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Welcome

Custom PC Issue 211

/ FROM THE EDITOR

Graphic design

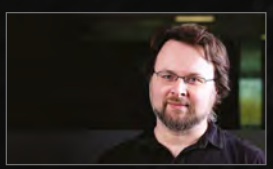
Over the past few weeks, I've been thoroughly immersed in the epic landscape of Assassin's Creed: Valhalla. I've never been a fan of previous Assassin's Creed games, but the history nerd in me loves that you can largely ignore the stealthy assassin aspect of this game, for which I don't have the patience, and go all out on Viking melee combat, while exploring today's big cities as they were in the old Anglo-Saxon kingdoms.

What also really struck me is just how beautiful this game looks. The attention to detail is superb, the textures look amazing and the scenery is just incredible. It does this despite not having a single mention of DLSS or ray tracing in the graphics options, and we've decided to add it to our GPU test suite this month. We've also added Cyberpunk 2077, which does support those features, but has been far less well received than expected.

It's been a bit of an eye-opener in terms of performance in our GPU Labs test (see p38). What's become really clear is that Nvidia and AMD have very different GPU architectures, and there are definite pros and cons to each approach. For example, the £600 Radeon RX 6800 (just) beats the £1,399 GeForce RTX 3090 in Assassin's Creed: Valhalla at 1,920 x 1,080 (yes, really!), while AMD GPUs don't support ray tracing at all in Cyberpunk 2077, at least not yet.

The latter game is seriously demanding too – not even the mighty GeForce RTX 3090 can cope with it at 4K with Ultra ray tracing, even with some help from DLSS. It still pushes your GPU hard without ray tracing enabled too. With some new game tests in the mix, AMD and Nvidia's GPUs compete much more closely with each other.

The elephant in the room, of course, is that it's hard to track down most of these cards at the moment. It's worth reading James Gorbold's column on p114 for a general update on the stock situation here. In the meantime, though, it's still very interesting to see two GPU makers competing in the high end again – it's some food for thought for the future, and for if/when the stock problems are ever resolved. CPC



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CUSTOM PC

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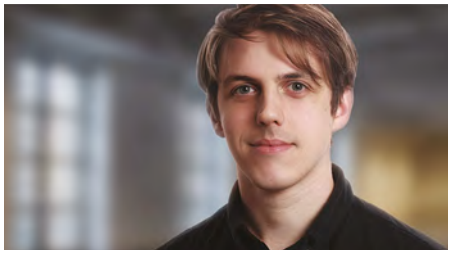

RICHARD SWINBURNE / VIEW FROM TAIWAN

HAS AMD MISSED ITS CHANCE?

AMD has released its best products ever, but hardly any of them are on the shelves to buy, argues Richard Swinburne

Intel is lighting the figurative rocket to get its 11th-generation Intel Core processors out the door. New motherboards with its 500-series chipsets (Z590, H570, B560) are already in the shops months before its CPUs are available to fill the sockets. Current Intel 10th-gen CPUs can use these new boards, but I wouldn't bother, as the upcoming 11th-gen CPUs look set to be considerably better.

Will it be worth the wait until March? Well, it's not like you can buy an AMD Ryzen 9 5900X anyway. AMD's latest CPUs are scoring all the benchmark wins, so you'd think the perpetual underdog would be seeing its best times ever, but what good are all the awards and reputation if there's nothing on the shelves to buy? For months there have been back orders of Ryzen 9 5000-series CPUs (and Radeon RX 6000-series GPUs). Has AMD lost its chance to take a big chunk of market share?

If the increasingly frequent leaks are to be trusted, Intel's 11th-gen CPUs actually seem to hold up to AMD's Ryzen 5000-series CPUs in single-threaded performance, despite the parallel expectation that they will be power-hungry 14nm chips compared with AMD's power-efficient 2nd-generation 7nm designs. While power efficiency, heat and noise are certainly factors weighing on buying decisions, there's ongoing high demand for new PCs and upgrades right now – if there are only Intel chips available to buy, and their performance is just as good, then people will definitely buy them.

