily available.

In gameplay terms, Hypnospace Outlaw is simple. It's effectively Papers, Please meets GeoCities content moderation, but with its own little twists. All activities are carried out using the in-game operating system's interface: missions are received via email and take place within the browser, while other programs include the aforementioned virtual pets, a music player, 'helpful' assistants and a floating head. The latter alerts you to new messages and can read out text from webpages to save you straining your eyes.

The latter feature, sadly, is a Windows exclusive, relying on Microsoft's text-to-speech system. On macOS and Linux, the talking head falls back to a 'wah-wah' noise reminiscent of the teacher from Charlie Brown shouting into an empty tin cup. Like Papers, Please, though, the simplicity of the actual gameplay belies a surprising depth. There's a very clear plot at play, although its conclusion is unlikely to come as a surprise to anyone paying even a little attention to what they're reading, and the breadth of content included is staggering.

From teenagers' self-congratulatory homepages to fans of the 'coolpunk' music genre, and a pizza shop with one of the most annoying songs in history, there's an impressive number of pages to visit. It's unlikely the player will see it all on the first run-through too, with the game's semi-linear nature making it possible to hit the end game after only exploring a fraction of the content.

Sadly, Hypnospace Outlaw isn't entirely fully polished. The intro video can't be skipped, making starting from scratch rather annoying, although at least the tutorial can be skipped. There's no support for Steam's cloud save feature either, making it difficult to play through the game on multiple machines. Also, for a game doing little other than 2D graphics and video playback, it chews up a surprising amount of CPU time, although the period-appropriate screensavers when the game is left idle add another authentic touch.

We're nitpicking here though. Fans of twitch shooters or action role-playing games won't find much to keep them entertained, but for anyone looking for a game that's a little different – or who perhaps had their own embarrassing GeoCities page back in the 1990s – Hypnospace Outlaw manages to simultaneously feel both nostalgic and fresh. Support for a page generator means that user-generated content should begin to flow post-launch too, helping to keep interest in the game alive.

Hypnospace Outlaw is available to buy now from Steam and **gog.com**, priced at £15.49 inc VAT.

Find a breach, hit it with the ban-hammer and earn coins for your work

NEWS IN BRIEF

Google launches Edge TPU dev board

Google has finally launched its own Raspberry Pi-like development board, with a focus on artificial intelligence. The Edge TPU Development Board is released under the Coral sub-brand, formerly the division responsible for the company's AIY project kits. It includes a quad-core ARM Cortex-A53 processor, 1GB of LPDDR4 memory, 8GB of eMMC storage and one of Google's Edge Tensor Processing Unit (Edge TPU) deep learning acceleration chips. Boards are available to order from **mouser.co.uk** for £151.75, while an Edge TPU in a USB accelerator is also available for £73.19 (both inc VAT).

