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CPU SHOWDOWN

INTEL ATTEMPTS TO CATCH UP WITH AMD, BUT IS IT TOO LATE?

1 14 CPUs REVIEWED, FROM £130 TO £750

2 TESTED IN GAMES AND APPLICATIONS

3 FIND THE RIGHT CPU FOR YOUR NEEDS

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+ DEEP TECH DIVE

+ NEW CPUs REVIEWED

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Welcome

Custom PC Issue 213

/ FROM THE EDITOR

Core-to-core combat

Form a circle, folks, because we're going to witness a clash of arms between two grizzled veterans. I'm not sure we've ever seen such a tight fight between Intel and AMD. When AMD64 ruled the CPU kingdom, Intel was flailing around with NetBurst. When Core later reclaimed Intel's honour, AMD was floundering with Bulldozer.

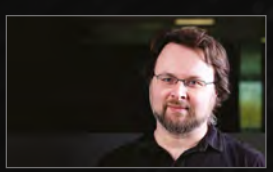
Even the first Ryzen vs Core battles were fought on different terms, with Intel winning on gaming performance and AMD leading on multi-threaded performance. This time it's different. Technically, AMD still wins on core counts, but that's largely irrelevant when there aren't any Zen 3 CPUs with more than eight cores available to actually buy.

It mainly comes down to choosing a Rocket Lake-S or Zen 3 CPU with six or eight cores, both with decent gaming performance and solid multi-threaded speed. Remarkably, Intel is the underdog in this fight, pricing its CPUs below AMD. Intel is also still stuck on a 14nm process, meaning its chips have higher power draw. As you can see in our Labs test on p40, it's tight, but it's great to see fierce competition in the CPU market.

What's not so great to see is GPU stock still being far from able to meet demand. We've reviewed Nvidia's GeForce RTX 3060 (see p16) and AMD's Radeon RX 6700 XT (see p19) in this issue, but both are already out of stock. Richard Swinburne explores some of the reasons on p8, and we also have a full feature on the problems facing the UK tech market on p88.

It looks as though we're going to be mired in this miserable swamp for many more months, though, so we're no longer putting scores in graphics card reviews until this is sorted – we'll show you how new GPUs perform, but we simply can't give them realistic scores when they're not available at anywhere near the recommended retail price.

Instead of listing non-existent recommended retail prices on the Elite list, we're now listing the general Buy it Now price on eBay. We hate doing this, and we still don't recommend handing money to eBay scalpers if you can wait, but with no end of this situation in sight, we wanted to at least represent the cost of building a new custom PC more honestly. CPC



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CUSTOM PC

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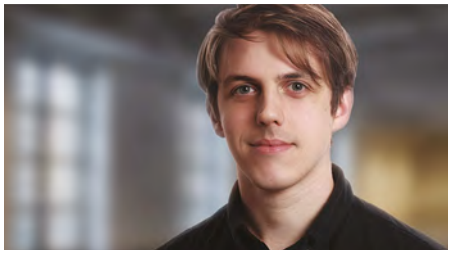

RICHARD SWINBURNE / VIEW FROM TAIWAN

SO WHEN CAN I BUY A NEW GPU?

Richard Swinburne explores some of the factors contributing to the current GPU supply problems

This question has been on everyone's minds for months, and I'm attempting to answer it. However, in the process of digging into as many internet rabbit holes as I could find on the subject, there's a lot of opinion and little on specifics of what's happening this year. We're already a third of the way through the year and forecasts are *still* vague.

Rick Lane has taken in-depth look at this situation on p88, but I also wanted to share my own findings while speaking with people in Taiwan. The whole semiconductor industry is anticipated to grow by anywhere from 11-20 per cent in 2021, depending on which analysts you read, but what does that mean for us? When can we get affordable graphics cards? Well, spoiler alert, put the credit card away because it's really not looking good.

> Well, spoiler alert, put the credit card away because it's really not looking good

The brief version is that this is a multifactorial situation. More companies are putting silicon chips in their products; there's the 'demand shock' caused by the global pandemic; cryptocurrencies are exploding in value; Apple has shifted its wholesale supplier from Intel to TSMC; and global air freight has collapsed, grossly inflating the costs of sea shipping.

Nvidia and AMD GPUs are exclusively made by TSMC and Samsung, the only two manufacturers to offer leading-edge production. AMD uses TSMC's 7nm process to make Radeon 6000-series GPUs and Nvidia uses Samsung's 8nm process to make its RTX 3000-series chips, although it's rumoured to be returning to TSMC this year because Samsung's chip yield is poor. It must be really bad if Nvidia is willing to fight everyone else for space at TSMC.

TSMC's biggest customer, however, is Apple. Since last year, the company began to move away from Intel CPUs to use its own silicon in Macs, requiring an ever-bigger chunk of TSMC's production, shrinking the space for everyone else.

To make matters worse, as transistor size gets smaller, more parts of the production process require EUV (extreme ultra-violet) tools. However, EUV is slower at making chips than older manufacturing methods, so each wafer takes longer to make, meaning fewer are made per month.

TSMC has committed to more capacity, with a huge 62 per cent budget increase this year – its biggest ever – and it's already grown monthly 5nm capacity by 15 per cent since December 2020. Yet, that's still not enough. All this demand has caused wafer prices to rise by up to 20 per cent, with a further 15 per cent rise expected. The cost of making a GPU is expected to remain its highest ever for the rest of the year. Yikes.

Graphics cards also need a bucketload of GDDR6/6X memory, but the memory industry has already seen steady price increases since late last year and they're expected to continue rising through 2022. This also goes for standard DDR4 kits, so hold onto what you have or buy new memory now if you need it.

The one, small, wild card is consumer demand. Talking to some salespeople in the USA and EU, the tentative expectation is that once travel restrictions are eased, the demand for home entertainment will drop, potentially by a lot if this happens as we hit the summer. That's good news for enthusiasts still holding out for an upgrade, because I want to enjoy the summer, but I also still want to play games. **GPC**

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

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TRACY KING / SCEPTICAL ANALYSIS

BEWARE NOSTALGIA

Tracy King has been spending money on old computers to replay her favourite childhood games, but the memories don't match reality

Growing up, we weren't a console family. My cousin had an Atari and then a NES, which were fun when I visited, but because my dad was a computer salesman at a time when home computing was brand-new, our house always had computers. We didn't own them, but that was a benefit as we got regular upgrades. My popularity on our council estate may have been related. My dad worked for Apple in the early 1980s, then Apricot, Tandy and Amstrad.

I loved the Tandy TRS-80, with its bafflingly obscure games (Cuthbert in Space or Pettigrew's diary, anyone?) and the Amstrad CPC series, which could run more famous games, such as The Hitchhiker's Guide to the Galaxy or The Hobbit.

These computers were superior to my cousin's consoles for many reasons. There was a much wider range of games (first on disk then cassette). The games themselves were usually made by bedroom coders, so they had a charm and originality missing from console games. And, perhaps most importantly, those PCs had word processing software (cue future professional writer) and the ability to write my own code. I'm still fond of BASIC.

But my fondness for those old machines means I now GOTO EBAY (geddit?) to try and recapture that childhood wonder and anticipation. This has proved an expensive hobby but also, I'm sad to report, not a particularly positive one. These old machines are worth a few quid. In working order, an Amstrad CPC 464 can go for up to £200, despite the fact that you can play the old games on emulators. Indeed, I've grabbed a few emulations of old favourites, including Fantasy World Dizzy, the 1989 classic by the Oliver Twins.

But emulations weren't the same. The itch wasn't scratched. My sleek laptop or desktop simply didn't match the gameplay. Compensating for a slightly crappy joystick was almost part of the game itself. Load times added to the anticipation and therefore the reward. Or so I thought.

I've been spending a lot of money on eBay during lockdown on various old systems and cassette games. Expecting the pure joy of my childhood, or the satisfying relief of nostalgia fulfilled, I bought time machines. Let me tell you, we're spoiled now.

Those old systems were pioneering, yes. They represent the explosion of home computing and gaming that's central to many of our lives. But wow, they're bad to revisit. Not only do I not want to wait forever for a game to load, but I also don't want to be hit with game-breaking bugs that will never be patched. I don't want to be able to hit the BREAK key during loading to access cheats and spoilers. I don't want graphics limited not by design choice but by hardware limitations, and I don't want to have to restart a game from scratch every time I load it.

> Time had filtered out bad memories and left me with delightful ones

But of course, I had forgotten all the frustrations, or that at the time they were fine because that's all we had. Time had filtered out the bad memories and left me with delightful ones that, sadly, don't match the reality at all.

There are many contemporary games inspired by the classics, and I will give my money to those instead. They have all the good ideas without trying to pretend the actual old games and systems were good, because they were simply good for the time. Don't make the same mistake and try to go back. This is a cautionary tale. You can't and shouldn't revisit computers of the past. The loading times are too slow. 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

CORSAIR LAUNCHES MINI MECH KEYBOARD

Corsair is the latest tech firm to get into the mini gaming keyboard trend, launching its first ever 60 per cent mechanical keyboard. The K65 RGB Mini eschews the dedicated numberpad, F keys, cursor keys and so on in favour of a design that just keeps the core keys.

There's a choice of Cherry MX Red, Silent Red and Speed Silver key switches, and they're topped by a set of PBT double-shot keycaps. What's more, the keycaps can be swapped out for custom designs, and Corsair is offering kits with several colour options, including Onyx Black, Arctic White, Elgato Blue, Rogue Pink, Origin Red and Mint Green.

Other features include dynamic per-key RGB backlighting, which can be customised with Corsair's iCUE software, as well as a detachable braided USB Type-C cable. You also key a key puller, an optional Corsair logo key and an alternative spacebar with a 'radiant' design to let through the RGB lighting in the box.

The Corsair K65 Mini with Cherry MX Red key switches is available to pre-order from **scan.co.uk** for £110 inc VAT.

AMD ZEN 3 APUs APPEAR ON EBAY

There's been no official word on AMD's Zen 3-based APUs with integrated Radeon graphics yet, but Twitter user @Harukaze5719 recently spotted five Ryzen 3 5300G 'Cezanne' samples up for grabs on eBay, where they've already been sold. In addition to photos of the APUs, the auction also included screenshots of CPU-Z and Cinebench results.

The screenshots show a Socket AM4 running at 3.3GHz, with four cores and eight threads. The cache setup is also visible, with 256KB of L1, 2MB of L2 and 8MB of L3 cache. The latter is a massive reduction compared to the 32MB of L3 cache in the Ryzen 5 5600X.

The eBay seller, hugohk, has also posted a video review on YouTube (**custompc.co.uk/5300G**) showing it in action, including the integrated Radeon Vega 8 GPU with a modified driver. The video also shows the APU boosting to 4.15GHz in CPU-Z, and graphs of several benchmark results, including a 16 per cent boost in Cinebench R15 performance compared with the Ryzen 3 Pro 4350G.

GLORIOUS RELEASES BAREBONE KEYBOARD KIT

Silly-named peripheral maker Glorious PC Gaming Race has released a new barebone mini keyboard kit, featuring a modular design that enables you to install your own key switches and keycaps. The GMMK Pro 75 has a 75 per cent layout, meaning it lacks room for a numberpad, but maintains space for the dedicated Function and cursor keys of a standard keyboard, as well as Home, End, PgUp and PgDn, plus a clickable rotary volume dial.

The GMMK Pro 75 features a CNC-milled aluminium chassis, while Glorious says its gasket-mounted plate naturally dampens keystrokes. The setup also includes a detachable USB Type-C cable and 16.8 million-colour RGB backlighting. The Glorious GMMK Pro 75 barebone kit is available to pre-order from **overclockers.co.uk** now for £170 inc VAT.

LONGSYS PUBLISHES DDR5 PERFORMANCE DATA

Longsys has become the latest memory maker to announce that it has DDR5 memory modules in production, joining Team Group and Asgard, and it's also released some performance data testing on an unreleased Intel Alder Lake-S system. According to the firm's results in the AIDA64 Cache & Memory Benchmark, 32GB of Longsys DDR5 memory (with an effective speed of 6400MHz) can read and write at 35,844MB/sec and 32,613MB/sec respectively.

Comparatively, Longsys says its equivalent 32GB of 3200MHz DDR4 memory reads and writes at 25,770MB/sec and 23,944MB/sec respectively. The DDR5 memory's CAS latency of 40 is much higher than the 22 of the DDR4 memory, resulting in a higher latency of 112.1ns compared to the DDR4 memory's 56.8ns, but the high frequency means the former is much quicker – 39 per cent quicker, in fact.

No desktop PC systems currently support DDR5 memory, but Intel's forthcoming Alder Lake platform is said to support it, and there are rumours of a DDR5-supporting AMD platform arriving this year too.

BE QUIET! UPDATES COMPACT CPU COOLER

Low-noise cooling specialist be quiet! has updated its Pure Rock Slim CPU cooler with a design that can accommodate a CPU with a 130W thermal design power (TDP), compared to 120W for the original design. The cooler has three heatpipes with aluminium caps, and a 92mm Pure Wings 2 PWM fan, which be quiet! says has a 'high-quality rifle bearing'.

In addition, be quiet! says the cooler's new AM4 mounting bracket will ensure easy installation in alignment with the cooler's airflow. According to be quiet!, the Pure Rock Slim 2's compact design is ideal for cases with limited space, allowing you to fill all your memory slots without the cooler getting in the way. The Pure Rock Slim 2 is available to pre-order from **scan.co.uk** now for £23.48 inc VAT, with stock expected at the end of April.

SAMSUNG UNVEILS AFFORDABLE 980 SSDs

Samsung has unveiled a new line-up of NVMe SSDs in its 980 series. Unlike the 980 Pro drives released last year, the standard 980 drives use the PCI-E 3 interface rather than PCI-E 4. However, there are also some changes compared with Samsung's previous 970 line-up, with Samsung claiming they improve power efficiency by up to 56 per cent compared with the equivalent 970 Evo drives.

The new drives are also Samsung's first SSDs to not feature any DRAM cache on-board, helping to reduce costs. Instead, the 980 series uses host memory buffer (HMB) technology, which gives it direct access to the host system's DRAM instead. Samsung claims the new 980 drives can perform sequential reads at up to 3,500MB/sec, and writes at up to 3,000MB/sec – the former is the same quoted speed for Samsung's 970 Evo Plus SSDs, while the latter is 300MB/sec slower.

The Samsung 980 SSD line-up is available in capacities of 250GB, 500GB and 1TB, with the 500GB drive currently available from **ebuyer.com** for £64 inc VAT.

Rumour control

OUR ROUNDUP OF THE LATEST UNCONFIRMED TECH GOSSIP. TAKE THESE STORIES WITH THE APPROPRIATE PINCH OF SALT

GEFORCE RTX 3080 Ti INBOUND

Tech Twitter is currently buzzing with rumours about a new high-end Ampere GPU from Nvidia being launched in mid-April. The GeForce RTX 3080 Ti is rumoured to sit in between the current RTX 3080 and 3090 in the current line-up, and feature 10,240 CUDA cores, compared to 10,496 in the RTX 3090 and 8,704 in the RTX 3080, meaning the 3080 Ti is likely to be much closer in performance to the 3090 than the 3080.

Chinese tech site **news.mydrivers.com** also says the new GPU will feature a 384-bit memory interface, as with the RTX 3090, but will come with 12GB of GDDR6X memory rather than 24GB. The site also says the card will have a driver that limits cryptocurrency mining performance, as with the RTX 3060 at launch.

Letters

Please send us your feedback and correspondence to
custompc@raspberrypi.com

Multi-room wireless?

Firstly, top marks on the magazine. Secondly, I'm thinking of creating a downstairs VR system, but I still want to be able to game on my desk upstairs. Instead of having two completely separate systems with a NAS box, I'm thinking of building one monster system and then having wireless accessories on the desk upstairs. I already have a wireless screen, but I'm struggling with wireless peripherals and speakers. Do you have any recommendations for getting gear to work through the floor, and are there any problems you think I might stumble across?

Keep up the great work, and please tell Tracy that I completely agree regarding the positive impact of gaming on mental health. I have a regular session with friends that really boosts my mood and fills that social void.

CRAIG ESBERGER

Edward: Thanks Craig. We couldn't agree more regarding the mental health positives of gaming, especially if it's social. As for wireless peripherals, it's a tricky one to judge. The range on most such peripherals is around 10m assuming there aren't significant signal-blocking materials in the way.

One wooden floor is unlikely to interrupt the signal of wireless peripherals such as Razer's DeathAdder V2 Pro too much

If you're directly below/above the receivers then one wooden floor is unlikely to interrupt the signal too much. We tested a headset and mouse in just such an arrangement and both worked fine. However, if there's any sort of brick or thicker walls in between the rooms, or if the transceivers are in a wireless signal black spot, you could see the signal sufficiently disrupted to cause problems.

When's the next issue out?

CUSTOM PC

MAY 06

Issue 214
On sale on Thursday, 6 May

Flight check

The '486 revisited' article in Issue 213 brought some smiles. I started my PC 'journey' in 1989 with a 286 using MS-DOS and Linux, then I forked out some astronomical sum for a 486-DX2 a few years later. The author mentions Strike Commander, which I didn't have, but I did have the superb European Air Wars, then later Microsoft Flight Sim 98. This all leads me to the question, why don't you do GPU tests on flight sims?

I currently use Microsoft Flight Simulator X: Acceleration, X-Plane 11.5 and I'm considering buying the latest Microsoft Flight Simulator. The latter two sims need considerable horsepower at full configuration, so couldn't you do reviews and graphic card tests on these, or are they small fry compared with the likes of Doom Eternal? As an 85-year-old RAF veteran, I'm not into Doom, Tomb Raider and so on.

ROBERT GOTT

Ben: We've had a lot of good feedback about Stuart's 486 article and I really enjoyed that step back in time too. Also, we certainly don't consider Microsoft Flight Simulator to be small fry. Its launch last year prompted us to do a flight sticks Labs test in Issue 207, and we gave the game a Premium Grade award in the same issue.

However, playing a comparatively low-pace game such as Microsoft Flight Simulator is quite different from playing a very fast-paced game such as Doom Eternal. You really notice the difference between high and low frame rates in the latter, but not so much on the former, where 30fps is generally fine.

Microsoft specifies a minimum of a GeForce GTX 770 to run the game, and recommends a GeForce GTX 970 – a mid-range GPU from seven years ago. You can set the game to its Ultra preset at 1,920 x 1,080, and it should play fine on an old GeForce GTX 1070.

It's for this reason that we haven't made it part of our regular GPU benchmarks, where we really need to tax the latest GPUs. I do think it's worth us doing a feature on flight sim hardware in the future, though, where we look at various hardware options, from multiple screens and peripherals to the core GPU and CPU software you need. We'll put it on the list.

Flight sims have come a long way since Strike Commander

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Reviews

ZOTAC GEFORCE RTX 3060 TWIN EDGE 12GB / £SOMETHING SILLY

SUPPLIER ebay.co.uk

We followed the recent launch of the GeForce RTX 3060 with interest. Nvidia said the card's driver would limit its cryptocurrency mining performance, and we were keen to see whether that would help the stock problems. The answer is, sadly, no. Mining is just one piece of the nightmarish stock supply puzzle, which we've investigated in more depth on p88.

As with all recent GPU launches, the retail stock was wiped out within a few minutes of the launch, and the cards soon appeared on eBay at inflated prices. These are depressing times if you want to buy a new GPU, and as such, we're not going to give new GPUs review scores until these problems are sorted. There's no point in reviewing this Zotac GeForce RTX 3060 Twin Edge 12GB card at its sub-£400 retail price when you can realistically only get one by handing over £600 to an eBay scalper.

It is worth us looking at how new GPUs perform, though, so we can report on how PC tech is progressing – you then at least have the necessary information to spec up a future purchase when all this silliness dies down, or decide if you really do want to pay inflated eBay prices.

SPEC

Graphics processor
Nvidia GeForce RTX 3060, 1320MHz base clock, 1777MHz boost clock

Pipeline
3,584 CUDA cores, 80 ROPS

RT cores
48 (2nd-gen)

Tensor cores
112 (3rd-gen)

Memory
12GB GDDR6, 1875MHz (15GHz effective)

Memory interface
192-bit

Card interface
16x PCI-E 4

Memory bandwidth
360GB/sec

Number of slots
2

Card length
224mm

A new GPU

Anyway, let's get back to the GeForce RTX 3060 itself. This chip is based on Nvidia's new mini GA106 GPU, which is based on Nvidia's latest Ampere architecture and packs 13,250 million transistors into a 276mm^2 die. If it's fully enabled, the chip gives you 3,840 CUDA cores, 30 RT cores and 120 Tensor cores. However, the GeForce RTX 3060 has two of its Streaming Multiprocessor blocks disabled, giving you 3,584 CUDA cores, 28 2nd-gen RT cores and 112 3rd-gen Tensor cores.

It's a neat little package, but it's a notable step down from the rest of the RTX range. The RTX 3060 Ti might seem like it's in the same league as the RTX 3060, but it's based on Nvidia's beefier GA104 GPU and contains 4,864 CUDA cores, so it's much more powerful.

The GeForce RTX 3060 is also equipped with a 192-bit memory interface and 12GB of GDDR6 memory running at 1875MHz (15GHz effective). That's not only more than the piddly 6GB of memory on its predecessor, the GeForce RTX 2060, but it's also more memory than you'll find on any current Nvidia card below the RTX 3090.

You're unlikely to use all that memory when running games at this GPU's targeted resolutions, but it does at least give you plenty of headroom. However, as it's only attached to a 192-bit wide interface, you only get 360GB/sec of total memory bandwidth – compare that with 448GB/sec on the RTX 3060 Ti, for example.

The card

We've been a fan of Zotac's no-frills entry-level cards for a while – they aren't packed with RGB lighting, but they do generally give you affordable access to the latest GPUs without making a horrible racket in the process. If it weren't for the current stock problems, this GeForce RTX 3060 Twin Edge 12GB card would be the same.

It has a small footprint, measuring just 224mm long (and the PCB underneath the cooler is much smaller), with a dual-slot cooler and a thin backplate. The cooler has Zotac's IceStorm 2.0 branding, and features a pair of 11-blade fans and a wide stack of aluminium heatsink fins and copper heatpipes. It

works well – it never got overly hot in testing and it wasn't noisy either. The fans stop when the GPU is idle as well, as is often the case with graphics card coolers now.

You only need a single 8-pin PCI-E power connector for it too, although it's irritatingly positioned in the middle of the card in this design.

Performance

Let's start with the good news, which is that the RTX 3060 is adept at handling the latest games at 1,920 x 1,080 with a fair amount of eye candy enabled. It happily ran Cyberpunk 2077 at the Ultra preset (with no ray tracing) at an average of 58fps, dropping down to a 99th percentile result of 49fps. It produced the same average frame rate in Assassin's Creed Valhalla at Ultra settings, and it averaged 64fps in Metro Exodus at Ultra settings too. It dropped down to a 35fps 99th percentile result in the latter, but it's still perfectly playable.

The situation becomes a bit muddier when you add ray tracing to the mix. The average of 54fps and 99th percentile result of 32fps is playable in Metro Exodus, but the respective 41fps and 75fps results from the RTX 3060 Ti are significantly smoother. The RTX 3060 also struggled in Cyberpunk 2077 with Medium ray tracing – its 99th percentile and average results of 31fps and 35fps respectively are borderline playable, but you really want more headroom for a first-person shooter.

Unlike AMD's GPUs at the moment, Nvidia does have another card to play here, which is DLSS. Enabling DLSS on the Balanced setting in Cyberpunk 2077 with Medium ray tracing boosts the frame rate to a solid average of 61fps and a 50fps 99th percentile result. However, it looks horribly blurry compared with running it at 1080p natively – DLSS is a good performance booster at higher resolutions, but it doesn't look great at 1080p and below.

It looks fine at 2,560 x 1,440, though, and the RTX 3060 copes well in Cyberpunk 2077 with Medium ray tracing and DLSS at this resolution. The RTX 3060 is also substantially quicker than its predecessor, the RTX 2060, in ray tracing, regularly doubling the frame rate. However, there's less of a boost in raw shader power – it's usually around 3-9fps ahead in our standard rasterisation tests.

The extra memory is also an advantage here – the 6GB RTX 2060 doesn't have enough memory to run our Doom Eternal test, but the RTX 3060 handles it without dropping below 159fps at 1080p – great if you have a high-refresh monitor.

What's striking about the results, though, is just how much more performance you get from the GeForce RTX 3060 Ti – those extra CUDA cores and memory bandwidth really allow the card to breathe. As a point of comparison, the RTX 3060 Ti's average of 88fps in Metro Exodus at 1,920 x 1,080 is a whole 24fps faster than the RTX 3060's result, and we saw sizeable differences across all our game tests.

Resizable BAR

The GeForce RTX 3060 is also Nvidia's first guinea pig to get support for resizable base address register (BAR) technology, which AMD first introduced with its RDNA 2 GPUs under the

Smart Access Memory moniker. It basically circumvents the previous 256MB limit that CPUs had for accessing GPU memory, allowing a CPU to tap directly into a graphic card's full allocation of memory when it needs it.

As Nvidia puts it, this means 'assets can instead be requested as needed and sent in full, so the CPU can efficiently access the entire frame buffer. And if multiple requests are made, transfers can occur concurrently, rather than queuing'. The feature needs to be enabled in your motherboard's BIOS, but it's currently supported on a variety of chipsets and CPUs from Intel and AMD, and the latter has just enabled it on its last-gen Ryzen 3000-series CPU as well.

As we've now moved to a Zen 3-based test rig, we tried it out on the GeForce RTX 3060, and while the performance difference isn't massive, it's certainly noticeable. It added an extra 4fps to the average in Assassin's Creed Valhalla at 1080p, and 5fps to the average in Metro Exodus at the same resolution. If your setup supports this feature, it's definitely worth enabling – it's basically a similar performance boost to a GPU overclock for free.

Conclusion

While we can't deliver a definitive verdict on the RTX 3060 until the stock chaos dies down, we can confidently say that it can handle PC gaming at 1,920 x 1,080 with decent settings, including ray tracing in some games. The resizable BAR support is also welcome and well worth enabling if you have a setup that supports it.

However, while the RTX 3060 represents a solid step up from the previous RTX 2060 in terms of memory and ray-tracing performance, it's a fair way behind the RTX 3060 Ti, which nominally doesn't cost that much more money at recommended retail prices. If and when the GPU stock situation calms down, we'd recommend saving the extra money for the Ti card if possible.

BEN HARDWIDGE

RESIZE BAR

+ Faster than RTX 2060
+ Loads of memory
+ Resizable BAR support
+ Decent 1080p gaming performance

LOW BAR

– Zero stock
– RTX 3060 Ti is much faster
– Struggles at 2,560 x 1,440
– DLSS looks blurry at 1080p

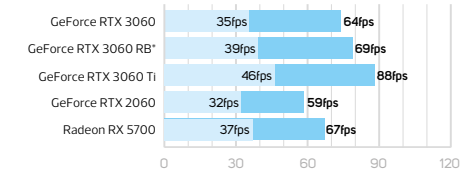
VERDICT

A decent card for gaming at 1080p and a solid step up from the RTX 2060, but it's not worth paying eBay prices for it, and the RTX 3060 Ti is significantly quicker.

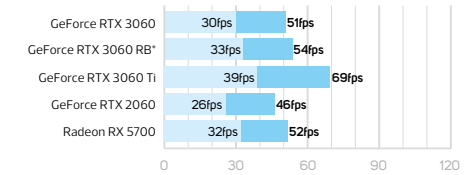
BENCHMARK RESULTS

METRO EXODUS

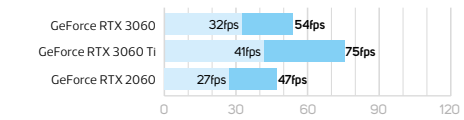
1,920 x 1,080, Ultra settings, HairWorks off, PhysX off



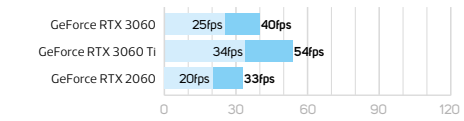
2,560 x 1,440, Ultra settings, HairWorks off, PhysX off



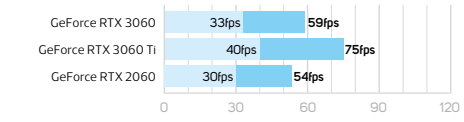
1,920 x 1,080, Ultra settings, High RT, HairWorks off, PhysX off



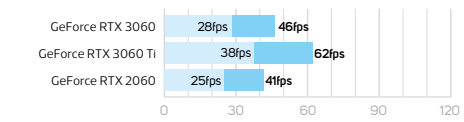
2,560 x 1,440, Ultra settings, High RT, HairWorks off, PhysX off



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

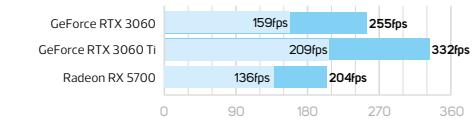


2,560 x 1,440, Ultra settings, High RT, HairWorks off, PhysX off, DLSS

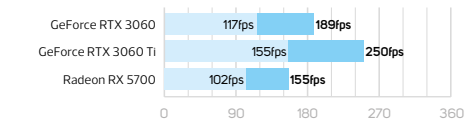


DOOM ETERNAL

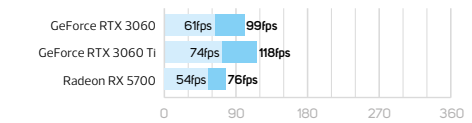
1,920 x 1,080, Ultra Nightmare settings



2,560 x 1,440, Ultra Nightmare settings



3,840 x 2,160, Ultra Nightmare settings

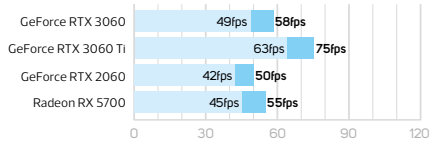


99th percentile Average

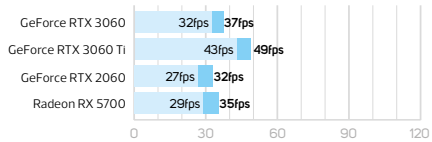
*RB = Resizable bar

CYBERPUNK 2077

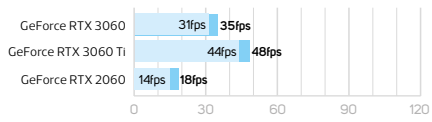
1,920 x 1,080, Ultra preset, no ray tracing



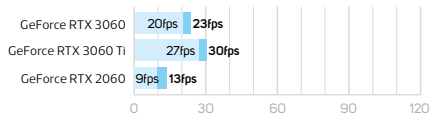
2,560 x 1,440, Ultra preset, no ray tracing



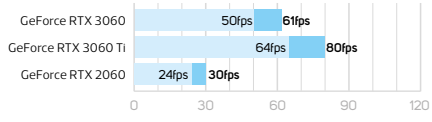
1,920 x 1,080, Ultra preset, Medium ray tracing



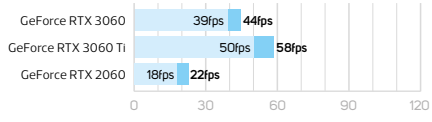
2,560 x 1,440, Ultra preset, Medium ray tracing



1,920 x 1,080, Ultra preset, Medium ray tracing, DLSS Balanced

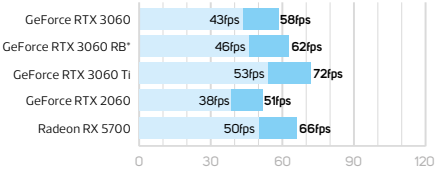


2,560 x 1,440, Ultra preset, Medium ray tracing, DLSS Balanced

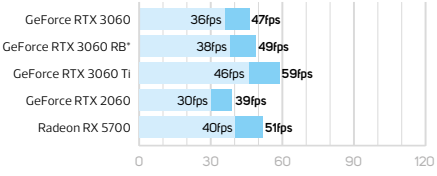


ASSASSIN'S CREED VALHALLA

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



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



99th percentile Average

*RB = Resizable bar

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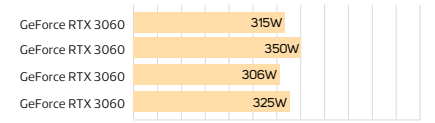
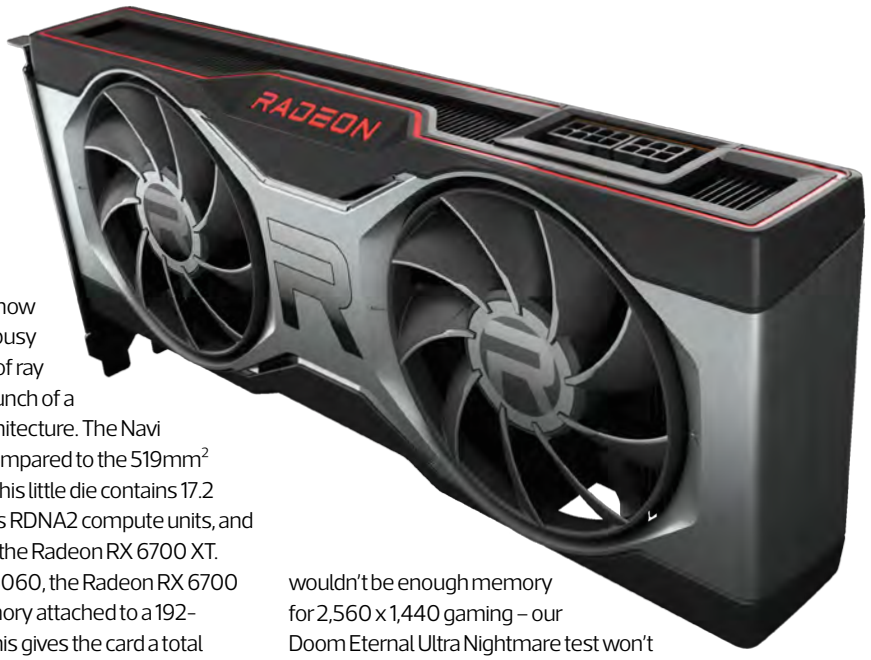


Lower is better

GRAPHICS CARD

AMD RADEON RX 6700 XT / £MORE THAN IT'S WORTH

SUPPLIER ebay.co.uk



With the 'Big Navi' launch now out of the way, AMD is busy fleshing out its line-up of ray tracing-capable GPUs with the launch of a new chip based on its RDNA2 architecture. The Navi 22 die measures just 336mm^2, compared to the 519mm^2 Radeon RX 6800-series GPUs. This little die contains 17.2 billion transistors and 40 of AMD's RDNA2 compute units, and the whole chip is fully enabled on the Radeon RX 6700 XT.

As with Nvidia's GeForce RTX 3060, the Radeon RX 6700 XT also has 12GB of GDDR6 memory attached to a 192-bit memory interface. On paper, this gives the card a total memory bandwidth 384GB/sec in conjunction with the 2GHz (16GHz effective) memory. However, AMD claims that the chip's 96MB of on-die Infinity Cache will significantly reduce latency here, as the GPU will have quick access to a large pool of memory that's much faster than the GDDR6 memory.

Each of the chip's 40 compute units contains a dedicated Ray Accelerator for ray tracing in games, along with 64 stream processors, making for a total of 2,560. What's more, the GPU has a game clock of 2424MHz – as a point of comparison, the mighty Radeon RX 6900 XT has a 2015MHz game clock.

It's for this reason that AMD's quoted board power of 230W isn't far off the 250W for the Radeon RX 6800 – the Radeon 6700 XT's small chip might have less parallel processing power than the Navi 21 chip in the Radeon RX 6800, but the high clock speed pushes up the power draw.

AMD says it's designed this card for gaming at resolutions of 2,560 x 1,440 and below, and for high refresh rate displays. It's for the former reason that the firm says the card has 12GB of memory. The other option with the way this chip's 192-bit memory interface works was to give it 6GB, and this wouldn't be enough memory for 2,560 x 1,440 gaming – our Doom Eternal Ultra Nightmare test won't even run with less than 8GB.

SPEC

Graphics processor
AMD Radeon RX 6700 XT, 2321MHz base clock, 2424MHz game clock, 2581MHz max boost clock

Pipeline
2,560 stream processors, 64 ROPS

Ray Accelerators
40

Memory
12GB GDDR6, 2GHz (16GHz effective)

Infinity Cache
96MB

Memory interface
192-bit

Card interface
16x PCI-E 4

Memory bandwidth
384GB/sec

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

Number of slots
2

Card length
267mm

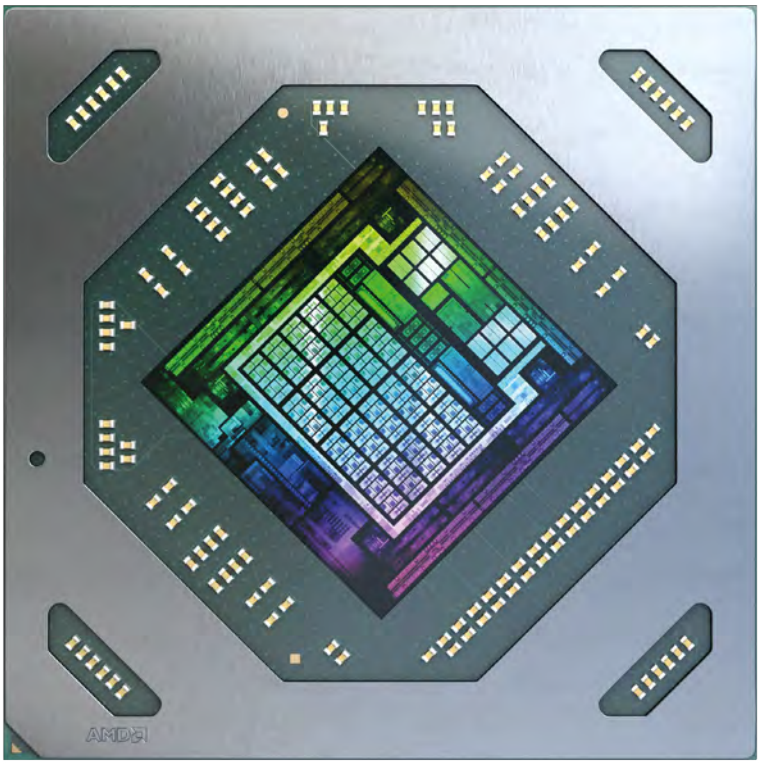
The card

This new GPU also introduces a new reference card from AMD. It's a neat little dual-slot design measuring 267mm long, with a die cast aluminium frame and a 10-layer PCB. It has a pair of dual-axial fans, a 6-pin and an 8-pin PCI-E power connector on the edge, and a big 'R' in the middle (and on the fans), the styling of which makes it look a bit like it's built for Team Rocket in Pokémon. It's a good-looking card, it remained generally quiet during testing and its zero-rpm mode means it doesn't make an annoying noise when idle.

It's much better than AMD's old reference blower designs – the only complaint is that, unlike the Radeon RX 6800 XT reference card, you can't change the colour of the red Radeon logo light on the edge. These reference cards are made by AMD for sale on **amd.com**, but this launch also sees AMD's third-party board partners launching their cards on the same day in a bid to increase supply. However, we have little faith that this supply will be able to meet current demand.

Performance

Despite only having a 192-bit memory interface, the Radeon RX 6700 XT is seriously powerful. In our non-ray-traced Metro Exodus, Assassin's Creed Valhalla and Doom Eternal tests, it was ahead of Nvidia's GeForce RTX 3060 Ti, a card with a 256-bit memory interface, so it looks as though AMD's Infinity Cache is doing its job.



AMD's new Navi 22 chip has a 336mm² die and contains 40 compute units

What's more, you can get a substantial bump in performance by enabling resizable BAR, if your motherboard and CPU support it. AMD calls this technology Smart Access Memory, and claims it can give you up to a 16 per cent speed boost. Amazingly, this claim bears up to testing – for example, in Assassin's Creed Valhalla at 1,920 x 1,080, the average frame rate jumped from 90 to 105fps (a boost of just over 16 per cent), and the 99th percentile minimum went from 65fps to 76fps too.

Interestingly, though, enabling resizable BAR made no difference to our Metro Exodus results, in contrast to the GeForce RTX 3060 (see p16), which got a performance boost from it.

The Radeon RX 6700 XT can happily churn out smooth frame rates in games at top settings at 2,560 x 1,440 – if you enable resizable BAR, it stays above 60fps in Assassin's Creed Valhalla, and its average of 73fps in Metro Exodus is a superb result. Its average of 52fps (and 99th percentile of 42fps) in Cyberpunk 2077 is a little slower than ideal, but it's in the same ballpark as the RTX 3060 Ti, and you'll only need to drop the settings a little to get a smoother frame rate. It can also churn out high frame rates in fast-paced, less demanding games, averaging a massive 341fps in Doom Eternal at 1080p, and 254fps at 2,560 x 1,440.

The other main contender here, of course, is the GeForce RTX 3070, which is ostensibly priced a bit higher than the Radeon RX 6700 XT (the RTX 3060 Ti is priced a little lower). Sadly, we weren't able to get hold of an RTX 3070 card to test on our new graphics test rig this month (which is why it isn't in the benchmark graphs), but we can get a rough ballpark of performance from our Issue 211 Labs test, which used our old Intel Coffee Lake rig.

Here, the RTX 3070 is 4fps faster in Cyberpunk 2077 at 2,560 x 1,440, and 2fps quicker in Assassin's Creed Valhalla, but enabling resizable BAR on the Radeon RX 6700 XT enables it to beat the RTX 3070's result by 8fps.

It's a shame we can't get a like-for-like comparison here, but as a rough gauge, you can see that the Radeon RX 6700 XT is generally only a small margin behind the RTX 3070, and ahead of the RTX 3060 Ti.

The exception here is ray-tracing performance, where Nvidia's cheaper GPU has the upper hand. There's still no ray-tracing support for AMD GPUs in Cyberpunk 2077, but in Metro Exodus, the RTX 3060 Ti was noticeably quicker than the Radeon RX 6700 XT with High ray tracing enabled. The Nvidia GPU also has the benefit of DLSS support, which can give it a helping hand in getting playable ray-tracing frame rates, although it looks blurry at resolutions below 2,560 x 1,440.

Ray tracing isn't AMD's strong suit, but it can at least do it. Its average of 66fps in Metro Exodus at 1,920 x 1,080 is still absolutely fine, but it struggles at higher resolutions, with a 99th percentile result of 32fps at 2,560 x 1,440 – a place where an equivalent to DLSS would be handy. AMD does have one such equivalent in the works, called FidelityFX Super Resolution, but it's still yet to be released.

Conclusion

It's hard to give a definitive verdict on a graphics card when we know you won't be able to buy one at the recommended retail price. In a normal, non-silly world, the Radeon RX 6700 XT would hit the balance about right. Ray tracing aside, its performance is generally in the same league as the GeForce RTX 3070, and ahead of the RTX 3060 Ti. That's in line with the recommended retail pricing compared with Nvidia's Founders Edition cards, and it's also a solid upgrade over AMD's previous Radeon RX 5700 XT.

The problem, of course, is that these prices bear no relation to the reality of inflated eBay prices. Also, if ray tracing is a priority then it's worth stepping up to the RTX 3070, as its stronger ray-tracing performance and DLSS support makes it much more viable, plus it will work in Cyberpunk 2077.

That all said, if you are prepared to pay scalper prices, AMD GPUs generally seem to go for less money than their Nvidia equivalents, likely because they're not as good at cryptocurrency mining. If a Radeon RX 6700 XT costs £100-£200 less than an RTX 3070 on eBay, then it's worth buying the Radeon instead for gaming.

BEN HARDWIDGE

MEOWTH

- \+ Loads of memory
- \+ Awesome Valhalla performance
- \+ Boost from Smart Access Memory

TRUBBISH

- – No stock
- – No ray tracing in Cyberpunk 2077
- – Ray-tracing performance could be better

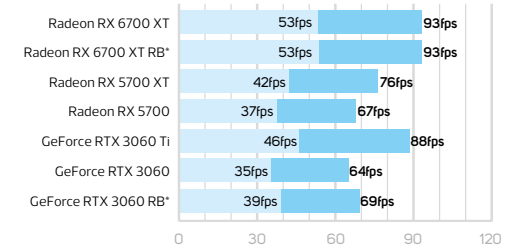
VERDICT

AMD still can't compete with Nvidia's ray-tracing performance, but the Radeon RX 6700 XT would otherwise be a decent GPU at its MSRP – it's a shame you can't actually buy it at that price.