If there are only Intel chips available to buy, and their performance is just as good, people will buy them

It seems that TSMC simply can't make enough 7nm chips. AMD competes against several other companies for space on TSMC's production lines, which I think is partly why Nvidia went to Samsung to fab its RTX 3000-series GPUs. Even when you consider the limitations resulting from the global pandemic, there's nothing coming through to stores even months after launch. This considered, it seems Intel is (surprisingly) right to keep hold of its own fabs, regardless of the sting from falling behind leading-edge process technology.

There's clearly not enough capacity at Samsung and TSMC fabs for Intel to even consider it. Having *something* on the shelf is better than nothing, and – I almost can't believe I'm writing this – Intel might actually be in a great position if it has products to buy and its 11th-gen CPUs aren't that bad; it's not as if most people need more than eight cores anyway.

The new motherboards featuring Intel 500-series chipsets are also consistently more expensive than those with the previous 400-series chipsets. That appears to be the price of enabling PCI-E 4, which we've seen with AMD's B550 boards too. If you're on a stricter budget and you're not using a PCI-E 4 NVMe SSDs, you can still install an 11th-gen Intel CPU in a motherboard with a 400-series chipset with a BIOS update. However, with Intel unlocking memory overclocking on its non-Z chipsets for the first time, you might want to check around for B560 motherboard bargains first anyway. After all, even 3600MHz DDR4 memory isn't that much more expensive than slower memory these days.

With motherboard makers enabling Ryzen 5000-series CPU support on (some of) their B450 motherboards, 2021 should make extremely fast 6-core CPU systems more affordable all round, if you can forego PCI-E 4. Hopefully this year's CPU competition will be great, and end up bringing us some competitive pricing, if only AMD can get some products on the shelves. CPC

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


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TRACY KING / SCEPTICAL ANALYSIS

LOSING CONTROL

Tracy King is wary of drawing parallels between 2005's World of Warcraft pandemic and today's real-life pandemic

The pandemic didn't give me an excuse to practically live inside video games, I was doing that anyway, but games have now become the only way I get to go anywhere. I often talk about how I spent months in Final Fantasy IX during a difficult period of my life, and credit the game with getting me through it.

There's nothing wrong with that, as long as I could control how much and when I played. It was a way of escaping a few things over which I had no control, without real consequences. Control is what the problems with the lockdown and pandemic are all about. It's not about whether we prefer being at home playing games rather than going out, it's the fact we no longer have a choice.

All we can control is our behaviour within the constraints of the pandemic, and that's of great interest to behavioural scientists, epidemiologists, and anyone else studying how we're all acting and how to make everyone behave a certain way.

Veteran World of Warcraft players will remember this, but younger readers may not know that a full-blown pandemic broke out in WoW in 2005. Known as the Corrupted Blood incident, it was born of an error in which a raid boss, Hakkar the Soulflayer, cast a debuff that a) drained HP, b) was highly contagious and c) only worked within the raid area. Except the coders forgot to factor in pets.

Like bats and COVID, WoW pets started to spread the 'disease' outside the raid area, and everyone infected, including NPCs, passed it to anyone with whom they came into contact until, yep, there was a virtual pandemic. Chaos ensued, but so did kindness, criminality and sometimes hilarity.

The scale of the event (WoW had over 6 million players then) was so great, Corrupted Blood attracted the attention of real-world pandemic experts, who have been using the data to try to model how and why real-world societies act. Lots of positive articles have been written about this, including claims that video games may save the world. Researchers have even proposed deliberately starting in-game pandemics just to harvest data (which would be unethical and therefore unlikely to happen).

But while there are some obvious parallels between real-world behaviours and virtual, I don't think this particular line of thinking will go anywhere. Gamers aren't toddlers who can't grasp the consequences of our actions. We know WoW isn't real life – that's precisely the point. While there are some downsides to dying in-game, it's not Game Over forever, and you know there's a team of developers working hard to fix the problem and who can hard reset servers in a pinch, like gods.

> We know WoW isn't real life – that's precisely the point

Corrupted Blood lasted less than a month, and plenty of players thoroughly enjoyed it while it lasted, whatever role they chose to play. Others chose not to play at all, and resumed once it was over. This isn't how real life works, particularly if you, your family or friends have been affected by the disease.

The similarities in behaviours are a curiosity, yes, but also an exercise in cherry-picking, ignoring crucial differences (including the different landscape of social media and politics in 2020/1 and the resurgence of conspiracy theories), which massively influence behaviour.

