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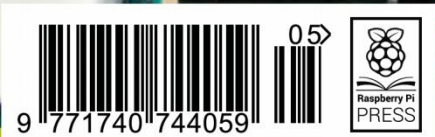
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Welcome

Custom PC Issue 200

/ FROM THE EDITOR

200 issues later

As you've no doubt already deduced from the glossy decorative parts of the front cover, this is the 200th issue of **Custom PC**, and while we don't want to entirely disappear up our own posteriors in our rose-tinted specs, we've marked the occasion with a special feature on p84. While I only worked on Issue 1 as a freelancer, and didn't join the full-time team until a few months later, I remember the build-up to the launch well, and it was an exciting time in PC journalism.

Looking back on Issue 1 shows just how far we've come since those early days, when the PC was finally starting to break free from its bland business machine moorings. We no longer have to tolerate the whiny racket of 80mm fans, liquid cooling is now readily available in sealed packages, and cases now have loads of dedicated holes and spaces for cable routing.

Meanwhile, mini-ITX machines now have performance that can rival full-sized desktop rigs, and we have access to amazing custom lighting setups. PC hardware enthusiasm is no longer considered a niche hobby either – Intel deliberately manufactures multiplier-unlocked processors for us, and hardware makers are falling over themselves to make more products that meet our needs.

Of course, technology continues to plough ahead, and the march towards more powerful PC hardware shows no sign of letting up. All the CPUs we covered in Issue 1 were 32-bit, single-core models, as there were no 64-bit desktop CPUs then, let alone even dual-core processors. Conversely, there's a massive Labs test of sub-£1,000 CPUs in this issue (see p40), that goes all the way from 6-core mid-range models to top-end chips with 16 cores. AMD has even just launched a 64-core desktop CPU (see p12).

In 2003, not many people would have predicted that our print magazine about desktop PCs would still be here in 2020, 200 issues later, but it's a huge privilege to be able to continue doing what we love. We hope you enjoy reading Issue 200 just as much as people loved reading Issue 1 at the time. **CPC**



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CUSTOM PC

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Contents

Welcome to Issue 200

Highlights

08 20 years of change

From windowed hard drives to pencil-modded GPUs, Richard Swinburne looks at how PCs have changed over the past two decades.

16 GeForce NOW

Nvidia's game-streaming service is now out of beta. We try out the official experience.

20 Corsair air cooler

Corsair is well known for its all-in-one liquid coolers, but it's now applied its R&D skills to a full-on CPU air cooler that's a bit different to the norm.

40 CPU clash

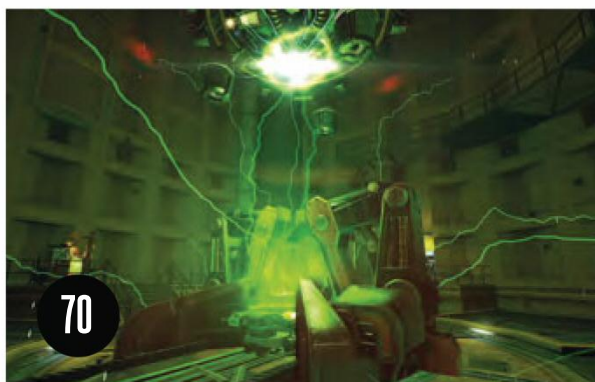
We dive straight into the carnage between Intel and AMD, testing 15 of the latest CPUs, from 6-core workhorses to 16-core monsters.

68 Mods vs games

What's the difference between a mod and a game? Rick Lane explores the impact of modding on PC gaming.

70 Black Mesa

We play through Crowbar Collective's remake of Half-Life, which makes the disappointing Planet Xen section much more interesting.



76 How memory works

Don't know your tRCD from your tCL? Edward Chester explains how your PC's memory works its magic.

84 200 issues of Custom PC

Custom PC veteran Ben Hardwidge looks back to 2003, when the very first issue of Custom PC was being put together.

90 Iron Maiden

Two minutes to Midnight! Nope, wrong iron maiden, but still a good one. Ali Abbas based this stunning PC build on the infamous medieval torture instrument.

96 Hobbytech

Gareth Halfacree explores the hark back to 1990s social networking, the tilde.club, and tries out the Orange Pi 4 B and Pi Hut ZeroDock.

102 3D-print your own PC case

Modding extraordinaire Antony Leather shows you how to design a PC case from scratch with CAD, and then 3D-print it.

107 Retro tech: Slot processors

Holograms, black boxes and mountains of cache. Ben Hardwidge recalls the weird moment when Intel's CPUs came in slot format.

Cover guide



Regulars

- 3 From the editor
- 8 Richard Swinburne
- 10 Tracy King
- 12 Incoming
- 14 Letters
- 38 Custom kit
- 60 How we test
- 62 Elite products
- 68 Inverse look
- 74 Reality check
- 94 Hobby tech
- 99 For the win
- 100 Customised PC
- 102 How to guides
- 107 Retro tech
- 110 Readers' drives
- 114 James Gorbald



Reviewed this month



Reviews

GAME STREAMING

16 Nvidia GeForce NOW

CASES

18 Kolink Big Chungus

COOLING

20 Corsair A500

NETWORKING

22 Synology DiskStation DS220jj

PERIPHERALS

24 Corsair M55 RGB Pro

25 Corsair MM500 Extended 3XL

3D PRINTING

28 Dremel Digilab 3D45

LAPTOPS

30 MSI GT76 Titan DT 9SG

PC SYSTEMS

32 Scan 3XS Vengeance RTX Ti

34 The Official Fnatic Gaming PC

Custom kit

- 38 Tablet Pillow Stand
- 38 T-Core Portable Charger
- 38 Panic Button
- 39 Privise Webcam Cover
- 39 KeySmart Pro

CPU Labs

- 41 Intel Core i3-9350KF
- 42 Intel Core i5-9400F
- 43 AMD Ryzen 5 3600
- 44 Intel Core i5-9600K
- 46 AMD Ryzen 5 3600X
- 47 AMD Ryzen 7 3700X
- 48 AMD Ryzen 7 3800X
- 50 Intel Core i7-9700K
- 51 AMD Ryzen 9 3900X
- 52 Intel Core i9-9900KF
- 53 Intel Core i9-10900X
- 54 Intel Core i9-9900KS
- 55 AMD Ryzen 9 3950X
- 56 Intel Core i9-10920X
- 57 Intel Core i9-10940X

Games

- 69 Darksiders Genesis
- 70 Black Mesa
- 72 Transport Fever 2
- 73 Journey to the Savage Planet
- 74 Doctor Who: The Edge of Time

Hobby Tech

- 96 Orange Pi 4 B
- 98 Pi Hut ZeroDock



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RICHARD SWINBURNE / VIEW FROM TAIWAN

20 YEARS OF CHANGE

From windowed hard drives to pencil-modded GPUs, Richard Swinburne looks at how PCs have changed over two decades

As it's 2020, and this is the 200th issue of **Custom PC**, I've been thinking back over my past two decades of building PCs, so crack out your rose-tinted glasses with me as I look back at how the industry has changed.

Firstly, back in 2002 the ATI Radeon 8500 wasn't necessarily faster than the equivalent GeForce 3, but it provided better image quality (an important factor when you had analogue monitor inputs) and helped to cement Radeon as a top-tier graphics brand. I bought the cheaper Radeon 8500 LE instead. This version could be 'pencil-modded' to bump up the voltage on the core and memory, enabling overclocking further than the full 8500 card. Sadly, a carefully placed bit of graphite can no longer upgrade you to a premium graphics card!

Soon afterwards, in 2003 Corsair's Pro-series memory added LEDs with a practical use, showing an active read-out of how intensively the memory subsystem was being accessed. The LEDs bounced through green, orange and red depending on the exact load, and the effect was both good-looking and informative. Unfortunately, Corsair was unable to update the technology beyond the days of DDR, and the Pro series was shelved when DDR2 took over.

In the early 2000s, Western Digital also injected some enthusiast spark into the previously banal storage market. Its Raptor was *the* drive on which to store your Windows XP installation, and the 10,000rpm spindle speed gave a trade-off between never-before experienced responsiveness at the expense of a persistent high-pitched whine.

If you could afford two or more of them in RAID 0, your HDTach results would be highly enviable. The 3rd-generation Raptor X even had a window on it, so you could see the heads

zipping around inside, and a few modders went even further by opening them up and inserting some LEDs.

Intel's Core architecture later arrived in 2006, and its superiority over the previous NetBurst architecture is well documented history. What's less well documented, in my opinion, is that the late LGA775 era was the last set of PC platforms that allowed truly affordable high-end performance.

You could overclock even the cheapest models via the front side bus to get decent performance. For example, a cheap 1.8GHz Core 2 Duo E6300 could be pushed to a decent 2.4GHz, while the later Core 2 Quad Q6600 was a firm enthusiast favourite. This was later killed off when Intel moved to the Quick Path Interconnect (QPI). For me, Sandy Bridge was bittersweet. It

was celebrated for its easy overclocking to a very high frequency, but it normalised a locked platform, and unlocked K-series chips that have commanded a price premium ever since.

In recent years, what really changed the game (ahem) for me has been outside the case – displays with variable refresh rates. Kudos to Nvidia for being disruptive to displays and launching G-Sync in 2014, which pushed AMD to react with FreeSync. Regardless of which side of the fence you sit, these monitors have been hugely successful, because few technologies improve the quality of experience to such a degree while still being affordable (true HDR is very much not affordable). The momentum behind FreeSync ultimately pushed Nvidia to open support for G-Sync to more VRR displays, boosting the options for GTX/RTX card owners. It's a rare win for consumer choice.

If you'd like to share some of your own favourite memories about PC building, let me know on Twitter! **GPC**

Sadly, a carefully placed bit of graphite can no longer upgrade you to a premium graphics card!

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan [@ricswi](#)

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TRACY KING / SCEPTICAL ANALYSIS

LOCALISATION DILEMMAS

Tracy King analyses the sometimes controversial choices facing game localisation teams, where what's acceptable differs between countries

Game localisation is an entire industry of its own. Knowing what American or British audiences want compared with Japanese or Korean gamers is a specialist skill. Not only do different markets have different cultures and politics, but also different laws. Australia, for example, is fairly censorious of violence and gore in games. But what happens when two very different cultures clash, and a Western publisher wants to change the content of, say, a Japanese game?

On one hand, the creative vision of the game designers and writers should be respected. On the other hand, game publishers have a responsibility to not promote content that isn't acceptable to the market in which it's sold. This leads to some difficulties and occasional controversies. The most recent is *Persona 5 Royal*, which has made headlines because some of the scenes are undoubtedly homophobic.

The game's publisher, Atlus, has changed character dialogue for the Western release after backlash that gay characters were portrayed negatively. The result is essentially two different games.

One of them is written for Japan, with the implication that it's okay to be a bit homophobic there, and the other for the USA and UK, where it's recognised that this sort of content can lead to real-world discrimination, intolerance and bullying.

But, of course, it isn't okay to be homophobic in Japan either. While any individual culture is complex, LGBT rights in Japan have historically been more progressive than, say, the UK. In surveys, younger Japanese citizens in particular are very tolerant. I can't see how they're any happier with a homophobic storyline than anyone else. Maybe the localisation to change that content sends the message that it's not okay anywhere. I asked Ed Fear,

director of forthcoming British/Japanese game *Murder by Numbers* (Mediatonic), for his thoughts.

'I'm not one of those people who believes this kind of localisation/culturalisation to be censorship but, at the same time, the original creators should at least be consulted where possible. I think the people who cry "censorship" would be surprised at how often the original creators would rather their work be enjoyed by the widest possible audience than adhere strictly to their original template. Often, it's not even about parts that were done particularly deliberately, so the changes aren't a problem.

It's a balancing act – keeping the flavour of the original while making it as accessible as possible. It's very easy to go too far and change something just because it might seem a little odd, but that will in turn make it more homogeneous, which I don't think is desirable.

As a minor example of the latter, there's a scene in *Murder by Numbers* where the main character is fired by her boss and she says, 'I thought we were friends!' We got a note back saying that this would feel very strange to a Japanese audience, because no one in Japan would say that. In the end, I fought back on it – not only because the game is set in America, where it isn't that odd, and secondly, because I think a degree of 'strangeness' is important when dealing with foreign material. If you smooth everything out, it may look like something home-grown – but then what was the point in it being made abroad?'

As more media (games, and indeed films, such as the recent Korean smash hit *Parasite*) from non-Western cultures break into the mainstream in the West, the more culture clashes and localisation controversies will arise. But that also means that each culture learns from the other, which can't be bad. **CPC**

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming [@tkingdot](#)



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Incoming

FRACTAL UNLEASHES DEFINE 7 RANGE

The next generation of Fractal Design's acclaimed Define range is now here, and it includes an 'XL' model. Among the new features are a redesigned interior that can take up to a 285mm E-ATX motherboard, as well as a new design of mounting bracket, which means you can use any unused fan mount to attach a hard drive or SSD, or even a pump for your water-cooling system.

The case also has what Fractal calls a 'dual-layout' design. You can either have a clean interior with loads of room for a water-cooling setup, or you can detach the right-hand side of the motherboard tray and set up a large storage bay section, with room for up to 14 hard drives. As with the Define R6, the new Define 7 also retains the top 5.25in drive bay mount, although it can be converted into an extra 140mm front fan mount if you're not going to use it.

Meanwhile, the XL model can hold up to a massive 480mm radiator in the front or top, and it also offers the potential for even more storage, with two 5.25in bays and up to 18 hard drive bays. The Fractal Design Define 7 cases are available now, starting at £140 inc VAT from scan.co.uk for the base model, and £190 inc VAT for the XL version.



PALIT PASSIVELY COOLS GEFORCE GTX 1650

Palit has launched a fanless GeForce GTX 1650 card called the KalmX. The card retains the full standard specification for a card in its class, with a 1485MHz base clock and 1665MHz boost clock, but it uses a massive heatsink and no dedicated fans.

The heatsink doing all the work has a dual-heatpipe design that covers the GPU and VRM. As with many GTX 1650 cards, there's no additional PCI-E power connector either – the card runs purely from the power coming from the PCI-E slot, and has only a 75W TDP.

The KalmX heatsink is rather larger than the standard for this type of card, so it takes an extra slot, and because it's sitting there essentially stewing in its own heat rather than blowing it anywhere, it's advisable to give it some room. Having a well-cooled case is also a must for this sort of cooling.

PHIL HARTUP

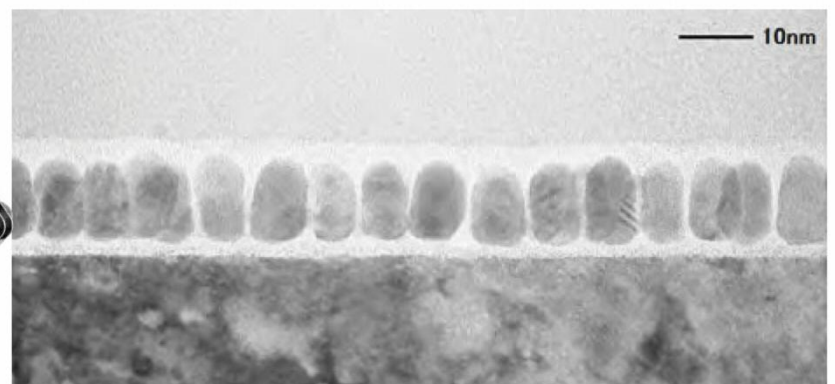


HAMR TIME

Showa Denko (SDK), the largest independent manufacturer of hard disk platters, claims that 70–80TB 3.5in drives could soon be a possibility, thanks to its advances with Heat Assisted Magnetic Recording (HAMR) technology. The new SDK platters use a platinum/iron magnetic alloy film, and SDK claims the platters are nearly ready for full-scale production.

The drives themselves are touted as plug and play replacements for existing 3.5in drives, so there should be little discernible difference from a consumer's point of view. HAMR involves temporarily heating the hard drive platter during the write process, making it more amenable to magnetic effects and allowing much smaller areas of the platter to be used for writing, increasing the data density.

PHIL HARTUP



Rumour control

PHIL HARTUP'S ROUNDUP OF THE LATEST UNCONFIRMED TECH GOSSIP. TAKE THESE STORIES WITH THE APPROPRIATE PINCH OF SALT

INTEL PLANNING MORE POWERFUL GPUS

Tech website **digitaltrends.com** claims to have been leaked a document, which suggests that Intel has plans for much more powerful GPUs than the relatively unthreatening DG1 device it showed off at CES earlier this year. The DG1 has a thermal design power (TDP) of 75W, which is at the very low end when it comes to GPUs. However, according to the document, Intel is planning GPUs with TDPs of 75W, 150W, 300W and 400/500W.

The document references 'Tile modules' on the GPUs. The smallest model in the line-up featuring a single Tile, the next one has two and then you finally get Tiles on the 400W/500W TDP model.

INTEL CORE i9-10900K BENCHMARKS SURFACE

A new set of benchmarks for the Intel Core i9-10900K has surfaced from Twitter user **@TUM_APISAK**, which posted screenshots of the CPU apparently running the 3DMark Firestrike and Time Spy tests. In the screenshots, the Core i9-10900K scored 28,462 on the Firestrike physics test and 13,142 on the Time Spy CPU test. Posted alongside these screenshots are the equivalent scores for the AMD Ryzen R9 3900X, showing a Firestrike test score of 27,137 and a Time Spy score of 12,624.

64-CORE AMD THREADRIPPER LANDS

The first desktop PC CPU with 64 cores has now launched. The AMD Threadripper 3990X is now the most powerful CPU in its class by an almost embarrassing distance, going well beyond what any home PC could reasonably need. The specification is mighty, with 64 cores (and 128 threads via SMT), a base clock of 2.9GHz and a maximum boost clock up to 4.3GHz.

There's also a huge 256MB total of L3 cache. The overclocking potential is also faintly terrifying, with the world record clock speed currently sitting at 5.57GHz, achieved by the Korean overclocking team Safedisk.

However, with a price of £3,690 inc VAT from **scan.co.uk**, the 3990X is out of the reach of most people's finances, and most desktop software isn't optimised for such a large number of cores yet either. As a statement of technological prowess, though, it's going to take some beating.

PHIL HARTUP



A be quiet!
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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 above is a distorted close-up of a piece of hardware featured 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? 200' in the Subject field, as well as your postal address.

Previous winners

The winner from our Issue 198 competition was David Nash, who correctly identified the ARCTIC Freezer 50 TRCPU cooler from p24. Congratulations David, we'll be in touch shortly to get your prize sorted out.

Terms & conditions
Competition closes on Friday 3 April. Please see p99 for our competition terms and conditions.

Letters

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

Broken Bluetooth

I've just finished building my new PC, and I've had difficulties with Bluetooth. It's mentioned in the motherboard manual as being part of the 'Wireless Communication Module' together with Wi-Fi, but nothing else is said about it. My old PC had no Bluetooth, so I bought an inexpensive USB 2 dongle, which worked fine.

However, I was surprised and disappointed to find that my £2,400 new PC provided a poor Bluetooth signal, making the keyboard occasionally erratic and the mouse unusable. I spent hours installing the latest drivers, as well as trying (and failing) to get the old dongle working, but nothing helped. Then a friend suggested that the PC's metal case might be interfering with the signal from the motherboard's Bluetooth signal. Sure enough, removing the case's sides fixed the problem, but I didn't want to leave the innards permanently exposed.

I then found that the motherboard comes with an antenna, which I had assumed was just for Wi-Fi, since the manual simply calls it a 'Wi-Fi antenna'. I'd ignored it because my PC uses Ethernet, but I wondered whether it might assist the Bluetooth signal as well, and indeed my mouse and keyboard then suddenly began to work.

I was undoubtedly slow in realising what was happening, but it might have helped if the Gigabyte User Manual had issued a warning.

JIM WESTHEAD

When's the next issue out?

CUSTOM PC

Issue 201

on sale on Thursday, 2 April



Ben: Indeed, there are all sorts of problems with using an internal wireless adaptor with no antenna – there's potential for interference all over the place plus, as you said, it's encased in a box too. In fairness to you, it doesn't sound like your manual was much help. Hopefully, printing your letter will help anybody else in the same boat.

CRTs vs LCDs

I used a high-quality 22in Mitsubishi Diamond Pro 2070SB CRT monitor up until around three years ago. I got it for £15 locally from eBay, but it cost £1,000 new – no one wanted old bulky CRTs then, but I had the desk real estate for it. It went up to 2,048 x 1,536 at 86Hz, and up to 160Hz at lower resolutions, although the refresh rate was simply to eliminate eye fatigue on CRTs. It had no need for G-Sync, FreeSync or any of that nonsense and there was no lag. You could also choose which resolution you wanted, depending on what you were doing.

I replaced it with a 27in LG 4K IPS FreeSync monitor, and a 27in Acer XF270HU 144Hz IPS FreeSync display. However, the CRT was better at motion, especially over the Acer, which didn't feel comfortable to view – I use it for my music PC now. Modern screens produce a crisper, sharper image (especially text), while a CRT produces a more natural image.

The higher-end CRTs were the pinnacle of very established technology, whereas LCDs are still relatively new – even now, the ultimate test of lip sync in broadcast is performed on tiny CRTs that cost £15,000. What became a faff with my CRT was the lack of VGA outputs on graphics cards. Even when using an adaptor, it was a pain getting Windows and games to recognise the resolutions and refresh rates my monitor could use. I had to use some very non-intuitive software to force the resolution. With the IPS displays, I know I can buy a graphics card and it will just work.

STUART HARRISON

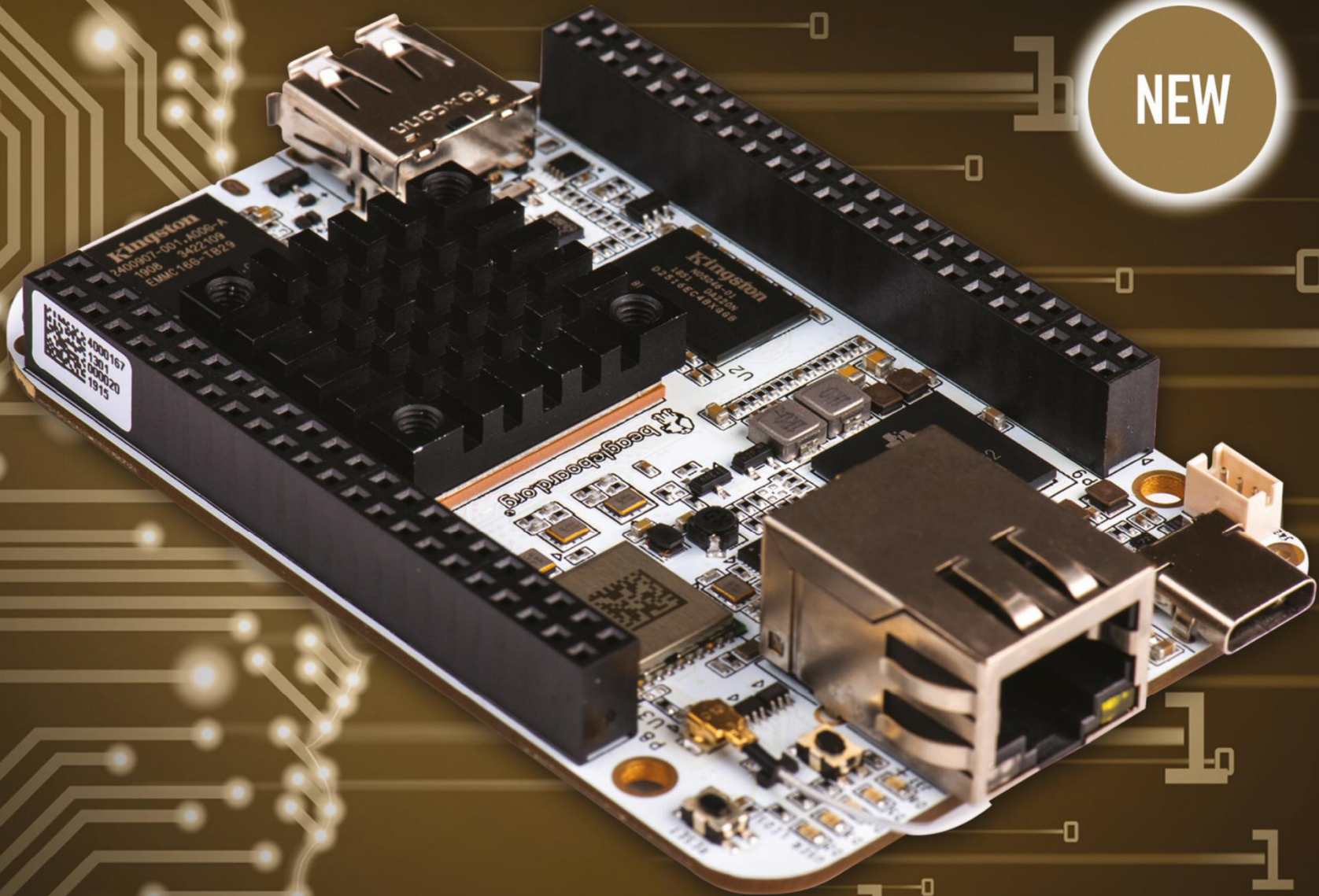
Ben: I remember that Mitsubishi monitor from the time, Stuart, and I was highly envious of anyone who had one. Having a high-quality aperture-grille tube with that size of diagonal, and at those resolutions, was amazing at the time. It took me quite a long time to finally give up my last CRT (a 19in Sony Trinitron) and take the LCD route, but I don't think I'd go back now. High-quality CRTs definitely have their benefits, but I think for most people they're outweighed by their drawbacks.



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Reviews

GAME STREAMING SERVICE

NVIDIA GEFORCE NOW /

FREE (basic account) / **£4.99** per month (Founders Pass)

SUPPLIER nvidia.com/geforce-now

Game streaming is an increasingly hot prospect, as various tech companies scramble to become the Netflix for games. It's a prize that's both elusive and tantalising. The lofty demands for both sharp image quality and low latency make game streaming much harder to realise than streaming video. Game-streaming services do exist, in the form of platforms such as Shadow and Google Stadia, but both are far from perfect.



Enter GeForce NOW, Nvidia's attempt to seize the game streaming crown. In Beta since 2015, it saw its public launch in January this year. Structurally, it's more closely aligned to Shadow than Google Stadia. Rather than being a platform with its own storefront, it offers an alternative way to play games you already own (or are free to play). When launched, it connects remotely to an Nvidia virtual machine. From here, you can launch games that you own in your various online accounts, such as Steam, the Epic Store, EA Origin and Uplay.

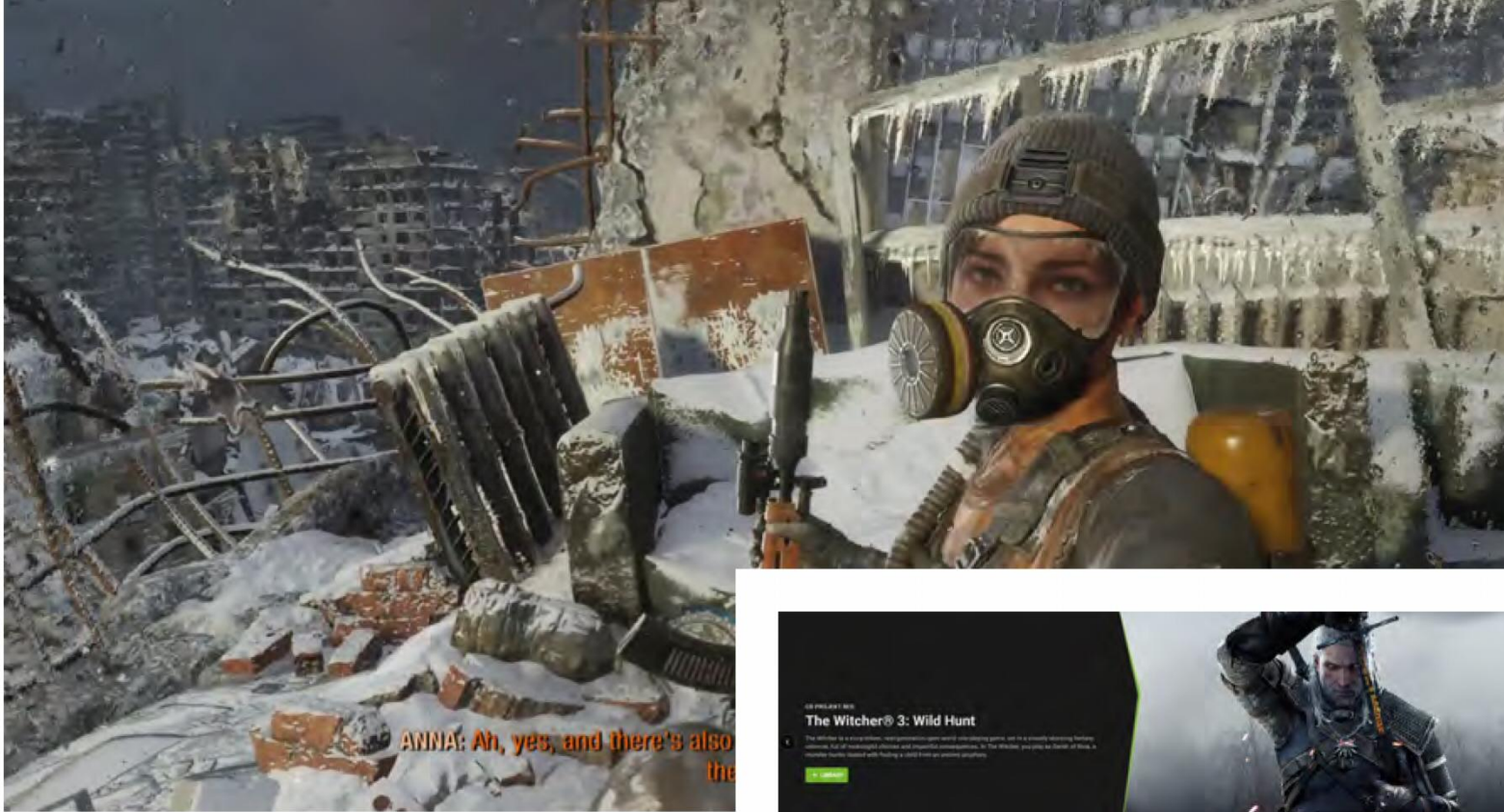
GeForce NOW has several advantages over Shadow. Firstly, around 400 games on NOW can be played instantly, with no requirement to install them on the virtual machine. A few of them include Metro Exodus, Borderlands 3, Apex Legends and Path of Exile. Other games, such as Hitman 2, are also available, but first need to be installed during your session; given you'll need to install them again when you leave the session, this isn't that practical.

GeForce NOW is also much more affordable than Shadow. It's free by default, although you'll be limited to play sessions of one hour, and have only standard access to the servers, so you may have to queue before being able to play. If you're willing to pay £4.99 a month for a Founders Pass, however, you get priority access to the servers for six hours at a time. The Founders Pass also lets you play games such as Metro Exodus with RTX enabled.

Launching games

Launching games is straightforward, albeit rather counter-intuitive. To access a game, you first have to search for it via the searchbox at the top of the menu, then add it to your GeForce NOW library. Some games are featured in a Netflix-style carousel menu on the front page, but there's no comprehensive list of which games are available on the NOW menu. In other words, you need to find out for yourself whether a game you want to play can be streamed.

Once you launch a game, assuming you don't have to queue, you're taken to your virtual machine's desktop. From here, you have to log in to the appropriate storefront account – Epic



The complex visuals of Metro Exodus translate less well over streaming, although that's partly down to those blurry ice textures

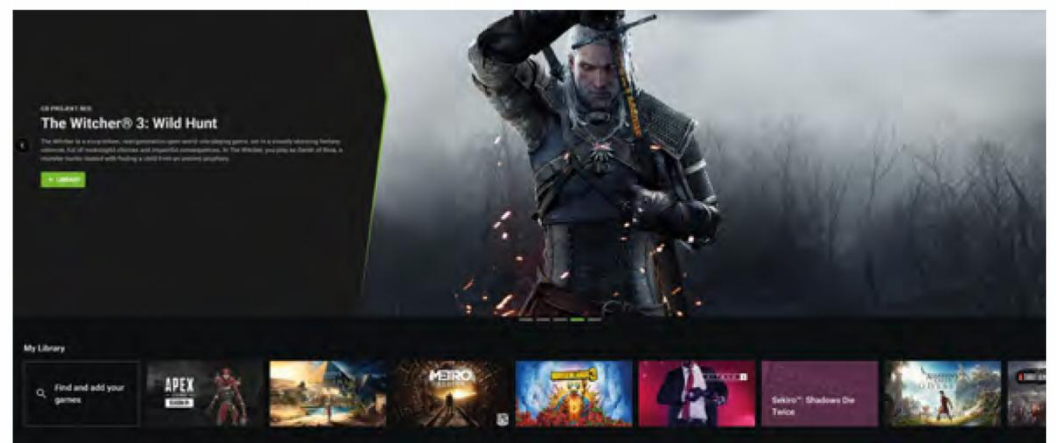
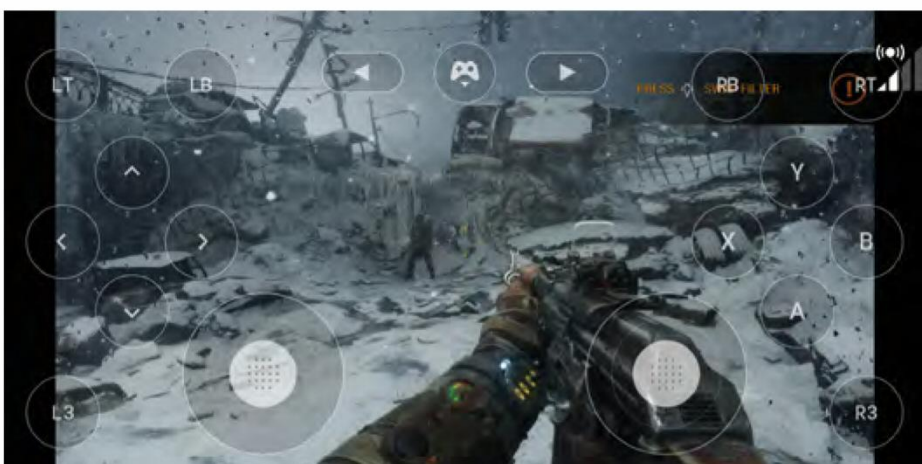
for Fortnite, Origin for Apex Legends and so on. When you quit GeForce Now, you will also have to log in to that storefront again when you relaunch. Also, you can't quit one game in NOW and then launch another – you need to leave the virtual machine entirely and launch the new game from the GeForce NOW menu. This process is much fiddlier than on Shadow, where the virtual PC is essentially yours to use like your home rig.

Gaming performance

Fiddly setup aside, the gaming performance is very impressive, provided you have a fast and stable connection. Nvidia recommends 15Mb/sec for 60fps gaming at 720p, and twice that for the same frame rate at 1080p. Ideally, you also want to be connected to your router via Ethernet. In reality, you're going to want a faster connection though. We tested it on a desktop PC with an Ethernet connection averaging download speeds of 76Mb/sec, and our experience was mostly excellent.

We tested several games, including Metro Exodus, Borderlands 3 and Apex Legends. We were able to get a smooth experience on all three titles, with perfectly playable image quality at 60fps in 1080p. That said, even in these ideal circumstances, there's a slight watery texture to the image for each game.

This was most notable on realistic-looking games such as Metro Exodus, but less of a problem with the cartoonish visuals of Borderlands and Apex. However, when taxing the network connection (by deliberately starting downloads and streaming on other devices), the image became much grainier, and a warning for a 'Spotty connection' repeatedly appeared on the right side of the screen.



RTX on a phone

Of course, using GeForce NOW on a high-end desktop PC is a bit like watching Netflix in a cinema. It isn't the right situation to appreciate its potential. With this in mind, we also downloaded the Android app, and tried playing Metro Exodus on a phone. In other words, the least suitable device for playing this type of game.

In this scenario, GeForce NOW's potential is much more apparent. Being able to play Metro Exodus with RTX enabled on a 7.5in phone screen feels like wizardry, even with the Honor 7's virtual gamepad clogging up the screen (ideally you want to buy a bespoke gamepad to play like this properly). The key issue here is the switch from a tethered connection to a wireless one. When sat close to the router with a clean line, the experience was remarkably smooth, although we'd encounter points where the image would pixelate and occasionally stutter.

The further we moved away from the router, however, the more GeForce NOW struggled to maintain the connection – you ideally need to be in the same room. Streaming YouTube on a second phone caused much more interference, rendering the game not quite unplayable, but certainly not pleasant to play, even close to the router.

Conclusion

From a technological perspective, GeForce NOW impresses, and the overall package makes it the best PC game-streaming

service currently available. Nonetheless, it's difficult to see its target market. Dedicated PC players simply won't stand for the varying image quality and queuing for servers, while the UK's current Internet infrastructure makes it too unreliable as a mobile gaming platform. If you have a strong Internet connection, a low-end laptop and want to play high-end PC games without forking out for all the kit, then GeForce NOW is an ideal way to do it. Otherwise, you're currently better off with a dedicated gaming PC or laptop.

RICK LANE

The menu lacks a comprehensive rundown of the games that are compatible with it

Streaming Metro Exodus on a phone is quite remarkable. Don't try to play it with the virtual gamepad though

E-ATX CASE

KOLINK BIG CHUNGUS / £201 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

BIG LEBOWSKI

- + Excellent cooling
- + Extensive RGB lighting
- + Decent water-cooling support

BIG BROTHER

- No dust protection
- Expensive
- Fans lack PWM control

If you're bored with the usual black boxes that usually grace our review pages, then Kolink's Big Chungus will look quite refreshing. It chucks a lot of the usual expectations of modern PC cases out the window, in favour of a mammoth, outlandish-looking design that stands out from the crowd. As always, there's a price for experimentation, though, and the Big Chungus tips the scales at over £200.

Assuming you'll be using it for more than an occasional LAN party showstopper, the Big Chungus will need some significant space too, standing nearly 70cm tall and 65cm deep, while its hefty 34cm width gives it a massive desk footprint. Despite its part-aluminium construction, it's not light either, weighing in at 16kg thanks mainly to copious amounts of tempered glass.

A lot of this volume is taken up by a large red-anodised stand, which leans the case backwards. The interior is

rotated as a result, with the tiny rear section barely able to accommodate a single rear 120mm fan and rear I/O panel. On the plus side, the front has been elongated and has a slightly ridiculous quartet of 120mm fans – the most we've ever encountered in a stock case configuration before.

All four fans sport digital RGB lighting, and can be controlled using an included remote control and lighting hub, or via a 3-pin RGB connector that can hook up to your motherboard. There are also two LED strips on the underside. The controller allows you to set various lighting effect modes, with a choice of 11 static colours, but motherboard software usually offers significantly more options. It's a good addition, but the fan hub lacks one important feature – the ability to control the fans' speeds. Out of the box, they're reasonably quiet, although still louder than you'd expect from most motherboard-controlled case fans at low loads.



We spotted a slightly strange issue with the fans too, where the noise from air entering the fans seemed to fluctuate. On closer inspection, the fan speed was changing every ten seconds or so, which caused a noticeable change in the pitch. We even switched PSUs to make sure it was indeed the case fans, but the issue was still there. Otherwise, the fans look fantastic, especially when viewed through the tempered glass front panel.

There's glass all around the case, in fact, with each of the four sections held in place by thumbscrews. Once removed, you gain easy access to the fan mounts for mounting radiators. As you'd expect from such a large case, there's space for E-ATX motherboards, and up to 360mm radiators in the front and base areas. However, due to the case's internal design, it sadly can't support 420mm radiators in place of those four 120mm fans.

The red base attaches using screws, but thankfully the rest of the case comes pre-assembled. The base is an essential part of the case too, as it houses the front panel connectors, including a power button, USB 2 and USB 3 ports, a Type-C port and audio jacks.

There's plenty of hardware clearance, though, with 175mm of room for CPU cooler height, 335mm graphics card clearance and a 220mm-long PSU mount.

If you plan on kitting out the case with 2.5in or 3.5in drives, you'll also find a pair of 2.5in/3.5in mounts, plus an additional two dedicated 2.5in mounts. There's enough gadgets and mod cons to build and house a monstrous system, but there's plenty of omissions too.

SPEC

Dimensions (mm)

336 x 651 x 668 (W x D x H)

Material

Steel, aluminium, glass

Available colours

Black

Weight

16kg

Front panel

Power, 1x USB 3, 1x USB 2, 1x USB 3.1 Type-C, stereo, mic

Drive bays

2 x 2.5/3.5in, 2 x 2.5in

Form factor(s)

E-ATX, ATX, Micro-ATX

Cooling

4 x 120mm front fan mounts (4 x fans included), 1 x 120mm rear fan mount (fan included), 3 x 120mm base fan mounts (fans not included), 2 x 120mm roof fan mounts, (fans not included)

CPU cooler clearance

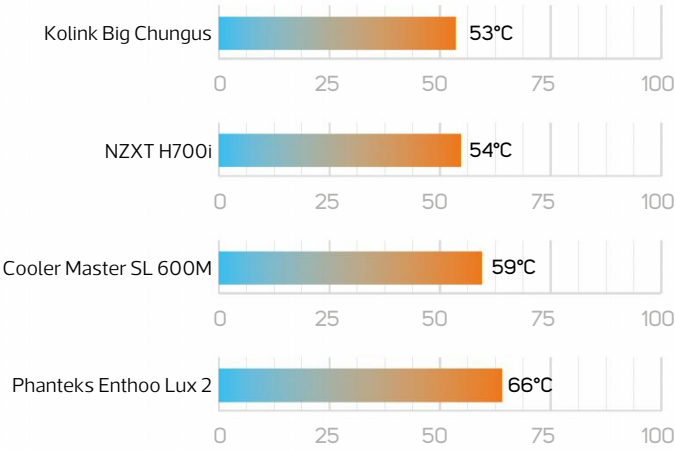
175mm

Maximum graphics card length

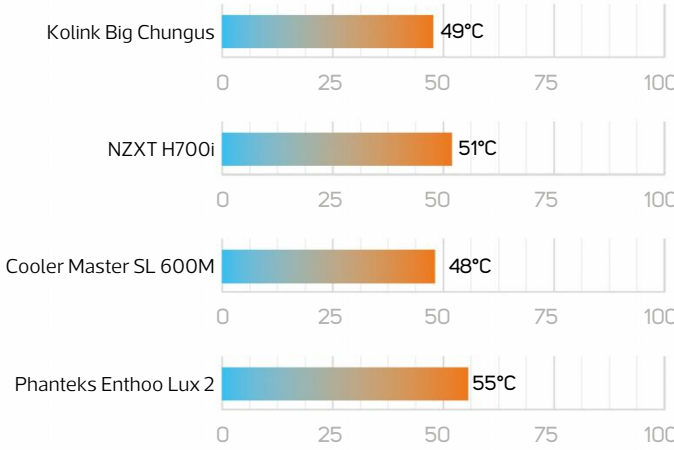
335mm

TEMPERATURE RESULTS

CPU DELTA T



GPU DELTA T



There are no dust filters, for example, so dust ingress will require the regular use of a vacuum cleaner or air duster. Also, while there’s plenty of space for cable tidying, there are no cable covers to hide the spaghetti – a feature that we’ve seen in numerous premium cases recently. Given that both panels are made from see-through glass, you’ll need to be a cable-tidying ninja to avoid creating an unsightly view.

Performance

The fans churn through a decent amount of air, and with four of them acting as intakes, dust will only likely get in through the front panel, with air pressure leaning strongly on the positive side. With so many open vents and a battery of reasonably powerful 120mm fans, it wasn’t surprising to see the Big Chungus hit some impressive cooling numbers either. The CPU delta T of 53°C was better than the mighty NZXT H700i on its full speed setting, and 6°C cooler than the Cooler Master SL600M.

Meanwhile, the GPU delta T of 49°C was also excellent and only second to the Cooler Master SL600M’s exceptional result of 48°C, bettering the NZXT H700i by a couple of degrees too. It’s a shame, then, that the included fans couldn’t be a bit more powerful under high loads, then rein themselves in at other times, as the cooling results could be even more impressive.

Conclusion

In spite of its unique design, there are fewer compromises with the Big Chungus than we’ve seen with other uniquely designed showcases. You get USB Type-C support, plenty of airflow, lots of places to stow and route cables, and the case comes mostly pre-assembled. We’ve seen kits comprising hundreds of parts and poor instructions with similar cases in the past, so the Big Chungus is comparatively simple in this respect. The RGB lighting is extensive and good-looking, and there’s ample water-cooling support as well.

There are several negative points, though, which are that like most cases of this ilk, there are big open areas devoid



of dust filters. It’s also massive, and your build will need an extensive cable-tidying session. Your PC will be really heavy as well, even with just an air-cooled interior.

The biggest issue, though, from an everyday point of view, is that the fan speed can’t be controlled. This is compounded by the fact that the fan speeds seem to fluctuate regularly, which could be annoying if you’re sitting next to it. As an occasional showcase to wow people at LAN parties, the Big Chungus is fantastic, but we’d swap out the fans if we were going to use it on a daily basis.

ANTONY LEATHER

VERDICT

An outlandish-looking and easy-to-build showcase, but it has some niggles as an everyday home for your PC.

COOLING
28/30

FEATURES
13/20

DESIGN
25/30

VALUE
13/20

OVERALL SCORE

79%

CPU AIR COOLER

CORSAIR A500 / £83 inc VAT

SUPPLIER scan.co.uk



HEATSINK

- + Excellent cooling
- + Exceptional memory clearance
- + Great build quality

HEATSTROKE

- Noisy at full speed
- More expensive than liquid coolers
- Too tall for some cases

It may seem strange that Corsair hasn't had extensive repertoire of air coolers to match its liquid cooler range, but the company did actually try a while ago, with mixed results. This month, though, it's most definitely back in the air-cooling game with the A500. It's a monstrous £80 dual-fan cooler, which aims to offer premium air cooling and a hefty amount of overclocking headroom.

This massive cooler's measurements stretch to 169mm long and 171mm tall, with the latter measurement meaning you'll need to pay careful attention to your case's CPU cooler height limit, as many cases won't be able to accommodate it. It also weighs close to 1.5kg, so you won't want to drop it on your foot either.

The box is enormous too, but inside there's no mass of cables for hooking the A500 up to your PC via USB, nor RGB lighting controllers. In a rare moment for Corsair, the cooler is devoid of lighting or any fancy software control. You get a few accessories in the box, though, such as a splitter cable, which allows you to power both 120mm ML-series fans from a single 4-pin header, as well as a long-reach screwdriver and tube of thermal paste. You won't need to use the latter right away, as the contact plate comes with a layer of pre-applied thermal paste, but it's good to know you won't need to buy

more paste if you upgrade your CPU.

The rest of the kit includes the cooler's simple mounting mechanism. Plates are fixed to the cooler, and they sport sprung thumbscrews, which attach to threaded pins on additional plates that you secure to your CPU socket. These thumbscrews sit underneath the enormous central

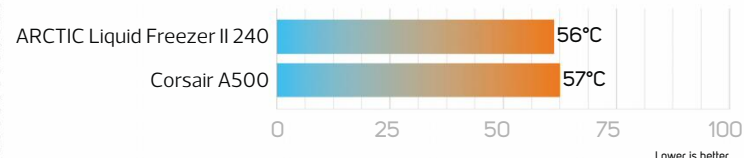
heatsink, but there's has a cut-out section inside the heatsink that allows the included screwdriver to find its way down to secure them. The cooler itself actually looks very attractive too, with a high-quality removable metal cap on top of it, which hides the heatsink cut-out and heatpipe tops, but also includes a vent in the top to allow the rear fan to breathe.

The installation process is quick, whether you're using the A500 on Intel's LGA1151 or LGA2066 sockets or an AMD Socket AM4 platform. Neither Socket TR4 or TRX40 are supported, but all LGA115x sockets are covered, as are all AMD sockets back to FM1 and AM3, as well as both of Intel's LGA2011 sockets.

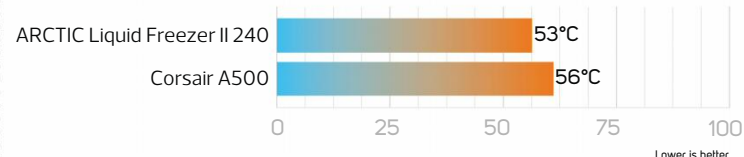
Corsair claims that the A500 has a 250W thermal design power (TDP) cooling capacity, which would be enough power to handle any CPU up to Intel's 18-core models. A lot of this cooling power comes down to the fans, which

TEMPERATURE RESULTS

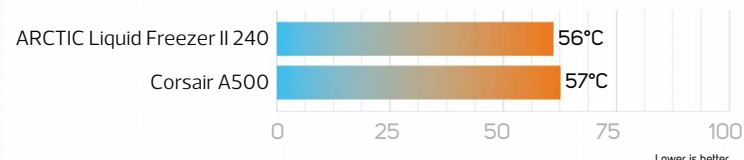
AMD SOCKET AM4 DELTA T



INTEL LGA1151 DELTA T



INTEL LGA1151 DELTA T



SPEC

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

Heatsink size with fans (mm) 144 x 169 x 171 (W x D x H)

Fans 2 x 120mm

Stated noise 36dBA

can reach an ear-splitting speed of 2,400rpm at full speed. Interestingly, though, Corsair has also opted for both 6mm and 8mm heatpipes with the A500; the company claims this adds the ability to deal effectively with CPUs with both low and high TDP. There are four heatpipes in total, and they all make direct contact with the CPU.

With such a huge width, you'd be right in thinking the A500 would foul your motherboard's memory slots. However, in a very clever bit of design, Corsair has added a slide-and-lock fan mount mechanism, where the fans are mounted in sliders that can be raised or lowered to cater for different memory heights. It's an essential move, too, because Corsair's Dominator and Vengeance memory modules are some of the tallest on the market. At some heights, however, the fans can end up with some of their blades sitting above the heatsink, reducing airflow through it.

The fans can be detached from the brackets too, should you need to replace them or use other models. Each bracket can also be removed separately, and it's much easier to deal with these brackets for mounting your fans than the usual metal fan clips.

At full speed, the fans certainly aren't quiet, hitting rather unpleasant noise levels and with a raspy tone. However, if you use PWM control, they can fall to 400rpm, and at this speed, they were inaudible outside our test system. We tested the A500 in our revised test systems this month, with ARCTIC's Liquid Freezer II 240 being the other cooler we've included in the new results. It's a worthy comparison, because like any large, expensive air cooler, it needs to perform similarly to all-in-one liquid coolers to be worth it. The A500 has a tough task too, seeing as it costs around £20 more than ARCTIC's latest 240mm all-in-one liquid cooler.



Performance

In our AMD Socket AM4 system, where the A500 was dealing with a Ryzen 7 1700 overclocked to 3.9GHz using an MSI X470 Gaming Pro Carbon AC motherboard, both coolers performed the same, with just 1°C between them. Moving to our overclocked Core i5-9600K system with a manual all-core overclock to 4.8GHz using an Asus ROG Strix Z370-E Gaming, we saw more of a difference. Here, we saw a 53°C delta T for the liquid cooler and 56°C for the Corsair A500, admittedly with higher noise levels on the Corsair cooler.

Finally, there was our LGA2066 system, where our 4.2GHz 10-core Core i9-7900X sat at 56°C with the liquid cooler, and 57°C with the A500. The A500 is certainly louder than the liquid cooler at full speed, but it's equally quiet at lower speeds.

Conclusion

The Corsair A500 is a welcome addition to the large selection of air cooler offerings already available, especially with its innovative approach to avoiding tall memory modules. It's very well made, it looks good and it's easy to install. Best of all, it also kept up with a 240mm liquid cooler in all our tests, all but matching it in two of them.