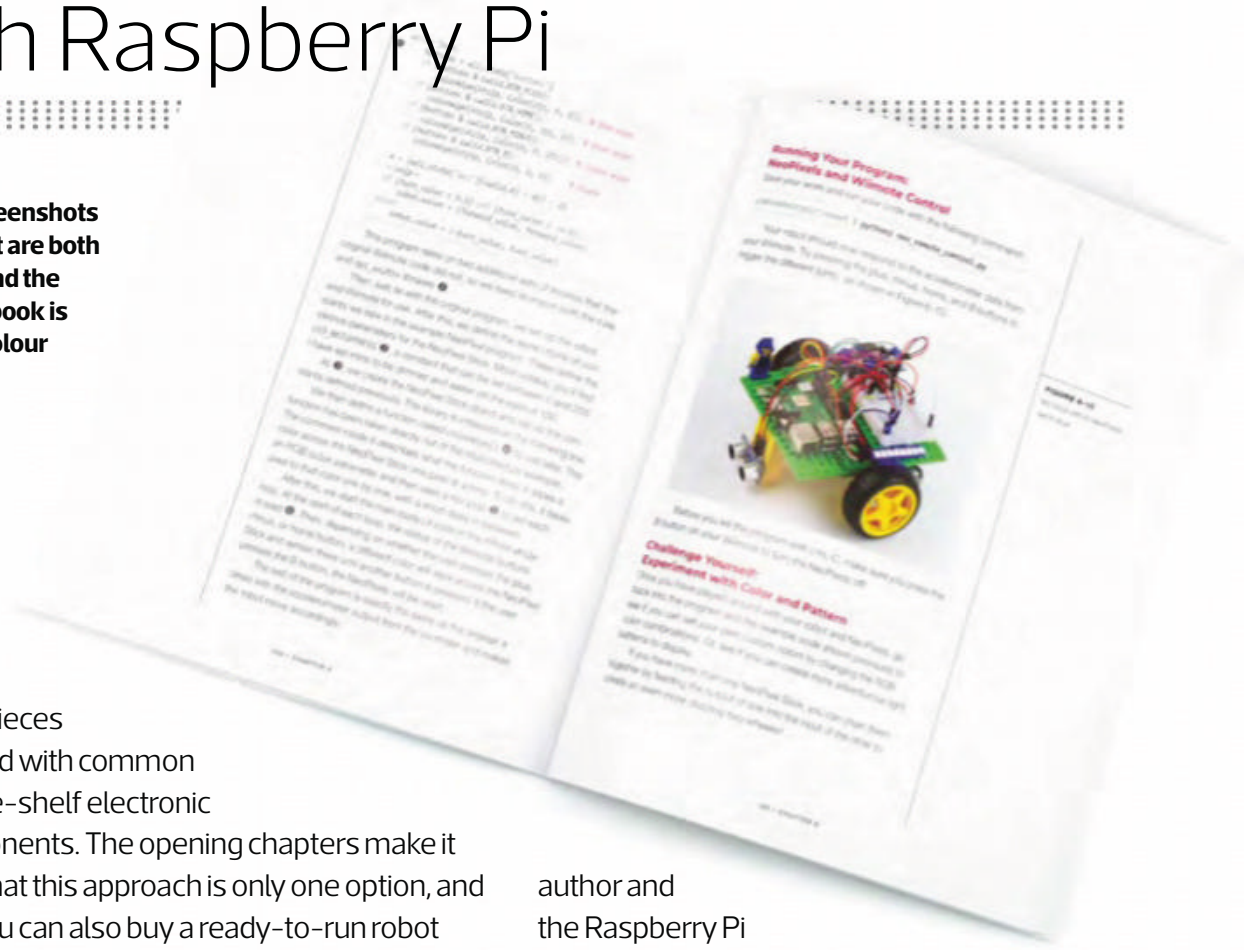
REVIEW

Learn Robotics with Raspberry Pi

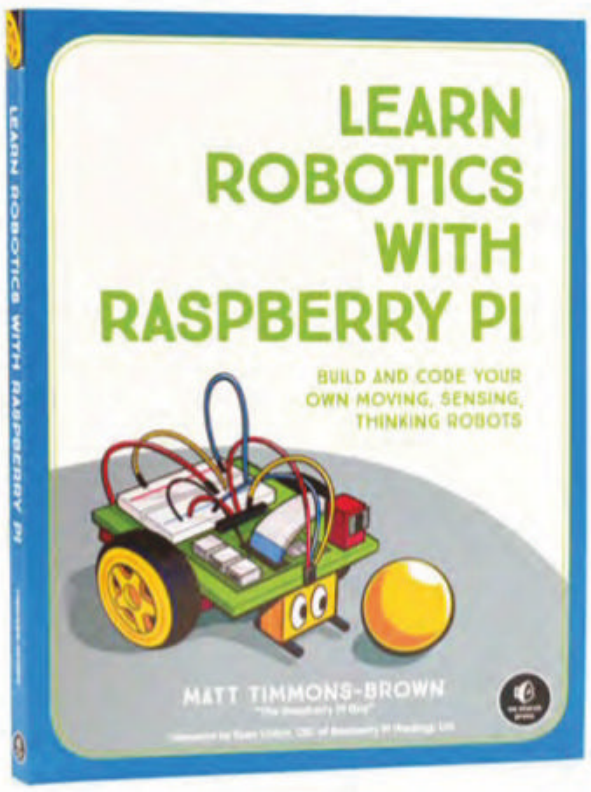
The trouble with guides to robotics is that, typically, they fall into one of two categories. One is a hands-on publication that only walks you through the basics of setting up an off-the-shelf kit before running out of pages. The other is a high-level overview that fails to teach anything practical.

Learn Robotics with Raspberry Pi, by Matt Timmons-Brown, lifts itself out of the first box by including hands-on examples of relatively advanced topics. While the core is still about building a relatively simple two-wheel robot, the later chapters go into a little more depth than most robot guides. It includes a chapter on using the Raspberry Pi Camera Module to perform Python-powered object recognition, with you programming the robot to recognise and follow a yellow ball around the room.

First, though, you have to build your robot. Timmons-Brown has opted to keep your options relatively open. The robot you'll see built throughout the book, to which Timmons-Brown engagingly refers in first-person style as 'my robot', is based on readily available Lego pieces coupled with common off-the-shelf electronic components. The opening chapters make it clear that this approach is only one option, and that you can also buy a ready-to-run robot chassis to save yourself some time while still following through the bulk of the book.



The screenshots and text are both clear, and the whole book is in full colour



Matt Timmons-Brown's first published book does exactly what the title claims

The remaining chapters, after a rather muddled introduction to basic electronics, follow the tried-and-tested formula of building the reader's knowledge piece by piece. Starting at the very beginning with setting up the Raspberry Pi, the robot is constructed over the course of multiple chapters, each of which adds new capabilities. You go through line following, Bluetooth control via a Nintendo Wiimote, LEDs, a speaker and the aforementioned Raspberry Pi Camera Module for a bit of machine learning intelligence.

The whole book is presented in full colour, which is used to excellent effect in the photography and Fritzing-powered breadboard diagrams. However, the wiring layouts can be confusing in the latter thanks to frequently crossing wires.

It's also a shame that images of the text-based terminal have been taken with the wrong code page set – a common problem for people connecting to a Raspberry Pi from a Windows SSH client – turning menu borderlines into ugly accented letters. Less explicable is the decision to list all the component prices in US dollars, when both the author and the Raspberry Pi hail from Cambridge.

These nitpicks are minor, however. By and large, the book is clear, friendly and easy to follow, with code fragments typically numbered to make their explanations in the text clearer. By the end of the book you should, indeed, have built a working robot with a wide range of capabilities, although you can also stop at any point after Chapter 4 and have a functional device.

A set of appendices round out the book, starting with recommendations for other books and websites, with Timmons-Brown's YouTube Channel, The Raspberry Pi Guy, getting the lion's share of the focus, naturally. That's followed by a handy GPIO diagram, although there's no explanation of what the pins actually do, along with a guide to reading the colour bands on resistors, and a brief but relatively complete guide to soldering.

If your goal is to build a Raspberry Pi-powered robot with your own hands, Learn Robotics with Raspberry Pi is the book to choose. It's up-to-date, accessible and does exactly what it claims on the cover. It's available now from amazon.co.uk for £13.99 (VAT exempt), or from your favourite bookseller under ISBN 978-1593279202. CPC

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree

ANTONY LEATHER'S

TOP TOOLS

TAPPING TOOLS

If you've ever wondered how screw threads are made, the answer usually involves some form of tapping tool, even if it's fitted to a machine in a factory, rather than the hand tool we're analysing here. Tapping tools cut into an object, creating a specific size of thread, and they're useful for all manner of different tasks. You can use one to create threaded holes for mounting water-cooling hardware, fan controllers and internal components, such as hard disk trays.

One great aspect of tapping tools is that you only need to buy the taps you need. The actual tap wrench is compatible with most of them, as long as the sizes aren't extreme, so you don't need to invest in a large tap set. For PCs, you'll be dealing with three thread sizes, and the taps you need for them will have corresponding sizes. The most common are 6-32 and M3, which are both used in most PCs, but often for similar tasks, which can make them tricky tell apart.

M3 is the finer, smaller thread of the two and is often used to mount SSDs and optical drives. It's occasionally used in motherboard standoffs too, but so is the larger 6-32 thread. The latter is commonly used on case thumbscrews to secure side panels, PSUs and graphics cards, as well as hard disks and removable case objects such as hard drive cages. Other components that use one or the other, depending on the manufacturer, are radiators and reservoirs. When dealing with these components, make sure you identify the screw thread size first.

One other thread size that's often used in PCs is G1/4, which is the size used for water-cooling component fittings. Common uses for taps with water-cooling hardware are adding extra ports to reservoirs, or cutting threads in distribution plates. Fan screws are the one exception to tapping, because the screws used are generally self-tapping. That means they bite into the soft fan plastic themselves, rather than needing a pre-threaded hole.

There are a couple of different tap thread tools to consider. The standard wrench tool allows taps to be inserted into clamps in the centre, with arms on either side to allow you to turn it. There are also ratchet wrench tools, which can be slightly easier to use. To start tapping, you need to drill a hole that's slightly smaller than the thread size. For example, an M3 screw has a width of 3mm, so you'd want to drill the pilot hole for an M3 tap with a 2.5mm drill bit.

Tapping sheet metal is relatively easy, but you can also tap thicker material, including acrylic and other plastics, using the same tools. However, we recommend using tapping lubricant if you're tapping thick materials. It helps to reduce friction, and will make your life much easier, as manually tapping can be tough work with thick materials. In these cases, you'll want to cut into the material a few millimetres at a time, before removing the tap, cleaning any cut material and then reinserting it to cut deeper. Eventually taps will wear out, but thankfully, they're cheap to replace. CPC

A tap wrench is akin to a manual drill and is compatible with various tap sizes

Taps bite into the material, creating a specific size of thread

You can create threads for common PC screw sizes, and even G1/4in threads for water-cooling components

Tapping thick materials manually can be tough, even in soft materials such as acrylic

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Modding is all about breaking rules

This month I've written about building your own dream PC (see p76), and how I created my own one over the past year or so. Sadly, I didn't fund the necessary components with a lottery win. Instead, I used long-term loan parts I had lying around, or I managed to organise sponsored hardware – that's one of the perks of the job, although believe me there are plenty of downsides too!