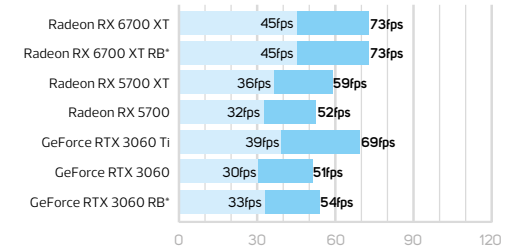
BENCHMARK RESULTS

METRO EXODUS

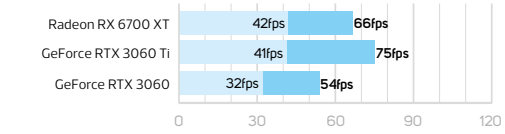
1,920 x 1,080, Ultra settings, HairWorks off, PhysX off



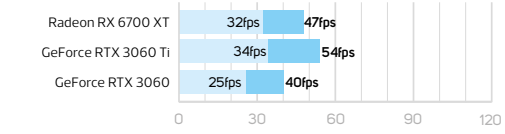
2,560 x 1,440, Ultra settings, HairWorks off, PhysX off



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

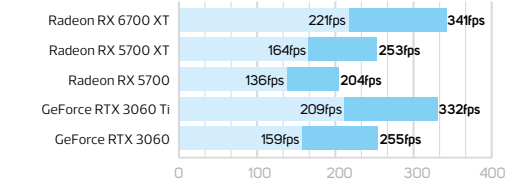


2,560 x 1,440, Ultra settings, High RT, HairWorks off, PhysX off

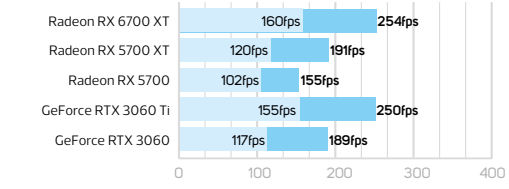


DOOM ETERNAL

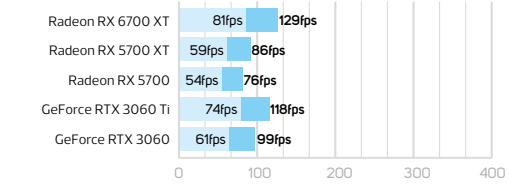
1,920 x 1,080, Ultra Nightmare settings



2,560 x 1,440, Ultra Nightmare settings



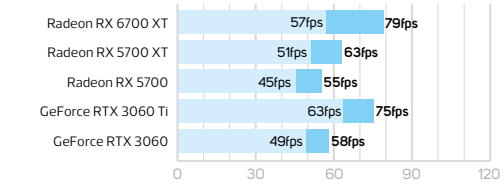
3,840 x 2,160, Ultra Nightmare settings



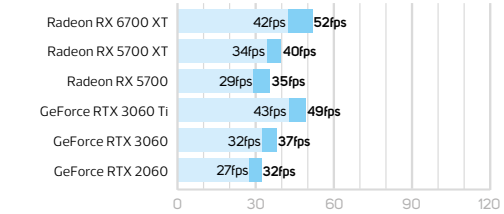
*RB = Resize bar

CYBERPUNK 2077

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

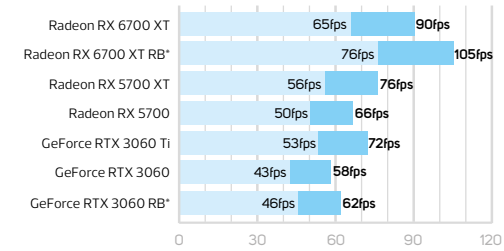


2,560 x 1,440, Ultra preset, no ray tracing

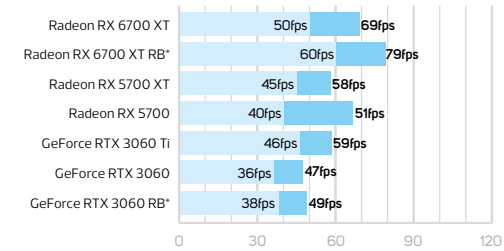


ASSASSIN'S CREED VALHALLA

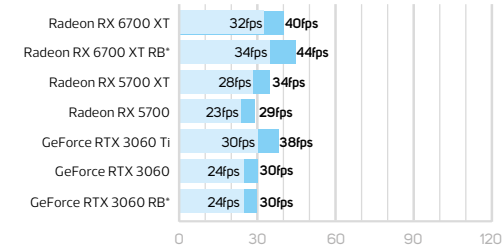
1,920 x 1,080, Ultra high settings, High AA



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



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



*RB = Resize bar

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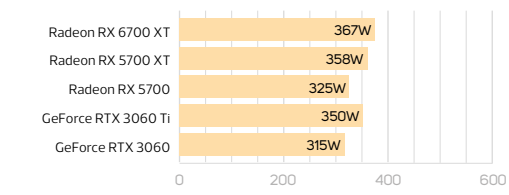

Lower is better

GAMING MOUSE

LOGITECH G PRO X SUPERLIGHT / £130 inc VAT

SUPPLIER logitech.com

Logitech's original G Pro Wireless (see Issue 187, p19) was an absolute game changer for the gaming mouse world. It had a great overall design that was truly ambidextrous, thanks to removable side buttons. Combine this with an incredibly low weight of just 80g, plus the latest fast-as-wired wireless technology and a top-notch optical sensor, and you ended up with a device that could truly be recommended to just about any buyer seeking a competitive gaming mouse. It was pricey but highly versatile.

The G Pro X Superlight is a new version of this mouse that drops its weight even further to just 63g, while also adding Logitech's latest 25,600DPI Hero sensor. Does this make it the best gaming mouse yet? Yes and no.

Starting with the good stuff, this mouse's shape is as fantastic as ever. The simple, almost symmetrical front-to-back curve, with its relatively straight and tall sides, combined with the overall small size of the mouse, makes it really easy to grip the sides and generally fling around the mouse in battle.

It's beautifully balanced and the plain matt black finish provides a good grip. Generally, thick rubber sides are preferable, as they last a long time compared with the thin soft-touch finishes on some mice. However, the finish on the original G Pro Wireless held up well, so we've no issues with the same material being used here.

What's more, this new mouse has, of course, shed 17g, and while we certainly wouldn't consider the drop from 80g to 63g to be essential, it's still noticeable. Combine all the above with the flawless wireless technology and you have a mouse that's just so effortless to use: there are no wires to snag and none of the excess heft of older wireless mice.

You can wire it up to your PC if you like though. The custom micro-USB cable plugs into the front of the mouse, allowing you to charge and continue gaming. A USB Type-A wireless dongle and micro-USB to USB Type-A adaptor is included in the box too, so you can have the dongle on your desk ready to plug into the mouse, and you can also have it close to the mouse for better reception. The dongle can be stowed inside the mouse as well, under a magnetically attached panel on the underside.

It's when it comes to buttons that we hit the first problem with this mouse. The removable buttons on the right side of the mouse, which allowed it to be used by left-handed users, are gone. While the right-handed market might be dominant, this ambidextrous ability was a significant plus point for the old G Pro Wireless. It's a huge shame to see it gone.

You also miss out on the bottom-mounted DPI button of that mouse. Now all DPI changes have to be done in software. That's not so bad for a main PC, but it limits the ease of using the mouse with multiple systems where you might not have the Logitech software installed. Logitech has even ditched the already modest RGB backlighting of the original mouse – the logo is now just a painted-on silver affair.

Thankfully, Logitech at least seems to have fixed the one major problem with the old model, which was its flaky left and right button switches. These switches often developed an unintentional double-click problem, which so far seems to have been fixed with the new version.

Conclusion

The G Pro X Superlight can legitimately claim to be the best gaming mouse on the market for right-handed FPS gamers. It's super-comfortable, has flawless performance and is indeed super-light. However, the loss of its ambidextrous capability, RGB backlighting and DPI button, all for the sake of 17g in weight, means you're paying the same price as the old mouse for fewer features.

EDWARD CHESTER

SUPER-LIGHT

+ Astonishingly light
+ Fantastic shape
+ Highly responsive
+ Good battery life

SUPER-BAD

– No longer ambidextrous
– No DPI button
– Very expensive

VERDICT

A superb competitive gaming mouse, although it's also very expensive.

DESIGN 17/20
FEATURES 15/20
PERFORMANCE 30/30
VALUE 19/30
OVERALL SCORE 81%

GAMING MOUSE

RAZER VIPER 8KHZ / £80 inc VAT

SUPPLIER currys.co.uk

We've been impressed with recent iterations of Razer's Viper mouse, with the newest ambidextrous shape (see Issue 195, p61) proving very comfortable to use. However, that iteration was hampered by a couple of issues with its buttons, which held it back from greatness.

With this latest iteration, though, Razer has fixed the button problems and added a new 20,000DPI optical sensor and the ability to poll at 8kHz, up from the typical maximum of 1kHz. The idea is that a faster polling rate reduces the potential for a split-second delay in a mouse report, which could end up being the difference between hitting a shot and not.

That said, in reality the 8K polling doesn't amount to much. For a start, many games simply don't support it, resulting in stutter and other mouse response oddities. Moreover, for those games that do support it, the difference is all but impossible to detect.

You're talking about a change from a 1ms delay to 1/8th of a millisecond, which is an impressive leap but when (on average) it takes dozens of milliseconds for a mouse click to register on screen – as shown by the latency analyser tool in the Asus PG279QNR monitor (see Issue 212, p20) – such a tiny saving is basically undetectable.

The same can largely be said of the uprated optical sensor. Sensors have been 'good enough' now for years, so again we couldn't detect any improvement with this mouse compared with the previous Razer Viper during games testing. The improvements here may not be groundbreaking, then, but the Viper's tracking and gaming performance is flawless, and there are many other attributes of its design that are similarly praiseworthy.

For a start, it's looks great, with its aggressive lines, all-black livery and that ever-snazzy Razer logo glowing from its rear. It has a classy symmetrical shape too, and it's also a truly ambidextrous mouse. So, unlike the Logitech G Pro X Wireless Superlight (see opposite), this mouse has Back and Forward buttons on both sides. Such setups can lead to the unused buttons occasionally being pressed accidentally, but we've not found this to be a problem with either the previous version of this mouse or this updated version.

Another great addition is the thick rubber used on the side sections, which provide superb grip no matter how dry or sweaty your hands become during gaming. Add in the tiny 71g overall weight (technically 2g heavier than the previous Viper) and generally well-balanced, compact shape and you have a truly great piece of mouse design. Meanwhile, the cable is of the modern low-resistance type, with the very flexible braided sheath ensuring that it doesn't push back against your movements.

In terms of features, joining the four side buttons are your standard array of Left, Right and scroll-wheel click buttons, while on the underside you'll find a DPI (dots per inch) resolution button with an accompanying RGB LED to indicate which of the five DPI settings is in use. You change the number of DPI settings and the DPI itself in software, along with the polling rate, lighting effects, left or right handedness and button assignments (including disabling the unused side buttons) in Razer's excellent software.

Conclusion

The Razer Viper 8KHz is a truly fantastic performance gaming mouse, and one that can be comfortably used by both right and left-handed gamers to full advantage, thanks to its truly ambidextrous design. It provides superb tracking performance, it's really comfortable to use, it's very light and it looks great too. The new 8kHz polling rate and 25K DPI sensor don't amount to particularly meaningful upgrades over the previous version of the mouse, but that hardly matters when the fundamental design is so good. At £80 inc VAT, the Viper 8K is expensive, but it's worth it if you can stump up the cash.

EDWARD CHESTER

VERDICT

Performance gaming mouse perfection, even if the 8kHz polling rate isn't a huge benefit.

VENOMOUS

+ Very lightweight
+ Great shape
+ Truly ambidextrous
+ Solid performance

TOOTHLESS

– 8kHz polling is rather pointless
– Quite expensive
– Basic feature set

DESIGN 19/20

FEATURES 15/20

PERFORMANCE 30/30

VALUE 22/30

OVERALL SCORE 86%

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GAMING HEADSET

LOGITECH G PRO X WIRELESS / £190 inc VAT

SUPPLIER logitech.com

The Pro X Wireless is Logitech's new flagship gaming headset. It includes the company's low-latency Lightspeed wireless technology, virtual surround sound and an overall premium look, feel and sound, but does it all add up to justify its high asking price?

The Logitech certainly makes a decent first impression when it comes to extras. Along with the headset and large wireless dongle in the box, you also get a detachable microphone, a spare set of earpads (giving you a choice of fabric or leatherette coverings), a USB Type-C charging cable and a little padded bag to hold it all.

However, the lack of an included analogue cable immediately highlights one missing feature here, which is any sort of analogue input. While the similarly priced and featured Razer BlackShark V2 Pro has a 3.5mm jack input, so you can use the headset with a phone or any other device, the Pro X is limited to USB devices.

Taking a closer look at the headset reveals just the sort of premium look and feel you'd expect for its price. The headband is deeply padded, with an attractively stitched leatherette covering. The earcup arms are also made from thick metal, while the earcups themselves have a pleasant soft-touch black finish, with a reasonably classy-looking metallic plastic Logitech logo.

The socket for the microphone and all the controls are on the left earcup, including the USB Type-C port, power switch, volume dial and a microphone mute button. The volume dial is a free-spinning digital type, and we found it a little too easy to accidentally knock and too slow to adjust – comparatively, the Razer's analogue volume wheel is much quicker and easier to use.

In terms of comfort, the Logitech has a very strong clamping force that ensures much of the not inconsiderable 370g weight is held by the earcup padding, rather than the headband. This prevents the top of your head from getting sore and means this headset won't fall off, but the squeeze on the side of your head is a little strong. It was fine for an hour or two but it becomes uncomfortable for all-day use. The Razer headset has a much lighter fit (it's 50g lighter too), which is much more comfortable, though inevitably less secure.

The padding and earcup design also passively blocks considerably more sound than the Razer headset. If you like to really shut out the world around you, you'll prefer the Logitech, but if you like to maintain a little more sense of what's going on outside then the Razer is a better bet.

As for sound quality, Logitech has gone for a fairly treble-heavy sound that's aimed at enhancing the audibility of sound cues in games, rather than making for the most enjoyable music and general listening experience. It's not harshly shrill but there's very little bass or warmth when you're not using it for gaming.

The sound is also strangely close, with very little natural spaciousness. Logitech provides DTS virtual surround sound modes in its software, though, and these significantly improve the directionality and sense of space. In gaming, the headset does provide impressively crisp audio, making it easy to pick out footsteps and other audio cues that boomier headsets can muffle.

X-WING

+ Good build quality
+ USB Type-C charging
+ Good battery life

NABOO STARFIGHTER

– Not comfortable long-term
– No analogue input
– Treble-centric sound

SPEC

Audio config
Stereo and DTS virtual surround

Frequency range
20-20,000Hz

Sensitivity/sound pressure
91.7db

Mic frequency response
100-10,000Hz

Mic sensitivity
Not specified

Weight
370g

Extras
USB Type-C cable, carry bag, fabric earpads, wireless dongle, detachable microphone

Conclusion

A treble-centric sound profile and no-nonsense, quality design makes the G Pro X Wireless a solid gaming headset. It will help you pick out enemies better than more bass-heavy headsets. Those with larger heads my find it a bit of a tight fit, though, and its comparable lack of versatility makes it hard to fully justify its high price.

EDWARD CHESTER

COMFORT 14/20

FEATURES 17/20

SOUND QUALITY 32/40

VALUE 14/20

OVERALL SCORE 77%

VERDICT

A very high price makes this very gaming-focused, treble-heavy headset a slightly tough sell.

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GAMING KEYBOARD

RAZER HUNTSMAN V2 ANALOG / £250 inc VAT

SUPPLIER currys.co.uk

The Huntsman V2 Analog is Razer's new flagship keyboard, which not only sports high-end features such as optical switches, an RGB-adorned wrist rest and USB 3 pass-through, but also includes analogue switches. Like those on the Cooler Master MK850 (see Issue 193, p55), these switches can track the depth that you've pressed a key, allowing you to provide analogue input – like the analogue triggers on a gamepad – direct from the keyboard.

It's an intriguing technology and, unlike the MK850, Razer includes it in every key on this keyboard, so you can program the lot to act just how you like. The keys can also be set up to trigger two different actions depending on how far down the key is pressed. The problem is that it's quite tricky to get the level of finesse required to use them in a meaningful manner.

While it's easy to carefully press one or two keys precisely, combining the inputs required for smoothly steering a car or controlling an aeroplane are very tricky. It's a similar story when it comes to the two-level activation. It's such an unnatural feeling to try to tap a key with a certain amount of pressure when in the heat of battle.

Considering you can buy perfectly capable gamepads and joysticks for well below £100, the use case for such analogue input on a keyboard seems limited. Steering wheels are admittedly rather more expensive for half-decent models, but you can save £100 towards one by opting for a normal keyboard.

All that said, for slower-paced games such as Microsoft Flight Simulator, or for using the keyboard as an analogue control surface for music making, for example, there's greater scope here. More dedicated interfaces will still be preferable for both, but there's potential here as a one-stop shop.

Given their analogue ability, this keyboard's switches understandably have a linear action, so they lack the tactile feedback of some switches. However, they're still surprisingly loud. This seems to be down to a combination of the relatively light construction of the keyboard, so it doesn't dampen the sound that much, and the very sharp, clacking sound of the switches themselves. We measured a sound level of up to 67dB from a distance of 20cm, which compares to around 64dB from a typical keyboard with linear switches.

Every other aspect of this keyboard is very good indeed. For a start, it's very stylish, with its black colour scheme, aluminium top plate and fantastically integrated RGB lighting. The latter wraps around the edges of the magnetically attached, padded wrist rest, as well as the keyboard. Razer has also included premium doubleshot PBT keycaps, so they shouldn't wear to a shine and lose the key legends over time.

There are plenty of features too, with chunky multimedia buttons in the top right corner, along with a knurled volume wheel. There's also a USB 3 pass-through port on the left edge, which is a great feature – very few keyboards have USB 3 pass-throughs. However, the cables for the keyboard and pass-through are separate and exit the left rear of the keyboard (with no routing options), which seems a slightly odd arrangement.

HUNTSMAN

+ Good build quality
+ Stylish design
+ Loads of extra features
+ Versatile analogue switches

HARVESTMAN

– Expensive
– Other analogue input devices are better
– Loud keys

SPEC

Dimensions (mm)
448 x 140/229 x 43 (W x D x H)

Weight
1.20kg (1.67kg with wrist rest)

Format
Standard – 105 keys

Connection
USB 3

Switch type
Razer optical analogue

Switch life
100+ million keystrokes

Backlighting
RGB

Extras
USB 3 pass-through, padded RGB wrist rest, multimedia buttons

Conclusion

The Huntsman V2 Analog is a fantastic premium keyboard, with its RGB lighting, great design and plenty of extra features – including masses of easy programmability via Razer's software. However, its big selling point to justify the high price – its analogue keys – aren't entirely convincing, and the noisiness of the keys is slightly off-putting too.

EDWARD CHESTER

VERDICT

Analogue keyboard input looks likely to have niche appeal, but the rest of this keyboard is fantastic.

DESIGN 22/25
FEATURES 22/25
PERFORMANCE 20/25
VALUE 18/25

OVERALL SCORE 82%

GAMING CHAIR

AKRACING CORE SERIES EX-WIDE / £299 inc VAT

SUPPLIER scan.co.uk

Costing just £299 inc VAT, the AKRacing Core EX-Wide is among the cheapest gaming chairs we've tested, and while that cost cutting is all too evident in several ways, there are some surprisingly good touches to this chair as well.

The base of this chair is plastic but it actually looks rather good in its matt black finish. The castors spin freely and have a large diameter too, so they roll well. However, the tilt system is of the basic variety. It does tilt back but can't be locked into a reclined position.

It also pivots from a hinge at the back of the chair, so you have to raise the front in order to tilt back – superior tilt systems hinge from the front and drop down to tilt. As a result, you can't actually get the Core Series Ex-Wide to tilt back without putting your feet up on an object in front of you. The back does recline to be fully flat though.

As its name suggests, this is an extra-wide chair, sporting a seat that's 3.5cm wider than the regular AKRacing Core EX chair. However, unlike many other gaming chairs that have a more general small, medium and large sizing scheme, here, the EX-Wide doesn't also offer extra height, with its back measuring the same 83.2cm as the standard EX chair.

Comparing it with another large option, the noblechairs HERO, that chair's back rises to 89cm, making it better proportioned overall for taller as well as larger users. Also expanding the appeal of the noblechairs HERO are its near-flat wings on the side of the seat. These are low enough to allow you to stretch out your legs, sit cross-legged and just generally have room to move around. The EX-Wide, though, has fairly pronounced wings. With the extra width of the chair, there's still ample room to sit wide-legged but it's a little restrictive.

It's a similar situation with the hip wings. They're plenty wide enough – measuring 36cm at their narrowest point – but they're also quite pronounced, so if you have a particularly wide body, you won't comfortably be able to squeeze into the chair.

For lumbar and head support, AKRacing uses the typical cushions on elasticated straps system that we've seen on many other gaming chairs, and this setup is as mediocre as ever on this chair too. The head cushion is fine, although it's not very adjustable and the elastic won't last long, but the lumbar support cushion is only average.

It's among the better-profiled cushions we've tested, with gentle slopes to its edges, but it's still too hard and thick – while it's very supportive, it rather digs into your back. The whole gaming chair industry needs to come up with a better system for lumbar support in this price bracket.

Thankfully, the seat cushion is actually among the best we've tried. It's much more forgiving than the overly hard seats of some other gaming chairs in our recent Labs test, and the cushion drops off pleasantly at the front edge, so it doesn't dig into your thighs.

AKRacing has equipped this chair with '3D' armrests that slide forwards and back, twist left and right, and go up and down, but they can't be slid in and out in order to place them closer or further from the body. Moreover, they don't lock either, making it all too easy to knock them out of place.

Conclusion

A relatively low price means you get a decent amount of gaming chair for the money here, especially if you're after a larger chair. The pleasant seat cushion also offers better padding than many alternatives. However, the rather lacklustre design, basic tilt system and mediocre lumbar cushion system leaves us only marginally impressed.

EDWARD CHESTER

VERDICT

A big basic gaming chair for an attractive price, but there's not a lot to get excited about here.

CORE BLIMEY

+ Good seat padding
+ Decent value
+ Solid build quality

CORE MELTDOWN

– Only wide, not tall
– Not all that comfortable
– Mediocre lumbar support
– Basic tilt system

COMFORT 15/25

DESIGN 15/25

FEATURES 20/25

VALUE 22/25

OVERALL SCORE 72%

GAMING LAPTOP

GIGABYTE AORUS 15G XC / £1,899 inc VAT

SUPPLIER overclockers.co.uk

Gigabyte's Aorus machines have carved a sizeable niche in the gaming laptop space, and this new machine is its first model with an RTX 3070 GPU. This Ampere-based chip has 5,120 CUDA cores and 8GB of memory, and here, the RTX 3070 has a peak TDP of 105W, which means a moderate boost speed of 1290MHz.

The rest of the Gigabyte's specification is decent – there's a Core i7-10870H CPU with six cores that runs at 2.2GHz with a potential turbo peak of 5GHz, 16GB of dual-channel DDR4 memory, and both 2.5Gbps Ethernet and dual-band Wi-Fi 6. Meanwhile, the 512GB Phison SSD provides decent read and write speeds of 3,346MB/sec and 2,514MB/sec, but it could do with a larger capacity given the size of modern game installs.

The hardware slots inside a chassis made from black plastic. It might not be metal, but it looks sleek and classy, and build quality is decent – there's a little movement around the keyboard but hardly any flex anywhere else. There's plenty of internal access too: you can access both SODIMM slots, the wireless chip and the SSD, as well as a spare M.2 connector.

Around the edges, the Aorus serves up three full-sized USB 3.2 Gen 1 ports, a Type-C connector, and both HDMI and mini-DisplayPort outputs. It also has an SD card reader. It's a good everyday slate of features, but the last Aorus 15G laptop we reviewed had Thunderbolt and a fingerprint reader, and both of those features are missing here. The Aorus' 23mm thickness and 2kg weight are only middling too, although neither will prevent his machine from being slung in a bag. The 15G also has a webcam, but it's awkwardly placed below the display.

Meanwhile, the keyboard is a conventional chiclet model. It has a numberpad, large cursor and Return keys and per-key RGB LED backlighting. The buttons have reasonable speed, and they're quiet and comfortable to use – they're certainly good enough for mainstream gaming. But they don't have the crispness or deeper travel of the best chiclet keyboards. They're also a far cry from the mechanical keys used on last year's Aorus machine. The trackpad buttons push down too far as well, so we'd definitely use a USB mouse.

The 15G squares up against last month's PC Specialist Defiance VIII Pro, which included the same core components for £1,499 inc VAT. That machine had a larger SSD, a better-placed webcam and Thunderbolt support, alongside a three year warranty – the Aorus only has a two year deal. However, the PC Specialist suffered with a weaker, plainer chassis and a wobbly keyboard with poor backlighting, which are key considerations for a mobile machine.

The Aorus is also available with RTX 3060 and RTX 3080 GPUs for £1,599 and £2,299 respectively. There's the 15P XC as well, which ramps up the RTX 3070 to 130W for no extra cost – but that machine is hotter, louder, heavier and thicker.

SPEC

CPU
2.2GHz Intel Core i7-10870H

Memory
32GB 2933MHz DDR4

Graphics
Nvidia GeForce RTX 3070 Laptop 8GB

Screen
15.6in 1,920 x 1,080 IPS 240Hz

Storage
512GB Phison ESR512GTLCG-EAC-4 M.2 SSD

Networking
Dual-band 802.11ax Wi-Fi, 2.5Gbps Ethernet, Bluetooth 5

Weight
2kg

Ports
3 x USB 3.2 Gen 1, 1 x USB 3.2 Gen 2 Type-C, 1 x audio, 1 x HDMI, 1 x mini-DisplayPort, 1 x SD card slot

Dimensions (mm)
357 x 244 x 23 (W x D x H)

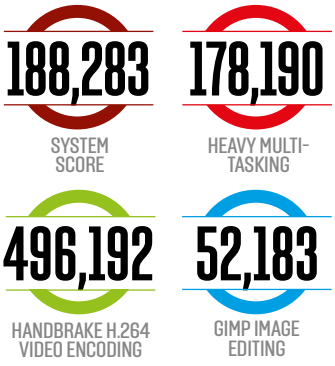
Operating system
Windows 10 Home 64-bit

Warranty
Two years parts and labour return to base

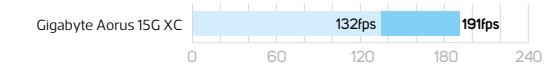
Performance

In our tough Cyberpunk 2077 and Assassin's Creed Valhalla benchmarks, the Aorus delivered 99th percentile minimums of 46fps and 40fps. Those scores were recorded at the games' highest quality levels, so you'll going to get smooth gameplay at 1080p with this GPU. The Cyberpunk scores didn't decline with Medium ray tracing and DLSS activated either. The Aorus delivered minimum and average frame rates of 131fps and 191fps in Doom Eternal, so you're easily going to get the pace for high-speed esports gaming from this machine.

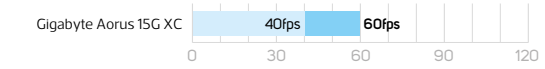
BENCHMARK RESULTS



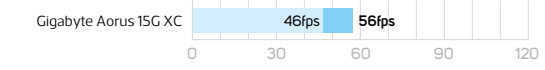
DOOM ETERNAL
1,920 x 1,080, Vulkan, Ultra Nightmare settings



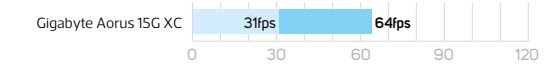
ASSASSIN'S CREED VALHALLA
1,920 x 1,080, Ultra High settings, High anti-aliasing



CYBERPUNK 2077
1,920 x 1,080, Ultra preset, no ray tracing



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



The results compare well with last month's PC Specialist laptop – the 15G was often a frame or two per second quicker than that cheaper laptop, and the Aorus' extra performance modes deliver a couple extra FPS too.

The 240Hz panel has a 1080p resolution with no active sync, but it's still satisfyingly smooth in fast-paced single-player and competitive games. The screen has good quality too: it renders 91.9 per cent of the sRGB colour gamut with great colour temperature and delta E figures of 6,461K and 0.84, and its contrast ratio of 1,021:1 is on par with most laptop IPS panels. This display delivers reasonable depth and accurate colours, so it's a good option for gaming and media use.

There are downsides though. The peak brightness of 286cd/m^2 is only good enough for indoor use, and the panel can't handle the wider DCI-P3 and Adobe RGB colour gamuts. The speakers are middling too: the mid-range is a little muffled, the bass could be punchier and volume is mediocre.

Meanwhile, in our application benchmarks, the Intel processor delivered a decent overall result of 188,283, which rose to 193,247 in the 15G's beefier performance mode – both results are better than the PC Specialist and this machine will still handle gaming, everyday work and photo editing without

issues. However, it's possible to find laptops with the RTX 3070 and AMD's Ryzen 7 5800H for less than the Aorus' price, and AMD's chip is faster across the board.

The 15G is a superb thermal performer as well. When gaming, it's one of the best high-end laptops we've tested for ages – its fan noise is subdued, the exterior remains cool and the GPU consistently ran at speeds beyond 1400MHz while maintaining a solid delta T of 58°C. In work benchmarks, the laptop was barely louder, although here, the CPU did peak with a delta T of 68°C before throttling to lower speeds. Nevertheless, in single-threaded and multi-threaded tests the Core i7 CPU ran at 4.6GHz and 3GHz respectively, so it's hardly slow.

Not surprisingly, battery life is ordinary. The Aorus lasted for six hours when handling basic work and four hours during a tougher productivity test, but only an hour during games.

Conclusion

The Aorus serves up impressive gaming speed and a good 1080p display alongside great thermal performance and a smart chassis. However, it does suffer from an patchy I/O option, an underwhelming keyboard and a higher price than similarly specified rivals. Indeed, it's not tricky to find RTX 3070 laptops for less money, and sometimes with better AMD CPUs. That said, that price gets you a decent screen, solid build quality and low-noise operation. It could be cheaper, but it's a well-built laptop if you can afford it.

MIKE JENNINGS

VERDICT

The 15G is a solid gaming laptop with great thermal ability and low-noise operation, although it's a bit pricey for the spec on offer.

PEERLESS

- \+ Fast in 1080p games
- \+ Decent 240Hz display
- \+ 2.5Gbps Ethernet
- \+ Great thermal ability

TASTELESS

- – Mediocre CPU
- – Underwhelming keyboard
- – Pricier than rivals
- – Some missing features

PERFORMANCE **21/25**

DESIGN **22/25**

HARDWARE **19/25**

VALUE **18/25**

OVERALL SCORE **80%**

INTEL H510 GAMING PC

SCAN 3XS GAMER RTX / £1,299 inc VAT

SUPPLIER scan.co.uk

Scan's 3XS Gamer RTX marks the debut of Intel's Rocket Lake (see p80) CPUs. Intel claims that Rocket Lake delivers big improvements in the number of instructions per clock (IPC), alongside increased memory speeds and integrated PCI-E 4 support. Scan's affordable rig deploys the excellent Core i5-11600K, which is a 6-core chip with Hyper-Threading. It has a 3.9GHz base clock that peaks at a 4.9GHz turbo frequency.

In this Scan system, it's paired with 16GB of 3000MHz DDR4 memory, a 2TB hard disk and a 1TB Intel 660p M.2 SSD with read and write speeds of 1,885MB/sec and 1,766MB/sec. That's solid pace for everyday computing, but the budget nature of this machine means that Scan hasn't included a faster PCI-E 4 SSD.

Meanwhile, graphics power comes from an EVGA GeForce RTX 3060 card, which has been overclocked, with its initial boost clock speed of 1777MHz leaping to 1882MHz. It also comes with 12GB of memory – 4GB more than the RTX 3060 Ti – but it operates on a narrower bus and delivers less bandwidth than the Ti-branded card.

It all slots into an Asus Prime H510M-A, which is a micro-ATX motherboard with a basic specification. It only has two memory slots and one M.2 connector, all of which are occupied. That M.2 slot doesn't support PCI-E 4 – that's only offered on the 16x PCI-E slot – and the board has entry-level Realtek ALC897 audio.

The rear I/O has two USB 3.2 Gen 1 ports, but four slower USB 2 connectors and no Type-C port, and it only has three audio jacks. The H510 chipset means the K-series CPU can't be multiplier-overclocked either.

Scan has chosen a smaller case than usual to match the micro-ATX motherboard, with the Antec Dark Phantom 301M having a tempered glass side panel and a smart slash of RGB LED lighting on its matt black façade – with a button to change the lighting. The top has two USB 3.2 Gen 1 ports, and on the inside, you'll find impeccable tidy cabling, and pairs of 2.5in and 3.5in drive mounts.

Scan has installed the radiator for the 240mm Corsair Hydro H100x cooler at the front of the case, which means the top of the motherboard isn't obscured and the chassis doesn't feel cramped. The Antec chassis is small too, measuring just 402mm tall and 420mm deep, and it has reasonable build quality. The only notable omission is a USB Type-C port. The rig is rounded off with a semi-modular 550W Corsair PSU with solid 80 Plus Gold certification.

Scan's budget rig lines up against the Chillblast Fusion Palladium (see p34). That PC costs more at £1,599 inc VAT, but the higher price translates to 32GB of memory, a PCI-E 4 SSD and a better motherboard. The Chillblast PC also has a sturdier, larger case and an AMD Ryzen 5 5600X processor.

The two machines trade blows on warranties. Scan's three year parts and labour deal is bolstered by a year of on site service, while the Chillblast includes five years of labour coverage. That extra year of parts coverage really adds value to the Scan deal, however.

SPEC

CPU
3.9GHz Intel Core i5-11600K

Motherboard
Asus Prime H510M-A

Memory
16GB Corsair Vengeance RGB Pro 3000MHz DDR4

Graphics
EVGA GeForce RTX 3060 12GB

Storage
1TB Intel 660p M.2 SSD; 2TB Seagate Barracuda hard disk

Networking
Gigabit Ethernet

Case
Antec Dark Phantom 301M

Cooling
CPU: Corsair Hydro H100x with 2 x 120mm fans; GPU: 2 x 90mm fans; rear: 1 x 120mm fan

PSU
Corsair TX550M 550W

Ports
Front: 2 x USB 3.2 Gen 1, 1 x audio; rear: 2 x USB 3.2 Gen 1, 4 x USB 2, 2 x PS/2, 3 x audio

Operating system
Microsoft Windows 10 Home 64-bit

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

Performance

Intel's latest processor improves on the preceding Core i5-10600K, but it still can't topple AMD's almighty Zen 3 architecture. Its image editing score of 64,961 is nearly 7,000 points beyond the previous Core i5 part, but the Chillblast's AMD chip was nearly 5,000 points ahead. The Intel CPU was around 50,000 points quicker than its predecessor in our heavily multi-threaded Handbrake test, but it never overhauled AMD's rival silicon.

The Core i5-11600K is an improvement on the last-generation Core i5 part, though, and it's still easily fast enough for gaming, photo editing, mainstream content creation and conventional work. Its single-threaded score outpaces older chips such as the Ryzen 9 3900XT and the Core i9-10900K too. AMD's Zen 3 chips remain faster still, bit they're also pricier.

There was little between the two machines in gaming tests. The Scan was a couple of frames per second ahead of Chillblast in Assassin's Creed Valhalla, and it snuck ahead in some of the Metro: Exodus benchmarks, but the Scan fell behind in Doom Eternal and Cyberpunk 2077.

Those nuances aside, the RTX 3060 remains good for 1080p gaming. It ran Assassin's Creed and Cyberpunk 2077 with 99th percentile minimums of 47fps and 50fps and proved playable with medium ray tracing– so you'll get smooth gameplay in most single-player games at top graphics settings. The RTX 3060's Doom Eternal minimum of 161fps means this PC will easily handle esports titles at 1080p on high refresh rate monitors as well.

When gaming, the Scan is reasonably quiet – it's only a little louder than the Chillblast and easily manageable, while the GPU peaked at boost speeds of just under 1900MHz. In a full-system stress test, the noise levels were moderate, but the CPU did throttle at 4.1GHz. In an all-core work test, the noise levels were impressively quiet, but the CPU's initial speed of 4.6GHz throttled to 4.2GHz. In a single-core work test, the chip comfortably sat at 4.9GHz.

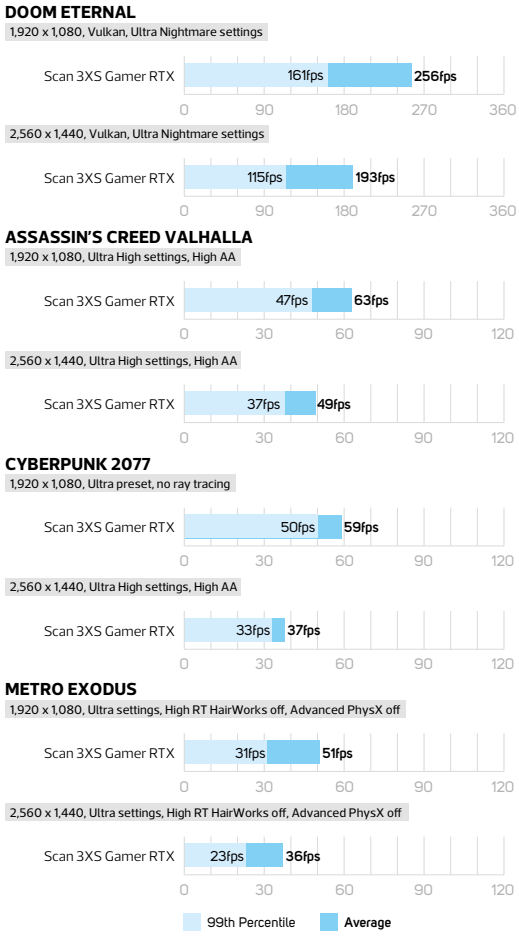
CYPRESS HILL

+ Great 1080p gaming pace
+ Loads of storage space
+ Compact, straightforward case
+ Good warranty

CYPRESS COVE

– Ryzen 5 5600X remains quicker
– Entry-level motherboard
– No PCI-E 4 SSD

BENCHMARK RESULTS



64,961
GIMP IMAGE EDITING

500,689
HANDBRAKE H.264 VIDEO ENCODING

223,563
HEAVY MULTI-TASKING

200,664
SYSTEM SCORE

Conclusion

The RTX 3060 offers solid 1080p pace, and the Scan's Core i5-11600K beats its predecessor and has decent performance. The Scan is quiet and affordable as well – it's one of the cheapest Ampere PCs around in these very strange times for GPU supply, enabling you to pick up a new GPU for a non-ridiculous price. However, there are noticeable cost-cutting measures – the Chillblast system has a better motherboard, superior SSD and more memory, but if money is tight, the Scan offers a respectable and affordable route into 1080p gaming.

MIKE JENNINGS

PERFORMANCE 19/25
DESIGN 20/25
HARDWARE 18/25
VALUE 24/25
OVERALL SCORE 81%

VERDICT

Solid 1080p gaming pace, a decent new Intel CPU and a low price, but there are compromises throughout.

AMD B550 GAMING PC

CHILLBLAST FUSION PALLADIUM / £1,599 inc VAT

SUPPLIER chillblast.com

The GeForce RTX 3060 is Nvidia's newest and cheapest Ampere GPU (see p16), and the Chillblast Fusion Palladium's Gigabyte-made card sees its stock speed of 1777MHz overclocked to 1807MHz.

It's accompanied by an AMD Ryzen 5 5600X CPU, which comes equipped with six SMT-enabled cores with a boost peak of 4.6GHz. The rest of the specification is impressive for a mid-range machine. There's 32GB of 3200MHz memory, and the 1TB Seagate FireCuda 520 SSD uses PCI-E 4 to return fantastic read and write speeds of 5,002MB/sec and 4,295MB/sec. The Corsair power supply is 80 Plus Gold-certified and semi-modular, and the warranty is excellent – a five year labour deal with two years of the all-important parts coverage.

All the gear connects to a micro-ATX Asus Prime B550M-A motherboard. It ticks the basic boxes, with four memory slots, two M.2 ports and a pair of vacant 1x PCI-E slots. It also has dual-band Wi-Fi 6. That second M.2 connector doesn't support PCI-E 4, though, and the Realtek ALC7887 audio hardware is entry-level.

Meanwhile, the rear I/O panel only has three audio jacks and no USB Type-C port. For everyday gaming and computing, this board is fine though. You'll get more features on a pricier ATX board, but this little motherboard nails the basics.

It's all housed in a Corsair iCUE 4000X chassis. It looks superb, with darkened tempered glass panels. It has a trio of RGB LED intake fans, which are synchronised with the two fans and waterblock on the great-looking Corsair Hydro iCUE H115i Elite Capellix cooler, and the effect is striking – the 4000X combines brooding design with splashes of colour.

The case has tremendous build quality and some welcome additions: its roof-mounted dust filter has a tab for easier removal; there's a USB Type-C port on the top; and it has pairs of 2.5in and 3.5in drive mounts. The cabling around the rear could be tidier, but Chillblast has kept it tidy at the top and it's impeccably neat at the front, where it matters most. The only issues are the rear cables blocking the 3.5in drive bays, and the CPU cooler's radiator obstructing the memory slots.

Chillblast's machine lines up against this month's Scan 3XS Gamer RTX (see p32), which pairs the RTX 3060 with a new Intel Core i5-11600K processor. Scan's £1,299 machine significantly undercuts the Chillblast on price, but it also has a poorer motherboard, less memory and a smaller chassis than the Palladium.

Performance

The RTX 3060 is ideal for 1080p gaming. In Assassin's Creed Valhalla and Cyberpunk 2077, the Chillblast delivered 99th percentile minimums of 46fps and 51fps at 1080p, which means you'll get smooth gameplay at top graphics settings. The Chillblast also returned playable scores in Cyberpunk 2077 with medium ray tracing applied. You can get borderline playable frame rates in these games at 2,560 x 1,440 as well, although you'll need to dial back the settings to achieve 60fps averages.

In the easier Doom Eternal benchmark, the RTX 3060 delivered 99th percentile minimums in triple figures at both tested resolutions, which indicates that this card has

SPEC

CPU
3.7GHz AMD Ryzen 5 5600X

Motherboard
Asus Prime B550M-A WiFi

Memory
32GB Corsair Vengeance LPX 3200MHz DDR4

Graphics
Gigabyte GeForce RTX 3060 12GB

Storage
1TB Seagate FireCuda 520 M.2 SSD

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

Case
Corsair iCUE 4000X

Cooling
CPU: Corsair Hydro iCUE H115i Elite Capellix with 2 x 120mm fans; GPU: 2 x 90mm fans; front: 3 x 120mm fans; rear: 1 x 120mm fan

PSU
Corsair TX650M 650W

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

Operating system
Microsoft Windows 10 Home 64-bit

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

BENCHMARK RESULTS

226,797 SYSTEM SCORE

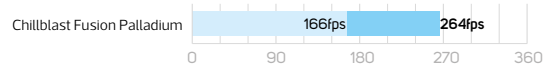
277,391 HEAVY MULTI-TASKING

543,328 HANDBRAKE H.264 VIDEO ENCODING

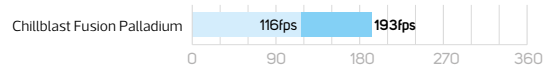
69,746 GIMP IMAGE EDITING

DOOM ETERNAL

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

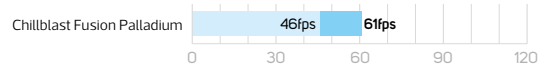


2,560 x 1,440, Vulkan, Ultra Nightmare settings

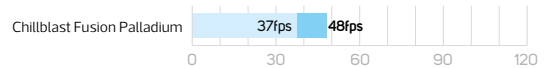


ASSASSIN'S CREED VALHALLA

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

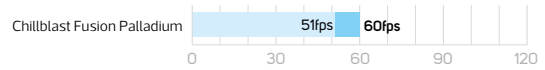


2,560 x 1,440, Ultra High settings, High AA

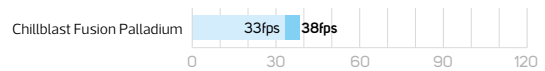


CYBERPUNK 2077

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

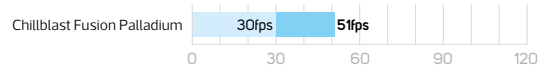


2,560 x 1,440, Ultra preset, no ray tracing

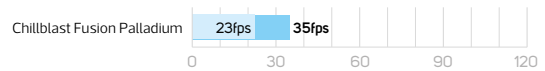


METRO EXODUS

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



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



99th Percentile Average

solid esports potential. There's little to choose between the Chillblast and the cheaper Scan when it comes to gaming, with both machines trading blows.