It does cost more than the ARCTIC liquid cooler, but it also comes with two expensive fans and is a product that ultimately feels more premium. The only fly in the ointment was that, at full speed, the fans were far noisier than those on the Freezer II 240, while the cooler didn't offer better cooling. However, if you're not too fussed by fan noise, or if your CPU will rarely be hitting the limiter, we can definitely recommend the A500.

ANTONY LEATHER

VERDICT

The A500 is powerful, attractive and innovative, but it's also a little pricey.

LGA115x

COOLING

35/40

FEATURES

15/20

DESIGN

18/20

VALUE

17/20

FITTING

Easy

OVERALL SCORE

85%

AM4

COOLING

36/40

FEATURES

15/20

DESIGN

18/20

VALUE

18/20

FITTING

Easy

OVERALL SCORE

87%

LGA2066

COOLING

36/40

FEATURES

15/20

DESIGN

18/20

VALUE

18/20

FITTING

Easy

OVERALL SCORE

87%



NAS BOX

SYNOLOGY DISKSTATION DS220J / £149 inc VAT

SUPPLIER span.com

Despite a relentless upgrade schedule a few years ago, we haven't seen a new entry-level two-bay NAS from Synology for a while. The DS218j was the last NAS from the company we reviewed, which was released in early 2018. Currently retailing for around £150 inc VAT, it's still a fantastic NAS and noticeably quicker than the DS216j in a couple of tests, although they shared a very similar specification. The DS218j also has a fair bit in common with its new successor, the DS220j, which we're reviewing here.

The new model still has 512MB of RAM, which is perhaps a bit on the small side for heavy users wishing to simultaneously dish out 4K video while dealing with multiple surveillance streams. This is the reason why most four-bay models have at least 1GB of RAM. On the plus side, the DS220j also sees Synology moving from DDR3 to DDR4, so there is at least an upgrade in memory bandwidth.

However, that's not the most significant change to its popular J-series two-bay NAS. The big one is that CPU now has four cores, stepping up from the Marvell Armada 385 88F6820 32-bit dual-core CPU in the DS218j to an ARM-based Realtek RTD1296 quad-core 1.4GHz CPU, which is also 64-bit.

The DS220j is otherwise practically identical to the DS218j. There are two rear USB 3 ports, which can accommodate USB storage, or even USB speakers, making use of the on-board Audio Station app. These ports can also be used to connect Wi-Fi dongles for storing the NAS in places without a wired Internet connection.

The front of the NAS is devoid of ports too, with just a power button and indicator lights. Inside, you'll find the usual quiet 92mm fan and anti-vibration hard disk mounts, with a couple of screws securing the slide-off case, with only slight clicks audible from the hard disks inside.

The NAS also supports Synology's latest DSM 6.2 operating system, which is blissfully easy to use and set up from the start. We can confirm that, despite using a new CPU, the DS220j does already support Plex Media Server, which can often be a sticking point with new NAS



models. There's Logitech and iTunes media server support too, and the operating system can provide Synology's own photo, video, audio and surveillance servers too.

Meanwhile, the ability to create a Dropbox-like personal cloud is one of Synology's trump cards, and you can also synchronise your actual cloud storage services such as Dropbox and Google Drive with your NAS, potentially saving storage space on your PC. Sadly, there's no on-board video transcoding support – you'll need to step up to more expensive models for that feature.

In terms of performance, we saw a peak read speed in the quad HD video stream playback test of 114MB/sec, which was nearly 25MB/sec quicker than the with the DS218j. The file directory read speed of 19MB/sec was a touch slower than the 23MB/sec we saw with the old model, but the write speed of 24MB/sec was more than double the 11.6MB/sec we saw with the DS218j.

Conclusion

With a quad-core 64-bit CPU at the helm, the DS220j feels snappier, especially when flitting through its operating system while carrying out other tasks, which bodes well if you're a moderate to heavy NAS user. The comparatively low amount of memory may limit some very demanding users, but the DS220j is still an entry-level NAS. Indeed, for under £150, the DS220j offers excellent value for a two-bay NAS with this feature set, and it has a wealth of tools at its disposal to back up and dish out your data.

ANTONY LEATHER

VERDICT

A big CPU upgrade makes Synology's already solid design feel snappier, making for a great-value two-bay NAS.



PERFORMANCE
32/35

FEATURES
32/35

VALUE
24/30

OVERALL SCORE

88%

OLYMPUS

OM-D
E-M1 Mark III



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Take your professional photography to new heights and never get weighed down.

The new Olympus E-M1 Mark III is amazingly compact and lightweight and fits perfectly in your hand.

It packs pro-level technology and superior image stabilization – so you're free to go further with your handheld shooting style.

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Find out more at your local Olympus retailer or go to olympus.co.uk #breakfreewitholympus

GAMING MOUSE

CORSAIR M55 RGB PRO / £25 inc VAT

SUPPLIER scan.co.uk

AMBIDEXTROUS

- + Ambidextrous design and button layout
- + Good gaming performance
- + Excellent value

AMBIVALENT

- Slightly odd shape
- Heavy left and right buttons
- Arguably too big for most users

For all the exciting developments we've seen in gaming mice over the years, one section of the market is all too often neglected: left-handed mice. Almost no popular gaming mice are produced in left-handed variations, leaving the only option to go with an ambidextrous mouse. Even then, while many mice have symmetrical shapes, all too often they lack thumb buttons on both sides, so they lack a truly ambidextrous design. The Corsair M55 RGB Pro, then, isn't just a symmetrically shaped mouse but a proper ambidextrous one. What's more, with a price of just £25, it's a bargain too.

Another feather in the cap of the M55 RGB Pro is that it's relatively light, weighing in at just 86g. That's hardly record-breaking, but Corsair in particular has tended to produce quite heavy mice, so it's a break from the company's track record.

Corsair has opted for an interesting shape for the M55 RGB Pro as well. The likes of the Logitech G Pro Wireless or Glorious PC Gaming model O, which are also lightweight and ambidextrous, have a relatively uniform width (with a slight dip in the middle section) and rise to a peak height in the middle of the mouse's length. This seems to be the most universal shape that can suit the widest variety of grip styles and hand sizes. Here, though, the M55 RGB Pro has a flared back section that's wider and taller than the rest of the mouse.

We didn't really find this shape to be an ideal match for any grip style. For fingertip grip, the bulky back end gets in the way, reducing the range of motion of the mouse under your palm. For palm grip, the high back end worked well, but the extra width at the back meant it didn't nestle all that

comfortably in the crook of the palm.

Claw grip seemed to be the most suitable style for the shape, although the slippery hard plastic on the top surface doesn't provide quite enough grip. Thankfully, you get fully rubberised and textured sides, which provide good purchase for your thumb and little/ring fingers.

You get two pairs of thumb buttons on either side of the mouse, along with left and right buttons, plus a scroll wheel with a single DPI button behind it. The two sets of

side buttons worked surprisingly well, providing comfortable and precise access for your thumb, and the spare buttons on the opposite side didn't get in the way. Even if you do accidentally hit them, you can disable them, or program all the buttons, using Corsair's iCUE software.

The feel of the buttons is mostly decent too, with no mushiness and a precise response. However, the left and right click are a little heavy, and the scroll wheel rocks from side to side a little too much.

You can also adjust this mouse's single lighting zone via software. A backlit Corsair logo on the rear can be set to any colour and a variety of colour-changing patterns, such as Rainbow and Colour Pulse. An indicator light above the DPI button also changes colour depending on the DPI setting you've chosen. You get four DPI modes and colours by default, but you can assign more. We couldn't fault the tracking of the 12,000DPI optical sensor either – this is an excellent gaming mouse for the money.

Conclusion

The Corsair M55 RGB Pro is a decent ambidextrous gaming mouse for a surprisingly good price. Its shape isn't the most universal, but the performance is excellent and the price is right.

EDWARD CHESTER

VERDICT

A competent and versatile gaming mouse for a great price.

SPEC

Weight 86g

Dimensions (mm) 124 x 68 x 40 (L x W x H)

Sensor 12,400dpi

Buttons 7 (left, right, scroll wheel, 2 x back/forward, top DPI)

Cable 1.8m braided

Extras 1x RGB lighting zone

MOUSE MAT

CORSAIR MM500 EXTENDED 3XL / £40 inc VAT

SUPPLIER corsair.com

MOUSE MAT

- + Transforms entire desk into a mouse mat
- + Well made
- + Good value compared with smaller mats
- + Ideal for multi-monitor setups

MOUSE TRAP

- Extra depth of limited benefit
- Not the cheapest 3XL mouse mat
- Too large for most people

It's not often we deem a mouse mat worthy of a full-page review, but the Corsair MM500 piqued our interest. With a colossal area of 1220 x 610mm, this '3XL' mat is large enough to cover an entire desk with plush, squishy loveliness. Having such an enormous mouse mat may sound like a gimmick, but having recently been won over by extra-wide mouse mats that run all the way under your keyboard, we were intrigued to know if there was any merit to stretching a mat even further.

In theory, there are several benefits to these extended mats. The first is that you have the ability to truly go to town on your mouse placement and movements, flinging your mouse all over your desk without the risk of it falling off your mat. Moreover, by having the mat fully extend under your keyboard, you avoid the annoying situation that can occur on small desks, where you usually don't have room for a large mouse mat without it encroaching on where you want your keyboard to sit.

The extra space can also be useful for multi-monitor setups. You may have one monitor mainly for work and another alongside it mainly for gaming, and with this mat, you slide the keyboard and mouse over to one or the other depending on what you're doing. A larger mat means you don't have to move

the mouse mat as well.

Then there's the fact that having one large surface on which you rest both your keyboard and mouse ensures that both the keyboard and mouse mat are more stable. The keyboard helps to hold down the mat,

while the latter provides a non-slip surface for your keyboard. You also get a soft, warm-to-the-touch surface for your arms and hands wherever they rest on your desk. It's like having a built-in, squishy wrist rest for your whole desk.

But is it worth moving from just an extra-wide mat, such as the Corsair MM300, to a 3XL mouse mat? We found that the back 20-30cm of the MM500 added very little in terms of practical benefits. Very occasionally, we would push the mouse beyond the depth limits of a mat such as the MM300, but otherwise, the MM500 just looked good and gave a pleasant soft landing for our speakers and monitor.

However, the extra length did come in handy for our multi-monitor setup. With the likes of the MM300, we still had to shift along the mat a little to get right in front of the gaming display. However, with the MM500, we didn't have to move it at all. As such, we were largely won over. Aside from the hassle of completely clearing your desk to lay down the mat for the first time, it's a surprisingly worthwhile upgrade, even if it does make coffee spills considerably more of a pain to clean up.

The MM500 is just as well made as any other decent soft mouse mat. You get a braided edge, which can be a pain on smaller mouse mats, but the braiding is well out of the way of your mouse here. In terms of value, the sheer amount of material you get for the price also means it's considerably cheaper per unit area than smaller mats. You can get slightly cheaper 3XL mats, but there's not much in it.

Conclusion

Believe the hype, it's worth getting an extra-large mouse mat. If you haven't tried one before, we recommend giving one a try. Whether you really need to go all the way to 3XL is another matter though. There's little practical benefit for most users over regular extended versions, but it's great if you have a multi-monitor setup. This Corsair mat is good quality and affordable too.

EDWARD CHESTER

VERDICT

How big is too big for mouse mats? Apparently we haven't reached the limits yet.

OVERALL SCORE

76%



SPEC

Construction Foam rubber with cloth top and stitched edges

Dimensions (mm) 1220 x 610 x 3 (W x D x H)



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3D PRINTER

DREMEL DIGILAB 3D45 / £1,100 inc VAT

SUPPLIER box.co.uk



Despite various Chinese companies offering some compelling and very affordable 3D printers at the moment, there's still clearly a market for an easy-to-use, yet feature-packed, 3D printer. Dremel has capitalised on this situation with its range of Digilab 3D printers and the current flagship, the 3D45, offers the biggest print area of its current range. However, tipping the scales at over £1,000 inc VAT, does it justify the price when many of its cheaper rivals offer bigger print areas?

Its huge footprint of 65cm x 41cm is partly due to the enclosed print chamber, which helps to seal and filter printing fumes, while also providing a warmer environment to print objects, which can improve print quality. The filament is also stored internally and, to reduce its bulk, Dremel has taken the decision to require the use of its own proprietary filament spools.

Thankfully, these spools aren't digitally locked, and the filament diameter of 1.75mm is widely available, meaning that many users appear to have easily modified their Dremel printers to be able to use externally mounted third-party spools. That's just as well, because at roughly £15 for 500g, Dremel's filament costs roughly twice the price of most third-party filament. Dremel's spools do come with RFID tags, though, which allows the printer to identify the filament being used.

You get full control over the removable heated print bed and nozzle temperatures too, with the heated bed helping to slow post-print cooling, which can lead to warping. The 3D45 is able to operate using a wired or Wi-Fi network connection, as well as with USB flash drives using its USB port, with a touch-screen making it easy to set up these devices, as well as configure and calibrate the printer. Small screws underneath the bed allow you to level it with aid from a sensor in the print head, and the level is checked before each print too.

There's also a live video feed of the print bed, which is extremely useful if you plan on housing it in a different room from your PC, with the option to print over the Internet using Dremel's software. Meanwhile, the software is simple to use and handles most common object files, with the option to add supports to overhanging sections.

The print volume isn't massive, at just 255 x 155 x 170mm, which is smaller than some of the cheaper competition. However, its 50-micron nozzle printing is competitive, plus it supports Nylon, PETG, ABS and PLA filament. Prints were also reliable and detailed, with only one mishap in dozens of prints coming from loose melted filament. This happened at the start of the print and required the print to be paused and resumed once we'd removed the offending object. The nozzle and bed heating could be faster, though, as they can take five to ten minutes to warm, especially from cold.

Conclusion

The main issues with the Dremel Digilab 3D45 are a smaller than average print bed, long heating times and the inability to use cheaper, third-party filament spools out of the box. However, as an easy introduction to large-volume 3D printing, it's superb, with its informative touch-screen and manual offering a gentler learning curve than the competition. The video feed is extremely useful too, so if you want to get into the world of 3D printing with minimal fuss, we thoroughly recommend the Digilab 3D45.

ANTONY LEATHER

VERDICT

A brilliantly complete and accessible 3D printer, although its print volume is on the small side.

3D FILAMENT

- + Live print bed video feed
- + Wi-Fi, LAN and USB print support
- + Good quality, reliable printing

DOT MATRIX

- Nozzle and bed heating can take a while
- Small print volume
- Expensive

SPEC

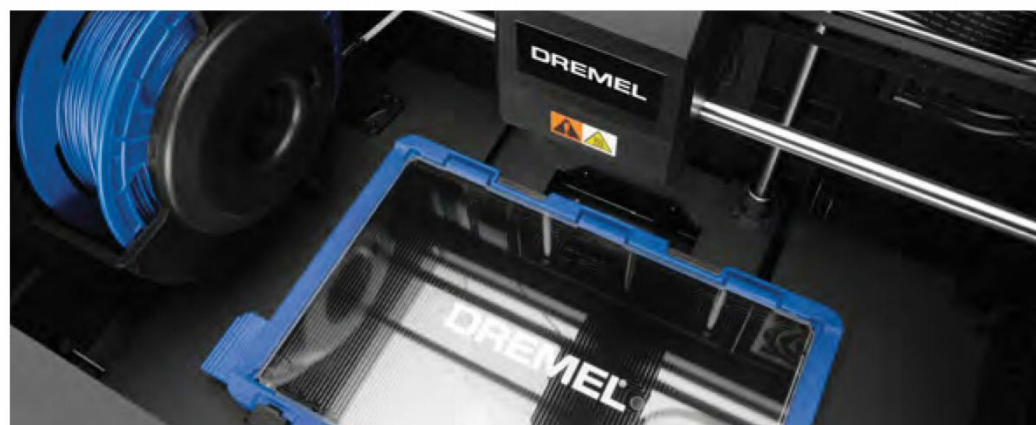
Dimensions (mm)
645 x 406 x 404 (W x D x H)

Weight
21.5kg

Connections
USB, Wi-Fi, LAN

Materials
ABS, Nylon PLA, PETG
(1.75mm Dremel spool)

Layer thickness
50 microns (0.05mm)



DESIGN
32/35

FEATURES
32/35

VALUE
24/30

OVERALL SCORE

88%

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GAMING LAPTOP

MSI GT76 TITAN DT 9SG / £4,000 inc VAT

SUPPLIER overclockers.co.uk

The MSI GT76 Titan lives up to its name, weighing 4kg, costing four grand and being packed with desktop-level hardware. There's the desktop RTX 2080 GPU, for starters, which has 2,944 stream processors and 8GB of memory, and the boost frequency is overclocked from 1710MHz to 1755MHz.

Likewise, the Core i9-9900K is one of Intel's beefiest consumer chips, with eight Hyper-Threaded cores alongside a peak boost clock of 5GHz. The rest of the specification is monstrous too. There's 64GB of DDR4 memory, and a 1TB RAID 0 array made from two Samsung PM981 NVMe SSDs. You get a 1TB hard drive as well, and networking is handled by dual-band 802.11ax Wi-Fi and Killer 2.5Gbps Ethernet.

This isn't the first laptop we've seen with components at this level. The £3,799 Alienware Area 51m included the RTX 2080 with an overclock, alongside a Core i9-9900K CPU, 32GB of memory and a similar RAID SSD storage setup. The MSI weighs 4kg and comes with two power bricks that add 1.8kg, and it's 397mm wide and 42mm thick. The Alienware is slimmer and lighter at 31mm and 3.87kg, and its power bricks weigh 1.5kg.

The MSI beats the Alienware for connections though. It has four full-sized USB 3.2 Gen 2 ports and two

Type-C connectors, one of which supports Thunderbolt 3. There are HDMI and mini-DisplayPort connectors as well, alongside two audio jacks and a micro-SD slot. What's more, there's full internal access with two free memory slots.

The machine looks like a typical gaming laptop, with loads of RGB LEDs and huge cooling vents. Build quality is generally good too, but it's not flawless. The screen is robust, but there's some movement in the wrist rest and the plastic underside is flimsy.

You get a SteelSeries keyboard with per-key RGB backlighting, and quiet, consistent switches with a reasonable amount of travel. It's fine for typing and general gaming. However, these buttons still suffer from familiar flaws, lacking the precision and snap of mechanical units. This keyboard also has slim numberpad keys and no macro buttons. The Alienware is better. While its keyboard remains spongy, it has more travel and five macro buttons. Meanwhile, the MSI's touchpad is fine, but the buttons are underwhelming, with inconsistent clicking.

Performance

We weren't able to test the GT76 using Nvidia FrameView due to a software error, but FRAPS still demonstrated this machine's abilities. We used MSI's default Comfort mode, which runs the GPU at around 1860MHz. Here, all of the frame rates at 4K stayed above 30fps, which is playable, but you're going to need to drop the resolution below the native 4K settings for smooth gameplay at top settings. However, that's more than enough power for a VR headset.

The Alienware's 1080p screen is a better match for the hardware. Testing at 1080p saw the MSI deliver minimum frame rates of 91fps and 76fps in Shadow of the Tomb Raider and Total War: Warhammer II, but the Alienware was slightly ahead.

SPEC

CPU

3.6GHz Intel Core i9-9900K

Memory

64GB 2666MHz DDR4

Graphics

Nvidia GeForce RTX 2080 8GB

Screen

17.3in 3,840 x 2,160 IPS 60Hz

Storage

2 x 512GB Samsung PM981M.2 SSDs in RAID 0, 1TB hard disk

Networking

Dual-band 802.11ax Wi-Fi, Killer 2.5Gbps Ethernet

Weight

4kg

Ports

4 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 2 Type-C/Thunderbolt 3, 1 x USB 3.2 Gen 2 Type-C, 1 x HDMI, 1 x mini-DisplayPort, 1 x micro SD, 2 x audio

Dimensions (mm)

397 x 330 x 42 (W x D x H)

Extras

Bluetooth 5

Operating system

Microsoft Windows 10 Home 64-bit

Warranty

Two years parts and labour return to base

Similarly, in Comfort mode, which runs the CPU at 4GHz, the MSI's application performance is also behind the Alienware. The MSI was a little quicker in our image editing test but slower in most other benchmarks. The MSI's overall score of 200,848 lagged behind the Alienware's 223,481.

The MSI has CPU and GPU overclocking through its Sport and Turbo modes, but neither are transformative. In Sport mode, the GPU ramps up to 1875MHz to deliver a couple of extra frames per second in games, and the CPU ran between 4.4GHz and 4.7GHz to improve the application benchmark result to 217,751.

The Turbo mode proved too much for this machine's thermal hardware though. The GPU ran at 1900MHz but gaming results either remained static or declined. The CPU also then throttled to around 3.6GHz, which reduced the application benchmark result to 188,415. Technically, the i9-9900K can reach 5GHz, but it never attained that frequency here.

The MSI's CPU and GPU delta Ts of 74°C and 68°C are high as well – the former result is within a couple of degrees of the Alienware, but the latter is far hotter. The base stayed cool, but the area above the keyboard was extremely hot. Noise levels were modest, and match the Alienware in the Comfort and



Sport modes, but the MSI was far too loud in Turbo mode. Meanwhile, the storage array is good, with read and write speeds of 3,188MB/sec and 2,884MB/sec respectively, but we're not sure why MSI has used a RAID array – a single 1TB NVMe drive would be just as fast and would come with less risk.

The screen is great though. The 4K IPS panel has a middling refresh rate of 60Hz and no active sync, but its brightness level of 407cd/m² is massive, its black level of 0.35cd/m² is reasonable and its contrast measurement of 1,163:1 is decent enough to deliver great vibrancy and depth. The colour temperature of 6,672K is great, the delta E of 3.33 is solid and the display handles 99.8 per cent of the sRGB gamut. It's a good screen, with better contrast and brightness than the Alienware – and that 4K resolution makes everything look crisp. However, the Alienware has 144Hz G-Sync and a more realistic gaming resolution for the hardware.

Meanwhile, the speakers are loud and bassy in their default Music mode, but with a muddy high end and dominant treble that lacks detail. The Movie mode has less clarity and the Gaming mode sounds tinny. As usual, don't expect much battery life here either – the MSI lasted for just under an hour in a gaming test.

Conclusion

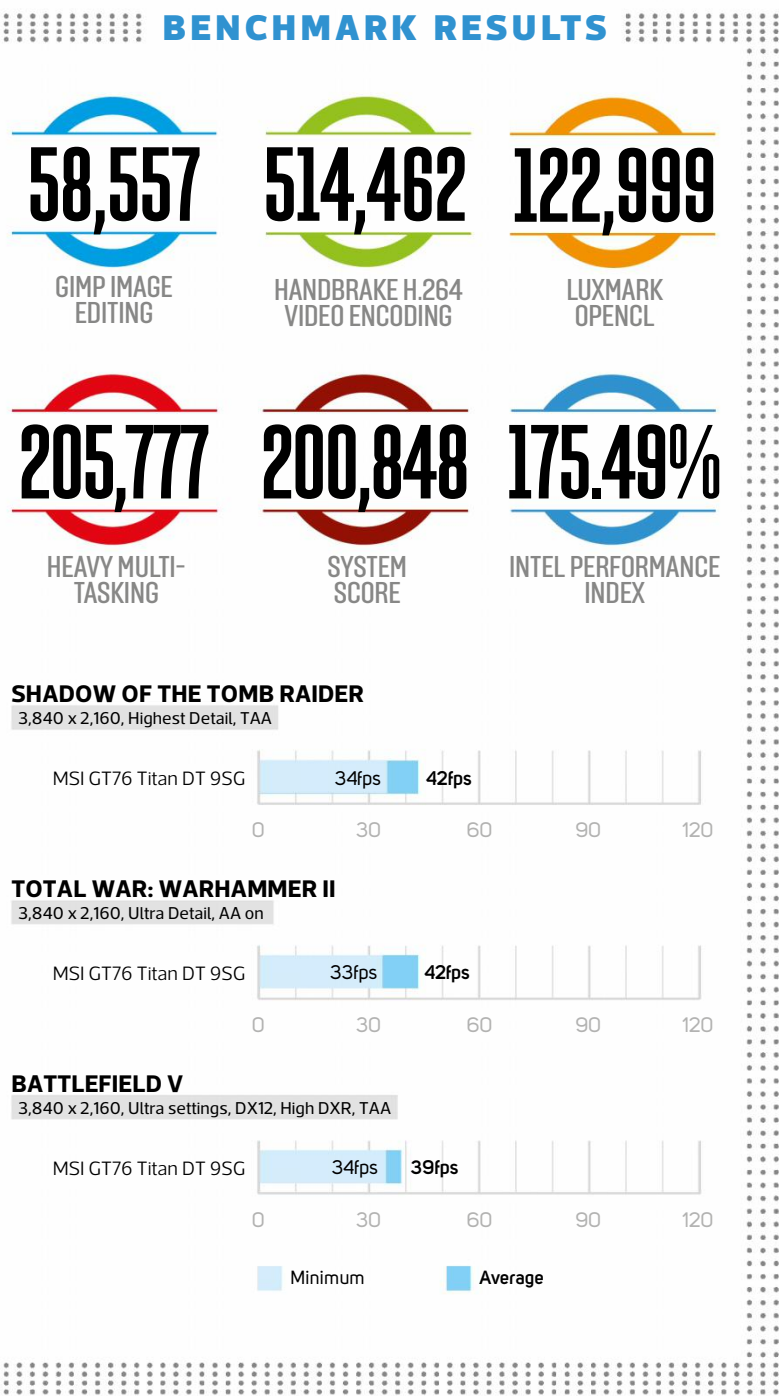
The MSI has huge power, good storage, lashings of memory and a decent screen, alongside superb wired and wireless connection options. Despite that, though, it's less than the sum of its parts. The Alienware is cheaper, slimmer, lighter, quieter and faster. It's easy to see why people want laptops with desktop components – they scythe through games and productivity tasks. However, there are better options available for less money elsewhere.

MIKE JENNINGS

VERDICT

A fast powerhouse with a great screen, but you can get better top-end gaming laptops for less money elsewhere.

- TITAN**
- + Very fast in games and applications
 - + High-quality 4K screen
 - + Superb connection options
- TITANIC**
- Expensive
 - Very large and heavy
 - Gets hot
 - Rivals are quicker



PERFORMANCE
23/25

DESIGN
17/25

HARDWARE
21/25

VALUE
15/25

OVERALL SCORE
76%

GAMING PC

SCAN 3XS VENGEANCE RTX TI

£3,200 inc VAT

SUPPLIER scan.co.uk

Scan's pricey 3XS Vengeance RTX Ti system tries to serve up enough power for work and play without making too much of a racket. It comes equipped with AMD's monster Ryzen 9 3950X CPU, which has 16 cores (and 32 threads via SMT), 64MB of L3 cache and respective base and boost clocks of 3.5GHz and 4.7GHz. It's designed for content creation and other tough work applications, but it can also be used for gaming.

The high-end CPU is joined by an EVGA GeForce RTX 2080 Ti card. Despite Super-branded GPUs arriving further down the pack, the RTX 2080 Ti remains one of Nvidia's more powerful options, with its 4,352 stream processors and 11GB of memory. Scan's engineers have also tweaked the boost

clock by 100MHz to 1645MHz, and added 50MHz to the memory speed.

The rest of the specification is well chosen. There's 32GB of 3200MHz DDR4 memory, which is overkill for gaming but useful for productivity software, and the 2TB Corsair MP600 SSD uses the high-speed PCI-E 4 interface. It's a minor shame that there's no hard disk to offer more space for large files and games, but 2TB is more than enough for most people's needs, especially if you use a NAS box. Meanwhile, the Corsair RM650x power supply is fully modular and has an 80 Plus Gold certification, which is all good to see.

It all connects to an Asus ROG Strix X570-F Gaming motherboard, which has the requisite hefty heatsinks and RGB LEDs – there are two vacant memory slots, a free M.2 port and a 16x PCI-E 4 slot with SLI support. There are plenty of free SATA ports and fan headers as well, along with four USB 3.1 ports, plus three USB 3.2 Gen 2 Type-A ports and a Type-C socket on the rear. The SupremeFX S1220A audio is good too, and Scan

has added its own dual-band 802.11ac Wi-Fi card. The motherboard's feature set isn't huge, and there are no on-board buttons or displays, but it covers the essentials.

Meanwhile, the NZXT H710i chassis is sturdy and smart, with subtle sandblasted metal on the outside and a neat cover to hide cables on the inside. Scan has fitted the Corsair Hydro H150i CPU cooler's radiator to the front of the chassis, where it extends into the PSU shroud's cutaway. Scan's cable tidying is impeccable, and nearly all of the motherboard's upgrade paths easy to reach – it's a very neat interior.

Three 2.5in drive bays adorn the PSU shroud, and there are two more at the rear, alongside two free 3.5in bays. Scan has kept the cables neat at the back as well, with the help of NZXT's cable-routing trenches. A band of RGB LEDs illuminates the internals in blue, and the colour is matched by the lights on the motherboard, CPU cooler pump block, memory and GPU.

Finally, Scan's warranty remains one of the best deals around, with three years of parts and labour coverage with a year of on site service. That's important if your PC is a key work tool.

Performance

The 16-core CPU is a beast. In our heavily multi-threaded Handbrake video encoding test, this Scan PC scored 959,116, which is around 350,000 points higher than systems with



SPEC

CPU

3.5GHz AMD Ryzen 9 3950X

Motherboard

Asus ROG Strix X570-F Gaming

Memory

32GB Corsair Vengeance Pro RGB 3200MHz DDR4

Graphics

EVGA GeForce RTX 2080 Ti 11GB

Storage

2TB Corsair MP600 M.2 SSD

Networking

Gigabit Ethernet, dual-band 802.11ac Wi-Fi

Case

NZXT H710

Cooling

CPU: Corsair Hydro H150i RGB Pro with 3 x 120mm fans; GPU: 2 x 90mm fans; rear: 1 x 140mm

PSU

Corsair RM650x 650W

Ports

Front: 2 x USB 3.1 Gen 1, 1 x USB 3.1 Gen 2 Type-C, 1 x audio; rear: 3 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 2 Type-C, 4 x USB 3.1 Gen 1, 1 x optical S/PDIF, 5 x audio

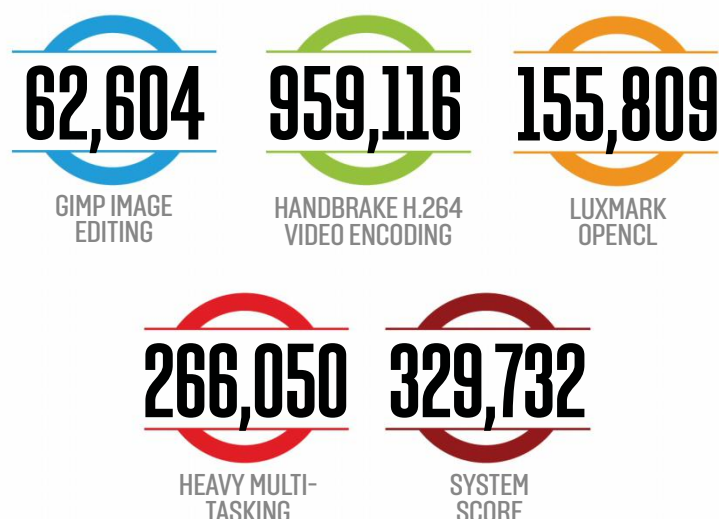
Operating system

Microsoft Windows 10 Home 64-bit

Warranty

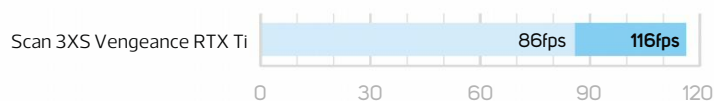
Three years parts and labour, first year on site, then return to base

BENCHMARK RESULTS

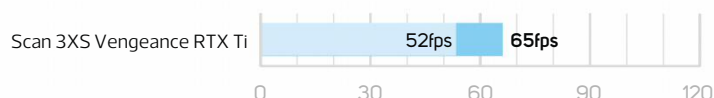


SHADOW OF THE TOMB RAIDER

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

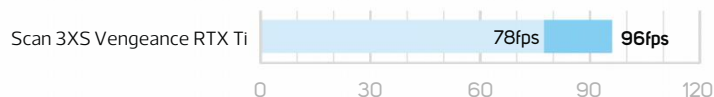


3,840 x 2,160, Highest Detail, TAA

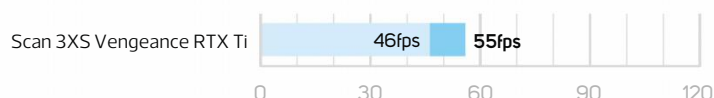


TOTAL WAR: WARHAMMER II

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

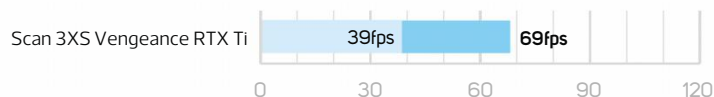


3,840 x 2,160, Ultra Detail, DX11, FXAA

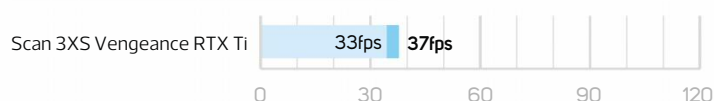


BATTLEFIELD V

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



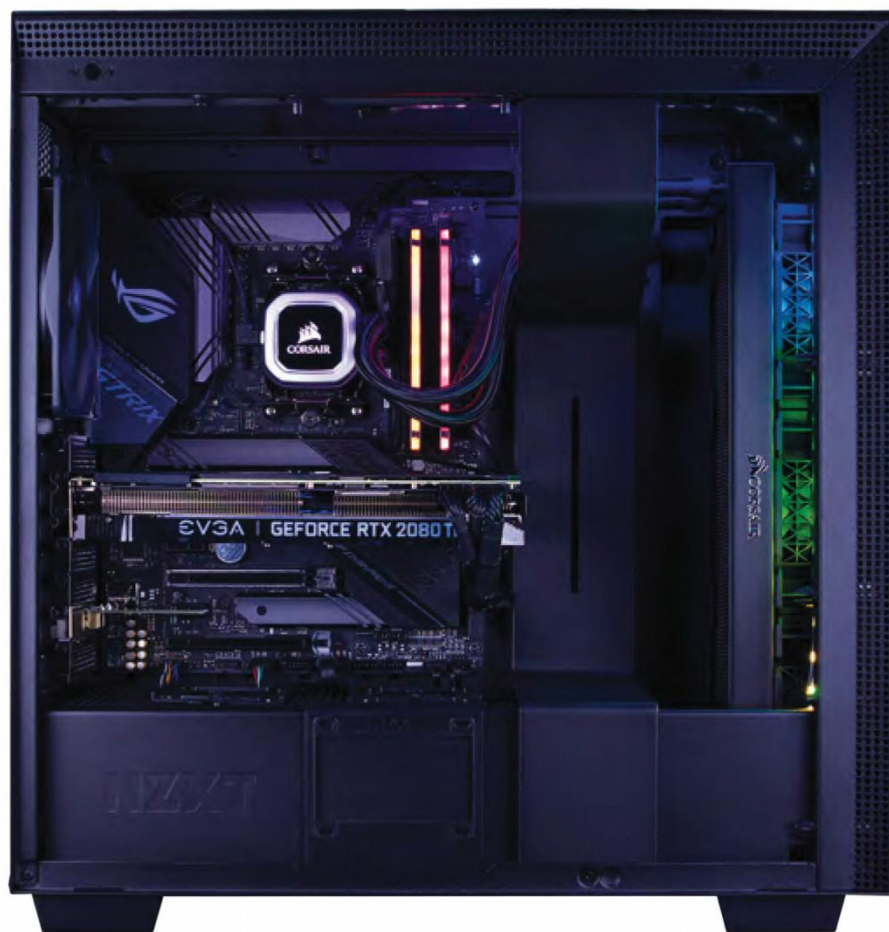
3,840 x 2,160, Ultra settings, DX12, High DXR, TAA



99th percentile Average

the Intel Core i9-9900K and Ryzen 7 3800X. The Scan's multi-tasking score is similarly dominant, and its overall result of 329,732 is superb, and barely any different from the overall results of overclocked Ryzen 9 systems.

This PC will easily handle heavily multi-threaded workloads, making it a winner for content creation applications and other relevant workloads. You'll get a little more power by opting for a chip such as the Threadripper 3970X in the Chillblast Fusion Conqueror (see Issue 199, p32), which scored 1,119,641 in the Handbrake test and returned an overall result of 382,767, but those extra cores certainly don't double performance and few workloads will really need them.



The Scan's brilliant CPU performance is bolstered by the SSD's read and write speeds of 4,972MB/sec and 4,257MB/sec, which are fantastic. The GPU is no slouch either. At 4K, the overclocked RTX 2080 Ti returned 99th percentile frame rates of 52fps in Shadow of the Tomb Raider and 46fps in Total War: Warhammer II. It fared less well in Battlefield V with ray tracing on High, but that 99th percentile frame rate jumps up to 52fps if you enable DLSS, where it still looks good.

Meanwhile, the 360mm Corsair all-in-one liquid cooler does a solid job of cooling the CPU, with a great peak delta T result of 46°C. The GPU delta T peaked at a reasonable 56°C as well, and the Scan never made much noise – there's a low fan rumble during gaming and work, but it's quieter than most high-end gaming machines we review.

Conclusion

Scan's PC impresses in several areas. It has huge CPU power, a very fast GPU and a good specification elsewhere. The case is unfussy and effective, and this PC's great benchmark results are delivered with little noise. It's an expensive, specialist build though. You only need this CPU if you're undertaking tough, heavily multi-threaded work tasks, and the GPU is only justified if you want to play games at very high resolutions.

Despite that, the Scan offers good value. It loses the expensive bells and whistles that ramp up the cost of 16-core rivals, while maintaining performance. It's an excellent, straightforward option for work and play.

MIKE JENNINGS

VERDICT

Fantastic all-round performance inside a smart, subtle build.

16 CORES

- + Superb game and application speed
- + Accessible, understated design
- + Fast PCI-E 4 SSD
- + Quiet operation

16-BIT

- Expensive
- Few motherboard extras
- Extra cores only useful for specialist workloads

PERFORMANCE

23/25

DESIGN

23/25

HARDWARE

23/25

VALUE

21/25

OVERALL SCORE

90%

GAMING PC

THE OFFICIAL FNATIC GAMING PC / £1,599 inc VAT

SUPPLIER pcworld.co.uk

Global esports team Fnatic has enlisted PC Specialist to build its official desktops, and this model is the flagship. Not only will it be sent to the pro players, but it will also be sold on the high street at PC World. It's not the only Fnatic-branded desktop – PC Specialist is selling three alternative specifications – but it's the most important.

It deploys an Asus Radeon RX 5700 XT card, with 2,560 stream processors and 8GB of memory. It runs at reference speeds, which means a boost clock of 1905MHz. It's a fast GPU, but it lacks the support for real-time ray tracing offered by Nvidia's GeForce RTX chips.

The Ryzen 7 3700X CPU runs at its stock speed too, which

means base and boost clocks of 3.6GHz and 4.4GHz. It's a versatile chip, with enough speed for gaming and eight cores for multi-threaded content creation. The rest of the specification is decent. There's 16GB of 3200MHz memory, a 500GB Samsung 970 Evo Plus SSD and a 2TB hard disk. Dual-band 802.11ac Wi-Fi is included too. Meanwhile, the Corsair TX650M power supply is reasonable: it's semi-modular and has an 80 Plus Gold rating.

It all connects to a basic Asus ROG Strix B450-F Gaming motherboard. It has two spare memory slots, a vacant M.2 connector and plenty of free SATA ports, as well as SupremeFX S1220A audio. The rear has a USB 3.1 Type-C port and plenty of full-sized USB ports as well. The B450 chipset means you don't get PCI-E 4 support though.

It's a decent specification, but it's expensive. If you spend this amount of cash elsewhere, you can easily bag yourself a GeForce RTX 2070 Super card. If you want to save money, systems with the Radeon RX 5700 XT or GeForce RTX 2060 Super usually cost under £1,400.

The system is housed in a Corsair iCUE 465, which is a well-made, unfussy mid-tower case with tempered glass panels. Build quality is excellent, the RGB LED intake fans look good and the side panel is decorated with Fnatic and PC Specialist logos.

The cabling is neat at the front too, helped by a PSU shroud and rubber grommets lining the holes. PC Specialist's own-brand FrostFlow CPU cooler looks good too, with a chrome-ringed waterblock/pump unit, and the radiator fitted to the exhaust mount with two 120mm fans. There are two more exhaust fans in the roof as well.

In terms of room to work and upgrade room, the spare M.2 connector and memory slots are easy to access, and there are four 2.5in mounts and a free 3.5in bay at the rear. There are no free connectors on the RGB lighting control board at the rear, though, and the hefty graphics card blocks the SATA ports. The bottom of the motherboard also feels cramped because it's flush with the PSU shroud, and the top of the board is blocked by the roof fans.

Finally, the warranty includes three years of labour coverage and a year of parts protection, with one month of collect and return service. That's fine, although we'd prefer to see more parts cover.

Performance

When gaming at 1080p, the Fnatic's 99th percentile frame rates sat at 75fps or beyond. Top-tier games run well, and it easily has the speed to play esports titles at high frame rates. It can cope well at 2,560 x 1,440 too. Its 99th percentile figures at this tougher resolution sat at 50fps or beyond. It can't quite handle 4K though – in two of our games, its 99th percentile

SPEC

CPU

3.6GHz AMD Ryzen 7 3700X

Motherboard

Asus ROG Strix B450-F Gaming

Memory

16GB Corsair Vengeance Pro RGB 3200MHz DDR4

Graphics

Asus Radeon RX 5700 XT 8GB

Storage

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

Case

Corsair iCUE 465X

Networking

Gigabit Ethernet, dual-band 802.11ac Wi-Fi

Cooling

CPU: PC Specialist FrostFlow 120 with 2 x 120mm fans; GPU: 1 x 90mm fan; front: 3 x 120mm fans; top: 2 x 120mm fans

PSU

Corsair TX650M 650W

Ports

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

One year parts and labour with first month collect and return, followed by two years labour only return to base



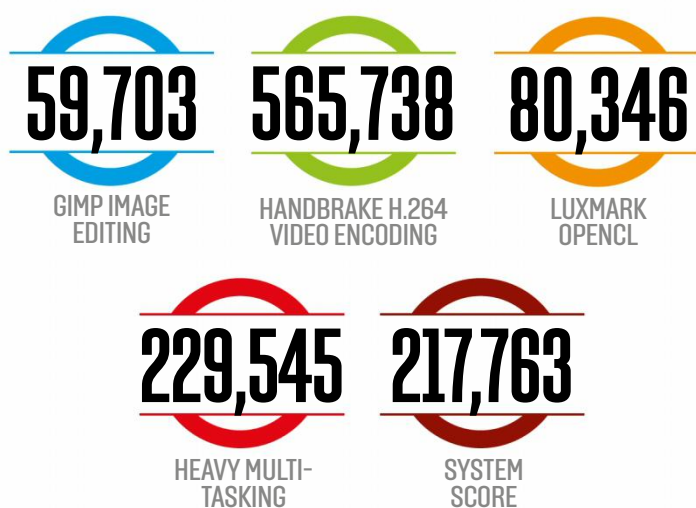
FANTASTIC

- + Smart Fnatic branding
- + Decent gaming performance
- + Quiet, robust chassis

FANATIC

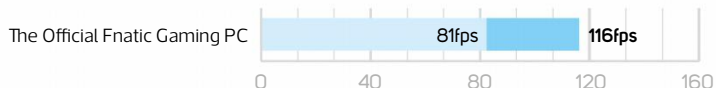
- Pricier than competitors
- Basic motherboard
- Some upgrade paths blocked
- No ray tracing

BENCHMARK RESULTS



SHADOW OF THE TOMB RAIDER

1,920 x 1,080, Highest Detail, TAA

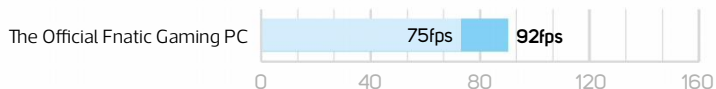


2,560 x 1,440, Highest Detail, TAA

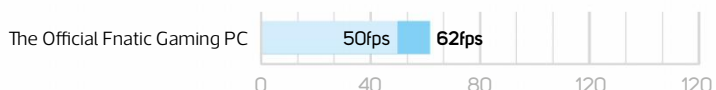


TOTAL WAR: WARHAMMER II

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



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



BATTLEFIELD V

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



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



99th percentile Average



frame rates dipped below 30fps. This AMD GPU is also quicker than Nvidia's GeForce RTX 2060 Super, but the latter supports real-time ray tracing. That said, the Radeon RX 5700 XT is the clear choice at this price if raw frame rates are your top priority.

Meanwhile, the Ryzen 7 3700X processor is solid. Its single-threaded results match equivalent Intel chips, and in multi-threaded tests it has the ability to motor through work tasks. The SSD is decent too, with read and write speeds of 3,062MB/sec and 2,919MB/sec. However, this Fnatic rig is one of the slowest systems we've seen with this CPU. PCs with this chip routinely get overall system scores of beyond 220,000 points.

The Fnatic PC is a great thermal performer though. The CPU and GPU delta Ts of 45°C and 48°C are good, and the machine makes less noise than most gaming systems, despite all those fans – you'll barely notice it once it's under your desk.

Conclusion

This Official Fnatic Gaming PC offers enough gaming speed for esports and single-player titles alongside a solid CPU and a robust case. However, it also has a basic motherboard and a high price. While it's no surprise that this branded PC is expensive, cheaper machines offer similar performance. This PC offers a solid way to support your favourite esports team, but you'll get better gaming performance if you shop around.

MIKE JENNINGS

VERDICT

Solid design and performance for a high-street PC, but more power is available from cheaper rivals.

PERFORMANCE

19/25

DESIGN

21/25

HARDWARE

19/25

VALUE

17/25

OVERALL SCORE

76%

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

TABLET PILLOW STAND /

£19.99 inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

The Tablet Pillow Stand is comfy and foamy, with three little plastic ridges amid the comfy foaminess, which enable you to balance a phone or tablet computer while you operate it. While it lacks the precision and fortitude of a metal or rigid plastic stand, the pillow stand can do its job fine – it doesn't take a suspension bridge level of heavy engineering to keep a tablet at a visible angle, after all. The sides of the stand are soft, and you can rest your arms on them while you're using the screen, so there's no risk of encountering even mild discomfort or inconvenience either. It's ideal for sofa or bed use.

Brillo ●●●●○ Pillow



T-CORE PORTABLE CHARGER / **£23.99** inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

Cramming a large amount of power into the smallest possible device is always a worthy endeavour, and the T-Core portable charger makes an admirable fist of it. The T-Core is a handy size, being easy to carry in a pocket, and is fully loaded with a 10,000mAh battery, which is good for nearly three refills of the average Samsung phone, or as many as five refills for an iPhone.

The T-Core can be recharged via micro-USB, Type-C USB or an iPhone lightning connector, which is a neat idea, meaning you only need to carry the USB cable you'd usually use to charge your phone to also charge the T-Core. There are two USB 2.1A outputs, which provide reasonably fast charging. Remaining charge is indicated by a readout showing the percentage, which is the best way to do it. The T-Core looks simple, but the design is deceptively clever.

Sore ●●●●○ Core



PANIC BUTTON

£8.99 inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

A button you can press to indicate that you're in a state of panic seems like an incredibly useful item to have in 2020, but this particular one isn't up to much. When you press the button, it makes one of five incredibly annoying noises and flashes a light. If you press it enough you could probably annoy somebody into helping you with whatever it was that was causing you to panic, if only to get you to stop pressing the button.

Almost as annoying as the sound is the fact that the panic button isn't particularly solid. It slides about and the button presses unevenly. If you can't even rely on your panic button to be solid in a crisis, then what's it even good for? Annoying people, apparently – it's very good at that.

Panic ●○○○○○ Don't panic



PRIVISE WEBCAM COVER / £6.90 inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

The front-facing webcam has been a standard piece of equipment in laptop PCs for years, and stories about what can happen if somebody takes control of it are almost as old as the inclusion of said device. The traditional solution is a piece of tape, but the Privise offers a more refined solution. Instead of simply taping over the webcam back and forth, the Privise Webcam Cover is a little sliding door with an adhesive back.

It fits snugly over normal-sized webcams, or even selfie smartphone cameras (case notwithstanding), and provides a cover with a clean opening and shutting action, despite its relatively tiny size. You also get three of them in a pack, so you've got spares. Securing a webcam in this way can feel embarrassingly paranoid, but if you're going to do it, this is a good, unobtrusive method, and it has the added bonus of protecting your webcam lens at the same time.

Big Brother ●●●●○ Privacy



KEYSMART PRO / £54.99 inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)

The KeySmart Pro is an unusual keyring design, in that it provides tracking and locator features, while not quite being as good at holding keys as a regular keyring. It stores keys in two ways.

The first is via a loop on the back through which you can hook a regular keyring, which is ideal for car keys and other devices that might, while still technically being keys, don't fit the traditional shape. Keys that do fit the usual shape are stored inside the body of the device. You unscrew the end, remove one of the many fiddly little washers from the inside and hook the key into place. It's a bit of hassle, and the washers will easily go missing, but at least you only have to go through this process when adding keys.

Once added, the keys swing out like the attachments on a Swiss Army Knife, as demonstrated by the included bottle opener, and there's the option to add other gadgets as well, with space for ten items. This arrangement is fine, but it feels a little more effort than



just having your keys on a chain. The best part of the KeySmart Pro is that it includes a tracking system – it's the same one found on the Tile keychains, and it allows you to follow your keychain via GPS, or sound an alarm on it from your phone.

You can also sound an alarm on your phone with your keys, if that's an appropriate reaction to your situation. What makes the KeySmart especially good with regards to the tracker is that it also has a micro-USB charging port, where most similar systems rely on disposable batteries. There's also an LED, so you can see where you're aiming your key in the dark.

Headlock ●●●●○ Deadlock

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

LABS TEST

May the cores be with you

.....

Antony Leather reviews 15 sub-£1,000 CPUs to see whether AMD or Intel should get your cash

How we test

The CPU landscape includes a huge variety of models, but this month we've focused on sub-£1,000 CPUs that cover three different CPU sockets. We're still a way off any major new CPU launches in 2020, but the current pack have all seen price cuts in recent months. As a result, now is a great time to work out where your money should be spent if you're looking for an upgrade or building a new PC.

Our CPU test systems include an MSI MEG Z390 Ace for Intel LGA1151 CPUs, an MSI MEG X299 Creation for Intel LGA2066 CPUs and a Gigabyte X570 Aorus Master for AM4 CPUs. Common test hardware includes 16GB of Corsair Vengeance RGB Pro 3466MHz DDR4 memory, a 2TB Samsung 970 Evo SSD and an Nvidia GeForce RTX 2070 Super graphics card, along with an EKWB Phoenix liquid cooler and Corsair RM850i PSU.

All systems used the latest EFI versions, as well as the latest version of Windows 10 with security updates installed, as well as the latest drivers. We record results at both stock speed and overclocked, and our benchmarks include the CPC RealBench suite, comprising single-threaded image editing, multi-threaded video encoding and multi-tasking tests. We also run a timed Adobe Premiere Pro 4K video project export, as well as Cinebench R20's single and multi-threaded tests.

Meanwhile, we test gaming performance using Far Cry New Dawn and Metro Exodus, recording the 99th percentile minimum and average frame rates. Finally, we also measure the total system power consumption while idle and under load, running Prime95's smallfft test with AVX disabled to load each CPU.