The PC is fantastic, but I'll admit the build was stressful and hugely time-consuming. It's also received a lot of online criticism. You get the odd vocal voice incorrectly assuming I was loaded and bought all the hardware myself, and also that I could have made better hardware choices. Plenty of people simply don't understand what PC modding is all about, and that the usual considerations surrounding a PC build, such as value, component choice and cooling, simply don't apply.

Neptune's Trident, by Brian Carter

Below certain budgets, most of us should rightly focus on key areas that address our needs. If you're building a gaming rig, you'll want the most powerful graphics card you can buy, potentially cutting budgets from other areas, such as the case or CPU, as a result.

You don't *need* that lustworthy £200 Phanteks Evolv X; a sub-£100 case such as the Lian Li Lancool One will give you an extra £100 to spend to boost those frame rates, while still offering a great home for your hardware. Similarly, if you're not planning on overclocking your CPU to its limits, and don't mind slightly higher noise levels, a £30 CPU air cooler has more than enough cooling power for a mainstream CPU – you don't *need* to spend £150 on an RGB-clad, all-in-one liquid cooler.

Generally, it pays to be sensible, which is why we show you how to build PCs to specific budgets, and have our hardware-packed Elite list every month. However, PC modding is about making exceptions and breaking the usual rules of PC building – it's making a PC a particular way because you want to, not necessarily because it will offer the best bang per buck.

For starters, a lot of PC mods are highly impractical. Some of them have open-air cases with a complete lack of dust protection. Others are enormous, or extremely small, and working with them is tricky as a result. Plenty of mods border on heresy when it comes to hardware choices and cooling systems too. Some of them have overzealous liquid-cooling loops, as well as radiators placed next to each other, so the air entering the second radiator is already quite warm.

That was the case in one of my favourite case mods – Neptune's Trident by Brian Carter. The Lian Li case Carter used is great for housing large radiators, but he chose a trio of smaller models, in order to fit with the project's 'trident' name – it's essentially a tri-pronged spear, represented both by a front panel feature, three water-cooling loops and three radiators. Excessive? It's not just excessive, it's

ridiculous and it too received criticism for its less-than-efficient water-cooling system. However, it's a work of genius in terms of building a PC around the trident theme.

I've seen plenty of scratch-built projects that appear to have poor airflow too. However, the only person that's really able to judge a PC mod is the person that built it. The machine will have been created with their idea in mind, but I'm not just talking about aesthetics here, which are subjective anyway. Even the hardware choices are likely to be made for very specific reasons, whether it's to fit in a small case, suit a colour scheme or simply because the modder wanted to use that hardware.

Much of the criticism I received was along these lines too. People wondered why on earth I'd used the Phanteks Evolv Shift case, when its default cooling is quite poor. Of course, that aspect was a major focus of my project, and I modded the case to improve airflow and to fit custom water-cooling components. Put simply, I wanted to use this particular case, as I love the design – it has a very small footprint, which is great for my small office, plus I saw plenty of potential for modding.

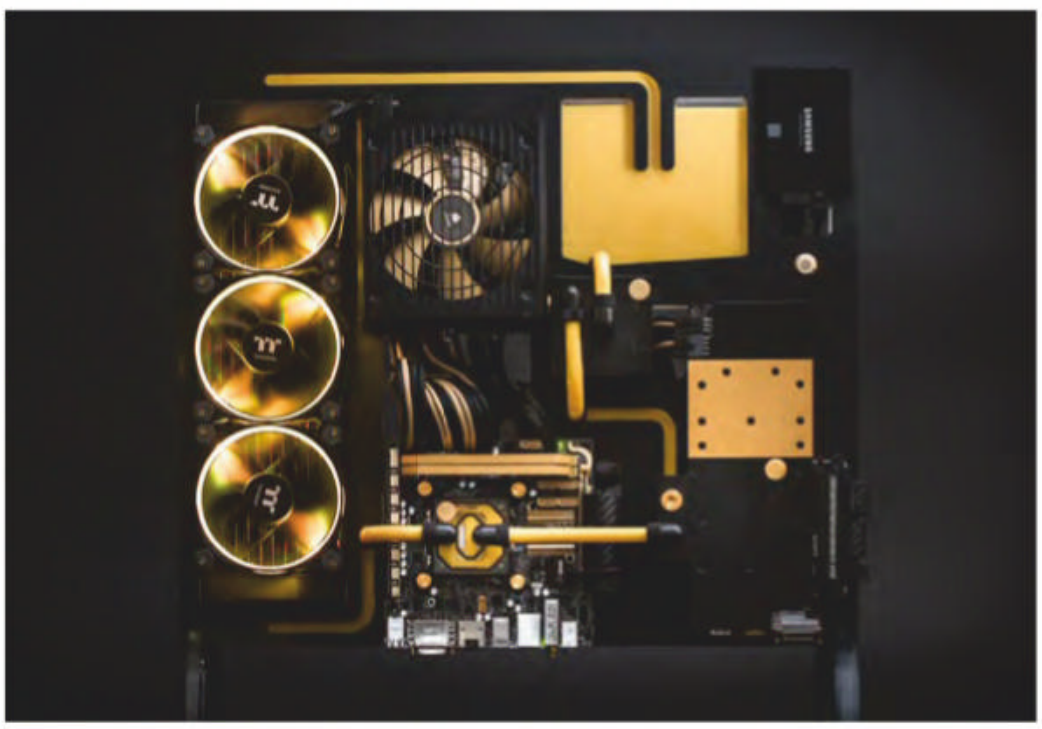
Other folks thought I was silly to use ASRock's X299E-ITX/ac mini-ITX motherboard, as it costs far more than the cheaper ATX motherboards and requires expensive SODIMM memory. Thankfully, both ASRock and Corsair were keen to sponsor the project, but even if I had to buy the hardware, I'd have opted for the same motherboard, seeing as it's the only mini-ITX X299 board available, although admittedly I'd have gone for cheaper SODIMM memory.

Clearly, my focus was to build a very powerful mini-ITX PC, so any suggestion of using a larger motherboard just didn't make sense. The cooling system is also questionable if you view it from a purely functional perspective. The RTX 2080 Ti and Core i9-9980XE are two hugely powerful components, and it would be perfectly logical to have double the cooling power I've used. However, there simply wasn't room in the case to house any more radiators, and while the cooling system is certainly pushed to its limits, I won't be putting the CPU and GPU under maximum load simultaneously.

PC modding is whatever you want it to be. You don't have to follow set rules. You don't need to use specific hardware, and that extends to the cooling system too. While I'd love to have greater cooling headroom, my machine's temperatures are perfectly acceptable. There are also plenty of PC mods that go to the other extreme and water-cool low-end hardware simply to make the focus of the build an elaborate, over-the-top water-cooling loop.