Corrupted Blood as a pandemic model case study makes for fun novelty headlines, but the reason games offer perfect escapism in a pandemic is because we know they're not real life, and – crucially – not real death. Let's not deliberately conflate them. 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

NVIDIA ANNOUNCES GEFORCE RTX 3060

Nvidia has announced plans to expand its line-up of Ampere gaming GPUs further with the introduction of the GeForce RTX 3060. Priced from £299, the RTX 3060 contains 3,584 CUDA cores, which is a big drop from the 4,864 found in the RTX 3060 Ti (see p39).

Bizarrely though, it comes with 12GB of GDDR6 memory, compared to 8GB on the 3060 Ti. That's likely a product of the narrower 192-bit memory interface, compared with the 256-bit interface on the RTX 3060 Ti. If Nvidia had the choice of equipping it with either 6GB or 12GB of memory, it decided to go for the latter.

The RTX 3060 also goes a little way towards making up for its lack of CUDA cores with a higher boost clock speed of 1.78GHz, compared to 1.67GHz on the 3060 Ti. The GeForce RTX 3060 will also support Nvidia's DLSS technology, and Nvidia claims the RTX 3060 will provide '10x the ray tracing performance of the GeForce GTX 1060'.

However, given that the GTX 1060 is a Pascal GPU that's over 4.5 years old, and has no dedicated ray-tracing hardware, that's not a massive boast. We'll be interested to see how it holds up against Nvidia's other RTX cards.

The Nvidia GeForce RTX 3060 is due to be released in late February, and we hope to get a sample card in for review in our next issue.

KINGSTON JOINS PCI-E 4 SSD CLUB

Memory maker Kingston has announced plans to launch a new PCI-E 4 M.2 NVMe SSD, with the company claiming read and write speeds of up to 7,000MB/sec. Codenamed 'Ghost Tree', Kingston revealed the SSD as a part of its product roadmap at the all-digital CES 2021 trade show. The company says the new SSD will come in capacities of 1-4TB and stretch the 4x PCI-E 4 interface 'to the limit'.

Comparatively, Samsung's 980 Evo claims the same 7,000MB/sec read speed (hitting 6,800MB/sec in our tests), but the claimed write speed drops to 5,000MB/sec. If Kingston can hit 7,000MB/sec on the write speed as well, it will have a performance champion.

The company also announced a new NV-branded series of PCI-E 3 NVMe SSDs at CES, plus a line-up of USB 3.2 Gen 2x2 external SSDs. Kingston says the new products are due for release later in the year.

AIR COOLER PROMISES LIQUID COOLING PERFORMANCE

Looking more like a radiator with a CPU contact plate than your average heatsink-and-fan assembly, IceGiant's ProSiphon Elite promises 'a mould-breaking way of keeping your CPU cool'.

IceGiant says its patented ProSiphon technology moves a non-conductive liquid between the heatsink's fins via hot air and gravity, so you don't get the usual pump noise of an all-in-one (AIO) liquid cooler. Nevertheless, the company says the cooling power on offer is comparable to that of an AIO cooler.

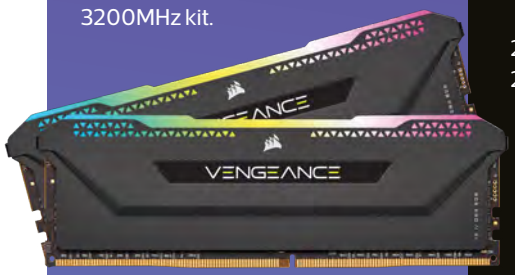
The IceGiant ProSiphon Elite is compatible with all current Intel and AMD CPU sockets, and won't clash with your memory modules if their height measures under 48mm. The colossal air cooler is available to pre-order now from **overclockers.co.uk** for a price of £179 inc VAT.

CORSAIR INTRODUCES LOW-PROFILE RGB MEMORY

Corsair has brought out some new RGB-equipped memory modules that measure just 44mm tall, which the company says will offer 'wide compatibility with nearly any PC build'. In terms of height, the new Vengeance RGB Pro SL modules are a good 12mm shorter than Corsair's Dominator Platinum RGB DIMMs, but they're still over 10mm taller than the company's non-RGB LPX modules.