Contents

.....

- › Intel Core i3-9350KF / p41
- › Intel Core i5-9400F / p42
- › AMD Ryzen 5 3600 / p43
- › Intel Core i5-9600K / p44
- › AMD Ryzen 5 3600X / p46
- › AMD Ryzen 7 3700X / p47
- › AMD Ryzen 7 3800X / p48
- › Intel Core i7-9700K / p50
- › AMD Ryzen 9 3900X / p51
- › Intel Core i9-9900KF / p52
- › Intel Core i9-10900X / p53
- › Intel Core i9-9900KS / p54
- › AMD Ryzen 9 3950X / p55
- › Intel Core i9-10920X / p56
- › Intel Core i9-10940X / p57
- › Results graphs / p58

INTEL CORE i3-9350KF / £131 inc VAT

SUPPLIER ebuyer.com

Intel's quad-core dominance ended when Ryzen hit the scene in 2017 but before that, when CPUs such as the Core i5-6600K were the kings of mainstream overclockable enthusiast systems, these CPUs were highly desirable and supremely quick in games. The Core i5-6600K was a £250 chip, though, so those on a budget had to look lower down the ladder. Sadly, below the Core i5 range, Intel only offered limited overclockable options, with the likes of the Core i3-7350K being limited to just two cores.

As such, the Core i3-8350K was a breath of fresh air. It not only offered double the core count of the constrained Core i3-7350K, but it

YOU ONLY LIVE TWICE

- + Great overclocking headroom
- + Fast in some games
- + Affordable

DIE ANOTHER DAY

- Dire multi-threaded performance
- Desperately needs Hyper-Threading
- Core i5-9400F is a better all-rounder

SPEC

Base frequency 4GHz

Turbo frequency 4.6GHz

Core Coffee Lake

Manufacturing process 14nm

Number of cores 4 x physical

IGP None

Hyper-Threading No

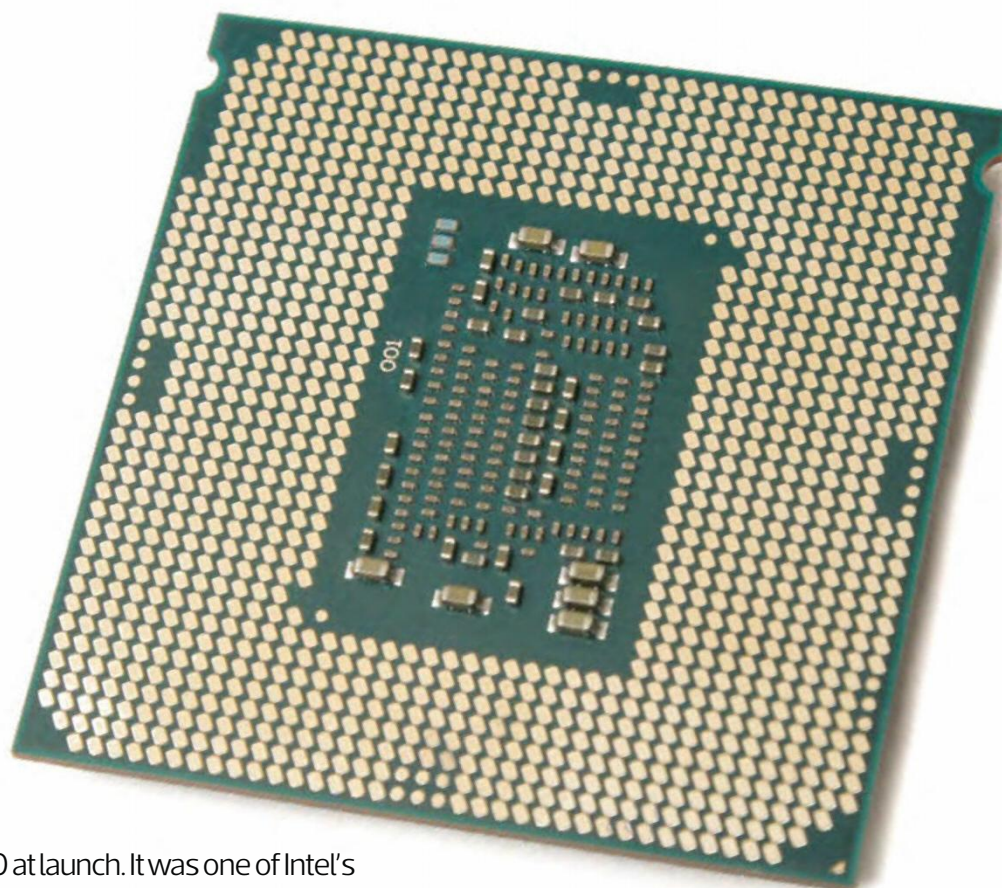
Cache 8MB L3 cache, 1MB L2 cache

Memory controller Dual-channel DDR4, up to 2400MHz

Packaging Intel LGA1151-V2

Thermal design power (TDP) 91W

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



cost under £160 at launch. It was one of Intel's success stories in the face of Ryzen and was a superb budget gaming and overclocking CPU. The current Core i3-9350KF, though, has much stiffer competition.

With the 'KF' suffix denoting a lack of on-board graphics and a cheaper price tag, this CPU undercuts the Ryzen 5 3600 by £25, but it's relying solely on clock frequency for its performance. It's still manufactured using Intel's aging 14nm process and has just four non-Hyper-Threaded cores. In comparison, the Ryzen 5 3600 has six cores with Simultaneous Multithreading, so it can operate on 12 threads at a time. This lack of Hyper-Threading – a feature that's missing from most of Intel's sub-Core i9 desktop CPUs – is a major thorn in the Core i3-9350KF's side. What's more, it has far less cache than its rivals too.

However, it can reach a peak boost frequency of 4.6GHz, which means it's still a potentially quick CPU for lightly threaded tasks such as gaming. It also overclocks easily, with our sample hitting 5.1GHz across all four cores using a vcore of 1.32V, adding 500MHz to an already impressive stock speed boost.

The Core i3-9350K kept up with the Ryzen 3600 in our image editing test, which stresses single-threaded performance, but was left in the dust in the heavily multi-threaded Handbrake video encoding test, as well as our multi-tasking test. Only once it was overclocked could the Intel CPU better it, and only in the image editing test, which responds well to clock speed. In Cinebench, the Ryzen CPU's extra cores and threads saw it double the Intel CPU's score, and it was a huge amount quicker in Premiere Pro too.

The tables were turned in games, though, with Far Cry New Dawn still working well with the Core i3-9350KF adding around 10 per cent to the 99th percentile minimum frame rate with a similar outcome in Metro Exodus. These leads were extended once we'd overclocked the Intel CPU. However, these are far from as impressive as the gains the AMD CPU had in the content creation tests that were up to 100 per cent faster.

Conclusion

It's clear that Intel still enjoys significant leads in frame rates in some games and the Core i3-9350K's ability to overclock to 5GHz across all cores means that in some titles, it's a compelling cheap gaming CPU. This won't be the case everywhere, though, and its multi-threaded performance is utterly dire, even at this price. If you're looking to build a cheap, overclockable gaming PC, it's worth considering, but the Core i5-9400F with its six cores is a better all-rounder, while the Ryzen 5 3600 is much quicker when all cores are called into action.

VERDICT

Still holds its own in some games but there are better options all round.

PERFORMANCE
26/50

FEATURES
13/15

VALUE
30/35

OVERALL SCORE
69%

INTEL CORE i5-9400F / £145 inc VAT

SUPPLIER scan.co.uk

When the Core i5-8400 was first released, the lack of cheap Coffee Lake-compatible motherboards meant that it didn't provide particularly good value, as its lack of overclocking made it a poor choice to couple with an expensive Z-series board. Eventually, though, once cheaper motherboards arrived, it proved its worth,

SPEC

Base frequency 2.9GHz

Turbo frequency 4.1GHz

Core Coffee Lake

Manufacturing process 14nm

Number of cores 6 x physical

IGP None

Hyper-Threading No

Cache 9MB L3 cache, 1.5MB L2 cache

Memory controller Dual-channel DDR4, up to 2400MHz

Packaging Intel LGA1151-V2

Thermal design power (TDP) 65W

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

bettering equivalent 1st and 2nd-generation Ryzen CPUs in games, and costing significantly less than the K-series models. A few years later and the lack of overclocking remains with the Core i5-9400F but cheap motherboards are plentiful now, so there's no need to wait to make the most of this chip. To the uninitiated, the addition of an F signifies that this particular iteration of Intel's 6-core 9000-series CPU lacks integrated graphics. Thankfully, it's cheaper than the Core i5-9400 as a result, leaving you with change from £150. Frequencies are fairly lowly, though, especially compared with the upper tiers of Intel's 9th-generation CPUs. The peak Turbo Boost frequency is just 4.1GHz and its base clock is 2.9GHz – a long way back from the 3.7GHz of the likes of the 9600K. It also lacks hyper-threading, so its six cores can only handle six threads at a time. You still get 9MB L3 cache, though, which is as much as the 9600K. What's more, despite a 14nm manufacturing process, the Core i5-9400F has a TDP of just 65W, making it a potentially handy CPU for a low-power, low-heat and affordable gaming system. Our game tests bore this out too, with Far Cry New Dawn's 99th percentile minimum frame rate of 88fps

bettering all the AMD CPUs on test, with a similar result in Metro Exodus too. However, once overclocked, only the Ryzen 5 3600 and Ryzen 5 3600X were noticeably slower and even then just by single digits, which was the same in Metro Exodus too. The problem for the Core i5-9400F and most of Intel's CPUs in general, is that they get monstered in other benchmarks. The Core i5-9400F's system score of

OVERCLOCKING

- + Good gaming performance
- + Modest cooling requirement
- + Cheap

SILICON LOTTERY

- Poor multi-threaded performance
- Only worth it for gaming
- No overclocking

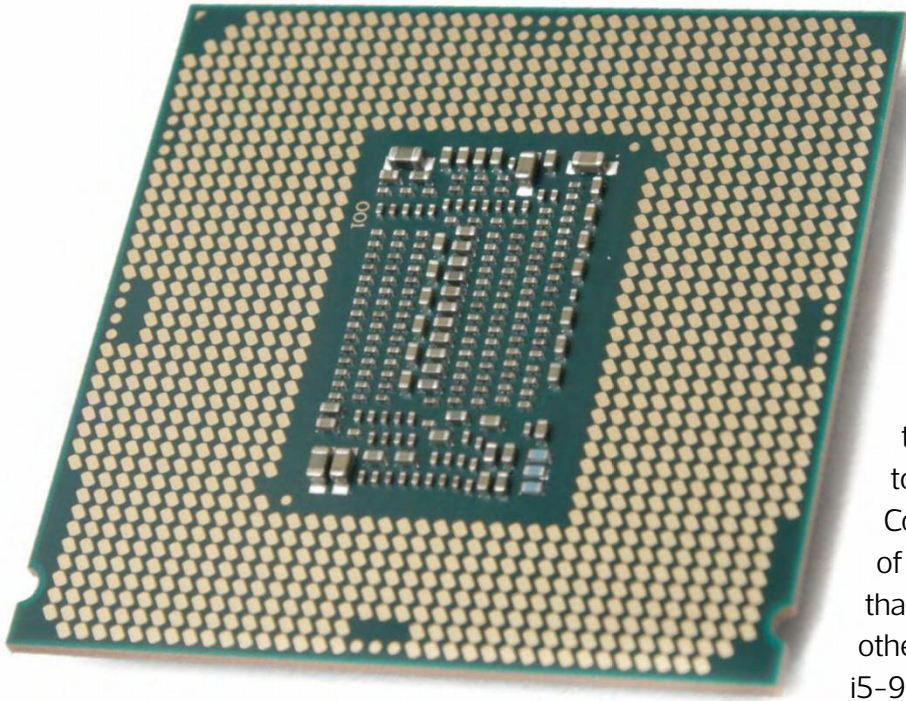
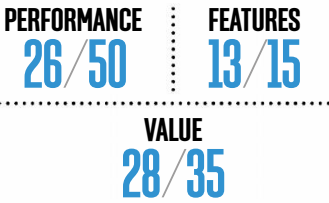
129,805 was woeful, with the Ryzen 5 3600 managing 185,659, with huge leads in the multi-tasking and video encoding tests. Despite Intel's dominance further up the scale in Adobe Premiere Pro, the fact the 6-core Intel CPU lacks Hyper-Threading meant it was vastly inferior to the AMD chips here too. It took nearly a minute and a half longer to complete our relatively short 4K video project export, meaning that budding content creators should avoid the Core i5-9400F. Cinebench offered a similar situation with the Ryzen 5 3600 outstripping it by over 1,000 points and offering far better single-threaded performance too.

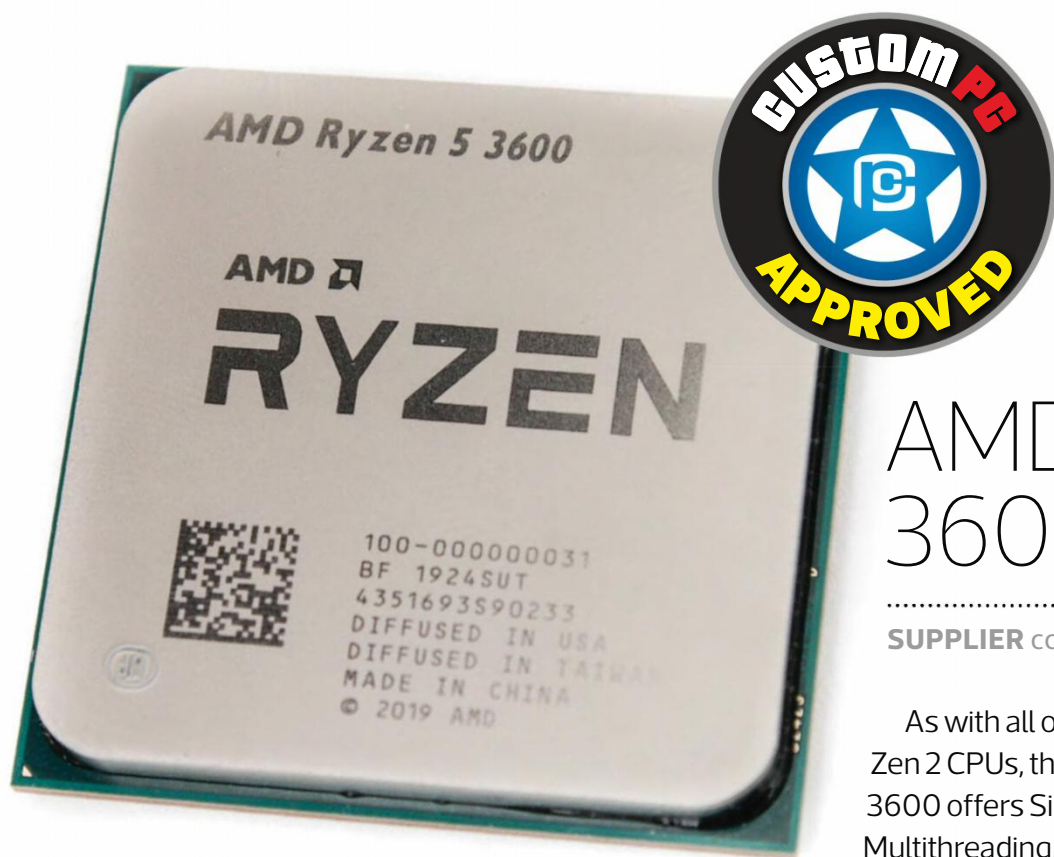
Conclusion

If ever there was a clear case for Intel to add Hyper-Threading to its entire product stack, the likes of the Core i5-9400 are it. Below the Core i9-9900K, Intel is lacking in multi-threaded grunt, which means these CPUs are only worth considering for pure gaming systems. Admittedly, the Core i5-9400F is still worth considering as a budget gaming CPU and punches above its weight here, offering slight gains over AMD's more expensive options too. However, AMD offers a huge amount more performance outside of games for similar cash and isn't far behind in terms of frames per second either. The gap has closed considerably with Zen 2, and as the similarly priced Ryzen 5 3600 was only a little slower in games, but huge amounts quicker elsewhere, it's a much better buy.

VERDICT

Without Hyper-Threading, this Intel CPU stands no chance outside of games, but it's worth considering as an affordable gaming chip.





AMD RYZEN 5 3600 / £157 incVAT

SUPPLIER cclonline.com

AMD's 6-core Ryzen CPUs have long been among our favourites thanks to their excellent all-round multi-threaded performance and affordability. This has been borne out in sales too, with them outselling every other desktop CPU in recent times. In fact, the Ryzen 5 3600's predecessor was the most popular CPU bought via retailers during the end of 2018 and into 2019.

The Ryzen 5 3600 has a lot to live up to, then, but the 7nm Zen 2 architecture has helped it to offer a lot more across the board, especially in games. Even better, its launch price of nearly £200 has been cut to under £160, meaning it massively undercuts the Core i5-9600K and now competes with the Core i5-9400 and Core i5-9500.

SPEC

Base frequency 3.6GHz

Turbo frequency 4.2GHz

Core Zen 2

Manufacturing process 7nm

Number of cores 6 x physical (12 threads)

IGP None

Simultaneous Multithreading Yes

Cache 32MB L3 cache, 3MB L2 cache

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging AMD Socket AM4

Thermal design power (TDP) 65W

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

As with all of AMD's Zen 2 CPUs, the Ryzen 5 3600 offers Simultaneous Multithreading, so unlike Intel's current Core i5 and Core i7 desktop CPUs, it packs an extra punch in multi-threaded tasks. In this instance, it gives you the ability to process 12 threads at once via its six cores. It has a hefty 32MB L3 cache and, as indicated by the lack of an X at the end of its name, it has a TDP rating of just 65W compared to 95W for the Ryzen 5 3600X. However, it boosts to just 4.2GHz compared to the latter's 4.4GHz. We also saw an all-core boost frequency of just under 4GHz, but the X-edition CPU sat at 4.1GHz, so it's a little quicker all round.

One of the best reasons to buy previous iterations of this CPU was that, thanks to an unlocked multiplier, overclocking it was easy and rewarding. With a 4.2GHz peak boost clock, any frequency above this figure will offer gains to both peak single- and all-core boost frequencies. Plumbing in 1.425V to allow our CPU to stretch its legs, we hit 4.25GHz, which added 50MHz to the single-core boost and just over 250MHz to the all-core boost.

However, while that's faster than the Ryzen 5 3600X's all-core boost, the latter has a stock peak boost of 4.4GHz, meaning it retains more of a lead over its non X-edition sibling than the Ryzen 5 2600X did after

overclocking. Even so, the fact that you can add to the peak and all-core boost with a manual overclock means it's one of the few 3rd-gen Ryzen CPUs to benefit in both areas from a manual overclock.

With a system score of 185,659, the Ryzen 5 3600 easily outstrips the Core i5-9600K, Core i5-9400F and Core i3-9350K in RealBench. Even applying massive overlocks to those K-series CPUs didn't see them match the 3600's stock speed scores. Once overclocked, the AMD CPU extended its lead to 207,899 with a similar story playing out in Adobe Premiere Pro and Cinebench. On the other hand, our game tests revealed performance that was noticeably slower than most Intel CPUs and overclocking only yielded small gains where even the Core i3-9350K was faster, albeit by less than 10 per cent in both titles.

Conclusion

For the money, the Ryzen 5 3600 is an excellent all-rounder and while it's a little slower in some games than Intel's equivalents, it more than makes up for this with massive multi-threaded performance. If you dabble in content creation as well as gaming and have a budget of around £150, it's a no-brainer.

VERDICT

A huge amount faster than its predecessor and the new benchmark for a sub-£200 all-rounder.

FLAT WHITE

- + Great all-rounder
- + Excellent multi-threaded performance
- + Good value

FLAT TYRE

- Slower than Intel CPUs in some games
- Cheaper Ryzen 7 2700 is sometimes faster when overclocked
- Little overclocking headroom

PERFORMANCE
33/50

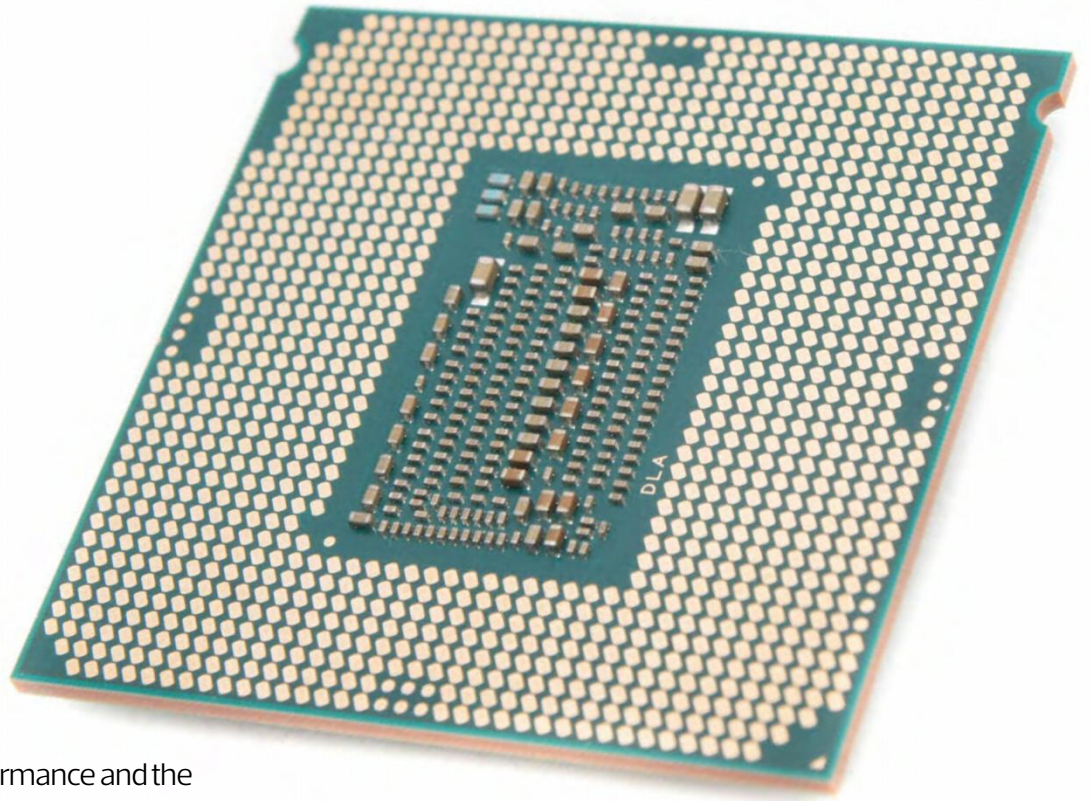
FEATURES
13/15

VALUE
34/35

OVERALL SCORE
80%

INTEL CORE i5-9600K / £180 inc VAT

SUPPLIER [amazon.co.uk](https://www.amazon.co.uk)



While Intel might fairly be accused of being caught napping a couple of years ago, releasing the first round of Coffee Lake CPUs several months after Ryzen Landed, the fact is that the Core i7-8700K, and later the Core i5-8400, both went on to be popular CPUs. However, the Core i5-8600K felt a little lacking from the start, with AMD already offering more grunt in multi-threaded applications for the same cash, meaning the venerable Core i5 was no longer the best affordable all-rounder.

The Core i5-9600K, sadly, offers little on top of this already struggling CPU, but excellent

gaming performance and the reintroduction of a soldered heatspreader meant it was still a popular option for the frame rate obsessed. When you read this, Intel's 10th-generation mainstream desktop CPUs will still be a few months away at least, but rumour has it that the company will be introducing higher core counts and, more importantly, Hyper-Threading across the board.

If this is true, the latter will boost the next equivalent Core i5 CPU's credentials in multi-threaded applications, but this is just rumour for now. In the meantime, the Core i5-9600K has received a substantial price cut since its launch just over a year ago, falling from just under £260 to under £190. This means it now sits between the Ryzen 5 3600X and Ryzen 7 3700X, which cost £190 and £260 respectively, and both have more threads thanks to support for AMD's equivalent of Hyper-Threading, Simultaneous Multithreading.

The Core i5-9600K is no slouch, though, and can reach 4.6GHz on one core and up to 4.3GHz in all-core boost. However, while frequencies have improved over its predecessor, that's about it. This is the third generation of Intel's 14nm manufacturing process, and the 9MB L3 cache and 1.5MB L2 cache are the same as you'd see on its predecessor too. On the plus side, we managed to hit 5.1GHz using 1.3V, adding an impressive 500MHz to the maximum boost frequency and 800MHz to the all-core boost.

In terms of performance, at stock speed, even the cheaper Ryzen 5 3600 was quicker in every test outside of games, but the Core i5-9600K wasn't far behind once overclocked. However, applying an overclock to the AMD CPU made it significantly quicker in Adobe

Premiere Pro, Handbrake and Cinebench. Thankfully, the Core i5-9600K is still a speed demon in games, even bettering the Ryzen 9 3950X by a sizeable margin in Far Cry New Dawn, and by around 10 per cent in Metro Exodus too, adding even more to its lead once overclocked, but with our system drawing less than 250W from the wall under full load.

Conclusion

The Core i5-9600K's gaming prowess won't be seen in every game, and will diminish at higher settings and resolutions where the situation becomes more GPU-bound. However, at 1080p with a reasonably powerful graphics card, it's clear that some titles do still get a significant advantage from using Intel silicon. As soon as you step out of games, though, the Intel CPU loses its appeal entirely, and cheaper AMD offerings walk all over it.

With the addition of Hyper-Threading and higher frequencies, its successors could turn around this situation, but unless you only use your PC for gaming, there are better options in this price league that could save you a huge amount of time when creating content.

VERDICT

An excellent CPU for gaming, but it offers terrible value for money elsewhere.

PERFORMANCE
31/50

FEATURES
13/15

VALUE
31/35

OVERALL SCORE
75%

CHEESECAKE

- + Great overclocking headroom
- + Fast in games
- + Easy to cool

CHEESY FEET

- Dire multi-threaded performance
- Not all games and settings will show benefits
- Newer Intel CPUs due out this summer

SPEC

Base frequency 3.7GHz

Turbo frequency 4.6GHz

Core Coffee Lake refresh

Manufacturing process 14nm++

Number of cores 6 x physical (6 threads)

IGP Intel UHD Graphics 630

Hyper-Threading No

Cache 9MB L3 cache, 6 x 256KB L2 cache

Memory controller Dual-channel DDR4, up to 2666MHz

Packaging LGA1151-v2

Thermal design power (TDP) 95W

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

NEW

Wireframe

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AMD RYZEN 5 3600X / £190 inc VAT

SUPPLIER currys.co.uk

Under the hood, the Ryzen 5 3600X and its cheaper sibling on p43 are identical. Both of these processors have two core chiplet dies (CCDs) with four cores apiece, as well as an I/O die that sports an improved dual-channel memory controller and PCI-E 4 root complex. On both CPUs, two cores are disabled, bringing the total to six

SPEC

- Base frequency 3.8GHz
- Turbo frequency 4.4GHz
- Core Zen 2
- Manufacturing process 7nm
- Number of cores 6 x physical (12 threads)
- IGP None
- Simultaneous Multithreading Yes
- Cache 32MB L3 cache, 3MB L2 cache
- Memory controller Dual-channel DDR4, up to 3200MHz
- Packaging AMD Socket AM4
- Thermal design power (TDP) 95W
- Features Precision Boost 2, Precision Boost Overdrive, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE

cores rather than eight. This also accounts for the fact that the Ryzen 5 CPU has 1MB less L2 cache than the 8-core Ryzen 7 3700X, as each core has its own 512KB allocation of L2 cache, which is therefore lacking on both of AMD's 3rd-gen Ryzen 6-core CPUs.

However, it has the same 32MB L3 cache and actually a higher base frequency than the Ryzen 7 3700X. Plus, when running multi-threaded tasks, the all-core boost sat at 4.1GHz rather than 4GHz with the 8-core CPU. At £190, though, it's significantly more expensive than the Ryzen 5 3600, and while you get the larger, more capable, Wraith Spire CPU cooler included in the box, the question is whether the X-edition CPU's stock speed frequency advantage gives it enough of an edge to justify that extra cash.

When it came to overclocking, we didn't manage to reach a higher frequency with the Ryzen 5 3600X than with its cheaper sibling, with both processors hitting a wall at 4.25GHz even when raising the vcore to 1.425V. This means there's a 150MHz frequency deficit compared with the CPU's peak single-core boost, potentially leading to slower results in lightly threaded applications. It also means using that it's best to use AMD's Precision Boost Overdrive to overclock the Ryzen 5 3600X than standard all-core overclocking, as you'll see a modest all-core boost jump, but not lose that peak boost frequency.

The added stock speed performance, thanks to higher boost frequencies, was tangible, with a system score of 202,642 compared to 185,659 for the Ryzen 5 3600, with a couple of hundred points added to the Cinebench multi-threaded score and a result of 501 compared to 471 in the single-core test too. It shaved nearly 15 seconds off the Premiere

WATER SLIDE

- + Good multi-threaded performance
- + A match for the Core i7-9700K in some tests
- + Costs less than £200

WATERWORLD

- Slower in some games than equivalent Intel CPUs
- Ryzen 5 3600 is nearly as quick but costs less
- Ryzen 7 3700X costs just £70 more but is much faster

Pro export time too, even bettering the Core i7-9700K here, yet it only drew another 9W under load than the cheaper Ryzen 5.

Game performance was also slightly higher than the Ryzen 5 3600 in Far Cry New Dawn, with 2fps being added to the 99th percentile minimum frame rate, but no gains in Metro Exodus. On balance, such numbers don't entirely convince us that the higher clock speed is worth the extra cash.

Conclusion

While there are tangible benefits from the Ryzen 5 3600X's higher boost frequencies, we're not sure the extra cash is warranted over the Ryzen 5 3600. With very similar gaming performance and modest gains in our other benchmarks, as well as no additional overclocking headroom, the Ryzen 5 3600X just isn't that compelling an upgrade. It's still a fantastic CPU for the cash, but it's pipped to the post by the cheaper 6-core CPU. It also sits in the shadow of the awesome Ryzen 7 3700X, which is significantly faster across the board and costs only £70 more.

VERDICT

A great 6-core CPU, but there are better options above and below it in this price league.

PERFORMANCE
34/50

FEATURES
13/15

VALUE
32/35

OVERALL SCORE
79%





AMD RYZEN 7 3700X / £260 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

AMD made some interesting tweaks to its product stack with the introduction of Zen2, and one of them was the positioning of the Ryzen 7 3700X compared with the 2nd-gen Ryzen line-up. Like the Ryzen 7 2700X, this chip has eight cores and 16 threads, but it also has a low TDP of just 65W.

However, the frequencies aren't in any way lowly. The peak single-core boost of 4.4GHz is only 100MHz lower than that of the Ryzen

7 3800X and just 200MHz lower than that of the Ryzen 9 3900X. The all-core boost we've observed was a fair bit lower than its 8-core sibling, though, with the Ryzen 7 3800X hitting 4.2GHz as opposed to 4GHz for the 3700X in multi-threaded tasks.

Thanks to the Zen2 architecture, though, this potent 8-core CPU is still very power-frugal. At stock speed, our test system drew just 185W from the wall with the 3700X under load, which is lower than the draw with Intel's Core i5-9600K installed.

The 3700X and 3800X lack the monstrous L3 cache of the 12 and 16-core Ryzen CPUs, as only two Core Complexes are active, with four cores and 16MB L3 cache apiece. Still, 32MB is a decent amount of L3 cache for a mainstream CPU. Meanwhile, the 512KB L2 cache per core totals 4MB and, like other Zen2 CPUs, there's an improved memory controller too, meaning speeds up to around 3600MHz can run in tandem with the CPU's Infinity Fabric, boosting performance.

In terms of performance, AMD's Ryzen 7 and Ryzen 9 CPUs stormed our RealBench tests, with huge image editing scores, and the Ryzen 7 3700X beat the more expensive Core i7-9700K in our video encoding and multi-tasking tests too. A system score of 234,491 puts it ahead of the Core i7-9700K again, and it even pipped the Core i9-10900X to the post here, although both of Intel's Hyper-Threaded 8-core CPUs scored higher.

Cinebench saw the 3700X yet again outperform the Core i7-9700K, as did Premiere Pro, where the 3700X nearly matched the Core i9-9900KF too. The 3700X was also one of AMD's faster CPUs in games, being not much slower than

the Ryzen 9 3950X, but it's ultimately still noticeably slower than Intel's mainstream CPUs in these specific tests.

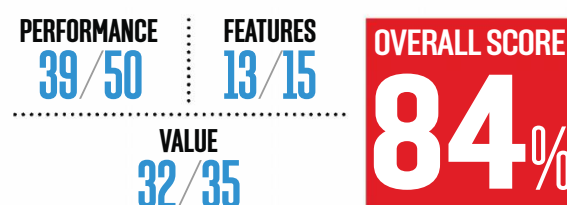
When it came to overclocking, we hit an all-core overclock of 4.3GHz, but no higher, despite pushing the vcore all the way to 1.425V. This is a 300MHz improvement over the stock speed all-core boost, and just 100MHz short of the 3700X's peak single-core boost clock, so it's potentially a better option than using Precision Boost Overdrive on this CPU. This overclock saw significant boosts to our Handbrake test, and cut the Adobe Premiere test time by ten seconds, while adding nearly 400 points to the Cinebench multi-threaded score. However, it made little difference to gaming performance.

Conclusion

The fact that the Ryzen 7 3700X now costs just £260 means it offers even better value than last year and, for a multi-purpose PC, it's the best option below £300. It falls short of Intel in some games, but this won't be the case everywhere and it offers great value for multi-threaded tasks. The Ryzen 7 3800X is only a little faster and not worth the extra cash.

VERDICT

A brilliant sub-£300 all-rounder, which offers better value for money than the similarly priced competitors.



8-CORE

- + Excellent value
- + Much faster than previous generation
- + Power-frugal

8-TRACK

- Slower than Intel in some games at certain settings
- Requires fast memory for the best performance
- Not much overclocking headroom

SPEC

Base frequency 3.6GHz

Turbo frequency 4.4GHz

Core Zen 2

Manufacturing process 7nm

Number of cores 16 x physical (16 threads)

IGP None

Simultaneous Multithreading Yes

Cache 32MB L3 cache, 4MB L2 cache

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging AMD Socket AM4

Thermal design power (TDP) 65W

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

AMD RYZEN 7 3800X / £309 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

AMD's mainstream product stack has been squished at the top end, thanks to the addition of the new 12-core and 16-core models at the summit. These chips haven't just made life difficult for the Ryzen 7 3800X, but for the entire CPU market in general. This is the first time we've looked at AMD's fastest 8-core Ryzen CPU, but it already looks quite different to when it launched, due to a hefty £70 price cut from its launch price of £380. It's now priced at around £310, but is that enough for it to be worth buying over the cheaper Ryzen 7 3700X?

ZEN

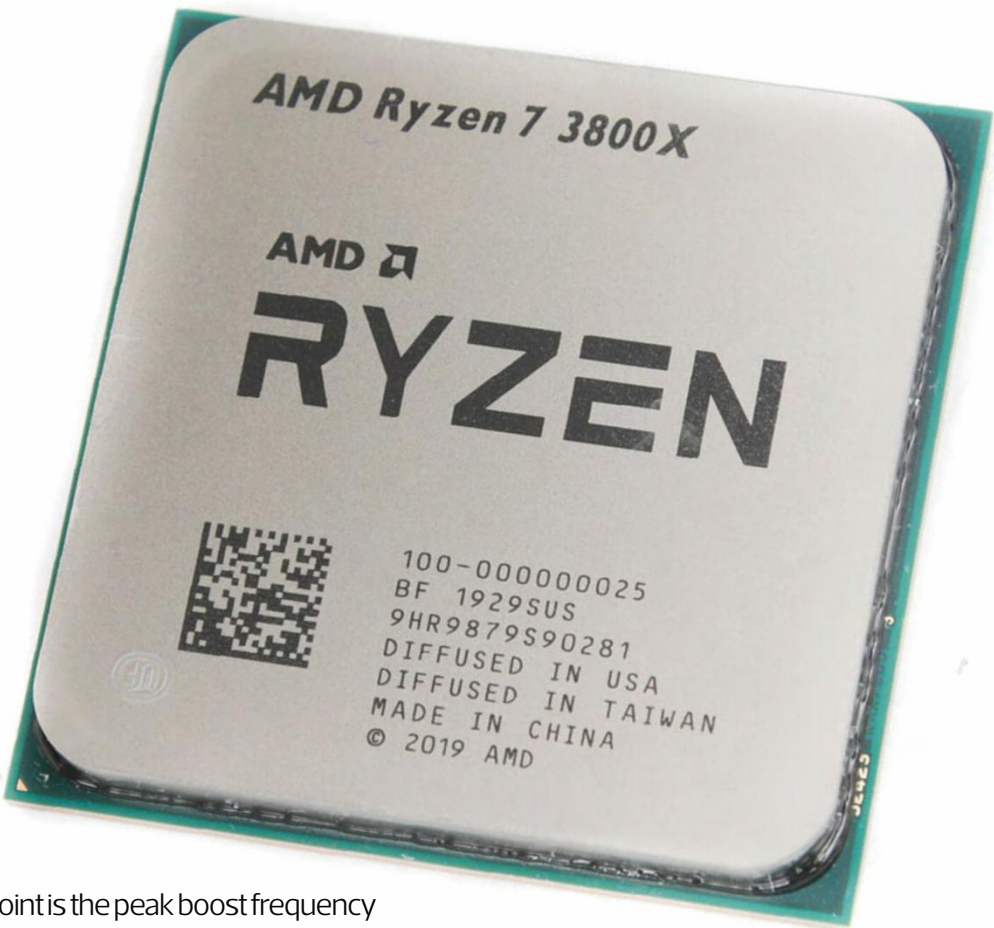
- + Great multi-threaded performance
- + Good overclocker
- + Matches pricier Intel CPUs in many tests

BULLDOZER

- Intel chips are faster in some games at certain settings
- Poor value compared to the Ryzen 7 3700X
- Outperformed by the Core i9-9900KF

SPEC

Base frequency	3.9GHz
Turbo frequency	4.5GHz
Core	Zen 2
Manufacturing process	7nm
Number of cores	8 x physical (16 threads)
IGP	None
Simultaneous Multithreading	Yes
Cache	32MB L3 cache, 4MB L2 cache
Memory controller	Dual-channel DDR4, up to 3200MHz
Packaging	AMD Socket AM4
Thermal design power (TDP)	105W
Features	Precision Boost 2, Precision Boost Overdrive, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE



Its main plus point is the peak boost frequency of 4.5GHz, which is the second highest of any mainstream Ryzen CPU, so it will be no slouch in lightly threaded applications. Its all-core boost speed, or at least the one while testing with our all-in-one liquid cooler, was 4.2GHz. This frequency is noticeably higher than that of the Ryzen 7 3700X and also the Ryzen 9 3900X, which managed 4.05GHz, albeit across four additional cores.

The Ryzen 7 3800X lacks the huge cache of the latter, as it only has two Core Complexes enabled, meaning it has 32MB of L3 cache and 4MB of L2 cache, which isn't dissimilar to AMD's current 6-core parts. The CPU also comes with AMD's Wraith Prism RGB cooler, just like the Ryzen 7 3700X, but you also have to deal with a higher TDP of 105W with the 3800X.

In terms of performance, at stock speed, the Ryzen 7 3800X punched well above its weight, bettering the Core i7-9700K and Core i9-10900X in many tests, but ultimately failing to topple the more expensive Core i9-9900KF. Still, with similar performance in Cinebench and Premiere Pro, it represents much better value.

We then applied our maximum 1.425V vcore and the Ryzen 7 3800X managed to hit a mighty 4.4GHz, which is the highest all-core clock speed of any mainstream Zen 2 CPU we've tested so far. This meant that, like its sibling, we only cut 100MHz from the peak boost frequency, but added 200MHz to the all-core boost. As such, a manual all-core overclock is potentially a better option than using Precision Boost Overdrive on this CPU.

Once overclocked, the 3800X was generally neck and neck with the Intel Core

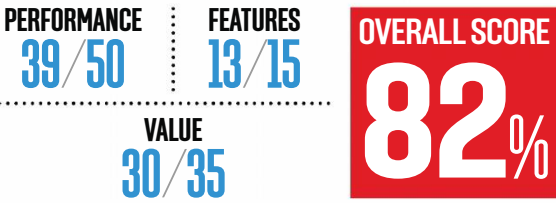
i9-9900KF until we came to the game tests, where it was still noticeably slower in these specific games at 1080p. Overclocking helped, but its 88fps 99th percentile frame rate in Far Cry New Dawn still paled compared to the 100fps achieved by the Core i9-9900KF.

Conclusion

The Ryzen 7 3800X finds itself in a tricky position, with the Ryzen 7 3700X snapping at its heels and costing £50 less, while Intel's mainstream CPUs remain quicker in some game titles, especially at 1080p. The fact that the 3800X only offers modest gains over its sibling means that the latter is the better buy – that extra £50 would be better spent on a decent CPU cooler, or put towards a faster SSD. If games are a concern, the Core i9-9900KF does cost significantly more money, but matches the 3800X in multi-threaded tasks while beating it in games. The Ryzen 9 3800X is a decent CPU, but the 3700X is ultimately a better buy.

VERDICT

A fast, powerful and overclockable 8-core CPU, but the Ryzen 7 3700X offers better value for money.



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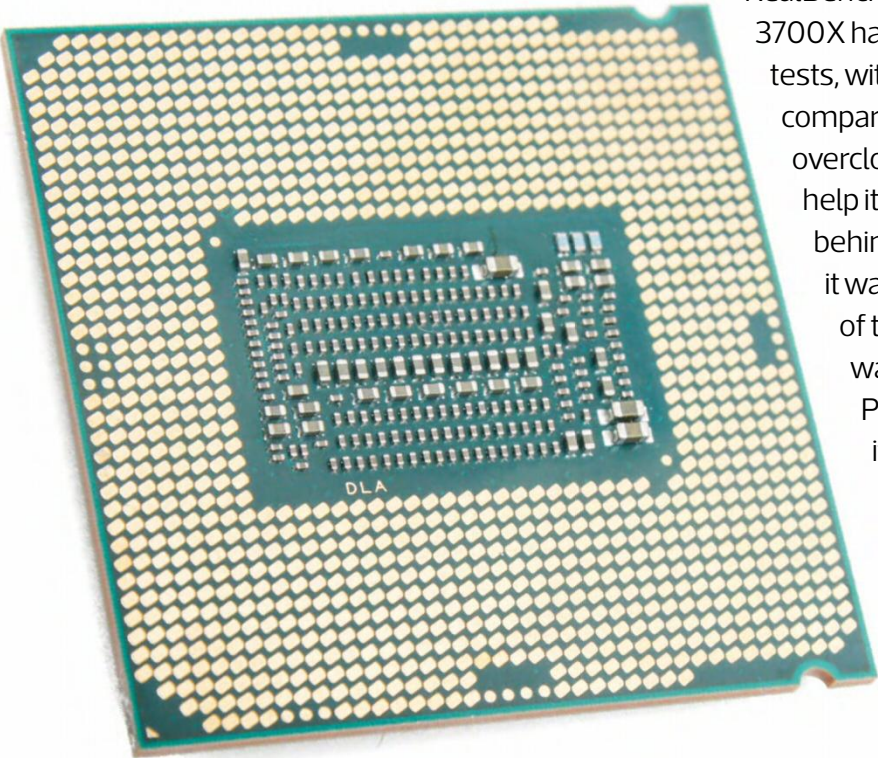
INTEL CORE i7-9700K / £369 inc VAT

SUPPLIER ebuyer.com

The Core i7-9700K has been through some serious mood swings during its lifetime, largely thanks to price. It's a solid CPU for gaming, but its initial price of nearly £500 was a tad steep. In order to combat the threat from AMD, though, this price has steadily fallen, and it's now settled at just £369. This price doesn't sit near any other

SPEC

- Base frequency 3.6GHz
- Turbo frequency 4.9GHz
- Core Coffee Lake refresh
- Manufacturing process 14nm++
- Number of cores 8 x physical (8 threads)
- IGP Intel UHD Graphics 630
- Hyper-Threading No
- Cache 12MB L3 cache, 8 x 256KB L2 cache
- Memory controller Dual-channel DDR4, up to 2666MHz
- Packaging LGA1151-v2
- Thermal design power (TDP) 95W
- Features Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE, MMX



AMD CPU, with the Ryzen 9 3900X costing £70 more and the Ryzen 7 3800X costing £70 less. With this new price in mind, we were interested to see how it now stacks up compared with the last time we looked at it.

As Intel has enabled Hyper-Threading on its other 8-core K-series CPUs, it was left with no option but to remove the feature on the Core i7-9700K in order to create a solid difference between the Core i7 and Core i9 ranges. However, this move also severely hampers the Core i7-9700K's multi-threaded performance, which makes it tough to compete with AMD's rivals.

It does offer some impressive boost frequencies, though, and for much less money than the Core i9-9900K. It can reach 4.9GHz on one core and 4.6GHz if all cores are chugging along. However, it also has 4MB less L3 cache than the Core i9 CPU. If you don't need on-board graphics, there's also a KF version, which shaves another £30 or so off the price.

In terms of overclocking, the Core i7-9700K is another Intel CPU that views 5GHz as an easy target, hitting 5.1GHz with a vcore of 1.3V across all eight cores, which was even higher than we managed with the Core i9-9900K.

The Core i7-9700K was no slouch in our RealBench tests, but even the Ryzen 7 3700X had the measure of it in most tests, with a system score of 234,491 compared to 205,979. Even overclocking the Intel chip couldn't help it here. It was a long way behind in Cinebench too, where it was only marginally ahead of the Ryzen 5 3600X, which was also quicker in Premiere Pro. Overclocking did boost its credentials here, but only enough to better the AMD 6-core CPU, with the Ryzen 7 3700X clearly being a much better buy for exporting 4K video projects.

CORE

- + Good overclocking headroom
- + Excellent in games
- + Reasonably easy to keep cool

NETBURST

- Poor multi-threaded performance
- Not very power-efficient
- Much better value available elsewhere

Gaming was an entirely different story, with the Core i7-9700K almost dominating the graphs, offering the highest frame rates in Metro Exodus and the second best results in Far Cry New Dawn – miles ahead of the AMD competition. As always, though, we should stress that this won't be the case in all games, and raising the settings in these games would result in far less of a difference.

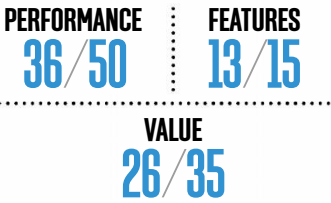
Power consumption was high for an 8-core CPU too, but then it is built on a 14nm manufacturing process.

Conclusion

The Core i7-9700K is a stunning gaming chip, but it isn't really worth the extra money over the Core i5-9600K in our tests, at least once the latter is overclocked. Outside games, however, there's a severe lack of multi-threaded performance, which sees far cheaper AMD CPUs better the 9700K. It's hard to recommend the Core i7-9700K as an all-rounder, given how much extra performance you can get elsewhere for less money. If you're building a rig purely for games, the much cheaper Core i5-9600K is often just as fast.

VERDICT

Another Intel CPU that's crying out for more threads, although it's a monster in games.



AMD RYZEN 9 3900X / £440 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

If you'd said that 12-core CPUs would be available for under £450 on mainstream desktop platforms two years ago, we'd probably have laughed in your face. However, the Ryzen 9 3900X landed last summer, took the PC industry by storm and caused some serious problems for Intel.

While the X570 platform lacks quad-channel memory support and enough PCI-E lanes to properly deal with several GPUs or many M.2 SSDs being accessed at the same time, the fact that this mainstream chipset can still handle several speedy PCI-E 4 M.2 SSDs, and accommodate 12-core and 16-core powerhouses, is a great benefit. It means AMD is offering serious content creation-crunching performance for very reasonable prices, and with comparatively cheap and varied motherboard options too.

With 12 cores (and 24 threads via SMT), as well as the benefits of the Zen 2 architecture, the Ryzen 9 3900X even outshines the Threadripper 2950X in many tests, and its

price has dropped by around £40 since its launch as well. It boasts two Core Chiplet Dies (CCD) with two Core Complexes (CCX) each, and each of those CCXs sport four cores. However, four cores are disabled on this CPU, bringing the total to 12.

You also get the same huge 64MB L3 cache as the Ryzen 9 3950X, with just a small cut in the L2 cache thanks to four cores being disabled. Meanwhile, the 3900X offers the second fastest peak boost frequency of all 3rd-gen Ryzen CPUs at 4.6GHz, and it hit 4.05GHz across all cores in our multi-threaded tests.

As such, the benefits of overclocking are variable. We only managed to achieve an all-core overclock of 4.3GHz, even when we pushed the vcore up to 1.425V. This results in a huge 300MHz step down from the stock speed peak boost, but it does give you a 250MHz increase to the all-core boost. Precision Boost Overdrive will likely add a little more to the all-core boost, while enabling you to keep that 4.6GHz peak boost, but it won't be the best option for maximising multi-threaded performance.

In terms of performance, the RealBench system score of 306,884 was second only to the Ryzen 9 3950X, beating the mighty Core i9-10940X in every RealBench test. It was neck and neck with the Intel CPU in Cinebench too, but the Intel chip was significantly quicker in Premiere Pro, as was

24-CARAT GOLD

- + Excellent multi-threaded performance
- + Better value than Intel for content creation
- + Power-efficient

24-HOUR SHIFT

- Slower than Intel in some games
- Poor overclocking headroom
- No faster than Ryzen 3700X in games



the Core i9-10920X. The AMD CPU was slightly quicker in Far Cry New Dawn as well, but dropped a little behind in Metro Exodus.

Even when overclocked, the Core i9-10940X failed to topple the Ryzen 9 3900X in RealBench but it managed a faster Handbrake score, with the AMD CPU not benefiting that much from overclocking. The Intel CPU's massive all-core overclock gave it a commanding lead in Premiere Pro as well, while edging out a lead in our game tests, albeit with far higher power consumption.

Conclusion

If you have £500 to spend on a CPU and need it primarily for content creation, or if you game at high resolutions, the Ryzen 9 3900X is brilliant. It matches or betters far more expensive Intel CPUs and is one of the best AMD CPUs in games. Intel still has a lead in some games at certain settings, but if you play at higher, more GPU-limited resolutions and also need multi-threaded grunt, the Ryzen 9 3900X is unbeatable.

VERDICT

With fantastic multi-threaded power and solid gaming pace, the Ryzen 9 3900X is the best sub-£500 CPU.

PERFORMANCE
45/50

FEATURES
13/15

VALUE
29/35

OVERALL SCORE
87%

SPEC

Base frequency 3.8GHz

Turbo frequency 4.6GHz

Core Zen 2

Manufacturing process 7nm

Number of cores 12 x physical (24 threads)

IGP None

Simultaneous Multithreading Yes

Cache 64MB L3 cache, 6MB L2 cache

Memory controller Dual-channel
DDR4, up to 3200MHz

Packaging AMD Socket AM4

Thermal design power (TDP) 105W

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

INTEL CORE i9-9900KF / £448_{inc VAT}

SUPPLIER laptopsdirect.co.uk

As much as AMD fans might have liked to preach the virtues of the Ryzen 7 2700X over the Core i9-9900K, Intel's ability to hit super-high frequencies, as well as its low inter-core latencies, meant that the latter Core i9-9900K was supremely quick in games. If you wanted to hit extremely high frame rates, perhaps on high refresh rate monitors, it was the go-to CPU, and any game with a modicum of CPU-limited frame rates saw AMD lag behind. AMD has since clawed back an awful lot of ground with Zen 2, though, so is Intel's Hyper-Threaded 8-core CPU still a monster for gaming?