You don't have to spend a fortune to create your own customised PC either. It costs little money to remove all the fixtures and fittings in your case and fill it with RGB fans, or to cut ventilation holes in an otherwise low-airflow case, so you can fit a monstrous overclocked PC inside it. You should never be afraid to build the best PC for you, and with PC modding, that's not just a tip, it's an essential requirement. It's not surprising, then, that practically all the best PC modding projects feature seemingly unusual designs or hardware choices. CPC

Our dream PC build isn't about getting the best cooling, or value, but building a powerful mini-ITX machine that looks unique



Open-air cases, such as Alex Banks' Loramentum, can look fantastic, but they leave components at the mercy of dust

Antony Leather is Custom PC's modding editor @antonyleather

How to Add vents to side panels

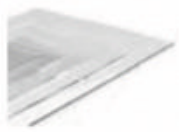
Antony Leather shows you how to modify your case's side panels to let your graphics card breathe

TOTAL PROJECT TIME / 4 HOURS

Plenty of PC cases sport vertical GPU mounts these days, and while many incorporate them as optional features, often with a need to buy a PCI-E riser cable, some mini-ITX cases only offer a vertical GPU mount. However, vertical GPU mounts often result in the graphics card's cooler being placed right next to a solid clear side panel, obstructing airflow and causing much higher temperatures.

Thankfully, there are ways to improve this situation. This month, we're looking at how to modify your side panel if the area in front of your graphics card's cooler is made from acrylic, or even create a new one if it's made from tempered glass.

TOOLS YOU'LL NEED



Sheet acrylic / ebay.co.uk

Marker pen / Most hardware stores

Jigsaw, Dremel or table saw / amazon.co.uk

Dust filters / overclockers.co.uk

114mm holesaw and holesaw mandrel / amazon.co.uk

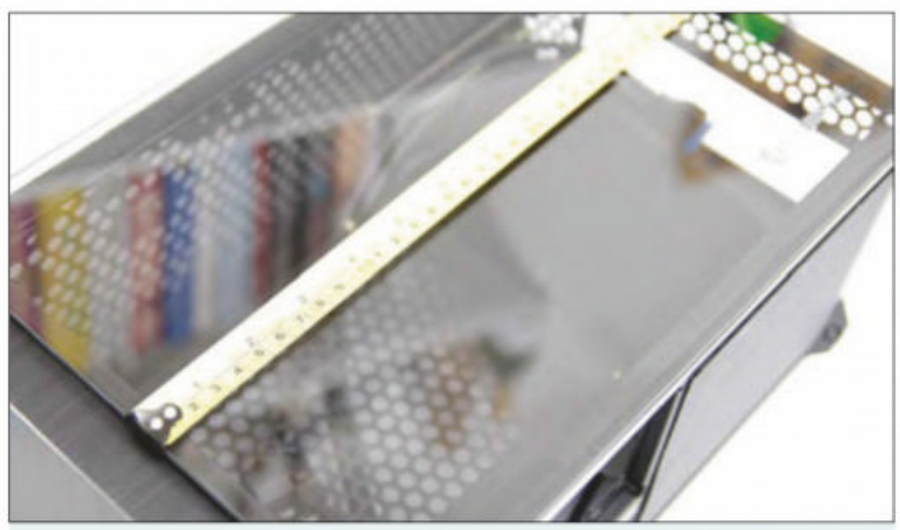
240, 400, 800 and 2,000-grit sandpaper / amazon.co.uk

Drill and drill bits / Most hardware stores

Mini blowtorch / Most hardware stores

1 / IDENTIFY PANEL MATERIAL

If your side panel is made from tempered glass, you'll need to create a new one, as it will shatter if it's cut or drilled. If it's made from clear acrylic, you can skip to step 19 to begin working on adding your new air vents.

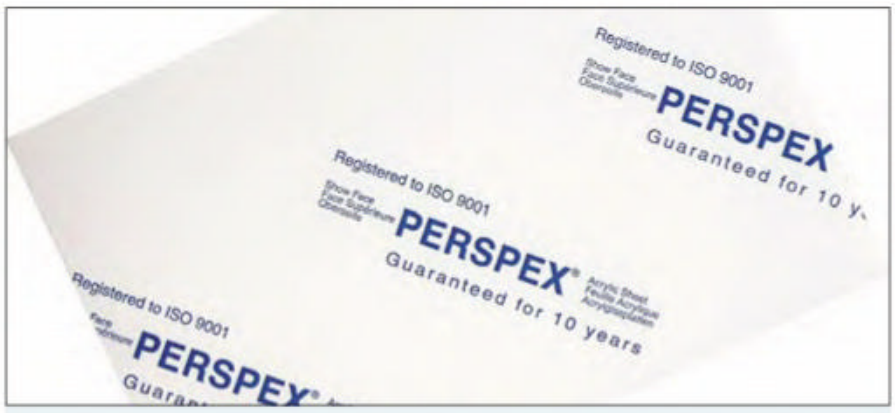


2 / MEASURE UP

To create a new panel using acrylic, start by measuring the size of the existing panel so you can order the correct size of acrylic sheet. If you're cutting the sheet yourself, aim for an area that's a little bigger than the original panel.

3 / CHECK THICKNESS

Acrylic sheet comes in a variety of thicknesses, but you need to confirm your existing panel's thickness, as its mounts and screws will be designed with this thickness in mind. This measurement is often written in the specifications or on the box.



4 / ORDER ACRYLIC SHEET

You can get acrylic sheet for just a few quid from eBay. If you don't have the tools to cut the sheet yourself, you can employ the services of a company such as **sheetplastics.co.uk**, which can also cut clear acrylic sheet to a specific size for a little more money, and even round the corners and add screw holes.

5 / IDENTIFY FITTINGS

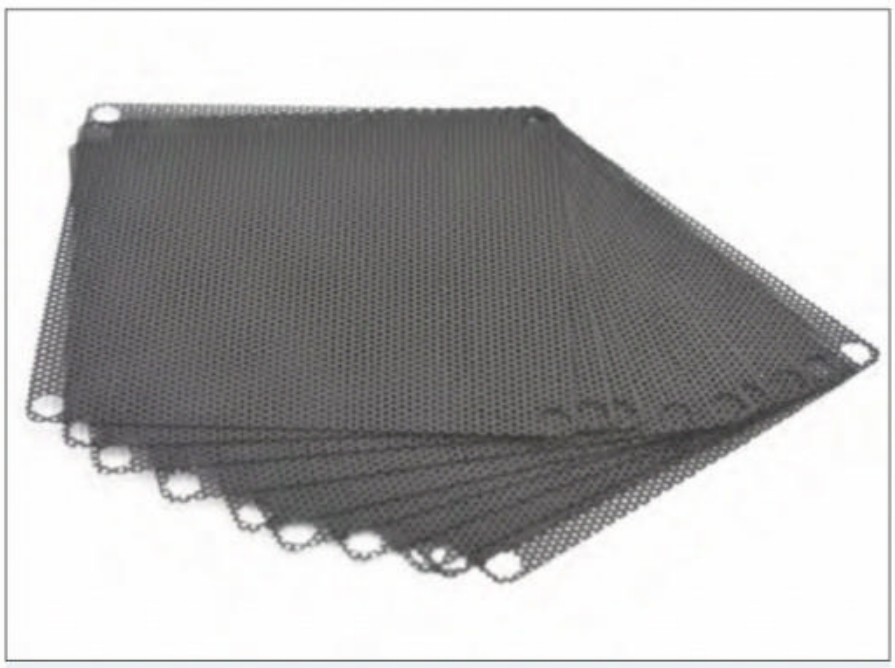
Side panels use all manner of fittings to be secured, but you need to check if they're transferrable to your new side panel. Screw-on panels should be simple enough, but you'll need to assess whether it's feasible to transfer more complicated fittings.