The RTX 3060 can't handle 4K gaming, though, and its Metro Exodus ray-tracing scores prove that it's hindered by the toughest single-player titles. The RTX 3060 Ti is significantly quicker – in Metro Exodus, it gives you an extra 8fps at 1080p.

Meanwhile, the Ryzen 5 5600X outpaces Intel's newer chip. Its image editing score of 69,746 is in front of the Core i5-11600K inside the Scan by nearly 7,000 points. In our heavily multi-threaded Handbrake test, the AMD part scored 543,328, which isn't far behind a Core i7-10700K and is nearly 43,000 points beyond the Scan system. The Chillblast's overall score of 226,797 is rapid, and indicates that this PC will handle gaming, photo editing and other moderate content-creation tasks.

These moderate components helped the Chillblast to perform well in thermal benchmarks. During gaming tests, the GPU boosted to frequencies beyond 1900MHz and the machine was extremely quiet – you'll barely hear it beneath your desk. The noise hardly increased during full-system stress tests, and in single and multi-core tests, the CPU achieved consistent speeds of 4.6GHz and 4.2GHz.

Conclusion

Chillblast's rig performs well in several key departments – the processor, memory and storage are excellent, the case is sturdy and smart, and it has a great warranty. The RTX 3060 is a solid 1080p gaming card, and the whole system is impressively quiet.

The motherboard could offer more features, though, and Scan's machine is a much cheaper RTX 3060-based alternative with similar gaming performance, albeit with weaker components elsewhere. If you want a 1080p gaming system with more memory and CPU power than the Scan, though, the Chillblast is a better machine if you can afford it.

MIKE JENNINGS

PROTON

+ Top-notch Ryzen 5 CPU
+ Solid 1080p gaming ability
+ Robust, good-looking case
+ Decent warranty

NEUTRON

– RTX 3060 Ti is faster in games
– Underwhelming motherboard
– Comparatively expensive

PERFORMANCE 20/25

DESIGN 21/25

HARDWARE 21/25

VALUE 18/25

OVERALL SCORE 80%

VERDICT

Chillblast's rig delivers solid 1080p gaming speed, a great CPU and a smart, sturdy case, but it's comparatively expensive for the performance on offer.

Custom kit

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

KONTROLFREEK PERFORMANCE GRIPS STRIPS / **£14.99** inc VAT

SUPPLIER amazon.co.uk

The KontrolFreek Performance Grips Strips pack contains a set of 28 grippy pads to attach to keyboards, mice and gamepads. The pads stick onto their devices easily enough, and they're easy to remove as well. Cleaning the back of the pad allows them to stick again and they don't leave behind any residue. The grip surface is also comfy, like a sort of squashy tyre tread; plus, as you'd expect, they're also grippier than the smooth plastic surface on most peripherals.

The strips make gamepads and mice a little comfier to use, but using the pads on a keyboard didn't feel like it made an improvement. That said, using the grips as markers on specific keys could be helpful for using a keyboard in a VR game, where blindly trying to find your fingers' location on the keyboard can be an issue. For a little bit of risk-free, reversible customisation on peripherals and devices, the Grip Strips offer a good way to make a device feel more personalised and comfy.

Gripe ●●●●○ **Grip**

G-LAB RUBIDIUM XXL GAMING MOUSE PAD / **£14.99** inc VAT

SUPPLIER amazon.co.uk

The G-Lab Rubidium XXL Gaming Mouse Pad fits into the category of gaming mousepads designed to cover your whole desktop gaming area, with both your mouse and keyboard seated on it. Measuring 800 x 300mm, the Rubidium doesn't stretch too far length-wise, but it's wide enough to comfortably accommodate all your gear and still provide you with a mouse area of a size comparable with an ordinary mousepad.

RGB lighting is supplied by LEDs around the edge, powered by micro-USB and controlled by a button on the left-hand side of the pad. The effect isn't spectacular – you could spend ten times as much money on a mousepad that's spectacular – but it frames the area attractively without poking you in the eyes with ostentation. The surface of the pad is fine, and the rubbery base that prevents it from sliding is fit for purpose, largely because there's just so much surface area that doesn't need to be that grippy to stay in place.

Elemental ●●●●○ **Elementary**

POWR CARD HOLDER WALLET / **£9.99** inc VAT

SUPPLIER amazon.co.uk

The POWR card wallet is small, square and metal, which aren't necessarily the first qualities that might be associated with a wallet, but that's where you can end up when you're going all in on minimalism. The POWR is made of aluminium and features RFID blocking to protect the cards inside from being read by nefarious types. You can store eight cards in the POWR, and a click of the switch on the bottom neatly burps them out the top in a sort of staggered fan arrangement that looks quite clever.

You don't need a lot of extra cards to fill it up for it to work properly either – even with just a couple of cards in the wallet, nothing falls out until you press the button. The only downside to all this is that the pursuit of minimalism to this extent leads to a situation where the wallet is an uncomfortable lump in your pocket. A few nods to comfort and style wouldn't have gone amiss, but this wallet is ideal if no frills gives you chills.

Wallet inspector ●●●○○ **Wallet maker**

CABLE GUYS THE CHILD PHONE AND CONTROLLER HOLDER / £19.99 inc VAT

SUPPLIER amazon.co.uk

The Cable Guys Holder line-up involves figures of characters from movies and TV serving as holders for devices, specifically phones and gamepads. They're a bit like Funko Pops that have had to get a job. This particular Cable Guy is the little green lad from The Mandalorian and it is a good likeness, with the overall style being rather reminiscent of the classic Star Wars figures from way back when.

There are no mechanisms or electronics within the figure itself, although it's supplied with a 2m dual USB Type-C/micro-USB cable, which gives you good reach to plonk down your Baby Yoda somewhere a good distance from a port and still hook up your phone. The tray part that holds the device rotates and tilts, which enables you to pick the best angle, but it doesn't make much of a difference, and the layout of this part makes using it for wired pads a bit awkward. The centre of gravity is also low and the whole unit is hefty, making it very hard to knock over.

Using force ●●●●○ **Using The Force**

HAVIT MOUSE BUNGEE

/ £16.99 inc VAT

SUPPLIER amazon.co.uk

The havit Mouse Bungee is a glorious example of the type of peripheral where somebody has thrown every conceivable feature at the design, in order to see how much can be added before it collapses into some sort of super-dense gadget singularity, or costs too much. Either way, the havit is first and foremost a device for keeping your mouse cable out of the way, and in this regard it works well. The rubbery arm that holds the mouse cable isn't the best, and the device isn't weighty, but the havit has a secret weapon, which is a cleanable, reusable gel grip on the base that anchors it like a limpet.

Beyond the simple mouse-holding duties, the havit has a nifty little light, because lights are cool, and a 4-port USB 2 hub, because USB ports are useful. It's perhaps slightly ironic that the perfect device to plug into a desktop USB 2 hub is a mouse, and as the havit is a mouse bungee, you can't easily connect a mouse to it and then use it as a bungee. However, it works fine for other devices, and having the ports on either side, with the USB Type-C connection to the PC on the back, keeps the setup reasonably neat and tidy.

Nothing ●●●●○ **Everything**

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

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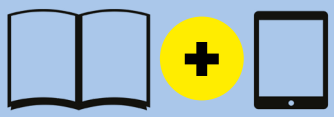

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LABS TEST

Core meltdown

Antony Leather pits 14 CPUs against each other, covering old and new chips from AMD and Intel, including Intel's new Rocket Lake-S processors

How we test

Competition in the CPU market is fierce, and while AMD has the upper hand, Intel has the advantage of better availability and price cuts across its Comet Lake CPUs. This month, Intel also launched its 11th-gen Core line-up, codenamed Rocket Lake-S, and for the first time in over five years, we have a new Intel microarchitecture, rather than just another speed bump or increase in the number of cores, even if it's still produced on a 14nm node.

AMD's Zen 2 and Zen 3 CPUs are also still in the running, so we've got a mix of the lot in this Labs test, from 6-core budget CPUs to 16-core monsters. We've also included all three of Intel's new K-series Rocket Lake-S CPUs.

Our CPU test systems include an MSI MEG Z490 Ace motherboard for Intel 10th-gen mainstream CPUs, an Asus ROG Strix Z590-E Gaming WiFi for its 11th-gen Core CPUs and an MSI MPG B550 Carbon WiFi for AMD's AM4 CPUs. Common test hardware between the test rigs includes 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz DDR4 memory, a 2TB Samsung 970 Evo SSD and an Nvidia GeForce RTX 3070 Founders Edition graphics card, along with dual 240mm radiators and a custom water-cooling system.

All systems use the latest version of Windows 10 with security updates, as well as the latest BIOS versions and drivers. We record results at both stock speed and overclocked, and our benchmarks include the CPC RealBench suite for image editing, video encoding and multi-tasking tests, Cinebench's single and multi-threaded tests, Far Cry New Dawn and Watch Dogs: Legion.

For our game tests, we record the 99th percentile minimum and average frame rates either using the game's built-in benchmark or Nvidia FrameView. Finally, we also measure the idle and load power consumption of the whole system, using Prime95's smallfft test with AVX disabled to stress the CPU.

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AMD RYZEN 5 3600 / £179 inc VAT

SUPPLIER box.co.uk

Despite being launched nearly two years ago, the Ryzen 5 3600 is still for sale, and for good reason – it offers decent performance against Intel's cheaper 4-core and 6-core CPUs for under £180 inc VAT. The question is whether a Zen 2 processor can cut it in 2021.

Under the hood, you get six cores and 12 threads thanks to Simultaneous Multithreading. What's more, this chip was among the first of AMD's CPUs to use a 7nm manufacturing process, so it's very power-frugal too, with our system drawing just 179W under load with this CPU installed.

You get 32MB of L3 cache and 3MB of L2 cache, which is a sizeable boost over its predecessor, the Ryzen 5 2600, but under the hood it lacks the refinements and lower latencies offered by the Zen 3 architecture. Compared with Intel's offerings, the Ryzen 3000-series had to compete with both Intel's 9th-gen and 10th-gen CPUs, and the Zen 2 microarchitecture showed its age against the latter. However, they remained excellent value, especially when paired with low to mid-range GPUs.

With a peak boost frequency of 4.2GHz, this CPU is a fair bit less potent than its Ryzen 5000-series counterparts – its successor, the Ryzen 5 5600X, is able to hit 4.6GHz. In all-core boost mode, the Ryzen 5 3600 can hit 4GHz, so any frequency above this figure with a manual overclock will result in better multi-threaded performance than stock speed. We hit 4.25GHz with a vcore of 1.375V, adding a clock speed bump to both the all-core and peak boost frequencies.

However, it could only muster 58,000 points in our image editing test and 473,815 in our video encoding test – both results are significantly slower than the Ryzen 5 5600X, but it was a match for the stock speed Core i5-10600K, which is more expensive, and it's quicker than the Core i5-10400F too.

It's clear that Intel has made big strides with Rocket Lake-S too, with the Core i5-11600K able to beat the Ryzen 5 3600 convincingly, adding well over 300 points to the Cinebench R23 single-thread score, and hitting 11,286 on the multi-threaded Cinebench test compared to 9,414 for the Ryzen 5 3600. However, the latter was again a match for Intel's 10th-gen 6-core CPUs and far faster than the Core i5-10400F.

When it came to gaming, with our RTX 3070 at the helm and running at 1,920 x 1,080, the Ryzen 5 3600 showed its age and it was far slower than the Ryzen 5 5600X and Core i5-10600K in Far Cry New Dawn, even once overclocked, although it wasn't too far behind in Watch Dogs: Legion.

Conclusion

The Ryzen 5 3600 is showing its age, given AMD's huge strides with Zen 3, and the CPU was certainly a bottleneck with our RTX 3070 in Far Cry New Dawn. However, with no sub-£300 option in the Ryzen 5000 series, you have no choice but to opt for older models if you need a cheaper CPU. If you're upgrading from an older AMD CPU, it remains a solid choice and it also supports PCI-E 4.

Alternatively, Intel's Core i5-10600K is also worth considering if you're buying a new setup, as it costs just £30 more and offers similar multi-threaded performance. The Intel chip also offers superior gaming performance, especially once overclocked, as long as it's paired with a powerful graphics card.

SPEC

Base frequency 3.6GHz

Max boost 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, 3MB L2

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, SSSE3, SSE3, SSE2, SSE

FLAT WHITE

+ Good value
+ Decent multi-threaded performance
+ Similar performance with competition in GPU-limited games

FLAT TYRE

– Can bottleneck in some games
– Little overclocking headroom
– Core i5-10600K noticeably faster in games

VERDICT

Still a solid option for Socket AM4 upgraders on a budget, but the latest tech is significantly faster.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
31/50	12/15	32/35	75%

AMD RYZEN 9 3900X / £410 inc VAT

SUPPLIER currys.co.uk

In a rare case at the moment of a component being available for less than its original launch price, AMD's 12-core Ryzen 9 3900X will set you back around £410 inc VAT. What's more, unlike the Ryzen 9 5900X it's readily available shops. Considering that this price buys you a 12-core CPU with 24 threads, that's an awful lot of CPU for your cash.

The Zen 2 microarchitecture that's under the hood isn't as advanced as the latest Zen 3 CPUs, but it still made some sizable gains over AMD's 2nd-gen Ryzen CPUs. Zen 2 marked the point when AMD made the move to Core Chiplet dies (CCDs), with two quad-core CCXs in each CCD. Cache sizes were increased from 8MB per quad-core CCX to 16MB, and AMD has to activate both CCDs with the Ryzen 9 3900X, so you get the same 64MB L3 cache as the 16-core Ryzen 9 3950X.

Being a Zen 2 CPU, the CCDs (but not the I/O chip) are all built on a 7nm manufacturing process, so it's far easier to cool and overclock compared with Intel's own 12-core CPUs, which exist solely on its high-end desktop platform. It has a fairly lofty 4.6GHz peak boost frequency too, but the all-core boost frequency rarely topped 4GHz with our sample, even though it was water-cooled.

Even pushing the vcore up to 1.425V couldn't get us past 4.3GHz, so while this means a manual overclock will offer higher multi-threaded performance, it also means a 300MHz step down from the stock speed peak boost of 4.6GHz in lightly threaded software, with slower benchmark data as a result. AMD's Precision Boost Overdrive and Automatic Overclocking features could well offer a better balance if you need the best of both worlds.

In addition to lower clock speeds, Zen 2 also has a slower IPC rate than Zen 3 CPUs. As a result, its lightly threaded image editing score of 60,284 is comparatively low. The likes of Intel's Core i9-10850K and Core i9-10900K were significantly faster once overclocked, while the Ryzen 9 5900X was also much quicker.

The 3900X's extra cores give it the upper hand in multi-threaded applications, though, gaining a sizeable lead over the two Intel CPUs in our Handbrake video encoding test, particularly when we overclocked the 3900X. Again, though, the Ryzen 9 5900X was massively quicker here.

Cinebench revealed the Ryzen 9 3900X at a disadvantage to the two Intel 10th-gen 10-core CPUs in the single-threaded benchmark as well, but with a significant advantage over them in the multi-threaded benchmark, although again the mighty Ryzen 9 5900X is the best CPU here.

The real issue for the Ryzen 9 3900X comes with gaming, and with our RTX 3070 offering some decent horsepower, it's clear that the Ryzen 9 3900X was a bottleneck in both our game tests – only AMD's Zen 3 CPUs can compete with Intel here.

Conclusion

As a £400 multi-threaded powerhouse, the Ryzen 9 3900X is still a good choice if your primary need is lots of cores and threads – only the pricier Ryzen 9 5900X offers more performance on mainstream desktop platforms, and it's completely sold out everywhere. However, while Intel's 10-core CPUs are certainly slower here, the Core i9-10850K is £30 cheaper, significantly faster in games and only 10-15 per cent slower in multi-threaded tests once overclocked.

SPEC

Base frequency 3.8GHz

Max boost 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, 6MB L2

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, SSSE3, SSE3, SSE2, SSE

THE AVENGERS

+ Excellent multi-threaded performance
+ Actually available
+ Power-efficient

JUSTICE LEAGUE

– Slower than Intel in some games
– Meagre overclocking headroom
– Manual overclock means slower lightly threaded performance

VERDICT

A good choice for a potent multi-threaded CPU, but the Zen 2 architecture is no match for Intel's 8-core and 10-core CPUs in games.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
39/50	12/15	27/35	78%

AMD RYZEN 5 5600X / £320 inc VAT

SUPPLIER cclonline.com

Looking back at AMD's previous 6-core X-edition models, it's clear that the Ryzen 5 5600X demands considerably more from your wallet. With a price of over £320 inc VAT, it's already out of reach for anyone with a budget of £250 or less, which includes many people that will have settled for an Intel Core i5 in the past.

The situation also isn't helped by the current climate, where stock has been intermittent and prices generally higher than they should be. That said, the Ryzen 5 5600X is still a stunning CPU that really showcases the prowess of AMD's Zen 3 architecture, so let's take another look at how it stacks up in 2021.

CHIPS

+ Good overclocker
+ Great gaming and multi-threaded performance

BOILED POTATOES

- Core i5-11600K just as fast in content creation
- Equivalent Intel CPUs faster in some games
- Far cheaper Core i5-10600K still good for gaming

SPEC

Base frequency 3.7GHz

Max boost frequency 4.6GHz

Core Zen 3

Manufacturing process 7nm

Number of cores 6 x physical (12 threads)

IGP None

Simultaneous Multithreading Yes

Cache 32MB L3, 3MB L2

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging AMD Socket AM4

Thermal design power (TDP) 65W

Features Precision Boost 2, Precision Boost Overdrive 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE

This chip gives you an additional 200MHz over the Ryzen 5 3600X, with a peak boost frequency of 4.6GHz, but under the hood there are significant changes aside from clock speed. The L3 cache in a Core Complex (CCX) is now unified, with double the amount of L3 cache at 32MB, and there are more cores per CCX too, each with direct communication with the other cores.

This arrangement drastically reduces latency and results in sizeable gains in instructions per clock (IPC), leading to stellar gaming performance that matches or betters the competition from Intel. You also get additional features such as Precision Boost Overdrive 2, which can boost performance and lower power consumption, plus most motherboards based on AMD's aging 400-series chipsets support Ryzen 5000-series CPUs, as long as you have the latest BIOS update.

The 5600X's score of 72,195 in our image editing test wiped the floor with any Intel Comet Lake CPU, but the Core i5-11600K was only a little way behind, and that's with the early Intel software and BIOS version we were using. It was a similar story in our video encoding test, and the overall system score put the AMD CPU slightly ahead of the Core i5-11600K – even overclocking the Intel chip couldn't put it in front of the AMD CPU.

However, Cinebench gave the single-threaded result to Intel, while the two CPUs were level-pegging in the multi-threaded test. It was tit for tat in the game tests too, but overall, the Intel CPU was slightly faster albeit with much higher power consumption. There's some overclocking headroom too – we managed to get all of the 5600X's cores running at 4.7GHz with a 1.25V vcore, which enabled it to better the Intel CPU in both Cinebench tests, although the Core i5-11600K still had a higher 99th percentile minimum frame rate in Far Cry New Dawn.

Conclusion

The Ryzen 5 5600X is still a fantastic CPU, but its high price means it's edging into premium territory, handing Intel an advantage with its Rocket Lake-S-based Core i5-11600K priced at £259 inc VAT from **scan.co.uk**. The two CPUs are very close in performance terms, with Intel ahead in some games, at least with our RTX 3070, and the AMD chip ahead slightly in multi-threaded workloads.

Now that Intel supports PCI-E 4 too, the only main benefit of paying more for the Ryzen 5 5600X is its lower power draw. Otherwise, the Core i5-11600K is now our recommended CPU in this league. Meanwhile, if you need a budget gaming CPU, Intel's older Core i5-10600K offers better value.

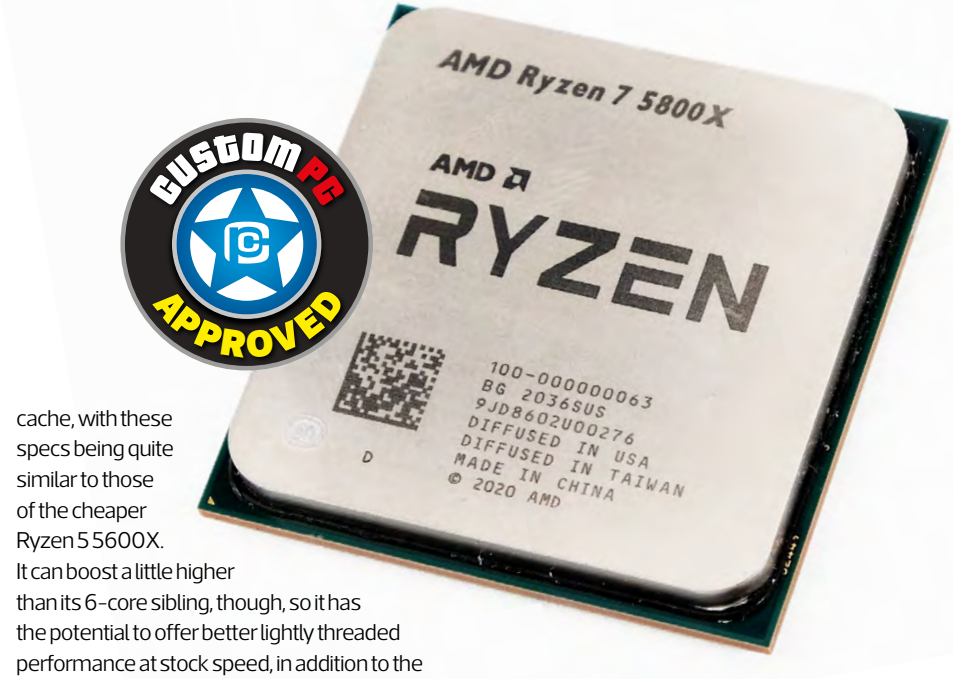
VERDICT

Still a stunning CPU, but its high price makes Intel's Core i5-11600K a better buy, and the Core i5-10600K offers better value for gaming on a tight budget.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
37/50	12/15	29/35	78%

AMD RYZEN 7 5800X / £410 inc VAT

SUPPLIER cclonline.com



This 8-core 16-thread CPU sports AMD's Zen 3 architecture and 7nm manufacturing process, and can boost one of its cores up to 4.7GHz. The biggest boon of the Ryzen 7 5800X, though, is that it's actually available to buy. It has the same TDP as the 12-core Ryzen 9 5900X for a very good reason too. It can boost all eight of its cores up to 4.5GHz in multi-threaded applications.

In our initial review last year, it picked up an award with its ability to keep up with Intel's 10-core CPUs in a range of tasks, while offering decent bang per buck. At this time, the Ryzen 9 5900X cost only £100 more, making it a slightly better buy if you could stretch your wallet. However, with the Ryzen 9 5900X barely in stock and retailing for closer to £200 more than the Ryzen 7 5800X when it does appear, the 5800X is suddenly more attractive.

As the 5800X has just one CCD active with two 4-core CCXs, you get half the cache of the Ryzen 9 5900X at 32MB L3 and 4MB L2 cache, with these specs being quite similar to those of the cheaper Ryzen 5 5600X. It can boost a little higher than its 6-core sibling, though, so it has the potential to offer better lightly threaded performance at stock speed, in addition to the benefits of having more cores and threads.

The Ryzen 7 5800X proved to be the fastest CPU at stock speed in our image editing test with a score of 77,569. Intel's Core i9-10900K could only manage 64,424 and the Core i9-11900K sat at 71,269. It was faster than both of them in our video encoding test too despite a 2-core, four-thread deficit to the Core i9-10900K, albeit by a tiny amount, but that was enough to gain the 5800X a higher system score overall. Comparably, the Ryzen 9 3900X achieved a similar system score thanks to a much higher video encoding test result.

The Core i9-11900K managed a higher single-thread score in Cinebench, with the Ryzen 7 5800X matching the Core i7-11700K here. Interestingly, both the Core i9-11900K and Core i9-10900K were faster in the Cinebench multi-threaded test, showing that AMD has lost some ground here, although the latter draws more than 100W extra to get there.

When it came to gaming, the Ryzen 5 5800X was only a couple of frames per second off the pace in Watch Dogs: Legion, but offered the fastest stock speed performance in Far Cry New Dawn, bettering every CPU except the overclocked Intel 11th-gen 8-core chips.

There's not much overclocking headroom on the 5800X though. We could only reach a 4.6GHz all-core overclock using a vcore of 1.25V, which is 100MHz lower than the peak boost frequency, and just 100MHz higher than the all-core boost we observed, so it didn't add much to the performance.

Conclusion

With solid availability and excellent stock speed performance across the board, the Ryzen 7 5800X is in a good position to fend off Intel's new 11th-gen CPUs. However, it's still currently very expensive – if you're not bothered about PCI-E 4 support, Intel's 10-core Core i9-10850K offers better value for multi-threaded performance, but the Ryzen 7 5800X remains a great all-rounder with particularly strong gaming performance.

SPEC

Base frequency 3.8GHz

Max boost frequency 4.7GHz

Core Zen 3

Manufacturing process 7nm

Number of cores 8 x physical (24 threads)

IGP None

Simultaneous Multithreading Yes

Cache 32MB L3, 4MB L2

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging AMD Socket AM4

Thermal design power (TDP) 105W

Features Precision Boost 2, Precision Boost Overdrive 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE

ESPRESSO

+ A match for Intel's 8-core and 10-core CPUs
+ Excellent all-round performance
+ Power-frugal

INSTANT

– Overclocked Intel CPUs faster in some games
– Ryzen 9 3900X has better multi-threading value
– Overclocked Ryzen 5 5600X has similar gaming pace

VERDICT

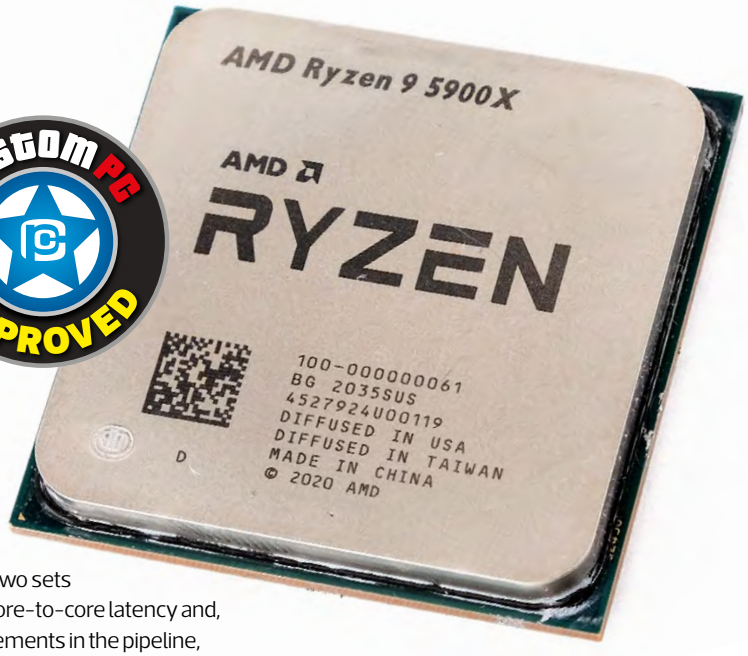
Stunning out-of-the-box performance that Intel still struggles to beat convincingly, although it's expensive.

PERFORMANCE 41/50 | FEATURES 12/15 | VALUE 28/35

OVERALL SCORE 81%

AMD RYZEN 9 5900X / £599 inc VAT

SUPPLIER overclockers.co.uk



The Ryzen 9 5900X is certainly right up there as a highly desirable bit of silicon, but it has a couple of drawbacks in the current climate. The first is that the price that rarely dips below £600, which is £100 higher than at launch. The second is the fact that it's rarely in stock.

As much as we love the Ryzen 9 5900X, not being able to buy it at the recommended price (if you can buy it at all) takes the wind out of its sails. We hope this 12-core, 24-thread CPU will return to the shops soon, but in the meantime, we can also see how it compares with Intel's new 11th-gen CPUs as well as others, so you can make an informed choice.

It has a peak boost frequency of 4.8GHz, and the L2 cache still stands at the 6MB of its predecessor, as does the total L3 cache at 64MB. The core chiplets are made using a 7nm manufacturing process, and the Zen 3 architecture boasts unified core complex dies (CCDs) that sit next to the same I/O die found on Zen 2 CPUs. In each CCD, there are eight cores all sharing 32MB of L3 cache, rather than the cache being split between two sets of four. This lowers core-to-core latency and, in addition to improvements in the pipeline, make the Ryzen 9 5900X as potent in lightly threaded applications as it is in multi-threaded ones.

In our test system it regularly hit that 4.8GHz peak boost too, while the all-core boost sat at 4.1GHz. That's a fair bit lower than the 4.5GHz all-core boost the Ryzen 7 5800X managed, but that chip only has eight cores rather than 12. We managed to coax it up to 4.6GHz with an all-core overclock and vcore of 1.25V, which should add plenty of multi-threaded performance while only losing a little lightly threaded grunt.

The lower all-core stock speed boost saw it perform the slowest of all the Zen 3 CPUs in our image editing test, although it was still faster than the Core i9-10900K and Core i9-11900K. It monstered our heavily multi-threaded video encoding test, though, and was miles ahead of any other CPU here except the Ryzen 9 5950X. It was a similar story in Cinebench, again coming a strong second, but Zen 3 no longer holds an advantage over Intel's latest CPUs in the single-threaded Cinebench test.

Meanwhile, Far Cry New Dawn suffered a little from the low all-core boost and was improved by our overclock, but was still a match for Intel's 10th-gen CPUs. The Core i9-11900K and Core i7-11700K were quicker, though, especially when overclocked, but in all cases, the Intel chips draw a lot more power, and often well over 100W more than the 5900X under load.

SPEC

Base frequency 3.7GHz

Max boost frequency 4.8GHz

Core Zen 3

Manufacturing process 7nm

Number of cores 12 x physical (24 threads)

IGP None

Simultaneous Multithreading Yes

Cache 64MB L3, 6MB L2

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, SSSE3, SSE3, SSE2, SSE

INFLATABLE KAYAK

+ Awesome multi-threaded performance
+ Good single-threaded performance
+ Decent frame rates

INFLATABLE PRICE

- Price and supply issues
- Loses ground in lightly threaded tests
- Ryzen 7 5800X offers better value

Conclusion

If prices and stock levels were normal, the Ryzen 9 5900X would be the ultimate all-rounder for around £500, but the fact it costs £600 (when you can even find it) at the moment means it's not quite as attractive as before. Intel's latest CPUs were also ahead in both our test games, albeit not by huge margins. Its multi-threaded performance is stellar, but that hardly matters if you can't actually buy it. The Ryzen 9 5900X is still our favourite CPU if you can find it, but AMD needs to sort its supply issues.

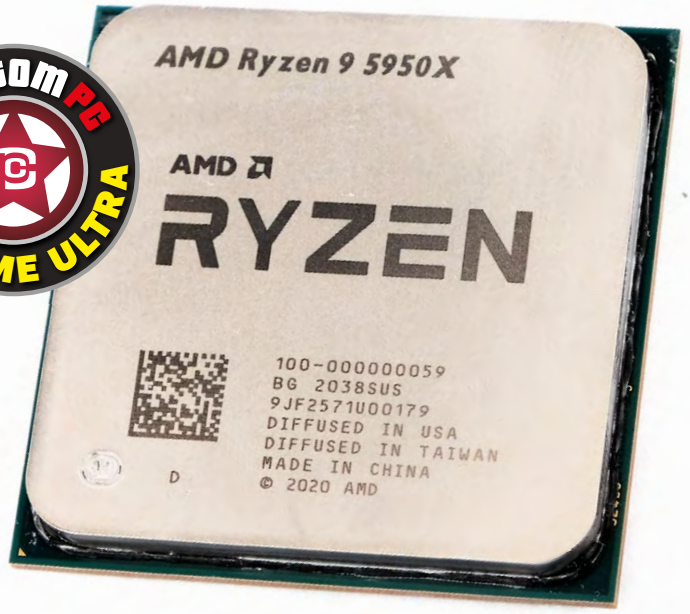
VERDICT

Still a monstrous CPU, but its inflated price and poor availability blunt its potential.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
45/50	12/15	24/35	81%

AMD RYZEN 9 5950X / £750 inc VAT

SUPPLIER currys.co.uk



We managed to spot the Ryzen 9 5900X in stock once or twice over the last few weeks so were able to get a handle on its current inflated price. However, one CPU that has been practically non-existent in the shops is AMD's Ryzen 9 5950X. Its launch price of £750 inc VAT was already high, but ultimately worth paying for this blisteringly fast and powerful behemoth of a CPU that was great in games and stellar for content creation too.

However, prices now range from its launch cost to up to £900 inc VAT, so it's tricky to make any firm judgements right now, especially as we couldn't even find it in stock anywhere at the time of writing. Assuming the supply situation eventually gets better, and you can actually buy one, this is a great CPU for heavily multi-threaded work.

If there's one aspect that sets AMD apart from Intel at the moment, it's the fact that you can even buy a 16-core CPU for a mainstream desktop platform at all. If you want more than ten cores on an Intel CPU, you need to head to its high-end desktop X299 platform and LAG2066 CPUs, and the Ryzen 9 5950X made a lot of those CPUs redundant when it was released. Even Intel's flagship 18-core CPUs offered extremely poor value in comparison. Sure, you don't get quad-channel memory or dozens of PCI-E lanes with the Ryzen 9 5950X, but if you just want oodles of multi-threaded grunt, it's unbeatable, plus you get PCI-E 4 support.

It has to stay within a 105W TDP at stock speed, though, so you likely won't see more than 3.9GHz in all-core boosting. The single-core boost was particularly aggressive, however, often peaking at 5.05GHz in our water-cooled system, which is above the stated 4.9GHz peak boost. Like the Ryzen 9 5900X, it has the full 64MB of L3 cache and 8MB of L2 cache as well.

In terms of performance, the 5900X managed the second highest image editing score and was second only to the Ryzen 7 5800X. It was also the only CPU we've tested to get over 1,000,000 points in the video encoding test out of the box, standing head and shoulders above the rest of the field, with the biggest system score result too. What's more, under load the system drew just 217W from the mains.

With so many cores, overclocking will mean some tough decisions. We added a huge 800MHz to the all-core boost, reaching 4.6GHz with 1.25V, but that means losing over 400MHz compared with the peak boost frequency. This pushed up the system score to nearly 400,000, and the Cinebench R23 multi-threaded score rose from an already huge 25,634 to 30,747.

Gaming performance was stellar too, with the second highest average frame rate in Far Cry New Dawn and a decent 99th percentile minimum too, although overclocking saw it lose ground. It was a match for AMD's other Zen 3 CPUs in Watch Dogs: Legion, but Intel held a slight advantage here.

Conclusion

The Ryzen 9 5950X still has the wow factor as the ultimate mainstream desktop CPU. Nothing else comes close to it without venturing into the HEDT space, and the fact it's also great in games is remarkable. If you can actually find one for under £800 inc VAT, it's the best desktop CPU you can buy – it's just a shame AMD is having so many supply problems.

HEXADECACORE

- \+ Incredible multi-threaded performance
- \+ Good gaming performance
- \+ Power-frugal

HEXACORE

- – Major supply problems
- – Low all-core boost clock
- – Ryzen 7 5900X is just as fast in games

SPEC

Base frequency 3.7GHz

Max boost frequency 4.9GHz

Core Zen 3

Manufacturing process 7nm

Number of cores 16 x physical (32 threads)

IGP None

Simultaneous Multithreading Yes

Cache 64MB L3, 8MB L2

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging AMD Socket AM4

Thermal design power (TDP) 105W

Features Precision Boost 2, Precision Boost Overdrive 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE

VERDICT

Still the most powerful mainstream desktop CPU ever, if you can find one.

PERFORMANCE 48/50 | FEATURES 12/15 | VALUE 20/35

OVERALL SCORE 80%

INTEL CORE i5-10400F / £130 inc VAT

SUPPLIER scan.co.uk

Intel has only geared up to offering more affordable 6-core CPUs over the past couple of CPU generations, with the likes of the Core i5-9400 offering decent gaming performance for a low price. The Core i5-10400F is particularly tempting with its price of just £130 inc VAT. However, being a 65W 14nm CPU means very constrained clock speeds, with a peak frequency of just 4.3GHz that falls to just 4GHz with all cores under load.

This puts it at a distinct disadvantage compared with the rest of Intel's 10th-gen CPU line-up this month, with the Core i5-10600K able to hit a 4.7GHz peak boost and 4.5GHz with all cores loaded. However, the Core i5-10400F fights back with its very low price, which significantly undercuts AMD's Ryzen 5 3600.

It also keeps the same 12MB L3 cache of the Core i5-10600K, and Intel has sensibly enabled Hyper-Threading on it too, so you get 12 threads for its six cores. Being an F-series CPU, you don't get integrated graphics, but the non-F model only costs £17 more if you don't need a discrete GPU. As this isn't a K-series CPU, it also lacks the ability to overclock the multiplier, so you're stuck with the above lowly frequencies, although this also means you won't need a particularly powerful CPU cooler.

LIQUID NITROGEN

+ Only £130
+ Very low power consumption
+ Only needs cheap CPU cooler

STOCK COOLER

- Limited clock speeds hinder performance
- Bottlenecks mid to high-end GPUs
- Ryzen 5 3600 much more powerful for just £50 more

The Core i5-10400F's performance was rather dismal in our RealBench test suite, only managing 38,420 points in our lightly threaded the image editing test, compared to 58,405 for the Ryzen 5 3600. It wasn't much better in the video encoding test either, where it was 150,000 points short of the Core i5-10600K and even further behind the Ryzen 5 3600.

Overall, its score of 128,319 was a long way from challenging the Ryzen 5 3600, which managed 198,828. The lack of megahertz was laid bare in the single-threaded Cinebench test with a result of just 782, which was barely half the score of the Ryzen 5 3600 and Core i5-10600K. The multi-threaded test again had it performing well below those two CPUs, but with a peak power draw of just 153W, it was also by far the most power-frugal CPU on test.

It was a mixed bag in games too – in Watch Dogs: Legion, the Core i5-10400F was only 7fps behind the Ryzen 5 3600 with a minimum 99th percentile of 62fps vs 69fps. However, it was a long way behind the Ryzen chip in Far Cry New Dawn, with a minimum 99th percentile of 71fps compared to 83fps for the AMD CPU.

Conclusion

Given the price difference between the Core i5-10400F and the Ryzen 5 3600, we can't be too harsh on the Intel chip, as it mostly justifies its price tag of just £130 inc VAT, and it doesn't need a powerful cooler either. There are some instances where it's disappointingly slow, though, and it's very clear that it bottlenecked our GeForce RTX 3070 test card with its curtailed frequencies. As a budget gaming CPU, so long as it isn't paired with a particularly powerful graphics card, or you game at settings that put more load on the GPU, it can do the job, but it's worth spending a bit more money if it's at all possible.

SPEC

Base frequency 2.9GHz

Max boost frequency 4.3GHz

Core Comet Lake

Manufacturing process 14nm

Number of cores 6 x physical (12 threads)

IGP No

Simultaneous Multithreading Yes

Cache 12MB L3 cache, 6 x 256KB L2 cache

Memory controller Dual-channel DDR4, up to 2666MHz

Packaging LGA1200

Thermal design power (TDP) 65W

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

VERDICT

Its low frequencies mean poor content creation performance and game bottlenecking, but it's an affordable gaming CPU if you pair it with the right hardware

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
25/50	12/15	32/35	69%

INTEL CORE i5-10600K / £216 inc VAT

SUPPLIER scan.co.uk

Intel's Core i5-10600K got off to a good start when it first launched last year. It outpaced AMD's Zen 2 Ryzen CPUs in games and was competitive with them in content creation, but sadly for Intel, AMD's Zen 3 CPUs were just around the corner, with the Ryzen 5 5600X offering even better gaming grunt and massively outstripping the Core i5-10600K in multi-threaded tasks too.

Fast forward to 2021 and the Core i5-10600K is often discussed as a viable CPU for several reasons. For starters, the Ryzen 5 5600X has seen its price jacked up and stock dwindle, while the Core i5-10600K has enjoyed mostly constant supply and a sizeable price drop, now costing a little over £200. This is over £100 cheaper than the Ryzen 5 5600X and only £30 or so more than the Ryzen 5 3600, although unlike both those CPUs, it lacks PCI-E 4 support.

Unlike the Core i5-10400F, though, the Core i5-10600K can stretch its legs in terms of frequency, peaking at 4.8GHz with a 4.5GHz all-core boost frequency, thanks to a TDP of 125W vs 65W, although it sports the same 12MB of L3 cache. It also lacks Turbo Boost Max Technology 3 and Thermal Velocity Boost, which are included with the Core i9-10900K and help to boost performance in some situations. Additionally, the Core i5-10600K has a KF model too, which lacks integrated graphics, but costs just £180 inc VAT.

In terms of performance, the 10600K's image editing score of 60,437 puts it way behind AMD's Ryzen 5000-series CPUs, which all managed scores above 70,000 and the Ryzen 5 3600 was only a little short of this. An overclock to 5.1GHz with a vcore of 1.325V saw this figure rise to 64,915. which offered more of an advantage, but it still wasn't enough to eclipse the Ryzen 5 3600's stock speed score in the video encoding test, which was even higher once we'd overclocked it as well. As a result, the Ryzen 5 3600 was faster in the overall system score at stock speed and when overclocked.

Meanwhile, in Cinebench R23, the Core i5-10600K had a lead in the single-threaded test and was a match for the AMD CPU once overclocked. In games, the Intel chip finally started to pull ahead with a minimum 99th percentile of 94fps in Far Cry New Dawn versus 83fps for the Ryzen 5 3600, but again the new Core i5-11600K was even quicker, with a figure of 109fps.

Watch Dogs Legion was less CPU-intensive and the Core i5-10600K matched the best-performing CPUs on test, although only the Core i5-10400F and Ryzen 5 3600 were noticeably slower here. That's all good, but it's also worth bearing in mind that the new Core i5-11600K only costs another £50 or so and is a huge amount faster.

SPEC

Base frequency 4.1GHz

Max boost frequency 4.8GHz

Core Comet Lake

Manufacturing process 14nm

Number of cores 6 x physical (12 threads)

IGP Intel UHD Graphics 630

Simultaneous Multithreading Yes

Cache 12MB L3, 6 x 256KB L2

Memory controller Dual-channel DDR4, up to 2666MHz

Packaging LGA1200

Thermal design power (TDP) 125W

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

TURBO

+ Good gaming performance
+ Reasonable multi-threaded performance
+ Plenty of change from £250

TURBOT

– Core i5-10600KF offers better value
– Core i5-11600K is much faster
– No PCI-E 4 support

Conclusion

If you can do without integrated graphics, the Core i5-10600KF is identical to this CPU and offers better value – it's a superior all-rounder compared to the Ryzen 5 3600 for a similar price, especially when it comes to gaming performance. The Core i5-10600K is still a decent CPU with the benefit of integrated graphics, but in this price bracket the Core i5-11600K is definitely worth the extra money, with better gaming performance and far superior multi-threaded performance too.