The latest price cuts to both AMD's Ryzen chips and Intel's Cascade Lake-X CPUs mean that Intel's former mainstream

flagship now costs under £480, but there's now a lot more choice out there. For starters, the Core i9-9900K has since been outdone by the 5GHz all-core boosting Core i9-9900KS, and there are also other options available that didn't exist a year ago. First and foremost is the CPU we're reviewing here. The Core i9-9900KF is simply a Core i9-9900K without on-board graphics that shaves a few tenners off the price. Admittedly, you lose the ability for your PC to work without a discrete graphics card, which can be useful for troubleshooting, but AMD's non-APU Ryzen CPUs lack this feature too. You also save a lot more money compared with the Core i9-10900X, and while previous-generation HEDT CPUs such as the Core i9-9820X go for similar amounts of cash, they offer far lower frequencies. Out of the box, the Core i9-9900KF can hit 5GHz on up to two cores and happily sits at 4.7GHz across all cores in multi-threaded applications during our tests. You get 16MB of L3 cache and 2MB of L2 cache, giving it slightly more cache than the Core i7-9700K, in addition to twice the number of threads, thanks to the inclusion of Hyper-Threading support. In terms of performance, the Core i9-9900KF was in the same ballpark as AMD's CPUs in the image editing test and had the measure of the Ryzen 7 3800X in our heavily multi-threaded Handbrake video encoding test too, although it was outgunned by the similarly priced Ryzen 9 3900X. It was fairly even overall, with a system score of 243,615 compared to 241,240 for the AMD Ryzen 7 3800X. Comparatively, the Core i9-10920X scored 245,615, while the Ryzen 9 3900X managed a much higher 306,884. It was an identical story in Cinebench too, where our all-core 5GHz overclock only added a couple of hundred points. It was reasonably



quick in Premiere Pro as well, but not much faster than the Ryzen 7 3800X at stock speed and a little slower once both chips were overclocked. Far Cry New Dawn, though, gave Intel the advantage, with a massive lead over the Ryzen 9 3950X, but a slimmer one in Metro Exodus.

HYPER-THREADING

- + Excellent in games
- + Reasonable multi-threaded performance
- + Huge range of motherboards

HYPERKIDS

- Slower than AMD in content creation
- Still expensive
- AMD is more power-efficient

SPEC

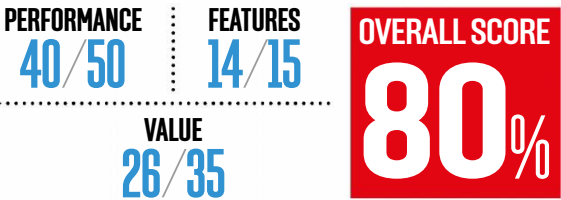
Base frequency	3.6GHz
Turbo frequency	5GHz
Core	Coffee Lake refresh
Manufacturing process	14nm++
Number of cores	8 x physical (16 threads)
IGP	None
Hyper-Threading	Yes
Cache	16MB L3 cache, 8 x 256KB L2 cache
Memory controller	Dual-channel DDR4, up to 2666MHz
Packaging	LGA1151-v2
Thermal design power (TDP)	95W
Features	Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE, MMX

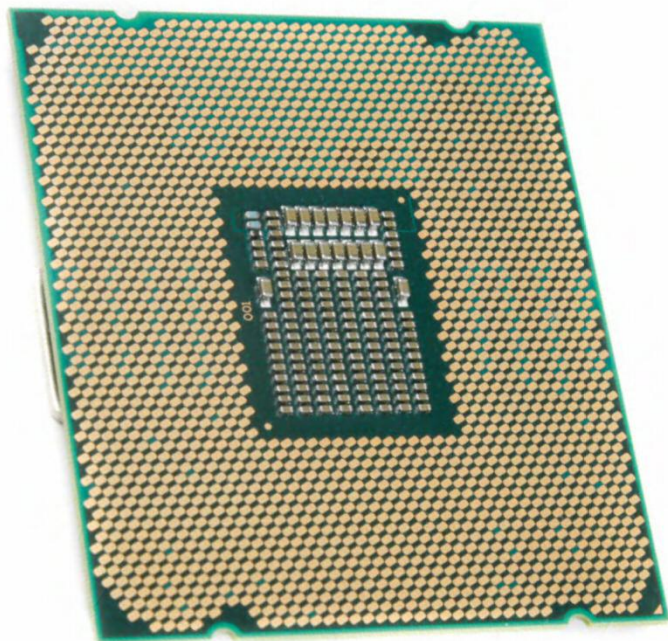
Conclusion

While it's no match for AMD's 3rd-gen Ryzen CPUs in multi-threaded tasks, the Core i9-9900KF is a heck of a lot better than Intel's non-Hyper-Threaded options, and its gaming prowess in many titles means that the Core i9-9900KS isn't a hopeless all-rounder. Games are certainly where it's strongest, but if you dabble in the odd bit of content creation too, it's a decent option if you have the money for it. Outside of dabbling, though, AMD's CPUs quickly start to offer much better value for money.

VERDICT

Worth considering for a high-end gaming PC, but it can't compete with AMD's 3rd-gen Ryzen CPUs on value for money.





INTEL CORE i9-10900X / £612 inc VAT

SUPPLIER novatech.co.uk

Intel's had a tough time reacting to the competitive thread of AMD's Ryzen and Threadripper CPUs. It has combatted the latter by massively increasing the number of cores in its CPUs, from the 10-core Core i7-6950X to the 18-core Core i9-7980XE, and it's combatted the former with massive price cuts.

Add in the supply shortages, and it's clear that Cascade Lake-X hasn't had an easy ride. Both Intel and AMD also have increasingly powerful mainstream offerings, which makes

it hard to see a solid place for a CPU such as the and the Core i9-10900X. It has only two more cores than Intel's Core i9-9900K, and six fewer cores than AMD's slightly more expensive 16-core Ryzen 9 3950X.

Under the hood you'll also find a slightly different CPU die to the others in the Cascade Lake-X range, courtesy of a Low Core Count die (LCC) rather than Intel's High Core Count (HCC) monolithic die that it uses in CPUs with more than ten cores. This is now the third generation of Intel CPUs that are compatible with Intel's X299 chipset, and it could well be the last as well, but that hasn't prevented Intel from increasing the PCI-E lane count from 44 to 48, giving its HEDT platform one advantage over AMD's mainstream platforms. Every Cascade Lake-X CPU supports the maximum number of PCI-E lanes too, which wasn't the case in the early days of the LGA2066 socket.

However, while AMD's X570 chipset has fewer PCI-E lanes, and also lacks the X299 platform's support for quad-channel memory, it does offer PCI-E 4 support. If you just need a powerful CPU, a single GPU and a couple of large, very fast M.2 SSDs, X570 is definitely worth considering over X299.

Apart from the use of an LCC die, the Core i9-10900X is otherwise similar to the other two Cascade Lake-X CPUs we've included in this sub-£1,000 CPU group test. All have 19.25MB of L3 cache, 1MB L2 cache per core, a 165W TDP and are built on Intel's 14nm++ manufacturing process. There's just 100MHz between their peak Turbo Boost Max 3 frequencies too, with the Core i9-10900X sitting at the lower end at 4.7GHz, but with the joint highest all-core boost frequency of 4.3GHz.

With lower frequencies than its mainstream counterparts, the Core i9-10900X didn't fare

particularly well in RealBench, with image editing scores that were slower than every AMD CPU on test. Its video encoding score was reasonable, but it barely beat the Core i9-9900KF here, and it was bettered by the cheaper Ryzen 9 3900X.

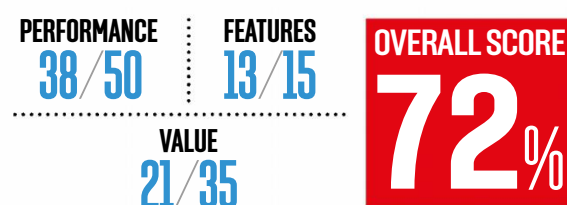
The Core i9-10900X's system score couldn't even keep up with the Ryzen 7 3800X in RealBench, and the Ryzen 9 3900X was quicker in Premiere Pro, which means the 10900X isn't a great option at stock speed. However, we managed to overclock it to 4.8GHz, which saw it better the Ryzen 9 3950X in Premiere Pro and increase its poor gaming results to frame rates that no AMD CPU could match. The downside was that power consumption then rocketed to 465W, from an already high 345W.

Conclusion

Without a massive overclock, the Core i9-10900X is average at best, even in games, but it does have some redeeming qualities once tweaked, most notably in games and Adobe Premiere Pro. However, it's not as fast as cheaper Intel CPUs in games, and the Ryzen 9 3950X is far more powerful in most other tests.

VERDICT

Faster than AMD's options in games once it's overclocked, but the Core i9-10900X is otherwise hard to recommend.



PCI-E LANES

- + Large overclocking headroom
- + More PCI-E lanes than mainstream platforms
- + Excellent overclocked performance

COUNTRY LANES

- High power consumption
- Ryzen 9 3950X generally faster
- Poor at stock speed
- Expensive

SPEC

Base frequency 3.7GHz

Turbo frequency 4.7GHz

Core Cascade Lake-X

Manufacturing process 14nm++

Number of cores 10 x physical (20 threads)

Hyper-Threading Yes

Cache 19.25MB L3 cache, 10 x 1MB L2 cache

Memory controller Quad-channel DDR4, up to 2933MHz

Packaging LGA2066

Thermal design power (TDP) 165W

Features Turbo Boost Max Technology 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE, MMX

INTEL CORE i9-9900KS / £690 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

It's always great to see manufacturers releasing halo products that tip their hats to PC enthusiasts, with the goal of creating a special product rather than a disruptive influence. While we love the thinking behind the Core i9-9900KS, though, it has suffered stock problems, and a delayed launch have meant that it never became a worthwhile consideration.

SPEC

- Base frequency 4GHz
- Turbo frequency 5GHz
- Core Coffee Lake refresh
- Manufacturing process 14nm++
- Number of cores 8 x physical (16 threads)
- Hyper-Threading Yes
- Cache 16MB L3 cache, 8 x 256KB L2 cache
- Memory controller Dual-channel DDR4, up to 2666MHz
- Packaging LGA1151-v2 (Coffee Lake)
- Thermal design power (TDP) 127W
- Features Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE, MMX

The cheapest example we could find cost nearly £700 and, given that most Core i9-9900K CPUs can reach a 5GHz all-core overclock and cost £200 less, it's already hard to recommend the Core i9-9900KS, in spite of its extremely rapid out-of-the-box credentials.

It has a base frequency of 4GHz and, when boosting, all of its cores can reach 5GHz. Comparatively, only two cores were able to stretch that far with the Core i9-9900K at stock speed, and the Core i7-9700K could only reach 4.9GHz on a single core. Engage all the cores, though, and the Core i9-9900K sits 300MHz lower than the Core i9-9900KS and the Core i7-9700K dips to just 4.6GHz. The Core i9-9900KS' all-core boost speed is also 300MHz higher than the Ryzen 9 3950X's single-core boost frequency.

Under the hood is a CPU that's identical to the Core i9-9900K, except for some specially binned silicon. It uses Intel's aging Coffee Lake refresh architecture and a 14nm++ manufacturing process. Plus, unlike Intel's Core i3, Core i5 and Core i7 CPUs, you also get support for Hyper-Threading, meaning it can execute 16 concurrent threads from its eight cores.

AMD's Zen 2 architecture is blistering in our image editing test, and the only CPU to come close to topping 63,000 points is the Core i9-9900KS, which still falls short of matching the Ryzen 5 3600X, let alone the faster AMD chips. However, the Intel chip's eight 5GHz boosted cores meant it could outstrip both the Ryzen 7 3700X and Ryzen 7 3800X in our video encoding and multi-tasking tests – the only CPUs that could beat these results had more than eight cores.

ESPRESSO

- + 5GHz on all cores at stock speed
- + The best gaming performance
- + Decent multi-threaded performance

INSTANT

- Not much faster than the Core i9-9900K
- Disappointing overclocking
- Ryzen 9 3950X is better for content creation

The Core i9-9900K also beat those AMD CPUs in Cinebench.

In terms of pricing, however, the Ryzen 9 3950X costs a similar amount of money to the Core i9-9900KS, and offers far more performance everywhere except gaming, including a faster export time in Premiere Pro too.

In games, however, the Core i9-9900KS is lightning fast, managing the highest results in Far Cry New Dawn, while Metro Exodus seemed to prefer CPUs that lacked Hyper-Threading, which isn't unusual. It was still quicker than the Ryzen 9 3950X here, and extended its lead once we'd overclocked it to 5.1GHz too. The overclock was a little disappointing, given that the CPU can already reach 5GHz at stock speed, but it was achieved without any additional voltage. It drew noticeably more power than AMD's 8-core CPUs at both stock and overclocked speeds though.

Conclusion

Knocking the price and availability might seem a bit harsh, given that the Core i9-9900KS was only ever meant to be a limited-edition halo product, but even halo products need to stand up against the competition. While the Core i9-9900KS is a stunning gaming CPU, and the fastest 8-core CPU on test elsewhere too, it's just far too expensive to be worth considering. It lacks the multi-threaded grunt of the similarly priced Ryzen 9 3950X, and an overclocked Core i9-9900K will provide similar gaming performance for much less money.

VERDICT

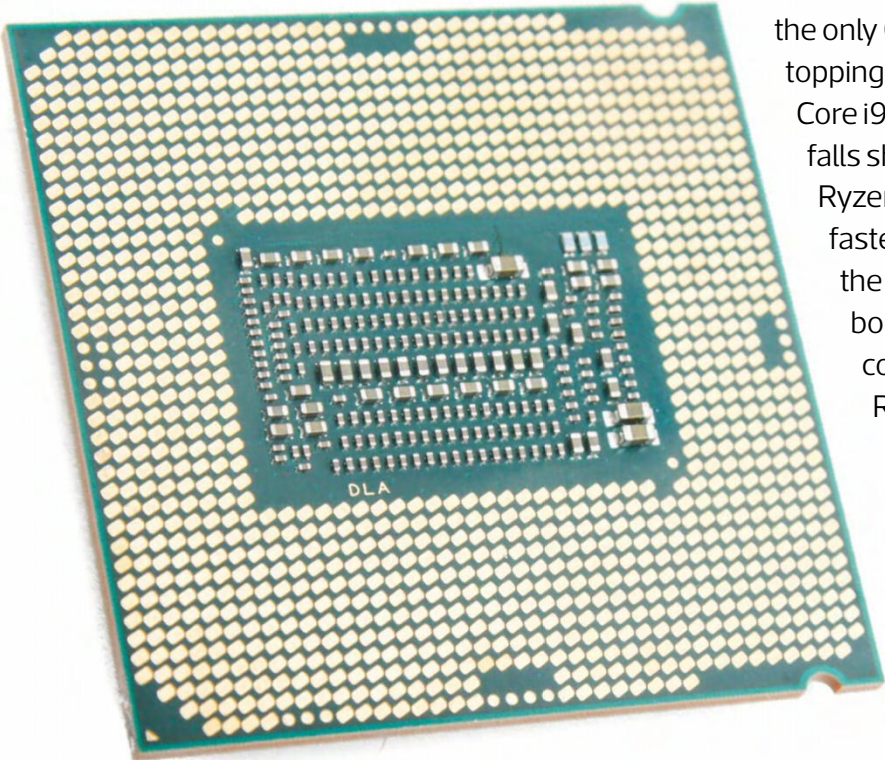
A brutally fast gaming CPU but it's far too expensive compared with the competition.

PERFORMANCE
41/50

FEATURES
13/15

VALUE
21/35

OVERALL SCORE
75%



AMD RYZEN 9 3950X / £698 inc VAT

SUPPLIER [overclockers.co.uk](https://www.overclockers.co.uk)

As if AMD's monster 16-core mainstream CPU wasn't disruptive enough, it's fallen £50 since launch and now sits at under £700. It's certainly not affordable for everyone, but considering it keeps up with Intel CPUs that cost close to £2,000 a year ago, its value, even at this price, is hard to dismiss. So much so that it resulted in Intel slashing prices of its Cascade Lake-X CPUs and even then, they still only offer niche appeal.

As well as 16 cores and 32 threads courtesy of Simultaneous Multithreading, the Ryzen 9 3950X uses AMD's 7nm Zen 2 architecture to great effect. It's far easier to tame in terms of cooling than Intel's Core i9-10980XE or Core i9-10940X, which sport 18 and 14 cores respectively. It has a massive 64MB L3 cache

HOT CHOCOLATE

- + Massive multi-threaded performance
- + Awesome bang for your buck
- + Good choice of motherboards

HOT WATER

- Cheaper 3rd-gen Ryzen CPUs perform similarly in lightly threaded software
- Limited overclocking headroom
- Slower than Intel CPUs in some scenarios

SPEC

Base frequency 3.5GHz

Turbo frequency 4.7GHz

Core Zen 2

Manufacturing process 7nm

Number of cores 16 x physical (32 threads)

Simultaneous Multithreading Yes

Cache 64MB L3 cache, 16 x 512KB L2 cache

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging Socket AM4

Thermal design power (TDP) 105W

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



and 8MB L2 cache, and has the highest peak boost frequency of any 3rd-gen Ryzen CPU at 4.7GHz, although that will drop to around 4GHz once all 16 cores are under load.

Whether or not you want to overclock this CPU is a tricky question. We managed an all-core manual overclock of 4.35GHz using a vcore of 1.375V. This will obviously see better multi-threaded performance, but as overclocking disables boosting, that's as high as things will go, meaning you lose 350MHz of single-core boost. This will result in slower performance in lightly threaded tasks.

The competition doesn't really come in the form of any mainstream CPU from Intel, as the only CPU we'd recommend in this category that gets close to the Ryzen flagship's price is the Core i9-9900K, but it offers half the number of cores and correspondingly costs less than £500. This means the 3950X sits in a rather lonely position, lacking the PCI-E lanes and quad-channel memory of Intel's HEDT CPUs. However, if you're just concerned with raw performance, then the Core i9-10920X and Core i9-10940X are definitely in its sights.

Unfortunately for Intel, the AMD CPU does exceptionally well in most tests. It was blistering in our image editing test, the fastest by a long way in the video encoding and multi-tasking tests and its system score of 326,395 at stock speed was higher even than the overclocked Core i9-10940X. It was totally dominant in Cinebench and once overclocked, managed to top 10,000 points. Only in Adobe Premiere Pro was it

slower than Intel's HEDT CPUs, where the Core i9-10920X and Core i9-10940X held commanding leads once overclocked and were quicker at stock speed too.

In games it was the fastest of AMD's offerings, but in Far Cry New Dawn, Intel still enjoyed a noticeable lead with its mainstream CPUs, but its Cascade Lake-X CPUs were poor until overclocked, where they matched the Ryzen 9 3950X. Metro Exodus was a similar story. However, drawing just 242W at stock and 340W when overclocked under load means it's far more efficient.

Conclusion

It might still fall short of Intel in some games, but the gap is closer than ever and, in many games, and more GPU-bound settings, doesn't exist at all. It's overkill for a gaming system, though, where Intel's Core i9-9900K is still a monster and Intel is often quicker in Adobe Premiere Pro too, but if you need the best all-rounder, the Ryzen 9 3950X is fantastic.

VERDICT

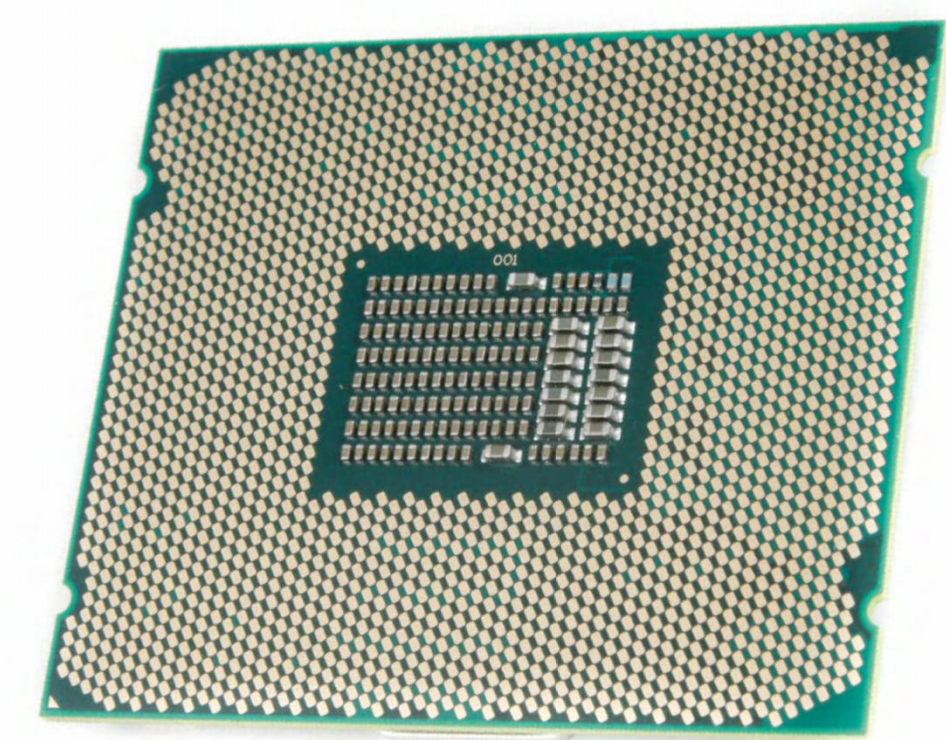
A stunning all-rounder with serious multi-threaded grunt and reasonable gaming pace.

PERFORMANCE
48/50

FEATURES
13/15

VALUE
25/35

OVERALL SCORE
86%



INTEL CORE i9-10920X / £712 inc VAT

SUPPLIER novatech.co.uk

Intel's Core i9-10920X costs only a little bit more money than AMD's Ryzen 9 3950X, at least from some retailers (supply of Cascade Lake-X chips is still short, see p114). However, it has four fewer cores than the Ryzen 9 3950X – that's not quite as big a deficit as with the Core i9-10900X, but it immediately puts this Cascade Lake-X chip at a disadvantage against the 3950X in many multi-threaded tasks, which isn't great from a value point of view.

STICKY TOFFEE PUDDING

- + Decent overclock potential
- + Loads of PCI-E lanes
- + Good Premiere Pro performance

STICKY FINGERS

- High power consumption
- Ryzen 9 3950X is faster in most tests
- Poor at stock speed

SPEC

Base frequency	3.5GHz
Turbo frequency	4.8GHz
Core	Cascade Lake-X
Manufacturing process	14nm
Number of cores	12 x physical (24 threads)
Hyper-Threading	Yes
Cache	19.25MB L3 cache, 12 x 1MB L2 cache
Memory controller	Quad-channel DDR4, up to 2933MHz
Packaging	LGA2066
Thermal design power (TDP)	165W
Features	Turbo Boost Max Technology 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE, MMX

Unlike the Core i9-10900X, the 10920X is also based on Intel's High Core Count (HCC) die, which is also used in the top-end Core i9-10980XE, except several of its cores are disabled in the 10920X. Like its Cascade Lake-X counterparts, it uses a 14nm++ manufacturing process, has 19.25MB of L3 cache and 12MB of total L2 cache. It has a 165W TDP, and at stock speed, it can hit a peak boost of 4.8GHz, while loading all cores will see each one hitting 4.3GHz, which is the same as the Core i9-10900X.

It's worth reiterating some X299 platform statistics in case you haven't read the review of the Core i9-10900X, which are that Intel has increased the PCI-E lane count from 44 to 48, giving it more of an advantage over AMD's X570 platform. The latter does offer PCI-E 4 support, but it has fewer lanes at its disposal and you only get the extra bandwidth if you're using PCI-E 4 devices, which doesn't include any of Nvidia's current top GPUs. If you want to run many PCI-E devices with the maximum number of lanes, X299 is still a better option than X570 in some cases.

Comparatively, the price of AMD's 3rd-gen Threadripper CPUs and X399 motherboards means AMD now has limited options for high-end desktop systems below its mighty TRX40 platform, especially with the early demise of the Threadripper 2920X.

While the 10920X stormed to fourth place in our video encoding test, it was still outperformed by the cheaper Ryzen 9 3900X, which was also quicker in every other RealBench test, as well as Cinebench. However, in Adobe Premiere, the Core

i9-10920X was faster than every AMD CPU and was a match in games too, although it was a little slow in Far Cry New Dawn.

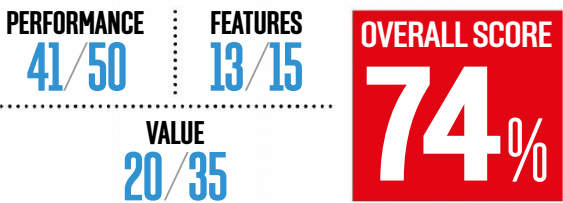
Incredibly, we got all 12 cores up to 4.9GHz using a 1.3V vcore, which transformed performance. It then bettered the Ryzen 9 3900X in our video encoding test and nearly matched it in Cinebench, while putting itself out of reach in Adobe Premiere. It also leaped ahead of the Ryzen 9 3950X in Metro Exodus and matched it in Far Cry New Dawn. However, this overclock resulted in huge power consumption, which at 517W, was more than double that of our system with the 16-core Ryzen 9 3950X running at stock speed.

Conclusion

Had the Core i9-10920X arrived at this price a year ago, Intel would have had a winner on its hands, but the CPU market is now quite crowded and there are better options. The Ryzen 9 3950X offers similar or better performance in most tests for the same cash, while the Ryzen 9 3900X is much cheaper and quicker in some tests, which puts the Core i9-10920X in a difficult situation. It's fast when overclocked, but it needs to be cheaper to really compete.

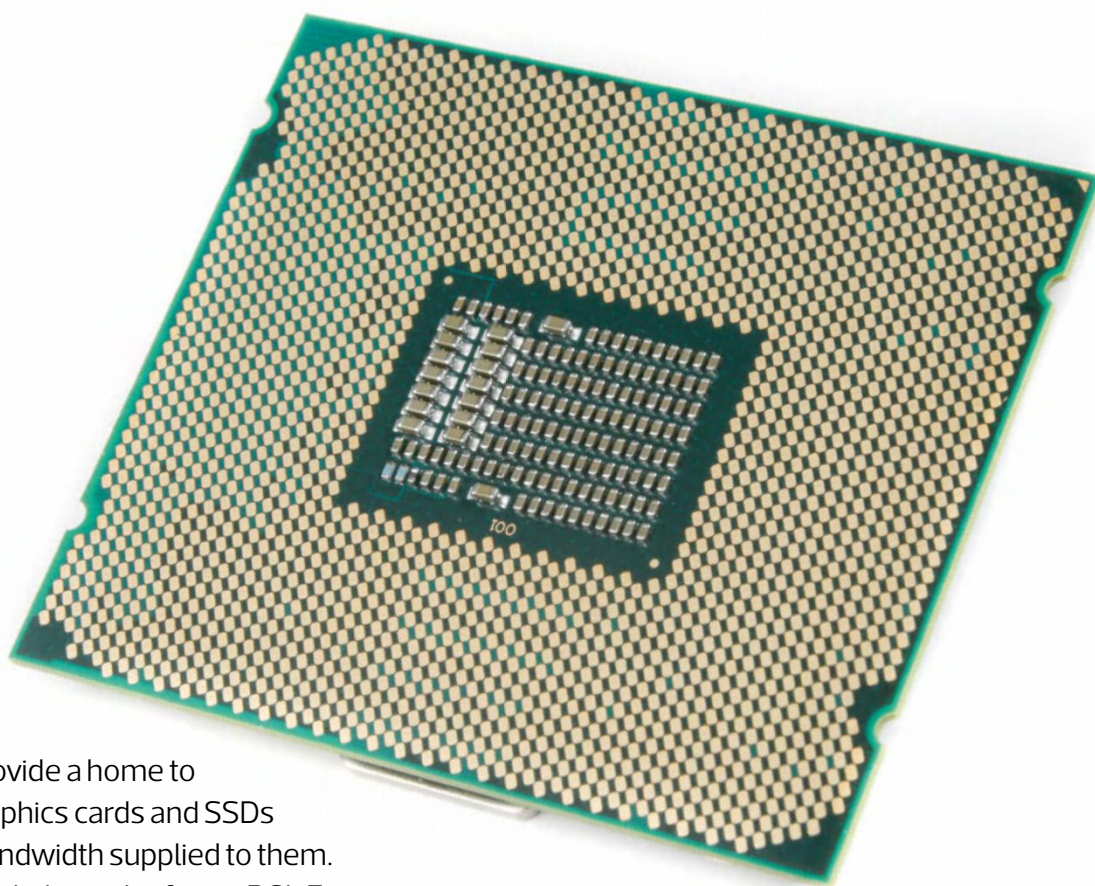
VERDICT

Worth considering for a video editing PC, but otherwise, there are several better options.



INTEL CORE i9-10940X / £828 inc VAT

SUPPLIER novatech.co.uk



With the Core i9-10980XE out of reach in this sub-£1,000 Labs test, the Core i9-10940X is Intel's most potent weapon on test this month, and at £828, also the most expensive CPU in this roundup. This means it's the target for AMD's Ryzen 9 3950X, which undercuts it by £100 and offers an additional two cores over and above the Intel CPU's 14. However, aside from multi-threaded performance, there's a number of reasons why you might consider the Core i9-10940X over the Ryzen 9 3950X.

Firstly, the accompanying X299 platform is mature and motherboards can now be bought for under £150. That's less than the price of any AMD X570 motherboards we could find – you'd need to lose PCI-E 4 support and dip down to boards based on AMD's older X470 or B450 chipsets to get a similarly priced motherboard. Secondly, you get quad-channel memory support with X299, as well as 48 PCI-E lanes, meaning

you can provide a home to several graphics cards and SSDs with full bandwidth supplied to them.

AMD might have the faster PCI-E 4 protocol, but while some X570 motherboards offer three or more M.2 PCI-E 4 slots, there are still bandwidth limitations that will hinder the performance when hammering several M.2 PCI-E SSDs at the same time. That's clearly not an issue for most of us, but high-end content creators dealing with lots of massive files would benefit from opting for X299 or either of AMD's HEDT Threadripper platforms, which have even more PCI-E lanes, in particular linking the CPU to the chipset.

The Core i9-10940X also has a 4.8GHz peak boost frequency and can reach 4.1GHz across all cores under multi-threaded loads, so it's a little slower on the latter than the other two Cascade Lake-X CPUs in this group test. It has the same 19.25MB L3 cache as its siblings, but more L2 cache at 14MB, thanks to fewer cores being disabled on its High Core Count (HCC) die.

In terms of performance, the Core i9-10940X was the most powerful of all Intel's CPUs in our RealBench tests, coming second only to the AMD Ryzen 9 3900X and 3950X. It matched the former in Cinebench and was quicker than both the AMD chips in

Adobe Premiere pro, albeit not by as much as the price difference would suggest.

It was similar in our game tests too, but in a familiar story, a monster overclock of 4.9GHz across all 14 cores allowed the CPU to offer similar performance to the Ryzen 9 3950X outside of games and was massively faster in Adobe Premiere Pro. The overclock lifted its previously mediocre gaming results above AMD's reach too, but at a huge cost to power consumption, which hit 576W and was even a significant 378W at stock speed.

Conclusion

The Core i9-10940X is a beast of a CPU when overclocked and offers stellar Adobe Premiere performance when outputting 4K video projects. It also matches or betters the Ryzen 9 3950X in games and comes close in other content creation software. Ultimately, the AMD CPU offers better value for money, but if you're prepared to overclock your CPU, and spend a lot of time in Premiere Pro and dabble in the odd gaming session, it won't disappoint. **GPC**

SPEC

Base frequency 3.3GHz

Turbo frequency 4.8GHz

Core Cascade Lake-X

Manufacturing process 14nm

Number of cores 14 x physical (28 threads)

Hyper-Threading Yes

Cache 19.25MB L3 cache, 14 x 1MB L2 cache

Memory controller Quad-channel DDR4, up to 2933MHz

Packaging LGA2066

Thermal design power (TDP) 165W

Features Turbo Boost Max Technology 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSE3, SSE2, SSE, MMX

AUTOBAHN

- + Huge all-core overclocking potential
- + More PCI-E lanes than mainstream platforms
- + Great Adobe Premiere performance

M25

- Huge power consumption, especially when overclocked
- Ryzen 9 3950X is cheaper and faster in many tests
- Poor at stock speed

VERDICT

A beast once it's overclocked, but only in select applications.

PERFORMANCE
43/50

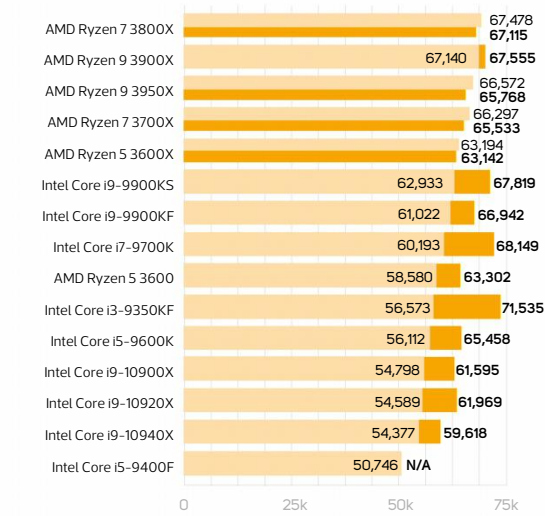
FEATURES
13/15

VALUE
19/35

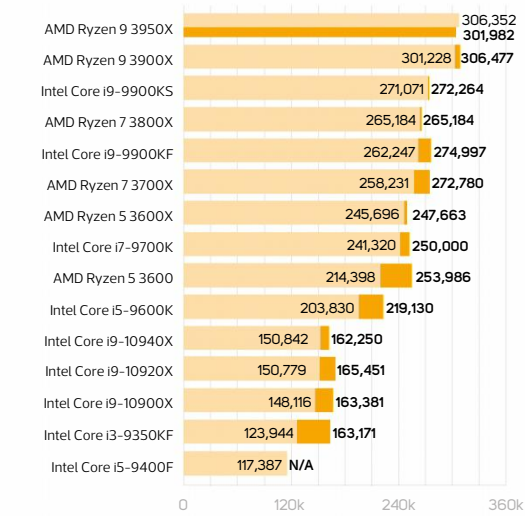
OVERALL SCORE
75%

CPU LABS RESULTS

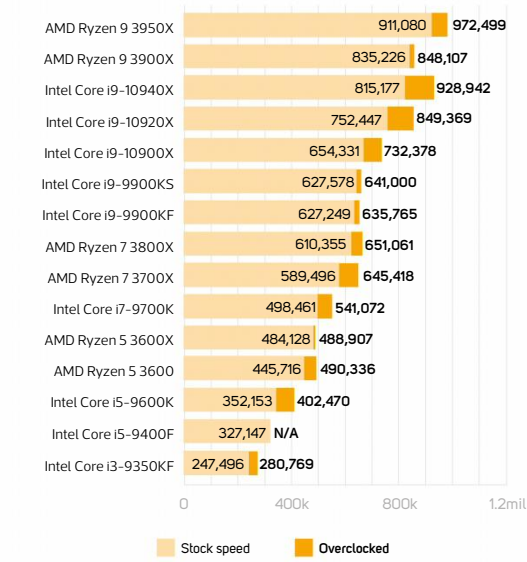
GIMP IMAGE EDITING



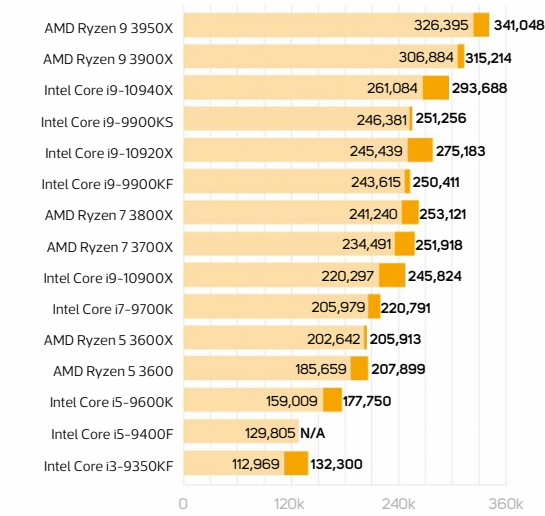
HEAVY MULTI-TASKING



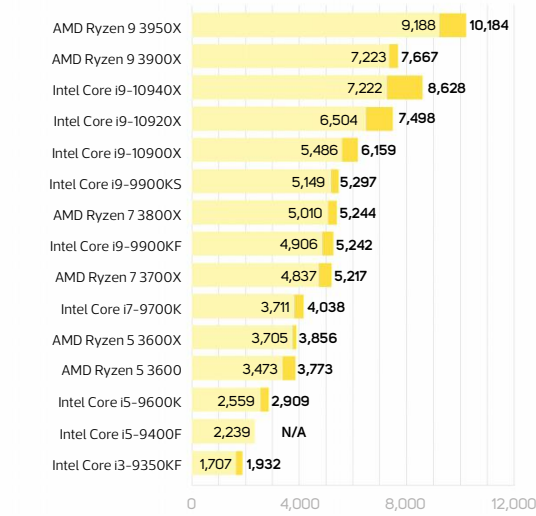
HANDBRAKE H.264 VIDEO ENCODING



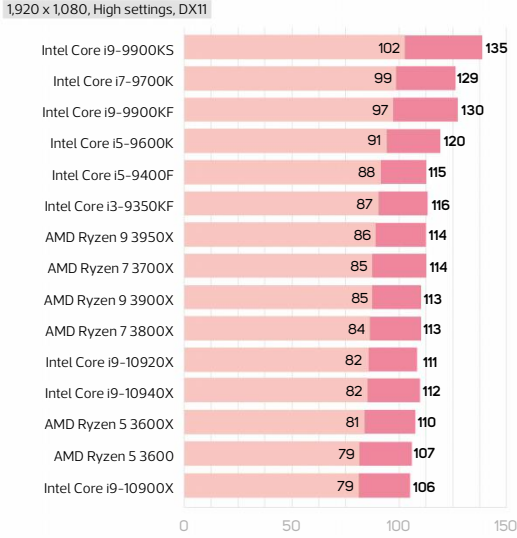
SYSTEM SCORE



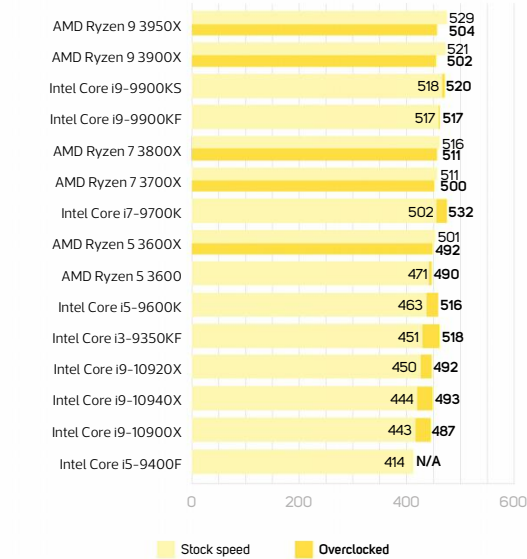
CINEBENCH R20 MULTI-THREADED



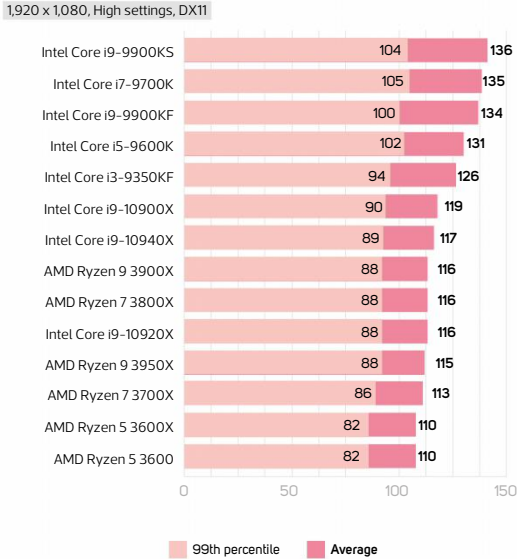
STOCK SPEED FAR CRY NEW DAWN (FPS)



CINEBENCH R20 SINGLE-THREADED



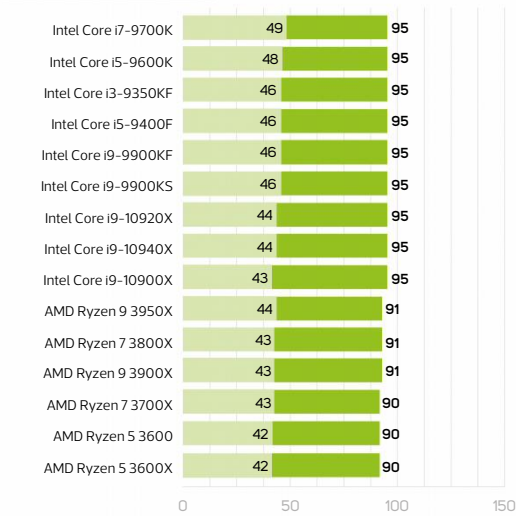
OVERCLOCKED FAR CRY NEW DAWN (FPS)



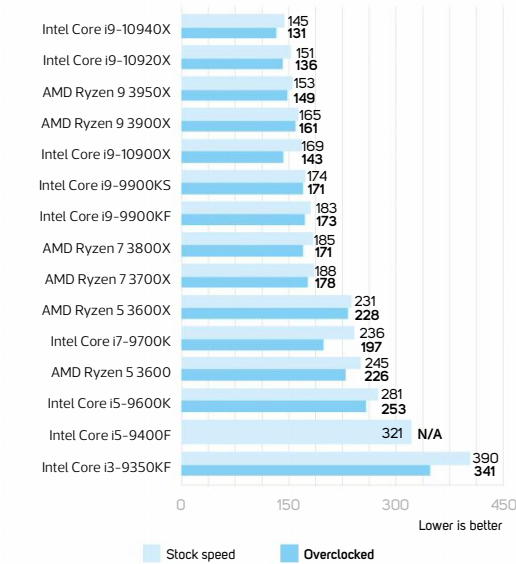
CPU LABS RESULTS

STOCK SPEED METRO EXODUS (FPS)

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

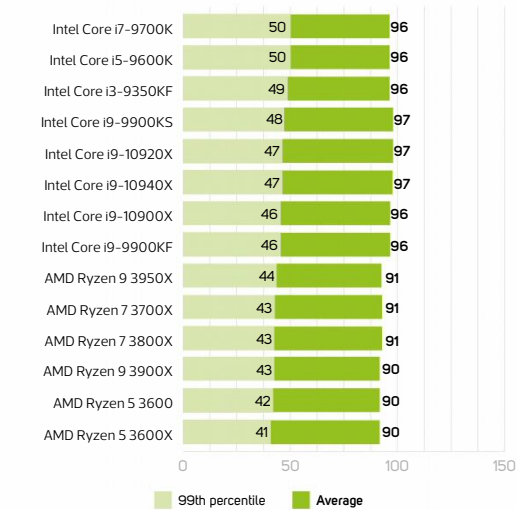


ADOBE PREMIERE PRO 4K VIDEO EXPORT (SECONDS)



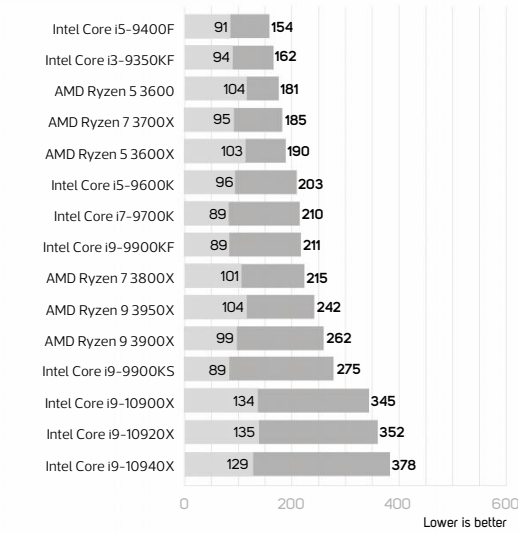
OVERCLOCKED METRO EXODUS (FPS)

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



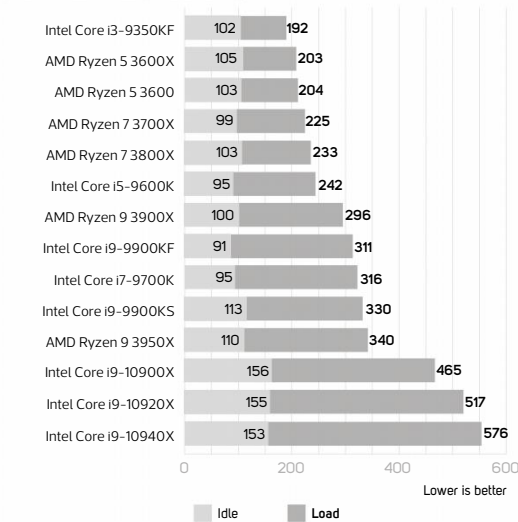
STOCK SPEED TOTAL SYSTEM POWER CONSUMPTION (WATTS)

Windows Desktop / Prime95 smallfft



OVERCLOCKED TOTAL SYSTEM POWER CONSUMPTION (WATTS)

Windows Desktop / Prime95 smallfft



How we test

MOTHERBOARDS

TEST PROCESSORS

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

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

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



PROCESSORS

TEST MOTHERBOARDS

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

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

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



MONITORS

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



CPU COOLERS

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



TEST KIT

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

INTEL LGA1151

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

INTEL LGA2066

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

AMD AM4

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

AMD TR4

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

GRAPHICS CARDS



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

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

TEST KIT

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

GAME TESTS

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

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

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

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



POWER CONSUMPTION

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

CUSTOM PC AWARDS



EXTREME ULTRA

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



PREMIUM GRADE

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



PROFESSIONAL

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



APPROVED

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



CUSTOM KIT

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

CUSTOM PC REALBENCH

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

GIMP IMAGE EDITING

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

HANDBRAKE H.264 VIDEO ENCODING

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

LUXMARK OPENCL

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

HEAVY MULTI-TASKING

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

Core component bundles

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

Budget system with integrated graphics

Quad-core CPU, basic gaming

Needs a micro-ATX or ATX case.

We recommend a 350W 80 Plus power supply.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3400G	scan.co.uk	#194, p20	£120
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	#176 p80	£0
GRAPHICS CARD	AMD Radeon RX Vega 11 integrated into CPU	N/A	#194 p20	£0
MEMORY	8GB (2 x 4GB) Corsair Vengeance LPX 3000MHz (CMK8GX4M2A 3000C16)	scan.co.uk	#176 p80	£42
MOTHERBOARD	MSI B450M Mortar (micro-ATX)*	scan.co.uk	#182 p50	£88
STORAGE	500GB WD Blue SN500 (M.2 NVMe)	ebuyer.com	#191 p78	£59

Total £309

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

Budget gaming system

Quad-core CPU, 1080p gaming

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



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i3-8100	cclonline.com	#191 p78	£107
CPU COOLER	Rajjintek Juno Pro RBW	overclockers.co.uk	#191 p78	£12
GRAPHICS CARD	Zotac Gaming GeForce GTX 1660 Super	ebuyer.com	#199 p46	£199
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX 3000MHz (CMK16GX4 M2A2666C16)	scan.co.uk	#191 p78	£67
MOTHERBOARD	Gigabyte B360M DS3H (micro-ATX)	scan.co.uk	#191 p78	£75
STORAGE	500GB WD Blue SN500 (M.2 NVMe)	ebuyer.com	#191 p78	£59

Total £519

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 2060 (1080p gaming with ray tracing and some 2,560 x 1,440 gaming)	ebuyer.com	#199 p50	£270
SWAP STORAGE	Kingston A2000 1TB	laptopsdirect.co.uk	#196 p30	£149

Mid-range all-purpose system

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

Needs an ATX case. We recommend using a 550W power supply with 80 Plus Bronze certification. See Issue 193, p76, for a similar example build guide.



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3600	cclonline.com	#200 p43	£157
CPU COOLER	Deepcool Gammaxx GT	scan.co.uk	#192 p52	£35
GRAPHICS CARD	Zotac GeForce RTX 2060 Super Mini	ebuyer.com	#199 p53	£339
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3200MHz (AX4U320038G16-DT60)	cclonline.com	#199 p57	£100
MOTHERBOARD	MSI X570-A Pro (ATX)	cclonline.com	#193 p48	£150
STORAGE	1TB Corsair MP600	amazon.co.uk	#193 p26	£172
Total £953				

UPGRADES

SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 Super (2,560 x 1,440 gaming with real-time ray tracing)	scan.co.uk	#193 p16	£450
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	#166 p54	£90
SWAP CPU COOLER	ARCTIC Liquid Freezer II 240	scan.co.uk	#196 p26	£60

Mid-range gaming system

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

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



COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 3700X	overclockers.co.uk	#200 p47	£260
CPU COOLER	ARCTIC Liquid Freezer II 240	scan.co.uk	#196 p26	£60
GRAPHICS CARD	Nvidia GeForce RTX 2070 Super	scan.co.uk	#193 p16	£450
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U3600 38G17-DT60)	cclonline.com	#199 p57	£138
MOTHERBOARD	Asus ROG Strix X570-E Gaming (ATX)	overclockers.co.uk	#193 p44	£300
STORAGE	1TB Corsair MP600	amazon.co.uk	#193 p26	£172
Total £1,380				

UPGRADES

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

Core component bundles cont ...