However, that's still a good amount of clearance for the memory to sit under a large CPU heatsink, or under an all-in-one liquid cooler's radiator in the roof of your case. Despite the shorter height, each SL memory module comes equipped with ten RGB LEDs, which can be customised with Corsair's iCUE software and synchronised with other iCUE-compatible gear.

A wide range of kits is available, going up to a frequency of 3600MHz and a capacity of up to 128GB (4 x 32GB), with black and white colour options. The Vengeance Pro RGB SL kits are available to buy now from **scan.co.uk**, with prices starting from £91 inc VAT for a 16GB (2 x 8GB) 3200MHz kit.



THERMALTAKE MAKES RGB GAMING DESK

After blinging up almost every possible part of a PC setup with RGB LEDs, tech manufacturers are now equipping furniture with them. Not only can you get chairs with RGB lighting options now (see p55), but Thermaltake has also brought out an RGB-equipped gaming desk.

The L-shaped ToughDesk 500L RGB Battlestation Gaming Desk features electric height-adjustment control (complete with an anti-collision sensor), and comes with an integrated, full-surface mousepad with RGB lighting. The lighting can be controlled with Thermaltake's iTAKE software, but is also compatible with Razer's Chroma RGB software. Meanwhile, cable-routing channels under the surface enable you to keep your cable clutter out of the way.

Rumour control

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

GEFORCE RTX 2060 GETTING RERELEASED?

In an apparent bid to appease customers dismayed by the lack of Ampere stock, Nvidia has reportedly resurrected the GeForce RTX 2060 and RTX 2060 Super. Tech site **overclocking.com** claims that it's talked to several Nvidia board partners, who say they've received GPUs from Nvidia with an aim to remake their Turing-generation cards.

It's not necessarily a terrible idea, but the site also claims that the RTX 2060 cards could be priced at €300 (around £262 inc VAT), with the RTX 2060 Super cards going for just above €400 (around £349 inc VAT).

If that's true, it would represent shockingly bad value for money, given that the GeForce RTX 3060 Ti (if there was any stock) costs £369 inc VAT and offers performance comparable with the much quicker GeForce RTX 2080 Super. The site speculates that the move could be aimed at equipping OEM system builders with cards for customers, rather than retail, however.

NVIDIA AMPERE COMES TO LAPTOPS

Gaming laptops are about to become a whole lot more powerful, thanks to the release of Nvidia's latest mobile GPUs, which are based on the company's Ampere architecture. Nvidia says that over 70 laptop models with the new chips have already been announced.

Three new laptop GPUs have been announced – the GeForce RTX 3060, 3070 and 3080, with 3,840, 5,120 and 6,144 CUDA cores respectively. In the case of the RTX 3080, that's a big drop from the 8,704 CUDA cores found in the desktop version (see p43), although the laptop RTX 3060 has more CUDA cores than its desktop equivalent.

The new chips also feature a new way to boost clock speed according to gaming needs, rather than being set statically by the laptop. Nvidia claims that Dynamic Boost 2.0 'uses AI to balance power between the CPU, GPU and GPU memory ... managing power on a per-frame basis'. Nvidia has also introduced WhisperMode 2.0, where you set the noise level you're prepared to tolerate yourself, and Nvidia's 'AI-powered algorithms' do the rest.

Among the many laptops announced with the new chips is the Razer Blade 15 Advanced (pictured), which features a GeForce RTX 3080 laptop GPU and a 240Hz 2,560 1,440 screen in a machine measuring 16.99mm thick.

PAT GELSINGER RETURNS AS INTEL CEO

Acclaimed chip architect and business executive Pat Gelsinger is returning to Intel as CEO in February 2021, replacing Bob Swan. Along with John Crawford, Gelsinger was in charge of the design of Intel's 486 CPU (see p106), and the two also worked together on the design of Intel's first 32-bit desktop CPU, the 386.

After 30 years of working at Intel, from 1979 to 2009, Gelsinger left to join EMC, but he says he's now 'thrilled and humbled' to 'come back "home" to Intel in the role of CEO during what is such a critical time for innovation, as we see the digitisation of everything accelerating'. Gelsinger described the move as 'the greatest honour of my career'. Could this change result in Intel fighting back harder and more effectively against the threat from AMD's Ryzen CPUs? We'll have to wait and see.