VERDICT

The Core i5-10600KF is the one to get if you're on a tight budget, but Intel's new Core i5-11600K is even better if you can run to it.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
31/50	14/15	32/35	77%

INTEL CORE i5-11600K / £259 inc VAT

SUPPLIER scan.co.uk

We've recommended Intel's Core i5 K-series CPUs plenty of times over the years, as they usually offer a good step up from the cheaper runs of Intel's lineup, with decent multi-threaded support and stellar gaming performance. The former has recently been lacking, though, with AMD becoming the king of multi-threaded bang per buck since Ryzen's introduction. With Rocket Lake-S, though, we're looking at a new microarchitecture from Intel for the first time in five years.

Cypress Cove hasn't had an easy birth, being backported from Intel's 10nm Sunny Cove to a 14nm process, thanks to 10nm production issues. The maximum core count in this generation has also dropped from ten in Comet Lake to eight in Rocket Late, as a result of Cypress Cove's limitations. The Core i5-11600K uses Intel's solder thermal interface (STIM) between the core and heatspreader and the die has been thinned to further improve thermals too.

You also finally get PCI-E 4 support, and the standard model we're reviewing here includes Intel Xe graphics in a fairly basic form, which is more potent than its old HD graphics. As with the Core i5-10600K, there's a version without integrated graphics that will cost less money, but at just over £250 inc VAT, the Core i5-11600K already offers pretty good value.

It has a peak boost frequency of 4.9GHz and an all-core boost of 4.6GHz with 12MB of L3 cache. These are quite similar specifications to the Core i5-10600K, but the new chip also gets twice the L2 cache at 512KB per core. Sadly, there's not much overclocking headroom compared with Comet Lake. We could only hit a maximum all-core frequency of 4.8GHz, which is only a 100MHz step down from the peak boost frequency, so a more involved per-core overclock will likely prove more effective. Even with a 1.4V vcore, we couldn't get our system stable above this clock speed with our sample.

In terms of performance, the score of 68,355 in our lightly threaded image editing test was a huge boost over the 60,437 of the Core i5-10600K, which is quite exciting considering this was achieved with an early BIOS and software. It wasn't enough to match the Ryzen 5 5600X, which stood at 71,941, but that chip costs a lot more money. The video encoding test result was 14 per cent faster than its predecessor too, but again a little slower than the Ryzen 5 5600X.

The situation was much closer in Cinebench R23, with the 11600K beating the 5600X in the single-threaded test and matching it in the multi-threaded test. Intel had a clear win in games too, with the Core i5-11600K outperforming both the Ryzen 5 5600X and Core i5-10600K by big margins in Far Cry New Dawn. It was quicker than the AMD chip in Watch Dogs: Legion as well. The downside here is the power draw, with our system drawing 235W with the Core i5-11600K running at full load compared to just 164W with the Ryzen 5 5600X.

SPEC

Base frequency 4.1GHz

Max boost frequency 4.8GHz

Core Rocket Lake-S

Manufacturing process 14nm

Number of cores 6 x physical (12 threads)

IGP Intel Iris Xe Graphics 32

Simultaneous Multithreading Yes

Cache 12MB L3, 6 x 215KB L2

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging LGA1200

Thermal design power (TDP) 125W

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

7NM

+ Great gaming performance
+ Costs just over £250
+ Improved multi-threaded performance

14NM+++

- Ryzen 5 5600X has edge in multi-threaded work
- High power draw
- Not much overclocking headroom

Conclusion

Intel has finally given enthusiasts a much-needed boost across the board – the Core i5-11600K is not just significantly faster than the Core i5-10600K in content creation, but in games too. Overclocking was limited with our early BIOS and sample, but it's significantly cheaper than the Ryzen 5 5600X and is ultimately a better buy, even at stock speed. Assuming the prices stay sensible, this is our current favourite sub-£300 CPU.

VERDICT

A significant step up from the Core i5-10600K and better value than the Ryzen 5 5600X – a great CPU for the money.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
36/50	14/15	33/35	83%

INTEL CORE i7-10700K / £300 inc VAT

SUPPLIER scan.co.uk

Intel's line-up of 14nm Comet Lake desktop CPUs differs from Rocket Lake-S due to the addition of a 10-core model sitting above the 8-core CPU here. The Core i7-10700K has always been piggy in the middle, though, lacking the multi-threaded prowess of the Core i9-10900K and more recently, the excellent Core i9-10850K, but not offering much more gaming grunt than the Core i5-10600K. Still, seeing as you can actually buy it, unlike many of AMD's latest CPUs, and it undercuts AMD's Ryzen 7 5800X by £100, it's a CPU we're keen to put through its paces.

Compared with the Core i9-10850K with its ten cores, you get a slightly lower peak boost frequency of 5.1GHz vs 5.2GHz, while its all-core boost frequency of 4.7GHz is 100MHz lower than the more expensive chip, thanks to a lack of Thermal Velocity Boost, which is also missing from the Core i7-11700K.

Unlike the Core i5-10600K, it does at least include Turbo Boost Max Technology 3. As you get eight cores rather than ten, there's also less L2 cache at 2MB than the 10-core chip, which is half that of the Core i7-11700K too and you get 16MB of L3, compared with the 20MB in the Core i9-10850K.

Overclocking was quite easy and just required 1.325V to hit an all-core frequency of 5.1GHz, which matches what you'd see from a single core in peak boost and adds 400MHz to the stock speed all-core boost too. This did see the peak power consumption of our system rise from 275W to 364W though.

In terms of performance, its result in our lightly threaded image editing test was nearly identical to that of the Core i5-10600K and also noticeably slower than the Core i9-10850K, while the Ryzen 5 5600X, which costs around the same price, was a lot faster. The AMD CPU was only 8 per cent slower in the video encoding test too, despite a 2-core, four-thread deficit. Overall, the 5600X was also faster than the 10600K in the overall system score at stock speed and when overclocked.

Meanwhile, Cinebench R23 saw a near 300-point boost to the single-threaded score, showing how much Rocket Lake-S improves upon Comet Lake given that the Core i7-10700K and Core i7-11700K have similar frequencies. The former did manage to beat the Ryzen 5 5600X in the multi-threaded Cinebench test, but both the 5600X and the Core i5-11600K weren't that far behind. The Core i7-10700K and Ryzen 5 5600 X were also evenly matched in Far Cry new Dawn, with the Core i7-10700K pulling ahead once overclocked, and with slimmer margins of victory in Watch Dogs: Legion.

Conclusion

As with many of Intel's CPUs, it's worth recommending the integrated graphics-less Core i7-10700KF instead of the Core i7-10700K, as it costs just £270 inc VAT, but the full-fat 10700K still struggles to justify its price. The Core i5-10600K and Core i5-11600K are much cheaper, and the latter is faster in games, supports PCI-E 4 and is nearly as quick in multi-threaded tasks, despite having fewer cores and threads. The Core i9-10850K and Core i7-11700K are also in a different league in terms of multi-threaded workloads, but only cost £70-£100 more. The Core i7-10700K is far from terrible, but it finds itself squeezed out by CPUs above and below it.

COMET

- \+ Good overclocker
- \+ Keeps up with Core i9-10900K in games
- \+ Beats Ryzen 5 5600X in Cinebench for less money

SPACE JUNK

- − Zen 3 is faster at stock speed
- − High power consumption when overclocked
- − No PCI-E 4 support

SPEC

Base frequency 3.8GHz

Max boost frequency 5.1GHz

Core Comet Lake

Manufacturing process 14nm

Number of cores 8 x physical (16 threads)

IGP Intel UHD Graphics 630

Simultaneous Multithreading Yes

Cache 16MB L3, 8 x 256KB L2

Memory controller Dual-channel DDR4, up to 2933MHz

Packaging LGA1200

Thermal design power (TDP) 95W

Features Turbo Boost Max 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1+ BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE, MMX

VERDICT

A decent CPU for gaming and content creation, but there are easy ways to save cash or get more performance from other models.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
35/50	14/15	30/35	79%

INTEL CORE i7-11700K / £399 inc VAT

SUPPLIER scan.co.uk

It's thanks to the back port from 10nm Sunny Cove to 14nm Cypress Cove that means 10-core CPUs aren't practical with Intel's LGA1200 package for Rocket Lake-S. As a result, we now have two 8-core CPUs at the top of the range, with the Core i7-11700K likely to be siphoned off the lower rungs of the binning scale, and available more cheaply and in higher quantities than the Core i9-11900K, as a result of it not needing to hit such high frequencies.

It can still hit a 5GHz peak boost on up to two cores, thanks to the inclusion of Turbo Boost Max Technology 3, but it lacks the support for Thermal Velocity Boost that allows the flagship Core i9-11900K to reach 5.3GHz. The all-core boost of the latter can hit 4.8GHz, while the Core i7-11700K sits 200MHz lower at 4.6GHz.

Overclocking proved tricky too, as we were aiming for the usual 5GHz and higher target with which we're familiar with on Comet Lake CPUs, but the Core i9-11700K could only reach 4.9GHz with a voltage of 1.37V. This means we're losing 100MHz in the peak boost but gaining 300MHz on the all-core boost, but given that we were using an early-release BIOS, this situation may improve in the future.

Rocket Lake-S doubles the amount of L2 cache per core so you get 4MB as opposed to 2MB with its predecessor, but you still get the same 16MB of L3 cache, and it's still built on a 14nm manufacturing process. That said, this CPU does sport Intel's first entirely new microarchitecture for the first time in five years, and the Core i7-11700K also supports PCI-E 4, although this isn't guaranteed on older motherboards based on Intel's 400-series chipsets.

With a score of 68,239 in our lightly threaded image editing test, the Core i7-11700K was streets ahead of its predecessor, but still a few thousand points away from the Zen 3 AMD CPUs. Amazingly, it managed to outpace the Core i9-10900K here, and it nearly matched the Core i9-10850K in our heavily multi-threaded video encoding test despite having fewer cores. Its system score was again a match to the Core i9-10850K, faster than the Ryzen 5 5600X and not far short of the Core i9-11900K.

Meanwhile, its Cinebench single-threaded score of 1,598 is reasonable but a way off the 1,700 points achieved by the Core i9-11900K. However, its Cinebench multi-threaded result of 5,772 was significantly faster than that of the Core i7-10700K, Ryzen 5 5600X and within spitting distance of the Core i9-10850K, Core i9-11900K and Ryzen 7 5800X.

The latter was a little quicker in Far Cry New Dawn at stock speed, but once overclocked, the Intel CPU was slightly faster, with a noticeably higher average frame rate in Watch Dogs: Legion at both stock and overclocked speeds. Power efficiency was comparatively poor, though, and was worse when overclocked.

Conclusion

Despite only having eight cores, the Core i7-11700K is more attractive than the Core i9-11900K – it performs similarly across the board yet it has a cheaper price. It's not a great overclocker, at least with our early findings, but it offers excellent gaming performance and much more grunt in multi-threaded tasks than the Core i5-11600K and trades blows with the Ryzen 7 5800X. Importantly, it's slightly cheaper than the AMD CPU, making it a better buy if you prioritise gaming performance over power efficiency.

SPEC

Base frequency 3.36GHz

Max boost frequency 5GHz

Core Rocket Lake-S

Manufacturing process 14nm

Number of cores 8 x physical (16 threads)

IGP Intel Iris Xe Graphics 32

Simultaneous Multithreading Yes

Cache 16MB L3, 8 x 512KB L2

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging LGA1200

Thermal design power (TDP) 125W

Features Turbo Boost Max 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE, MMX

JCB

- \+ Nearly as quick as Core i9-11900K
- \+ Significantly faster than Core i7-10700K
- \+ Matches or outpaces AMD in games

GARDEN SPADE

- − Core i5-11600K is similarly quick in games
- − Poor power efficiency
- − Not much overclocking headroom

VERDICT

Fast at stock and overclocked speeds, and a compelling alternative to the Ryzen 7 5800X.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
39/50	14/15	28/35	81%

INTEL CORE i9-10850K / £350 inc VAT

SUPPLIER scan.co.uk

We quite liked Intel's belated 10-core 14nm Comet Lake CPU due to the fact that it had better availability than the Core i9-10900K and cost quite a bit less too. What's more, this month its price has been cut to just £350 inc VAT, making the Core i9-10850K a bit of a steal if you want a 10-core multi-purpose system with plenty of grunt for gaming and content creation. However, the key question is how it performs against Intel's new Rocket Lake-S CPUs.

You get the same ten cores and 20 threads as the Core i9-10900K, a 5.2GHz peak boost frequency, which is only 100MHz short of the Core i9-10900K, with the same deficit on the base frequency, as well as the Turbo Boost Max 3 and 2 speeds. Its 4.8GHz all-core boost frequency is pretty potent too, being just 100MHz short of the 10900K again, and in our water-cooled system, we saw temperatures remain below 75°C in stress tests.

You get 20MB L3 cache and 256KB of L2 cache per core, with the latter being half that of the Core i7-11700K. That CPU costs £50 more, despite having two fewer cores, but has the advantage of the new Cypress Cove architecture, which has netted the Core i5-11600K and Core i7-11700K awards already this month.

Overclocking in our test system saw us achieve an all-core clock speed of 5.1GHz with a vcore of 1.35V – we couldn't go further before Cinebench R23 refused to remain stable. This figure still adds a good 300MHz to the all-core boost, but does lop 100MHz from the Turbo Boost Max Technology 3 peak boost across up to two cores.

In terms of performance, the 10850K's stock speed result of 63,284 in our lightly threaded image editing was a mid-table result and no match for AMD's Zen 3 CPUs – it was also much slower than the Core i7-11700K. The Core i9-10850K also saw off the Core i7-11700K in our heavily multithreaded video encoding test, though, and pipped it to the post in the system score, maintaining its lead once overclocked.

The Ryzen 9 3900X is also worth mentioning here, as it offers more multi-threaded grunt in this price league, in both RealBench and Cinebench and also recorded a higher single-threaded Cinebench result. The Core i7-11700K also beat the Core i9-10850K in Cinebench, as did the Ryzen 7 5800X, but not by much and all these CPUs cost considerably more money too. Critically, at this price, the 10850K is significantly faster than the Ryzen 5 5600X for not much more money.

It also offered decent performance Far Cry New Dawn, matching the Ryzen 5 5600X and sticking close to the Core i7-11700K, only being a few frames per second off the top spot once overclocked and a little faster than the AMD chip in Watch Dogs: Legion too.

Conclusion

In spite of Rocket Lake-S's launch, the Comet Lake-based Core i9-10850K still makes for a hotlist-worthy addition to our line-up this month, offering ten cores, high frequencies and plenty of lightly threaded and multi-threaded performance for your cash. It's a better all-rounder than the Ryzen 5 5600X, yet costs only a little more. It's also cheaper than the Core i7-11700K while bettering it in multi-threaded workloads. It remains a good buy if you don't need PCI-E 4 support, and lean more towards multi-threaded grunt than gaming, but still dabble with gaming occasionally.

SPEC

Base frequency 3.6GHz

Max boost frequency 5.2GHz

Core Comet Lake

Manufacturing process 14nm

Number of cores 10 x physical (20 threads)

IGP Intel UHD Graphics 630

Simultaneous Multithreading Yes

Cache 20MB L3, 10 x 256KB L2

Memory controller Dual-channel DDR4, up to 2933MHz

Packaging LGA1200

Thermal design power (TDP) 125W

Features Thermal Velocity Boost, Turbo Boost Max 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE, MMX

COMET LAKE

+ Good overclocker
+ As fast as Core i9-10900K in most tests
+ Matches or outpaces Ryzen 5 5600X

COMET PUDDLE

– No PCI-E 4 support
– High power consumption
– Rocket Lake-S has faster lightly threaded pace

VERDICT

A price cut helps the Core i9-10850K to stay competitive in multi-threaded workloads, even when pitched against newer competition.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
38/50	14/15	30/35	82%

INTEL CORE i9-10900K / £450 inc VAT

SUPPLIER scan.co.uk

With poor stock levels at the start, and the introduction of a similar, cheaper option in the form of the Core i9-10850K, it's little wonder the 14nm Comet Lake-based Core i9-10900K isn't on the tip of anyone's tongue right now. AMD stole a lot of its limelight with its Zen 3 CPUs too, but thanks to a price cut and better availability, it's now more of a contender if you have around £450 inc VAT to spend on a powerful CPU.

Like the Core i9-10850K, you get 12MB of L3 cache, plus 4MB (256KB per core) of L2 cache. You also get support for Intel's Thermal Velocity Boost tech, which increases the CPU frequency according to thermals and motherboard capabilities. What's more, the Core i9-10900K can hit 5.3GHz across up to two cores at the same time – the joint highest frequency of any CPU on test, being equal to the peak 2-core boost of the Rocket Lake-S Core i9-11900K.

In addition, you also get an all-core boost frequency of 4.9GHz. We've seen higher all-core clocks from Intel in the past, such as the Core i9-9900KS, but not with more than eight cores. We managed to get a bit further when we overclocked the Core i9-10900K, reaching 5.1GHz with a vcore of 1.285V across all cores, but we failed to get all of its cores up to the peak single-core stock boost frequency of 5.3GHz.

Out of the box, the Core i9-10900K is still the fastest mainstream desktop CPU in Intel's product range, despite the launch of Rocket Lake-S. It beats the Core i9-11900K in our heavily multi-threaded video encoding test, but only just in the Cinebench multi-threaded test, despite having two more cores. The new kid on the block beat it fair and square in our lightly threaded image editing test, though, and posted an outrageous single-threaded Cinebench score of 1,700 compared to just 1,342 for the Core i9-10900K.

In Far Cry New Dawn, the Core i9-10900K was reasonably quick at stock speed but AMD's 8-core, 12-core and 16-core Zen 3 CPUs were faster. Even the far cheaper Core i5-11600K was as fast as the Core i9-10900K here, and kept up once both CPUs were overclocked too. In this test, both the Core i7-11700K and Core i9-11900K were even faster, extending their leads once overclocked.

Watch Dogs: Legion was less variable, but the Core i9-10900K posted the joint highest frame rates on test, matching the Core i9-11900K, while AMD's Zen 3 CPUs were a few frames per second off the pace.

Power consumption is definitely not the Core i9-10900K's strong point though – with the 10900K installed, our test system drew the highest stock speed and second highest overclocked wattages on test, of 378W and 410W respectively.

Conclusion

The Core i9-10900K is still a monster CPU, but the fact that the Core i9-11900K nearly matches it in multi-threaded workloads, despite having two fewer cores, really goes to demonstrate Rocket Lake-S's potency compared with Comet Lake. Ultimately, the Core i9-10850K offers better value than this Core i9 CPU, and the Ryzen 7 5800X is also just as fast in multi-threaded workloads and games for less cash. As with other Intel chips, it's also worth highlighting the fact that there's a Core i9-10900KF model without integrated graphics for around £50 less, which will make for a better all-round buy than the AMD Ryzen 7 5800X if you don't need PCI-E 4 support.

EARTH CORE

+ Decent gaming performance
+ Good multi-threaded performance
+ Fast out of the box

APPLE CORE

– No PCI-E 4 support
– Core i9-11900K nearly as quick in multi-threaded work
– Other CPUs are faster in games

SPEC

Base frequency 3.7GHz

Max boost frequency 5.3GHz

Core Comet Lake

Manufacturing process 14nm

Number of cores 10 x physical (20 threads)

IGP Intel UHD Graphics 630

Simultaneous Multithreading Yes

Cache 12MB L3, 10 x 256KB L2

Memory controller Dual-channel DDR4, up to 2933MHz

Packaging LGA1200

Thermal design power (TDP) 125W

Features Thermal Velocity Boost, Turbo Boost Max Technology 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE, MMX

VERDICT

Still a monster CPU, but the KF version is the only variant that's worth your cash.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
39/50	14/15	24/35	77%

INTEL CORE i9-11900K / £539 inc VAT

SUPPLIER scan.co.uk

When rumours surfaced that Intel was reducing the core count of its Rocket Lake-S flagship to eight cores from ten with Comet Lake, it seemed a questionable decision, especially given the gaping chasm between Intel and AMD in mainstream desktop multi-threaded performance.

However, due to issues backporting the 10nm Sunny Cove architecture to 14nm on the desktop, Intel apparently had no choice.

As such, it decided to concentrate on making the fastest 8-core CPU possible, most likely with an emphasis on wrestling the single-threaded and gaming performance crowns back from AMD.

In addition to a hefty boost in instructions per clock (IPC) compared with Comet Lake, the Core i9-11900K can also hit a 5.3GHz peak boost thanks to Thermal Velocity Boost and up to 4.8GHz across all cores. The former is 300MHz higher than the Core i7-11700K and the latter is 200MHz higher, which aren't small differences. Despite our initial concerns about Intel dropping two 8-core Rocket Lake-S CPUs at the same time, the fact that the Core i7-11700K is nearly £150 cheaper than the Core i9 model starts to make sense; it's also potentially a lot slower because of the clock frequencies.

Both CPUs benefit from Intel's solder thermal interface material (STIM) between the core and heatspreader, and have thinner-than-average dies to aid heat transfer further. They also have double the L2 cache of their predecessors, at 512KB per core, and 20MB of L3 cache. What's more, they support PCI-E 4, so you can use those shiny new M.2 SSDs with ridiculous read and write speeds.

As with the other Rocket Lake-S CPUs we tested, overclocking was a little trying, but the Core i9-11900K did at least manage to get to 5.1GHz across all cores with a vcore of 1.32V, which is much better than the other 11th-gen models on test this month.

The Core i9-11900K wasn't quite able to topple AMD's Zen 3 CPUs in our lightly threaded image editing test, but it came within spitting distance of the Ryzen 9 5900X and Ryzen 9 5950X, and it was the only Intel CPU to break the 70,000-point mark.

Incredibly, it was only just behind the Core i9-10900K in the video encoding test, despite having fewer cores, offering similar performance to the Ryzen 7 5800X and also beating the Core i9-10850K.

It managed to beat the Ryzen 7 5800X in Cinebench R23 as well, and again matched the Core i9-10900K here, despite having two fewer cores. Meanwhile, it managed the highest frame rates in Far Cry New Dawn, with the two 8-core Rocket Lake-S CPUs being the only models on test to top 150fps averages, and it had the highest 99th percentile minimum too, as well as the joint top result in Watch Dogs: Legion, albeit only just.

SPEC

Base frequency 3.3GHz

Max boost frequency 5.3GHz

Core Rocket Lake-S

Manufacturing process 14nm

Number of cores 10 x physical (20 threads)

IGP Intel Iris Xe Graphics 32

Simultaneous Multithreading Yes

Cache 20MB L3, 10 x 512KB L2

Memory controller Dual-channel DDR4, up to 3200MHz

Packaging LGA1200

Thermal design power (TDP) 125W

Features Thermal Velocity Boost, Turbo Boost Max Technology 3, Turbo Boost 2, FMA3, F16C, SHA, BMI / BMI1 + BMI2, AVX-512, AVX2, AVX, AES, SSE4a, SSE4, SSSE3, SSE3, SSE2, SSE, MMX

SR71 BLACKBIRD

+ Chart-topping gaming performance
+ As fast as Intel's 10-core CPUs
+ PCI-E 4 support

SOPWITH CAMEL

– Can't beat Ryzen 9 5900X outside games
– Cheaper Core i7-11700K is nearly as fast
– Power-hungry

Conclusion

Make no mistake, the Core i9-11900K is a force to reckoned with, and the cheaper KF version could offer even better value. However, it's far from a knockout blow against AMD, and its power draw is high too. The fact it only has eight cores means the likes of the Ryzen 9 5900X are left mostly unscathed, although we're certainly looking at a new gaming king here. The more sensible enthusiasts will opt for the Core i7-11700K, though, which is far cheaper and nearly as fast in terms of real-world performance. CPC

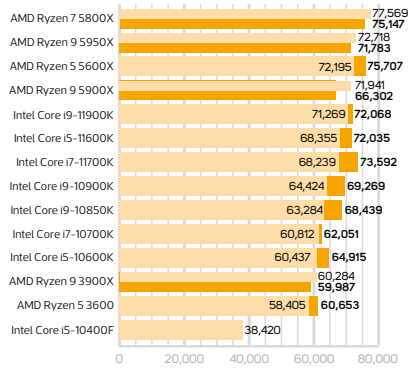
VERDICT

A lightning-fast, if pricey, CPU that brings the fight to AMD, but it's not quite a knockout blow.

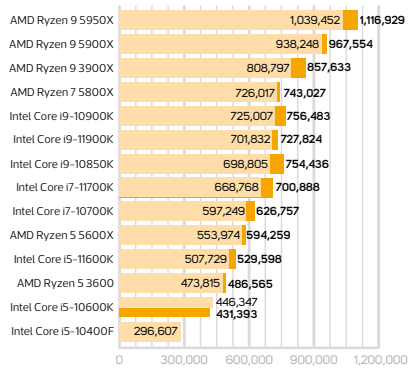
PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
41/50	14/15	25/35	80%

CPU LABS BENCHMARK RESULTS

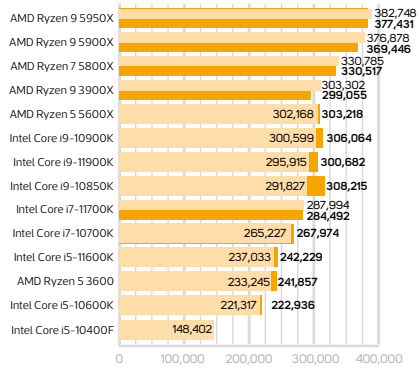
GIMP IMAGE EDITING



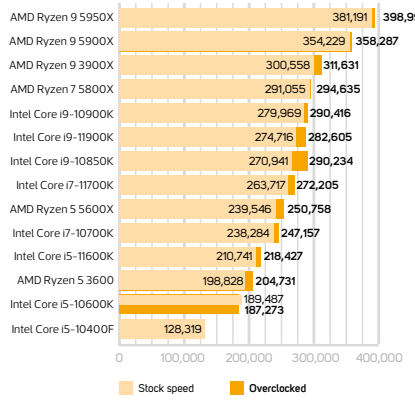
HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTI-TASKING

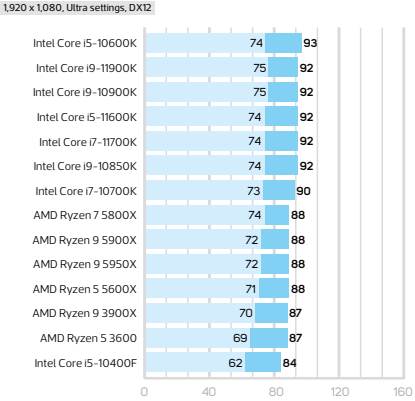


SYSTEM SCORE



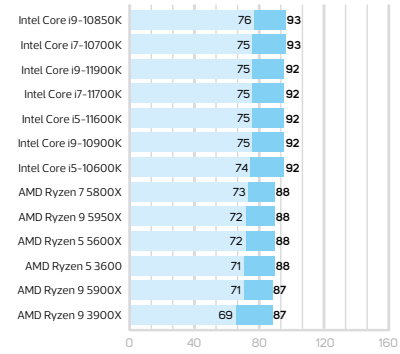
STOCK SPEED WATCH DOGS: LEGION (FPS)

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



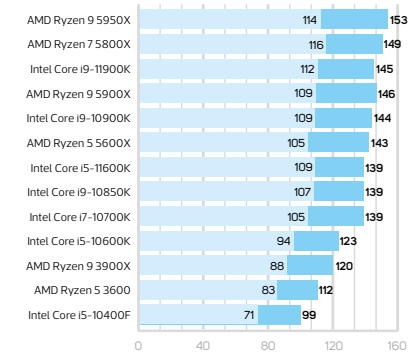
OVERCLOCKED WATCH DOGS: LEGION (FPS)

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



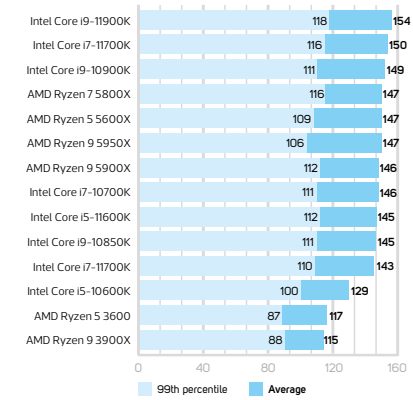
STOCK SPEED FAR CRY NEW DAWN (FPS)

1,920 x 1,080, Ultra settings

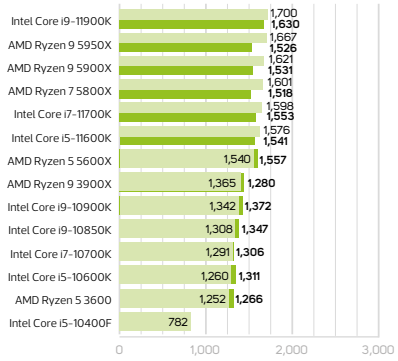


OVERCLOCKED FAR CRY NEW DAWN (FPS)

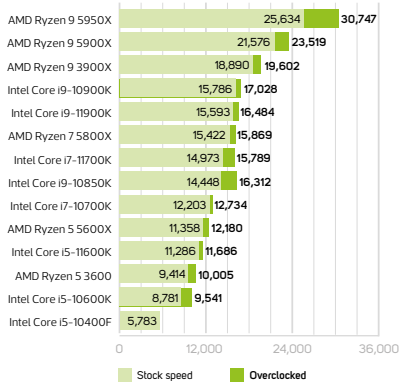
1,920 x 1,080, Ultra settings



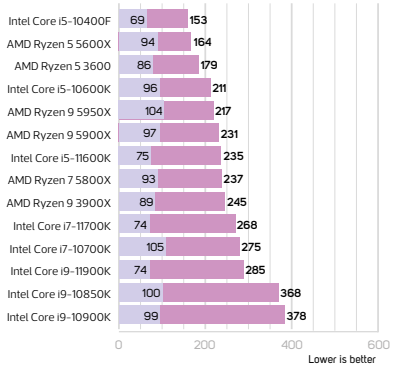
CINEBENCH R23 SINGLE-THREADED



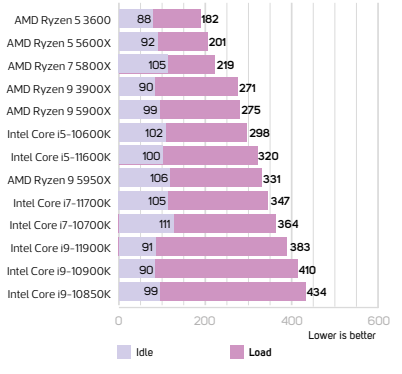
CINEBENCH R23 MULTI-THREADED



STOCK SPEED TOTAL SYSTEM POWER CONSUMPTION (WATTS)



OVERCLOCKED TOTAL SYSTEM POWER CONSUMPTION (WATTS)



LABS TEST

Z590 MOTHERBOARDS

Antony Leather puts six brand-new Z590 motherboards through their paces

How we test

This month we're taking a look at some shiny new LGA1200 motherboards based on Intel's new Z590 chipset. We've picked six boards that cost between £200 and £440, to see what sort of features and performance is available across a range of prices and determine which is worth your cash if you're planning on buying one of Intel's new Rocket Lake-S CPUs.

Our test kit includes 16GB of 3466MHz Corsair Vengeance RGB Pro RAM and an Nvidia RTX 3070 Founders Edition graphics card. Windows 10 is installed on a 2TB Samsung 970 Pro SSD along with a Corsair MP600 PCI-E 4 SSD, and these are also used to test the speed of any M.2 ports as well as heatsink performance. The SSDs' internal temperature sensor is used to see how well any M.2 heatsinks perform under load using back-to-back runs of CrystalDiskMark's entire battery of tests.

Our motherboard and CPU cooling rig uses a Barrow Ropilema test bench with a full custom water-cooling loop, which includes two 240mm radiators and a Laing DDC pump in order to eliminate any cooling bottlenecks.

Tests include our RealBench suite of benchmarks, Far Cry New Dawn, Cinebench R23's single and multi-threaded tests, and total system power consumption, which is measured at both stock and overclocked speeds. We also use RightMark's Audio Analyzer software to measure the dynamic range, noise level and total harmonic distortion of the on-board audio.

Our scores are based on a weighted calculation including performance, features and value with the overall score being the sum of those three values. Testing is performed using the latest BIOS versions available at the time of writing.

Contents

- ASRock Z590 Extreme / p57
- ASRock Z590 PG Velocita / p58
- Asus ROG Strix Z590-E Gaming WiFi / p59
- Asus TUF Gaming Z590-Plus WiFi / p60
- MSI MAG Z590 Tomahawk / p61
- MSI MEG Z590 Ace / p62
- Test results / p63

ASROCK Z590 EXTREME / £195 inc VAT

SUPPLIER scan.co.uk

We've been impressed by ASRock's Extreme motherboards over the years, thanks to their balance of premium features and affordability, and the Z590 Extreme is no different. For a start, the price is right – it's the only board on test this month to come in at under £200, even if it is only by £5. Aesthetically, it's a winner too, with a snazzy cut-out on one side that also plays host to a GPU support bracket.

You get power and reset buttons too, which is very rare on sub-£200 boards, and even the VRM heatsinks, which sit on top of a 14-phase power delivery, include a heatpipe to spread the load. There are splashes of RGB lighting on the PCH heatsink and VRMs plus a USB 3.1 Type-C header too.

So far so good, but inevitably some cuts have been made. There's no Wi-Fi, but if you want to add it, ASRock includes an M.2 port just for Wi-Fi modules, with aerials included in the box. There are three M.2 ports, but only the top slot supports PCI-E 4 and it will be disabled if you use a 10th-gen Comet Lake CPU. Thankfully, you can move the heatsink from the top slot to the second slot if you want, and this heatsink made a big difference to the peak temperature of our test M.2 SSD, dropping it by 24°C.

There's no Thunderbolt 4 Type-C port – most other boards this month lack them too – but it still includes a header for use with add-in cards if needed. There's also 2.5 Gigabit LAN and seven 4-pin fan headers too, although ASRock's BIOS and software-based fan control is quite basic compared with the rest of the field this month. The audio is basic too, but Realtek's ALC1220 codec is still very capable.

Updating the BIOS was a simple process, with the update feature scanning your USB drive for a compatible file and finding it instantly. However, while we managed to overclock our Core i9-11900K to 5.1GHz using a vcore of 1.38V, this showed up as 1.28V in CPU-Z and other monitoring software, even if we had maximum loadline calibration enabled, which was a little concerning.

Still, it proved stable, except in Cinebench, where for some reason the CPU would clock down to 2.5GHz despite its temperature sitting under 90°C. We lifted all the power and thermal restrictions in the EFI we could find, but couldn't fix it, so this result was slower than stock speed.

In other tests, stock and overclocked performance was right on the money, and it was the most power-frugal board under load at stock speed too. There's no VRM temperature output, so we can't comment on that, but given that the issue above happened within a minute of starting the Cinebench test, we doubt they're getting too toasty.

Conclusion

Apart from a slight wobble in one of our benchmarks once overclocked (which is most likely due to the very early BIOS version we're using), the ASRock Z590 Extreme is a solid motherboard for the cash. It has all the gear you need to build a high-end Rocket Lake-S system with PCI-E 4 – only the slightly tricky overclocking, and average BIOS and software cost it an award.

BATTLESHIP

- \+ Good value
- \+ Attractive design
- \+ Thunderbolt 4 support

ROWING BOAT

- – CPU throttled when overclocked in some benchmarks
- – Basic BIOS and software
- – MSI MAG Z590 Tomahawk is more capable for a bit more cash

SPEC

Chipset Intel Z590

CPU socket Intel LGA1200 (Comet Lake, Rocket Lake-S)

Memory support 4 slots: max 128GB DDR4 (up to 4800MHz)

Expansion slots Two 16x PCI-E 4, three 1x PCI-E 3

Sound 8-channel Realtek ALC1220

Networking 1 x Dragon 2.5 Gigabit LAN, Intel Gigabit LAN

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

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

Dimensions (mm) 305 x 244

VERDICT

A solid effort but the early BIOS we used had some teething issues.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
23/35	29/35	29/30	81%

ASROCK Z590 PG VELOCITA / £276 inc VAT

SUPPLIER scan.co.uk

We love the design of the ASRock Z590 PG Velocita, with its raised circuitboard window feature and subtle but vivid RGB lighting. Plus, while it's not exactly wallet-friendly at £276 inc VAT, it's still far from the most expensive offering this month and it includes loads of features too.

The 14-phase power delivery is cooled by two large heatsinks connected with a heatpipe and one sports a small, embedded fan with a second fan included in the box. However, even in its out-of-the-box configuration, the VRMs only hit 53°C in our stress test. The embedded fan was quiet too, and both it and the optional included fan can be controlled via the EFI.

There's a trio of M.2 ports, one of which supports PCI-E 4 SSDs, but unlike its cheaper sibling this month, all three slots include heatsinks. The all-important one for PCI-E 4 SSDs did a great job at cooling our SSD, with the temperature falling from a peak of 88°C to just 57°, although there's no underside cooling as you get with the Asus ROG Strix Z590-E Gaming WiFi.

Further premium extras include an LED POST code display, along with power, reset and clear-CMOS buttons, and if you want to add extra lighting to your system, you get pairs of 4-pin and 3-pin RGB headers as well.

Like the Z590 Extreme, you get a graphics card support that prevents heavy cards from sagging, although you'll need to check there's clearance in your case, as it protrudes by a couple of inches. There's no Thunderbolt 4 port on the rear I/O panel, but there's a header on the motherboard if you want to use an add-in card. The panel offers a total of seven Type-A USB ports and single Type-C port as well, but only the Type-C header on the PCB supports full 2x2 20Gbps speeds.

The extra cash also gets you 802.11ax Wi-Fi and an extra Gigabit Ethernet port, with the primary port offering up to 2.5 Gigabit speeds. Display outputs are also included, so if your CPU has integrated graphics and your graphics card fails, you won't be without a PC. There's also an impressive count of eight fan headers, but ASRock's fan control features are a little limited compared with the competition, especially when it comes to its Windows-based software.

Thankfully, there was none of the CPU throttling once overclocked that we saw with the cheaper ASRock board, although the voltage did appear to drop under load despite loadline calibration being set to a high level. Thankfully, this didn't result in temperatures or power consumption that were abnormally high and our CPU sat happily at 5.1GHz with 1.38V applied and 1.3V reported in CPU-Z. Performance was solid across the tests at stock speed and when overclocked, and the audio performance was excellent too.

SPEC

Chipset Intel Z590

CPU socket Intel LGA1200 (Comet Lake, Rocket Lake-S)

Memory support 4 slots: max 128GB DDR4 (up to 4800MHz)

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

Sound 8-channel Realtek ALC1220

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

Cooling Eight 4-pin fan headers, VRM heatsinks with heatpipe and cooling fan, M.2 heatsinks

Ports 6 x SATA 6Gbps 1 x M.2 PCI-E 4, 2 x M.2 PCI-E 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 1 x USB 3.1 Type-C header, 5 x USB 3, Thunderbolt 4 header, 21 x LAN, 3 x surround audio out

Dimensions (mm) 305 x 244

Conclusion

If you have between £250 and £300 to spend on a Z590 motherboard and you don't mind the lack of a Thunderbolt 4 Type-C port, the ASRock Z590 PG Velocita Strikes an excellent balance of features, overclocking performance and value, and it looks great too.

CHEESECAKE RECIPE

+ Good M.2 and VRM cooling
+ Attractive design
+ Plenty of overclocking and testing tools

RECIPE FOR DISASTER

− No Thunderbolt 4 Type-C port
− BIOS and software are quite basic
− There are cheaper options that also overclock well

VERDICT

Attractive, with plenty of features, and it held our CPU to a steady 5.1GHz all-core overclock

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
29/35	32/35	24/30	85%

ASUS ROG STRIX Z590-E GAMING WIFI / £340 inc VAT

SUPPLIER overclockers.co.uk

There's plenty to drool over with the Asus ROG Strix Z590-E Gaming WiFi, which is just as well considering it costs £340 inc VAT. One of the standout highlights is its M.2 SSD support. There are two slots that support PCI-E 4 SSDs and an additional two slots that support PCI-E 3 SSDs, with one also offering a home to SATA M.2 SSDs. They all feature a simple tool-free latch securing mechanism that takes seconds to install an SSD.

All four are covered by large heatsinks and the primary slot not only includes a snazzy RGB-illuminated logo, but has a thermal pad that cools the underside of M.2 SSDs as well. This resulted in the lowest M.2 SSD load temperature on test at just 55°C. However, the heatsink sat so close to our backplate-fitted graphics card that we couldn't access the release catch without a screwdriver, so we've docked a couple of points from Asus here. You can run two GPUs in PCI-E 4 mode thanks to two slots supporting this faster standard rather than just one, although you're still limited to eight PCI-E lanes apiece.

The rest of the board is beautiful, with an illuminated ROG logo and acrylic strip on the I/O shroud and an all-black design that's mostly colour-neutral. You don't get the full complement of on-board overclocking and testing tools, but there is a clear-CMOS button, LED POST code display and a USB BIOS FlashBack button. Both air and water-cooled systems will benefit from its feature set too, with eight 4-pin fan headers and a thermal sensor, so you can control fans based on coolant temperature. Despite the price tag, there's no Type-C Thunderbolt port – only a header as with most of the other boards.

Meanwhile, the VRM heatsinks are huge and linked with a heatpipe, plus there's an optional fan you can attach for extra cooling. However, the latter isn't really needed, seeing as the highest temperature we saw during our stress test was 59°C. This board also has display outputs, so if you end up without a graphics card, you can at least use your PC.

You also get a pair of 2.5 Gigabit Ethernet ports and 802.11ax Wi-Fi and Asus has added Realtek's ALC 4080 audio codec. The audio performance was a little disappointing, but this could be down to the early software and drivers we used.

The ROG Strix Z590-E Gaming WiFi hit the top RealBench system score at stock speed in this test, and had the highest Cinebench single-threaded score too, without topping the power consumption graph. Overclocking wasn't as slick as the MSI boards, though, requiring a lot more tweaking and Asus' AI Suite Software was a little hit or miss as to whether it applied the set vcore or not. However, in the end we managed a 5.1GHz all-core clock with 1.34V, again achieving the highest system score.

140MM FAN

- \+ Good M.2 and VRM cooling
- \+ Dual PCI-E 4 M.2 and 16x PCI-E slots
- \+ M.2 latches make installation easy

80MM FAN

- − M.2 heatsink blocks GPU release latch
- − Average audio performance
- − No Thunderbolt 4 Type-C port

SPEC

Chipset Intel Z590

CPU socket Intel LGA1200 (Comet Lake, Rocket Lake-S)

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

Expansion slots Two 16x PCI-E 4, one 16x PCI-E 3

Sound 8-channel Realtek ALC 4080

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

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

Ports 6 x SATA 6Gbps 2 x M.2 PCI-E 4, 2 x M.2 PCI-E 3, 1 x USB 3.1 Type-C, 1 x USB 3.1 Type-C 2x2, 1 x USB 3.1 Type-C header, 4 x USB 3, 2 x USB 2, 1 x Thunderbolt 4 header, 1 x LAN, 3 x surround audio out

Dimensions (mm) 305 x 244

Conclusion

The ROG Strix Z590-E Gaming WiFi is beautiful, loaded with features and it offers better value than the MSI MEG Z590 Ace. It's clear there's still some fine tuning to be done in the weeks before the official Z590 launch, but they're minor and if we had around £300 to spend, this is the board we'd buy.

VERDICT

A gorgeous motherboard that's dripping with features

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
34/35	31/35	21/30	86%

ASUS TUF GAMING Z590-PLUS WIFI / £225 inc VAT

SUPPLIER overclockers.co.uk

Among the more affordable of Asus' motherboards, the TUF range has tended to look and feel quite low-end before now, but the TUF Gaming Z590-Plus WiFi feels far more grown-up. There's a 14+2 phase power delivery, enormous passive heatsinks and all three of its M.2 ports are equipped with heatsinks too, with a peak VRM temperature in our stress test of 56°C.