4K gaming system

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



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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 9 3900X	overclockers.co.uk	#200 p51	£440
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	#175 p20	£120
GRAPHICS CARD	Nvidia GeForce RTX 2080 Ti	scan.co.uk	#189 p20	£982
MEMORY	16GB (2 x 8GB) ADATA XPG Spectrix D60G 3600MHz (AX4U3600 38G17-DT60)	cclonline.com	#199 p57	£138
MOTHERBOARD	MSI Prestige X570 Creation (E-ATX)	overclockers.co.uk	#193 p48	£420
STORAGE	1TB Corsair MP600	amazon.co.uk	#193 p26	£172
Total £2,262				
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	#166 p55	£90
SWAP CPU	AMD Ryzen 9 3950X (16 cores)	overclockers.co.uk	#197 p24	£698

Heavy multi-threading workstation

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



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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Threadripper 3960X	overclockers.co.uk	#197 p18	£1,250
CPU COOLER	Enermax Liqtech II TR4 240 (240mm AIO liquid cooler)	overclockers.co.uk	#186 p44	£130
GRAPHICS CARD	Zotac Gaming GeForce GTX 1660 Super	ebuyer.com	#199 p46	£199
MEMORY	32GB Corsair Dominator Platinum RGB 3466MHz (CMT32GX4 M4C3466C16)	scan.co.uk	#197 p20	£286
MOTHERBOARD	ASRock TRX40 Taichi (E-ATX)	overclockers.co.uk	#198 p44	£470
STORAGE	1TB Corsair MP600	amazon.co.uk	#193 p26	£172
Total £2,507				
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 2070 Super (2,560 x 1,440 gaming with ray tracing, and some 4K gaming)	scan.co.uk	#193 p16	£450
SWAP CPU	AMD Threadripper 3970X (32 cores - massive multi-threaded power)	overclockers.co.uk	#197 p19	£1,770
ADD SECONDARY STORAGE	6TB Seagate BarraCuda Pro	cpc.farnell.com	#166 p50	£216

Mini PCs

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

Mini-ITX



Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	ASRock Z390 Phantom Gaming-ITX/ac	scan.co.uk	#185 p50	£177
AMD X570 (AM4 budget)	Gigabyte X570-I Aorus Pro WiFi	overclockers.co.uk	#195 p24	£227
AMD X570 (AM4 mid-range)	Asus ROG Strix X570-I Gaming	overclockers.co.uk	#198 p20	£270

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Metallic Gear Neo Mini	amazon.co.uk	#195 p48	£60
MID-RANGE	Phanteks Enthoo Evolv Shift Air	overclockers.co.uk	#195 p49	£95
PREMIUM	Lian Li PC-Q37WX	overclockers.co.uk	#195 p47	£225

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	#143 p17	£42

Power supplies

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
800W SFX	SilverStone StriderSX800-LTI	scan.co.uk	#185 p82	£160



ATX Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	#176 p28	£55
BUDGET QUIET	be quiet! Pure Base 500	aquatuning.co.uk	#196 p24	£68
BUDGET RGB	Phanteks Eclipse P400A	novatech.co.uk	#194 p24	£84
SUB-£100	Lian Li Lancool One Digital	overclockers.co.uk	#184 p32	£95
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	#187 p24	£135
HIGH-END	NZXT H700i	overclockers.co.uk	#196 p51	£170
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	#187 p24	£200
LUXURY	Cooler Master Cosmos C700M	awd-it.co.uk	#183 p28	£410

Micro-ATX



Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z390 (LGA1151)	Asus ROG Maximus XI Gene	overclockers.co.uk	#189 p28	£285
AMD X399 (TR4)	ASRock X399M Taichi	scan.co.uk	#179 p28	£318
AMD B450 (AM4)	MSIB450M Mortar	scan.co.uk	#182 p50	£88

Cases

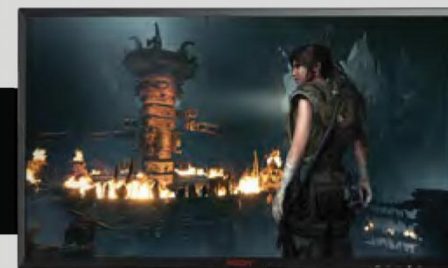
CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	overclockers.co.uk	#180 p46	£47
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	#161 p26	£80

Networking



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER (WI-FI 6)	TP-Link Archer AX6000	amazon.co.uk	#196 p57	£250
MESH ROUTER (WI-FI 5)	Netgear Orbi 2-Pack (RBK50)	amazon.co.uk	#172 p57	£260
PREMIUM MESH ROUTER (WI-FI 6)	Asus AiMesh AX6100	amazon.co.uk	#196 p54	£350
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	#196 p58	£60
SINGLE-BAY NAS BOX	Synology DS118	box.co.uk	#174 p34	£146
DUAL-BAY NAS BOX	Synology DiskStation DS220j	span.com	#200 p22	£149
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	#174 p34	£180

Monitors



AMD FreeSync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN BUDGET 1,920 X 1,080	AOC G2460VQ6	amazon.co.uk	#174 p52	£114
24IN MID-RANGE 1,920 X 1,080	AOC C24G1	cclonline.com	#191 p28	£180
24IN 240Hz ESPORTS 1,920 X 1,080	AOC AGON AG251FZ	cclonline.com	#187 p48	£292
27IN 2,560 X 1,440	Samsung C27HG70	ebuyer.com	#171 p28	£445

Nvidia G-Sync

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN 2,560 X 1,440	AOC AGON AG241QG	amazon.co.uk	#169 p55	£400
27IN 2,560 X 1,440	Asus ROG Swift PG279Q	ebuyer.com	#155 p48	£721
35IN ULTRA-WIDE 3,440 X 1,440	AOC AGON AG352UCG6	overclockers.co.uk	#180 p52	£670
27IN 4K PREMIUM	Asus ROG Swift PG27UQ	scan.co.uk	#181 p31	£1,956
35IN ULTRA-WIDE HDR 3,440 X 1,440	Asus ROG Swift PG35VQ	scan.co.uk	#198 p58	£2,700

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	£170
25IN MID-RANGE 1,920 X 1,080	Asus VG258QR	currys.co.uk	#190 p54	£269

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN 4K	AOC U2790PQU	lambda-tek.com	#194 p30	£293
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	£45
MECHANICAL	Corsair K68 RGB	ebuyer.com	#181 p53	£120
MECHANICAL MMO	Corsair K95 RGB Platinum	scan.co.uk	#164 p26	£140
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	#193 p56	£130
LUXURY MECHANICAL	Razer Huntsman Elite	scan.co.uk	#193 p59	£189

Gaming mice



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Corsair M55 RGB Pro	scan.co.uk	#200, p24	£25
FIRST-PERSON SHOOTER	SteelSeries Rival 600	cclonline.com	#184 p59	£65
MMO	Razer Naga Trinity	scan.co.uk	#186 p52	£79
AMBIDEXTROUS	Razer Lancehead Tournament Edition	currys.co.uk	#177 p53	£60
ULTRA LIGHTWEIGHT	Glorious PC Gaming Race Model O	overclockers.co.uk	#195 p58	£45

Peripherals and audio cont ...

Game controllers



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEERING WHEEL & PEDALS	Logitech G920 Driving Force	currys.co.uk	#159 p55	£180
GAMEPAD	Microsoft Xbox One Wireless Controller	argos.co.uk	#191 p56	£45

Speakers

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

Gaming headsets



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Sennheiser GSP 300	amazon.co.uk	#194 p56	£90
SURROUND	Asus ROG Centurion	cclonline.com	#163 p49	£216
WIRELESS	SteelSeries Arctis 7	currys.co.uk	#178 p58	£115
PREMIUM WIRELESS	Corsair Virtuoso RGB Wireless SE	overclockers.co.uk	#195 p30	£180

PCs and laptops



Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET PC WITH INTEGRATED GRAPHICS	Falcon Raptor RX	AMD Ryzen 5 3400G stock speed	AMD Radeon RX Vega 11	falconcomputers.co.uk	#176 p52	£400
SUB-£1,000 GAMING	AlphaBeta i5 RTX	Intel Core i5-9600KF stock speed	Nvidia GeForce RTX 2070 Super	alphabetapc.com	#197 p40	£999
8-CORE GAMING	Wired2Fire Predator	AMD Ryzen 7 3700X stock speed	Nvidia GeForce RTX 2060 Super	wired2fire.co.uk	#196 p40	£1,290
GEFORCE RTX 2080 SUPER GAMING	CyberPower Ultra 7 RTX	AMD Ryzen 7 3800X stock speed	Nvidia GeForce RTX 2080 Super	cyberpowersystem.co.uk	#199 p34	£1,895
PREMIUM MINI-ITX	Corsair One i160	Intel Core i9-9900K stock speed	Nvidia GeForce RTX 2080 Ti	corsair.com	#190 p32	£3,250
16-CORE GAMING	Scan 3XS Vengeance RTX Ti	AMD Ryzen 9 3950X stock speed	Nvidia GeForce RTX 2080 Ti	scan.co.uk	#200 p32	£3,200
WATER-COOLED 16-CORE GAMING	Scan 3XS Vengeance RTX Ti Fluid	AMD Ryzen 9 3950X OC to 4.3GHz	Nvidia GeForce RTX 2080 Ti	scan.co.uk	#197 p42	£4,499
THEADRIPPER PC	Chillblast Fusion Conqueror	AMD Ryzen Threadripper 3970X stock speed	Nvidia GeForce RTX 2080 Ti	chillblast.com	#199 p32	£5,999
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	2 x Nvidia GeForce RTX 2080 Ti	scan.co.uk	#145 p58	£12,916

Laptops



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

Games



RICK LANE / INVERSE LOOK

MOD CONS

What's the difference between a mod and a game?
Rick Lane explores the impact of modding on PC gaming

Is Black Mesa (see p70) a game or a mod? This conundrum has been bouncing around my head ever since I finished Crowbar Collective's incredible remake of Half-Life. What started out as an absurd pipe dream in 2004 is now a complete redesign of Valve's masterpiece in the latest version of the Source engine. It includes an entirely rebuilt Black Mesa Facility, and a new version of Xen that's massively expanded and reimaged.

Given the extent of the work involved, alongside the fact that it's available on Steam for £14.99, it's reasonable to ask, is Black Mesa really a mod any more? On the other hand, is calling it a game unfair to the legion of modders who have worked so hard across the years to bring this remake into fruition?

Does it even matter? Well, the difference between mods and games has been contentious in the past. You only need look back to the paid mods fiasco of 2015, where Steam and Bethesda introduced (and then very quickly retracted) a small number of purchasable mods on Skyrim's Steam workshop. The community reacted furiously, on the basis that mods are enthusiast productions, which should always be free, and that such a move by Bethesda would open the floodgates to developers cashing in on their communities.

Regardless of whether Bethesda and Valve were right or wrong, the line between mod and game is clearly significant, but that line is also often vaguer than most think. A classic example is Counter-Strike. It's one of the biggest multiplayer games in the world, but it started as a simple mod for Half-Life, taking the technology and tools of that game and creating

an entirely distinct experience. This is a fairly well-known story, but by the same logic, one could also argue that Half-Life is simply a mod for Quake. Half-Life runs on GoldSrc, a heavily modified version of the Quake engine that Valve licensed from id.

It may seem absurd to call Half-Life a mod, but what exactly is it that makes Half-Life more worthy of the 'game' definition than Counter-Strike? We talk about games as if they're somehow more significant than mods, yet many mods are responsible

for some of the most significant shifts in the game industry. For a relatively recent example, look at DayZ – a mod for ArmA 2, which took its military-sim setting and altered it into a gritty zombie survival game. Alongside Minecraft, DayZ was one of the key titles that influenced the rise of the survival game.

But DayZ's influence was even more far-reaching – it was so popular that it ended up generating its own modding community. One of these sub-mods was called DayZ: Battle Royale. This became so popular that its creator, Brendan Greene (known online as 'PlayerUnknown'), decided to create a standalone game named PlayerUnknown's Battlegrounds, one of the most popular games of the past couple of years. And Battlegrounds, of course, was the main inspiration for Fortnite.

In other words, you can trace an entire shift in how people play to a single mod for a relatively niche military sim. I'm still not sure how you define the line between mods and games, but I know that PC gaming would be a very different place without mods. **CPC**

It may seem absurd to call Half-Life a mod, but what makes it more of a 'game' than Counter-Strike?

Rick Lane is Custom PC's games editor [@Rick_Lane](#)

Darksiders Genesis

/ **£24.29** inc VAT

DEVELOPER Airship Syndicate / **PUBLISHER** THQ Nordic

Darksiders Genesis is essentially a buddy-cop movie set in Hell. It sees two of the four horsemen of the apocalypse – War and Strife – dispatched by the arbiters of reality, known as the Charred Council, to check up on Lucifer. Shockingly, the Council believes that the lord of Hell might have been misbehaving, and wants the horsemen to set Satan straight.

As with every Darksiders game, the story is hot nonsense and all the better for it. The script gleefully revels in the absurd machinations of Hell's various demonic overlords, while the rapport between the two protagonists is never less than delightful. Strife is the axe to War's grindstone, constantly chatting, jibing and joking while War grunts and harrumphs his vaguely irritated replies. It's a classic straight man/jester act – it's just that the performers happen to be the harbingers of doom.

The two characters also form Genesis' key mechanical gimmick, as each of them has a unique fighting style. War is all brawn and blades, getting in close and hacking at enemies with his sword. Strife, on the other hand, is a gunslinger, preferring to blast opponents with his twin pistols. Genesis is designed as a cooperative game, with two players each controlling a character, but it's entirely possible to play through the game as a single player, with Genesis letting you switch between the two heroes at any point.

The combat is slick and satisfying, and it evolves pleasingly across the course of the game. As you progress, you'll unlock new moves, new special powers such as War's ability to create a ring of stabbing blades around himself, and new weapon modes such as Strife's charge-shot. Unlike, say, Diablo, Genesis isn't exclusively a combat game, with puzzle-platforming sections that



work surprisingly well given the isometric viewpoint. To complement this half of the game, certain items in your inventory are designed as much for puzzling as fighting.

These include Void Grenades, which create portals you can use to access new areas, and War's boomerang-like spinning blade, which can activate remote switches.

Mechanically, there's little wrong with Genesis.

Instead, the game's main problem is the emphasis on replaying levels. Character progress is geared in such

a way that you'll always be slightly underpowered for the coming stage.

The idea is to encourage players to go back to older levels and use new equipment to explore new paths, but it ends up just making you feel like you're being forced to grind, which is particularly frustrating given the game has such a propulsive forward momentum. Despite this, Genesis remains a well-crafted bit of ridiculous action, and upholds the series' well-earned reputation for punching above its weight.

RICK LANE

GENESIS

- + Delightfully daft story
- + Cracking combat
- + Fun puzzling element

EXEGESIS

- Annoying emphasis on grind

/ VERDICT

Despite a rather grindy midgame, Darksiders Genesis is a finely crafted ARPG spin-off.

OVERALL SCORE

80%





Black Mesa / £14.99 inc VAT

DEVELOPER Crowbar Collective / PUBLISHER Crowbar Collective



After 16 years in development, Crowbar Collective's remake of the original Half-Life is (basically) complete. While Black Mesa: Earthbound was released eight years ago, that version only took players from Gordon Freeman's arrival at the facility through to his teleportation to Xen. However, Half-Life's famously underwhelming finale was left out, as Crowbar Collective opted to spend more time fashioning it into something special.

That second half of the game is finally out, and calling it a second half isn't an overstatement. Crowbar Collective's interpretation of Xen is nothing short of remarkable, comfortably transcending Valve's original work, and making Black Mesa not just a remake but a game in its own right.

Before we discuss this more recent update, though, it's worth briefly going over Crowbar Collective's work on updating the Black Mesa parts of the game. Eight years since release, these parts hold up remarkably well. While they undoubtedly show their age in certain areas, Black Mesa still offers a massive visual upgrade over the original Half-Life. Key scenes such as the introductory tram ride have been packed with additional detail, while the scientists and guards of the facility are now unique personalities rather than eerie clones.

What made Black Mesa particularly interesting was that, although it was broadly a recreation, it wasn't afraid to add its own spin on certain aspects of Half-Life, even making edits to the original structure where it felt necessary. Certain chapters, such as On a Rail and the mid-part of Surface Tension, had the more tedious sections edited out. It still treated the more iconic moments of the Half-Life story with the respect they deserved though. The resonance cascade, the monster in the Blast Pit and the battle with the helicopter in Surface Tension were all carefully recreated.

Even without the Xen chapters, Black Mesa is an astonishing bit of work; a fan remake that goes above and beyond what anyone could have expected. Freed from the

SURFACE TENSION

- + Huge visual upgrade
- + Faithful recreation of key levels
- + Incredible redesign of Xen

UNFORESEEN CONSEQUENCES

- Source showing its age in some areas
- Interloper level too long



constraints of remaining faithful to the original (because nobody cared that much for Xen anyway), Crowbar Collective has let its imagination run wild, creating what's effectively a whole new chapter in the Half-Life story.

The Xen portion of the original Half-Life consisted of four chapters, named Xen, Gonarch's Lair, Interloper and Nihilanth. Black Mesa follows this structure, but radically expands and alters the content within those chapters. The first chapter itself is a prime example. In the original Half-Life, this chapter is just a few minutes long, and consists of Gordon hopping across a few floating islands down to a larger island at the bottom.

Black Mesa's Xen, by comparison, offers two solid hours of nonstop exploration and combat, in the prettiest and most detailed environments we've ever seen created in the Source engine. The opening few minutes are a barrage of kaleidoscopic alien vistas, a vast expanse of rocky islands teeming with strange plants and wildlife. Crowbar Collective's work brings the Source engine about as close to modern production values as possible.

Beyond the visual improvement, however, Black Mesa's Xen lends Half-Life's alien world a far more coherent sense of place. The ecosystem shows us multiple different types of environment, ranging from those indigo islands to lush green swamplands with leaves the size of cars. It also shows us the Black Mesa facility's own attempt to explore Xen in much greater detail. One of the early highlights sees you exploring an abandoned mobile laboratory established by the Lambda team on the planet itself.

Xen has its fair share of combat encounters, but the focus is more on exploration and puzzling. That all changes in Gonarch's Lair. Previously a straightforward boss fight, Crowbar Collective has expanded this chapter into a spectacular cat-and-mouse chase through Xen's seemingly

endless subterranean caverns. There are some incredible scripted sequences in this chapter. One sees you trapped in a tiny cave while the Gonarch stabs at you from above with its pincer-like legs. It's phenomenal, breathless material that's up there with the best action sequences from Half-Life 2.

Gonarch's Lair is the highlight of Black Mesa's Xen remake. By comparison, Interloper is where Crowbar Collective stumbles. Most of this chapter takes place in a huge alien factory, where Xen's overlord, the Nihilanth, creates the foot soldiers in its army. It's an impressive piece of level design that features puzzles galore. Unfortunately, it's also too long, and repeats the same beats and environments too many times. There are good bits to it, but you'll be glad once it's over.

Luckily, Black Mesa ends on a high, with the titanic battle against the giant, baby-headed Nihilanth. In the original battle, Nihilanth had the ability to teleport Gordon into various different places. Crowbar Collective has wisely decided to remove this ability, refining the battle into a straightforward and spectacular grudge match. If you ever wanted to know what it's like to have a building thrown at you, well, Black Mesa has you covered.

At the time of writing, Black Mesa isn't 100 per cent finished. Crowbar Collective is making some final updates to the multiplayer side of the game, as well as polishing up a few areas of the Black Mesa facility itself to bring it more in line with the visual fidelity of Xen. Even without those final tweaks, however, Black Mesa remains a stunning update for Half-Life.

It's comfortably as good as any remake from major studios in recent years, happily sitting alongside big-budget redesigns such as Shadow of the Colossus and Resident Evil 2. If you're thinking of replaying the Half-Life series in anticipation of Half-Life: Alyx, we strongly recommend starting with Black Mesa.

RICK LANE

/ VERDICT

A thrilling and meticulous remake that begins as a nostalgia trip and ends as a whole new experience.

OVERALL SCORE

90%





Transport Fever 2 / £31.99 inc VAT

DEVELOPER Urban Games / PUBLISHER Good Shepherd Entertainment

BULLET TRAIN

- + Fun feedback loops
- + Lovely vehicle models
- + Good introductory campaign

BRITISH TRAIN

- Poor economy simulation
- Sandbox lacks depth

/ VERDICT

Transport Fever 2's simple vehicular pleasures just about make up for its simulation's lack of depth.

OVERALL SCORE

70%

Transport Fever 2 sees you assume the role of a budding city logistics tycoon. Your goal is to transform isolated rural backwaters into hives of industry by connecting them to the resources and goods they need.

Whether you're playing through the campaign or creating your own transport empire in the sandbox mode, the game's basic function is the same. You'll be presented with a detailed 3D map covered in settlements, each of which needs one or two different resources that can be created by establishing a production chain. If a city needs bread, for example, you need to connect a farm to a food production factory, then connect the factory to the city.

The fundamentals are identical for all modes of transport. You need to create stops, stations or ports at each point along the chain, create a new 'route' that connects those stops together, then assign vehicles to that route. You earn money each time you make a successful delivery or collection. Each vehicle type has its own benefits and drawbacks. Trucks are cheap, for example, but they're also slow and have limited carrying capacity. Trains are faster and can carry more cargo, but they're also more expensive.

The result is a gently pleasing game of constructing and refining increasingly intricate transportation networks. There's a quaint joy to establishing a new inner-city bus route that helps people get around without causing traffic snarl-ups, or seamlessly connecting a new train line to existing tracks. It helps that the vehicles are so delightfully detailed – you can even see the route stops changing on the front of individual buses. Maps also evolve dramatically

across the course of a game, cities and factories grow and thrive, while your transport network evolves from Victorian wagons and steam engines to bullet trains and jet liners.

Transport Fever's main issue is engendering a sense of challenge. It's hardest at the start, as you need to outlay large amounts of money to get your networks running. Once they're set up, however, your economy quickly becomes a perpetual money-making machine, and potential brakes on your growth, such as congestion and pollution, don't have the expected impact.

The campaign offers more structure than the sandbox, going from setting up wagon trails in the Old West to establishing high-speed rail lines in Japan. However, it's also mainly a tutorial for the sandbox mode, and there's little more depth to the sandbox than the campaign. This doesn't prevent Transport Fever 2 from being an engaging virtual train set. Just don't expect it to offer much more reward than a new vehicle every now and again.

RICK LANE





Journey to the Savage Planet

£23.99 inc VAT

DEVELOPER Typhoon Studios/ PUBLISHER 505 Games

Journey to the Savage Planet is a gaudy sci-fi adventure that excels at assimilating ideas from other games, but struggles to bring much that's original to the table. You play an interstellar explorer whose ship has crash-landed on a mysterious world. Your job is to evaluate the planet for potential colonisation on behalf of your employer, the totally not oppressive Kindred Technologies.

Savage Planet offers a blend of platform-based exploration, light puzzling and lighter combat. The planet is an eye-catching collection of floating islands dominated by a vast alien megastructure at the centre. You start at the frozen fringes of the planet, and to explore further, you need to collect resources to unlock new equipment, such as a jetpack and a grappling hook. You then traverse new paths, unlocking more equipment.

Savage Planet feels great beneath your fingers, and its motley alien world is rife with dramatic vistas and strange wildlife that constantly invites exploration. It also seems

huge while being impressively self-contained. You can complete the main story in five to ten hours, although the optional side-missions and abundance of secrets will roughly double that time.

However, the game never really evolves beyond these basics. The platforming is fine, but not amazing. The puzzles are gently enjoyable, but rarely captivate. The combat has some neat little gadgets, such as acid grenades and a sticky goo that can snare enemies in place, but most of the alien creatures you face aren't especially challenging.

That said, Savage Planet also has comedy. It's an openly ridiculous game, blending Paul Verhoeven-like capitalist satire with 1990s TV-style slapstick humour. Almost every alien you kill gunges you with vibrant goo when it dies, while your spaceship's viewing screen constantly blares adverts for the latest life-improving space product.

It's intermittently funny, but unfortunately, it approaches humour like a medieval siege, barraging you with stupid jokes and stupider noises (nearly all the aliens make some kind of fart sound, for example). The funniest character is your own protagonist, whose hands silently convey more humour than the rest of the script. The way he shakes goo off his fingers after poking an alien plant in its bulbous eye; the way he stumbles out of your spaceship's cloning machine after being killed for the umpteenth time – these elements add a unique flavour to Savage Planet.

Journey to the Savage Planet is the equivalent of a Saturday morning cartoon. It's daft, colourful and rarely less than pleasant, but it's also never especially challenging.

RICK LANE

SAVAGE

- + Visually delightful
- + Intermittently funny
- + Enjoyable exploration

SAUSAGE

- Humour can irritate
- No real ideas of its own

/ VERDICT

An entertaining sci-fi adventure, but despite all the noise it makes, it fails to stand out from the crowd.

OVERALL SCORE

65%



REALITY CHECK

Rick Lane flies a virtual TARDIS, steps into a moving comic book and looks at Nvidia's new VR super-sampling

OPINION

SHARE TACTICS

Sharing images and video is now a common part of modern gaming. It's always fun to share a daft screenshot or a cool video from your games with friends, but the ability to create and share media varies wildly between different virtual reality devices.

For example, if you want to take a screenshot on the Valve Index, you simply press the trigger and system-menu button at the same time.

Compare this simplicity with the equivalent system on the Oculus Quest. On this device, you need to open the Oculus menu, go to the Sharing section, select 'Take photo' and then wait in-game for the Quest to actually take the shot.

It's an unwieldy process, which makes it near impossible to get decent in-game shots to share. The Quest's video recording functions aren't much better either.

One of the big problems when it comes to broadening the appeal of VR is communicating to people just what VR implies. Good quality images and videos can make this communication easier, but VR hardware manufacturers need to make it easy to create and share this media in the first place.



REVIEW

DOCTOR WHO: THE EDGE OF TIME / £14.99 inc VAT

DEVELOPER Maze Theory / PUBLISHER Playstack

All I want from a VR Doctor Who game is to see the TARDIS phase into existence in front of me, and then seamlessly step through its tiny blue doors into its huge interior. That's it. Whatever else happens, if a Doctor Who VR experience can get that moment right, it has a shot at being worth playing.

Doctor Who: The Edge of Time fluffs it. The TARDIS appears in front of you, you open the doors and walk straight into a loading screen. It's a deeply deflating experience that sums up this mediocre game. The Edge of Time sees you play as a nameless Doctor companion who is washing their clothes in a laundrette when reality starts to break down. Moments later, the Doctor appears on a TV screen, and explains that reality has been infected by a virus. The Doctor herself is trapped at the edge of time (whatever that means), so she needs your help to rectify the situation.

It's a typical Doctor Who tale, which is to say that it's a barrage of nonsense, but it hopes you won't notice that if it explains everything fast enough. However, it's also

hard not to get carried away by its relentless upbeat tone, and it has the benefits of being amusingly written and superbly acted. Despite being stuck on the dark side of time, Jodie Whitaker still makes a holographic appearance as the Doctor, and is just as excellent VR as she is on TV.

Unfortunately, the sharp script and sharper acting are let down by what's an inescapably basic VR game. To fix reality, you need to find three 'time crystals' located on three different planets. This amounts to three abridged Doctor Who adventures stapled together, interspersed with simplistic puzzle solving and the occasional bit of stealth.

Part of the issue is that the game has no consistent mechanics. For example, early in the game, you get to 'fly' the TARDIS, which amounts to turning the dials and pulling the levers in a certain order. The appeal of this is obvious, but the mechanic never appears again after that initial puzzle.

Later in the game, you need to sneak around an ancient temple patrolled by Daleks in a fun-but-basic stealth sequence.

Five minutes later, you're hiding yourself inside





a Dalek casing and fighting your way to the objective. The game never focuses on one idea long enough to get the most out of it, making it feel more like a prototype than an actual game. The only consistent tool you're given is the Sonic Screwdriver, which you use for opening doors and little else.

There are other issues too. Visually, the game veers between passable and downright ropery. Also, moving around before the game is ready will cause the screen to cut to black, before the game respawns you back to where you need to be. The story might be enough to keep a Doctor Who fan interested, but as an interactive VR experience, *The Edge of Time* is best left alone.

DOCTOR WHO

- + Excellent acting
- + Funny script

DOCTOR NO

- Looks rough in places
- No real mechanical core
- Fudges the TARDIS introduction

VERDICT

Despite a decent script and Jodie Whittaker's voice talent, *The Edge of Time* is undone by ropery visuals and a lack of meaningful interactions.

OVERALL SCORE

45%



NEWS

IMMERSIVE ARTWORK

Back in 2016, Oculus released Quill, a VR painting app that's roughly equivalent to Google's Tiltbrush, letting users create 'immersive artworks' using an array of different tools that can then be explored in VR. In other words, it lets you create paintings through which you can walk.

There's a good chance you haven't heard of Quill, which is probably why Oculus has now released Quill Theatre, a free program for the Oculus Quest that lets you view

existing Quill artworks, and also gives Quill artists a proper way to show off their works.

Quill Theatre's selection of available artworks is curated, but there are some truly impressive works among them. One that particularly stands out is *The Remedy* (pictured), a ten-minute fantasy animation that's essentially a moving comic book in which you can walk around. Quill Theatre is integrated into the TV app on Oculus Quest, although Quill itself is still a Rift-only program.

NEWS

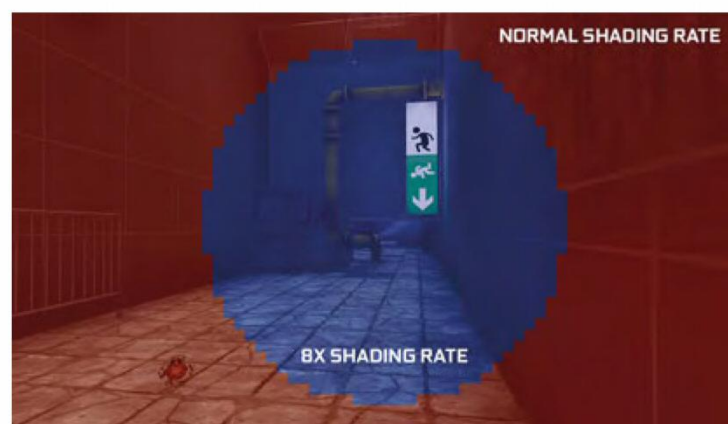
NVIDIA ADDS VR SUPER-SAMPLING

Nvidia's GeForce RTX cards are known mainly for their ray-tracing capabilities, but the latest driver update means owners of RTX GPUs can now also see benefits in VR. Nvidia has added a new variable-rate super-sampling (VRSS) feature into its latest update, designed to increase the visual fidelity of PC VR games while maintaining playable frame rates.

VRSS uses a specific approach known as 'foveted super-sampling', where it focuses sampling on the image towards the centre, while maintaining the periphery of the image at the standard shading rate. In other words, you'll get the best image quality in the place where your eyes normally focus on the image, making for much faster performance than

super-sampling the whole image.

The benefits for VR are obvious, since it sharpens the area viewed through the lenses in VR goggles. The tech is also designed to dynamically scale according to available GPU power, increasing the sampling rate to up to 8x on powerful GPUs, or disabling itself if the GPU begins to struggle. **GPC**



TOTAL RECALL

EDWARD CHESTER EXPLORES THE INNER WORKINGS OF MODERN MEMORY. NO MIND TRICKS INVOLVED

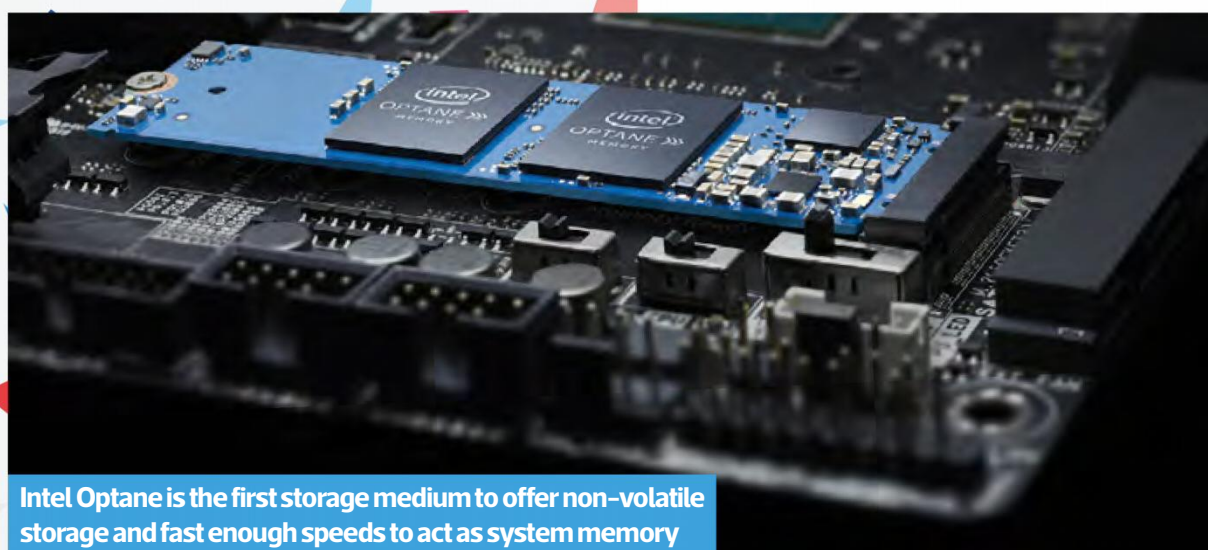
There are few elements of computing that are more misunderstood than random access memory, or RAM. It's both incredibly important for maximising performance of other components, yet it can't boost performance in and of itself. Moreover, with different CPUs benefiting in different ways from different RAM speeds, and other processing units such as GPUs often using their own dedicated RAM, there's a lot of confusion over the

exact role of system memory. So, to help clear up the situation, we're going to get right back to basics and explore the inner workings of the memory that sits at the heart of modern-day PCs.

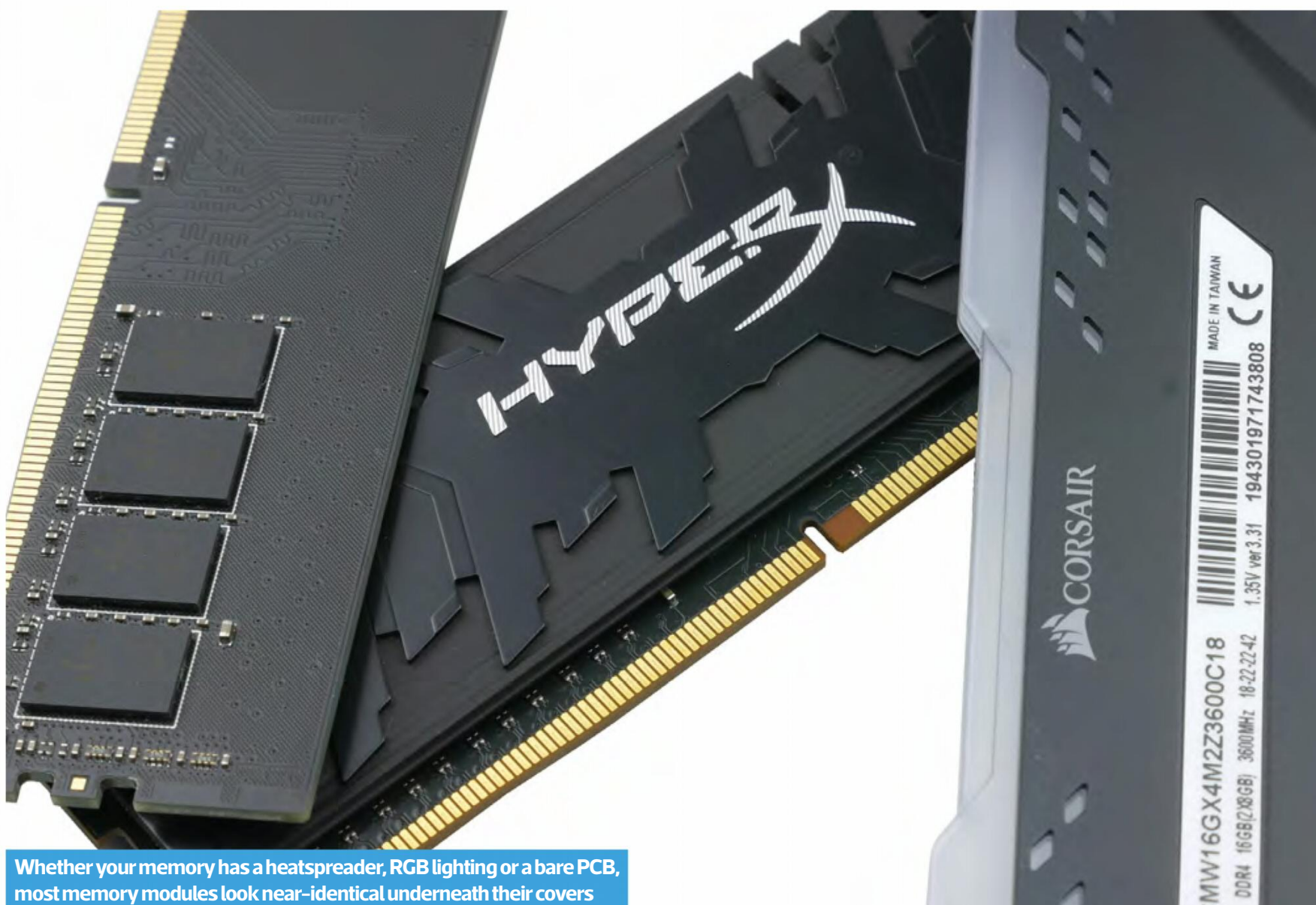
THE BASICS

At its most basic, main system memory is simply a temporary storage place for the data that your PC's CPU and other processing components, such as GPUs, are working on. In theory, a CPU could retrieve all data directly from long-term storage such as hard drives and SSDs, but because these storage mediums are relatively slow, a faster intermediary is required. When a program starts, data is loaded into memory from long-term storage, which is why you get those classic game and program loading times where files are being retrieved from long-term storage.

The need for separate long-term storage is twofold. First, making system memory large enough to store all the data



Intel Optane is the first storage medium to offer non-volatile storage and fast enough speeds to act as system memory



Whether your memory has a heatspreader, RGB lighting or a bare PCB, most memory modules look near-identical underneath their covers

we need would make it hugely expensive – there’s a reason why most systems make do with around 16GB of RAM. Secondly, and more importantly, system memory isn’t able to retain its data when power is lost: it’s volatile. As such, non-volatile storage such as hard drives and SSDs is required to retain data when you switch off your PC.

This is one area where Intel’s recently developed Optane technology can help. Optane is a storage medium that’s both non-volatile and yet fast enough to not need a faster intermediary. Data can be loaded straight out of Optane storage and written back again. However, Optane still isn’t as fast as conventional memory, and it’s expensive as a long-term storage medium, so for most PC applications, the RAM/SSD dichotomy is here for the foreseeable future.

There are also further layers to this collecting of data into faster mediums. Once data goes from memory into the CPU (or other processing units), there are generally several further layers of ever faster, ever smaller memory known as caches. For most

CPUs, you get three levels of cache. Level one (L1) cache is the fastest and smallest, and it sits right inside individual processing cores. Then we have L2 cache, which is also generally dedicated to a single CPU core but offers a larger capacity. Finally, there’s L3 cache, which is much larger again and is generally shared across several cores.

SRAM IS EXTREMELY QUICK, SO IT’S THE OBVIOUS CHOICE FOR A MEMORY TECHNOLOGY THAT SITS CLOSEST TO THE PROCESSING UNITS OF A CPU

Meanwhile, for GPUs, even main system memory isn’t fast enough for the amount of data it needs to process, so it has its own dedicated video RAM (VRAM). This memory intercepts any data relevant to graphics processing and takes over the job of providing that data for the GPU.

It’s this hierarchy of data access that allows our computers to both store huge volumes of data indefinitely and still provide lightning-

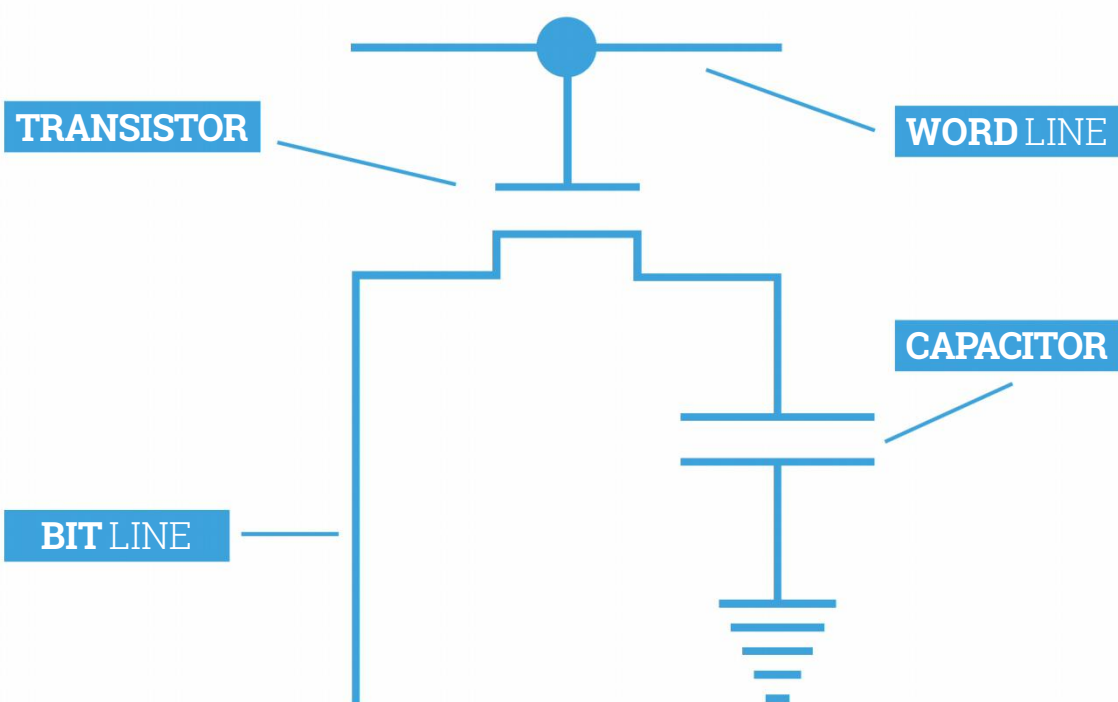
quick data processing, such as the processing required for rendering 3D graphics in games.

Crucially, you can also see from this setup how the roll of memory is intrinsically linked with the overall speed of a PC. If your memory, or the internal caches of a processing unit, aren’t large or fast enough, they’ll hold back performance. However,

equally we can see that buying ever faster memory doesn’t make a CPU or GPU itself faster – it simply eliminates a bottleneck.

WHAT IS DRAM?

By and large, each of the types of memory, from on-chip caches through system memory, to long-term storage, all use fundamentally different technologies for storing data. For instance, caches tend to



Each bit of memory is made up of a single transistor and capacitor connected to a bit line and word line

be a variant of static RAM (SRAM). This relies purely on a clever arrangement of transistors to form a circuit that can permanently store (so it's static) a bit of information, as long as power remains on. This makes it ideally suited for large-scale production alongside the many other transistors that make up a CPU or GPU.

Moreover, SRAM is extremely quick, so it's the obvious choice for a memory technology that sits closest to the processing units of a CPU. However, because it requires six transistors for every bit of information to be stored, it's very space-inefficient, making it unrealistic as a means of producing larger stores of main system memory.

At the other end of the scale, you have memory such as the NAND flash that's used in SSDs. This memory also relies on transistors, but a different type that can trap a small electrical charge. These are great for long-term storage, as the charge can be trapped almost indefinitely even without power. However, relatively speaking, it's very slow and you can also only write to it a limited number of times, which is no good for main system memory.

Instead, main system memory is made up of dynamic RAM (DRAM). This uses just a single transistor coupled with a single capacitor to store one bit. The capacitor can store an electrical charge, which denotes the binary 1 or 0 depending on if it's charged or

not, while the transistor is used to switch the charge of the capacitor. This much simpler arrangement is far more space-efficient than SRAM, so it's much cheaper to manufacture. It's also much faster than NAND, and you can write to it as many times as you like.

Crucially, though, DRAM is much slower than SRAM, and it also requires the state of each memory cell to be refreshed continuously. This is because capacitors quickly leak electrical charge, so the charge has to be restored regularly. What's more, the mere act of reading the charge on the

WHEN A READ OR WRITE REQUEST ARRIVES, WE JUST NEED TO SPECIFY ON WHICH ROW THE DATA SITS AND IN WHICH COLUMN THE WORD STARTS

capacitor drains it, meaning any read data has to be written back again. This need to constantly refresh the charge is in large part why DRAM is so slow compared with SRAM.

CREATING MEMORIES

While the basic building block of DRAM is the simple coupling of a capacitor and a transistor, there is of course a lot more involved with making a memory module. The first step is stringing together thousands of these cells into an efficient grid arrangement (a memory array). Laid

out in this way, each cell can be located, or addressed, according to the intersection of the row and column in which it sits.

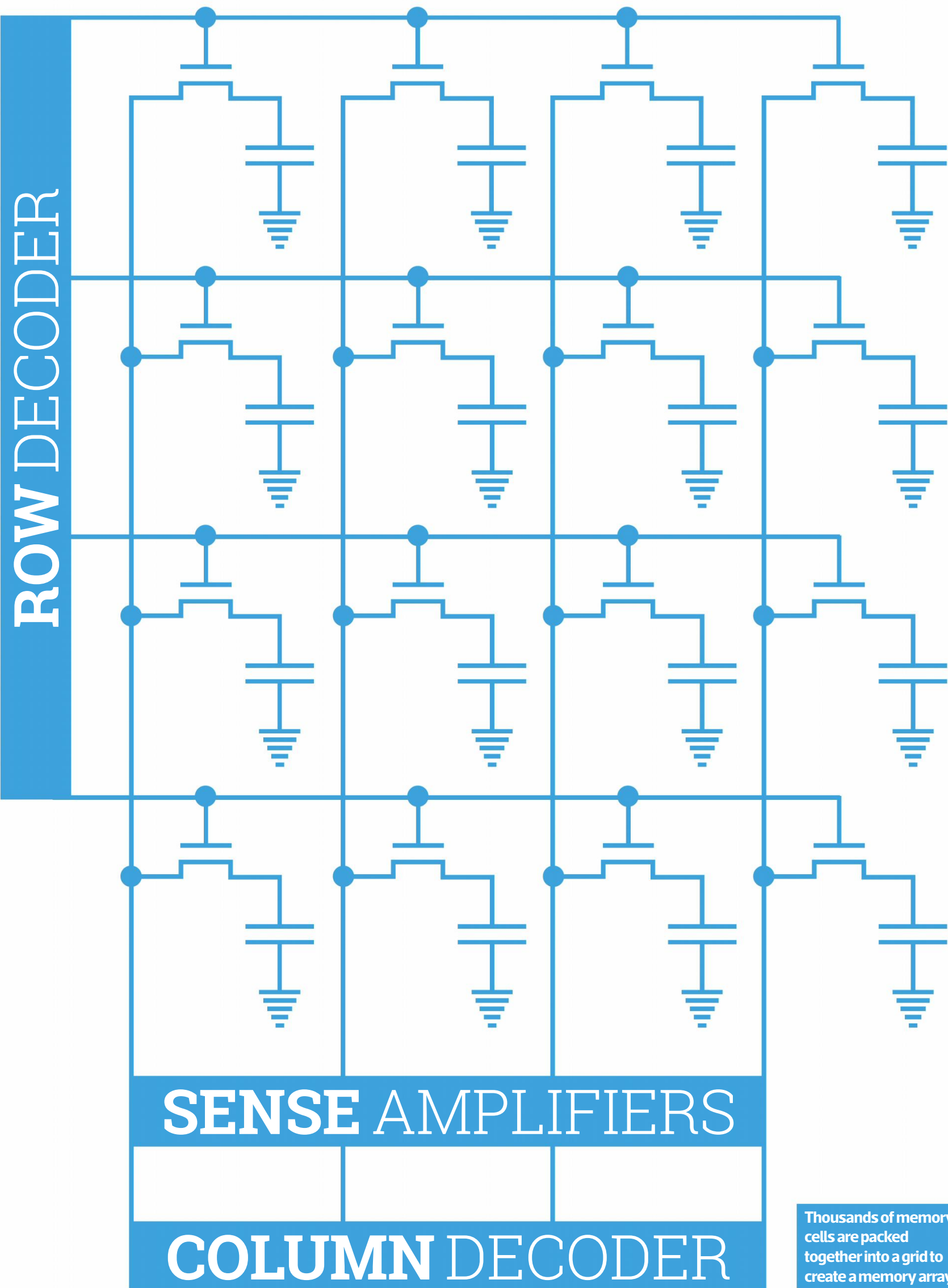
Connecting each row of cells is a single pathway that's known as the word line. Meanwhile, each column is similarly connected to a bit line (there are technically two bit lines). These are so called because the word line is the one that selects the portion of data (the word) to be read or written, while the bit lines are the ones that read or write the 1s and 0s (the bits) that make up that word.

Each entire row of the grid is called a page, with multiple words making up each page. Notably, data can only be read or written in a minimum chunk size of a word. So, when a read or write request arrives, we just need to specify on which row the data sits and in which column the word starts. Except, it's a bit more complicated than that, due to the requirement to constantly be refreshing the charge in the whole array, and because of the way that simply reading a cell causes the charge to be drained from the cell.

Regardless of whether you're reading or writing data, though, when interacting with a DRAM array, the first step is the same. When the memory request arrives, the row that's storing the data you need is activated by sending a voltage to the row. This activates the transistors in that row, connecting each corresponding storage capacitor to its bit line, which in turn causes the stored value of the capacitor to be passed onto the bit line.

Because the charge from the capacitors is so small, it requires amplifying to be read correctly. As a result, all the data from the bit lines for the entire row is sent through what are appropriately called sense amplifiers, which amplify the signal to a level at which the rest of the system operates.

Once the whole row has been loaded into the sense amplifiers, it's then considered active and sections (columns) of it can be accessed for reading or writing. Crucially, only one row per array can be active at a time, making data access



Thousands of memory cells are packed together into a grid to create a memory array

happen in bursts – you want to perform as many quick operations on the open row as possible before having to close it and move onto the next one.

When the system finishes with a row – multiple read and write operations can be performed on it at once – the sense amplifiers have to write the data back into the cells (regardless of whether only read operations have been performed on it), in order to refresh the row and maintain the existing data.

It's a highly complex process and, thanks to its bursty nature, it's one that means memory access is very dependent on parallelism, with multiple memory banks constantly working

in parallel to keep downtime to a minimum and provide a steady flow of data. This row and column access also leads us on to one of the most often misunderstood aspects of RAM – timings.

NO TIME TO DELAY

Around a decade or so ago, one of the hot new topics of PC enthusiast circles was the pursuit of low memory timings. All of a sudden, it wasn't enough just to have RAM with a fast clock speed but also RAM with low timings. But what do those timings mean, and are they still as important as they once appeared?

Memory timings describe the performance of a RAM module according to four parameters, which measure the time it takes for the memory to respond to certain internal commands. All four of these numbers relate back to that whole row/column layout and row refresh requirement.

The first of the four measurements that you'll see slapped on the side of memory modules is called CAS latency (tCL), or column address strobe latency. This figure is generally considered to be the most important of the four numbers, as it describes the fastest possible response time of the DRAM in an ideal scenario.

It's a measure of how many clock cycles it takes between a column address arriving to memory and the data for that address to start flowing back in response. Crucially, the desired row must already be active before this number applies. If it's not, additional time is required. The tCL setting is a fixed time agreed between the memory controller and the memory, not a minimum as with the other three numbers.

Next up is tRCD, or row address to column address delay. This is the minimum number of clock cycles it takes to open a row (if a different row isn't already open) and access the required column. In other words, in situations where a row isn't already active, it's the additional minimum potential delay that's added to tCL before data starts being read. So, the total delay to reading the first bit of memory from DRAM is now tRCD + tCL.