INTEL SPILLS BEANS ON ROCKET LAKE

Intel has lifted the lid on some of the details of its forthcoming 11th-gen desktop CPUs, which are due for release in March this year. The new CPUs will be based on the Cypress Cove microarchitecture, representing the biggest architectural desktop CPU change since Intel released its first Skylake chips in 2015.

Among the benefits touted by Intel is an increase in the number of instructions per clock (IPC) of up to 19 per cent compared with its previous Core architecture. The new CPUs will also finally support PCI-E 4, with up to 20 lanes in each CPU, and there's official support for 3200MHz DDR4 memory as well.

Interestingly, though, the new chips aren't going big on core counts, with the top-end Core i9-11900K having eight cores (16 threads), compared to the ten cores in the current Core i9-10900K and 10850K. According to Intel, however, the Core i9-11900K is capable of boosting up to 5.3GHz.

In the meantime, all the major motherboard manufacturers have unveiled various boards based on Intel's new supporting Z590 chipset, although the new CPUs will also be compatible with existing motherboards based on 400-series chipsets with a BIOS update.

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– No RGB fans
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SPEC

Compatibility
AMD Socket TR4, TR4X

Radiator size with fans (mm)
120 x 394 x 52 (W x D x H)

Fans
3 x 120mm

Stated noise
8-27dBA

Cooling a CPU with over 20 cores can be a challenge, and when it comes to dealing with Threadripper CPUs, having a large enough contact plate to cover the giant heatspreaders on AMD's high-end desktop CPUs is also important. Generally, coolers with these big heatspreaders perform better than those without them. At the very least, it gives them an advantage, and helped the Cooler Master MasterLiquid ML360 RGB TR4 to pick up an award in our recent Threadripper cooler Labs test (see Issue 207, p40).

It was also one of the more affordable coolers to offer decent cooling and compatibility with AMD's Socket TR4 and TR4X, so we were keen to see what Cooler Master has done with this new tweaked version. The MasterLiquid ML360 Mirror TR4 isn't a complete redesign, but it sports new fans, a tweaked pump and a sturdier mounting plate.

The fans are Cooler Master's new Air Balance models, which use a refined bearing and a new blade design. Despite topping out at 1,800rpm, which is 200rpm slower than the older models, they offer slightly higher static pressure at full speed, and they're quieter too.

That's a welcome change, although the actual airflow figures are understandably lower with the new fans. They still lack RGB lighting as well, which is a shame, as some of Cooler Master's RGB-equipped fans with other ML-series coolers have looked fantastic. However, using these fans would likely see this cooler's already lofty price tag rise further.

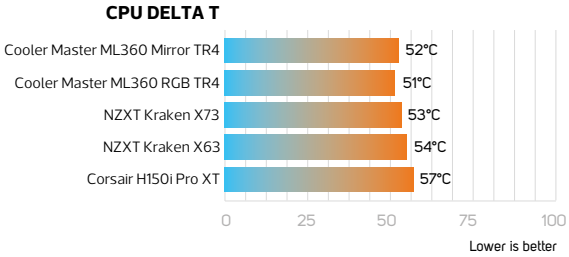
Sadly, Cooler Master doesn't include any form of software control, which you'll find on Corsair and NZXT's equivalents, giving you command over the pump, fans and lighting from the convenience of the Windows desktop. With the MasterLiquid ML360 Mirror TR4, you'll be forced to use the EFI or your motherboard's own software, with the latter often being hit or miss in terms of flexibility. Cooler Master also only includes enough screws for the included fans, so you'll need an extra dozen 6-32 radiator screws if you want to add another row of 120mm fans.

Each fan is equipped with a PWM cable, and Cooler Master has included a 3-way splitter cable, so you can power all of them from a single 4-pin header, which will cut down on cable clutter. The pump is powered using a 3-pin header, so you'll want to make sure it's not set to PWM mode in your motherboard's EFI. Thankfully, if you connect it to your motherboard's pump header (if it has one), your board should recognise what you've done and likely set it to full speed.

Even then, the pump was almost inaudible from just 1ft away, just making a slight, low hum. It was a little quieter than the pump on the older cooler too. If you're looking for a quiet all-in-one (AIO) liquid cooler, the MasterLiquid ML360 Mirror TR4 scores very highly. The radiator is also extremely compact, despite being a 360mm model. It measures just 27mm thick and 394mm long, so it should fit in any case with a triple 120mm fan mount.