They also sport Asus' new securing latches, which remove the need for the tiny, fiddly screws we usually use with M.2 SSDs. Unlike the ROG Strix Z590-E Gaming WiFi, though, only the top M.2 slot supports PCI-E 4 SSDs and if you use an older Comet Lake CPU in the board, this slot will be disabled too. That still leaves a pair of other slots that support either PCI-E 3 or SATA M.2 SSDs. Despite its price, you also get a Thunderbolt 4 header, albeit not a Thunderbolt port, as well as 2.5 Gigabit Ethernet and 802.11ax Wi-Fi.

The rear I/O panel offers six Type-A USB ports, four of which are USB 3 or faster, while there's also a Type-C 2x2 port that offers 20Gbps of bandwidth as well as a Type-C header on the PCB for compatible cases. The usual Realtek ALC 1220 audio codec is included rather than the ALC 4080 codec of its bigger sibling, with the full complement of audio inputs and outputs too. Sadly, there are no overclocking and testing tools such as clear-CMOS buttons or power switches, which were included on the cheaper ASRock Z590 Extreme.

Overclocking was a similar deal to the ROG Strix Z590-E Gaming WiFi, with us needing to tweak various power limits and loadline calibration to get a stable all-core result of 5.1GHz with 1.36V, which was far more involved than with the MSI MAG Z590 Tomahawk.

Meanwhile, the PCI-E 4 M.2 port heatsink did a reasonable job at cutting the SSD temperature from 88°C to 67°C. This was the joint-highest result on test, but it's enough to prevent your SSD from throttling under sustained heavy loads.

The stock speed performance was a little slow in RealBench and Cinebench, but Far Cry New Dawn saw the highest stock speed result on test. Overclocking saw similar gains to the rest of the boards, but again this board was towards the lower end of key graphs. We also spotted an issue with the EFI, which would repeatedly fail to POST, reporting a missing CPU fan, although the splitter cable we used may have cause the issue, and this could well be explained by the early BIOS we used.

SPEC

Chipset Intel Z590

CPU socket Intel LGA1200 (Comet Lake, Rocket Lake-S)

Memory support 4 slots: max 128GB DDR4 (up to 5133MHz)

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

Sound 8-channel Realtek S1220

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

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

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

Dimensions (mm) 305 x 244

TUF

+ Effective M.2 and VRM cooling
+ USB Type-C header
+ Handy M.2 tool-less latches

FLUFF

− EFI failed to detect CPU fan on occasions
− Tedious overclocking
− No I/O panel Thunderbolt 4 port

Conclusion

This is the most grown-up TUF board we've seen and the Asus TUF Gaming Z590-Plus WiFi has plenty going for it as well as an attractive price tag. It has decent VRMs, good M.2 cooling, plenty of fan headers and USB ports, and Asus' EFI and software is mostly excellent. However, the MSI MAG Z590 Tomahawk is a slightly better buy, especially if you're overclocking, while the ASRock Z590 PG Velocita is worth the extra cash if you want more premium features.

VERDICT

Slightly wobbly EFI and overclocking, but it's a decent board for the cash.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
24/35	31/35	26/30	81%

MSI MAG Z590 TOMAHAWK / £235 inc VAT

SUPPLIER box.co.uk

The MAG Z590 Tomahawk has a lot to live up to given the prowess of MSI's B450 and B550 chipset-based siblings. With a price of £235, it's just about the right side of £250 and cheap enough to be compared with the Asus TUF Gaming Z590-Plus WiFi and ASRock Z590 Extreme.

You get 14+2+1 power phases, two separate and enormous VRM heatsinks and a trio of M.2 heatsinks catering for the single PCI-E 4 and additional pair of PCI-E 3 M.2 ports too. The former's heatsink kept the SSD temperature at no more than 70°C under load, although this was the highest result on test and 13°C warmer than the ASRock Z590 PG Velocita.

TOMAHAWK

- \+ Good value
- \+ Great BIOS
- \+ Easy overclocking

TOM, A HAWK

- – Average M.2 cooling
- – Poor software
- – An extra £40 gets you a lot more features

SPEC

Chipset Intel Z590

CPU socket Intel LGA1200 (Comet Lake, Rocket Lake-S)

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

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

Sound 8-channel Realtek ALC 4080

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

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

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

Dimensions (mm) 305 x 244

There's only a small amount of RGB lighting, so if you prefer function over form, you won't get any arguments from this board, although you do get 3-pin and 4-pin RGB headers if you need more pizzazz. Despite the price, you also get Realtek ALC 4080 audio, Intel 2.5 Gigabit LAN and 802.11.ax Wi-Fi. MSI has nailed its audio implementation too, as we saw a dynamic range of 113dBA, which although not quite as good as the more expensive MSI MEG Z590 Ace, is still very good for a cheaper board.

The rear I/O panel offers display outputs, so if your CPU has on-board graphics, you'll be able troubleshoot a flaky graphics card or even use your PC without one. There's a generous total of seven Type-A USB ports, five of which are USB 3 or faster, plus there's a USB 3.1 Type-C 2x2 port with a Type-C header on the PCB as well. Sadly, there's no Thunderbolt support whatever, which is in stark contrast to its more expensive sibling in this Labs test, but then no other board on test has Thunderbolt ports on the rear I/O panel either.

There aren't any on-board overclocking and testing tools, although for some reason, MSI includes a USB BIOS FlashBack button even though there are unlikely to be any more CPU generations launched on LGA1200. Thankfully, overclocking itself was blissfully simple and in stark contrast to the ASRock and Asus motherboards this month. We just had to input a vcore of 1.36V to get a stable all-core overclock to 1.51GHz, with no other tweaking necessary.

Meanwhile, the VRMs were kept fairly cool at a peak of 58°C in our stress test, and while the EFI was excellent, MSI's software is very disjointed and clunky, and hasn't improved much compared with the B550 and Z490 boards we reviewed a while ago.

There were no issues with performance, though, with the MAG Z590 Tomahawk sitting near the top of the graphs in every test; the only issue was very high power consumption under load at stock speed.

Conclusion

If you need a Z590 motherboard but don't fancy spending much more than £200, then the MSI MAG Z590 Tomahawk is a goof buy, especially if you want to overclock your CPU. Our only concern is that paying an extra £30-£40 would enable you to bag the ASRock Z590 PG Velocita, which is better-looking and has more features.

VERDICT

A great motherboard for the cash that's easy to overclock too.

FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
24/35	33/35	26/30	83%

MSI MEG Z590 ACE / £440 inc VAT

SUPPLIER scan.co.uk

There's no way around it; £440 is a lot to spend on a motherboard, but the MSI MEG Z590 Ace does its best to justify its cost thanks to its gorgeous looks and masses of features.

It's also the only board on test to actually include full-fat Thunderbolt 4 ports – two of them – on the rear I/O panel. This means connecting the latest docks and monitors, or charging Thunderbolt-enabled devices with a maximum 15W output, are all a possibility and there are mini-DisplayPort connectors here too.

The massive VRM heatsinks are linked via a heatpipe, and while they lack the fans included on other boards, its VRMs only peaked at 54°C in our stress test and only the fan-assisted ASRock Z590 PG Velocita was cooler. There's a 16-phase CPU power delivery with 19 phases in total, plus a quartet of M.2 ports, one of which supports PCI-E 4 SSDs. There's a pair of 16x PCI-E 4 slots too, with a third 16x slot and two 1x PCI-E slots all supporting PCI-E 3.

As you'd expect at this price, you get power, reset and clear-CMOS switches, dual BIOS and an LED POST code display. Unlike its software, which is best avoided, MSI's EFI is excellent and just like the MSI MAG Z590 Tomahawk, overclocking was a simple case of applying a 1.33V vcore and getting a stable all-core overclock to 5.1GHz. However, even a 5.2GHz clock got us into Windows and halfway through a Cinebench run – given more tweaking time we're fairly sure that would have been achievable.

MSI's fan control in the EFI is fantastic too, and there's a thermal probe included in the box that will allow you to control fans based on coolant temperature. The rear I/O panel offers connectors for the 802.11ax Wi-Fi as well as a 2.5 Gigabit LAN port plus the usual audio ports for the ALC 4081 codec. There are eight USB Type-A ports here as well, plus a single HDMI output.

Performance was solid in all our benchmarks with the best results in Far Cry New Dawn and Cinebench once overclocked. Our tweaking efforts saw sizeable gains in the RealBench system score and gaming results too. This was backed up by stellar audio performance with a dynamic range of 118dBA and noise level of -117.8, although the M.2 temperature of our PCI-E 4 SSD hit 67°C; while nowhere near throttling, this is a way off the best results we've seen in this test.

SPEC

Chipset Intel Z590

CPU socket Intel LGA1200 (Comet Lake, Rocket Lake-S)

Memory support 2 4 slots: max 128GB DDR4 (up to 5600MHz)

Expansion slots Two 16x PCI-E 4, one 16x PCI-E 3, 2 x 1x PCI-E 3

Sound 8-channel Realtek ALC 4081

Networking 1x Intel 2.5 Gigabit LAN, Intel 802.11ax Wi-Fi, Bluetooth 5.2

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

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

Dimensions (mm) 305 x 244

ACE OF SPADES

+ Excellent VRM cooling
+ Thunderbolt 4 support
+ Excellent overclocker

ACE RIMMER

– Expensive
– Poor value if you don't need Thunderbolt 4
– Poor software

Conclusion

The good news is that, if you can afford the MSI MEG Z590 Ace, it has practically everything you could want from a high-end motherboard that you plan to keep at the heart of your PC for the next few years. It looks fantastic, has dual Thunderbolt 4 ports, plenty of M.2 ports with effective SSD and VRM cooling, plus an excellent EFI, fan control and thermal probe inputs, as well as eight fan headers. The Asus ROG Strix Z590-E Gaming WiFi is significantly cheaper and does sport many of the same features, but if you need the latest cutting-edge technology and a board with excellent overclocking credentials, the MSI MEG Z590 Ace is a fantastic choice if you can afford it. CPC

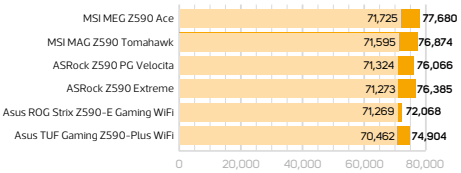
VERDICT

Fantastic from head to toe, but Thunderbolt support comes at a price.

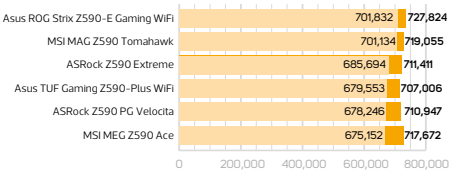
FEATURES	PERFORMANCE	VALUE	OVERALL SCORE
35/35	33/35	15/30	83%

Z590 MOTHERBOARDS LABS RESULTS

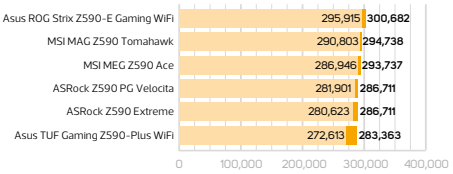
GIMP IMAGE EDITING



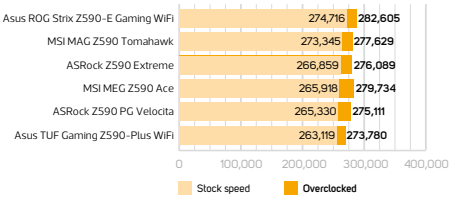
HANDBRAKE H.264 VIDEO ENCODING



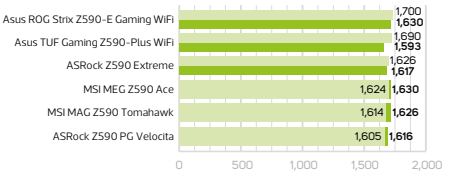
HANDBRAKE H.264 VIDEO ENCODING



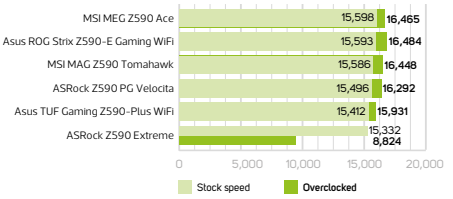
SYSTEM SCORE



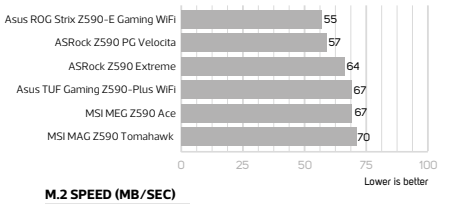
CINEBENCH R23 SINGLE-THREADED



CINEBENCH R23 MULTI-THREADED

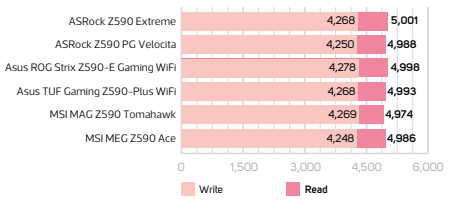


LOWEST M.2 TEMPERATURE (°C)



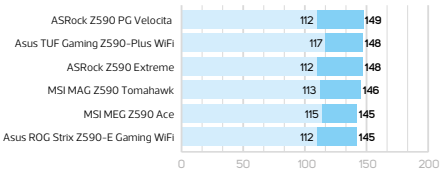
M.2 SPEED (MB/SEC)

CrysalDiskmark 32-queue depth



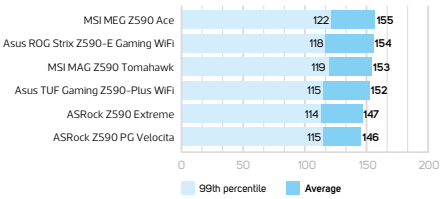
STOCK SPEED FAR CRY NEW DAWN (FPS)

1,920 x 1,080, Ultra settings



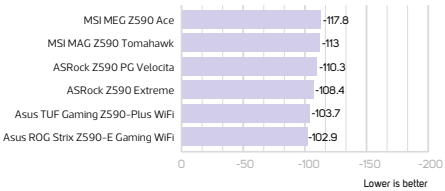
OVERCLOCKED FAR CRY NEW DAWN (FPS)

1,920 x 1,080, Ultra settings



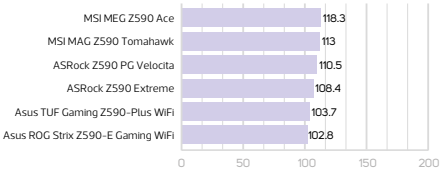
NOISE LEVEL (DBA)

RightMark Audio Analyzer 24-bit, 192kHz



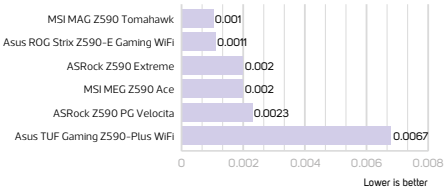
DYNAMIC RANGE (DBA)

RightMark Audio Analyzer 24-bit, 192kHz



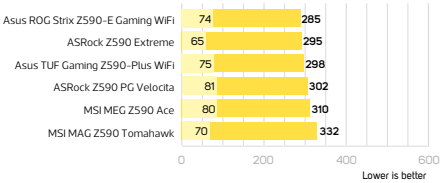
TOTAL HARMONIC DISTORTION (PER CENT)

RightMark Audio Analyzer 24-bit, 192kHz



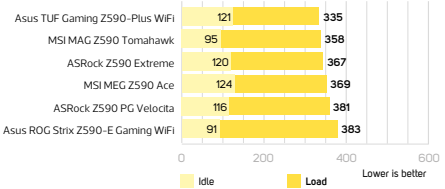
STOCK SPEED TOTAL SYSTEM POWER CONSUMPTION (WATTS)

Windows desktop / Prime95 smallfft



OVERCLOCKED TOTAL SYSTEM POWER CONSUMPTION (WATTS)

Windows desktop / Prime95 smallfft



How we test

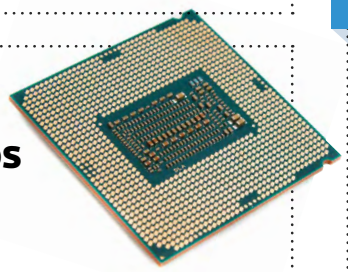
MOTHERBOARDS

TEST PROCESSORS

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

Common test hardware between our CPU test rigs includes 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz DDR4 memory, a 2TB Samsung 970 Evo SSD, a 1TB PCI-E 4 Corsair MP600 SSD and an Nvidia GeForce RTX 3070 Founders Edition graphics card.

All CPUs are cooled by a Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock. We test with our RealBench suite and Far Cry New Dawn on Windows 10 Home 64-bit. We also test the board's M.2 ports, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer.



PROCESSORS

TEST MOTHERBOARDS

- **Intel LGA1200 Rocket Lake**
  MSI MEG Z490 Ace
- **Intel LGA1200 Comet Lake**
  Asus ROG Strix Z590-E Gaming WiFi
- **AMD AM4** MSI MPG Gaming B550 Carbon WiFi

Common gear between our CPU test rigs includes 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz DDR4 RAM, a 2TB Samsung 970 Evo SSD and an Nvidia GeForce RTX 3070 GPU. Cooling comes from a Corsair Hydro-X water-cooling loop with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock.

We use the latest version of Windows 10 with security updates, as well as the latest BIOS versions and drivers. We record results at stock speed and overclocked, and our tests include the **CPC** RealBench suite for image editing, video encoding and multi-tasking, Cinebench's single and multi-threaded tests, Far Cry New Dawn and Watch Dogs: Legion.

For our game tests, we record the 99th percentile minimum and average frame rates either using the game's built-in benchmark or Nvidia FrameView. Finally, we measure the idle and load power consumption of the whole system, using Prime95's smallfft test with AVX disabled to stress the CPU.

MONITORS

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

CPU COOLERS

We measure the CPU temperature with 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, 16GB of Corsair Vengeance RGB Pro memory, 256GB Samsung 960 Evo SSD, Corsair CM550 PSU, Windows 10 64-bit.

INTEL LGA1200
Intel Core i9-10900K CPU overclocked to 4.9GHz with 1.2V vcore, MSI MEG Z490 Tomahawk motherboard.

AMD AM4
AMD Ryzen 9 5900X overclocked to 4.5GHz with 1.25V vcore, MSI MEG X570 Unify motherboard.

INTEL LGA2066
Intel Core i9-7900X overclocked to 4.2GHz with 1.15V vcore, MSI X299M Gaming Pro Carbon AC motherboard.

AMD TRX4
AMD Threadripper 3960X overclocked to 4.2GHz with 1.265V vcore, 32GB of 3466MHz Corsair Vengeance RGB memory, Samsung 960 Pro SSD, Corsair RM850i PSU, ASRock TRX40 Taichi motherboard.

GRAPHICS CARDS

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

TEST KIT

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

GAME TESTS

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

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

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

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

POWER CONSUMPTION

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

CUSTOM PC AWARDS

EXTREME ULTRA

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

PREMIUM GRADE

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

PROFESSIONAL

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

APPROVED

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

CUSTOM KIT

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

CUSTOM PC REALBENCH

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

GIMP IMAGE EDITING

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

HANDBRAKE H.264 VIDEO ENCODING

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

LUXMARK OPENCL

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

HEAVY MULTI-TASKING

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

Elite

Our choice of the best hardware available

Core component bundles

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

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	currys.co.uk	**#194** p20	£130
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#194** p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 11 integrated into CPU	N/A	**#194** p20	£0
MEMORY	16GB (2 x8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2 Z3200C16)	scan.co.uk	**#204** p74	£91
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	cclonline.com	**#204** p74	£75
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£53
		Total £349		

Entry-level RTX gaming

6-core CPU, 1080p gaming

Needs a micro-ATX or ATX case.
We recommend a 500W 80 Plus power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 3600	box.co.uk	**#213** p41	£179
CPU COOLER	ARCTIC Freezer 7 X	scan.co.uk	**#202** p20	£18
GRAPHICS CARD	Nvidia GeForce RTX 3060	ebay.co.uk	**#213** p16	~£630
MEMORY	16GB (2 x8GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2Z 3200C16)	scan.co.uk	**#204** p74	£91
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	cclonline.com	**#204** p74	£75
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£53
		Total £1,046		

UPGRADES

SWAP GRAPHICS CARD	AMD Radeon RX 6700 XT (1080p gaming with ray tracing and 2,560 x 1,440 gaming)	ebay.co.uk	**#213** p19	~£775
SWAP STORAGE	1TB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£95

2,560 x 1,440 gaming system

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

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-11600K	scan.co.uk	**#213** p49	£259
CPU COOLER	Antec Neptune 240	scan.co.uk	**#204** p16	£80
GRAPHICS CARD	AMD Radeon RX 6700 XT	ebay.co.uk	**#213** p19	~£775
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	**#210** p74	£107
MOTHERBOARD	ASRock Z590 PG Velocita	scan.co.uk	**#213** p58	£276
STORAGE	1TB Gigabyte Aorus NVMe Gen4 M.2 SSD (M.2 NVMe)	scan.co.uk	**#210** p74	£155
	Total £1,652			
UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£95

Mid-range gaming system

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

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 5800X	cclonline.com	**#213** p44	£410
CPU COOLER	Antec Neptune 240	scan.co.uk	**#204** p16	£80
GRAPHICS CARD	Nvidia GeForce RTX 3080	ebay.co.uk	**#211** p43	~£1,200
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	**#210** p74	£107
MOTHERBOARD	Asus ROG Strix X570-E Gaming (ATX)*	overclockers.co.uk	**#193** p44	£290
STORAGE	1TB Sabrent Rocket NVMe 4.0	amazon.co.uk	**#208** p51	£159
	Total £2,246			
UPGRADES				
SWAP CPU	AMD Ryzen 9 5900X (12 cores)	ebay.co.uk	**#213** p45	£750
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£95
SWAP CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	amazon.co.uk	**#185** p82	£105

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

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 an 850W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 9 5900X	ebay.co.uk	#213 p45	~£750
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	amazon.co.uk	#175 p20	£121
GRAPHICS CARD	Nvidia GeForce RTX 3090	ebay.co.uk	#211 p45	~£2,049
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	#210 p74	£107
MOTHERBOARD	MSI Prestige X570 Creation (E-ATX)*	overclockers.co.uk	#193 p48	£440
STORAGE	1TB Samsung 980 Pro	ebay.co.uk	#208 p52	£185
	Total £3,652			
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	#166 p54	£95
SWAP CPU	AMD Ryzen 9 5950X (16 cores)	ebay.co.uk	#212 p46	~£1,000

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

Heavy multi-threading workstation

Serious multi-threaded power, 1080p gaming

Needs an E-ATX case with room for a 280mm all-in-one liquid cooler. We recommend a 750W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Threadripper 3960X	scan.co.uk	#197 p18	£1,274
CPU COOLER	NZXT Kraken X63 (280mm AIO liquid cooler)	scan.co.uk	#207 p47	£130
GRAPHICS CARD	Nvidia GeForce GTX 1660 Super	ebay.co.uk	#199 p44	~£400
MEMORY	32GB (4 x 8GB) Corsair Dominator Platinum RGB 3600MHz	scan.co.uk	#197 p20	£292
MOTHERBOARD	ASRock TRX40 Taichi (E-ATX)	overclockers.co.uk	#198 p44	£470
STORAGE	1TB Samsung 980 Pro	ebuyer.com	#208 p52	£185
	Total £2,751			
UPGRADES				
SWAP GRAPHICS CARD	AMD Radeon RX 6700 XT (2,560 x 1,440 gaming with real-time ray tracing)	ebay.co.uk	#213 p19	~£775
SWAP CPU	AMD Threadripper 3970X (32 cores - massive multi-threaded power)	scan.co.uk	#197 p19	£1,790
ADD SECONDARY STORAGE	4TB Western Digital Blue	cclonline.com	#166 p50	£95

Mini PCs

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

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z490 (LGA1200)	Asus ROG Strix Z490-I Gaming	scan.co.uk	**#206** p40	£275
AMD B550 (AM4 budget)	Asus ROG Strix B550-I Gaming	scan.co.uk	**#206** p44	£190
AMD X570 (AM4 mid-range)	Asus ROG Strix X570-I Gaming	amazon.co.uk	**#198** p20	£290

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	overclockers.co.uk	**#206** p18	£100

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	**#143** p17	£55

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD B550 (AM4)	MSI MAG B550M Mortar	ebuyer.com	**#204** p42	£130

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	scan.co.uk	**#180** p46	£50
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	**#161** p26	£75

ATX cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	**#176** p28	£48
BUDGET QUIET	be quiet! Pure Base 500	scan.co.uk	**#196** p24	£70
SUB-£100	be quiet! Pure Base 500DX	scan.co.uk	**#202** p39	£99
COMPACT	Fractal Design Define 7 Compact	overclockers.co.uk	**#203** p32	£99
HIGH AIRFLOW	Fractal Design Meshify 2	scan.co.uk	**#212** p45	£129
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	**#202** p44	£139
SUB-£150	Fractal Design Define 7	overclockers.co.uk	**#204** p18	£140
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	**#187** p24	£215

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER (WI-FI 6)	TP-Link Archer AX6000	overclockers.co.uk	**#196** p57	£250
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	£150
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	**#200** p22	£152
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£211
2.5 GIGABIT DUAL-BAY NAS BOX	QNAP TS-231P3	ebuyer.com	**#212** p25	£275

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

Monitors

Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144Hz, VA, 1,920 x 1,080, F	AOC C24G1	ebuyer.com	#191 p28	£185
25IN, 240Hz, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	currys.co.uk	#209 p57	£329
25IN, 360Hz, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	overclockers.co.uk	#212 p20	£700

Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60Hz, VA, 4K, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£370
34IN, 144Hz, IPS, 3,440 x 1,440, W, F	iiyama G-Master GB3461WQSU	cclonline.com	#206 p53	£406
34IN, 144Hz, IPS, 3,440 x 1,440, W, F, G	LG UltraGear 34GN850	currys.co.uk	#206 p55	£949
38IN, 144Hz, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	currys.co.uk	#208 p30	£1,500
35IN, 200Hz, VA, 3,440 x 1,440, W, G, HDR	Asus ROG Swift PG35VQ	scan.co.uk	#198 p58	£2,350

Up to 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 144Hz, IPS, 1,920 x 1,080, F, G	AOC 27G2U	overclockers.co.uk	#201 p53	£220
27IN, 240Hz, IPS, 1,920 X 1,080, F, G	Asus TUF Gaming VG279QM	scan.co.uk	#209 p60	£349
27IN, 240Hz, IPS, 1,920 X 1,080, F, G	Acer Nitro XV273	alza.co.uk	#204 p25	£378
27IN, 144Hz, IPS, 2,560 x 1,440, F, G	Asus TUF Gaming VG27AQ	overclockers.co.uk	#201 p54	£460
27IN, 240Hz, TN, 2,560 x 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£540
27IN, 240Hz, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£700

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 75Hz, IPS, 2,560 X 1,440, F	LG 27QN880	ebuyer.com	#210 p26	£388

Peripherals and audio

Gaming keyboards

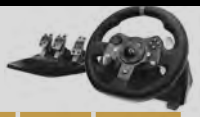
CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
MEMBRANE	Corsair K55 RGB	amazon.co.uk	#201 p45	£50
BUDGET TKL MECHANICAL	HyperX Alloy FPS Pro	amazon.co.uk	#201 p46	£70
MECHANICAL	Corsair K68 RGB	amazon.co.uk	#181 p53	£114
OPTICAL ESPORTS	Asus ROG Strix Scope RX	overclockers.co.uk	#209 p43	£125
MECHANICAL MMO	Corsair K95 RGB Platinum	scan.co.uk	#164 p26	£185
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	#193 p56	£150
PREMIUM TKL MECHANICAL	SteelSeries Apex Pro TKL	scan.co.uk	#212 p59	£190
LUXURY MECHANICAL	Ducky Shine 7 RGB	overclockers.co.uk	#212 p53	£180
LUXURY WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	scan.co.uk	#208 p60	£230

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Corsair M55 RGB Pro	amazon.co.uk	#200 p24	£35
FIRST-PERSON SHOOTER	SteelSeries Rival 600	box.co.uk	#184 p59	£65
MMO	Razer Naga Trinity	amazon.co.uk	#186 p52	£88
AMBIDEXTROUS	Razer Viper 8KHz	currys.co.uk	#213 p23	£80
WIRELESS	Corsair Dark Core RGB Pro	amazon.co.uk	#202 p25	£86
PREMIUM WIRELESS	Razer Deathadder V2 Pro	scan.co.uk	#210 p28	£125
ULTRA LIGHTWEIGHT	Roccat Burst Pro	currys.co.uk	#211 p28	£50
PREMIUM LIGHTWEIGHT	Logitech G Pro X Superlight	logitech.com	#213 p22	£130

Peripherals and audio cont ...

Game controllers



CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	currys.co.uk	#202 p50	£230
GAMEPAD	Microsoft Xbox One Wireless Controller	currys.co.uk	#191 p56	£55
BUDGET FLIGHT STICK	Logitech Extreme 3D Pro Joystick	currys.co.uk	#207 p52	£40
FLIGHT STICK	Thrustmaster T.16000M FCS HOTAS	scan.co.uk	#207 p56	£150

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET STEREO	Roccat Elo X Stereo	scan.co.uk	#210 p56	£40
STEREO	Epos | Sennheiser GSP 300	amazon.co.uk	#210 p54	£84
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£162
PREMIUM WIRELESS	Razer BlackShark V2 Pro	overclockers.co.uk	#211 p26	£180

Speakers

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

Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
WIRELESS MULTI-DEVICE	Logitech K780	currys.co.uk	#203 p58	£80
WIRELESS TKL MECHANICAL	Keychron K2 Version 2	keyboardco.com	#208 p57	£84
TKL MECHANICAL	Filco Majestouch Convertible 2 Tenkeyless	keyboardco.com	#203 p55	£140

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
ENTRY-LEVEL RTX	Scan 3XS Gamer RTX	Intel Core i5-11600K	Nvidia GeForce RTX 3060	scan.co.uk	#213 p32	£1,299
6-CORE GAMING	Wired2Fire Predator	AMD Ryzen 5 5600X	Nvidia GeForce 3060 Ti	wired2fire.co.uk	#211 p32	£1,413
8-CORE GAMING	Chillblast Fusion Commando 3060Ti	AMD Ryzen 7 5800X	Nvidia GeForce 3060 Ti	chillblast.com	#210 p34	£1,690
8-CORE RTX 3080 GAMING	PC Specialist Obsidian I	Intel Core i7-10700KF	Nvidia GeForce RTX 3080	pcspecialist.co.uk	#209 p40	£2,190
10-CORE RTX 3080 GAMING	CyberPower Infinity 910 RTX	Intel Core i9-10850K	Nvidia GeForce RTX 3080	cyberpowersystem.co.uk	#208 p42	£2,560
WATER-COOLED 16-CORE GAMING	Scan 3XS Absorbere	AMD Ryzen 9 5950X	Nvidia GeForce RTX 3090	scan.co.uk	#209 p46	£5,412
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	Nvidia GeForce RTX 3090	scan.co.uk	#145 p58	£14,048

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
RTX GAMING	Gigabyte Aorus 15G XC	Intel Core i7-10870H stock speed	Nvidia GeForce RTX 3070	15.6in 1,920 x 1,080 IPS 240Hz	overclockers.co.uk	#213 p30	£1,899

RICK LANE / INVERSE LOOK

PANNED PATENTHOOD

The patenting of Shadow of Mordor's Nemesis system is a disheartening event for the game industry, argues Rick Lane

Middle Earth: Shadow of Mordor's Nemesis System is one of the best game mechanics devised in the past ten years. It turns Shadow of Mordor's Uruks into recognisable, ever-changing personalities by giving them unique arrangements of character traits, then placing them within an ever-shifting political hierarchy that can be manipulated by the player.

The result is a system whereby the player can create and complete their own missions, which in turn can have dynamic story consequences down the line. For example, the player might decide to assassinate a particular Uruk, but that Uruk may return from the dead later in the game, now immune to the method you used to kill it last time.

The Nemesis System is one of the best story engines ever devised, and we expected Shadow of Mordor to see a race of imitators in the years following its release. But aside from its sequel, Shadow of War, no other game has attempted a similar system.

For years, I've wondered why, but it transpires the reason behind this dearth of similar games is that the Nemesis System was patented by Warner Bros. The company has been trying to get the system patented since 2016, but after initially rejecting the application in 2019, the US Patent and Trademark Office has now granted the patent.

Effectively, this means no other developer can create a similar system without risking legal ramifications. Now, you might think, Warner Bros created the Nemesis System (although specifically it was Monolith Productions that created it, which is owned by Warner Bros), so surely it can do what it wants with it.

No other developer can create a similar system without risking legal ramifications

The problem with this idea is that the game industry is built fundamentally on processes of iteration, and patents are anathema to iterative design. Imagine if Nintendo had patented the 'jump' following the success of Donkey Kong, or id Software had patented the process of shooting an enemy with a weapon upon releasing Doom, rather than making the game's engine open-source.

Shadow of Mordor also adopts an open-world game structure filled with all manner of patentable ideas borrowed from other games. It features Splinter Cell-style stealth, a climbing system borrowed from Assassin's Creed, and a counter-based combat system that's almost identical to the one in Batman: Arkham Asylum.

The patent doesn't necessarily mean other games with Nemesis-like systems won't get made. It all depends upon the patent's enforceability, and Warner Bros' willingness to enforce it. The patent's title, for example, mentions the phrase, 'Followers in computer games', which would theoretically include any game that features an escort mission or a party of characters.

There has long been a common understanding within the game industry that mechanics should not be exclusive, which is why patenting the Nemesis System is so crummy. Larger devs may have the clout to flaunt the patent's absurdly broad strokes, but given the dearth of imitators to Shadow of Mordor so far, it seems to be having the desired chilling effect – a deep shame for a system with such fantastic potential. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

Little Nightmares 2 / £24.99 inc VAT

DEVELOPER Tarsier Studio / **PUBLISHER** Namco Bandai

Little Nightmares 2 is a rare example of a prequel that's better than the original. Not much better, mind. You play as Mono, a skinny child who enjoys hobbies such as skulking around, wearing a paper bag on his head and (if you play like us), getting killed in horrible ways.

Beginning the game lost in a forest filled with dangerous traps, Mono soon arrives at a seemingly abandoned woodland lodge, where he encounters a little girl trapped in the basement. Releasing her, the pair escapes pursuit through the forest and make their way to a nearby city, where even more dangerous challenges await.

Little Nightmares 2 plays almost identically to the first game, using a handful of simple mechanics (primarily jumping and grabbing) to create straightforward but engaging physics-based puzzles. These are interspersed with tense stealth sections where you must avoid detection by one of the game's giant, twitching horrors, alongside chase sequences when the horror in question inevitably spots you.

If you've played Limbo or Inside, Little Nightmares 2 will feel familiar. Arguably overly familiar. Beyond a rudimentary combat system that's arguably more of a hindrance to the experience than a help, Little Nightmares 2 is very similar to the work of Playdead. The sequel also fails to iron out the creases of the original game. The pseudo-3D perspective frequently makes it difficult to judge the precise location of platforms and obstacles, while the insta-fail stealth and chases make its most intense sequences more frustrating than frightening.

Despite its flaws, there's still much to recommend here. The audio/visual design is superb, and Tarsier Studios has a knack for creating uniquely tactile worlds. Every material is meticulously modelled, every object perfectly weighted. It's also rich in detail – for example, the children's feet leave small depressions in soft surfaces like those as mattresses when they stand on them.

Plus, while the game isn't as scary as Amnesia or Alien: Isolation, it's creepy in a way that lingers long after you've finished playing. The regular dispersal of empty clothes flopped across furniture – as if the people wearing them simply evaporated – is particularly eerie.

Little Nightmares 2 is most vivid in its simple, understated storytelling. The relationship between Mono and his companion (who we aren't naming for spoiler reasons) is effectively communicated despite the almost total lack of dialogue. And while the plot is obscure for much of the game, the second half slowly builds to a genuinely excellent climax that has radical implications for how we perceive the events of the first game. The game's broad strokes may be too derivative for it to be truly special, but Tarsier successfully uses those conventions to deliver an entertaining horror and a surprisingly impactful story.

RICK LANE

MONO

+ Great art and world design
+ Sufficiently creepy
+ Good story with a great ending

NO-NO

– Structurally and mechanically safe
– Some frustrating sequences

/ VERDICT

Little Nightmares 2 isn't the best horror game ever made, but it is an example of a prequel done right.

OVERALL SCORE

70%

Dyson Sphere Program / £15.49 inc VAT

DEVELOPER Youthcat Studio / **PUBLISHER** Gamera Game

DYSON SPHERE

+ Highly engaging factory management
+ Astounding sense of scale
+ Supremely satisfying core loop

DYSON PRICES

– Suit management is fiddly
– Slightly iffy English translation
– More features yet to be added

Full disclosure, Dyson Sphere Program isn't a 'finished' game. It launched on Steam Early Access earlier this year, with approximately 12 months of further development planned before it officially hits version 1.0. That said, the experience it currently offers is already so rich and enjoyable that it feels complete, and as such, we simply couldn't wait to tell you about it. It's a wildly ambitious, utterly captivating game that's fantastic to play right now.

Dyson Sphere Program (DSP) is a factory-management sim that bears many similarities to the equally brilliant Factorio. Indeed, DSP copies large chunks of Factorio's core experience to serve as its own basic structure. Landing on a verdant planet in a faraway solar system, your initial goal is to establish a working factory. You do this by building drills to mine resources, and establishing conveyor belt systems to carry them to assembly lines where they're forged and constructed into new objects.

In this respect, Dyson Sphere Program matches Factorio for enjoyment. Figuring out the layout of individual assembly lines and finding optimal ways to ferry raw materials around your factory makes for a compellingly creative puzzle, while watching your factory grow and flow is hugely satisfying. Alongside building assembly lines, you also need to research new technologies, achieved by developing Matrix Cubes, the creation of which requires complex chains of production.

In short, it's an engaging facsimile that also makes a couple of welcome tweaks to Factorio's formula. One major benefit of the 3D world is that conveyor belts can be built at multiple levels, making it easier to weave new assembly lines into your existing factory. In addition, Sorters, which move resources on and off assembly lines, can be extended across multiple conveyor belts and set to filter specific items from the outset, which again adds considerable flexibility to your factory layout from early in the game.

Yet while all this is welcome, Dyson Sphere Program's true quality reveals itself a few hours into the game, specifically when you upgrade your character's flight capabilities for the second time (yes, your character can fly). At this point, you're able to depart the planet on which you're currently building, venturing across space to other worlds and even other star systems.

That's right, as well as being a factory sim, Dyson Sphere Program is also a space exploration game. As suggested by the title, your ultimate goal is to build a Dyson Sphere – a megastructure built around a star that's designed to harvest its energy output. Doing this requires you to find resources that don't exist on your starting planet, meaning you need to establish logistics systems on a truly cosmic scale.

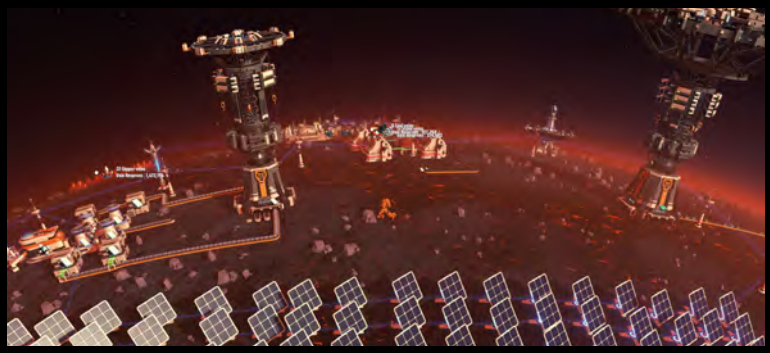
Indeed, Dyson Sphere Program represents the majesty of space in a way not experienced since the initial launches of No Man's Sky and Elite Dangerous. It's not just the way the game represents alien worlds and planetary orbits, but how you can harness the power of the universe itself to your own ends.

Your first glimpse of this scope comes in the form of a Planetary Logistics Station, which uses automated drones to ferry resources around the circumference of a specific planet. Later, you gain access to Interplanetary Logistics Systems, which uses automated spaceships to ferry cargo between planets. All of this is simulated on an individual scale, meaning you can follow individual vessels as they make their journeys through the cosmos.

Then there's the task of building the Sphere itself, which begins with a Dyson Swarm. This involves building a massive cannon that fires solar sails into the orbit of the nearest star. Soon, the star is surrounded by glittering motes of light, with ever more of them arcing across the sky like meteors, delivering energy to receivers built on the surrounding planets. And this is merely the start of the Sphere's construction.

DSP plays at a truly mind-boggling scale. Alongside all the above, you can build rocket silos designed to carry components to your Dyson Sphere, structures that harvest resources from gas giants, and even artificial stars that generate massive amounts of power. In short, DSP takes the mesmerising creative puzzling and feedback loops of Factorio, and extrapolates that formula to this ludicrous, dazzling conclusion.

It's not perfect, of course. The main issue is that your mech suit requires an annoying amount of micromanagement in order to operate. Firstly, it has to be regularly refuelled, which is rather irksome. However, the bigger problem is that your suit is laden with several arbitrary constraints that can only be removed via upgrading. For example, the placement of new



items and buildings is performed by drones that launch from your suit. Initially, you only have access to a couple of drones, which makes the placement of more common items such as conveyor belts a frustratingly slow process.

Aside from that, most of the game's current issues are a consequence of its Early Access nature. DSP is developed by a Chinese studio, and the English translation needs some work. It's fairly comprehensible, but some of the nuances of how DSP plays are poorly explained, which is a problem given that DSP isn't short of nuance. The other major issue is that, there currently isn't much reason to explore beyond your current star system. There are only one or two resources you can't acquire on your starting planet, and those can be acquired on the other planets within your local star system.

Developer Youthcat Studio has a full roadmap of planned features that will expand upon the existing core. Yet while DSP may not be as broad as the developers ultimately intend, that core already has more than enough substance to make DSP a fantastically engaging experience. It's easily the best factory management game since Factorio, and if the developer can continue to improve upon it, DSP might well eclipse Factorio as the industry standard for assembly-line puzzling.

RICK LANE

/ VERDICT

Despite being incomplete, Dyson Sphere Program is still a truly monumental project.

OVERALL SCORE

90%

NEBUCHADNEZZAR / £14.99 inc VAT

DEVELOPER Nepos Games / **PUBLISHER** Nepos Games

UR

+ Lovely isometric style
+ Strong puzzling core
+ Watching your city develop is fun

ERR

– Core loop becomes less fun as it goes on
– Not enough evolution in second half

/ VERDICT

Nebuchadnezzar might let you build the world's original cities, but compared with the might of Caesar III, it's a long way from Rome.

OVERALL SCORE

64%

Nebuchadnezzar harks back to the golden age of city builders, heralded by games such as Caesar III and Pharaoh. Tasking you with building the world's oldest cities, from primordial Ur to wondrous Babylon (complete with hanging gardens), Nebuchadnezzar's play revolves almost entirely around establishing production chains to sustain and entertain your ever growing populace. Every house you place in your city will attract settlers along its dusty roads, but maximising habitable space requires you to supply each house with specific goods.

There are three tiers of citizen in Nebuchadnezzar, each of which has differing demands. The middle tier, for example, requires fish and dates as a basic level of sustenance. Fish is obtained from piers built along coastlines, while dates must be grown on a farm.

Both items then need to be transported to a local market, which requires the service of a caravanserai if the market isn't within immediate range of the relevant production buildings. After this, market vendors must be hired and sent on patrols through neighbourhoods to sell wares directly to individual houses. In the early game, grappling with this production puzzle is fun, and watching your city slowly develop is undeniably satisfying.

However, as cities become more complex, the logistical elements of Nebuchadnezzar become more of a chore. Setting patrol routes for every single vendor in the game is fiddly and tedious, especially when any changes to your city layout also require you to adjust every affected route. It's also odd that citizens don't visit your markets themselves. Not only would this make city planning easier, but it would also lend your city streets more life.