7 / CONSIDER MACHINING

Local machining services, or acrylic sheet suppliers such as **sheetplastics.co.uk**, may be able to cut your desired pattern into the sheet. Manually lining up dozens of holes is difficult, but machining services can also be costly.

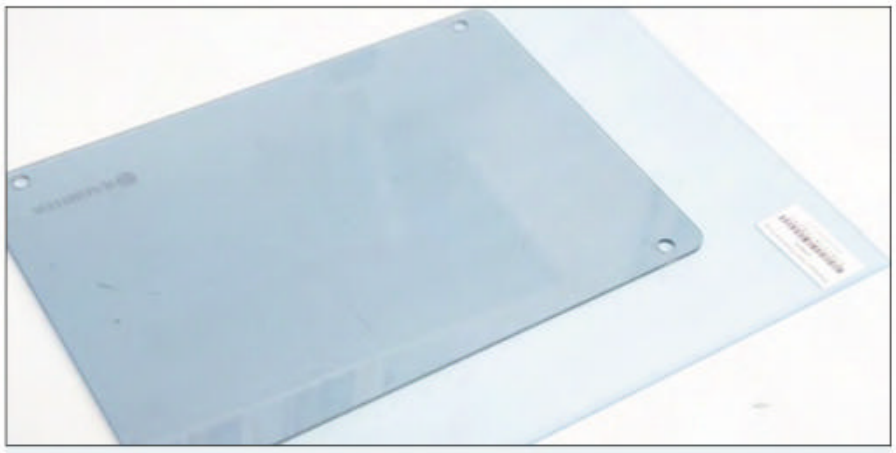
6 / CHOOSE VENT DESIGN

Drilling small vent holes is easy but doesn't offer as much benefit as a single large hole. However, the latter requires more tools and will also make a dust filter essential. You should aim to add vents to the area immediately above your graphics card's fan.



8 / CONSIDER DUST FILTERS

A dust filter will help to keep dust out of your graphics card cooler. Smaller holes will be a little more dust-resistant than large holes, but eventually smaller particles will get through them. Head to p110 to see how to install one.

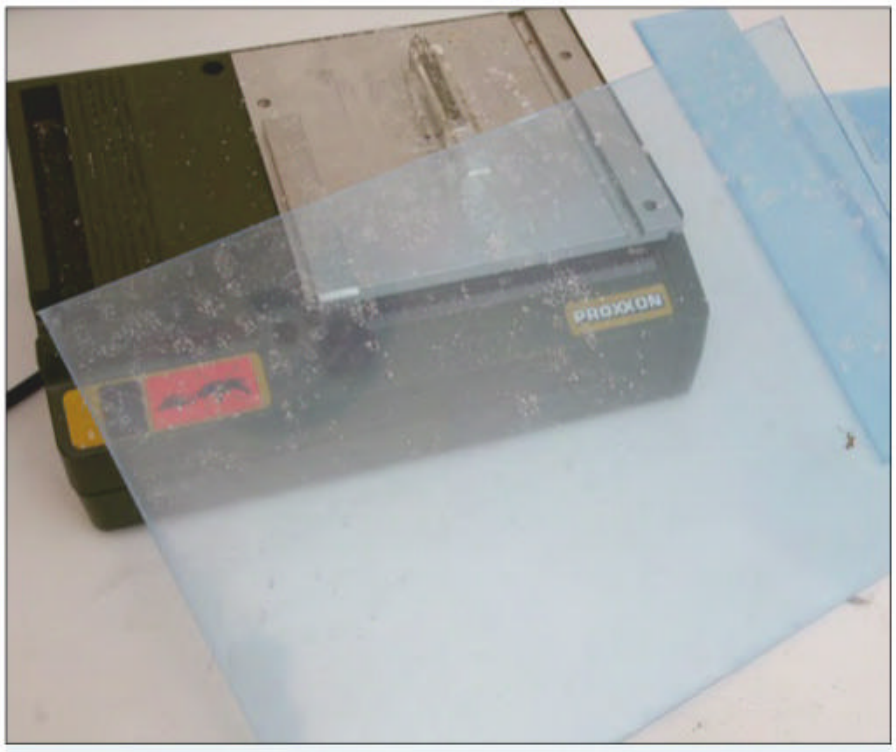


9 / USE OLD PANEL AS TEMPLATE

Lay the original panel on top of the new one. You can then use it as a template to mark up the new panel's vents and screw holes.

10 / MARK UP PANEL

Draw around the edge of the acrylic panel onto its protective film. Leave the film on the panel for as long as possible, as it will prevent scratches.



11 / CUT STRAIGHT LINES

We've used a mini table saw to cut the acrylic, but you can also use a jigsaw with a plastic-cutting blade or a hacksaw. If you have a large workbench with a clamp, you can also score the acrylic on both sides along the cutting points, then snap the sheet in two.

12 / ROUND OFF CORNERS

Acrylic is fairly soft, so rounding the corners can easily be achieved with 240-grit sandpaper, or a Dremel with a sanding wheel. Work from the corner point inwards, going towards the marked line you made earlier, then finish rounding off the sides.

13 / FINISH WITH FILES

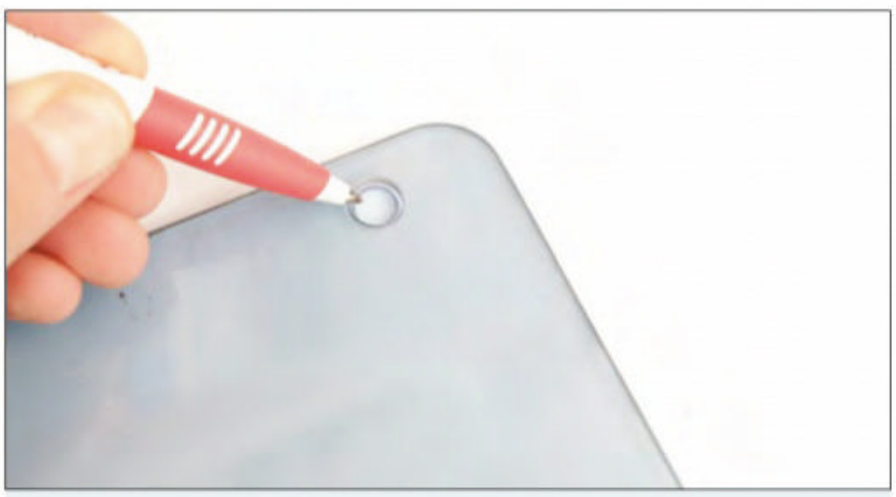
Alternatively, you can use files to achieve the same effect. Even large metal files will work on acrylic, but they eat into it quickly, so be careful not to overfile the corners. You'll likely need high-grit sandpaper to finish the rough edges.

14 / SAND EDGES

Use 400-grit sandpaper to smooth the cut edges and corners of the acrylic, before moving on to 1,000-grit paper. If you want a shiny, glass-like edge, you can then use 2,000-grit sandpaper, followed by a plastic polish such as Displex.