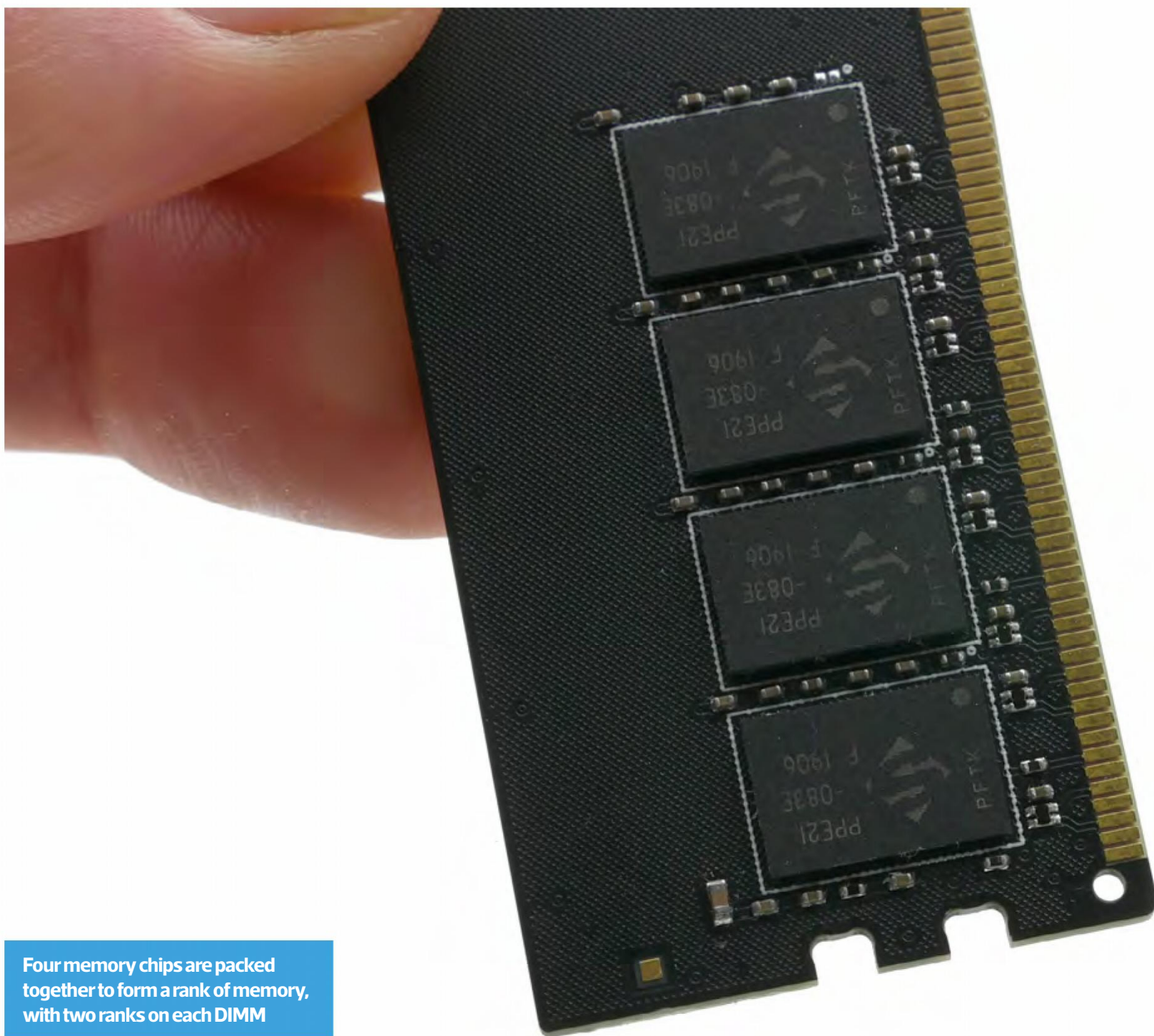
Next up is row precharge time (tRP), which is the minimum number of clock cycles it takes to close the current row (including precharging the cells from the currently active row) and open a new row. This figure again stacks on top of the previous two measurements, so the minimum time to read the first bit of memory if the wrong row is currently open is tRP + tRCD + tCL.

Finally, we have row active time (tRAS), which is the minimum number of clock cycles between a row active command (loading the row of the array) and issuing the precharge command (closing the row and precharging the cells as it leaves). In other words, it's the minimum time required for a row to be active to ensure data can be accessed.



You'll find the memory timings listed on most memory modules as a row of four numbers





Four memory chips are packed together to form a rank of memory, with two ranks on each DIMM

These timings are measured in clock cycles, so they vary in accordance with the clock speed of the RAM. As such, a faster clock speed with a slower latency can be faster than a slower clock speed with a faster latency, and vice versa. This is also why latencies have increased from older generations of DRAM, yet our RAM doesn't feel any less responsive. For the likes of the original DDR standard, tCL was around 3 whereas now it's upwards of 15. However, DDR back then ran at 200–400MHz, whereas DDR4 runs at ten times that figure. As such, the real-world latency is little different.

PERFORMANCE MATTERS

We've generally skipped over any talk of memory clock speed so far here, as the concept is so broadly understood. In short, the same general rules apply to DRAM

as any other component: all other factors being equal, a higher clock speed is better. However, the exact role of clock speed depends on two factors.

The first is simply whether your system will benefit from higher clock speed. Once you get past a certain point (around 3600MHz for both AMD and Intel's latest desktop platforms – as we saw in our recent RGB memory Labs test in Issue 199), faster-clocked RAM unlocks only a tiny fraction of extra performance from your CPU, GPU and other components. It simply no longer becomes a significant bottleneck for your system beyond a certain point.

Also, the dependence on memory speed varies significantly with the type of processing that's being performed. Some calculations are complicated, but are only being performed on relatively small or

quite fixed chunks of data, so they don't require a lot of data to be written to and read from memory. On the other hand, some calculations are relatively simple, but are being performed on massive data sets. For instance, a GPU is dealing with the latter situation, with it having to constantly churn through millions of simple calculations on a huge, ever-changing data set. That's why memory bandwidth is so crucial for GPUs.

Along similar lines, memory latency affects different applications in different ways. In the same way that vastly faster access times make SSDs feel faster than hard drives (even back when overall SSD read and write speed wasn't much better than hard drives), lower-latency memory also improves the experience for applications that require a quick response.



The tiny SPD chip is the only other major integrated circuit on a DIMM, other than the memory chips themselves

In theory, this most obviously affects workloads such as gaming, where the constantly changing nature of your interactions with the virtual world make for an ever-changing dataset, but it also applies to some more mundane workloads too. Conversely, a more fixed dataset that can be read from memory in a controlled, predictable manner – such as encoding video – cares very little about latency.

In our tests, however, tighter latency timings have made a miniscule difference to performance compared with the clock

the memory bus width (that's the number of parallel traces connecting the memory to the CPU, which is 64-bit) and dividing by eight (to convert from bits to bytes). Then, at the end of the number will be the tCL timing in the format CLxx. So, for 3000MHz memory with tCL 14, you'll get a figure of PC4-24000CL14.

COMPLETING THE PICTURE

Getting back to the internals of our memory modules, as you'd expect, a single memory bank alone doesn't make up an entire memory module. Instead, multiple banks of

operating parameters of the RAM to the system, such as voltage, clock speed and memory timings, but otherwise memory modules are quite bare boards.

Instead, the grunt work of taking full advantage of all the data parallelism created by having multiple memory banks in multiple ranks and on multiple DIMMS, is performed by the memory controller in your CPU. It's here that much of the work is performed to optimise the order in which data is sent to or requested from memory.

This is also partly why the likes of the first generation of Ryzen processors were so troublesome when it came to memory compatibility. With the controller being built right into the CPU, any gremlins with the new architecture and platform couldn't be cushioned by the RAM at least being controlled by a known quantity.

A SMALL CHIP CALLED THE SPD IS RESPONSIBLE FOR COMMUNICATING THE OPERATING PARAMETERS OF THE RAM TO THE SYSTEM

speed. Lower-latency memory undoubtedly makes for a faster system than higher-latency memory, but it's also more expensive, and that money would arguably be better spent on memory with a higher clock speed instead.

Regardless of your memory needs, the manufacturers of memory have thankfully made it relatively easy for you to know exactly what you're buying, even if you're still not entirely sure what speed you need. You'll generally get the four latencies advertised alongside the clock speed of the memory, with both figures nearly always printed on each memory module. And if these figures aren't shown, you'll at least generally see the PC4 number.

The PC4 numbering scheme tells us the type of memory (PC4 refers to DDR4, PC3 to DDR3 and so on). The next part of the number is the memory bandwidth, which is calculated by multiplying the clock speed by

cells, sense amps and data buffers are stacked together into bank groups. Several chips are then arranged together to form what's known as a rank of chips, just as you see on the side of a memory module. Slap another set of chips on the PCB and you have the classic dual inline memory module (DIMM).

Notably, your computer needs to account for all these steps when addressing the memory. As such, a memory request will specify the DIMM, the rank and the bank before getting to the rows and columns.

However, along with the memory banks themselves, there's very little to a memory module. A small chip called the Serial Presence Detect (SPD) is responsible for communicating the

AUTOMATIC PROFILES

One of the easiest ways to unlock the best performance from your memory is to hop into your BIOS and opt for either the Extreme Memory Profile (XMP) or AMD DOCP option. These options automatically set the modules to the settings to which they're rated on the packaging, overriding





the tendency for motherboards to run RAM at the low default base level clock speed and high latency timings.

These profiles work by taking advantage of the aforementioned Serial Presence Detect chip that's located on each stick of RAM. XMP is simply an extension of the SPD standard, which allows for memory manufacturers to specify not just a safe minimal performance level at which to run the module, but some overclocked settings too.

You generally get two XMP profiles for any given module. The first profile will be the safe option that should give you the rated performance figures you'll see on the box. The second profile will be a more extreme version that may not be as stable.

In general, XMP offers an easy, reasonably reliable way to ensure you're getting close to the most out of your RAM. However, as we saw with the

memory compatibility issues with the first generation of Ryzen CPUs, there are other factors at play, particularly as memory controllers are now built into CPUs. This applies doubly if you're overclocking your CPU. As such, it can be beneficial to take control of setting your memory clock speed and timings yourself, keeping a keen eye on just which setting or level causes your system to fall over.

MEMORY DECOUPLING

One aspect that can further complicate memory overclocking is that AMD Ryzen systems enable you to decouple the memory clock speed from the Infinity Fabric clock speed. These two frequencies are normally kept in lock step but, with the fastest of RAM, it can be beneficial to keep the Infinity Fabric running at a slower clock speed and run the memory faster. Moreover, you can even do the opposite, using slower RAM but overclocking the Infinity Fabric. If you compensate for the slower clock speed of your RAM by tightening the timings, this can result in better performance in some applications.

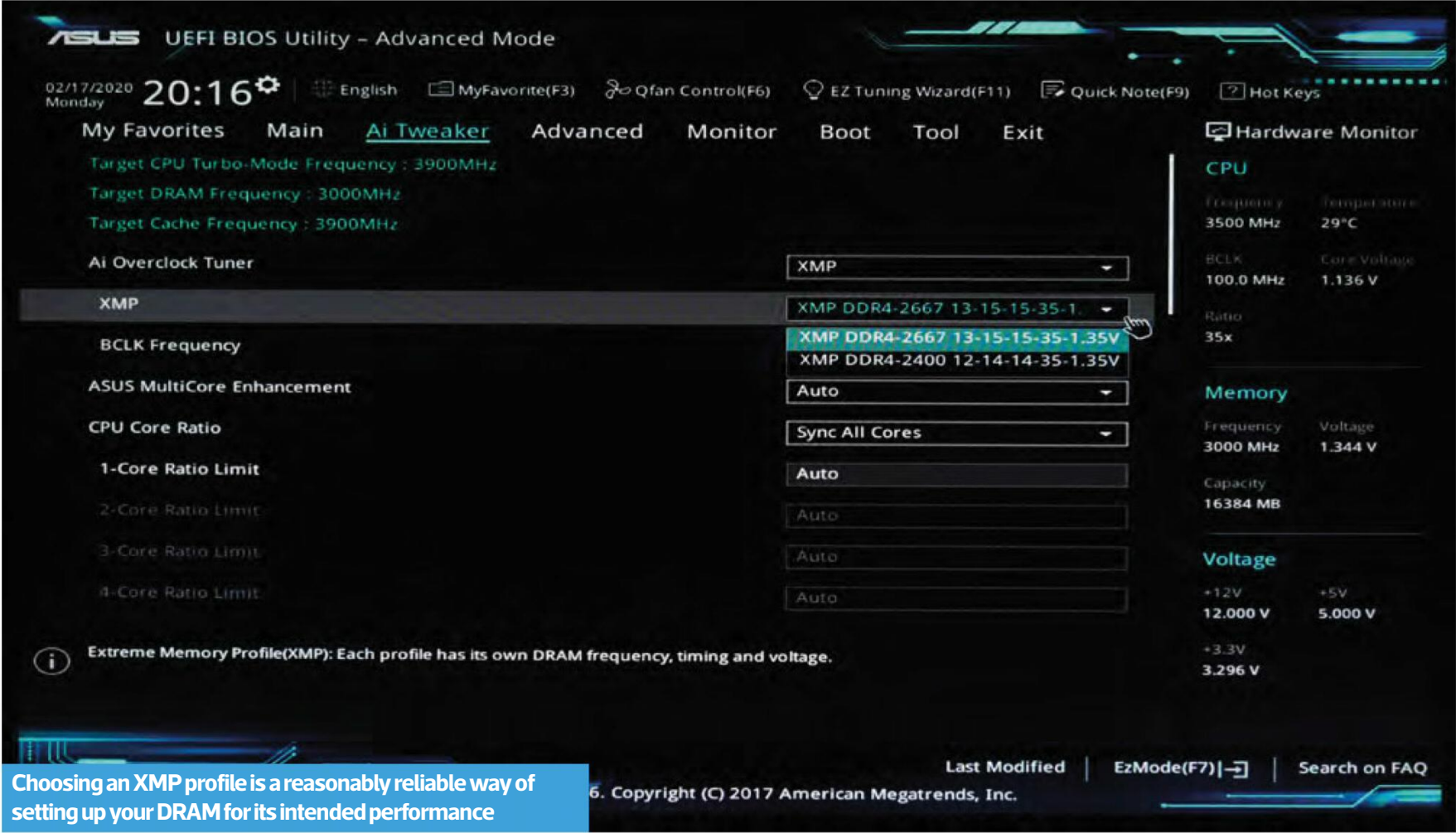
Infinity Fabric decoupling is an interesting tweaking option for people

who really want to experiment, but we've seen few instances of this tweak providing significant benefits outside of extreme overclocking scenarios. For AMD systems, opting for 3600MHz RAM with the tightest timings possible, and sticking to a 1:1 Infinity Fabric ratio, is the best route to peak performance.

THE FUTURE OF DRAM

The arrival of Intel Optane really set the cat among the pigeons in terms of potentially breaking the dichotomy of system memory and long-term storage. However, it remains too slow and expensive to truly be a viable replacement for most desktop PCs. If Intel can further improve speed and reduce costs, however, we could certainly see it become ever more commonplace in laptops, all-in-ones and other small form factor PCs.

Then there's DDR5, which has been on the horizon for a while, but reportedly won't likely arrive until at least next year. The doubling of data rates and lower power consumption will certainly make for an interesting potential step change in performance, but it's far enough off and unproven enough that we wouldn't hold off on upgrading now because of it. **GPC**



Choosing an XMP profile is a reasonably reliable way of setting up your DRAM for its intended performance

200 issues of CUSTOM PC

IN HONOUR OF OUR 200TH ISSUE, CPC VETERAN BEN HARDWIDGE TRAVELS
BACK TO THE SUMMER OF 2003, WHEN CUSTOM PC FIRST STARTED



Extrême ultra! It's now the name of one of our awards, but back in 2003 it was a phrase that members of the PC Pro office (including me) shouted at Gareth Ogden to taunt him. It's all a bit embarrassing now. Gareth had taken over PC Pro's Leisure section - a small part at the back of the magazine to where we relegated our game reviews, and he'd introduced a new 'Extreme' page to cover modding and overclocking, where many of the products had 'Ultra' in their name.

Games weren't considered important to most PC hardware magazines at this time. If you were interested in games, you bought PC Zone or PC Gamer. If you were interested in hardware, most PC magazines for tech-literate folks assumed you were an IT manager or a businessperson. A review of a graphics card was deemed to be a bit of fun that took up less than a page, while most of the space went on the serious PC kit - laser printers, scanners, everyday PCs. If you were lucky, you might see a 3DMark score on a PC review.

This was all about to change though. By the early 2000s, it was rapidly becoming clear that an awful lot of people were massively interested in PC hardware, and not because they wanted to run Excel faster. The introduction of the first 3D accelerator cards had elevated PCs well above consoles for gaming horsepower, and more and more people were realising that you didn't have to pay the inflated prices for top-end processors if you knew how to overclock a budget CPU.

The full cover for Issue 1 of Custom PC, with its arty design and mustard-coloured background



Some early drafts of how the cover for Custom PC could have looked

A REBELLION WAS BREWING AGAINST THE HORRIBLE OFF-WHITE COLOUR OF PC CASES



Issue 000 featured 32 pages of repeated content to bulk up the size, and was taken to trade shows to promote the idea of the magazine

People started looking at ways to get more performance out of their PCs. The standard heatsink and fan setup wasn't powerful enough if you wanted to get the most performance out of your CPU, and we started seeing primitive water-cooling setups based on aquarium pumps, as well as extreme coolers based on refrigeration units.

Meanwhile, a rebellion was brewing against the horrible off-white colour of PC cases. The original beige colour of PC kit might have looked fine in offices and schools, but it looked horrible in the home. To make matters worse, it would gradually become more off-white and progressively yellow as time progressed. To put this into perspective, nobody's TV or hi-fi equipment was off-white at this time – just computers, alarm clocks and interior walls.

Enthusiasts started spray-painting their PC off-white cases with automotive paint, and case manufacturers such as Cooler Master and Lian Li began producing silver aluminium cases. A modding community also sprang up around VIA's EPIA platform – a new mini motherboard standard dubbed mini-ITX, which featured an underpowered VIA CPU, based on the technology acquired when VIA purchased Cyrix. There was a rush to squeeze an EPIA board into various household objects and toys, and 'PC in a ...' became a theme. We featured one in a toy car in Issue 1.

A new magazine

Various websites had sprung up and taken notice of the new trend in PC hardware enthusiasm, from Tom's Hardware in the USA to Hexus and bit-tech in the UK, but magazines were still generally stuck in the off-white,

business-focused past. Gareth Ogden pitched an idea to the top folks at Dennis Publishing – a full magazine that took PC Pro's Extreme section mainstream. It wouldn't be a catch-all PC magazine that covered everything PC-related, but a specialist hardware enthusiast magazine.

There would be no printer or software reviews, and it would be able to dedicate several pages to a graphics card review if necessary. Meanwhile, the style and design would need to distance itself from the business-like approach of so many other PC magazines. It needed to look and feel more like a dynamic lifestyle magazine you'd have in the lounge than a text-heavy doorstop you'd find on an IT manager's desk.

The reaction was positive but cautious, and so began several months of exploring and experimentation under the codename 'Project Hotrod'. Focus groups were assembled, component and PC manufacturers were consulted and a boatload of market research was conducted. During this time, James Gorbod (who is still with us on p114) was also recruited into the fold, after previously editing PC Magazine in Dubai.

Custom PC was nailed down as the title, and the next step was to settle on a style. Many cover designs were trialled, some of which are shared in this feature, but eventually

WE THOUGHT IT WAS SO ADVANCED AND HIGH-TECH TO BE SENDING FILES TO THE PRINTER VIA ISDN

a logo was designed and a mock issue was made that could be taken to trade shows. Called 'Issue 000', it laid the foundation for what was to become **Custom PC**. By this time, the font had been nailed for the logo and Gareth and James had settled on a general style of writing and design. The main cover feature, Build your dream PC, is also one that we've regularly come back to over the years.

It wasn't a full issue. It contained 32 pages that were repeated several times to bump up the thickness, but it covered a bit of all the essentials, including news, reviews and games coverage. Issue 000 was well received, and work progressed towards the first proper issue.

During this time Julie Birrell was employed as a full-time production editor (and she's still here!), while Alex Watson and Josh Blodwell were brought on as staff writers and Daniel Emery edited the games section. The team then worked many long days and evenings on the first issue (see opposite), recruiting a team of freelancers (including me) to help out.

'We thought it was so advanced and high-tech to be sending files to the printer via ISDN,' recalls Julie Birrell about the process of assembling that first issue. That's how long ago this was. In case you're too young to remember, Integrated Services Digital Network



Voodoo PC was one of a few companies making systems targeted at enthusiasts, making good use of automotive paint and custom chassis mods

(ISDN) provided an early form of broadband in the UK. Eventually, the first issue went to press, and a bottle of bubbly was opened when the last page was finally sent to the printer.

However, if you look closely at the first issue, you'll also notice a killer typo on the spine, where it says 'Issue 1' rather than 'Issue 1', which severely narked the team who'd spent many long nights working on the first issue. At this point, news and features were covered on a freelance basis by Stewart Mitchell and Paul Hales, but there was an open space for a full-time role, which I went for. I'd just quit PC Pro and had worked on the first issue of **Custom PC** as a freelancer, before being brought on as full-time news and features editor for Issue 5. The first full **Custom PC** team was now complete.

A shaky start

I think it's okay to talk about this now, but **Custom PC** didn't get off to a great start when it was first released. We were really

pleased with the content, and the readers liked what we were doing too, but the arty cover designs weren't selling the magazine on the shelves. The cover for Issue 1 looks subtle and smart with its mustard-coloured background, but it doesn't scream 'awesome PC hardware!' You have to look at it for a couple of seconds to see what it's about.

The writing was nearly on the wall after Issue 4, where the lead cover feature – Windows XP Makeover – was about skinning Windows to customise it to your liking. It bombed. Our publisher called an emergency meeting, and we all agreed that we needed to restyle the cover to go big on photography that properly represented the hardware inside.

Issue 5 sold better, with a few shots of various PC hardware on the front. Then Issue 6, with just one large dynamically angled photo of a dual-channel memory kit, nailed it. **Custom PC** was now on the road to success – people clearly wanted big photos of fancy circuitboards in their face, and I can't say I blame them.

Issue 1 featured a very irritating typo on the spine – 'Issue 1' rather than 'Issue 1'



WHAT'S in 'ISSUE 1'?



Inside the Scan 3XS-H, which was reviewed in Issue 1 – cable tidying was a nightmare at the time

Cooler Master Musketeer

GOOD LOOKER TAKES 'TUNING UP' BACK TO ITS ANALOG ROOTS

Price £30.43 inc VAT
Supplier Overclockers, www.overclockers.co.uk
Manufacturer www.coolermaster.com

The description 'retro upgrade' is not as nonsensical as it first seems. Cooler Master's Musketeer system monitor is perhaps the first accessory that fits this tag. Occupying a 5.25in bay, the Musketeer is a front-panel display with three analog dials. They show fan voltage, the sound pressure level and temperature. Despite being slightly reminiscent of a Spitfire cockpit, the silver-edged dials are brightly backlit in blue and they look fantastic.

Two chrome sliders add to the retro feel. One lets you adjust the fan power (altering its speed and hence noise), while the other adjusts sound pressure. This sounds fancy, but all it does is allow you to set the maximum volume level of your speaker system to

assortment of cables and screws included. The temperature sensor is a thin probe that ideally needs to be taped to a chip, while the Musketeer can either connect directly to a fan or to both fan and motherboard.

Hooking up the sound pressure monitor feels more like connecting to a phone call in a 1930s telephone exchange than upgrading a PC. One 3.5in lead goes from the Musketeer to a custom back panel that occupies a PCI bracket. This panel has two 3.5in sockets. One loops (via an included wire) to the sound card's line-out socket, and your speakers connect to the line-out socket on the Musketeer's back panel.

The dials have been chosen to maximise visual impact: the voltage needle is constant, the sound needle twitches with every bass sound and the temperature gauge gradually

The Musketeer is unique. Turn on, tune in and have hours of pleasure watching the dials flicker as it monitors your system

especially given the relatively limited functionality the Musketeer offers when compared to other front-panel fan controls and temperature sensors that are available.

CONCLUSION

Turning on your PC and watching the needles on the dials of this stylish device leap into life is brilliant. While it may not offer a lot of functionality, for a relatively cheap price the Musketeer is cool and completely unique.

ALEX WATSON



The Cooler Master Musketeer didn't serve much of a practical purpose, but its analogue needle meters looked lovely

So what's inside the very first issue of **Custom PC**? Once you get past the contents page, you're presented with Gareth's introductory column, where he promises a new PC magazine that doesn't either assume you've never seen a PC before, or that you're an IT manager. 'We won't exclude people by using jargon unnecessarily,' he says. 'We'll drill down to the roots and discover the truth behind the jargon, and what it actually means to you.' It's a philosophy that we still apply to **Custom PC** today, as you'll find in our memory feature on p76.

Next follows a lengthy news section, which includes a column by Hexus founder David Ross, a whole page of game news and an interview with Crucial about the next new exciting standard in memory, DDR2. There's also a whole page dedicated to ATI's latest Catalyst GPU driver.

Reviews

Flick to the Reviews section and you're immediately presented with one of the key

reasons for **Custom PC**'s introduction – in-depth hardware reviews. The first review dedicates four pages to the Voodoo PC Envy M460 gaming laptop. The Voodoo brand has since been bought by HP, but at this time, Voodoo PC was an independent US system builder headed up by Rahul Sood, who later wrote a column for us.

Voodoo PC performed custom mods on cases, with high-quality etching and cutting, while also applying shiny automotive paint finishes. They looked radically different from the usual off-white boxes in other PC magazines at the time. It came with a rugged rucksack for transportation and featured an ATI Mobility Radeon 9600 GPU.

The next few pages feature reviews of prebuilt systems, and these are a bit of an eye-opener, as the side-on shots of the insides are radically different from the ones we feature in PC reviews now. Cable tidying clearly wasn't a key consideration at the time, even for enthusiast case manufacturers. The Scan 3XS-H reviewed in issue 1 is built inside a Cooler Master Wave Master case, which

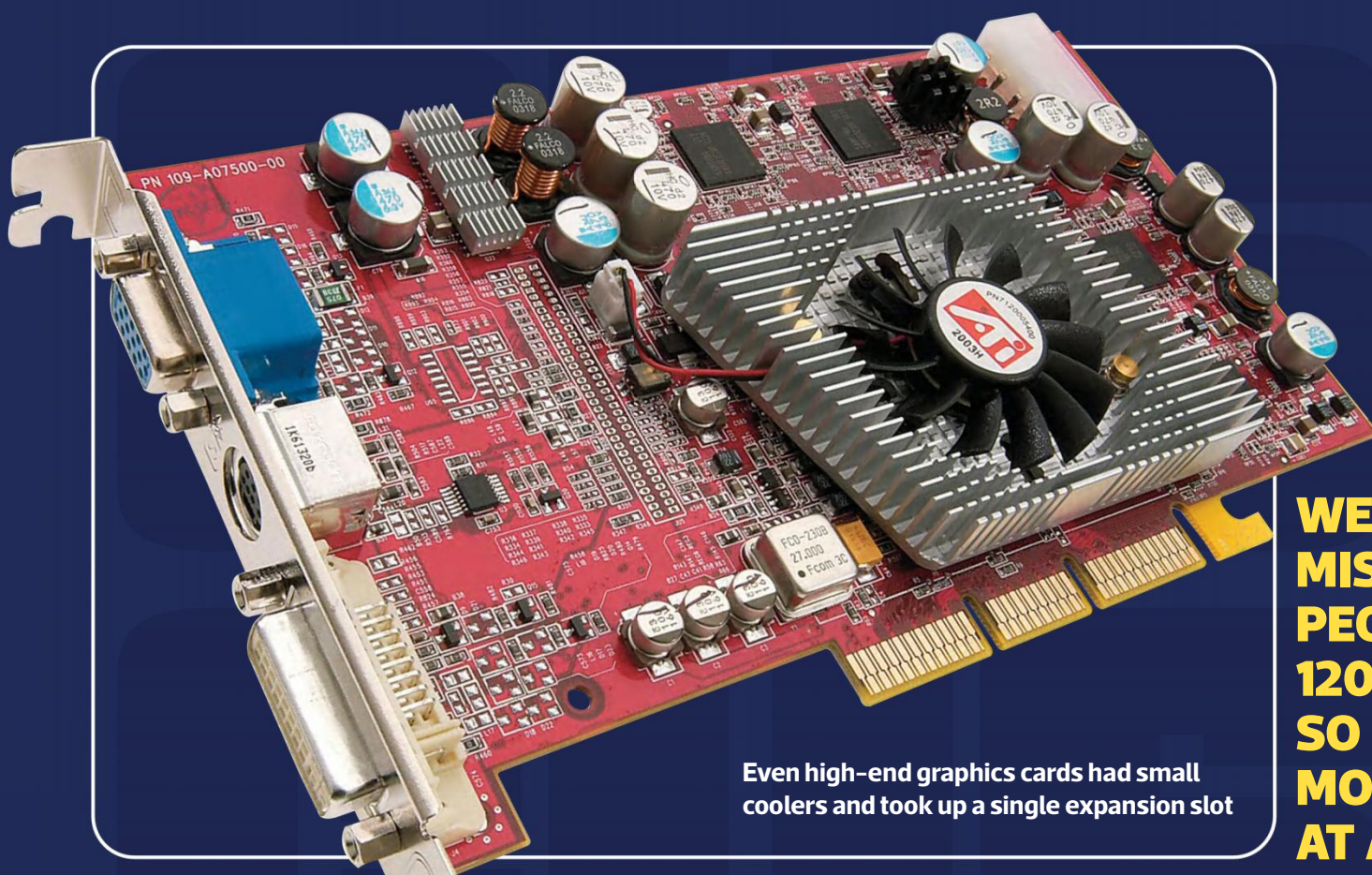
looked fine on the outside, but had few of today's case features on the inside.

The PSU is mounted in the top rather than the bottom, the motherboard has a standard yellow-coloured PCB and there are cables all over the place. They're neatly bunched together and tied to the chassis where possible, but there was clearly no way to easily hide cables at this time – there are no tidy rubber-grommets cable-routing holes around the motherboard tray, and there's no PSU shroud. Plus, the yellow, red and black PSU cables look radically different to the sleeved and braided cables we see now.

At this time, we were still heavily using Molex connectors to all sorts of gear, from fans and hard drives to cold cathode lights. The Scan PC in Issue 1 is filled with various Molex cables linked to splitters and adaptors. It also features cables for both SATA and IDE storage. The latter was a problem at the time for cable tidying at the time, as the standard flat IDE ribbon cables were ugly.

You could route them under your motherboard if the standoffs had enough clearance, but an alternative that had just been introduced at this time were 'rounded' IDE cables. These still had the bulky 40-pin connectors on either end, but then squeezed the wires into a bunch so it looked like a chunky round cable, rather than a flat ribbon cable.

In terms of spec, we've clearly come a long way as well. The Scan 3XS-H cost £2,466 inc VAT, and came with an AMD



Even high-end graphics cards had small coolers and took up a single expansion slot

WE MADE IT OUR MISSION TO PERSUADE PEOPLE TO USE 120MM FANS INSTEAD, SO YOU COULD GET MORE AIRFLOW AND AT A SLOWER SPEED

Athlon XP 3200+ CPU (which was only 32-bit), 1GB of Corsair PC3700 dual-channel RAM and a pair of 120GB hard drives in a SATA RAID array.

Another noteworthy review in Issue 1 is Corsair's first liquid-cooling system, the Hydrocool 200. It used a massive external pump unit and it cost nearly £200. That would have been fine if it worked well, but it was barely any better than a top-end air cooler and it made a lot of noise. We recommended buying a £25 Vantec AeroFlow air cooler instead.

Finally, there's a great product at the end of the reviews section that I'd forgotten about until recently – the Cooler Master Musketeer. This module fitted into a spare 5.25in drive bay and presented you with three analogue needle meters – one for temperature (with a sensor probe you would attach to a chip yourself), one for voltage and one for sound pressure, with the latter being connected to your sound card via analogue cables around the back. It didn't have much of a genuine practical purpose, but it gave a lovely retro analogue touch to your PC case.

Labs

There are two Labs test in issue 1. The first is on cases, which reveals more of the same issues with cases seen in the PC reviews. Case manufacturers had clearly started to notice that there was a market for non-beige, but there was still a lot to learn. Nearly every one of the cases in the Labs comes

equipped with 80mm fans, and we made it our mission to persuade people to use 120mm fans instead, so you could get more airflow and at a slower rotational speed, helping to avoid the horrible high-pitched noise often generated by smaller fans.

One case on test, the Beantech BT-80, is notable for being completely transparent with three horrible 80mm fans. 'If you want a transparent case to show off the internal components, you have to be prepared to accept the shortcomings,' we said, 'oh, and buy a pair of ear muffs.'

The other Labs test was graphics cards, all of which were either based on Nvidia's GeForce

FX 5900 Ultra or ATI's Radeon 9800 Pro. The latter was the superior GPU at the time, but all the cards are quite different from today's monsters. Both these GPUs were considered top of the range in 2003, but none of the cards has enormous coolers. There's usually a small heatsink and fan on the GPU, and nearly all of them take up a single expansion slot bracket. A notable exception is the Sapphire Atlantis Ultimate Edition, which has a large passive heatsink with no fan.

The Beantech BT-80's transparent design enabled you to show off all of your PC's innards, but its 80mm fans were noisy

LABS TEST CASES

BeanTech BT-80

Verdict: The expansion potential is transparent – but it's a noisy beast!

Price £109 inc VAT
Supplier www.kustompc.co.uk
Manufacturer www.beantech.com

The BeanTech BT-80 is made out of 5mm clear acrylic and is the only transparent case in this group test – a special inclusion for those who really love to gaze upon the insides of their PCs.

Other than the material, and thus its appearance, the BT-80 is a fairly standard mid-tower case with four 5.25in drive bays, two 3.5in external bays and five 3.5in internal bays.

However, you'd be silly to fill all the drive bays as there are only three 80mm fans – one sucks cool air into the front of the case, another one sucks it in at the side and the third fan flushes hot air out of the back.

This is just about adequate for a PC with a couple of hard disks, but we certainly wouldn't advise any more than this. Common sense tells us it's wrong to have more incoming air than outgoing, as the air gets trapped inside

and will eventually heat up and cause instability problems. Why BeanTech never made this simple logical connection is beyond us.

Then there's the noise. For comparatively low-speed fans (2,000rpm), they're very noisy and make an annoying low-frequency hum. This appears to be caused by the spinning fans transmitting a vibration into the plastic of the case, which then acts as a giant amplifier. On the plus side, the fans are made of clear plastic and are in keeping with the overall look and feel of the case.

Acrylic is nowhere near as strong as steel or aluminium, so it's best to be gentle when assembling a system inside the BT-80, and even more careful when moving it around. If you're after a distinctive case to take to LAN parties, the transport issues could be a serious problem.

Also, unlike an aluminium or steel case where everything is hidden away tidily inside, any dust build-up inside the BT-80 will turn it into a bit of an eyesore, so you'll probably have to give



it a good clean every few weeks.

At the end of the day, the BT-80 isn't a bad case; it's more a question of taste. If you want a transparent case to show off the internal components, you have to be prepared to accept the shortcomings – oh, and buy a pair of ear muffs.





The Beat the Office PC, which had a Vapochill phase change cooler running at -23.8°C – you could win the system if your PC could outperform it

All the cards on test also have an accelerated graphics port (AGP) slot connector. At this time, motherboards came with a dedicated high-speed slot for a single graphics card, and PCI slots for extra expansion cards.

Features

Finally, we come to the features, and the main one is 'Build a better PC'. Here we take you through which CPU to buy for various budgets, covering both Intel and AMD or options, and we also help you decide which type of monitor you need – and LCD or a CRT? As with so many of the reviews in this issue, a large chunk of the feature is dedicated to tidying cables.

So many cables were required at this time, and they looked horrible. In the feature, we recommended using plastic spiral cable wrap to keep your cables together and make them look better. 'The more adventurous can buy neon coloured cable management kits,' we said.

Meanwhile, the extreme customisation feature was Project Focus, a model Ford Focus that had been modded to accommodate a basic mini-ITX system. As we mentioned earlier, though, mini-ITX was very different at this time, being dominated by VIA's EPIA platform with integrated CPUs

– the processor in Project Focus only has a 533MHz clock speed.

What went and what stayed?

Some of the sections introduced in Issue 1 are still found in **Custom PC** today. In Issue 1, you'll find Custom kit, Elite, Readers' drives, Labs tests, Reviews and an Extreme customisation feature about a mod, just like this issue. There's also a column by James Gorbald, although it's in the Reviews section rather than at the back of the magazine.

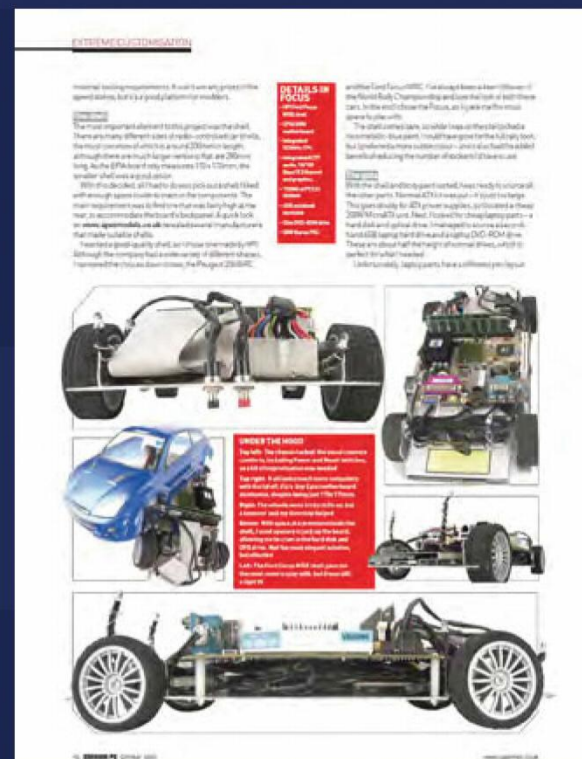
Some sections have notably gone though. At the back of Issue 1, for example, are a couple of lengthy columns about operating systems – Inside Windows and Inside Linux, written by David Moss and Liam Proven respectively. They were designed to offer a way to cover software in the most **CPC**-way possible, while also providing **Custom PC** with a hands-on opinion section, not dissimilar to PC Pro's Real World section. A lot of PC magazines did this at the time, although even then they felt like a bit of a relic of the past.

The columns were fine in themselves, but they didn't really work in the new context of **Custom PC**. Consistently, reader surveys said that readers didn't read them. It's for this reason that the sections at the back of the magazine, such as Hobby tech and Customised PC, now mostly involve hardware or a specifically hobbyist approach to software, so we can keep the magazine focused on its core subject area.

One other section that's since gone is Beat the Office. Here, we built an overclocked system with a phase change cooler (basically a refrigeration unit).

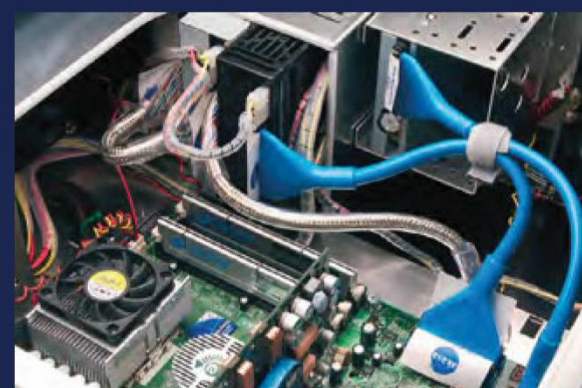
We ran our own benchmark suite on it, using open source freely available software, and challenged you to build a system that would beat its results – you could apply to receive a CD with our benchmarks on it in the post, with a £5 fee. If you won, you would take home the actual Beat the Office machine itself.

The problem was that the only people who stood a chance of winning were the ones with the enormous amounts of money needed for top-end cooling systems and components, which alienated most of our readership. We'd love to bring back a proper benchmarks leaderboard, though, as well as updating our benchmark suite. **CPC**



The subject of our extreme customisation feature, Project Focus, was based on a VIA EPIA motherboard with a 533MHz CPU

The photo from our cable-routing guide, showing the blue rounded IDE cables and use of plastic spiral wrap





THE IRON MAIDEN

ALIABBAS GUIDES US THROUGH THE CREATION
OF HIS NIGHTMARE VISION OF A PC

SYSTEM SPECS

Weight 56kg

Size (cm) 70 x 100 x 100 (W x D x H)

Build time Approximately 700 hours

Sponsors Cooler Master, Asus,
Thermaltake, Caseking

Case Cooler Master C700M

PSU Cooler Master V1300 Platinum

GPU Asus ROG Strix Geforce
RTX 2080 OC 8GB

CPU AMD Ryzen 9 3900X

Memory 16GB Thermaltake
WaterRam RGB DDR4 3200MHz

Motherboard Asus ROG Crosshair VIII

SSD Samsung 970 Pro 1TB

Cooling 2 x Thermaltake (TT) reservoir,
TT CPU and GPU waterblocks,
6 x TT Ring Plus fans, 2 x TT Pacific
CLM240 Radiators, TT Sync Controller,
2 x TT Pacific Flow Indicators

The torture device? Are you kidding me?. That was the first reaction I heard. 'Well, hell yeah!' is all I could reply. But then again, such is the way with most of my creations. While I've made some conventional cases in the past, I've found my passion is for combining computer hardware with striking cultural and historical themes, such as Vikings, Samurai, Pirates and Gladiators. An iron maiden just seemed like the logic next step.

I saw my first real iron maiden in Riegersburg, Austria, and I was fascinated by how they combined the disparate words 'iron' and 'maiden' together to describe such a monstrous device. I recall thinking that one day I would make a closet that looks like one, but never got around to that.

The iron maiden is, of course, an extremely unpleasant torture device. It was supposedly used in the Dark Ages by the rich and powerful to exact punishment on those that crossed them, although that's now widely believed to be a myth introduced in the 18th century. Either way, for my build, I wanted to evoke a specific era, so I concentrated on the period of the Spanish inquisition, between 1420-1498, when the

Grand Inquisitor himself was active, the evil Tomas de Torquemada. A man as much feared as he was evil.

The concept and theme

For the design, I took inspiration from the iron maiden itself as well as the individual words. So, rather than just focus on the original look of the torture devices, I strived to portray the beauty of the maiden and the raw look of iron.

I wanted to make the maiden of this PC as attractive as the theme would allow, to compensate for all the injustices inflicted by medieval torture. Of course, she looks far more attractive than the torture devices in museums, but that's artistic licence for you.

I knew the build would need an open cage rather than the closed closet of the real deal. This allows the PC's hardware, clad in Spanish gold, to be shown off. I also had the idea that she should have an altar for last confessions on the front, including a real wax candle that could somehow switch off all the lights when blown out. Sounds strange, but I love crazy stuff like this that hasn't been done before.

Add in a few spikes and pentagrams, as well as the Grand Inquisitor's lanterns, and the design concept was complete.



A Cosmos C700M sits at the heart of the mod

Hardware choices

The PC itself is a fairly conventional high-end, all-purpose build centred on an AMD Ryzen 9 3900X and an Nvidia GeForce RTX 2080. As such, the main hardware considerations were to do with the extra features that would need to be incorporated into the design, such as the flip-out screen and the candle.

I also worked with several sponsors for this case who provided much of the hardware.

The cage doors were created from dozens of small pieces of wood covered in Worbla



The face started as a polystyrene headphone holder

Perhaps most important, in terms of design, was the use of a Cooler Master Cosmos C700M case. Although it's heavily modified, you can just make out the underlying structure inside this build, and its swing-out doors are integral to the design.

Thanks also to Cooler Master for the V1300 Platinum power supply, Thermaltake for many of the water-cooling components and Asus for the ROG RTX 2080 Strix graphics card and ROG Crosshair VIII Formula motherboard. I also work for Caseking who provided me with several other little bits and pieces such as speakers and PCBs.

Let the torture begin ...

The Cooler Master Cosmos C700M is a pocket-sized case, at least by my standards, so I had to make adjustments to enlarge it. I built a double-floored wooden base to give the build more height – first because I knew

The flip-out monitor is concealed until a spike on the side of the case is moved. The monitor then slides out and up. When closed, you see the altar that holds the confession candle under the reservoir.

I cut open both side panels of the case in order to show off the insides of the PC. Around the whole case and attached to each hinged side panel, I then built cages that would represent the fearsome spiked doors that sealed the fate of the people who entered the iron maiden.

Each side of the cage was built from at least 80 small pieces of wood. These had to be cut very accurately to keep the two sides uniform and create the precise angled shape.

The whole cage was also painstakingly covered with Worbla. This is a type of thermoplastic sheeting that can be used to provide a tough, organic-looking covering to sculptures or, in this case, PC mods. This took hours of finger-burning labour, to clad the cages in such a way that, once painted and dry-brushed, it would look like a wrought iron contraption from a blacksmith. Studs and gems even found their way onto it because, like I said, this is to be the most beautiful iron maiden ever.

I also incorporated some occult symbols, such as a pentagram, behind the motherboard tray. This added further to the evil theme and helped to cover up all the wires behind it. The panel includes one opening for a fan and another removable section that provides access to an SSD.

On the other side of the PC, to add further to the Spanish gold theme, I created a design for a golden doubloon, which sits on top of the CPU waterblock. The memory waterblock

THE FLIP-OUT MONITOR IS CONCEALED UNTIL A SPIKE ON THE SIDE OF THE CASE IS MOVED. THE MONITOR THEN SLIDES OUT AND UP

I wanted the four inquisitor lamps on each corner and also to allow room for a monitor that pops out of the base.

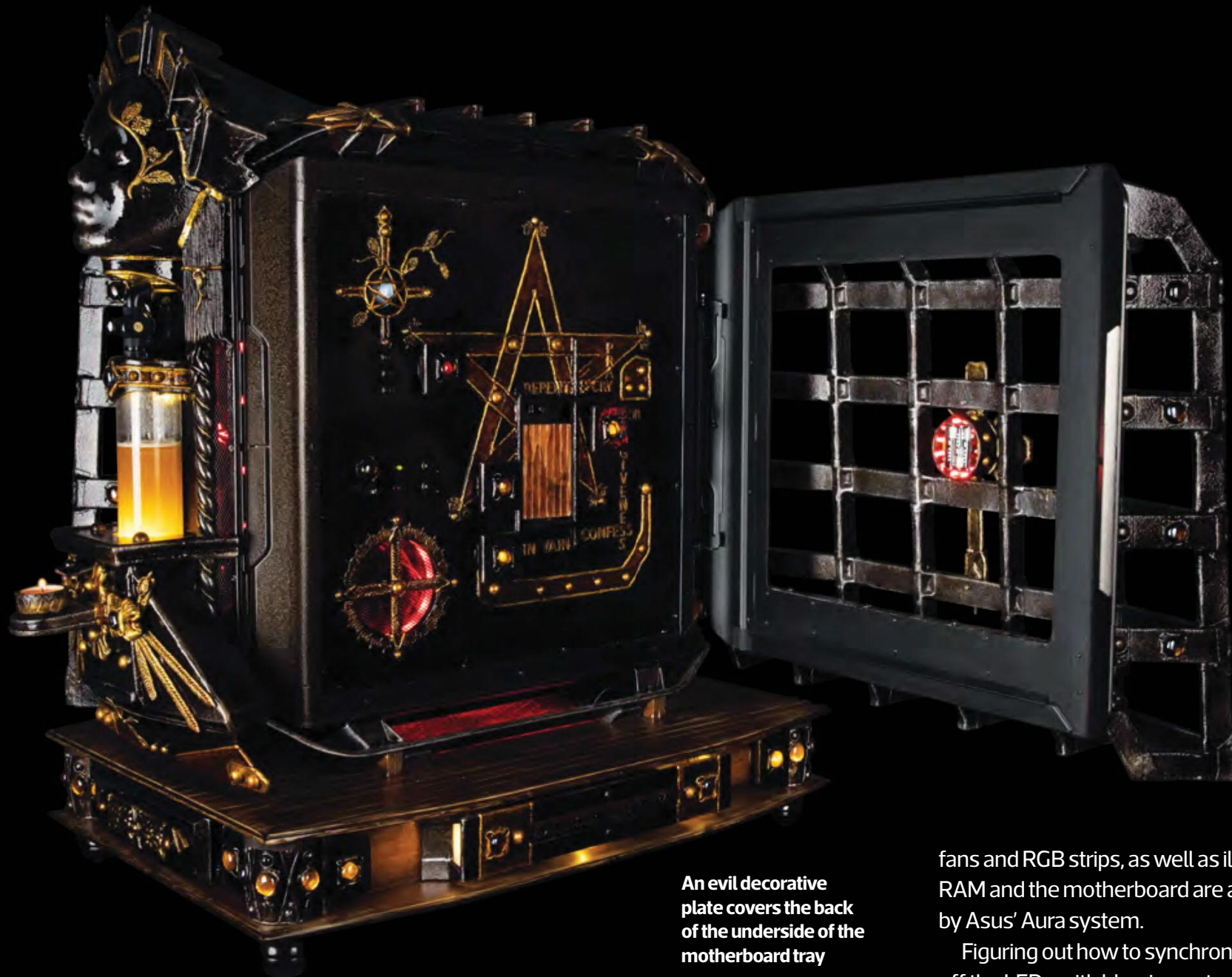
The base also enhanced the shape and size of the cage-like form I was aiming for. A set of turned feet were attached to the base to raise her even further.

Each corner has custom-made lanterns that are clad in gemstones and look like they're made from real wrought iron. In fact, they used to be beer bottles and are now lit up with a flickering effect that moves in time with sound.

also has a gold ingot design and the graphics card backplate is covered in an ornate wrought iron pattern, finished in more gold.

All these gold elements used the same technique to achieve the right weathered gold effect. I used a water-based gold acrylic paint and, while this was still wet, I pipetted drops of teak wood stain on top.

This part of the mod took around two weeks of patient work, but the effect worked out great. After the water evaporated, it left the pigments clumping irregularly to the



An evil decorative plate covers the back of the underside of the motherboard tray

golden acrylic paint, creating a weatherworn effect that still looked ornamental.

The face and headdress of the maiden was made by cutting in half a polystyrene headphone holder and cladding it in Worbla. The bonnet was then formed from pieces of cardboard and foamboard that were hot-glued into place and again covered in Worbla.

I also added hair to the maiden, which is made of, or should I say 'maid of', rolled

Worbla leftovers. After quite some time, and many blistered palms, I had around 30 strands of hair. I also decorated her cheeks with leaves and little buds made of leftover scraps of Worbla and gave her a single teardrop, which she sheds for every poor soul she devours.

The whole face was then finished in the same wrought iron paint effect as the rest of the case. Two pillars hold the head in place above the reservoir, which is topped by a cover shaped like a manacle.

To the top of the PC I added small pieces of wood to create an effect similar to a torture rack. I then finished off this idea with a pillory at the back of the case, which not only completed the torture but covered up the ports and wires.

This means that, if you're only using the pop-out monitor, there's just one visible cable for this whole PC, which is the power cable that plugs into the base. The monitor wires, as well as the keyboard and mouse dongle, are hidden behind the pillory.

Then it all came down to wiring. I used many LEDs that flicker in reaction to sound, via a sound control module. The Thermatake

fans and RGB strips, as well as illumination for RAM and the motherboard are all controlled by Asus' Aura system.

Figuring out how to synchronise switching off the LEDs with blowing out a candle was a challenge, and I won't tell you about all the times that I failed here. In the end, I set a light sensor to focus on the flame's brightest point. Once the flame is blown out, it triggers a relay, which is wired to the sound module.

Since the sound module is connected to all the LEDs it can extinguish them and they'll stay off until the candle is lit once more. This was quite a challenge and wouldn't have worked with a full-sized church candle that burns down. Instead, I used a tealight, so the flame would remain in the same place.

A prize winner

In January, I took my new beauty to the German Casemod Championship at Dreamhack Germany, where she appeared to haunt, impress and fascinate everyone who passed by. So much so, in fact, that she was voted the most spectacular case at the event.

What's more, my Iron Maiden mod has been nominated for the bit-tech mod of the year 2019 competition. If she wins, that means I will have won two of those competitions in a row, after my Spartacus PC won the 2018 one. As you can imagine, I'm really happy with how this mod turned out. **CPC**



A pillory covers the ports and cables at the back of the PC



GARETH HALFACREE'S

Hobby tech

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

ANALYSIS tilde.club

The modern Internet is dominated by the World Wide Web, and the modern World Wide Web is dominated by social networks. According to InternetLiveStats.com, around half the users of the Web are also Facebook users. Add in Twitter, Instagram and so on, and it would be fair to claim that the majority of web use comes down to social networking.