A bigger problem is that Nebuchadnezzar never evolves from this basic feedback loop. Other elements of early civilisation, such as war, religion and cultural development are scarcely represented. A basic trading system lets you exchange goods with other cities, but sadly it causes more problems than it solves. Trading is the only way to earn gold in the game, which is used for constructing buildings. However, the conditions for commencing trade with a new city are often so demanding that it's possible to run out of gold before a trade agreement can be broached.

Nebuchadnezzar's late game is rescued by its monument builder, which lets you design and construct your own megalithic temple, gardens or palace. Chipping away at your civilisational legacy offers a pleasant way to kill time while your city churns out new resources, but ultimately, it's insufficient compensation for Nebuchadnezzar's slow, empty-feeling late game.

If you've exhausted other recent city builders and have a taste for retro strategy, then Nebuchadnezzar does offer some classically styled puzzling fun. Otherwise, the ancient cities of Mesopotamia are best left in the past.

RICK LANE

THE ROOM 4: OLD SINS / £6.99 inc VAT

DEVELOPER Fireproof Games / **PUBLISHER** Fireproof Games

Originally designed as mobile games, the extremely popular Room series has been quietly creeping onto PC over the last few years. After last year's The Room VR impressed with its immersive take on object-based puzzling, The Room 4 is a more conventional affair.

Set in 1899, the Room 4 sees you searching a house for clues to the disappearance of a renowned engineer and his wife. The game begins at the culmination of this search, with your character investigating the final room in the house – the attic. Here, they discover a large, elaborate dollhouse that serves as the focus of puzzling, as well as a neat way for Fireproof Games to get around being limited to a single room.

The dollhouse is essentially one large, highly intricate puzzle box. It features multiple rooms filled with all manner of objects and contraptions that must be probed and manipulated to further the story. In many ways, the dollhouse is reminiscent of Resident Evil's Spencer Mansion, only without the zombies, giant spiders and other monsters hounding your footsteps. You'll find items in one room that unlock parts of a puzzle in another, while seemingly mundane objects such as lamps and statues act as keys when placed in the right spot.

The puzzling is rarely short of excellent. Every enigma is highly tactile, with objects covered in buttons, drawers, levers and other interactive elements that make grappling with them extremely satisfying. As with previous games, you still have access to your Eyepiece, which lets you glimpse into a realm known as the 'Null' world, essentially acting as a pointer system for where to start on the more complex conundrums.

Where the Room 4 stands out from previous games is its propensity for puzzles within puzzles. One example involves unlocking a particularly elaborate bureau. When opened, the top of the bureau reveals a large model train that offers a whole other conundrum that eventually links back into the bureau puzzles. This elegant flow between – and even within – individual puzzles really helps to carry the player along. Indeed, the pacing is generally superb, with puzzles always challenging you but rarely proving obstructive.

While mechanically delightful, the Room 4's narrative is less engaging. Delivered largely through text, the story about the engineer's discovery of the 'Null Element' is intriguing but not exactly gripping, while the resulting tensions that arise between him and his wife could easily be solved through a simple conversation. The mouse controls can also be a tad fussy. The game doesn't always register when you click and drag an item, especially for certain actions such as turning the pages of books.

These are minor flaws though. The Room 4 is the most accomplished entry in one of the best puzzling series around, offering a couple of evenings' worth of great entertainment for less than the price of a takeaway.

RICK LANE

Custom PC Approved

OLD SINS

+ Great puzzling
+ Clever dollhouse concept
+ Difficulty well judged

NEW SINS

– Story is a bit naff
– Mouse controls a little shaky

/ VERDICT

The story may be weak, but the Room 4 still offers the best object-based puzzling around.

OVERALL SCORE

85%

REALITY CHECK

Rick Lane battles homunculi in ancient Roman arenas in his latest roundup of VR news and reviews

REVIEW

GORN / £14.99 incVAT

DEVELOPER Free Lives / **PUBLISHER** Devolver Digital

Take a little bit of Superhot, a little bit of QWOP, mix them together inside a VR helmet, then slather the mixture in enough blood to shut down a black pudding factory, and you end up with GORN. Free Lives' ridiculous gladiator simulator is classic VR fodder, letting you experience what it's like to chop off a bodybuilder's arms and legs before smacking them across an oversized sandpit with a flail. GORN is well worth considering if you fancy a laugh and a workout at the same time.

A straightforward arena fighter, GORN puts you in the sandals of a neophyte gladiator in a Roman world that's somehow even more absurd than the actual ancient Rome. You square off against waves of squat homunculi, slicing and battering them with a range of increasingly preposterous weapons.

GORN is stupendously violent. Your musclebound opponents can have their limbs sliced off, their heads crushed and/or removed and their eyeballs gouged out. Even their jawbones can explode out of their faces. Rival combatants can also survive the severing of one or multiple limbs, leaving them biting at your ankles like the Black Knight from Monty Python and the Holy Grail.

This latter point hints at why GORN's VR grisliness strangely isn't nauseating or repulsive – the violence is distinctly cartoonish, making the experience more silly than shocking. Your enemies have a highly transient relationship with gravity, flailing about as if their bones are made of rubber. Similarly, your weapons were apparently designed by an evil clown, boasting floppy handles that lends them a toy-like appearance belying their brutal lethality.

GORN has no real story or broader arc, focusing purely on a series of arena fights. However, it packs an impressive amount of interactive nuance into its combat. Beyond basic swords and maces are throwing weapons, bows that must be manually drawn and fired, a wrist-mounted crossbow that has to be cranked for each shot, and even a literal hand-cannon. Enemies, meanwhile, sport varying types of shields and armour and will often attack you in groups, requiring you to think tactically about crowd control and how to defeat individual opponents.

There's nothing massively wrong with GORN, at least in terms of core features. The movement controls are rather idiosyncratic, with you pressing the face buttons of the touch controllers and then dragging your arms to move forwards and backwards. It's unusual, but it makes sense in the small arenas where combat takes place. GORN is also highly physical, and requires a clear 2 x 2m space in which to play. Try to play it in an inappropriate space, and you'll end up with bruised knuckles and/or a smashed computer screen.

GORN is by no means a VR masterpiece, lacking the style of Superhot or the ambition of Half-Life: Alyx to be considered a true great. However, its simpler VR pleasures are no less entertaining for that, and if Covid-induced cabin fever has got you ready to smash something, there are far worse outlets for that than GORN.

GORN

+ Satisfying, grisly combat
+ Amusing cartoon style
+ Easy to pick up and play

SCORN

- Unusual movement controls
- Needs a decent-sized open space

VERDICT

Simple and brutally effective, GORN is a messy and silly VR take on Roman gladiatorial combat.

OVERALL SCORE

80%

NEWS

HTC BODY TRACKERS

HTC has recently focused on increasing the level of immersion provided by its Vive headsets, introducing some new movement trackers to bring the player's full body into the VR space.

Firstly, HTC has released the latest version of the Vive tracker – a small, triangular-shaped plastic node worn around the user's forearms and calves. They enable the headset to locate the position of all the user's limbs and render that information in-game, bringing players one step closer to full-body immersion. Now at version 3, the latest iteration of the tracker is smaller, lighter and has a longer battery life than previous versions.

In addition, HTC has released a Facial Tracker, which hangs under the headset and maps the movements of your mouth and face. It's designed primarily for VR communication, letting you chat with other VR users in a more realistic way, although like the body trackers, it will likely have plenty of motion-capture potential as well. Both the Facial and body tracker are priced at £129 inc VAT each from **vive.com/uk**, although ideally you'll want one body tracker for each limb to get full-body immersion.

NEWS

WIRELESS PC GAME STREAMING ON QUEST

Aside from its price, the primary selling point of the Oculus Quest is its wireless gaming capability. However, you can only play games designed specifically for the Quest wirelessly. They must be bought from the Oculus store and downloaded directly onto the headset's built-in storage. If you want to use the Quest to play your old Rift games, or a game designed for SteamVR, then you need to connect your Quest to the PC using a Link-compatible cable.

That's the official line, anyway. Unofficially, there are a couple of wireless systems for playing non-Quest games on your Quest. The most notable is Virtual Desktop, a Quest app that lets you stream your PC directly to the Quest's display and boot up VR games from there.

However, in 2019 Oculus forced the developer of Virtual Desktop to remove its game-streaming capability, citing a failure to meet quality guidelines. The feature still existed, but getting it to work required sideloading – using third-party programs to install unofficial apps onto the headset.

In late February 2021, though, Oculus apparently had a change of heart, allowing the full version of Virtual Desktop onto the app store. In one fell swoop, this move has made wireless streaming of non-Quest games a whole lot easier. Now you just need to install Virtual Desktop, configure it to stream from your PC, select the game you want to play and off you go.

Virtual Desktop costs £14.99 inc VAT on Quest, but that's half the price of a decent Link-compatible cable, and much cheaper than the near-£80 inc VAT for Oculus' official Link cable. You'll need a 5GHz 802.11ac Wi-Fi router for optimum performance, and you'll still have to remain within 30 feet of your PC. However, that's much more convenient than constantly disentangling your legs from a 5m cable. CPC

ROCKET LAKE-S UNCOVERED

Edward Chester picks apart the details of Intel's intriguing new CPU line-up

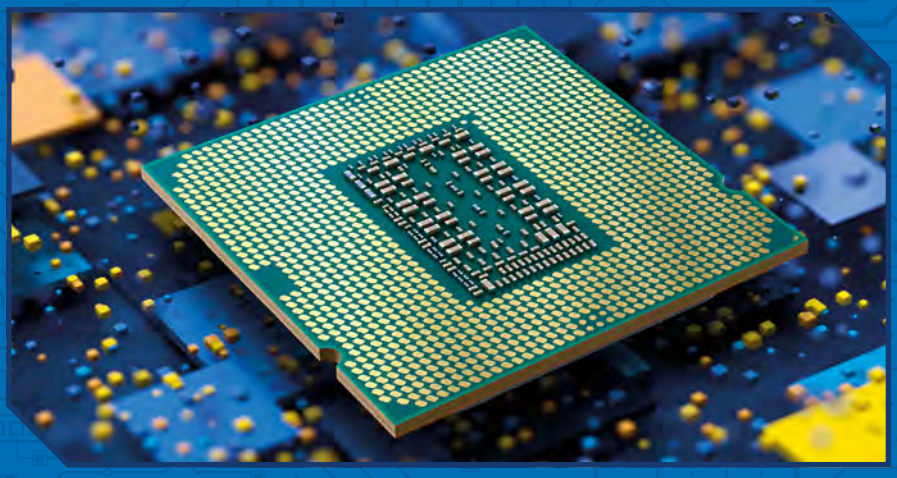
Intel's new Rocket Lake-S launch marks one of Intel's more interesting CPU development cycles in recent years. With well-documented delays in developing its 10nm manufacturing process, Intel has been forced to eke out ever more performance from its 14nm process and its aging Skylake microarchitecture. With Rocket Lake-S, though, it's taken a different route.

Instead of using a variation on the Skylake architecture, Rocket Lake-S uses a variant of the newer Sunny Cove core design found in Intel's 10nm Ice Lake mobile CPUs. In this case, however, the newer design has been converted so that it can be manufactured on the company's 14nm process, in a process called backporting.

This process isn't straightforward and means Intel has had to make several compromises, most notably maxing out the core count of these CPUs to just eight (16 threads with Hyper-Threading). However, the end result is still Intel's fastest ever instructions per clock rate (task dependent), making for compelling mid-range performance. Add in the fact that they're actually available, unlike AMD's Ryzen 9 CPUs, and you have a winning formula. But what's really under the hood?

Setting the scene

Before we dig deeper into the minutiae of Intel's new core design, let's establish what has and hasn't changed with the new chips. The new launch is of Intel's 11th-gen Core-branded desktop processors, with the codename for the whole processor being Rocket Lake-S.



That overall term consists of the CPU core, an integrated GPU, general I/O (USB, PCI-E and so on) and several other IP blocks that make up the whole system-on-a-chip (SoC). Many of these other blocks have their own codename, such as Xe graphics, and to an extent they can be combined in different ways to create different SoC designs, adding more CPU cores or more graphics execution units (EUs) for instance.

For the last several CPU launches, Intel's CPU and graphics blocks have largely remained unchanged in terms of overall design, with both being based on the Skylake microarchitecture. Instead, the number of CPU cores and graphics EUs has changed and tweaks have been made to I/O and other aspects of the SoC design, enabling Intel to increase performance, features and core counts without fundamentally changing the underlying architecture.

In the meantime, for its mobile CPUs, Intel has moved onto completely new SoC and CPU core designs for use with its 10nm manufacturing process. For its 10th-gen Ice Lake mobile CPUs, Intel designed the Sunny Cove CPU microarchitecture, while for its very latest 11th-gen Tiger Lake designs, it has moved on further to use the Willow Cove CPU, although the changes between Sunny and Willow Cove are relatively minor. Intel has also developed a new graphics engine that's included in Tiger Lake called Xe, which uses a new instruction set and provides considerably enhanced performance over previous generations.

All of which brings us to Rocket Lake-S, which backports the Sunny Cove CPU core design of Ice Lake and a cut-down version of its Xe graphics from Tiger Lake to the company's latest 14nm process. Joining these components are an uprated I/O stack that

KNOW YOUR CPUs

Rocket Lake-S uses a combination of newer CPU and GPU design but built on an aging 14nm process

Name	Comet Lake	Rocket Lake-S	Ice Lake	Tiger Lake	AMD Zen 3
Launch date	2019	2021	2019	2020	2020
Generation	10th	11th	10th	11th	3rd
Form factor	Desktop	Desktop	Laptop	Laptop	Desktop
Process	14nm++	14nm++	10nm+	10nm SuperFin	7nm
Max cores	10	8	4	4	16
TDP	125W	125W	28W	35W	105W
Core uArch	Skylake / Comet Lake	Cypress Cove	Sunny Cove	Willow Cove	Zen 3
IGP	Gen 9.5	Xe-LP	Gen 11	Xe-LP	-
IGP cores	24	32	64	96	-

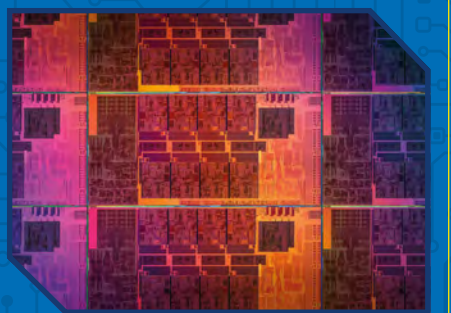
includes PCI-E 4 support to make for a much more modern CPU design, but built on an aging process.

That shrinking feeling

The exact reason why Intel has had such trouble getting its newer manufacturing processes to work well enough to make desktop-class CPUs still hasn't been made entirely clear. Early on in the 10nm node's development, problems with the overall process that led to too many defective chips being made were reasonably clear, but since then we've had two generations of mobile CPUs use the technology but still no desktop-class components.

The net effect, though, is that despite having finally updated its CPU design, Rocket Lake-S will be built on a process that, although refined over the years, has been used to produce chips that were available to buy nearly seven years ago.

The company debuted its 14nm process with its first mobile Broadwell chips back in October 2014. It used the then new process to die-shrink the previous 22nm microarchitecture design codenamed Haswell (such as the Core i7-4790K), but while Broadwell had a good standing on Intel's HEDT platforms, the mainstream desktop CPUs that were ostensibly launched in June 2015 were quickly brushed aside to make room for Skylake CPUs in August 2015, such as the Core i7-6700K, which used the same 14nm process but with a new microarchitecture.



Rocket Lake-S backports Intel's 10nm Sunny Cove microarchitecture to a 14nm process

At this point, the company was continuing with its tick-tock design process, with one CPU launch incorporating a new smaller process (tick) and the next launch using the same process but with a new microarchitecture design (tock). It was a cycle that built a great deal of customer trust due to its regularity, and enabled Intel to rely on a tried and tested manufacturing process when testing out a new architecture, and a tried and tested architecture when testing a new process.

However, since Skylake's launch, these smaller process ticks have failed to happen, causing Intel to rebrand its development strategy. Instead, we now have Process-Architecture-Optimization (PAO), which essentially leans into the idea that tick-tock was no longer viable and that the company would rely on iterating on its existing processes and microarchitecture designs in a much less predictable fashion.

That's why we've had multiple generations of Skylake-based CPUs that have stretched from a maximum of four cores all the way up to ten, all seemingly stuck on a 14nm process, when in fact they've used three different variants of 14nm, namely 14nm, 14nm+ and 14nm++. Likewise, we're already on the third iteration of 10nm in the mobile world, with 10nm+ and 10nm SuperFin used on the last two generations. All told, there's a chance this will be the final desktop CPU launch for Intel based on a 14nm process, but there's no guarantee.

ALL TOLD, THERE'S A CHANCE THIS WILL BE THE FINAL DESKTOP CPU LAUNCH FOR INTEL BASED ON A 14NM PROCESS

It's Sunny in Cypress

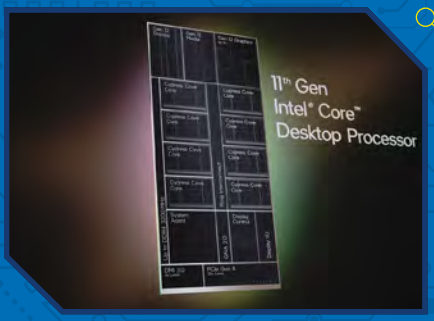
On the surface it may seem a fairly trivial task to take a microarchitecture design and manufacture it on a bigger scale. After all, isn't the tricky bit shrinking these designs? However, in practice, there are umpteen factors that make this quite a tricky process. For a start, the design needs to be tweaked to ensure it even still works on the larger transistors. The larger layout will change data path lengths, which could mess with clock timings, so the whole design needs to be re-optimised to account for these changes.

Larger transistors are generally more power-hungry too, so the density of a newer

CPU MODELS COMPARISON

The top end of Intel's new CPU range only just matches AMD's mid-range 5800X

Model	Core i9-11900K	Core i7-11700K	Core i5-11600K	Ryzen 9 5950X	Ryzen 7 5800X	Ryzen 5 5600X
SoC	Rocket Lake-S	Rocket Lake-S	Rocket Lake-S	Ryzen 5000	Ryzen 5000	Ryzen 5000
Microarchitecture	Cypress Cove	Cypress Cove	Cypress Cove	Zen 3	Zen 3	Zen 3
Cores / threads	8 / 16	8 / 16	6 / 12	16 / 32	8 / 16	6 / 12
Thermal design power	125W	125W	125W	105W	105W	105W
Base frequency	3.5GHz	3.6GHz	3.9GHz	3.4GHz	3.8GHz	3.7GHz
Turbo frequency (1-2 cores)	5.1GHz	4.9GHz	4.9GHz	4.9GHz	4.7GHz	4.6GHz
Turbo 3 frequency (1-2 cores)	5.2GHz	5GHz	N/A	N/A	N/A	N/A
Thermal Velocity Boost frequency	5.3GHz	N/A	N/A	N/A	N/A	N/A
All-core turbo	4.7GHz	4.6GHz	4.6GHz	N/A	N/A	N/A



Eight Cypress Cove cores are packed into the new Rocket Lake-S SoC

design may create problems with power delivery and hot spots on 14nm that it wouldn't on 10nm. It's for this reason that Intel has shaved off a fraction of a millimetre from the overall thickness of the CPU silicon, reducing the amount of the more thermally resistant silicon through which heat has to pass before hitting the soldered thermal interface material (STIM) and the heatspreader above.

It's also partly due to all these tweaks that Intel hasn't kept the same Sunny Cove name for its new Rocket Lake-S CPU architecture, despite it being all but identical in terms of its overall design. Instead, it has renamed the core Cypress Cove.

Core comparison

All of which brings us to today, with Intel launching a new range of CPUs with fewer CPU cores than the previous line-up, maxing out at just eight cores. That's two fewer than Comet Lake and eight fewer than AMD's Ryzen 5000 CPUs. That's a stark difference, whichever way you look at it. Intel can quite reasonably claim that eight cores is enough for the vast majority of buyers, but it's still embarrassing to only be able to offer half the number of cores as your competitor.

However, Intel promises an uplift in instructions per clock of 19 per cent with the move from Comet Lake to Rocket Lake-S, while the new Xe graphics also offers up to 50 per cent performance improvement over the Gen9.5 GPUs in Comet Lake. Given its continued manufacturing woes, those are impressive gains.

Despite the modest core count, though, Intel has slapped a hefty 125W TDP on these chips, which is the same as the 10-core Comet Lake chips and 20W more than the Ryzen line-up. The fact Ryzen doesn't include integrated graphics and uses a chiplet design certainly gives AMD more room for manoeuvre in this regard.

Intel will also offer variants of Rocket Lake-S that have the GPU disabled (with an F suffix) but these will just be the same dies with the graphics portion disabled, likely due to manufacturing defects that have damaged the GPU. They are set to be ideal upgrades for gamers, though, providing all the CPU grunt you need while saving a few pennies by ditching the unneeded integrated GPU.

Cypress Cove in depth

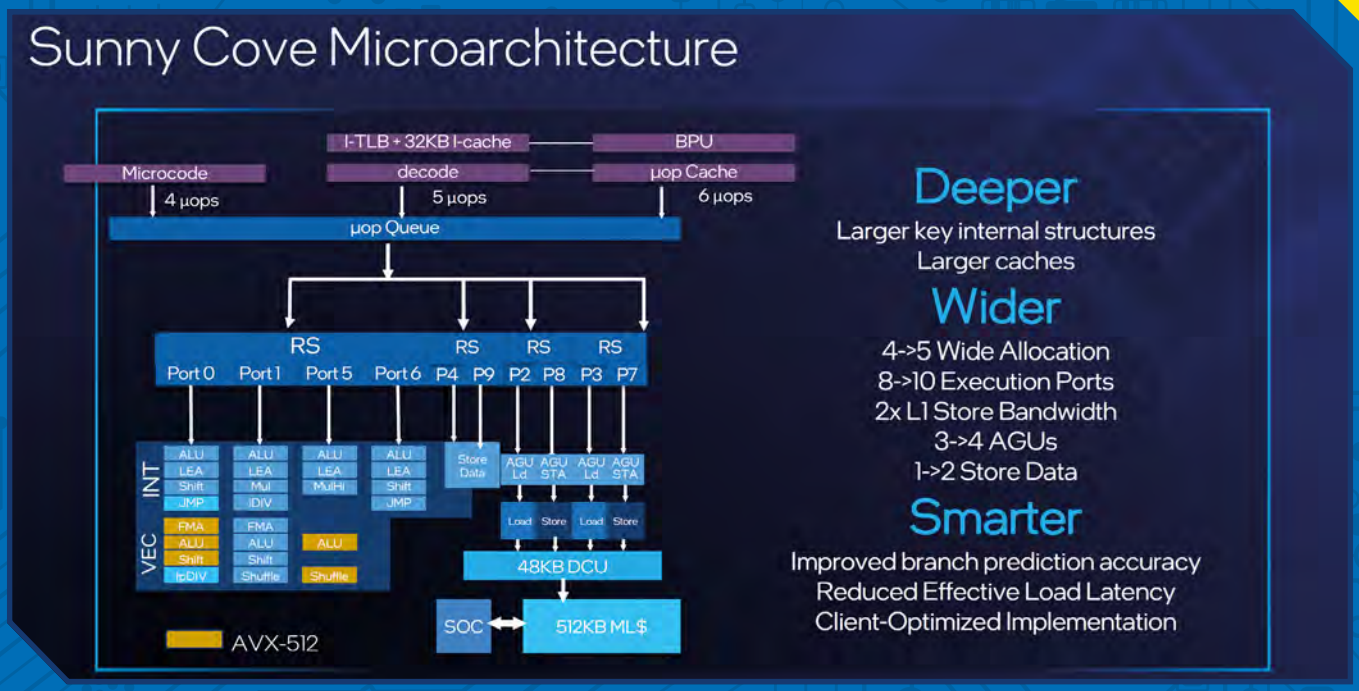
Despite Cypress Cove being an identical microarchitecture to Sunny Cove, both Cove designs are, of course, new to Intel desktop processors, and although they're not a revolutionary change from the Skylake design, there's a number of key changes. Before we get into those changes, though, as a quick recap, the basic setup of a modern CPU design has each core receiving instructions from software, which are then decoded by the core's front end into much smaller instructions called micro-ops, which are then processed by the back end or execution engine.

Balancing the speed at which the backend can churn through micro-ops and the front end can supply them is crucial to getting an overall high instructions per clock rate.

Inside the front end, caches are used to store instructions and micro-ops, and there's a lot of clever instruction prediction occurring, including a branch predictor. Branch prediction is required when a piece of software has a conditional element to it (IF this THEN do this ELSE do this) – that means there are multiple possible paths down which the next piece of code might go. Clever branch prediction sets up the rest of the CPU to deal with these multiple outcomes so that the execution engine isn't starved of micro-ops while the front end sorts itself out following a different path to the one expected.

The back end consists of an array of execution ports into which can be fed micro-ops. By having several different execution ports optimised for different functions, a range of different micro-ops can be performed at once. As such, designing the back end is all about deciding how many execution ports to have and what each one can do.

With Rocket Lake-S, the front end looks largely similar to Comet Lake from a block diagram perspective. The branch predictor feeds into the instruction cache, which is the same size as before, and it interfaces with



THESE CHANGES ENSURE DATA IS MORE LIKELY TO BE ON HAND AND ABLE TO MOVE AROUND THE CPU MORE QUICKLY AND EFFICIENTLY

The Sunny Cove microarchitecture on which Cypress Cove is based broadens the overall CPU execution path, allowing for an increase in single-threaded performance of up to 19 per cent

the microcode sequencer, decode engine (decodes instructions to micro-ops) and micro-op cache via the same 4-wide, 5-wide and 6-wide interfaces respectively.

However, under the hood there are several changes. For a start, there are unspecified changes to the branch prediction unit to increase accuracy, which helps to reduce the overall chance that the CPU wastes time and energy on incorrect path prediction.

The micro-op cache has also increased in size from 1.5K ops to 2.25K, which greatly reduces the chance that the back end will be starved of micro-ops from the front end. The reorder buffer, which manages the order of micro-ops, has also increased in size from 224 entries to 352, further increasing the overall likelihood that the data and instructions that are needed by the execution engine to operate at maximum throughput are ready and waiting.

These changes alone would probably be unnecessary were it not for Intel also increasing the size of the back end, with the execution engine increasing from eight execution ports to ten. This greater width allows for a 25 per cent increase in the number of micro-ops that can be dispatched per clock cycle.

However, not all micro-ops are the same, and indeed the execution engine's ports aren't all the same either. Each is optimised for a number of different functions, with four dedicated to integer and vector calculations, two dedicated to storing data and four address generation units (AGUs).

It's in these latter two categories that we see the new execution ports being added, so Rocket Lake-S has double the dedicated store data ports and an extra AGU dedicated to storage operations.

The net effect is that Rocket Lake-S has double the L1 cache storage bandwidth in comparison to Comet Lake, suggesting this was a key area proving a bottleneck in Intel's previous CPU designs.

Elsewhere, an increase in stores and caches throughout the core supports the greater number of storage functions and overall throughput of the CPU. In particular, the L1 data cache has increased by 50 per cent over Skylake (the first time Intel has increased the L1 data cache size in over a decade), and the L2 cache has doubled.

The L2 cache translation lookaside buffer (TLB) has also increased from 1,537 entries to 2,048. These changes all add up to ensuring data is more likely to be on hand and able to move around the CPU more quickly and efficiently, which not only helps to keep the CPU execution engine fed but helps with the integrated GPU performance too.

These sorts of increases inherently increase the local power draw for each block, which is one of the reasons why we tend to see such increases as CPU designs move to smaller process nodes that draw less power overall, because the larger thermal headroom allows it. As such, it's just the sort of area that will have been of particular concern when backporting this architecture.

The combined effect of these changes is a claimed 19 per cent increase in instructions per clock, which is largely seen borne out in our testing. These CPUs are indeed faster than Comet Lake (and sometimes faster than Zen 3) in single-threaded tasks such as gaming, and they can certainly still hold their own in multi-threaded tasks. Considering the massive gains AMD made with Zen 3 and the much discussed problems Intel is having with moving beyond 14nm, it's impressive that it has managed to close the gap to such an extent.

MICROARCHITECTURE COMPARISON

Cache and other data store sizes have increased across the board with Cypress Cove

	Haswell	Skylake	Sunny Cove / Cypress Cove
L1 data cache	32KB	32KB	Rocket Lake-S
L2 cache	3256KB	256KB	Cypress Cove
L2 translation lookaside buffer entries	1,024	1,536 16 (1G)	6 / 12 Shared 1,024 for 2M/4M 1,024 for 1G
Micro-op cache	1.5K µops	1.5K µops	2.25K µops
Out-of-order window	182	224	352
In-flight load operations	72	72	128
In-flight store operations	42	56	72

Added extras

Designing a new CPU isn't all about increasing performance for existing calculation expectations – it's also about extending support for future operations and features. To this end, Intel has added dedicated AVX-512 acceleration hardware, which allows these chips to massively outperform the competition when it comes to executing these tasks.

In basic terms, these are single instruction multiple data (SIMD) instructions (like other AVX extensions), which allow for a single instruction to be performed on up to 16 32-bit numbers all in one clock cycle. They're very useful functions for certain applications, such as AI, scientific workloads and video encoding – basically anything that has a predictable large data set that needs the same operation performing on it.

Indeed, Intel boasts of the added deep learning capabilities of these chips thanks to Intel's DL Boost technology, which is essentially a library of AVX-512 instructions. However, AVX-512 instructions are relatively rare for gaming and most everyday computing, where data is less predictable.

Regardless, testing by **anandtech.com** has shown that although Intel's AVX-512 acceleration is impressively fast, it causes massive spikes in power consumption and heat. The Core i7-11700K could hit as high as 290W peak power usage under these loads with a sustained draw of 225W. In the same peak power test, AMD's 5800X hit just 140W, although it also delivered a fraction of the performance.

This is why Intel offers an AVX-512 offset in its overclocking options, so you can tell the CPU to not use the overclocked settings for these functions, because an overclock while using AVX-512 acceleration would almost certainly guarantee a crash, but that same overclock could be fine for normal everyday use.

Xe Gen 12 graphics

Rocket Lake-S processors without the 'F' suffix also feature a significantly uprated graphics system. In fact, while Intel is jumping forward one generation with its CPU core design for Rocket Lake-S, it's jumping two generations ahead with its graphics, using the brand-new Xe graphics debuted in the just-launched Tiger Lake mobile processors.

Xe is a new graphics architecture for Intel that's been built from the ground up, with a new instruction set and some major reworkings of its internal processes, resulting in a claimed 50 per cent increase in performance for these desktop processors. However, externally, it doesn't necessarily appear that different in terms of its capabilities.

In particular, while both AMD and Nvidia's latest graphics cards brought full support for DirectX 12 Ultimate, Intel has only implemented some features. For instance, while you do get Tier 1 variable rate shading (VRS), you don't get Tier 2. You also don't get ray-tracing support of any kind. The latter is understandable for an integrated GPU, given that it's tough for even discrete GPUs to offer ray tracing at playable speed, but it still means there's plenty of catching up for Intel to gain feature parity with AMD and Nvidia's discrete GPUs.

The version of Xe graphics used in both the integrated desktop and mobile CPUs is the low-power version (Xe-LP), but there are also several variants of Xe for use in different systems. Joining the LP version that's used here, there's a high-performance gaming (HPG) variant aimed at use in discrete graphics cards and a high-performance (HP) option for use in data centre applications. However, there's no sign of the discrete GPU options as yet, and the HP data centre models only became available last November.

Taking a closer look at Xe-LP, there's plenty going on here, starting with the smallest principal structure of the design, the execution unit. In the Gen9 graphics of Comet Lake, each execution unit (EU) contained two 4-wide arithmetic logic units (ALUs), one of which was for floating point and integer functions (FP/INT), while the other was for enhanced maths functions such as trigonometry and logarithms. Each EU also had its own thread controller, thread state, and send and branch units. Instructions were separated off to be performed four at a time on each unit.

AVX-512 INSTRUCTIONS ARE RARE FOR GAMING AND MOST EVERYDAY COMPUTING, WHERE DATA IS LESS PREDICTABLE

For Xe, each EU now has one 8-wide ALU that can perform eight FP/INT calculations, along with a separate 2-wide complex maths unit that can run concurrently with the FP/INT pipeline. The thread controller is now also shared across two EUs.

This generally wider instruction setup is in line with the structures used by AMD and Nvidia in their latest graphics designs. However, it's still a long way off being as wide. Nvidia's Ampere breaks down workloads to be executed on a 32-wide scalar processor, while AMD Navi uses two 32-wide scalar processors. Nonetheless, the move from a 4-wide design to an 8-wide model should improve efficiency.

What's more, with all eight ALUs now able to run concurrently, integer performance has

doubled relative to Gen9. In addition, the new architecture adds support for 2x INT16 (16-bit) calculations and 4x INT8 (8-bit) calculations, increasing the performance gain of opting to use these lower-precision numbers for less critical calculations.

Next up in the overall structure of Xe is the subslice. This structure contains 16 EUs and incorporates an L1 cache, thread dispatcher, shared local memory (SLM), load/store and media sampler. In comparison, each subslice in Gen9 contained only eight EUs and didn't include an L1 cache, instead relying solely on the L3 cache shared across the whole GPU.

Accordingly, the full-fat Xe-LP combines six subslices with the L3 cache, geometry, raster and pixel dispatch engines, and several other blocks to form the full GPU. Gen9.5, though, would use eight subslices. In total, that gives the likes of Tiger Lake a whopping 96 EUs while Gen9.5 maxed out at 64.

Back to these desktop processors though. The Xe-LP graphics in Rocket Lake-S is a cut-down variant compared with the one found in Tiger Lake mobile processors. Instead of 96 EUs, you get just 32, which corresponds with only two subslices being implemented rather than six. This compares to the 24 EUs used in the Gen9.5 graphics of Comet Lake (three subslices), amounting to a 33 per cent increase in the total number of EUs.

As well as 3D graphics processing, the display engine of Rocket Lake-S also brings improved display output support. It will support up to three displays at up to 5K/60Hz with HDR support and can also support 4K/60Hz over embedded DisplayPort. HDMI 2 support has been added too. Video decoding has been improved as well, with 10-bit AV1, 12-bit HEVC and end-to-end video compression. In other words, ever higher resolutions, greater colour depths and the latest compression and transmission techniques have been embraced.

Intel also makes a point of showing that Rocket Lake-S supports resizable BAR, which AMD introduced a few months ago with the Smart Access Memory moniker. This allows a CPU to access the entirety of a GPU's VRAM, where previously it was restricted to just using 256MB, allowing for reasonably impressive performance gains particularly in games. However, resizable BAR has already been implemented on Comet Lake, so it's not really a new addition here.

Motherboard chipsets

Alongside its new CPUs, Intel is launching its new 500-series chipsets, with support for PCI-E 4 and DDR4 3200 among other features. However, in something of a surprise move – especially considering that PCI-E 4 support – Intel is also making Rocket Lake-S chips backwards compatible with most existing 400-series motherboards.

Only H410 and B460 boards won't support the new chips, as they lack the PCI-E lane support. Exact board support will vary and depend on firmware updates, but if you bought a 400-series board, it's worth checking the website – some of them are even capable of supporting PCI-E 4 with the new CPUs.

Further sweetening the deal for those looking to upgrade is that the new 500-series chipsets are also backwards compatible with Comet Lake processors, so for those who need a motherboard upgrade first, they can still use their old CPU. This isn't quite the level of backwards compatibility that AMD has managed to offer with its Ryzen processors over the years, but it's good to see Intel making some positive moves in this direction.

Aside from PCI-E 4, there aren't many hugely significant upgrades, but there are a few features that are good to have. USB 3 Gen 2x2 support is now included, with up to three ports available on Z590 motherboards. USB audio offloading is also supported, along with Thunderbolt 4 and the latest Wi-Fi 6E standard. The company's proprietary DMI link that connects the CPU to its chipset now also supports 8x DMI 3, doubling the bandwidth between the chipset and processor.

Intel is also launching the H570, B560 and H510 chipsets, which have fewer features. Unlike AMD's B-series chipsets, you can't use these cheaper chipsets to overclock your CPU, although the H570 and B560 chipsets will support memory overclocking, which was previously only available on Z-series motherboards.

Overclocking

Intel has implemented the same system for denoting which of its new CPUs will be overclockable, with a K suffix on the model names showing an unlocked multiplier. However, it's telling that Intel has chosen to

COMET LAKE VS ROCKET LAKE-S

Rocket Lake-S brings a host of new features, including PCI-E 4 and AVX-512 acceleration

	Comet Lake	Rocket Lake-S
CPU cores	Up to 10 cores / 20 threads	Up to 8 cores / 16 threads
I/O	CPU - 16x PCI-E 3	CPU - 16x PCI-E 4 + 4x PCI-E 4
	PCH - USB 3.2 Gen 2x1 (10G)	PCH - USB 3.2 Gen 2x2 (20G)
Graphics	Intel Gen 9 Graphics	Intel Iris Xe Graphics Architecture (Gen 12)
Memory	Up to 2933MHz DDR4	Up to 3200MHz DDR4
Software instruction sets	AVX and AVX2	AVX, AVX2, AVX-512, VNNI and GNA 2
Display	HDMI 1.4, HDCP 2.3, DisplayPort 1.4	HDMI 2b, HDCP 2.3, DisplayPort 1.4a
DMI	4x DMI 3	8x DMI 3
Wireless	Integrated Intel Wi-Fi 6 802.11ax	Discrete Intel Wi-Fi 6E 2nd-gen 2x2 802.11ax
Thunderbolt tech	Discrete Thunderbolt 3	Discrete Thunderbolt 4
	USB 3.1 and DisplayPort 1.4	USB 4 compliant

INTEL 500-SERIES MOTHERBOARD CHIPSETS

Intel is introducing four new 500-series motherboard chipsets, and for the first time, more than one of them supports memory overclocking

	Z590	H570	B560	H510
IA and BLCK overclocking	Yes	No	No	No
Memory overclocking	Yes	Yes	Yes	No
Total high-speed I/O (HSIO) lanes	50 (20 CPU + 30 PCH)	50 (20 CPU + 30 PCH)	50 (20 CPU + 24 PCH)	50 (20 CPU + up to 14 PCH)
Total PCI-E lanes (CPU PCI-E 4 + PCH PCI-E 3)	Up to 44 (20 CPU + up to 24 PCH)	Up to 40 (20 CPU + up to 20 PCH)	Up to 32 (20 CPU + up to 12 PCH)	22 (16 CPU + up to 6 PCH)
CPU PCI-E 4 lanes configuration support	1 x 16x + 1 x 4x / 2 x 8x + 1 x 4x / 1 x 8x + 3 x 4x	1 x 16x + 1 x 4x	1 x 16x + 1 x 4x	1 x 16x
Chipset PCI-E 3 lanes	Up to 24	Up to 20	Up to 12	6
DMI 3 lanes	8	8	4	4
SATA 6Gbps ports	Up to 6	Up to 6	Up to 6	4
System memory channels	2/2	2/2	2/2	2/1
Total USB 2 ports	14	14	12	10
USB 3.2 Gen 2x2 (20G) ports	3	2	2	0
USB 3.2 Gen 2x1 (10G) ports	10	4	4	0
USB 3.2 Gen 1x1 ports	10	8	6	4
Intel Rapid Storage Technology for PCI-E 3 storage ports (2x/4x M.2)	3 PCH	2 PCH	1 PCH	0
Intel Optane Memory support	Yes	Yes	Yes	No
Intel Rapid Storage Technology 18.3x	Yes	Yes	Yes	Yes
PCI-E RAID 0,1,5 support	Yes	Yes	Yes	No
SATA RAID 0,1,5,10 support	Yes	Yes	No	No
Discrete Intel Wi-Fi 6E and 6 support	Yes	Yes	Yes	Yes
USB audio offload	Yes	Yes	Yes	No
Bluetooth audio offload	Yes	Yes	Yes	No

focus on the memory overclocking capabilities of Rocket Lake-S than the CPUs themselves, as there's not a lot of headroom outside of extreme overclocking.

In our testing, in most instances we couldn't get the whole chip to surpass its single-core boost clock with an all-core manual overclock, rendering it pointless for workloads that aren't heavily multi-threaded.

However, the company is bullish about the new memory controller on Rocket Lake-S, predicting an increase in the average memory overclock result over previous chips. Plus, of course, these CPUs now officially support faster memory in the first place. The new controller also has gear two support, which essentially halves the clock speed in some instances, maintaining stability while allowing a faster maximum clock speed when overclocked. Latency options have also been widened to allow even greater options when it comes to balancing bandwidth and latency.

With this memory overclocking supported on H570 and B560 motherboards, as well as Z590, Intel has opened up the option of performance tweaking even on those cheaper boards. In addition, some high-end boards will allow you to switch the memory frequency live in Windows via Intel's Extreme Tuning Utility.

Intel has done its best to at least make it easy to get the most from its overclockable processors too. Its refreshed Extreme Tuning Utility includes AVX2 and AVX-512 offset options, as well as the option to completely disable AVX overclocking. The tool also provides the ability to disable Hyper-Threading on a per-core basis and apply a degree of per-core frequency control. The parameters that govern the Thermal Velocity Boost frequency can also be tweaked, allowing for even more performance to be extracted when the CPU is pushed to its thermal limit.

Real-world performance and power draw

While we've covered the relative performance of just about the entire desktop CPU market in our massive Labs test on p40, it's worth summarising the takeaways.

Two of our main tests take full advantage of as many cores as a CPU can offer. As such, we really saw the dominance of AMD's Ryzen 5000-series processors when it comes to this sort of parallel major number

Overclocking Enhancements

Even more gaming power and performance

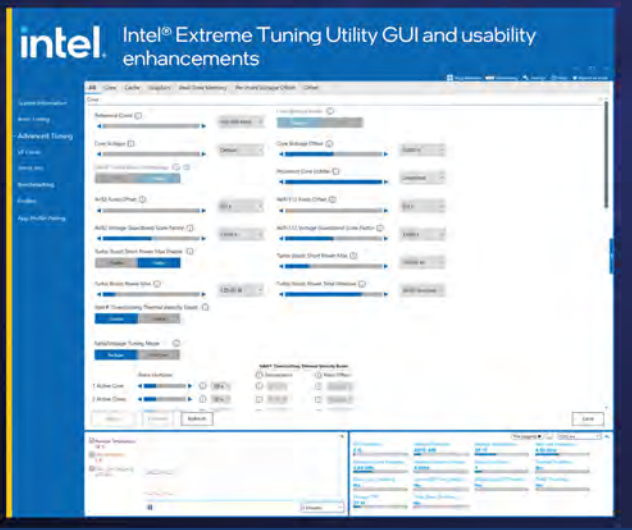
11th Gen desktop processors introduce new tools and features that deliver a more flexible overclocking and tuning experience.

New Overclocking Improvements

- Memory Overclocking on H570 and B560 Chipsets
- Integrated Memory Controller with Gear 2 & wider timings
- Real-time Memory Frequency
- AVX2 and AVX-512 Offset & Voltage Guard-Band Override
- AVX disable/enable option

Continued support for overclocking features

- Intel® Extreme Memory Profile (XMP)
- Intel® Overclocking Thermal Velocity Boost
- Per Core HT enable/disable
- Base Clock (BCLK) Overclocking
- Limited Per Core frequency
- PLL Trim Control for Core, Ring, Memory
- ...and more



INTEL HAS JUST ABOUT SCRAPED TOGETHER A CONVINCING PERFORMANCE ARGUMENT WITH ROCKET LAKE-S

crunching. Surprisingly, those processors also comfortably came top in our only lightly threaded image editing workload as well, showing that AMD really does still have solid all-round performance.

This is also borne out in Cinebench R23, where the Core i9-11900K does take top spot in the single-threaded test but by just three points, or just 0.2 per cent over the 5950X. Meanwhile, in the multi-threaded Cinebench test, the Ryzen 9 5950X beats the Core i9-11900K by 70 per cent. Even the 8-core 5800X pulls out a 3 per cent win here. When it comes to gaming, it's again a bit of a mix, with the Core i9-11900K trading blows with the Ryzen 9 5950X, but ultimately Intel has come out on top, if not by a huge margin.