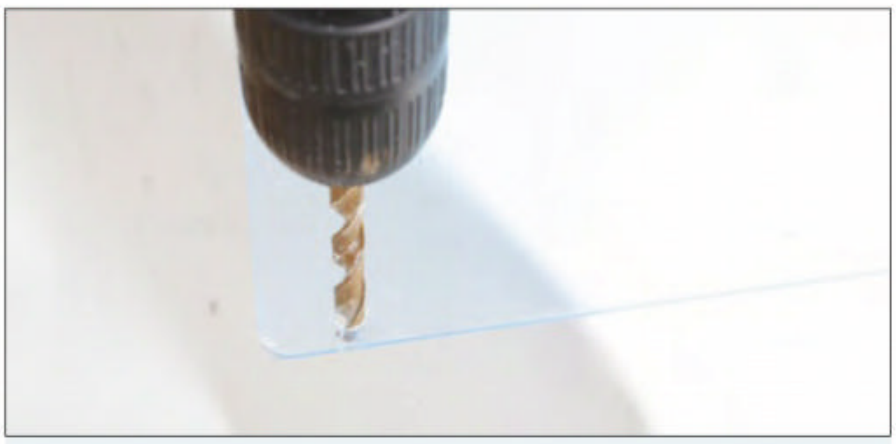
15 / FLAME-POLISH EDGES

Small blowtorches are perfect for flame-polishing the edges of acrylic to create a clear edge. Move the tip of the flame along the edges at 1in per second. The edge will melt and reform to create a seamless clear edge.



16 / MARK UP MOUNTING HOLES

Mark up the holes needed to fit your new panel to your case, again using the old panel as a template. Our side panel just uses thumbscrews mounted on rubber grommets, which is fairly simple, but other panel fittings may be more involved.



17 / DRILL MOUNTING HOLES

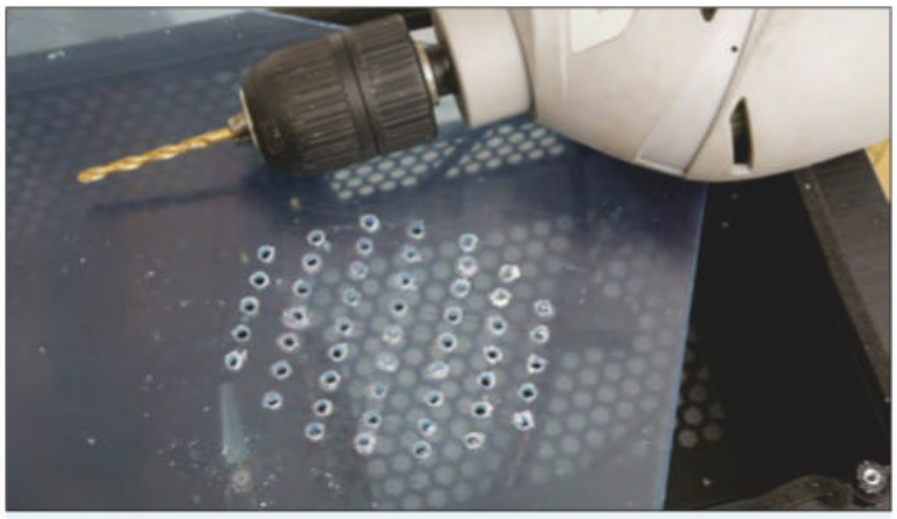
Never drill acrylic quickly or with force. Take your time and let the weight of the drill do the work, or you risk cracking the acrylic. If the hole you need is larger than 10mm, drill a smaller 5mm pilot hole first.

18 / TEST-FIT PANEL

With the holes drilled, use a file to smooth the edges if necessary, then test-fit the panel on the case. If one of the holes is slightly out, use a file to enlarge it. The tops of the thumbscrews will cover any small adjustments when they're in place.

19 / MARK UP VENT HOLES

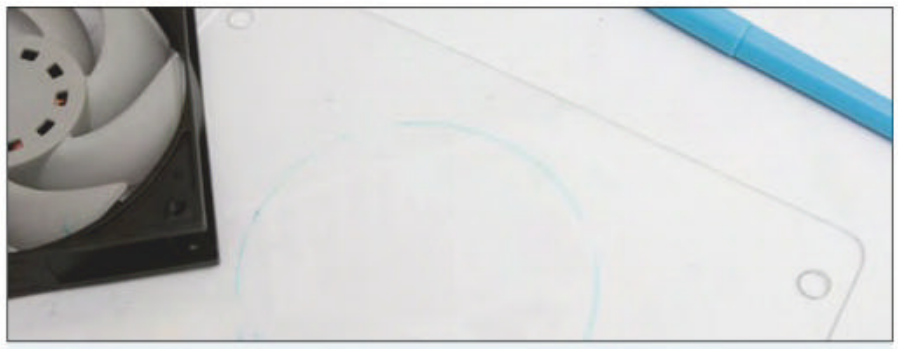
Install your graphics card in the case, then lay the panel on top. Draw your designed vent pattern onto the protective film. We've opted for a grid of holes sitting above the cooling fan.



20 / DRILL VENT HOLES

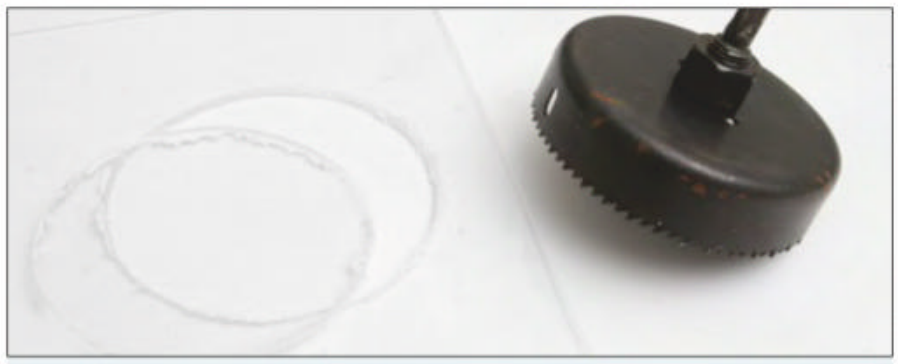
Use an appropriately sized drill bit to drill out your vent holes. We've opted for 5mm holes, which will prevent medium to large dust particles entering, while still allowing plenty of air into the case.

CUT A LARGE VENT HOLE



1 / ADD MARKINGS FOR LARGER HOLE

A single large hole offers the best GPU cooling, made with a holesaw or Dremel and cutting disc. You'll need a 114mm holesaw for a 120mm-sized dust filter, or you can mark a 114mm-wide circle and use it as a guide to cut with a Dremel.



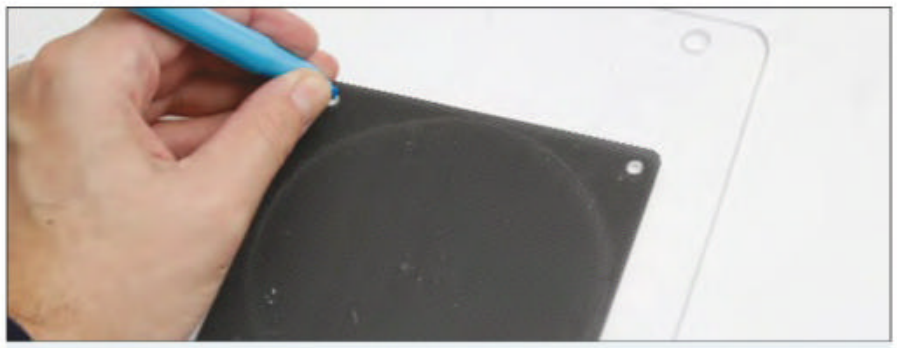
2 / DRILL VENT HOLE

We've used a holesaw and arbor, also known as a mandrel. The latter includes a small drill bit in the centre that acts as an anchor to hold the saw section in place. Allow the weight of the drill to do the cutting, so you don't risk the acrylic bending.