The modern web, though, is very different from the early days of the Internet. 'Back in ye olden Inter-Net tymes of the 1990s, if you were a (then youngish) nerd like me, you'd get an account on some server called **CyberFox.net** and your web address would be <http://CyberFox.net/~vixen>. (You were "vixen"),' wrote Paul Ford, founder of tilde.club, in October 2014. 'And you could put some web pages at that address. The early personal web grew up around these little "tilde sites"; that's what preceded blogging. The "~" is a little like the "@" on Twitter – a shortcut that says: "Here is a person."'

Listening to Fleetwood Mac, reading a blog post by Stevie Nicks and drinking perhaps more than he should was all it took for Ford



It's not exactly *Crysis*, but it's easy to get sucked into the ASCII-art games on tilde.club

to decide to bring back those early days. 'YES also i (sic) just registered <http://tilde.club> and will given (sic) anyone a shell account who wants one,' Ford told his Twitter followers. A day later, he had 100 requests for accounts.

While Ford followed through on his promise to set up tilde.club, the shell accounts were slow to follow. Having considerably underestimated demand – by the time approvals were paused, the queue had over 10,000 accounts pending – Ford set up a waiting list. For all but the lucky first

handful, five years would pass with little progress on setting up accounts.

Ford had, however, triggered something of a movement. Impatient to get started, some waitlist members followed in Ford's footsteps and set up servers of their own. They created what's now known as the 'tildeverse', a conglomeration of tilde.club-style sites, many of which cater to specific interest groups in a manner not dissimilar to the city-themed sections of our dear departed GeoCities.



There's an internal bulletin board, plus chat and mail for communication and collaboration

The original tilde.club, though, was increasingly closed off until, up to five years after originally signing up, waitlist members received notifications that they had been approved, but under new ownership. 'Recently Paul Ford has given me the pleasure of taking over tilde.club,' new system operator Michael Buchholz explained in an email. 'I do understand some of you have waited since 2014 for an account, which all involved do regret. But it is a new time and we all at tilde.club hope you join us on our new journey moving forward.'

It's now 2020, and tilde.club memberships are available with no waiting time. They're also free of charge, although donations towards the running cost of the server are welcome. Access is provided via SSH, using key pairs for security, although other tilde

sites have different requirements, including at least one that's accessible exclusively through the vintage Gopher protocol.

Once they're signed up and logged in, users have access to a chunk of hard drive space suitable for hosting simple websites. These sites typically, though not exclusively, evoke a 1990s aesthetic, aided by the complete lack of support for server-side scripting languages.

Acting as a webhost, though, is only a part of tilde.club. It's a social network too. Users have access to an internal bulletin board system and live chat, as well as on-server email, and both communication and collaboration are strongly encouraged. There are games too – primarily, though not exclusively, multi-user dungeons (MUDs), which are played out directly in the terminal, using the ASCII character set in place of graphics.

There's one major rule across all tildeverse sites: don't hack the Gibson



There are one or two nods to the modern web as well. The tilde.club server includes ttrv, a terminal-based client for the popular social network reddit. In all honesty, though, it's difficult to recommend using it once the novelty value has worn off.

All the code for running tilde.club is open-source and accessible at github.com/tilde.club, and it's this aspect that's really made the growth of the tildeverse possible. While the codebase has remained largely untouched since Ford created the server back in 2014, that's enough to get started running a tilde server of your own. However, for most tilde denizens, it's the community aspect of joining an existing server that's likely to be of most interest.

Those looking to join an existing server can apply at tilde.club now with no five-year wait expected; tildeverse.org contains a list of alternative tilde servers whose sysops have chosen to join the group, and tilde.club/~pfhawkins/othertildes.html has a longer list of known tilde servers, covering topics and interests ranging from lo-fi HTML artwork to collaborative science fiction authorship.

NEWS IN BRIEF

MNT Reform V2 design finalised

Open-source laptop specialist MNT Research has finalised the Version 2 design of Reform system, boosting the specifications considerably ahead of a Crowd Supply campaign launch scheduled for February 2020. The new model includes an NXP i.MX8M system-on-chip, 4GB of RAM and fanless cooling, plus a 1080p embedded DisplayPort panel. An improved keyboard also houses a secondary OLED display, tied into the system management processor. Pricing for the models – which will range from board-only to fully assembled versions – had not been confirmed at the time of writing. More information is available on mntre.com

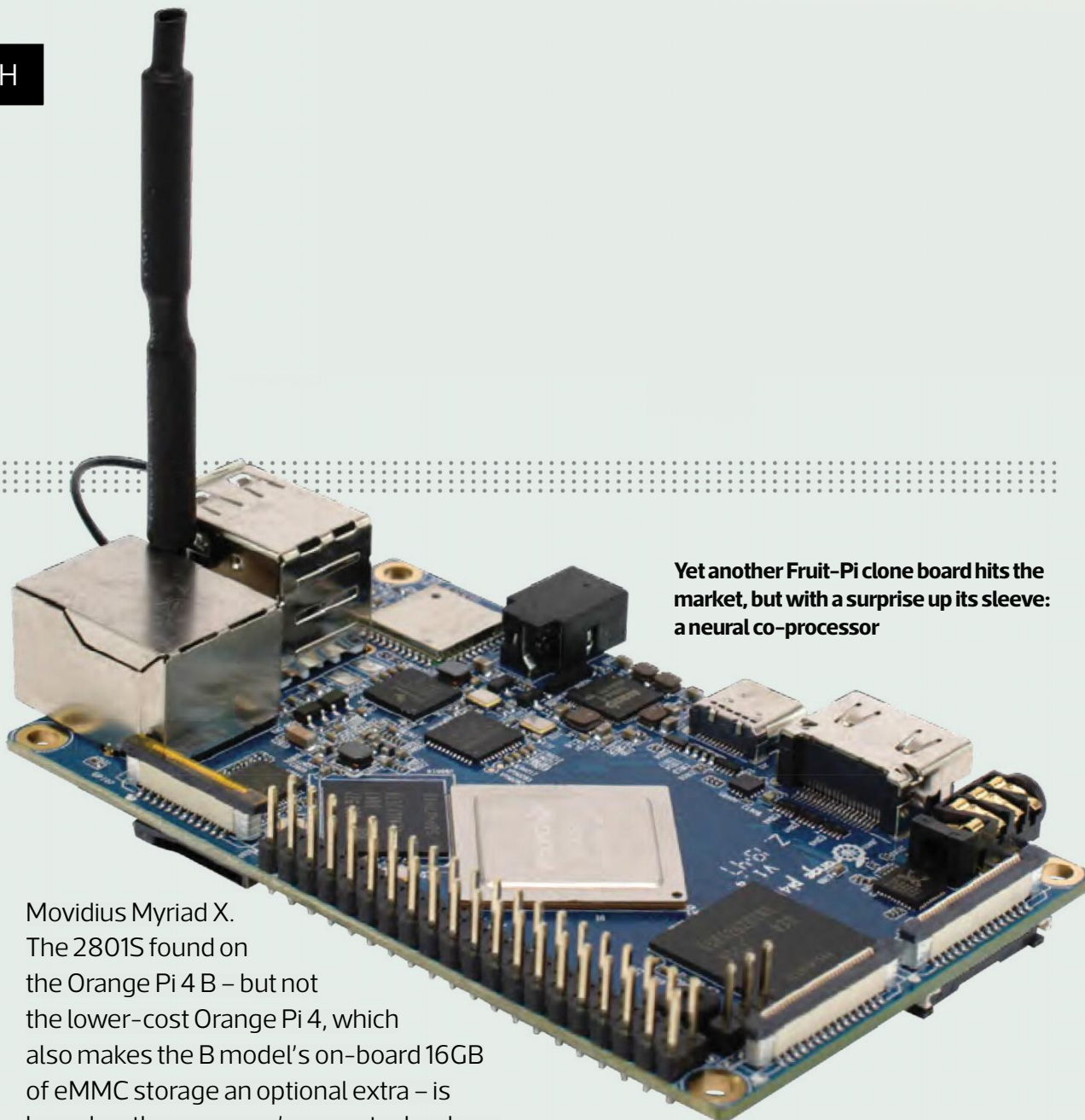
REVIEW

Orange Pi 4 B

Shenzhen Xunlong Software's Orange Pi family of single-board computers got its start like so many other fruit-themed Pi-suffixed designs: attempting to clone the original Raspberry Pi. In the years since, Xunlong's designs have diverged significantly from their inspiration, although the unoriginal moniker remains, and the Orange Pi 4 B is no exception.

Xunlong started to pull away from the competition with the launch of the Orange Pi Plus in 2015 (reviewed in Issue 143), which included features Raspberry Pi wouldn't add to its eponymous SBC family for quite some time – and, in the case of SATA connections, still hasn't. The Orange Pi 4 B, though, goes a step further by adding a coprocessor designed for neural network workloads.

That co-processor is a Lightspeeur 2801S Neural Processing Unit (NPU) from startup Gyr Falcon. This company made headlines in 2018 by claiming to have a USB-connected neural network accelerator that was 75 times more energy-efficient than Intel's



Yet another Fruit-Pi clone board hits the market, but with a surprise up its sleeve: a neural co-processor

Movidius Myriad X. The 2801S found on the Orange Pi 4 B – but not the lower-cost Orange Pi 4, which also makes the B model's on-board 16GB of eMMC storage an optional extra – is based on the company's same technology, but integrated directly onto the board itself.

The shift to an AI focus has resulted in the loss of a few features – starting with USB connections. The Orange Pi 4 B, unlike the Raspberry Pi 4 B, comes with just two full-sized USB ports of the slower USB 2 variety. There's a single USB Type-C connector offering USB 3 compatibility – along with, interestingly, DisplayPort support – for high-

speed peripherals, but its positioning leaves it at risk of fouling the full-sized HDMI port if you don't use the slimmest connectors.

There is a rarity to be found at the top of the board though: a single-lane PCI-E 2.1 header. Using it requires a low-cost break-out board and ribbon cable – not supplied with the review sample, sadly – in order to provide up to 500MB/sec of bandwidth.

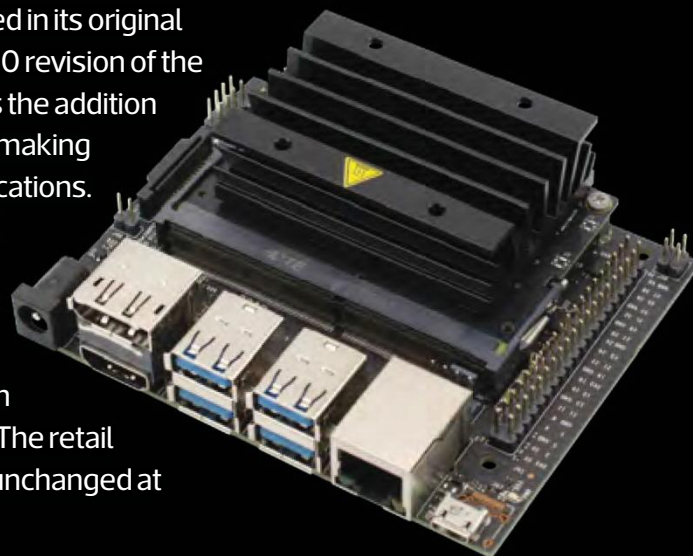


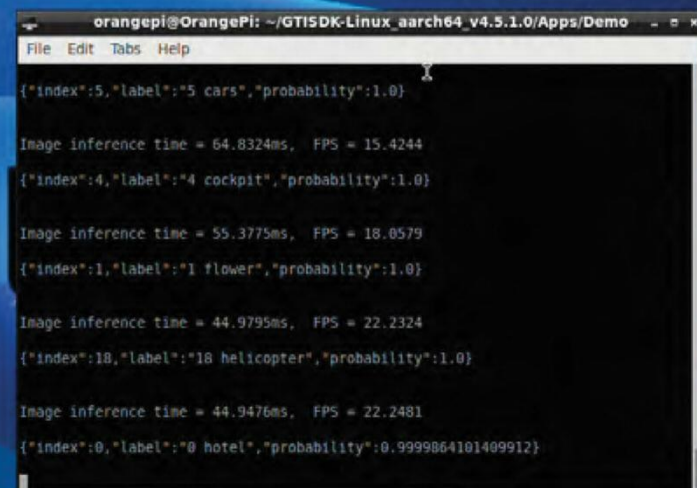
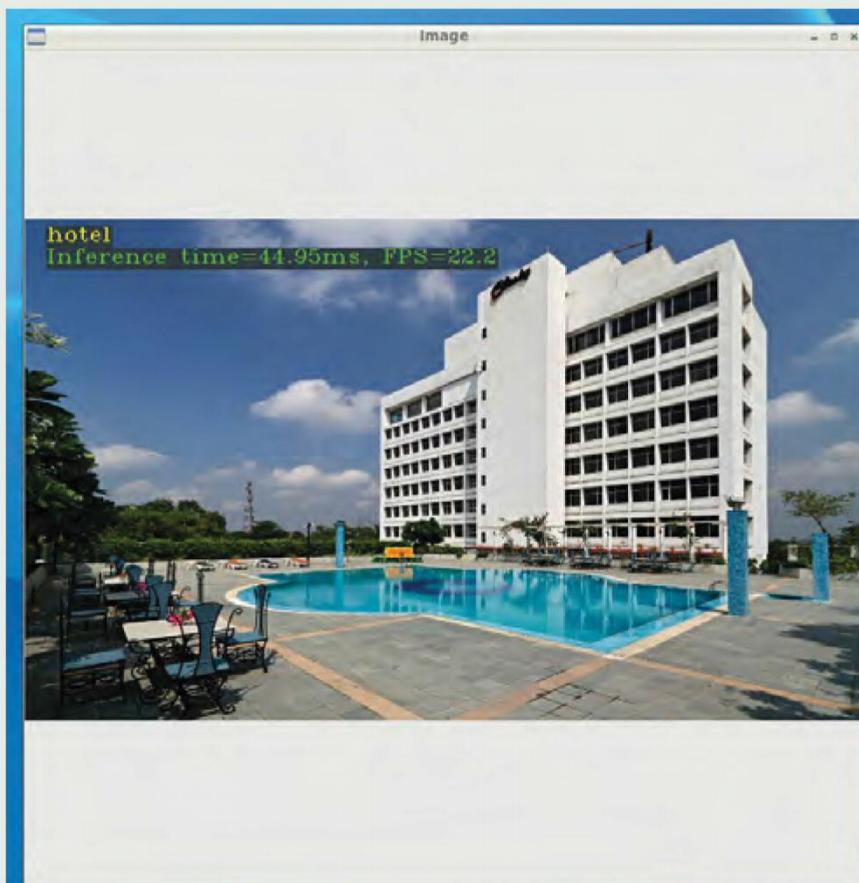
The Lightspeeur NPU is designed to accelerate neural network workloads at a very low power draw

NEWS IN BRIEF

Nvidia tweaks Jetson Nano design

Nvidia has launched a modestly upgraded version of the Jetson Nano Developer Kit (reviewed in its original form in Issue 191), bundling a new B0 revision of the carrier board. The biggest change is the addition of a second DSI camera connector, making the kit ready for stereo-vision applications. However, it comes at the cost of the remote power button and serial console connector. The updated carrier board is also compatible with the Jetson Nano Module, which includes on-board eMMC storage. The retail price of the Developer Kit remains unchanged at £95 (inc VAT, excluding shipping).





Running an image inference task on the NPU reveals impressive performance

Not that a lack of networking is an issue. The Orange Pi 4 B includes integrated dual-band Wi-Fi with a UFL connector for an external antenna, plus true Gigabit Ethernet. The latter easily matches the network performance of a Raspberry Pi 4 and the former exceeds it, although it's at the odd cost of a significantly reduced maximum range.

Elsewhere, the board includes a Rockchip RK3399 system-on-chip, which packs two high-performance ARM Cortex-A72 cores and four ARM Cortex-A54 cores into a pair of clusters, both running at 'up to' 2GHz.

There's an ARM Mali-T864 GPU, 4GB of dual-channel LPDDR4 memory and 16GB of eMMC storage, which is preloaded with an Android Open Source Project (AOSP) build.

As well as the HDMI 2 and DisplayPort 1.2 ports, both supporting 60Hz 4K displays, there are two LCD connectors and two MIPI CSI camera connectors. However, one of the latter pulls double duty, meaning it's possible to connect two LCDs and one camera, or two cameras and one LCD, at a time. Storage expansion is handled via micro SD, and there's a 5V 3A DC barrel-jack power input.

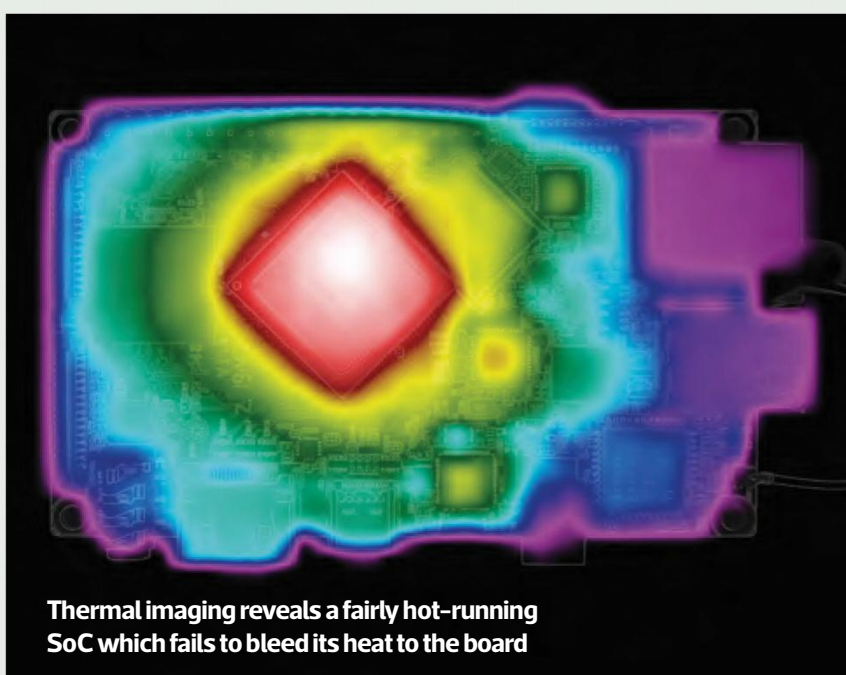
In general testing, running Xunlong's customised Ubuntu 18.04 Linux distribution, the Orange Pi 4 B is no slouch. It exceeds the Raspberry Pi 4 in some benchmarks, thanks to higher memory bandwidth and those two extra CPU cores, and trails behind in others – likely due to four of the six cores being weaker ARM Cortex-A54 units.

Firing up the NPU unveils the Orange Pi 4 B's true potential. Running a simple image inference workload, the NPU was able to accurately categorise images at a rate of between 15 and 25 frames per second, while increasing the power draw by just 1W over idle.

Sadly, the software side of the package lets it all down. To use the NPU with pre-configured software and pre-installed demos, you need to use an outdated build of Ubuntu, which fails to resize its root partition on boot. A newer, bug-fixed build offers the 3D acceleration missing from the earlier version, but doesn't include the software for the NPU. In both cases, stability was an issue and crashes occurred frequently.

The other software is simply outdated, rather than buggy. The bundled AOSP build is based on Android 8.1 with a November 2018 security patch level, and there's no sign from Xunlong to suggest a newer build is in the works.

At \$69.90 US (ex VAT) from orangepi.org, the Orange Pi 4 B isn't the cheapest SBC on the market, but given the high cost of buying an NPU accelerator separately, it's priced pretty aggressively. For anyone investigating edge and embedded neural network projects, it could be worth a punt, as long as you're willing to spend time polishing the software side of the setup yourself.



Thermal imaging reveals a fairly hot-running SoC which fails to bleed its heat to the board

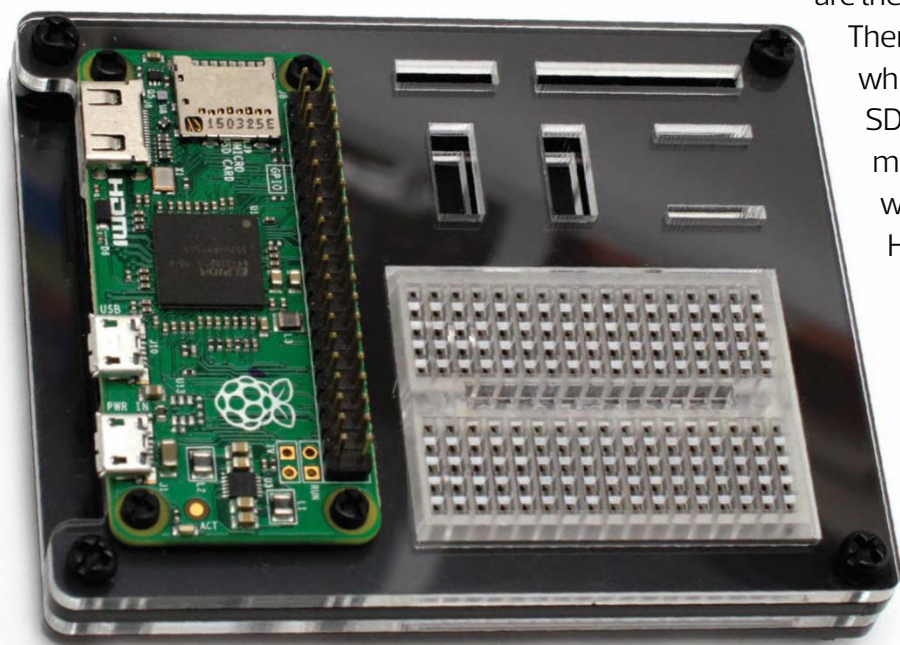
REVIEW

Pi Hut ZeroDock

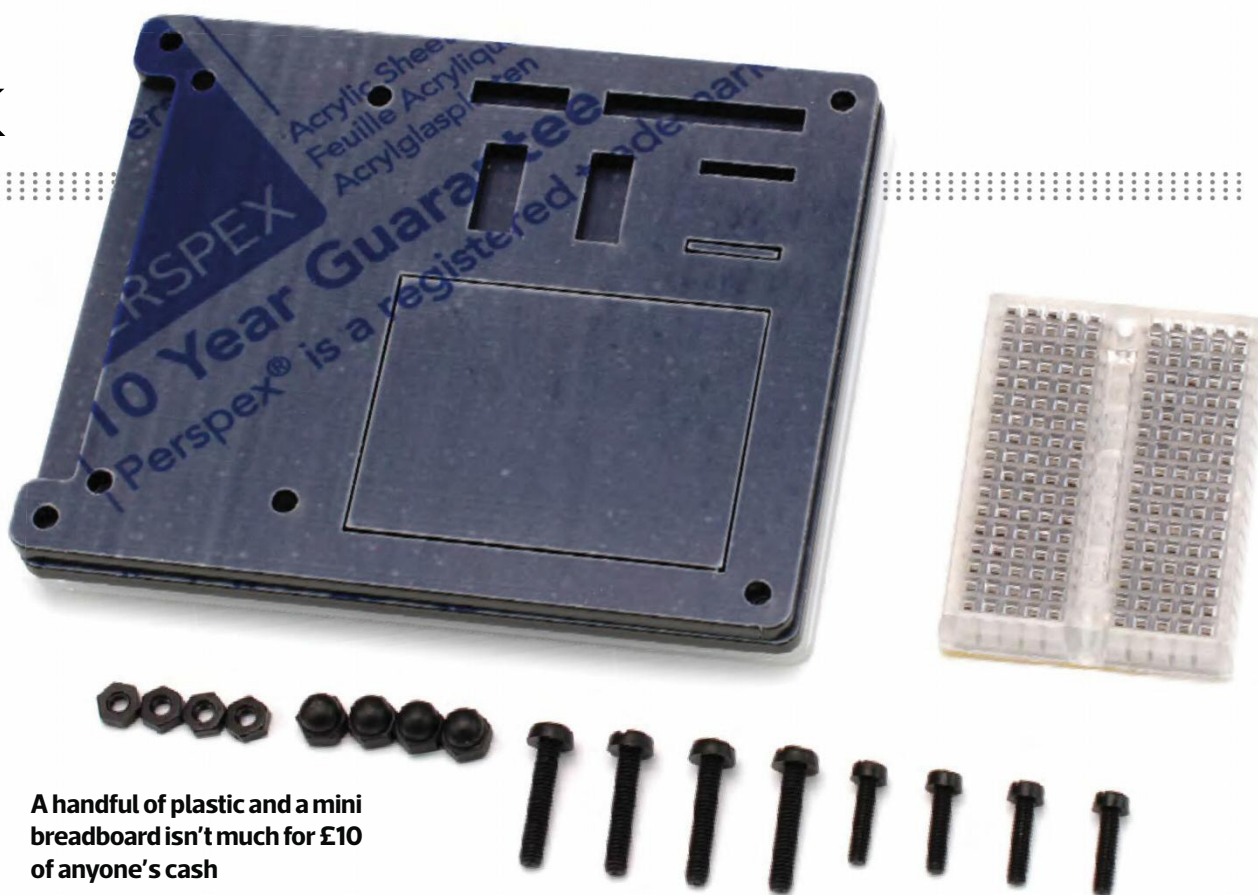
The Raspberry Pi Zero (see Issue 150) and Wi-Fi/Bluetooth-equipped Raspberry Pi Zero W (see Issue 166) are undeniably remarkable devices. Priced at just £4.80 and £9.30 inc VAT respectively, they're about as cheap as a computer can get – and their gumstick-like form factor makes them ideal for embedded applications, at least once you've finished development.

During development, though, their compact size and light weight aren't necessarily advantages, given their tendency to be pushed around the desk as you connect and disconnect cables and accessories. In this situation, the Pi Hut's ZeroDock aims to offer support. It contains no electronics or metal parts, bar the electrical traces underneath the compact breadboard bundled for prototyping purposes. It's just four alternating black and clear sheets of laser-cut Perspex, plus a handful of plastic nuts and bolts to hold it together.

Assembly is quick and easy. Pop three of the sheets together, attach any model of Raspberry Pi Zero – although the header-equipped H-suffix models are necessary if you don't want to supply and fit pins to the general-purpose input/output (GPIO) header yourself – and finish with the bottom layer, which includes nuts that double as feet.



The ZeroDock does exactly as promised, but is that enough to justify the price?



A handful of plastic and a mini breadboard isn't much for £10 of anyone's cash

The result is a relatively compact plastic creation that keeps the Raspberry Pi Zero entirely stable – it's dramatically less likely to be pushed around the desk as you attach and disconnect cables. All ports remain accessible, and there's a cut-out underneath to allow the board to breathe as the system-on-chip warms up.

The upper three layers have laser-cut holes in them, designed for storage of commonly-used accessories. The two smaller slots to the right are ideally shaped for micro SD cards, while the two larger slots to their left are the right size for USB dongles.

There's a large slot to the top, which can take a full-sized SD card or an adaptor for the micro SD cards, and another which can accept a mini-HDMI to HDMI adaptor.

It's a neat idea, and it does help to keep your desk a little tidier, but it also feels rather unnecessary. Most accessories are likely to spend their lives permanently attached to the Raspberry Pi Zero – those that don't are only held in place

loosely, so you can't use the ZeroDock as an easy means of transporting all the gear at once.

It's the prototyping area that saves the ZeroDock. The large rectangular cut-out to the bottom is perfectly sized for the bundled miniature solderless breadboard, which can either be slotted loosely in place, or attached permanently using the pre-applied adhesive backing. Once fitted, the breadboard provides an (admittedly limited) area for quick circuit building, positioned easily close enough to the Raspberry Pi Zero's GPIO header for tangle-free connection with short female-to-male jumper leads.

It's a shame no such leads are supplied, because that may have helped to justify the price. At £10 (inc VAT) from thepihut.com, it's the same price as the company's Raspberry Pi 4 case, which contains more acrylic, more fasteners and a bundled 5V cooling fan, although admittedly not the solderless breadboard.

The price puts the ZeroDock above even the most expensive Raspberry Pi Zero model, which is an admittedly low bar given the boards' bargain-basement pricing. For those who do a lot of prototyping of smaller circuits, limited to just the handful of components that would fit on the compact breadboard supplied, it's likely a price worth paying. For general users, though, the ZeroDock is simply too much money for too little utility. **GPC**

WIN

A 43in IIYAMA 4K MONITOR

Here's an amazing opportunity to fill your face with a massive 43in 4K monitor, thanks to the generous folks at iiyama. One lucky Custom PC reader will get an iiyama ProLite X4372UHSU-B1 monitor sent to their home.

- 43in IPS LED panel
- Remote control
- Stereo 9W speakers
- 4ms response time
- Headset hook
- 3,840 x 2,160 resolution
- 2 x HDMI and 2 x DisplayPort inputs
- USB 3 hub

SUBMIT YOUR ENTRY AT
CUSTOMPC.CO.UK/WIN

iiyama

The ProLite X4372UHSU-B1's resolution of 3,840 x 2,160, also known as 4K, offers a gigantic viewable area with four times more information and work space than a full HD screen. Its IPS panel also offers higher contrast, darker blacks and much better viewing angles than standard TN technology. The screen will look good no matter what angle you look at it.

It also has a PbP (picture-by-picture) function, which allows for the simultaneous display of

content from up to four different signal inputs. Divided into four, the screen offers users a workplace equal to four full HD displays put together, but without the bezel getting in your view and saving you the hassle with extra cables.

Meanwhile, the blue light reducer function substantially reduces the strain and fatigue caused by flickering and blue light emittance of regular monitors.

WORTH
£400



Competition closes on Friday, 3 April. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from Custom PC magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked.



ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear
and everything to do with PC modding

The water-cooling and modding boom

It's strange to think that I've been a part of the **Custom PC** team for more than half its life now. I was the team's modding and water-cooling expert when I first arrived, and those segments of the PC enthusiast scene were very small niches back then. When the financial crisis hit over a decade ago, I wondered if they would survive, given the sorry state of the PC market. With general PC sales declining, we've had years of grim reading, but it's actually really looking up for enthusiasts.

The PC modding and water-cooling scene has become huge over the past few years. Modding competitions with budgets of tens of thousands of dollars are commonplace. Meanwhile, professional modders number in their thousands and the water-cooling scene has never been bigger. In fact, using my favourite form of cooling is now easier than ever – there's a bigger array of parts and manufacturers than ever before, and it's also safer.

This is incredible given that I feared for their longevity just a few short years ago, but it's clear that these areas are now seen as essential parts of the PC hardware market. They're used by companies to promote their products while enthusiasts are more aware of modding and water cooling than ever.

The scrap between AMD and Intel also looks set to continue for several years at least, with the blue team yet to get a handle on the situation. This means that more and more power will be available on the desktop PC for less cash than before, so the need for exotic cooling isn't going to wane.

Basically, it's a fantastic time to be an enthusiast, and while dealing with so many product launches every year is exhausting, I still get a buzz reviewing the latest hardware and seeing how best to cool it. This year I'll also be dishing out more video content on these topics, as well as general hardware discussion, on the new **Custom PC** YouTube channel at custompc.co.uk/YouTube

I've enjoyed building some outlandish PCs, and the modding and water-cooling scenes are now more popular than ever



The best of CES

I hit the CES trade show in Las Vegas this year to check out the latest PC hardware, so I thought I'd share a few of the more interesting items on show. First up were Alphacool's new Eiswolf GPU all-in-one expandable liquid coolers. They come with AMD or Nvidia illuminated logos and they look fantastic in the flesh, giving the rather plain-looking original GPX Pro GPU AIO coolers a much needed aesthetic boost.

Another interesting concept was Lian Li's modular fan system. The fans simply click together and don't require cables to control their speed or

lighting. A control board at one end has single cables for those signals, which are controlled using software. It's an ingenious idea, so as long as the fans perform well, they seem like winners.

Phanteks, meanwhile, showed off a universal 120mm distribution plate that can be installed in practically any 120mm fan mount, as well as some new LED strings. These flexible strips can be secured to any surface, and look more like neon lighting strips than RGB LEDs, wrapping around your hardware to create some seriously funky lighting.



Alphacool Eiswolf GPU AIO cooler



Phanteks' universal 120mm distribution plate can be installed in practically any 120mm fan mount



Lian Li modular fan system



Phanteks' new LED strips can be secured to any surface

Hands on with Corsair's QL fans

Fans are becoming an increasingly important part of our PCs' aesthetics. We've moved on from single-colour LED fans to RGB models, and even digital RGB technology that allows you to control the colour of individual LEDs in an array.

Thanks to its memory and cases being a part of the same ecosystem, Corsair is in a rather enviable position when it comes to RGB lighting. It already has a range of RGB fans, but the QL series takes the range a step further, and addresses one glaring issue with RGB fans – how they look from the rear.

The fans are available in both 120mm and 140mm sizes, with

individual packs available, as well as 120mm triple packs and 140mm twin packs with Corsair's iCUE Lighting Node Core USB controller. There are 34 individually addressable LEDs in each fan, equipping a pair of inner and outer lighting rings, as well as the hub, with Corsair's usual vibrant RGB lighting.

The addition of a rear lighting ring means the view of them from any angle should be roughly the same, which is great news. These fans aren't particularly powerful, though, topping out at 1,500rpm with 1.55mm H₂O static pressure, but they're fantastic if you need your fans to look great from all angles. **GPC**



There are 34 individually addressable LEDs in each fan, covering the inner and outer lighting rings, as well as the hub



Corsair's new QL RGB fans have lights on both the front and back

How to 3D-print a PC case

Antony Leather shows you how to design a PC case with CAD and then 3D-print it

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HackSpace



hsmag.cc

TOTAL PROJECT TIME / 72 HOURS

We've looked at 3D printing numerous times over the years, but the steady progress of the technology, as well as falling printer prices, means it's now possible to create and print an entire PC case without spending a fortune. In fact, for just a few hundred pounds you can own a 3D printer that can print huge sections of a case in one go, so the main part of creating a custom rig is just designing it. Some CAD software is free to use, and 3D printing filament is affordable, so the only limits are the size of objects your printer can create.

It's not all plain sailing, though, as you'll need to ensure millimetre-level precision in many parts, while also thinking about cooling and mounting your hardware. We've teamed up with Dremel, which sent us its flagship 3D45 3D Printer, to show you how to start and make use of pre-created files, as well as how to download an entire case design to print at home without doing any designing yourself.

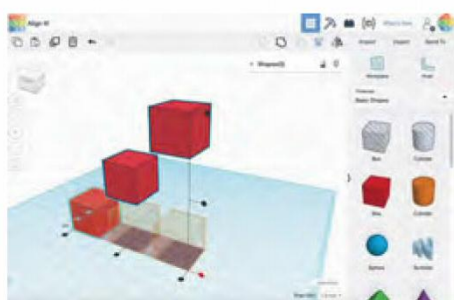
TOOLS YOU'LL NEED



Digital Vernier calliper
amazon.co.uk



3D printer or
printing service
amazon.co.uk



3D design app
or software
tinkercad.com



1 / CHOOSE YOUR PRINTER

3D printers have differing print areas, so work out the minimum print size you need in order to create your PC case. To save on space, you might want to use an SFX PSU and mini-ITX motherboard.



2 / PICK HARDWARE ORIENTATION

Popular small 3D case designs, such as Kolink's Rocket, position the motherboard on one side of the case, and the GPU on another, drawing in air through a side panel. These designs are easy to print and can allow for a range of cooling options, making them good options for a first try.



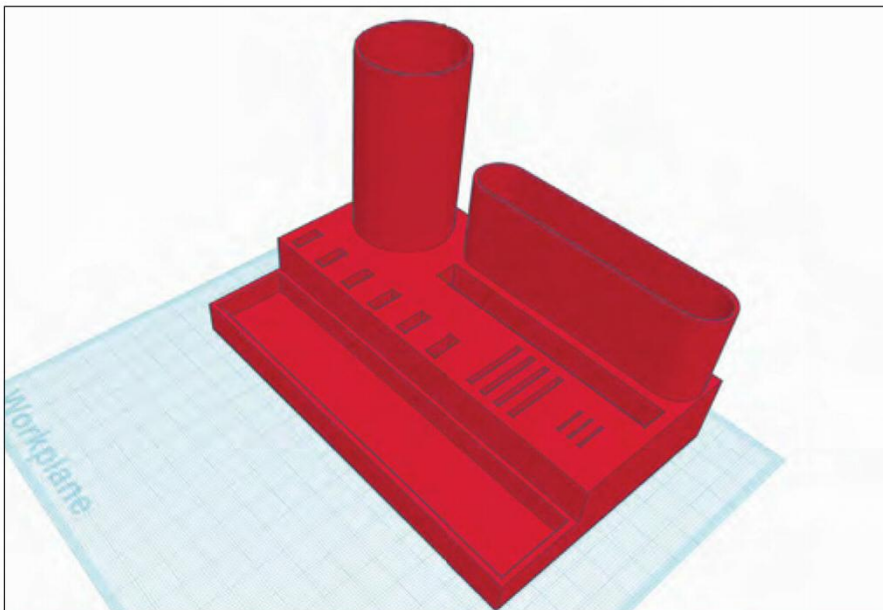
3 / LAY OUT HARDWARE

To get inspiration for design tweaks, lay out your hardware as you plan to position it in the case. This step can help when placing fan mounts, and working out how best to ventilate and cool your PC.



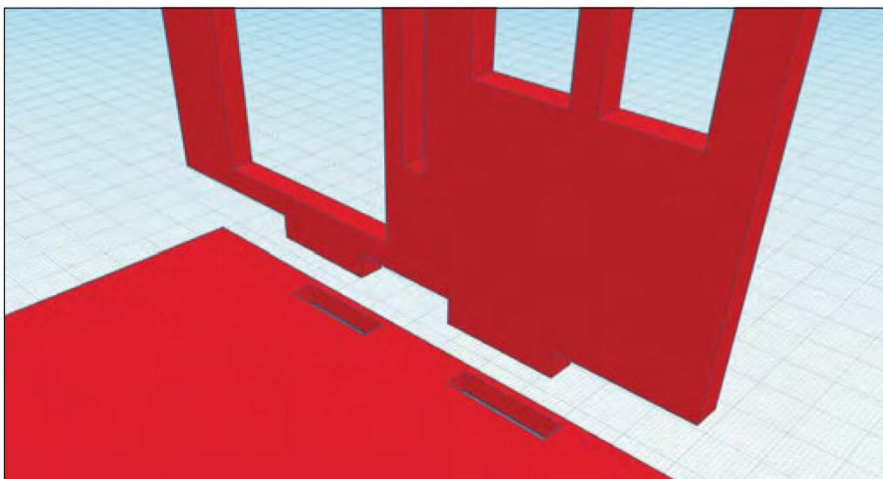
4 / CHOOSE 3D PRINT MATERIAL

There's a variety of 3D print materials available, including wood and metal effects. However, for some parts of the PC, it's best to use strong materials such as nylon, especially for supports or construction cubes.



5 / LEARN 3D DESIGN SOFTWARE

There's a plethora of software available, both free and paid, that's great for creating 3D-printable models. One of the best and simplest to use is TinkerCAD, which is an online app. You can design models down to a 0.1mm resolution with plenty of flexibility, and export your designs to STL files for use with 3D printers.



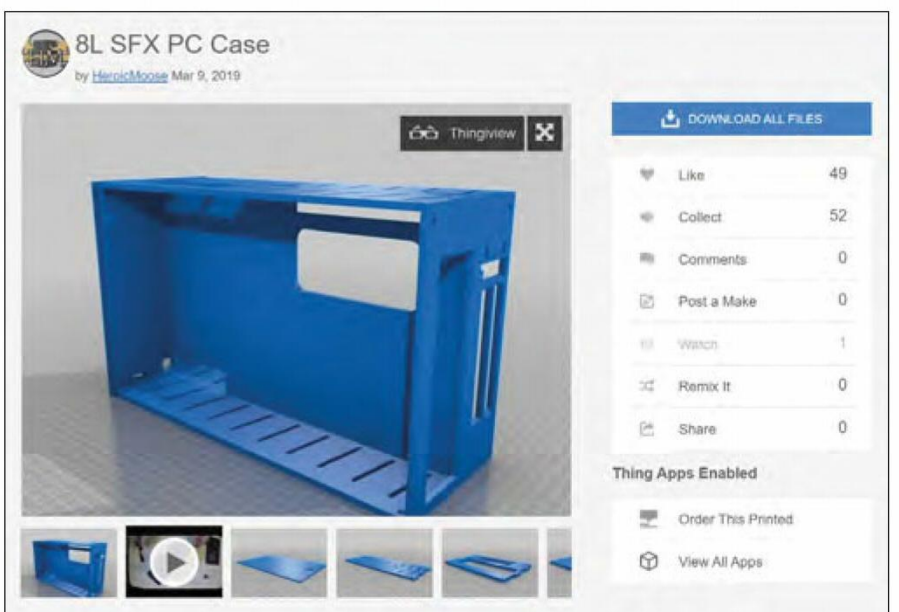
6 / CONSIDER SLOT-TOGETHER DESIGN

One way of constructing your case is to use flanges that slot into holes – in other words, a slot-together design. These designs require less time than construction cubes, but you'll need to work with a high degree of accuracy to ensure that the parts fit neatly together.



7 / USE MODDING CUBES

Companies such as Parvum Systems use modding or construction cubes to attach the various sections of case together. These cubes cost around £1 each and give some flexibility when it comes to mounting your components. Unfortunately, you can't 3D-print them, as the screws will split the print layers.



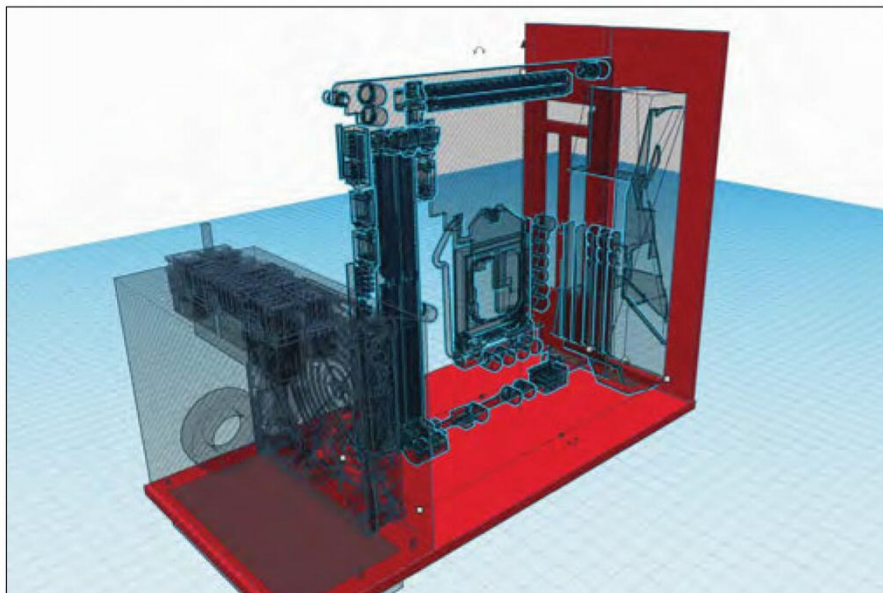
8 / SEARCH FOR EXISTING CASE PARTS

While creating an entire case yourself is rewarding, there are thousands of pre-rendered objects available that can save you time, so you can spend more time designing your case's unique details. Motherboard trays, I/O panels and expansion slot brackets are all worth borrowing for your build.



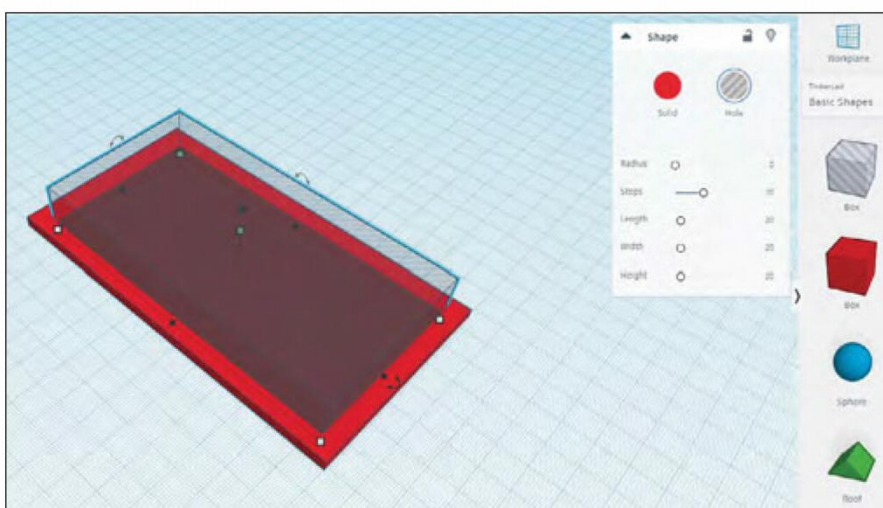
9 / USE A DIGITAL VERNIER CALLIPER

A digital Vernier calliper allows for very precise measurements of components. It can be very useful for modelling the fixtures, fittings and hardware, so you can accurately create your 3D case model.



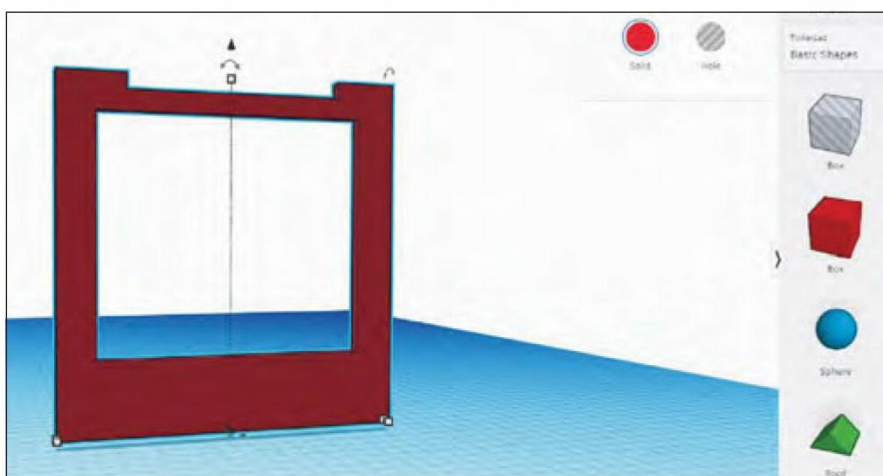
10 / USE 3D HARDWARE MODELS

To aid the design process, plenty of websites, such as tinkercad.com, thingiverse.com and 3dwarehouse.sketchup.com, have thousands of pre-rendered models available for you to download. However, you'll need to ensure that they've been rendered accurately and that they're the correct size.



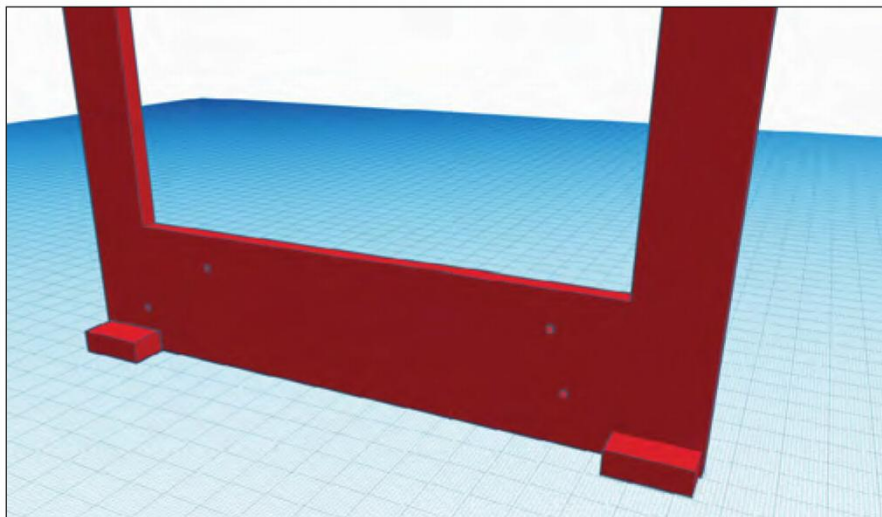
11 / CREATE HOLES

In TinkercAD, you create holes in objects by making a shape with the size of hole you need, and turning that object into a 'hole' using the Shape tool. You can use this method to add screw holes and vents to your designs.



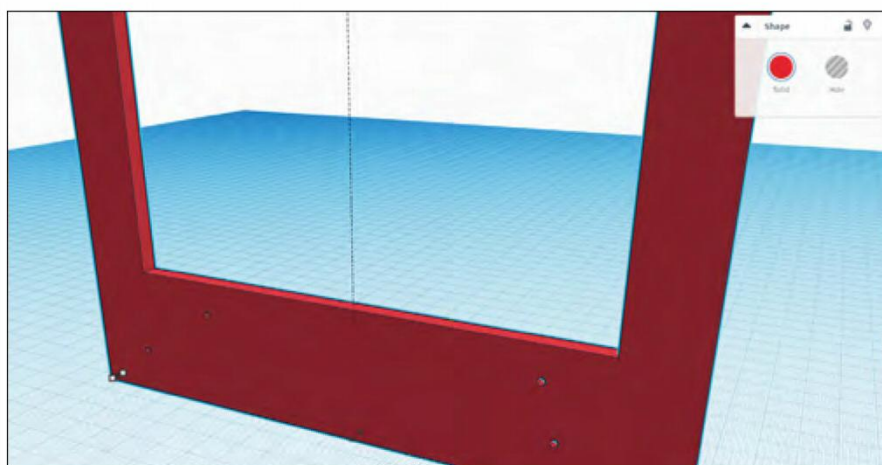
12 / CREATE MOTHERBOARD TRAY

Start with the motherboard tray, which only has one job - to secure your motherboard. It doesn't need to run the length of the case, and it's usually easiest to add motherboard standoffs yourself after printing, rather than beforehand.



13 / CREATE TRAY SUPPORTS

If you want to 3D-print the majority of the components, you can add large supporting feet to the motherboard tray, enabling you to secure it to the other panels in your case. Make sure these supports are large and thick enough to have holes drilled in them without breaking.



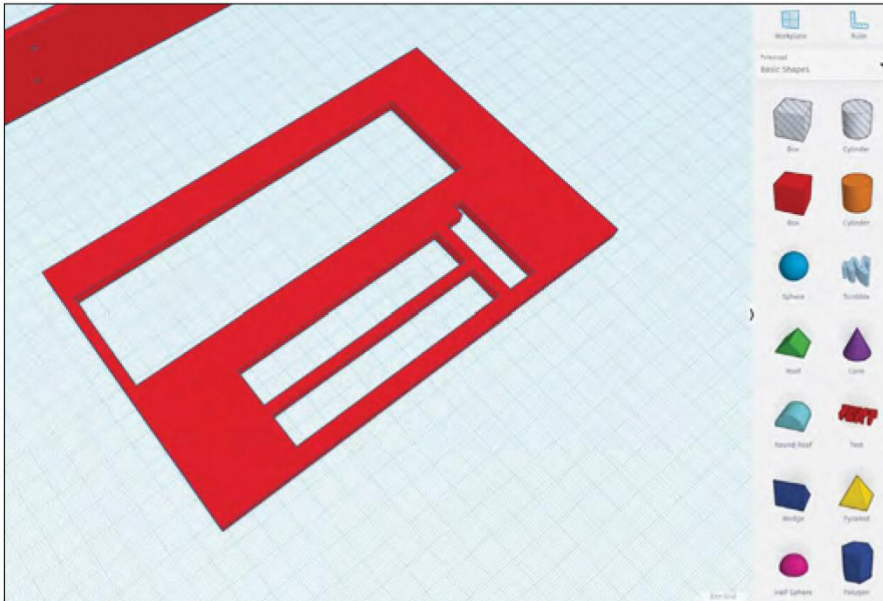
14 / CREATE MOTHERBOARD MOUNTS

If you're confident in your measurements, add the motherboard standoff holes, which for 6-32 screws need to be 3mm wide, using templates such as the ones available at custompc.co.uk/Standoffs. Alternatively, once you've printed the motherboard tray and rear panel, mark up the standoff holes and drill them.