As for power consumption, while edge cases such as AVX-512 acceleration can cause massive spikes on Rocket Lake-S, in our tests, the power draw wasn't quite so dramatic, but AMD still clearly has the edge here. Under load, our Intel test system drew 285W from the mains with the Core i9-11900K installed, which is certainly a lot, especially when compared to our AMD test system drawing just 215W from the mains with the Ryzen 9 5950X installed, despite the latter having double the number of cores.

However, that chip only ever uses the very best dies AMD can produce, which run at very high clock speeds without drawing too much power – as such, in these times it's very hard to find in the shops. As a more direct comparison with the Core i9-11900K, our test system drew 237W from the mains with the 8-core Ryzen 7 5800X installed – a chip that isn't binned quite so aggressively. That's still quite a lot less than the Core i9-11900K, but it's in the same ballpark for the core count.

The power draw situation is starker when we drop to the Core i5-11600K. Our Intel rig drew 235W with this chip at load, despite it being a 6-core part, whereas our AMD rig only drew 164W with the Ryzen 5 5600X at load. While the Core i5-11600K offers better bang per buck than the Ryzen 5 5600X, you'll want a decent cooler for it, and if you regularly run your PC at full load, the AMD chip will result in a smaller electricity bill too.

A mini comeback

When Intel first revealed that its new top-end desktop CPUs would be dropping down from ten to eight cores, many saw this as a capitulation, and in many ways, that has proven to be the case. For all the impressive gains in single-threaded performance with Rocket Lake-S, there's no getting round the fact that these are mid-range parts at best, even if it may seem odd to call a £500, 8-core CPU mid-range. You may not be able to buy an AMD Ryzen 9 CPU for love nor money but it categorically owns the high end of the market now, if multi-core performance is a concern.

Where multi-core performance isn't so much of a concern – and even for those apps that do support multiple threads, many don't truly take advantage of as many as 12 or 16 cores – Intel has just about scraped together a convincing performance argument with Rocket Lake-S. Its new CPUs are either close or ahead of Zen 3 in single-threaded performance, and once again Intel can comfortably claim the gaming performance crown, even if the margin is slim.

It's with this in mind that Intel is potentially set to clean up when it comes to CPU sales, as all the talk is of stock being ample at the moment. Rocket Lake-S may not be a record-setting halo product of a launch, but it's fast enough for most people, it's reasonably priced and there's a good chance you'll actually be able to buy one. **CPC**

Intel has expanded its overclocking capabilities, but there's not a lot of performance headroom in Rocket Lake-S

SUPPLY STRAIN

OVER THE LAST TWELVE MONTHS, BUYING A GRAPHICS CARD HAS BECOME HARDER THAN EVER. **RICK LANE** INVESTIGATES WHY

If you tried to buy a GPU in the past 12 months, chances are you struggled. If you tried to buy a GPU in the past six months, chances are you found it next to impossible. The launch of Nvidia's Ampere GPUs and AMD's Radeon 6000 series have both been met with unprecedented demand – demand that both companies have failed to meet. The likes of the RTX 3080, the 3060 and the Radeon 6800 all sold out within minutes of launch, and beyond a few brief windows of new stock, have been largely unavailable since.

But it isn't only these latest graphics cards that have become remarkably scarce. Head over to a retailer such as Scan or Overclockers, and you'll find that nearly all GPUs are either only available for pre-order, or not available at all. At the time of writing, the only Nvidia GPU you could purchase outright on Scan's website was a refurbished GeForce RTX 2080 Ti, which would set you back a whopping £1679.99. On Overclockers, meanwhile, you'd have to scan through five pages of unavailable cards before arriving at a product you could buy – another GeForce RTX 2080 Ti, going for £2,000.

It's reasonable to ask, what the hell is going on? Why is it next to impossible for a regular person to acquire a current-gen graphics card, let alone one at a reasonable price? The answer to this question is complicated, but to briefly summarise, it involves multiple unprecedented events that have rocked the manufacturing and distribution pipelines for GPUs, combined with several ongoing problems that have come to a head at the worst possible time.

'It's almost like a perfect storm of multiple different causes for the shortage,' says James Gorbold, director of content at Scan Computers. 'That's probably the main thing that I always try to get across to anybody.'

Pandemic pandemonium

By far the biggest and most immediate disruptor to the GPU industry is, of course, the Covid-19 pandemic.

As the world grappled with adjusting to a new reality across the first half of 2020, the various rules regarding lockdowns and ensuring safe working environments inevitably

impacted on both the manufacture and distribution of GPUs. Gorbold states that the pandemic began to cause problems sourcing hardware towards the end of 2019, when the lead time – the time between ordering a product and having it delivered into the warehouse – started to increase dramatically. 'The lead time on a lot of products were starting to double, which was a very worrying early sign,' he says.

Longer lead times on hardware shipping isn't unusual in the run-up to Christmas. China is the primary thoroughfare through which hardware components are shipped from their main manufacturing base in Taiwan (primarily from chip manufacturer TSMC), and the shipping companies are always busier than usual around that time of year.

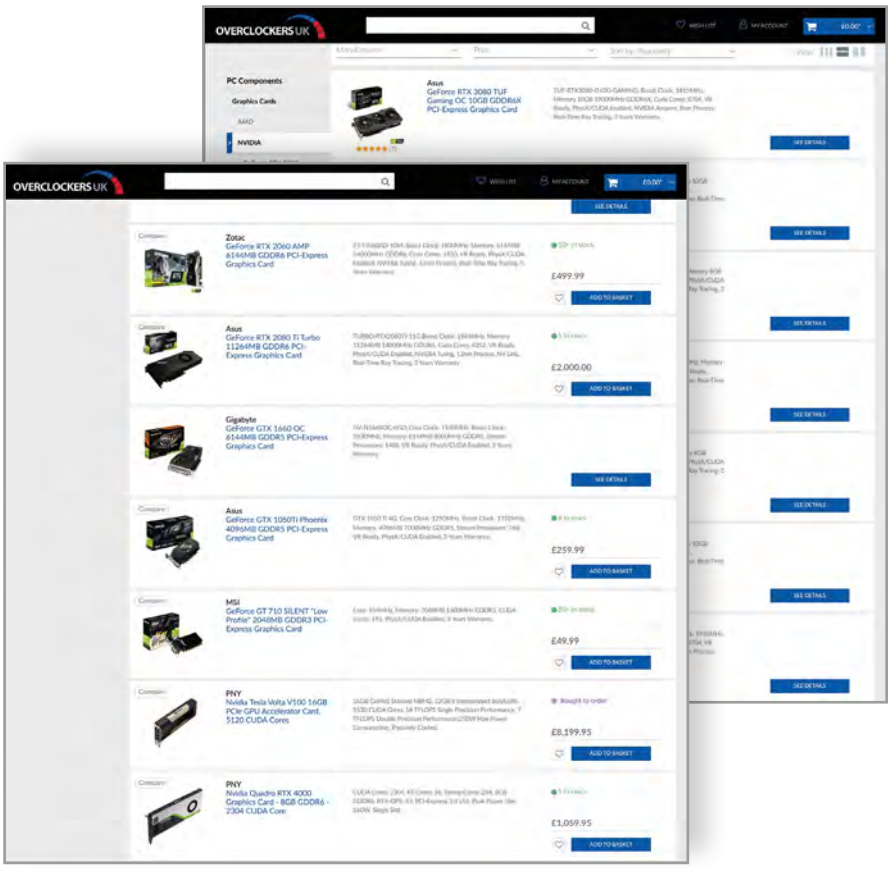
The difference during the 2019/2020 holiday season, however, is that after the New Year, those lead times didn't return to normal. By 29 January, all provinces in mainland China had implemented stringent lockdown measures. 'That also started to mean the cost of components increased as anything does during scarcity,' Gorbold says.

When the pandemic hit the UK, local retailers also had to reorganise to comply with lockdown and establish appropriate safety measures. In Scan's case, around 50 per cent of the company switched to working from home in late February, while the warehouse staff and the PC-building staff remained working on-site. Gorbold states that Scan experimented with PC-building staff working from home, but this dramatically increased Scan's own lead times.

'Our PC build facility and the warehouse are right next to each other,' he says. 'There are big benefits there in terms of logistics, because if you've got a bad cable, you can just send somebody down to the warehouse, get another cable, and that only delays the build by a few minutes. Whereas if you've got somebody building a PC in their home, how do you manage that?'

Lead times for shipping components from China continued to fluctuate during 2020. Gorbold states that, at the time of writing, they're 'similar to what they were pre-pandemic'. However, this isn't enough to compensate for the other effect the pandemic had on hardware availability – the massive (and we mean massive) increase in demand.

For Scan, demand began to spike around the first lockdown. Initially, this was mostly for office equipment such as laptops, webcams and office-based PCs, a consequence of people suddenly working from home needing to set up an office space. This may not appear to have much relevance to GPUs, but the huge spike in demand for office tech had a knock-on effect at the manufacturing level.



Overclockers has five pages of unavailable cards before you reach a product you can buy, including a last-gen card going for £2,000

> THE LEAD TIME ON A LOT OF PRODUCTS WERE STARTING TO DOUBLE, WHICH WAS A VERY WORRYING EARLY SIGN

'The actual manufacturers had very hard decisions to make.' Gorbold explains. 'Do they make unsexy office PCs for which there's suddenly massive demand? Or do they carry on making gaming motherboards for which there's, let's say, normal demand?'

Demand for office equipment has remained high throughout the pandemic. However, as lockdown progressed, this was accompanied by a second wave of demand specifically for gaming hardware.

Due to almost everyone being stuck at home, unable to go out to the pub or restaurants or on holiday, the residual income that would have been spent on those luxuries has instead been directed towards home entertainment, including gaming PCs.

'I think that there's been two things, not just a typical **Custom PC** reader going "Oh, I'm going to upgrade". But there's actually been a lot of new gamers coming into the market,' Gorbold says.

Brexit bureaucracy

The pandemic has had such a drastic effect on the hardware industry, let alone everywhere else, that we could easily spend this entire feature discussing it. But it's far from the only issue that's caused the hardware shortages of

Scan updates its customer service status daily, letting customers know how well they are currently able to keep up with demand

IN DECEMBER, THE ENTIRE NETWORK FOR SHIPPING FREIGHT FROM CHINA INTO THE UK WAS THROWN INTO CHAOS

the last year. Another major factor is everyone's other favourite topic of discussion in the UK, Brexit. In January, the legal ramifications of Britain's withdrawal from the European Union came into effect, meaning significant changes for any company trying to either trade with or ship products between the UK and the EU. This has had consequences for all UK hardware retailers and PC specialists attempting to get stock in across the English Channel.

'It's been a big impact,' says Steve Mason, Office Manager at CyberPower UK. 'Because a lot of the people from whom we buy products – the likes of MSI, Asus, Corsair and Cooler Master – might be based out of and manufacturing things out in the Far East, have European hubs from which they distribute a lot of their products. With the likes of MSI, for example, depending on where the stock is and how they're managing their inventory, we'll place an order with them for motherboards, graphics cards and so on. Some may come to us from Holland, others from Hong Kong.'

As with the pandemic, problems began before Brexit's transition period ended. In November and December 2020, uncertainties over whether the UK would leave the EU with a deal or not caused a surge in businesses trying to get as much stock out of the EU as possible, resulting in huge backlogs of freight trying to cross the border.

For example, CyberPower buys a lot of stock, including Intel processors, from Arrow Electronics, one of the biggest distributors in the UK, but Arrow's warehouses are located in the EU. 'I place an order with them on a Monday, we usually see stock on a Wednesday,' Mason says. 'That changed completely because during December the backlogs began, as people wanted to get as much stuff out of Europe as they possibly could just in case there was no deal. So lead times went from being one-to-two days, to one-to-two weeks.'

When January 2021 came around and the new trading regulations came into effect, the result was a significant complication and general slowdown of imports that Mason states was 'almost a replication' of the problems encountered with supply around March 2020.

'It takes a lot longer for things to be processed now, because the amount of administration is huge compared with what it was,' he explains. 'What it used to be was, you sent a purchase order, you received your order. That was it. Whereas now, there's customs codes, which we have to make sure that what we have on our declarations matches what's coming in for our vendors ... and if you get it wrong, it's inordinately expensive.'

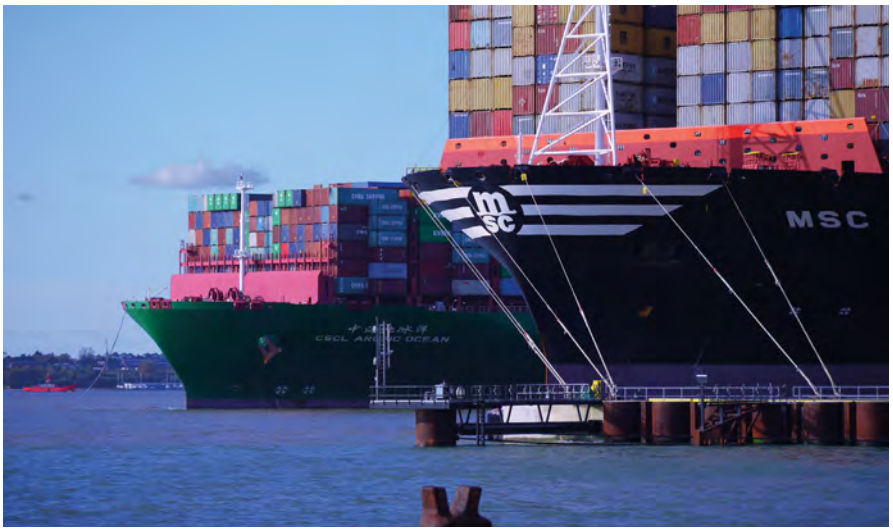
Compounding the problem was a general lack of guidance on filling in the massive amounts of new paperwork, not just for firms such as CyberPower, but for the courier and haulage companies such as DPD too. 'They were kind of, not making it up as they go along, but they were feeling it out as best they could, as with the rest of us,' Mason says.

The end result was that January and February were 'a huge mess' for bringing stock over the border in the UK. And all of this was occurring while the unusually high demand for PC hardware was still ongoing. As an example of the spike in demand, Mason notes that typically, CyberPower would expect to receive around 1,000 call from customers per month. During the pandemic, it received between 10,000 and 15,000 calls per month. 'You just can't step up to that,' he says.

Shipping shenanigans

The new regulations brought into force in January undoubtedly caused considerable disruption importing hardware into the UK. Astonishingly, however, events transpired

The transport situation in the run-up to, and shortly after, Brexit hasn't helped component supply



In December last year, congestion at the port of Felixstowe caused significant disruption in hardware imports. Image courtesy of the port of Felixstowe

towards the end of 2020 that were even more disruptive than Brexit. In December, the entire network for shipping freight from China into the UK was thrown into chaos by a combination of greedy shipping companies based in China, and massive congestion in UK ports.

As stated earlier, the holiday season is normally the busiest time of year for shipping freight from China. However, late 2020 saw unparalleled demand on Chinese shipping lines for a whole range of different products. The problems began earlier in the year, when China began exporting massive amounts of PPE as a consequence of the pandemic. Then, the months between September and December saw the release of new Apple and Samsung phones, the PlayStation 5 and the Xbox Series X/S, plus the new range of Nvidia and AMD GPUs, all of which were shipping out of ports such as Shanghai and Yanshan.

'The ports in China started to get quite busy,' Mason says. 'The boats basically became full out there – that's not happened for a long, long time. And this created a whirlwind of problems that continues as we speak. What basically happened is the shipping lines – I'll say it – they effectively held people who move containers around to ransom.'

Mason explains that, typically, a 40ft container costs £2,500 to ship from China to CyberPower's location in Gateshead. However, as demand increased and capacity dwindled, shipping companies such as CMA and ONE began jacking up the price. 'At one point, we were being quoted prices like £16,000 to move a 40ft container, without being guaranteed space on a vessel,' Mason says. 'They basically became pirates.'

The net result of this was a further slowdown of freight reaching the UK, and an increase in the cost of PCs and components. Mason states that where transport costs factored into a PC build normally come in at around £2-£3, that has since increased to £10-£15 per PC due to the exorbitant costs of shipping the parts out of China.

And this is just getting hardware out. Getting the hardware in has proved to be a whole other problem. In December last year, Felixstowe, the largest cargo port in the UK, became so congested that it basically shut down. A combination of delayed PPE shipments, IT problems and an excess of empty cargo containers stuck in port brought the whole operation to a standstill.

This meant ships had to reroute to other ports in the UK such as Southampton and London, which also became full. This in turn meant that ships ended up having to land cargo anywhere they could find, including outside the UK in places such as Antwerp, Rotterdam and even further afield.

Mason cites one example where a shipment of PC cases from NZXT ended up in Tangier, lost among hundreds of other containers that had built up as a consequence of all these delays. 'It was basically dropped off and just dropped,' Mason says. 'So all of these containers are basically forming this sort of metal city in Tangier, but there's no rhyme or reason or order to where everything is.'

As with the Brexit-related upheavals, the congestion issues in British ports have since settled. Shipping costs, however, while reduced from the highs seen in December, are still far higher than usual – between £5,000 and £10,000 according to Mason.

Crypto chaos

For all the disruption they've caused, the above events are, for the most part, freak occurrences. Going by historical precedent, the pandemic is likely to be a once-in-a-century event, with its end now hopefully in sight. Brexit, for all its

Tangier Med port, where CyberPower's NZXT container ended up

The GeForce RTX 3060 is Nvidia's first card developed with anti-crypto mining protections in its drivers

long-term implications and complications, isn't going to happen again. The various causes of last year's shipping debacle are unlikely to come together in the same way twice.

There is one issue, however, that has been smouldering away for years, and is unlikely to go away anytime soon. Specifically, it's two separate problems, but they come together to produce the same effect of depriving the market of GPUs. They are cryptocurrency mining and hardware scalping.

Hardware scalpers have been around for a long time, nibbling at the underbelly of GPU sales. However, the surge in popularity of crypto mining, catalysed by the skyrocketing price of Bitcoin and miners hoping to capitalise on similar price rises with other cryptocurrencies such as Ethereum, makes the two practices primary drivers behind why graphics cards sell out so quickly upon release.

From the retailer perspective, Scan has practices in place to try to minimise the effect of scalpers and miners. On the website, you can only order one card, and that accounts for the same series of card made by different manufacturers. In addition, Scan has processes in place that attempt to identify scalpers and miners apart from general consumers. 'You'll find scalpers setting up 20 user accounts, but they're all linked to the same bank account,' Gorbold says. On top of that, the Scan team also watches places such as eBay.

But these issues are considerably more long-running than the other factors we've discussed, so why are they still struggling with them? Gorbold compares it to an arms race. 'Somebody invents a better armour and suddenly your bullets are useless. So then somebody invents better bullets, and then somebody has to make better armour, and then somebody has to make better bullets,' he says. What's more, as crypto mining becomes more popular, these problems are only going to be exacerbated as miners grow more savvy about acquiring cards.

Ultimately though, only so much responsibility can be placed on the shoulders of retailers for grappling with these issues. While to an extent they can control to whom they sell, they can't ultimately control how many graphics cards manufacturers give to them, or the appeal of those cards to miners and scalpers in the first place. So what do the manufacturers have to say about all this?

Manufacturer maladies

Unfortunately, both AMD and Nvidia chose not to be interviewed for this article. Given that they're responsible for the production of the chips in such high demand, and therefore understand the situation better than anyone, and considering the larger number of people seeking answers to these ongoing and unprecedented stock issues, this isn't a constructive stance to take.

AMD did provide a statement to **Custom PC** claiming the company 'is focused on ensuring we have as much supply of Radeon RX 6700 XT graphics cards as possible available beginning 18 March'. In addition, AMD stated that it has 'implemented a number of processes to help prevent bots from purchasing products on **amd.com** and are manually auditing orders to limit the ability to order multiple products', which sounds similar to the process Scan has in place.

Further to this, AMD answered some questions posed during its reveal of the 6700 XT. When asked whether the company's new suite of cards will block mining features in any way, AMD's Director of Product Management Nish Neelalojanan said that 'the short answer is no, these will not be blocking any workload'.

Neelalojanan argued, however, that both the architecture and optimisations of the 6000 series makes it less viable for mining anyway, stating that 'mining specifically enjoys or scales with higher bandwidth and bus width, so there are going to be limitations naturally from an architectural level for mining itself. And also all our optimisations work, as always, is going to be gaming first'.

It's true that Nvidia's cards are more optimal for crypto mining than AMD's cards. However, that isn't going to prevent crypto miners from buying them for that purpose when there are no Nvidia cards available, which is the current situation. In addition, AMD's supply of cards has, of late, been considerably smaller than Nvidia's cards, making it even harder for PC users to acquire one between the scalpers and the crypto miners.

Neelalojanan also responded to this issue of stock levels, stating, 'What we're trying to do is have our partner cards available at the same time as our reference cards – this is an effort to get as many cards on the shelf on day one as possible.'

He also reiterated the point about bot-detection solutions and limiting multiple orders, alongside 'trying to have more cards available in physical retail stores, so that gamers can actually go and buy it'. There may have been more 6700 XT cards available on launch compared with other recent releases such as the Radeon RX 6800 series, but that still hasn't stopped them selling out minutes after launch.

Also, Nvidia's historically higher output hasn't prevented its cards from selling out

THE RTX 3060 HAS A BUILT-IN LIMIT ON HASH RATES IN AN ATTEMPT TO MAKE IT LESS PRODUCTIVE FOR MINING

AMD has promised more GPUs on shelves and more stringent anti-scalping measures for the launch of the Radeon RX 6700 XT

either, so AMD's approach seems unlikely to be sufficient to solve the problem. In addition, having cards available in physical retail stores doesn't help much when those stores aren't allowed to open due to lockdown measures.

Nvidia's response, by comparison, amounted to pointing us to a transcript of a finance call with Nvidia's CFO Collette Kress. In the call, which was made in late January, Kress admits that 'supply does remain tight at this time' and that 'our overall capacity has not been able to keep up with that overall strong demand we have seen'. In addition, on the subject of GPUs being used for crypto mining, Kress states that 'we don't have visibility on how much of the RTX 30-series demand comes from mining. We don't believe it's a big part of our business today'.

Given how these shortages coincided with the surge in cryptocurrency interest around the launch of the GeForce 30 series, this seems like an odd statement, while Nvidia's own policy towards the issue of cryptocurrency implies it's bigger than Kress makes out. In 2017, Nvidia's own investors actually filed a class-action lawsuit against the company, claiming the company had intentionally misled them over the number of sales being a consequence of crypto miners, although this case was dismissed in March this year.

However, unlike AMD, Nvidia has made an active effort to curtail the use of gaming GPUs in crypto mining. The RTX 3060 has a built-in limit on hash rates in an attempt to make it less productive for mining, dropping them to roughly 50 per cent of normal performance. At the same time, Nvidia has unveiled the CMP HX, designed specifically for crypto mining as an attempt to lure miners away from gaming GPUs.

It's an interesting strategy. Unfortunately, it also appears doomed to failure. While the RTX 3060 has driver protections against mining Ethereum, it can mine other cryptocurrencies in small amounts. A bigger problem, however, is that the 3060's anti-mining protections have already been cracked by Chinese crypto miners using customised mods, unlocking its full hashing potential. Nvidia later released a new driver for the RTX 3060 without the mining limit, which it says was an accident, but either way, the RTX 3060 is now fully capable of mining.

A fractious future

Many of the factors that contributed to the great GPU shortage of 2020 are slowly improving. Regarding the pandemic, it's likely the UK will return to a situation resembling normal operation within the next six months. The distribution pipeline for PC hardware is getting a handle on the new customs regulations and paperwork imposed by Brexit. Shipping costs are still abnormally high, but they're returning towards an equilibrium. It's reasonable to expect an increase in supply and a reduction in demand of GPUs through 2021.

Yet while it will likely become easier to buy a new GPU within the next few months, it still won't be easy. Crypto mining is only going to become more popular, not less, while hardware scalpers will be around as long as there's hardware to scalp. It's imperative that hardware manufacturers take these problems seriously. The fact that Nvidia doesn't even appear aware of the extent of the mining market is deeply troubling.

There are also further problems affecting the hardware market that we simply didn't have the space to discuss. There's currently a world shortage of semiconductor material, fundamental to all electronics from automobiles to GPUs. Indeed, the auto industry and the hardware industry are increasingly in competition. As vehicles become ever more reliant on computer chips, that demand takes on growing significance in chip manufacturing to the detriment of the GPU market.

The problems faced by the GPU market in the past 12 months may have been dramatic, but they were also, for the most part, short-term. The challenges that lie ahead have no foreseeable endpoint, and if they aren't tackled head on, this may well not be the last time that hardware stores are lined with empty shelves **CPC**

GARETH HALFACREE'S

Hobby tech

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

ANALYSIS
DOSBox GL Shaders

This side-by-side comparison of Moonstone's intro shows how the shader corrects the aspect ratio while also simulating a CRT

Anyone who has even a passing interest in vintage gaming will likely have found themselves firing up a classic title, either in emulation or on real hardware, and discovered the game isn't quite as remembered. The immersive graphics of memory seem to have been snatched away, replaced by harsh, blocky squares of simple colours.

The player's memory is partially to blame, of course: an old game with 320 x 200 graphics and a 16-colour palette is never going to be described as photorealistic, however generously. A lot of blame, though, should be placed on technology. The interpretation of vintage games through the lens of what has now become known as 'pixel art' reinforces a stereotype of large, highly visible pixels – but games were never meant to look that way.

The way a cathode ray tube (CRT) display and a liquid-crystal display (LCD) handle images is as different as night and day. An LCD, fed an image at its native resolution, will be pin-sharp along the edge of each pixel; a CRT will be smoother and less defined – and it's this lack of definition for which the low-resolution graphics of yesteryear were designed to exploit.

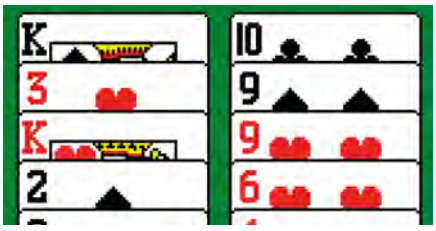
Today, only the most die-hard vintage gamers can make room in their lives – and wallets – for a good-quality CRT of decent size. For many, playing on an LCD is as good as it gets. Various efforts have been made to overcome the issue of pairing graphics that expect natural smoothing with displays that offer no such ability, including simple 'scanline' filters that erase every other row of the image, but few have come as close as shaders.

Small files of code, typically written in OpenGL Shading Language (GLSL), shaders give the user control over how graphics are rendered towards the vertex and fragment end of the pipeline. Simply put: they take a rendered scene in one end and modify it in some way before spitting it out of the other.

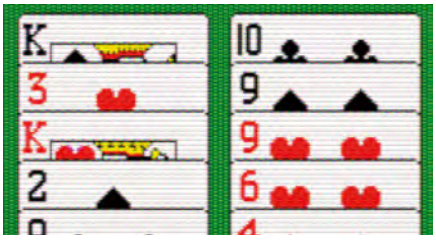
NEWS IN BRIEF

Raspberry Pi Pico gets CircuitPython support

The Raspberry Pi Pico microcontroller (reviewed in Issue 212) now has a fresh option for programming it: CircuitPython. Developed by Scott Shawcroft as a fork of MicroPython rebuilt with education in mind, CircuitPython is now available for the Raspberry Pi Pico and Adafruit, one of its biggest supporters, has published a detailed 'getting started' guide to assist users with installing and programming CircuitPython on the Pico. All major features are supported, including USB operation – currently unavailable in MicroPython. The guide is available from **custompc.co.uk/PicoCircuitPython**, while CircuitPython can be downloaded from **circuitpython.org**



Despite what modern pixel art may suggest, classic computer games were never designed to look blocky



A shader, such as Lotte's CRT, is a great way to get closer to how vintage games looked on original hardware

Quake is pictured here running the software renderer through the xBR filter – smooth, but rather like an oil painting

Emulation experts have turned to GLSL shaders in order to simulate the natural effects of CRT displays. Given shader-supporting emulators – among which you'll find the latest DOSBox emulator, designed to bring MS-DOS compatibility to modern PCs – it's possible to modify the image in a way that goes beyond simply blurring it or deleting every other line.

Playing Moonstone: A Hard Day's Knight, recently brought back to life by **gog.com** following a long time out of print, offers a quick showcase of the technology. In its stock form, using the DOSBox build supplied by **gog.com**, the graphics are blocky and harsh-edged – and, more concerningly, presented in entirely the wrong aspect ratio, leaving the titular knights looking squashed even before the trolls get involved.

Running the same game through a custom DOSBox configuration with a tweaked variant of the Lotte's CRT shader, though, brings the graphics a lot closer to how they're remembered from the days of old. The aspect ratio is corrected, doing away with the squat knights; the edges of pixels are smoothed out, and flat colours are replaced with a fair approximation of a CRT shadow mask. Even the curvature of the tube itself is simulated by rendering the emulator's output to a surface, which is then gently bent across both axes.

Where changing the appearance of a game would have once required buying an entirely new monitor, GLSL shaders mean you can chop and change as you desire. The CRT Geom shader, for instance, offers a more pronounced curvature with an overlay simulating the edges of the tube's mask, bringing the rounded corners many veteran gamers will remember. Others, such as CRT Easy Mode, choose to render the image in a different way.

Not all shaders aim to replicate a CRT display either. The xBR family of shaders, designed by the pseudonymous Hyllian with 16-bit console games in mind, use scaling rules to interpolate new pixels where none previously existed. The effect can be great for certain types of art, and it offers a dramatic improvement for text-based DOS games, but it results in a rather unsettling 'oil painting' effect when applied to more graphically complicated games.

The real benefit of shaders is that they operate independently of the underlying emulator: when a new or improved shader is made available, it drops into your existing emulator. They're also customisable – each shader file is a human-readable text-based source file, which is trivially tweakable in any text editor. How you get started with shaders will depend on your emulator, but DOSBox users can find a collection of popular shaders, including those used for this article, and instructions for using them at **github.com/tyrells/dosbox-svn-shaders**

REVIEW

Argon One M.2

Argon 40's iconic design returns in a new model designed to add high-speed storage

A quick glance at the Argon One M.2 reveals that creator Argon 40 is a true believer in the old adage 'if it ain't broke, don't fix it'. A quick look from a high enough angle and you'd be hard pushed to pick the new Raspberry Pi 4 case out of a line-up of the earlier Argon One Pi 4 (reviewed in Issue 197) and original Argon One (Issue 188).

Drop your eyeline down a little, though, and at least one change becomes clear: the new Argon One M.2 is a lot taller than earlier designs, thanks to a new daughterboard, which we'll discuss later.

Supplied as a kit, the Argon One M.2 offers all the same advantages as the Argon One Pi 4. The metal chassis connects to the system-on-chip and (entirely unnecessarily) the RAM chip in order to keep down temperatures, while a software-controlled fan offers active cooling when passive cooling isn't enough. Meanwhile, all the Raspberry Pi's various ports are brought out to the rear to simplify cabling, and there's also a smart power switch and a magnetic metal cover, which hides a colour-coded GPIO port with silkscreen pinout.

It brings a few improvements to the table too. The biggest is a move away from the micro-HDMI ports introduced on the Raspberry Pi 4 as a space-saving measure when the popular single-board computer family got dual-display capabilities. Where the Argon One Pi 4 simply brought the micro-USB ports around to the rear and left them otherwise unchanged, the new Argon One M.2 swaps them for full-sized HDMI ports in a vertical orientation – great news for those who haven't yet picked up micro-USB cables or adaptors.

The translucent plastic base has also seen a change, which is where you find the case's extra height over its predecessors. Rather than simply covering the boards attached to the metal upper, the new base includes a board of its own: a USB 3-to-SATA bridge supporting M.2 B-key and B+M-key solid-state drives (SSDs).

The Argon One M.2 isn't the first Raspberry Pi 4 case to take advantage of the new USB 3 ports to offer high-speed storage. The RetroFlag NESPi 4 (see Issue 210) housed a 2.5in SATA drive in a mock Nintendo NES cartridge and connected it to a USB-to-SATA bridge chipset too, but the company failed to do its due diligence and chose a bridge that's incompatible with the Raspberry Pi 4's USB-attached-SCSI Protocol (UASP) driver, resulting in a dramatic drop in performance.

Argon 40, thankfully, hasn't fallen into the same trap. The bridge chip is fully compatible with UASP on the Raspberry Pi, meaning it works out of the box without having to fiddle

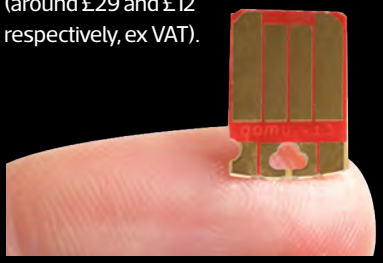
All ports are brought to the rear and the micro-HDMI is replaced with full-sized ports, but you lose a USB 3 port for the SSD

Argon 40 is a clear believer in the adage 'if it ain't broke, don't fix it'

NEWS IN BRIEF

QuickLogic launches Tiny Qomu FPGA board

QuickLogic has announced its own entry into the *omu family of ultra-compact development boards with the Qomu, combining a microcontroller and small field-programmable gate array (FPGA) in a device that fits almost entirely inside a USB Type-A port. 'The Qomu dev kit is a milestone for the industry in many ways,' claims QuickLogic's Mao Wang of the open-source design. 'It packs an incredible amount of functionality in the size of a USB port.' The Qomu is available to order now via **crowdsupply.com** at $40 US plus $16 global shipping (around £29 and £12 respectively, ex VAT).



Like its predecessors, the Argon One M.2 includes a hidden colour-coded GPIO header

around with USB quirk configuration. It's also undeniably fast. While it didn't hit the theoretical 500MB/sec read and 320MB/sec write limits of the drive on test, the FIO score of 387MB/sec read and 300MB/sec write is nothing to be sneezed at – it's also considerably faster than the performance you can get out of the Raspberry Pi's micro-SD slot.

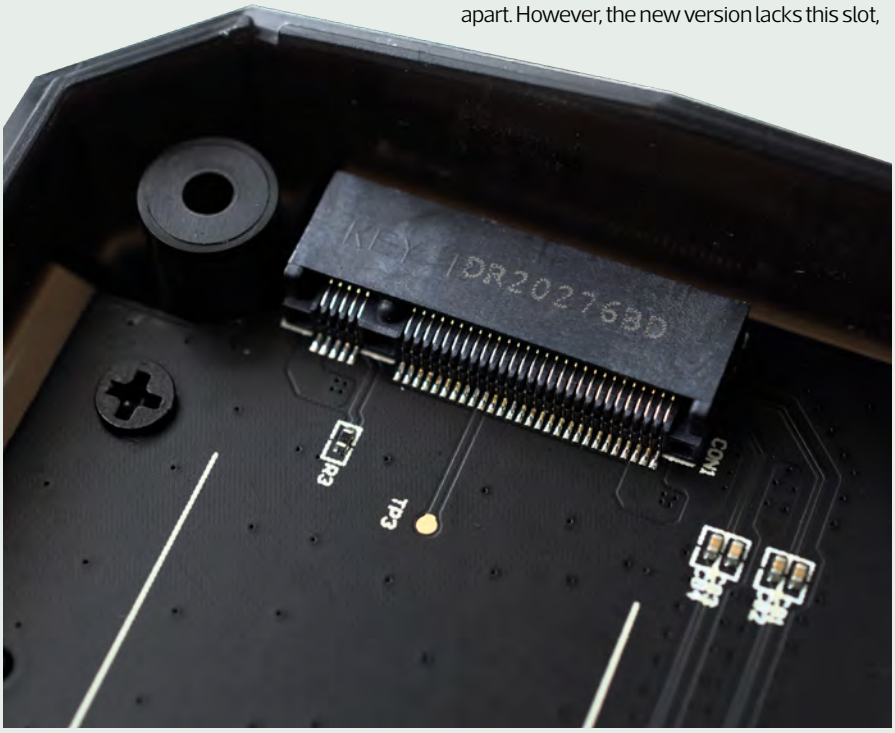
Speaking of which, there's one negative point to the new design – accessibility. Previous Argon One cases have included a cutout to provide access to the micro-SD slot, allowing you to change cards without taking the case apart. However, the new version lacks this slot, meaning any micro-SD swapping requires you to remove and replace the USB bridge at the rear of the case, plus the four screws holding the base onto the upper section.

As compensation, though, Argon 40 has finally populated the infrared receiver section of its daughterboard PCB. The company has even supplied software that reads input from the sensor via the Raspberry Pi's GPIO port, but there's a catch: it's written specifically for its proprietary infrared remote, available as an optional extra.

With few physical changes to the overall design, the Argon One M.2, not surprisingly, is just as good at keeping the Raspberry Pi cool as earlier models. During testing with excessive load on the CPU and GPU, the temperature slowly rose until it hit the user-configurable 55°C limit to activate the built-in fan at a tenth of its maximum speed. That's enough to keep the temperature from reaching any higher for the remainder of the benchmark, though at the cost of a quiet but audible buzz. The SSD remained well below its temperature limit as well, with a measured peak of 44°C.

The only complaint about the design of the cooling system is shared by the majority of cases, which is that there's no contact with the power management circuitry to the bottom left of the board. While this has no effect for general use, for those looking to overvolt and overclock a Raspberry Pi, it introduces thermal limits in terms of how high a board can be pushed. The Argon One M.2 is available now at **argon40.com**, for $45 US (around £33 ex VAT).

The M.2 slot accepts B- and B+M-keyed SSDs of any length



REVIEW

Big Data Girl

Fred Wordie's Big Data Girl, illustrated by Santiago Taberna in an eye-catching limited-colour format, is either a very important book or a missed opportunity – and it's difficult to decide without trying it with your own children. Funded via Kickstarter late last year, Big Data Girl positioned itself as highlighting the impact of 'big data' – data gathered, held, analysed and traded by big corporations for purposes from targeted advertising to healthcare provision – to both kids and adults in the form of a picture book.

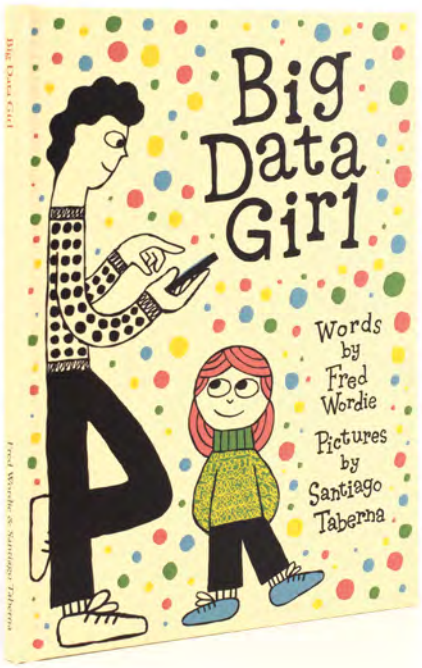
In this book, Big Data is – as the title suggests – a girl. A child, specifically, but one who seems to have an odd amount of freedom, and uses that freedom to befriend as many people as possible. 'She knew everything, about everyone – from where they'd shopped to how they had fun,' the book opens. '[She] was so helpful,' Wordie continues, 'you just couldn't hate her.'

Should you hate Big Data? The question is never raised in quite such bold terms but it's clear Wordie and Taberna are aiming to foster discussion, at least. To do this, the book leans on real-world examples of the use and abuse of (no capitals) big data. On the positive side of the ledger, Big Data uses information gathered from a reader's Kindle to recommend a new book, pores over credit card statements to recommend presents, and even offers medical advice to a friend with the sniffles.

Less positively, Big Data puts her foot in it with the gift of a crib to a family who had no idea their teenage daughter was pregnant – a tale based on a real-world case from 2012 when retail giant Target used a pregnancy-prediction algorithm written by statistician Andrew Pole to send a family coupons on baby products, including a crib, long before the family's teenage daughter had been ready to tell her parents she was pregnant.

After that, people treat Big Data with more suspicion – but the child tells them they simply have to trust her discretion, then starts making deliberate mistakes to suggest her knowledge isn't all-encompassing after all. 'She was the girl that we called "Big Data",' the book concludes, 'and could persuade anyone not to hate her.'

It's wonderfully presented, but suffers from occasional clunky rhymes



Aimed at adults and children, Big Data Girl attempts to raise questions about data gathering and analysis

With no footnotes or references to follow in order to find the real-world cases on which the book is based, there's not too much in this book that's really useful for adults.

For children, it's potentially of more value – but tested on a nine-year-old just ahead of Internet Safety Week, the message proved muddled with the allegorical representation of big data as a girl being lost. 'It's about knowing how to keep your friends' secrets,' the nine-year-old reader concluded – a fair guess, but far from Wordie and Taberna's intended interpretation.

The book also suffers from clunky writing at times, typically in service of the rhyming couplet format. Several lines fail to scan, while others sacrifice the passage's meaning on the altar of rhyme: 'her grasp of their lives did greatly define' works for no definition of 'define', with the word having been clearly chosen purely for its ability to rhyme with 'online' from the line above.

As a tool to introduce the concepts of big data and digital privacy to older children, though, there's definite merit – as long as you accept Big Data Girl as a starting point for discussion rather than a standalone explainer. Big Data Girl is available now exclusively from **bigdatagirl.com** for £18 in hardback (VAT exempt) or pay-what-you-want as a DRM-free PDF. CPC

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at freelance.halfacree.co.uk @ghalfacree

WIN

COOLER MASTER GAMING GOODIES

A CPU COOLER, GAMING HEADSET AND LIGHTWEIGHT GAMING MOUSE ARE UP FOR GRABS IN THIS GREAT BUNDLE

COOLER MASTER HYPER 212 RGB BLACK EDITION CPU COOLER

The Hyper 212 Black Edition features four heatpipes and a stacked fin array that ensures the least airflow resistance. What's more, it's nickel plated with a classy jet black finish.

It also comes with a 120mm SF120R RGB fan, with the option to add another fan in push/pull configuration. The fan's wide speed range of 650–2,000rpm can be fine-tuned for maximum cooling performance or near-silent operation. Meanwhile, the RGB lighting is certified to sync with motherboard RGB software or it can be controlled by the included compact RGB LED controller.

The Hyper 212 RGB Black Edition is compatible with AMD Socket AM4, AM3, AM2, FM2 and FM1 socket variations, and a variety of Intel CPU sockets, including LGA1200, LGA115x, LGA2066 and LGA2011/-v3.

COOLER MASTER MH670 GAMING HEADSET

The MH670 is a sleek, comfortable wireless headset that combines a latency-free 2.4GHz wireless connection with high-quality audio and near-universal connection options, providing both convenience and flexibility.

Its 50mm neodymium drivers deliver an incredibly rich soundstage to your eardrums, while its virtual 7.1 surround sound support expands that to its full potential, creating lush, powerful sound that's perfectly balanced for all game and music genres.

Meanwhile, the MH670's swivelling ear cups and leatherette cushioning provide comfort during the longest gaming sessions.

COOLER MASTER MM720 LIGHTWEIGHT GAMING MOUSE

The MM720 is a lightweight take on a legendary, fan-favourite gaming mouse, combining classic performance with modern sensibilities.

Its ultralight honeycomb shell has a familiar ergonomic, balanced design, and reduces the total weight to just 49g without compromising on durability.

Its innovative new ultra-weave cable reduces cable snag, while RGB illumination ensures all your kills get highlighted. Additionally, the gaming-grade 16,000 DPI Pixart optical sensor and optical switches will ensure top-tier performance for years to come. This mouse fits like a glove and packs a punch over the rest of the competition.

COOLER MASTER

SUBMIT YOUR ENTRY AT **CUSTOMPC.CO.UK/WIN**

Competition closes on Friday, 7 May 2021. Prize is offered to participants in the UK aged 13 or over, except employees of the Raspberry Pi Foundation and Trading, the prize supplier, their families or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from Custom PC magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked.

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Is it worth water-cooling your SSD?

I love my M.2 SSD, for a whole bunch of reasons. Firstly, I use a mini-ITX case, so having a 3.5in hard disk or 2.5in SSD means adding two more cables for every drive install. Having all your data on one or two M.2 SSDs strapped directly to your motherboard means you can shed the power and data spaghetti, and make your cable-tidying task much easier too – that's especially important in small cases.