3 / SAND EDGES

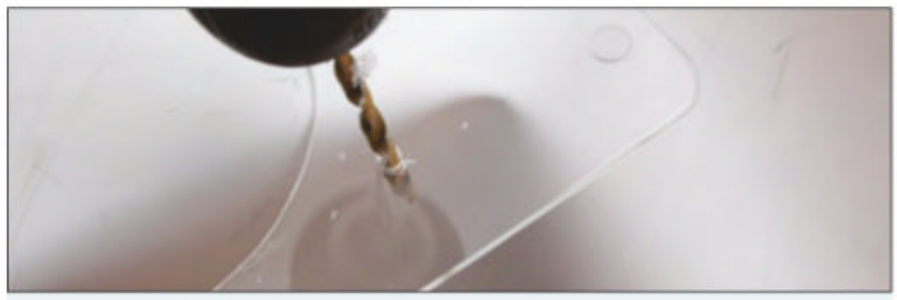
The edges of the hole will be quite rough, so remove any larger fragments by hand, then use 240-grit sandpaper to smooth the edge.

INSTALL DUST FILTER



1 / MARK UP FOR DUST FILTER

We recommend using a dust filter with the smaller drilled holes covered in this guide, but it's essential with the larger hole, or your graphics card will quickly clog with dust. Mark up the mounting holes over your vent hole using a 120mm filter as a template.



2 / DRILL FAN SCREW HOLES

Fan screws have a thread diameter of close to 5mm, so you need to use a 4.5mm drill bit to create a hole into which they can bite. Use a light pressure and slow drill speed to prevent the acrylic from cracking.

3 / INSTALL DUST FILTER

The screws are self-tapping and should bite into the acrylic to secure themselves. It doesn't matter which way around the you mount the filter, but it looks best if it's mounted on the outside of the panel.

4 / COMPARE PERFORMANCE

Finally, test your new panel's performance. Fixing the fan speed at 100 per cent, the smaller drilled holes lowered our GPU temperature by 6°C, while the larger hole knocked a massive 16°C off it. CPC

Readers' Drives

Forerunner

Tim Billins wanted to spruce up his NZXT Phantom case, making a custom side panel and PSU cover, while adding some Halo-inspired etching

/MEET THY MAKER

Name Tim Billins

Age 29

Occupation Service manager in the NHS

Location High Wycombe

Main uses for PC Gaming and media server

Likes Obviously gaming. Recently I've been playing Sekiro: Shadows Die Twice, as I'm a huge fan of the Dark Souls series, as well as Overwatch – I'm stuck in Platinum because I suck. I'm also a big movie lover – I'm always going to the cinema and adding to the Blu-ray collection.

Dislikes Battle royale games – they're awful and it's really disappointing to see that all multiplayer games seem to be going in this direction.

CPC: What was your main aim with this project, and what was your inspiration?
Tim: I wanted to try my hand at customising my PC, as I was upgrading the internal components. As this was my first attempt at case modding and creating my own custom parts, I wanted to see how many of my original ideas I could get into it with zero experience and fairly basic hand tools.

CPC: That case doesn't look like it originally came with a full-sized window side panel. How did you go about making and fitting your own custom panel?
Tim: The case itself is a white NZXT Phantom, and the original side panel had one 200mm fan and two 120mm fans in it. I've always liked the case, but the side panel in particular was looking very dated, so I bought some cast acrylic and cut it to size. That's what started me down the road of customising the interior, as the side panel looked really nice, but the insides didn't.

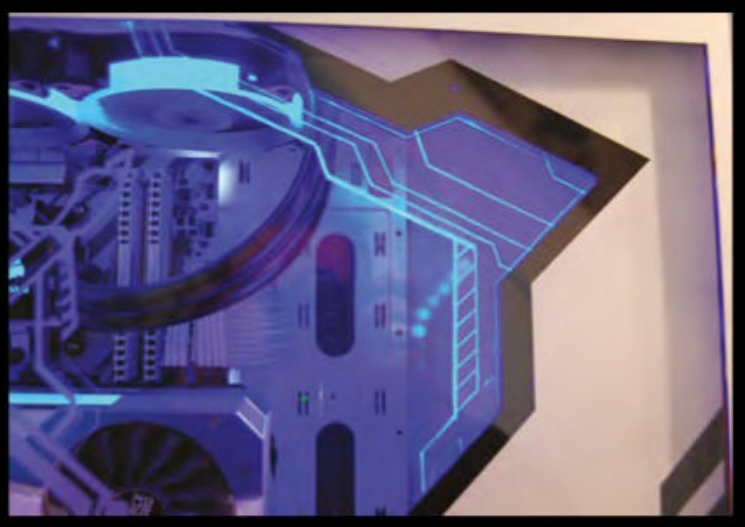
CPC: We love the way the drive bays are all hidden behind your custom side panel section. How did you make this piece?
Tim: It's made from two pieces of acrylic cut to shape with a Dremel. For the larger section, I sprayed black on the back, taped off my design and sprayed matt white on the front. For the illuminated insert, after cutting the shape, I used a Dremel to etch lines into the back of the acrylic, and fitted two blue LED strips along the edge using 3M tape.

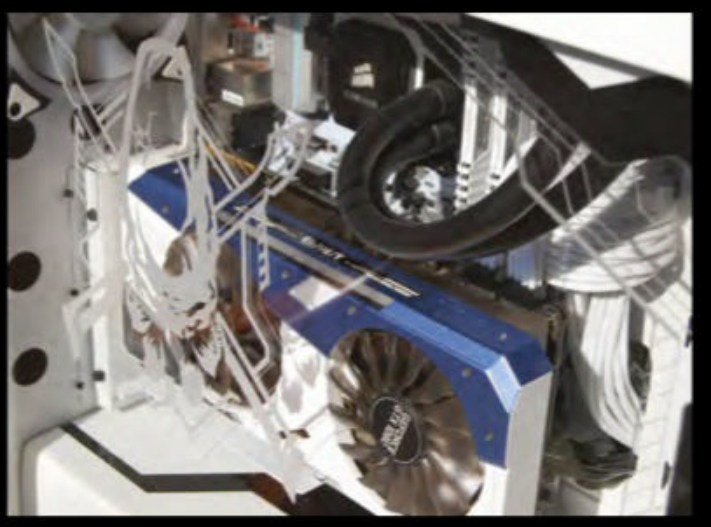
> I've always liked the case, but the side panel was looking very dated

CPC: Tell us about the etching on the side panel. What's the significance of the design and how did you go about doing it?
Tim: I've always been a huge fan of the Halo series, and after Gears of War came out on the PC, I took a bit of a gamble and guessed Halo would soon follow. I decided to go with the 'legendary' symbol from the game's highest difficulty setting. I'd never done any etching prior to this one, so I wanted a fairly simple design. Again, I used the Dremel. I etched the centre of the design on the back of the acrylic, and the edging on the front to give it a slight 3D effect. Luckily for me, Halo Infinite was announced shortly afterwards, and now we're getting the Master Chief collection too.