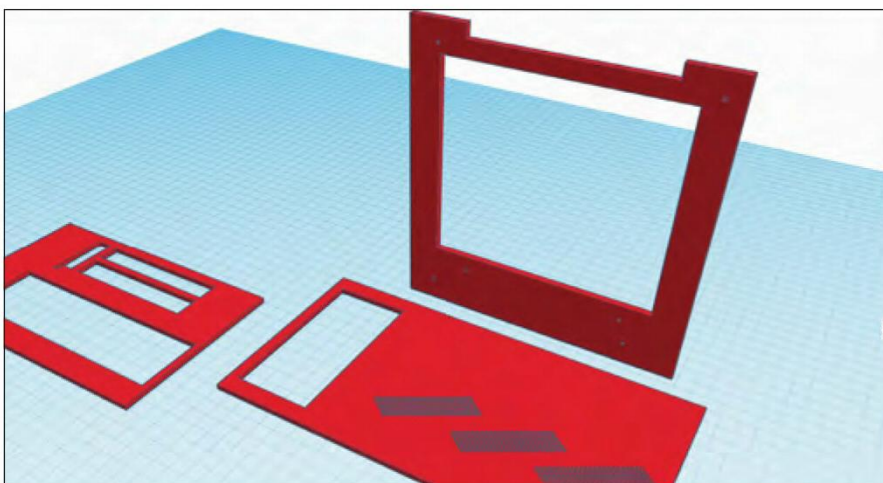
15 / TEST-PRINT

It's best to print a single section first, so you can test your printer settings. Large, flat objects can be prone to warping, so you may need to adjust the temperatures of the print nozzle or print bed, as well as trying other materials. You'll also need to see if your chosen thickness is sufficient to prevent too much flex.



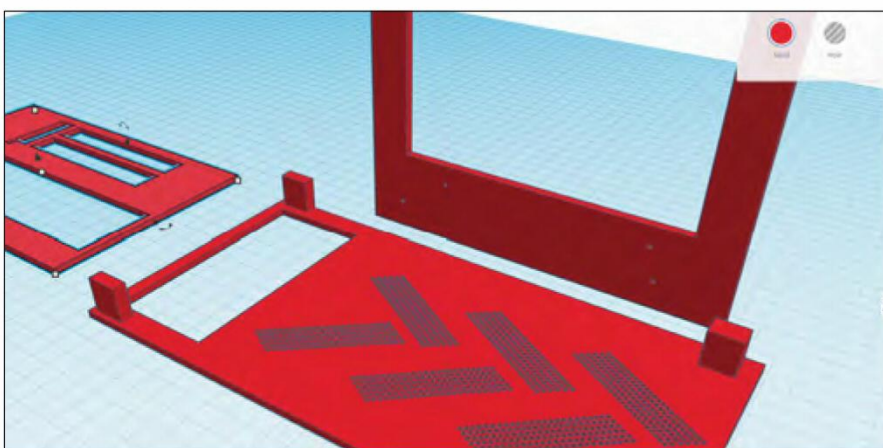
16 / CREATE REAR PANEL

The rear panel will need an I/O cut-out, as well as expansion slot brackets. You can use an existing case to measure the design elements, or use an existing model online, cutting away just the sections you need before adding them to your 3D model.



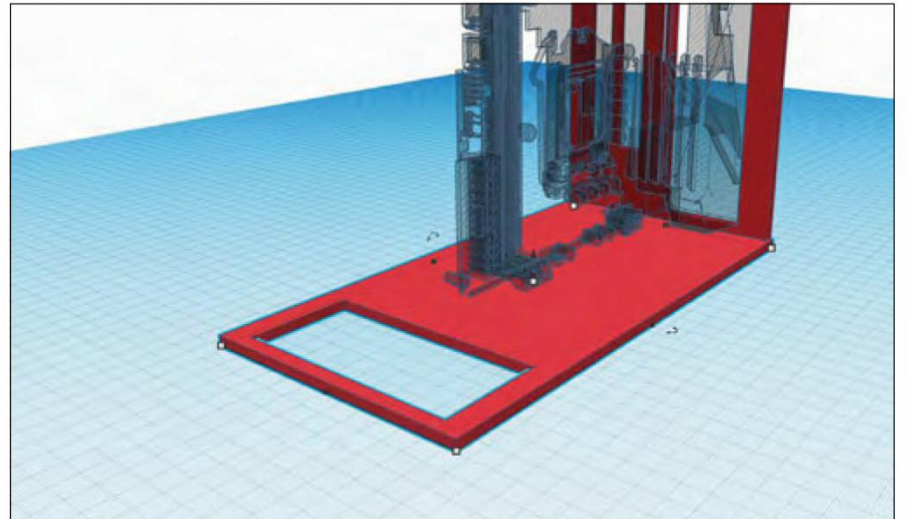
17 / CREATE THE BASE

The base will probably be a fairly simple object, depending on your hardware configuration, but you may want to place your PSU or fan mounts here, as well as add some ventilation holes. You want to have the front and rear panels sitting over the ends to create a clean look.



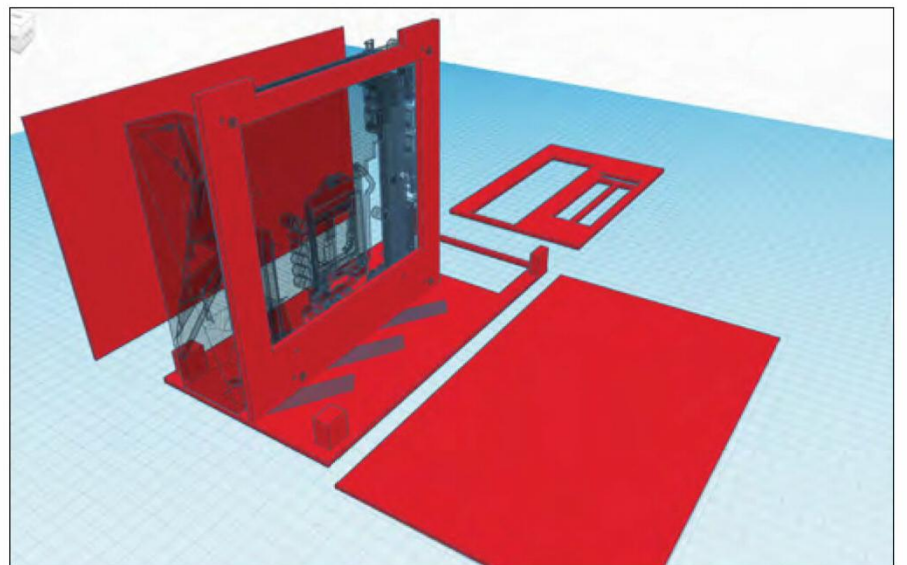
18 / ADD CASE FEET

Case feet will be essential if you want to give the base clearance for better airflow, or if you want to run a PSU cable underneath the case. However, if you want to experiment with feet designs, or have the option of removing them, you can print them separately and use mounting tape to secure them later.



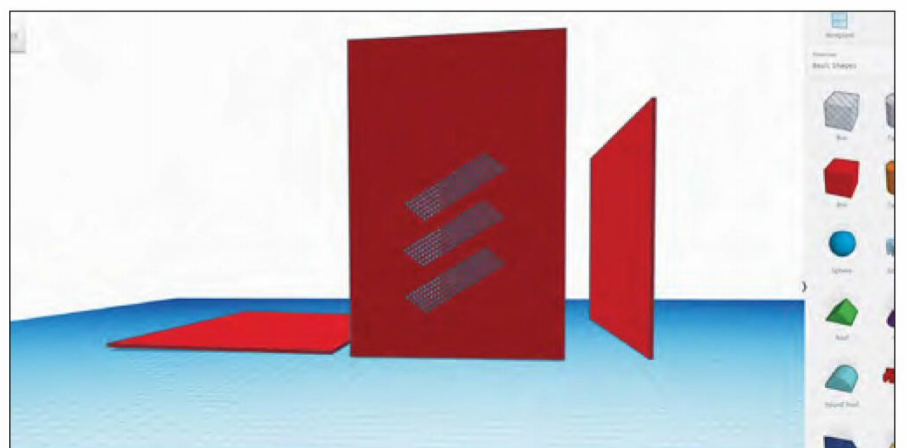
19 / CREATE PSU MOUNT

We've used an SFX PSU in our PC to keep its width as small as possible, which will also cut down on print material and print times. Mounting it in the front makes for the best use of space, and we recommend using an angled mains lead plug in this configuration.



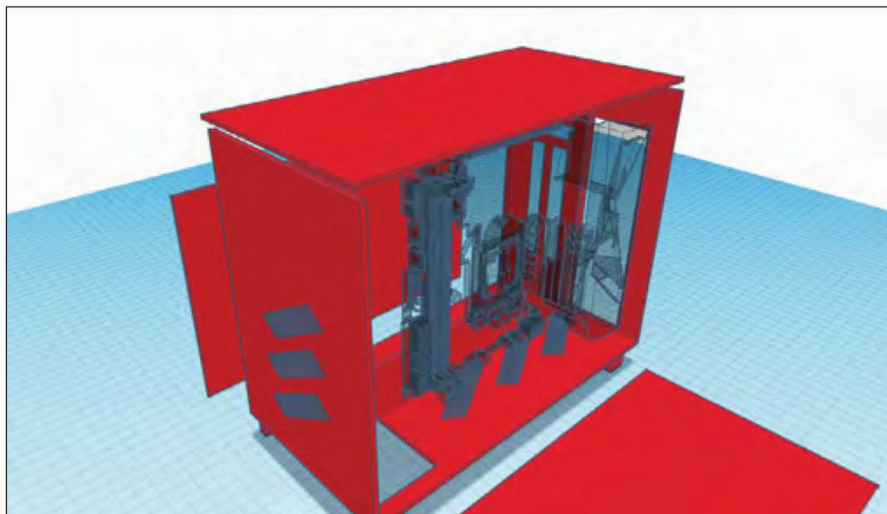
20 / CREATE SIDE PANELS

The side panels should sit on the outsides of all the other panels, in order to give your case a clean look. These will likely be the largest components you print, so if you haven't bought a 3D printer yet, make sure its print bed is big enough for these.



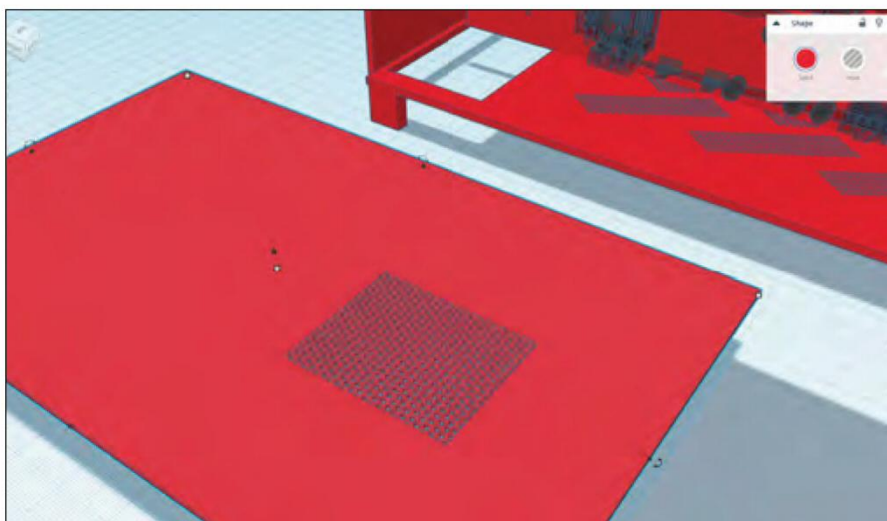
21 / DESIGN FRONT PANEL

You may want to add ventilation, or a fan mount and grilles, to the front panel. Or, in a case such as ours, mount the PSU on it. If you want to avoid using screws here, you can consider making push-fit pins part of the printed front panel, with matching holes for them in the roof and base sections.



22 / CREATE ROOF

For the cleanest look possible, the roof section should sit between the rear and front panels, and this area is where you'll want to place any fan mounts in a very small case. You could also consider a large opening for a window here, since our design will be using the side panels for ventilation.



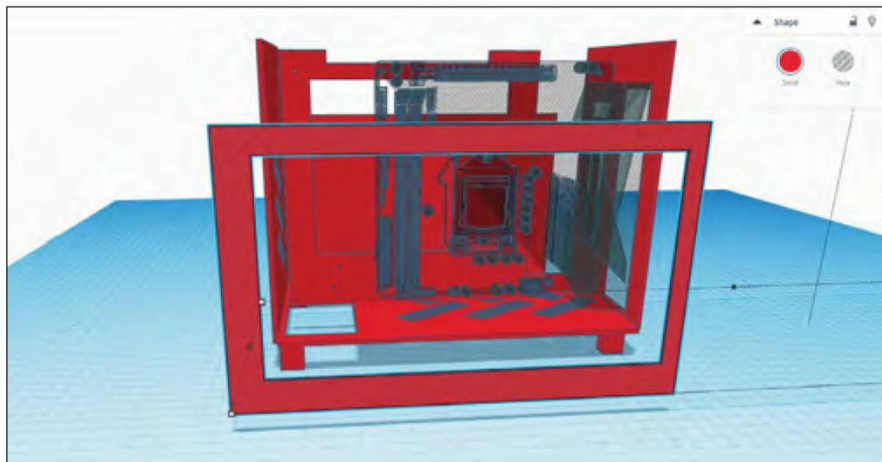
23 / ADD VENTILATION HOLES

The most important addition to our design is ventilation – we're adding side vents to allow the CPU cooler and GPU to breathe. These make a huge difference to cooling, so they're essential in a small case unless you have several intake or exhaust fans.



24 / DECIDE ON POWER SWITCH

You'll need a way to turn on your PC. You can consider using a momentary push button, which will require a specifically sized hole, as well as clearance behind it. However, you can also use an external or remote-controlled power switch to remove the need for a physical one.



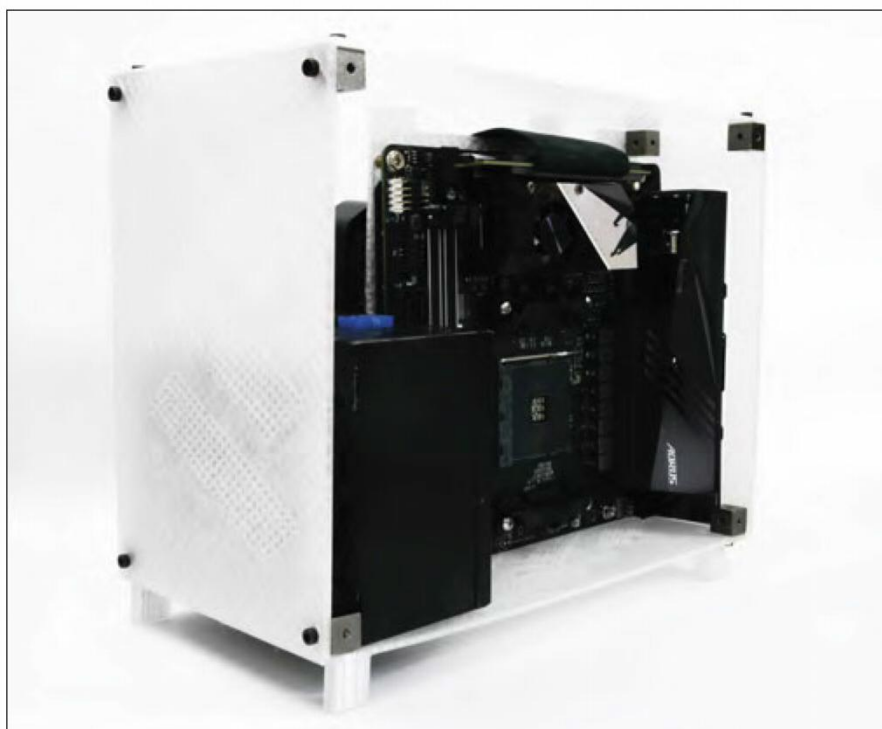
25 / CONSIDER SIDE WINDOW

If you plan on using liquid cooling rather than air cooling for your CPU, you can consider creating a side panel window opening. You want the rim to be at least 1in wide in order to offer enough strength, and you can mount clear acrylic inside it using mounting tape.



26 / INSTALL CONSTRUCTION CUBES

Print the motherboard tray and rear panel first, so you can continue working on them while the other parts print. You can install the construction cubes by drilling 3mm holes and securing them with long-thread 6-32 PC screws, taking care to align the motherboard with the rear I/O cutout.



27 / BUILD THE CASE

Install the rest of the case components, then install your hardware to make sure it all fits. You can consider sanding the 3D printed parts for a smoother finish, starting at 120-grit sandpaper, and working up to 1,000-grit, before using plastic primer and spray paint. **GPC**

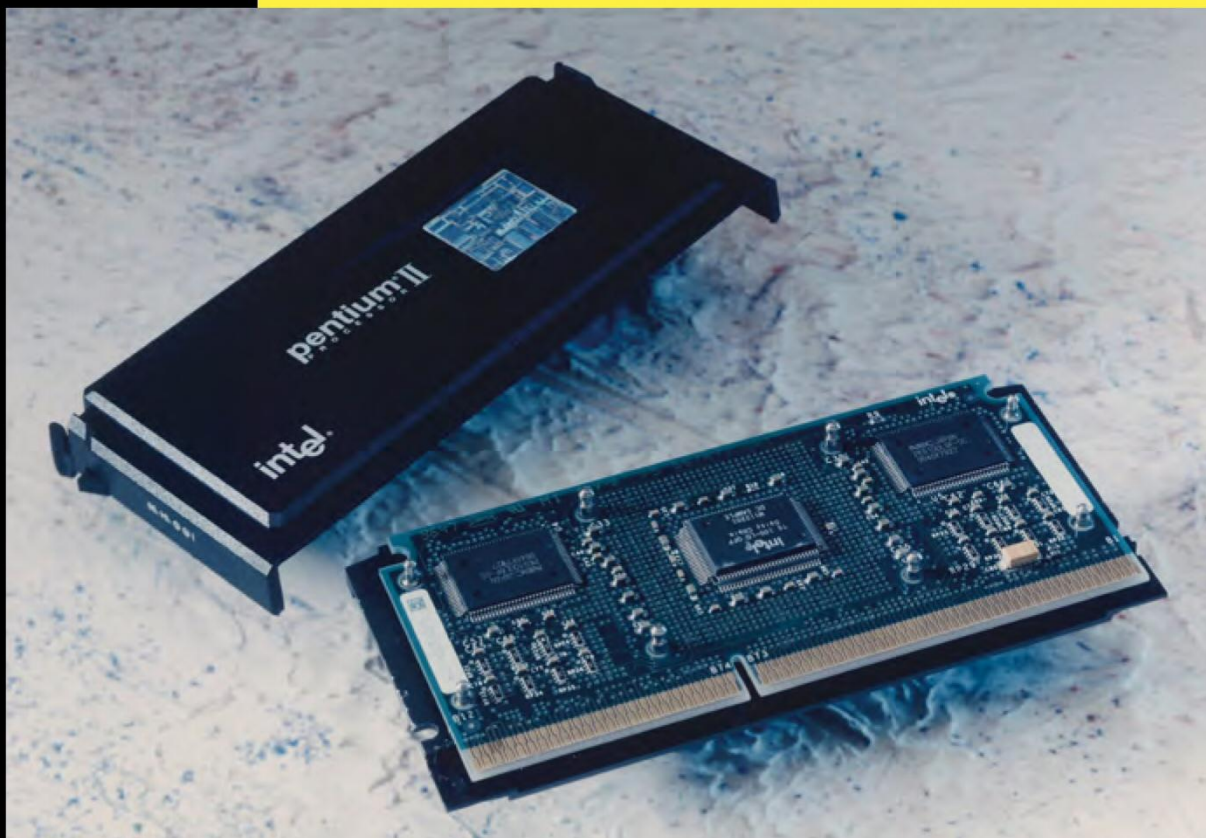
Slot machines

Holograms, black boxes and mountains of cache. Ben Hardwidge recalls the weird moment in time when Intel's CPUs came in Slot 1 format

Packaging your CPU inside a big box before slotting it into your motherboard seems like a recipe for a thermal catastrophe now, but for a brief period around the turn of the Millennium, Intel (and later AMD) mounted their CPUs on circuitboards inside sleek black packages. They looked great too. There was now room for proper logos and a flashy physical design. Instead of dropping a nondescript-looking ceramic square into your motherboard, you had a fancy black box with a hologram on the front.

With their slick packaging, the first Pentium II CPUs looked great in the TV adverts and promo shots. I remember wanting one just because they looked so good – a small hologram sticker clearly goes a long way towards manipulating people like me! To the uninformed, it looked like these attractive slot-based CPUs were the way of the future, but if you took a peek inside the box, they were clearly a result of technological limitations at the time.

An original SECC Pentium II – look at the size of the cache chips on either side of the CPU area



Cache for questions

To understand the need for slot processors, we need to start by going back a bit further in time. Before the Pentium II, Intel had two major CPU designs. It had the Socket 7 Pentium MMX for consumer PCs, which was the last gasp for the first Pentium design, now running at up to 233MHz. MMX stands for multimedia extensions, and it effectively enabled a lot more functions to be handled in software on the CPU, rather than in hardware. For example, an MMX CPU enabled you to properly use a software PCI modem, rather than a full hardware one, saving you some money.

For servers and workstations, Intel had also introduced the Pentium Pro, a massive chip that was heavily geared towards pure 32-bit computing. It lacked consumer frills such as MMX instructions, but you could run more than one Pentium Pro in parallel on a multi-socket board.

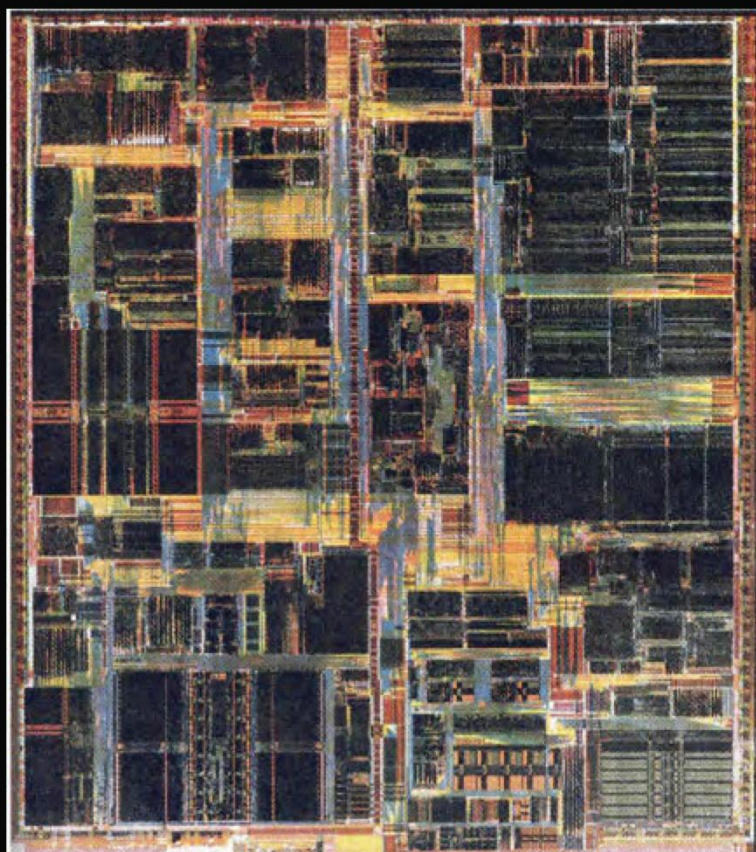
The Pentium Pro also had a massive L2 cache that ranged between 256KB and 1MB, depending on the model. At this time, there was no way to integrate this cache directly into the CPU die, but the Pentium Pro did incorporate its huge L2 cache in the same Socket 8 package as the CPU die, and it also ran the cache at the same speed as the CPU. There was a big problem with this approach at the time though – making these Socket 8 packages with full-speed cache was an expensive process, and there were low yields.

Intel wanted to combine the two ideas, making a desktop CPU with loads of L2 cache, as well as consumer features such as MMX. It also needed to be better at executing 16-bit code (which was still used by some software at the time) than the Pentium Pro and, most importantly, it needed to be affordable to manufacture on a large scale.

This meant compromising, as Intel knew it couldn't practically equip a mainstream desktop CPU with loads of full-speed cache in a socket



Inside a Pentium II die – that's 7.5 million transistors produced on a 350nm manufacturing process, and with no integrated L2 cache



package. The answer was to manufacture the CPU package on a usual square format without the L2 cache, and to then mount that package on a circuitboard that contained the cache, resulting in the Pentium II in 1997. It had 7.5 million transistors, produced on a 350nm manufacturing process.

Like the Pentium Pro, the CPU used a separate 'back-side bus' to communicate with the cache, but unlike the Pentium Pro, the Pentium II could only run the L2 cache at half the speed of the CPU. Intel attempted to counter the performance of the cache by first doubling the amount of L1 cache, from the Pentium Pro's 16KB to 32KB on the Pentium II. The Pentium II's L2 cache also had a 16-way associativity, compared with 8-way on the Pentium Pro. A higher associativity means the CPU has a greater chance of finding the data it needs in that cache, but that it can take longer to search for it than a cache with lower associativity.

The other way Intel bumped up the Pentium II's performance was by simply equipping it with *a lot* of this L2 cache. All the first models of Pentium II came with a pair of

large 256KB cache chips, giving you 512KB in total – more than you found on some Pentium Pro CPUs.

By the end of it, you had a circuitboard containing a full CPU package in the middle, with two large cache chips next to it. This was then encased in a box with a thermally conductive metal back. The whole package was called a single edged contact cartridge, or SECC, and you would then attach a heatsink and fan arrangement to the metal back, and slot the whole setup into your motherboard.

The SECC package looked good on the surface, but if you took one apart, you could see that it was a bit of a bodge job. I was working in a computer shop at the time, and we joked that the Pentium II was a 'Socket 7 on a circuitboard' – you could even see the solder points where the socket pins could have been located on the CPU package. It was still a normal square CPU package – it was just mounted on a board instead.

Performance was mixed. If you were running full 32-bit software in Windows 95, then the Pentium II was generally faster than the Pentium MMX, but the latter still had the edge in some 16-bit software, such as MS-DOS games. It also didn't help that the first Pentium II CPUs used the same 66MHz front side bus as the final Pentium MMX chips, with the first Pentium IIs running at 233MHz, 266MHz and 300MHz, and a 333MHz variant arriving later, following a die shrink to 250nm. This meant that, in some cases, the top-end 233MHz Pentium MMX was faster than the low-end 233MHz Pentium II.

Think outside the box

The processor's new clothes came well and truly off in 1998 when Intel introduced its budget range of Slot 1 CPUs, with the still ridiculous name of Celeron. The first generation of Celeron CPUs, codenamed Covington, removed all of the L2 cache from the circuitboard, as well as all the fancy, hologram-clad packaging. This left you with a peculiar-looking green circuitboard with a square CPU clearly soldered into the middle of it – Intel called this non-cartridge arrangement a SEPP format.

The lack of cache meant these Celerons performed poorly at the time, pushing people looking for a budget CPU towards AMD's K6 line-up, which still used the aging Socket 7 form

Slot 1 Celerons didn't come in a fancy chassis, and the first models didn't come with any L2 cache either. Photo by Qurren





The Pentium III maintained the front with the hologram, but used the new SECC2 packaging, which left the circuitboard bare at the back

factor that Intel had deserted. However, the next generation of Celerons in 1999, codenamed Mendocino, overturned this part of CPU market. They were still mounted on circuitboards at first, but Intel had now nailed a method to produce a small amount of L2 cache on the same die as the CPU, running at full speed.

These new Celerons came with 128KB of full-speed on-die cache, meaning they were quicker than the 1st-gen (and much more expensive) Pentium II CPUs in some applications. By this time, Intel's next generation of Pentium II CPUs used a 100MHz front side bus, rather than 66MHz, which provided a significant performance boost over their predecessors.

Accompanied by the new Intel 440BX chipset, the new CPUs ran at 350MHz, 400MHz and 450MHz, and Intel clearly hoped that this FSB tweak would help distinguish the Pentium II line-up from the new Celeron lineup, despite the latter's faster cache.

IF YOU TOOK ONE APART, YOU COULD SEE THAT IT WAS A BIT OF A BODGE JOB

Unfortunately for Intel, overclockers had started discovering that there was plenty of headroom for some of the Mendocino Celerons to go much faster, despite Intel locking down the multipliers in an attempt to prevent it. If you put a new Celeron in an Intel 440BX board, or a board with VIA's competing 100MHz FSB Apollo Pro chipset, you could try moving the 66MHz FSB jumper to the 100MHz setting. If you were lucky, and you had a decent heatsink and fan on your CPU, your 300MHz Celeron would suddenly be running at 450MHz, thanks to its 4.5x multiplier. Combine the clock speed with the full-speed cache and your £60 processor could potentially outperform a £400 one.

I remember this well, and bought a 333MHz Mendocino Celeron with a 5x multiplier, in the hope of running it at 500MHz. It booted, but soon fell over once you got into Windows. Thankfully, my VIA Apollo Pro board also gave me the option to run the FSB at 75MHz or 83MHz if you tweaked the jumper switches right, and the latter setting stably ran my budget CPU at 415MHz. I had no need to buy a Pentium II now.

'Slotket' adaptors enabled you to plug a Socket 370 CPU into a Slot 1 motherboard. Photo by Konstantin Lanzet

Final slots

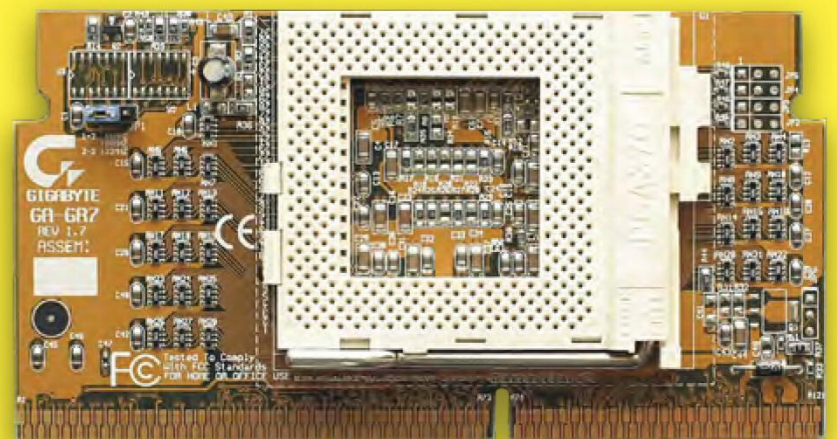
While the first Mendocino Celerons were still mounted on Slot 1 circuitboards in order to maintain motherboard compatibility, their L2 integrated cache design meant they no longer technically needed the rest of the circuitboard. A few months later, the first Socket 370 Celerons started appearing, with 'Slotket' adaptors required in order to plug them into Slot 1 motherboards. It was a bizarre setup that persisted for an unusual length of time.

Intel wasn't quite ready to give up Slot 1 yet. Intel started by tweaking the design of the CPU chassis, removing the metal plate at the back. The final arrangement, called SECC2, retained the plastic front cover with the hologram, but left the circuitboard and CPU die bare at the back, in order to facilitate better thermal transfer to the cooler.

Next came the Pentium III, codenamed Katmai, which added SSE instructions, but was still fundamentally based on the same P6 core as the Pentium II. It also still had an external half-speed L2 cache setup, with both the CPU and cache mounted on a circuitboard. It wasn't until the Coppermine (don't be fooled by the name – all the interconnects were aluminium, rather than copper) revision of Pentium III, with a die shrink to 180m, that Intel finally integrated 256KB of full-speed L2 cache into a CPU die containing 29 million transistors.

Later came a 133MHz front side bus and Intel's 820 chipset, accompanied by high-bandwidth but expensive RDRAM. However, the Slot 1 design still persisted. Even the first Pentium III to break the 1GHz barrier was based on a slot design. Intel needed to maintain compatibility, which was handy for many of us enthusiasts who had worked out that you could still run the latest CPUs on some old 440BX boards by overclocking the front side bus to 133MHz. There was also no shortage of Slotket adaptors at this time, enabling you to install Socket 370 CPUs into Slot 1 motherboards.

The final Slot 1 CPU I saw was an engineering sample of a 1.13GHz CPU that Intel sent to PC Pro magazine, but the chip was recalled due to stability problems. The slot era was now over, and motherboards based on Intel's later SDRAM-based 815 chipset only came in Socket 370 format. The Pentium III carried in on socket format, as did the later Pentium 4, and the CPU industry hasn't looked back since. Slot processors might have looked good, and a part of me misses the fancy casing with the holograms, but there's no doubt that integrating cache directly onto the die is a much faster and more efficient way of doing it. **CPC**



Readers' Drives

Project Z

Michael Sheppard made this open-air PC chassis from scratch, with some great custom cabling and a hardline water-cooling system



GPC: How did this project start, and what inspired you to build an open-air design?

Michael: The whole project hatched from a fellow modder who kindly donated two 360mm EKWB

SE radiators to me, after I helped him with the custom cables for his own build. I had also just built myself a DIY metal bender brake, so obviously I wanted to use that too.

This was my first mod that I've ever done from scratch, and I wanted to use an open-air design because I wanted to display the cables, as that's where my passion lies. However, I also didn't want the restrictions of working within a case and enclosing everything in such a tight space.

GPC: How did you go about designing the custom chassis?

Michael: I always knew that I wanted to use the 'Z' shape,

it was just a case of ensuring that all the gear was going to fit onto the framework. There was no CAD involved – I actually went back to basics, and used a pen and paper. I planned out every measurement, filling pages with sketches of different scenarios on where components could be placed. However, because it was a unique shape, there was no reference to which I could refer, so it was really just a learning process.

GPC: That's some very neat cable routing – how did you go about planning it?

Michael: I really wanted to show off my skills in crafting custom cables, so tidy cable management was a must! I even handcrafted all the combs myself to ensure they were exactly how I wanted them. Then it was a case of sketching where I wanted the cables to be placed onto the frame, using clean routes that avoided components. With the tubing, it was a case of

using short, simple and single bends, as it's not my strongest area. I chose the most logical tubing route in order to keep the build clean and tidy.

GPC: Where does the tubing go round the back?

Michael: It goes straight into a Y fitting to a tap or drain, then into the radiator, back out and to the pump. Nothing too complicated.

GPC: There are some clean bends in the water-cooling loop. What tubing did you use, and how did you bend it?

Michael: It's Alphacool's PETG tubing, and bending it involved using a heat gun at a low setting, a lubricated insert and bending by eye with a steady hand, taking it slowly with lots of patience. I'm still a beginner, so I made plenty of mistakes along the way, but with lots of trial and error, I was able to come up with the simple clean bends I needed.



/MEET THY MAKER

Name Michael Sheppard

Age 30

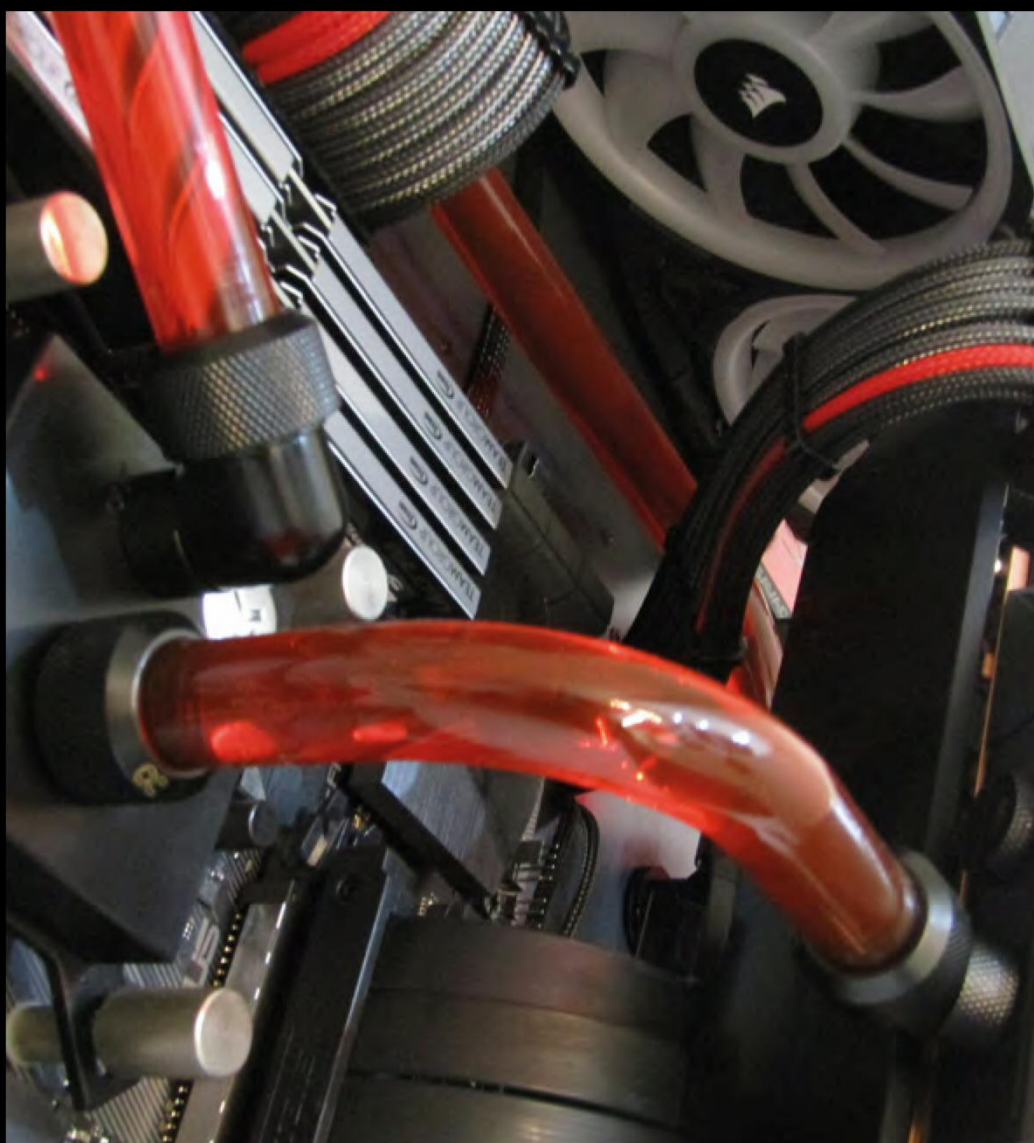
Occupation Chef

Location Sunderland

Main uses for PC Casual gaming, YouTube, music and learning graphic design

Likes PCs, modding, working on cars, spending time with my wife and daughter, cooking, eating, enjoying a craft ale or gin and listening to rock music

Dislikes Messy cables and sitting still



GPC: Tell us about the build process. What tools and materials did you use to make the various custom parts?

Michael: This build was a learning process, as I'd never worked on a project at this level before. After building the metal bender brake, I knew I wanted to use steel for the main frame. Once I had the sheet of steel in the right size, it was a case of making two simple bends with the braker to get the 'Z' shape.

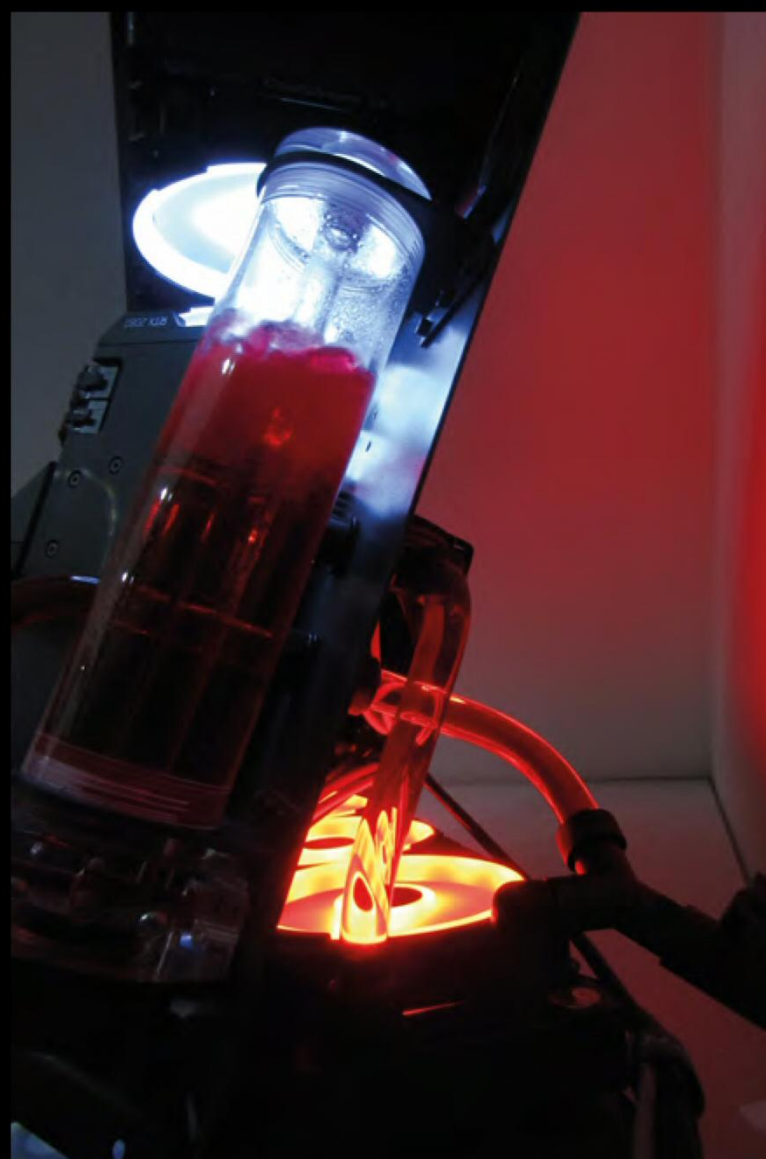
I then moved onto the placement of the hardware. I knew where I wanted the motherboard to be mounted from the start, so I worked the rest of the design around that. The radiator mounting was a little trickier; it took a lot of sketching onto the frame to ensure the placement was right, as I only really had one shot when it came to drilling holes into the frame.

I then lay the radiator on the chassis, and sketched onto the frame again before drilling. I also created handmade standoffs from

aluminium tubing, which worked great to lift the radiator off the frame slightly. This gave me a better idea of clearance, and after placing the pump as far over to the side as possible, I then had a good idea of the space available for a graphics card mounting bracket.

When it came to the graphics card mount, I made a template from cardboard to give me a good idea of where and how it would be mounted. Once I was happy with the template, I made the real bracket from a piece of 1.5mm steel. This was actually one of the hardest parts of the build, as it was such a small piece of metal that had to be grinded, shaped, filed, drilled and bent. However, it was vital for me to make sure these components were finished to a high standard.

The holes for the cables in the chassis were all created using a hand drill. I started with a template, and then the 48 holes were punched and drilled four times in 1mm increments from 1mm to 4mm. This was a very





SYSTEM SPECS

CPU Intel Core i7-8700K**GPU** EVGA GeForce RTX 2080 FTW3**Storage** 240GB HyperX Savage and 240GB Kingston KC 1000**Memory** Team Group Vulcan T-Force 3000MHz**Motherboard** Asus ROG Strix Z370G Gaming WIFI-AC**PSU** Corsair AX1200i**Cooling** EKWB Supremacy Evo Copper Acetal CPU waterblock, EKWB RTX 2080 Vector Copper Acetal GPU waterblock, 2 x EKWB 360 SE radiators, EKWB drain and Y-splitter fitting, 16mm Alphacool Eiszapfen hardline fittings, Alphacool Eisbecher 250mm pump-res combo, generic bulkhead fittings, 6 x Corsair LL120 fans

An unused makeup brush is great for removing dust, as the soft bristles get into all the crevices

lengthy process; I had to work slowly as there wasn't any room for error.

Once all the holes were made and the power supply was mounted to the chassis, I then made the custom cables and combs. I actually made the cables longer than I needed, so it would be easier to connect them, mount them to the chassis, and then trim and terminate them once they were in the correct position, as no two wires were the same length.

Keeping the build looking neat required me to make custom-length cables for each fan, as well as the RGB lighting. Both radiators have a fan hub and lighting hub mounted to them, and I made my own power connectors by shortening the hub wires so they could be hidden under the radiator. I then ran the USB header cable to the motherboard from the hub through the chassis for RGB control. The difficult part here was syncing the two radiators together – I opted to disguise this cable as a PSU cable, and ran it

with the power cables to join the hubs together.

The last main part was the getting the build to power on and off, and reset. I decided to opt for a PCI-E remote control – I didn't want to add a button to the build, as it would also mean adding more unnecessary wires and custom fabrications, leading to more clutter on the frame.

GPC: Why did you decide to position the graphics card at that angle?

Michael: The idea came to me while I was mocking up designs. I was still undecided on what waterblock I was going to use, but I always like to clear waterblocks with fluid on show. I didn't go for this look in the end, but I still like the positioning and it filled out the gap in the chassis perfectly. I mounted it by creating a custom bent steel bracket at a 45-degree angle, and it's affixed with four mounting screws – it's long enough to house the graphics card and accommodate a riser cable.

GPC: How are the PSU and reservoir mounted to the main chassis?

Michael: The PSU is mounted by two large U-shaped brackets, one on either end at the front and back. This is then affixed with an L-shaped bracket in the power supply mount. The reservoir is mounted using the standard top and bottom mounts, which each use three screws.

GPC: Did you come across any difficulties? If so, how did you solve them?

Michael: The longest bend on the tubing was one of the hardest parts for me. I found that making one bend was fine, but two always seemed difficult, as there was more room for error, and I would have to start it all again if it went wrong. I know this comes with experience, but I didn't make it any easier for myself by choosing an awkward-shaped chassis. It all came down to practice in the end – sometimes I needed to be able to stop, walk away and come back with a fresh pair of eyes.



Painting the frame was tough as well. I was really happy at the prep and priming stages, but putting on the top coat didn't go as planned. The weather was very much against me for a start, as it was too warm for the paint to adhere to the metal properly. I had to sand back the problem areas and try again. At this point, the only thing that helped was patience.

The final problem was that I misjudged the clearance for USB plugs going into the motherboard's rear I/O panel. The plugs clashed with the desk when the computer was put in place, so I had to order some 90-degree USB adaptors, which improved the look of the case anyway, as it all looked neater.

GPC: How are you planning to keep dust out of your components?

Michael: There's actually been very little dust building up since completing the build, but if I do notice any dust, I find that an unused makeup brush is great for removing it, as the soft bristles get into all the crevices.

GPC: How long did it take you to complete this build?

Michael: Projects such as this one take a lot longer than they should if you're a working dad. I had the chassis crafted in February last year, and I did little bits here and there throughout the year, but the bulk of the work was done during October. I finally finished it in late November last year, so it took ten months in total.



GPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?

Michael: I'm really proud of the end result, especially the cables. As a beginner with water cooling, I didn't want to create the outlandish runs that I've seen on other mods, but I'm really happy that I give it a go and I'll never look back – I urge everyone to give it a try! The only aspect I was a little dubious about was the paintwork on the frame, but it worked out in the end. I wish I could change the position of the SSD, though, as I would like it to be on show. **GPC**

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (@CustomPCMag) or Facebook (CPCMagazine), or email low-res ones to editor@custompcmag.org.uk. Fame isn't the only prize; you'll also get your hands on some fabulous prizes.

Corsair K70 RGB MK.2 SE – Cherry MX Speed



The Corsair K70 RGB MK.2 SE is a premium mechanical gaming keyboard that's built to last. It has a silver anodised brushed aluminium frame, as well as stunning white precision-moulded, double-shot keycaps. It's built to turn heads and withstand a lifetime of gaming. There's a detachable, soft-touch wrist rest too.

Meanwhile, its Cherry MX Speed mechanical keyswitches provide the reliability and accuracy you demand, with blisteringly fast 1.2mm actuation. There's also stunning per-key RGB dynamic backlighting, 100 per cent anti-ghosting with full-key rollover, 8MB of on-board memory, plus dedicated media controls.

Alphacool water-cooling gear

Water-cooling hardware manufacturer Alphacool is offering a choice of £150 worth of gear to every featured Readers' Drives winner. For your prize, you can select from DIY water-cooling kits, the Eiswolf and Eisbaer all-in-one CPU and GPU liquid coolers, as well as a vast range of individual components, including waterblocks (pictured), fittings, reservoirs, pumps



and radiators. Alphacool also makes coolant, tubing and fans, as well as modding and water cooling-related tools.



JAMES GORBOLD / HARDWARE ACCELERATED

SHORT SUPPLY

Intel's fabs used to be pride of the company, but they're now its Achilles' heel, argues James Gorbold

Supply shortages aren't new in the PC industry – just look at the highly volatile supply and price of memory over the years. However, what's new is a company such as Intel having such serious supply problems for so long.

The first signs of trouble appeared back in the summer of 2018, with Core i5 chips becoming scarce as Intel prioritised production of high-end CPUs. The situation became so bad that in September 2018, Intel issued an open letter citing massively higher-than-forecast growth in the server market as the primary cause of the shortage, and committing to extra investments in manufacturing.

Since then the situation has only deteriorated, with more product lines going short and, in some cases, disappearing. Intel's flagship 10-series Core X chips first launched in November, but four months later, barely a trickle has made its way onto shelves, with frankly pathetic single-digit deliveries reaching resellers and system builders.

The Core i7 and i9 K-series chips have been prioritised by Intel, so they haven't been too badly affected, but Core i5 supply continues to be hit and miss, with many models simply not being available. Laptop processors are also in shortage, and Intel's cash cow, its Xeon server CPUs, isn't in a great state either. It's not just CPUs either; it's also hard to get hold of enterprise SSDs in significant volumes.

All in all, it's quite an embarrassing situation, especially when owning its own fabs was historically a massive strength for Intel, enabling it to push out new process nodes faster than many of its competitors. While there are multiple causes for the shortage, including forecasting from both Intel and its customers, the two biggest causes are ongoing process transition problems and unexpected demand for certain products.

Barely a trickle has made its way onto shelves, with frankly pathetic single-digit deliveries reaching resellers

It's well documented how Intel expected to transition its CPUs from 14 to 10nm, but has had to keep pushing this move back due to poor 10nm yields. This has had two knock-on effects. Firstly, there's the introduction of additional stopgap 14nm processors and the complex juggle between investing in new 10nm fabs while keeping enough existing 14nm fabs operational, which clearly hasn't been achieved. Add a surge in demand for server-grade CPUs and SSDs of around 50 per cent from hyperscalers, such as Google, Facebook, Amazon and Microsoft, and you're looking at a perfect storm.

Supply shortages haven't just led to price increases, but also lost sales in many cases, because specific CPUs and SSDs haven't been available. As a result, while Intel has been losing market share in desktops and laptops, AMD has been surging ahead, outselling Intel at certain price points for the first time in decades. This has helped to fuel a dramatic rise in AMD's share price, of 131 per cent in the past year. It's not all doom and gloom for

Intel, though, as in the same period, its share price also grew a significant 30 per cent thanks to record revenue.

Looking forwards, Intel's manufacturing problems and the ongoing demand from hyperscalers isn't going away soon. It takes a long time to build a CPU, and billions of dollars and years to spin up new fabs. The supply shortage is expected to last a well into the summer, and quite possibly into 2021 and later.

Thank goodness this is happening now though. Can you imagine what this would be like when AMD didn't have any desirable mid-range or high-end CPUs, and had discontinued making server processors? The PC market would be facing global recession. **GPC**

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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