M.2 SSDs are also fast if you opt for the PCI-E NVMe variety, and you can customise them with all manner of heatsinks, from third-party models in different colours, such as the ones from the likes of EK, to the ones included with your motherboard. I haven't been this excited about storage since affordable 2.5in SSDs were first introduced a decade ago.

Cooling your M.2 SSD isn't usually an issue though. They certainly get hot, and they can start throttling above certain temperatures, but it's rare for this to happen unless you absolutely hammer them for long periods on a hot day or in a stuffy case.

Corsair's Hydro X Series XM2 waterblock enables you to plumb your SSD into a standard water-cooling loop

There are exceptions, though, such as my old rig that used the ASRock's over-the-top X299-E ITX/ac motherboard. Here, I installed my M.2 SSD into a slot that was easily accessible, but sandwiched between the slot and CPU waterblock. Sure enough, on a rather warm day, and in the rather stuffy Phanteks Shift case, my SSD started to slow down noticeably.

Eventually, I ran a benchmark on the SSD and found it was running at less than half its rated speed as the temperature was causing it to throttle. I ended up placing it in a less accessible, but better-ventilated port, where I also had room to mount a heatsink on the SSD, and the throttling issue was instantly solved.

These days, motherboards come with heatsinks and even some SSDs come with them. Throttling is rarely an issue, and even if you find your drive getting a bit toasty, adding a heatsink or dialling up your PC's airflow is usually enough to keep the heat in check.

However, I have water-cooled my M.2 SSD in the past with a homemade waterblock. Admittedly, this was more for show than cooling concerns, but

with the temperatures kept at a steady 45-55°C under load, and the heat being efficiently transported to the radiator instead of leaking onto other nearby components, it was kind of cool.

Corsair clearly thinks there's a gap in the market too, as it's released an M.2-specific waterblock. Yep, that's right – an actual retail waterblock for your SSD that will strap to any 80mm model. With its two G1/4in ports, it will connect straight to your water-cooling loop, and it also produces an SSD readily equipped with it – the MP600 Pro Hydro X.

Now, I'm the first person to admit that this is complete overkill. There's also the issue of certain parts of modern M.2 SSDs actually preferring higher temperatures, such as the memory. However, water-cooling isn't all about performance – let's be honest, a fair amount of it is to do with aesthetics and showing off as well.

Seeing as your typical modern CPU will still sit well above 60°C under load, even if it's water-cooled, an M.2 SSD with a waterblock is still going to be toasty, so any heat-preferring components are unlikely to suffer. As such, Corsair's Hydro X Series XM2 waterblock is potentially worth a look for water-cooling enthusiasts out there, especially as it only costs around £35.

Thankfully, I'm one such enthusiast, and Corsair sent me one of its new SSD waterblocks, so I could have a play with it. The block is fairly basic, with a clip-on mounting mechanism that uses thermal pads. There are pre-applied thermal pads for the upper and lower portions of the SSD, with extra pads included.

The block is fairly basic, with a clip-on mounting mechanism that uses thermal pads

A water-cooled SSD could be handy in a densely packed mini-ITX system with limited airflow

The latter will need to be used if your SSD has components on the underside. Out of the box, the XM2 was set up for PCI-E 4 SSDs, which have components on both sides. However, extra thermal pads are included to cater for other SSDs that need a thicker thermal interface on the underside, in order to make contact with the lower heatsink. We had to use these with our Samsung 970 Evo test drive, which only has components on one side – the SSD would only make contact with the parts when we used both the included thermal pads.

The top portion of the waterblock is essentially a slab of copper with a top black plastic housing containing a pair of G1/4in ports for your fittings. It's not too flashy, and simply includes a tiny Corsair logo with some raised triangular patterns, so it should fit in with most setups. There are no internal funnels or fins, so there's no specific inlet or outlet either.

With your SSD mounted in the lower section, you then need to clip this part onto the top section. This is very fiddly, as you need to apply a high amount of force to get the side clips slotted into place. The final clip needed gentle persuasion with a pair of pliers but it eventually clicked into place.

Be warned here though – don't use excessive force or you risk damaging your SSD. In the test system, back-to-back runs of CrystalDiskMark failed to push the SSD above 35°C according to HWiNFO with the waterblock installed.

Comparably, when sandwiched between our graphics card and CPU socket, and with our motherboard's M.2 heatsink attached, the same SSD reached 73°C in the same benchmark – a difference of 38°C. This will likely be lower in a well-ventilated case though.

The XM2 will, thankfully, reasonably priced and will leave you with change from £40, or you can buy it attached to one of Corsair's SSDs.

The cheap price is just as well, though, as there isn't much point in buying it other than for aesthetic reasons. Hammering the SSD for 20 minutes in unfavourable conditions still didn't result in it throttling, and while temperatures were drastically reduced by the waterblock, this didn't result in better performance.

However, I can completely sympathise with anyone that takes the plunge. It looks cool, it's simple to plumb into an existing loop and it will certainly keep your SSD cool. We suggest Corsair takes a look at the mounting mechanism, as it's rather fiddly, but if you want to have a water-cooled SSD to show off to your friends, or avoid potential throttling in a densely packed mini-ITX case, it's £35 well spent. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Improve graphics card cooling

Antony Leather shows you a quick and easy way to boost your graphics card's cooling with thermal pads

TOTAL PROJECT TIME / 2 HOURS

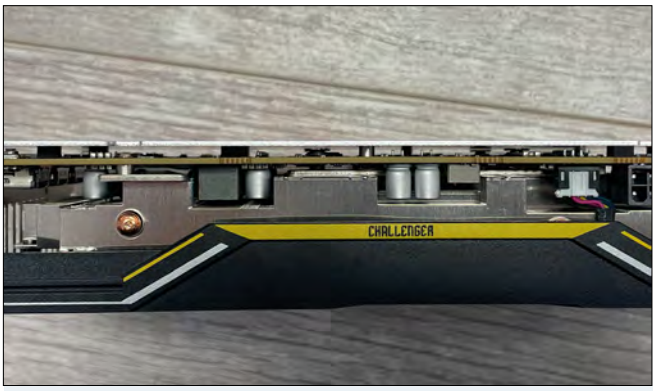
Graphics card cooling has improved a lot in recent years, with bigger, better and quieter coolers being used as standard. Even the stock coolers that come with reference models from AMD and Nvidia have abandoned horrible blower-type designs. However, while the latest coolers deal with the core, memory and (usually) other hot spots on one side of the PCB, the rear of the card, which also gets very hot, is often left to its own devices.

Even if there's a metal backplate, they rarely actually make thermal contact with the PCB, meaning the rear of the card can get extremely hot. What's more, this has been known to cause throttling, especially with RTX 3000-series GPUs. In this guide we'll show you how to check if your graphics card backplate is being used to cool your card's PCB and add your own thermal pads to boost its cooling.

TOOLS YOU'LL NEED

Micro screwdriver set
amazon.co.uk

Thermal pads
quietpc.com



1 / CHECK FOR EXISTING THERMAL PADS

If your graphics card backplate is warm to touch when it's in use, this isn't necessarily an indication that there are thermal pads installed underneath. Look at the PCB from the side, and you should be able to see them if they're present.

2 / SEARCH FOR ONLINE TEARDOWNS

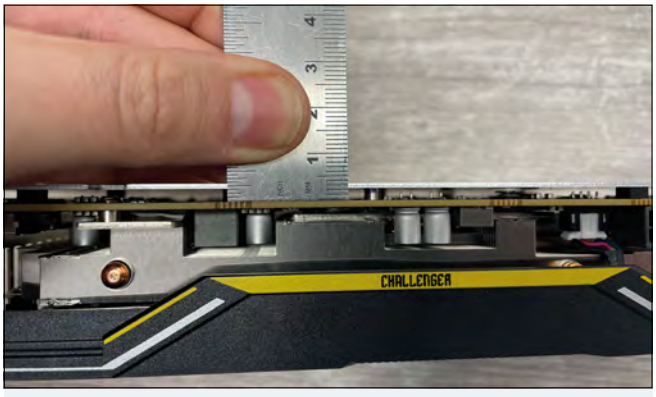
Some cooler housings can make it tricky to see if thermal pads are in place out of the box. If this is the case with your card, check Google for any online teardown videos of your particular model, as they'll likely show if pads have been used.

3 / CHECK BACKPLATE MATERIAL

There's no point adding thermal pads if your backplate isn't made of metal, so check you have a metal one first. If you remove the GPU from your PC for a few hours in a cool room, it should feel cold to touch if it's made of metal.

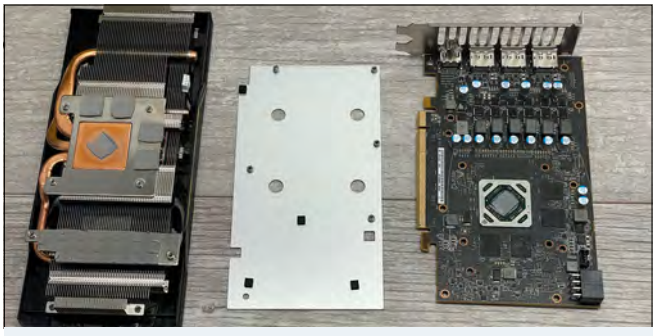
4 / MEASURE BACKPLATE TEMPERATURE

To see if your tweaking makes an impact later, first measure the temperature of the backplate using a thermal probe or IR probe. It's also worth seeing if the core GPU temperature drops, using software such as GPU-Z – RTX 3080 owners can also see the memory temperature using HWMonitor.



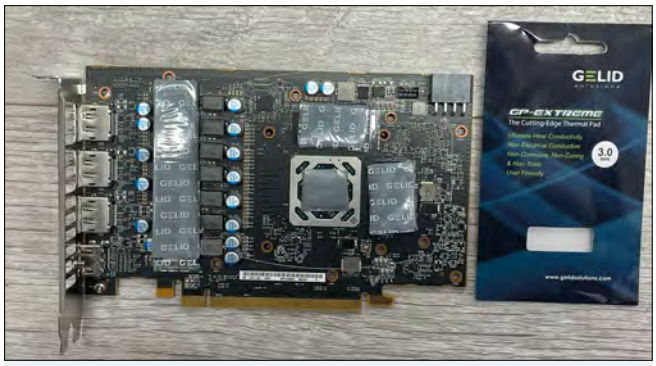
5 / WORK OUT PAD THICKNESS

Each graphics card is different, so you'll need to measure the required thickness of thermal pads. They need to make good contact between the PCB and backplate, so it's worth ordering one set of thick pads and a set of thin ones in case you need a little more.



6 / REMOVE COOLER AND BACKPLATE

Removing the cooler and backplate may void your warranty, so proceed with caution. Some backplates require the cooler to be removed first, but others will come straight off. In our case, we needed to remove the screws holding the core and VRM heatsink sections together, exposing the backplate screws.



7 / IDENTIFY PAD LOCATIONS

You'll want the rear of the GPU core, memory modules and VRMs to have corresponding thermal pads connecting the PCB to your backplate, so have a look at these areas on the front of the card (we've marked them with the pads wrapped in plastic here), so you know where to put the pads on the back.

8 / APPLY THERMAL PADS

If necessary, cut the pads to size, but you can be generous here, as there's no point having piles of unused pads. Make sure the entire GPU core, memory and VRM areas are covered, and if the heatsink makes contact with any other small hot spots on the front, add pads to the rear of these places too.

9 / REINSTALL COOLER AND BACKPLATE

Finally, check the pads make contact with the backplate by first cleaning it and then reinstalling it. We found that the peak GPU core temperature fell by 4°C and the backplate temperature rose by 6°C, showing that the backplate was now definitely aiding cooling with the pads installed.

How to Vinyl-wrap your PC

If you're not keen on the idea of spray-painting your PC, **Antony Leather** shows you how to customise it with vinyl wrap instead

TOTAL PROJECT TIME / 3 HOURS

Adding a splash of colour to your black or white PC case is a great way to make it stand out, but spray painting isn't for everyone. You may simply not have the open space or wherewithal to do it, plus it can be messy and needs practice if you want it to end in a great finish. It can also be expensive, with spray cans costing a tenner a pop, plus you'll need sandpaper, primer and clear coat too.

There is an easier, cheaper way to spruce up your PC case, though, which is using vinyl wrap. It comes in self-adhesive form, so for the most part, you just need to cut it to size and stick it to your PC. In this guide, we'll show you how to work out the best design for your case, cut the vinyl and apply, while also providing tips and tricks for using vinyl in other ways to customise your PC.

TOOLS YOU'LL NEED

Scalpel
Most hardware stores

Vinyl cutter
yolo.co.uk

Adhesive vinyl
amazon.co.uk

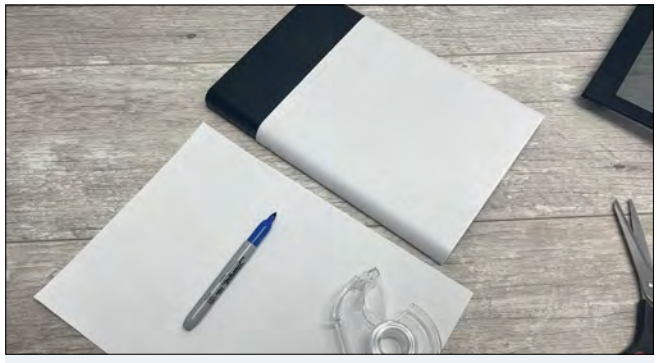
Transfer paper
amazon.co.uk

1 / DECIDE ON WRAP LOCATION

A lot of your pattern options will depend on your case's design, but we advise sticking to using large, less detailed areas, such as front panels and side windows. Otherwise, you'll spend too much time cutting out and trimming the vinyl.

2 / DISMANTLE YOUR CASE

If your case's exterior fittings are removable, you can make it much easier to apply the vinyl, especially when you're tucking away the edges, so they're out of sight. Dismantling your case can help when it comes to applying vinyl to areas that would otherwise be tricky.

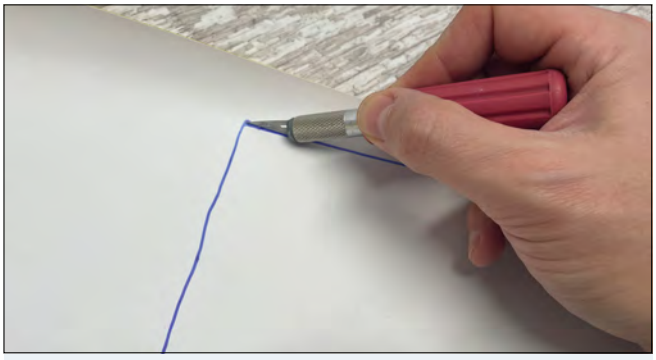


3 / MAKE A MOCK-UP

To work out your design and ascertain how much vinyl to buy, create mock-ups using paper and attach them to your panels using Sellotape. You can trim the pieces to size, which will be good practice for applying the vinyl.

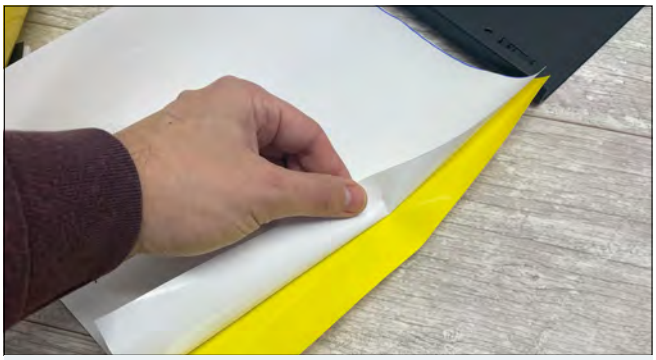
4 / TRANSFER DESIGN TO VINYL

Use your mock-up as a template to transfer the shape to your vinyl. Place it on the underside of the vinyl, which has paper material on which you can draw, without marking the vinyl. Just remember to place your paper face down.



5 / CUT VINYL

The best tool for cutting vinyl is a scalpel, as it makes it easy to cut in a continuous motion, while scissors can leave jagged edges that result in the vinyl lifting over time. Cut your vinyl on a cutting mat or cardboard, and not on a surface that can be damaged by the blade.



6 / PEEL OFF BACKING

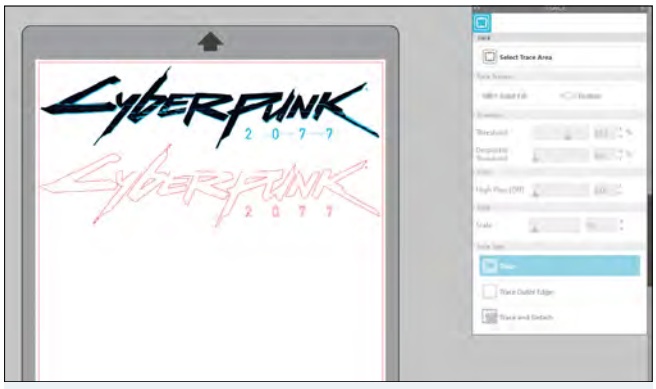
Once your shape is cut out, peel off the backing on one edge and apply the vinyl to the edge of your panel. Don't be tempted to remove all the backing, as you then run the risk of it flopping free and sticking to your case in the wrong position.

7 / APPLY USING A SQUEEGEE

Use a squeegee, credit card or similar flexible object to press the vinyl onto the surface in a swiping motion from side to side. This will prevent most air bubbles being formed as you apply it to the surface.

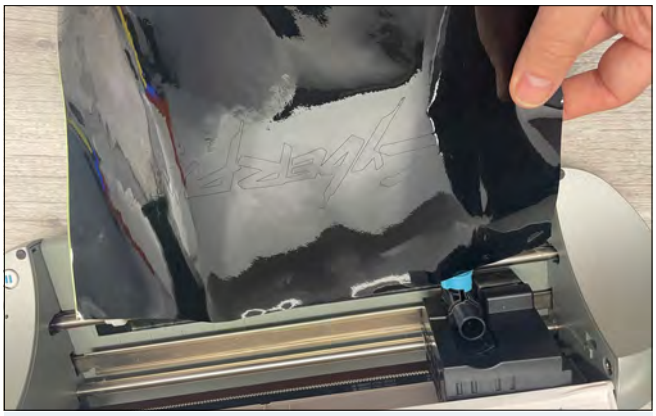
8 / REMOVE AIR BUBBLES

Occasionally, smaller air bubbles can form under the vinyl. If this happens, use your squeegee to work them to the edge of the vinyl where they should disappear. If they're stuck, you should be able to peel back the vinyl to remove them. It's important not to apply it too fast.



9 / CREATE TEXT OR PATTERNS

You don't need to stop at just covering large areas of your case with big sheets. You can create smaller designs, including text and logos, and apply them to your case, or on top of existing vinyl.



10 / USE CUTTING MACHINE

The best way to create objects such as text is to use a vinyl cutter. They can cut most soft sheet materials, and are fantastic tools for modding your PC, as your text and logos will be accurate and razor-sharp.

11 / USE TRANSFER TAPE

To lift these designs off the vinyl once it's been cut with the machine, transfer tape is used to peel it off the backing paper. It's reusable, relatively cheap and you just need to press it hard onto your design, so the adhesive side sticks to it.

12 / PEEL OFF DESIGN

Lifting the design off the backing paper can be tricky. It's best done a section at a time, bending down the backing paper and encouraging the vinyl to lift off and stay stuck to the transfer paper.

13 / APPLY TO CASE

Applying the design to your case is a lot easier than peeling it off the backing paper, and you can use the same method as before, where you press the design firmly onto your panel, before bending up the transfer paper and encouraging the vinyl to remain stuck to your panel.

14 / USE VINYL FOR OTHER CUSTOM JOBS

A cutting machine and vinyl can also be used to customise your PC, such as for masking material when you apply spray paint or glass etching. This works much like masking tape, except you can quickly create masking shapes that would take hours to make by hand.

15 / CREATE INTRICATE DESIGNS

A cutting machine can also be used to create highly intricate designs in almost any colour of vinyl. Many would likely take days or even weeks to create by hand, but any image you can upload to the cutter can be cut out of your vinyl. CPC

Folding@home

Join our folding team and help medical research

ACTIVE USER MILESTONES

USERNAME	POINTS MILESTONE
Slavcho	4,000,000,000
madmatt1980	900,000,000
Votick	500,000,000
Bloo_Toon	400,000,000
TrekkieStu	200,000,000
Neku	200,000,000
peete	100,000,000
bytemarq	100,000,000
Will_Walton	100,000,000
filreed	80,000,000
YCDCN22	70,000,000
GreenPig	70,000,000
pompeyrodney	70,000,000
Pennine_Lad	40,000,000
TokerRizla	40,000,000
bytesurfer	30,000,000
C2TBD	20,000,000
Chebob	20,000,000
Pedro8888	20,000,000
Granby	20,000,000
ausnic83	10,000,000
Haphestus	10,000,000
Lewisifer	20,000,000
Peanut.Rec.	20,000,000
PendragonOrion_ ALL_1Gpy...	8,000,000
Ratski	6,000,000

USERNAME	POINTS MILESTONE
geofftswin	4,000,000
Wickermonkey	3,000,000
Bluehubble	2,000,000
MDT	2,000,000
Team_DS-WHS2011	1,000,000
StoneColdJay	1,000,000
R0ric	1,000,000
Thunder	900,000
bughyz	900,000
RougeNikov	800,000
mhfz48	800,000
Iceman1975	600,000
Rabaks	600,000
Andy__k	600,000
revMaxx	400,000
PatWI	400,000
iamannie	400,000
Mister_M	200,000
dhhowells	200,000
capt_carl	60,000
toomanynotebooks	30,000
souper82	30,000

WHAT IS FOLDING?

Folding@home uses the spare CPU and GPU cycles for medical research, with a current focus on COVID-19. You can get the client from **foldingathome.org/start-folding** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag – we'll print all the milestones we can fit on the page. You can discuss folding with us and other readers online at the bit-tech forums (**custompc.co.uk/FoldingForum**).

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	DocJonz	14,846,645	15,089,885,659
2	Desertbaker	8,110,908	3,946,741,060
3	Slavcho	6,831,037	4,001,791,602
4	Lordsoth	5,774,790	5,475,957,321
5	PC_Rich	3,664,959	6,654,703,461
6	C2TBD	3,486,243	25,286,454
7	tarka_dahl	2,868,928	1,842,423,029
8	madmatt1980	2,580,898	963,237,793
9	TrekkieStu	2,562,641	251,242,634
10	Votick	2,541,687	521,726,234
11	KevinWright	1,985,701	1,435,290,490
12	kcanti	1,784,770	1,073,664,510
13	Neku	1,573,307	219,285,606
14	peete	1,447,851	136,808,093
15	Little_Willie	1,323,176	486,054,725
16	Simlec	1,219,137	374,486,742
17	gKitchen	1,209,625	237,192,656
18	1car1_Garforth	993,266	167,115,552
19	filreed	807,318	80,108,981
20	Dave_Goodchild	754,420	3,086,211,952

TOP 15 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	DocJonz	15,089,885,659	343,673
2	PC_Rich	6,654,703,461	165,459
3	Lordsoth	5,475,957,321	181,833
4	Shirty	5,266,143,058	39,848
5	Nelio	4,638,586,520	523,610
6	Slavcho	4,001,791,602	73,705
7	Desertbaker	3,946,741,060	70,180
8	HHComputers	3,544,050,839	85,007
9	Dave_Goodchild	3,086,211,952	160,587
10	piers_newbold	2,703,256,197	107,638
11	Scorpuk	2,565,487,007	57,788
12	clanseven	2,223,720,446	33,156
13	tarka_dahl	1,842,423,029	26,105
14	Unicorn	1,753,462,654	57,079
15	daxchaos	1,637,104,710	41,302

Retro tech

3DFX VOODOO 5 6000 RECREATED

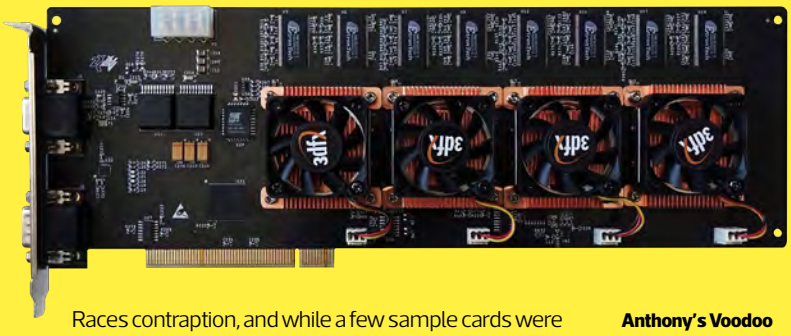
Ben Hardwidge talks to Anthony Zxclxiv about his fully armed and operational recreation of 3dfx's four-chip swansong, which he calls the Napalm 6000 SUX

With huge PCBs, external power bricks, up to 128MB of memory and a new chip codenamed 'Napalm', 3dfx's Voodoo 4 and Voodoo 5 cards looked set to race past the competition in a fiery blaze, trample on Nvidia's GeForce 256 and reinstate 3dfx at the top of the 3D graphics scene. It was 2000, and until recently, 3dfx had been the brand of the moment in 3D acceleration, but Nvidia's TNT2 and later GeForce 256 were making a bit of a mockery of 3dfx's Voodoo 3, which could only display games in 16-bit colour, rather than 32-bit.

3dfx had some new ideas to retake its throne, but it was beset by delays. The one idea that made it to production, several months after the GeForce 256, was the VSA-100 chip, codenamed Napalm. It could display 3D games in full 32-bit colour and it also introduced us to anti-aliasing, with a performance-killing (but very good-looking) option in the driver that used super-sampling. What's more, 3dfx could use its SLI (scan line interleave) technology to chain multiple VSA-100 chips together on one PCB.

The adverts in magazines looked great – the product stack started at the Voodoo 4 4500, which had one VSA-100 chip, with the Voodoo 5 5000 and 5500 having two VSA-100 chips and 32MB and 64MB of memory respectively (half of which would be shared with each chip). The Voodoo 5 5000 never made it to production, though, and the same also goes for a mysterious top-end card that was also featured in the ads – the Voodoo 5 6000.

This mighty card was so powerful, it needed an external power supply, and it had four VSA-100 chips on its massive circuitboard, each with 32MB of memory for a total of 128MB – huge at the time. There was no hardware transform and lighting, unlike the Nvidia GeForce and ATI Radeon, but 3dfx hoped it could make up for this with the sheer brute force of four graphics chips. It was a bit like a Dick Dastardly Wacky Races contraption, and while a few sample cards were produced, it never made it to the shops.



Anthony's Voodoo 5 6000 recreation can get all its power from a single Molex connector, with no need for an external power brick

Since then, the Voodoo 5 6000 has been the Holy Grail of 3dfx fans, but they're extraordinarily hard to find, which gave Russian electronics hobbyist Anthony Zxclxiv an idea – could he recreate one from scratch? After all, you can still buy VSA-100 chips on eBay, and he'd already experimented with recreating some other 3dfx cards.

Anthony's card can get all its power from a single Molex connector

VOODOO MAGIC

To start, he needed an original Voodoo 5 6000 card. 'A major hardware collector helped me,' says Anthony. 'His handle is Hard1k online.' He then needed to recreate the PCB as best possible, which is where Anthony's knowledge from his previous projects came in handy.

'I'm a hobbyist, but I have plenty of available time,' he says. 'Without my background in a variety of other projects, this one would be impossible for sure. Making the PCB wasn't

very complicated – I placed all the design blocks around the board and solved the puzzle that way – there were no other available variations.

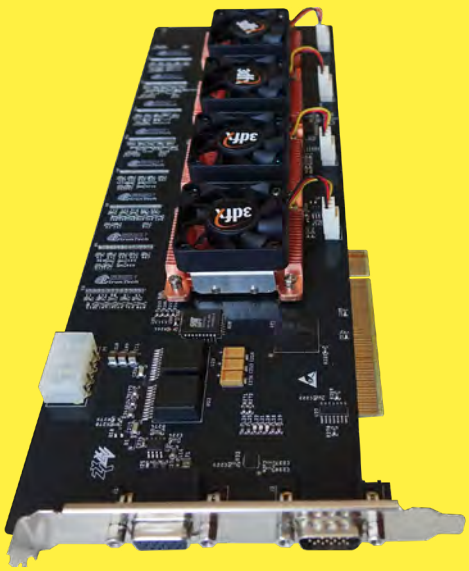
'Moreover, I'd already made a couple of working VSA-100 projects before, so this one wasn't a big deal. The BIOS is an original one, as are the drivers, so there was no need for me to tweak or modify these parts.'

Anthony's new card isn't just a straightforward copy though. 'It differs in some minor ways, I believe,' he says. 'I didn't see the original PCB, besides the top layers, so I can't give an exact answer. The power unit is completely different, of course.' It is indeed – while the original Voodoo 5 6000 needed an external power brick, Anthony's card can get all its power from a single Molex connector.

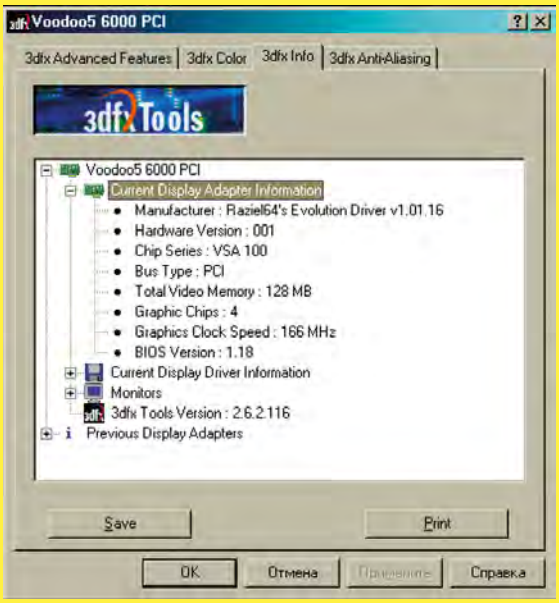
'Each pin of this connector is able to pass 8A,' he explains, 'and this card requires 5A on a 12V line – all the rest depends on the quality of your power supply and power wiring.' It may well be that the original Voodoo 5 6000 didn't technically *need* an external PSU, but that 3dfx erred on the side of caution given the general poor quality (and the lack of high-current 12V rails) of PC power supplies at this time.

The cooling setup is different too. 'I can't afford to produce a custom cooling system,' Anthony says, 'but this one is quite good and expensive. It uses heavy-duty server coolers powered from 5V instead of 12V – it all cost around $100 US. Also, the fans are durable ones with two ball bearings – you can't compare them with the original sleeve-bearing crap.'

The end result is a really cool-looking card that measures 311 x 110mm – Anthony is currently calling it the Napalm 6000 SUX (Special Unified Xcelerator). His card uses the PCI interface (the Voodoo 4 and Voodoo 5 cards came in both PCI and AGP versions), but Anthony says he's considering making an AGP version too. 'Modifications for AGP depend on the signalling level being 3.3V or 1.5V,' he says. 'The latter requires a lot of testing and work.'



The male VGA input enables you to use the Napalm 6000 SUX with a second graphics card



Anthony Zxclxiv has got his card working in Windows with both 3dfx and third-party drivers

Could he go one step further and even add a digital output, such as HDMI, to replace the analogue VGA output? 'Nope,' he says. 'It's not possible without complex FPGA development. Even if it was possible, there's no place to make a fan-out for digital RGB signals.' There are two VGA connectors on the backplate, though, a bit like the original Voodoo and Voodoo 2 cards. The male one is a 'VGA-in for another video card,' explains Anthony, 'if anyone has the intention of using one along with this card.'

CAN WE BUY ONE PLEASE?

The card all seems to work fine with both original 3dfx drivers and third-party drivers, and Anthony even says his card has some of the same quirks of the original 3dfx card. 'There is noticeable SLI banding in certain graphic modes,' he says – referring to the banding effect created by multiple chips working alternately on different scan lines on the screen. 'It's not as much as on the original card, but it exists.'

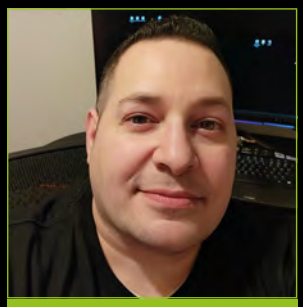
We ask him if he has any plans to release the schematics for his card to the community, or the Gerber files – an ASCII vector format used for PCB design. 'I have no plans to publish the Gerbers,' he says. 'However, I'm considering publishing all the 3dfx schematics I made by myself in the form of a small book or big booklet.' He warns that 'it takes a lot of work to make a board from a schematic, though, and the PCB for this board is beyond basic level – JLCPCB (a large PCB manufacturer in China) doesn't have the ability to produce it, so the production cost is quite high'.

If making your own card isn't a goer, could you maybe buy one ready-made? 'Yes, they will be available in a limited quantity,' says Anthony. 'The estimated price is $1,500 US (around £1,079).' If you're a 3dfx fan with cash to spare, you could soon buy a working 3dfx Voodoo 5 6000 card without having to track down an original sample. You can see more details about Anthony Zxclxiv's hardware projects on his Facebook page at **facebook.com/zxc64.hw** CPC

Readers' drives

Hello Christmas

Anthony Martino wanted to make a PC for his Hello Kitty-obsessed wife for Christmas, resulting in this red, white and green machine with loads of custom vinyl wrap



/MEET THY MAKER

Name Anthony Martino

Age 44

Occupation Professional poker player (PLO Cash Games)

Location Tampa, FL, USA

Main uses for PC Gaming and surfing the Net

Likes Roller skating, Dungeons & Dragons, Laser Tag and PC games

Dislikes Seafood, rude people, losing as an equity favourite in poker

CPC: So how did this project start? What inspired you to build this Hello Kitty Christmas PC?

Anthony: My wife of 15 years is a HUGE fan of the mouthless demon kitty, erm, I mean Hello Kitty. She has an entire room dedicated to all her plushies and other Hello Kitty doodads. Her favourite holiday is also Christmas, so combining the two was something sure to bring her joy.

CPC: What design cues from the Hello Kitty world were you looking to incorporate into your build, and how did you go about implementing them?

Anthony: Since this was a holiday-themed build, I was looking to incorporate Hello Kitty's colour scheme (red and white), which is perfect for a holiday theme. We took the white Thermaltake Snow Edition case (how appropriately named!) and got a partial red wrap done to give it a candy cane appearance. Then I added some green, with the red and white on the interior lighting and cabling, to round out the theme.

CPC: How did you create custom cutouts for pieces such as the custom fan guard?

Anthony: I wish I could take credit for this, but I've been utilising the extremely talented Jeff Mays of Jmmods (**jmmods.com**) for all the customised pieces inside the themed builds I've done. I don't have the equipment or know-how to produce those pieces by hand myself, but I have the design vision to put together a theme and explain to him what I need to make it happen

CPC: What's the red and white piece underneath the graphics card?

Anthony: That's a GPU support bracket. The newer GeForce RTX 3000-series cards are heavy, and I didn't want the card to sag at the end. Again, thanks to Jmmods for translating my vision into reality on that piece, and the same also goes for the custom PSU shroud and GPU backplate.

CPC: That's some really clean colour work on the outside. How did you get that finish?

Anthony: This time around, credit needs to go to a local friend, Carlos Alvarez, owner of SSP Vinyl. The folks there do vehicle wraps, window signage and so on, and he's always been great to work with when adding exterior case details, such as images, colour changes or lettering, for my custom PC builds. It's vinyl wrap rather than paint.

CPC: Did you have to modify the case in any way?

Anthony: Aside from the wrap, no major modifications were made to the case.

The newer GeForce RTX 3000-series cards are heavy, and I didn't want the card to sag at the end

CPC: We love the use of the screen on the NZXT Z63 cooler – did you make the image yourself, and does the system show any other images on the screen?
Anthony: My wife just downloads and uses the animated GIFs she finds that make her happy. At the end of the day, she's the one looking at it, so she gets to choose the images that speak to her. She has multiple Hello Kitty images that she rotates through the screen, and she changes them regularly.

CPC: Are you planning to replace any of the black parts (such as the rear fan and motherboard) with white parts at a later date, or spray them?
Anthony: No, the build is complete as it is.

CPC: What's your favourite part of your Hello Kitty PC?
Anthony: It's a toss-up between the amazing G.Skill Trident Z Royal RAM, which allowed us to put in red, green and white moving lights that mesh great with the theme, and the GPU bracket. The latter has a cool lighting effect – Jmmods has created a system that links the pieces he makes, so you can have a unified lighting effect – there's red and white lighting that flashes through them in the current setting, making a nice sequenced look.

CPC: Where did you get the custom cables?
Anthony: The custom cables were from **cablemod.com**

SYSTEM SPECS

CPU AMD Ryzen 7 5800X at stock speed

Case Thermaltake S100 Snow Edition Micro-ATX

Graphics card MSI Ventus GeForce RTX 3070

Storage 2TB Corsair MP400 M.2 NVMe SSD

Memory 32GB (4 x 8GB) G.Skill Trident Z Royal Silver DDR4 3200MHz

Motherboard ASRock B550M Pro4 Micro-ATX

PSU EVGA SuperNOVA 850W G5 Gold

Cooling NZXT Kraken Z63 280mm AIO RGB liquid cooler, 3 x Corsair QL120mm RGB LED fans, 2 x Corsair QL140mm RGB LED fans to replace the stock fans on the NZXT cooler

CPC: This isn't the first Hello Kitty PC you've built – what did you do differently in the other one?
Anthony: I built the other one around three or four years ago, and it was my first fully themed PC. It turned a lot of heads and caught a lot of attention when I released it. My wife loves the colour purple, but I asked her to trust me when I built that original one with the mostly white theme and splashes of red.

In that build, I replaced the NZXT logo on the PSU shroud with a coloured Hello Kitty piece that didn't light up (the new build has a light-up PSU shroud cover). In addition, the fan shroud wasn't as elaborate as this time around. The older build also featured SSDs with covers on them, which added some flavour to the inside, but lacked the GPU bracket that lit up.

The first one didn't have a customisable image on the CPU area either, and the standard G.Skill Trident Z memory modules weren't as nice-looking as the Royal models I used in the new build, plus I only filled two of the four memory slots in the old one.

CPC: Did you come across any difficulties? If so, how did you solve them?
Anthony: There were a few difficulties. The first case we purchased for this build was a smaller model, and we soon realised that it wouldn't have room for everything inside it, so we had to bump up the case size. Then, because of the design of the radiator on the NZXT cooler, I couldn't mount it all the way at the top front of the case. Instead, I had to lower it so that some of it goes down into the bottom of the case in order to make it all fit.

CPC: How long did it take you to complete this build, from start to finish?
Anthony: Once I had all the pieces, I was able to get it assembled within

Getting it made in time for the holidays, and seeing my wife's face light up when she saw it in action, made it all worthwhile

a day. The biggest time sink was working with my wife to agree on the graphics and colour scheme. There aren't many Christmas-themed Hello Kitty graphics out there, and a lot of what you find are low quality, or may have more pink colouring that doesn't mesh with the red/white/green theme I was trying to create.

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?

Anthony: I'm very happy with the end result. Being able to get it made in time for the holidays, and seeing my wife's face light up when she saw it in action, made it all worthwhile. CPC

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CORSAIR

To enter your rig for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (@**CustomPCMag**) or Facebook (**CPCMagazine**), or email low-res ones to **ben.hardwidge@raspberrypi.com**. Fame isn't the only prize; you'll also get your hands on some fabulous prizes, courtesy of Corsair.

Corsair Hydro X Series XD3 RGB Pump/Reservoir C

WORTH £151

The Corsair Hydro X Series XD3 RGB Pump/Reservoir Combo features a high-performance DDC PWM pump, integrated RGB lighting and in-loop temperature sensor to drive even the most compact custom cooling systems. It has a high-performance Xylem DDC PWM pump controlled via PWM to deliver the perfect flow balance for your loop. There are also 16 individually addressable RGB LEDs, which light up the pump head to produce stunning, customisable lighting effects to match your build.

Corsair Hydro X Series XC7 RGB CPU Water Block

WORTH £70

The Corsair Hydro X Series XC7 RGB CPU Water Block combines premium construction, vivid RGB lighting and extreme cooling performance to become the centrepiece of your water-cooling loop. It has a nickel-plated copper cold plate and more than 60 high-efficiency micro-cooling fins, which efficiently draw heat away from your CPU, lowering operating temperatures and allowing for maximum overclocks. You can choose the AM4/LGA1151 or LGA2066 version.

Corsair Hydro X Series XR5 240mm Radiator

WORTH £55

The Corsair Hydro X Series XR5 240mm Water Cooling Radiator delivers extreme custom cooling performance, with a 30mm radiator thickness and premium copper core. Its dual 120mm fan mounts on each side are ready for your most ambitious custom cooling build, and its 25 micron-thick cooling fins offer a high thermal transfer rate.

JAMES GORBOLD / HARDWARE ACCELERATED

GOOD RIDDANCE TO SLI AND CROSSFIRE

James Gorbold is that glad multi-GPU gaming is finally dead and buried

I remember getting genuinely excited when Nvidia brought back the SLI brand in 2004, as I had fond memories of linking together a pair of Voodoo 2 cards in the late 1990s and marvelling at the outlandish frame rates.

Unfortunately, neither SLI nor ATI/AMD's CrossFire equivalent tech really fulfilled on their promise of boosting frame rates. If you were lucky enough to play one of the few games that worked properly, you could expect a 60 per cent performance boost, but many games would micro stutter so badly that the whole experience was ruined, and you were better off disabling multi-GPU 'acceleration'.

Finally, in 2021, it's fair to say that the final nail has been hammered into the multi-GPU gaming coffin. I for one am pleased – apart from the terrible gaming experience I've already described, the user experience was poor too, with excess heat and noise, let alone the cost of paying for a second GPU that couldn't pull its own weight.

The decline started a few years ago, when game developers effectively gave up developing for SLI or CrossFire, as it's hard to optimise a game for multiple GPUs. This was always a tall order for developers, as the two technologies weren't compatible with one another, and they already have plenty on their plates when it comes to supporting the myriad of PC configurations.

What's more, despite the huge press coverage over the years, if I look back at Scan's sales figures, multi-GPU configs at most accounted for 7 per cent of gaming PCs, which is no doubt higher than the global average when you consider that 3XS Systems is a high-end brand. It wasn't worth developers' time optimising games for such a tiny number of gamers, especially when the payoff was often so poor.

> Multi-GPU configs at most accounted for around 7 per cent of our gaming PCs

For a short period, it looked like multi-GPU configurations might make a comeback when in 2016, Microsoft announced that DirectX 12 would add support for a new Explicit Multi Adaptor (EMA). However, the promises of mixed GPU configurations, including mixing Nvidia and AMD GPUs, in a system proved far too ambitious and EMA quickly faded into obscurity.

Thankfully, barely any modern GPUs support multi-GPU gaming now – of the GeForce 30-series, only the RTX 3090 has an NVLink connector. What's more, AMD and Intel have pretty much stopped developing the necessary platforms. Current AMD 500-series and Intel 500-series chipsets only provide 16 PCI-E lanes for GPUs, and any further expansion above 16 is dedicated to NVMe SSDs.

Intel even doubled the speed of the DMI link to the southbridge in its new 11th-gen Rocket Lake CPUs, in order to provide more bandwidth for extra devices that can now be integrated, such as Thunderbolt 4, USB 3.2 Gen 2x2 and Wi-Fi 6E, but didn't bother adding any more PCI-E lanes for GPUs because there was no demand for it.

While multi-GPU gaming is dead, and I hope this time for good, multi-GPU setups still thrives in the professional graphics market, where it's generally easier, although certainly not easy, to code applications such as rendering, CAE and CFD simulations and deep learning to run on multiple GPUs.

Nvidia designed NVLink precisely for this purpose, and its bigger sibling NVSwitch too. AMD and Intel are even designing workstation and server platforms with multiple GPU configurations in mind. Unlike a lot of tech, however, I don't see this trickling down in the gaming market. SLI and CrossFire are dead and buried, let's leave them that way. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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