CPC: How did you get those etched lines in the window to react so well to the lighting? Also, how did you get those lines so sharp?
Tim: Patience is the quick answer. I drew out the design on paper first, and sat the panel on top of it while I was etching to give me a makeshift stencil. I also made two white LED strips, which I wired into a rocker switch that can be accessed from the front of the case. I built the switch into a small clear panel, with a second 'legendary' symbol etched into it where the old optical drive bays used to be located.

CPC: Is that a custom PSU cover we see? How did you make it?
Tim: It is indeed. It was by far





I etched the centre of the design on the back of the acrylic, and the edging on the front, to give it a slight 3D effect

the easiest part of this mod, and I'd recommend starting here if you're thinking of trying your hand at customisation. It's just a rectangular sheet of acrylic bent to a 90-degree angle using a heat gun, and then sprayed.

CPC: You've gone to a lot of trouble to get as much white in the interior as possible. Did you just buy white components, or is there some custom paintwork too?
Tim: It's a mixture. The acrylic pieces are obviously all painted, but I also fitted a vertical GPU bracket. This part was originally black so I sprayed it white. I also sprayed the radiator and CPU pump retention clip with the same matt white paint to make it match as closely as possible. I also fitted white cable extensions to finish it off.

CPC: How long did it take you to complete this build?
Tim: Roughly four days, split over two weekends.

CPC: Did you come across any difficulties? If so, how did you solve them?

Tim: The main difficulty was sorting out the LED strips with the separate switch. The strips from my previous build were too big to fit where I wanted them, so I bought a roll of cheap white LEDs and wired them up myself. Again, I hadn't done this before, so I did some research and double-checked it all before firing it up for the first time. I had horrible visions of all my new components bursting into flames from a mistake I made. Fortunately it turned out okay.

CPC: What did you learn from the process of building Forerunner?
Tim: I mainly learned that modding can be fun. It's inspired me to try my hands at other bits and pieces. I've recently made a Raspberry Pi-based arcade emulator, along with my own arcade stick.

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?
Tim: The bend in the PSU cover has a small warped section from where I heated it unevenly, but for the most part, I'm really happy with it. Thanks to lots of planning and a bit of luck, it all seemed to come out well the first time. CPC

SYSTEM SPECS

CPU AMD Ryzen 5 1600 overclocked to 3.9GHz

GPU Palit GameRock GTX 1080

Storage 256GB Samsung M.2 SSD for the OS, 500GB Crucial SSD and 2TB Western Digital Blue hard drive for bulk storage

Memory 16GB Corsair Vengeance DDR4 2133MHz

Motherboard MSI B350 Tomahawk Arctic

PSU 1,000W EVGA Platinum

Cooling Corsair H100i, with four 120mm push-pull fans on the radiator, one 120mm intake fan at the front, and one 120mm exhaust fan at the back

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (**@CustomPCMag**) or Facebook (**CPCMagazine**), or email low-res ones to **editor@custompcmag.org.uk**. Fame isn't the only prize; you'll also get your hands on some fabulous prizes:

Corsair K70 LUX RGB keyboard with your choice of switches

Corsair's K70 LUX RGB keyboard features Cherry MX key switches backed by a lightweight, durable aluminium frame and dynamic, multi-coloured lighting. The USB pass-through port is positioned for uninterrupted gameplay, and ready for your mouse or wireless headset adaptor. You can also use CUE for sophisticated macro programming and dramatic lighting effects.

Meanwhile, 100 per cent anti-ghosting with full key rollover helps to ensure accuracy, while the Cherry MX key switches give you a linear response and fast actuation. Corsair will provide a keyboard with your own choice of Cherry MX Brown or Red switches.

Alphacool water-cooling gear

Water-cooling hardware manufacturer Alphacool is offering a choice of £150 worth of gear to every featured Readers' Drives winner. For your prize, you can select from DIY water-cooling kits, the Eiswolf and Eisbaer all-in-one CPU and GPU liquid coolers, as well as a vast range of individual components, including waterblocks (pictured), fittings, reservoirs, pumps and radiators. Alphacool also makes coolant, tubing and fans, as well as modding and water cooling-related tools.

JAMES GORBOLD / HARDWARE ACCELERATED

A NEW HOPE

James Gorbold is delighted to see a new mood and confidence emerging at AMD

As one of the original founding team of **Custom PC**, I'm delighted with the look and feel of the latest issue; a direct result of the new owners investing in the future of the magazine, not only by hiring full-time staff, but also with a new and improved design. Staying on the topic of investing in the future, I'm really pleased to see a new, energetic and enthusiastic AMD emerging.

While everybody I know at AMD always showed full confidence in the Zen CPU architecture, this confidence always seemed fragile. After all, most of the AMD employees left at the time were the survivors of culls from the bad years, always looking over their shoulders for the proverbial axe to fall. Recently, however, I've noticed a positive new trend at AMD. I don't just mean the obvious data, such as strong sales, increased market share and a return to profit, but also a growing sense of purpose and confidence.

This first manifestation occurred last year in the run-up to Black Friday, when, for the first time in years, AMD started to seriously invest in marketing. It wasn't just the usual activities any major manufacturer requests for a product launch, but delving deep into its war chests and funding major initiatives in order to drive sales.

Sure, the budget wasn't up to the level that the big three – Intel, Microsoft and Nvidia – were spending, but it was a sea change compared with the previous decade, in which AMD rightfully recognised that spending money to promote unappealing CPUs wouldn't be enough to meaningfully stimulate sales. There's always an element of push and pull in the market, and pushing a product that has zero pull rarely pays off.

The second manifestation of the revitalised AMD was a new series of events for its channel partners; an idea that large manufacturers typically arrange on an annual basis. These events are important not just for sharing details such as road maps, but also enabling two-way information sharing on market trends and, my personal favourite, sitting down with engineers and having open discussions about how to improve future products.

AMD also appears to have unlocked the travel budget, as I've started to bump into senior AMD staff from the USA with increasing regularity. Back in the 1990s and early 2000s, I saw senior UK staff too, but the UK team shrunk, being largely focused on sales, PR and marketing. It's growing again now, and I'm seeing more senior staff from the UK and USA.

> Three topics really caught my attention, and if delivered as discussed, they could really change PCs in a major way

Take the recent Develop3D Live event, where the local UK-based Pro Graphics team was in force, as AMD had a large stand showing off its Radeon Pro GPUs. However, a couple of senior product engineers and division managers were also attending the show, specifically on a recce to check out the UK market and talk to local partners.

Unfortunately, I can't reveal any of the specifics of those conversations quite yet, but I can say that three topics really caught my attention, and if delivered as discussed, they could really end up changing PCs and workstations in a major way later this year. The proof, of course, will be in the eating, and until I've got the new CPUs in my lab and been able to test them, I'm going to maintain my innate cynical outlook. However, even if what I've been told ends up having been overhyped, it's still really encouraging to see AMD finally emerge from its shell. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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