As we mentioned earlier, the pump section offers a large contact plate designed for Threadripper CPUs, and it comes pre-fitted with a mounting plate and sprung screws. All that's

TEMPERATURE RESULTS



left to do in terms of installation is secure the pump to the CPU socket, but this does mean the cooler isn't compatible with other CPU sockets, so it isn't transferrable if you switch to a different socket in the future.

On the flip side, it's one of the easiest coolers to install we've ever come across, taking under five minutes to apply the included thermal paste, mount the pump, and install the radiator and fans. Screws are also included to mount the radiator straight into your case, as you would do in the roof.

What's more, the pump sports digital RGB lighting, with a fantastic holographic effect that looks seriously funky compared with the basic lighting on its predecessor. It's not garish, though, and you can control it using a 3-pin RGB header, or an included SATA-powered controller if you'd rather not use your motherboard's RGB software.

Performance

Our Threadripper test system includes a 3rd-gen Zen 2 Threadripper 3960X, which has 24 cores and 48 threads, and has been overclocked to 4.2GHz with a vcore of 1.265V to keep results consistent. At idle and medium loads, the MasterLiquid ML360 Mirror TR4 was inaudible outside of our case, which is great.

With the fans and pump at full speed, the CPU delta T topped out at 52°C, which was actually 1°C warmer than the original cooler, but essentially within the margin of error of our testing. Still, this was far better than the Corsair H150i Pro XT and 1°C cooler than the NZXT Kraken X73 too.

It was also quieter than all the coolers we've included in the graphs and we'd easily choose it over the MasterLiquid ML360 RGB TR4 for the slightly lower noise levels at full speed. The fans are certainly audible, but are never unpleasant, so they won't be irritating when you're in the middle of lengthy rendering sessions. In any event, it's easily up to the task of handling an overclocked Threadripper CPU.

Conclusion

With an incredibly simple installation that takes minutes, a reasonable price tag for the performance, low noise levels and attractive RGB lighting, the Cooler Master MasterLiquid ML360 Mirror TR4 is an excellent AIO liquid cooler for Threadripper owners. Those three qualities are enough for an award, so if they're your main concern, this is the cooler to buy.

You can get slightly more for your cash, though, from the likes of NZXT's Kraken X63, which offered similar cooling plus the benefit of software control for its fans, pump and lighting for about the same price. If low noise is your primary goal and you're keen to fill that triple 120mm fan mount in your case, though, the MasterLiquid ML360 Mirror TR4 is an excellent choice.

ANTONY LEATHER

COOLING 38/40

FEATURES 14/20

DESIGN 16/20

VALUE 16/20

FITTING Easy

OVERALL SCORE 84%

VERDICT

Great cooling, low noise and easy installation, but it comes with precious few other features.

360MM AIO LIQUID COOLER

PHANTEKS GLACIER ONE 360 MP / £155 inc VAT

SUPPLIER overclockers.co.uk

DAISY CHAIN

+ Daisy-chain fans
+ Excellent cooling
+ Tube clips

DAISY WHEEL

– No software control
– Pump isn't the quietest
– Fans are noisy at full speed

With products in many PC categories, from liquid coolers to PSUs, it probably escaped most people that Phanteks doesn't have an all-in-one liquid cooler to its name. Cases, air coolers and RGB lighting are just some of the other products it makes, as well as some very fancy water-cooling components, but it has now teamed up with Asetek to create its very own AIO liquid cooler. The Glacier One is available in both black and white colours, and in a range of sizes, including 240mm, 280mm and the biggest 360mm model here – the Glacier One 360 MP.

It uses Asetek's 7th-generation pump, which sports a pure copper base with dense skived fins and is PWM-controlled. In an interesting move, Phanteks' addition is a large clip-on housing, which sports a beautiful infinity mirror equipped with digital RGB lighting. It looks fantastic, even if it isn't a part of the actual waterblock – it certainly makes the plain Asetek pump look a heck of a lot more attractive.

The RGB housing is compatible with Phanteks' own lighting connectors, but the cooler also includes an adaptor allowing you to hook it up to any 3-pin RGB header, so you're not forced into Phanteks' own ecosystem if you have other devices you want to synchronise with it. Being Asetek, the design for mounting the pump is simple and very familiar. In fact, it hasn't changed in years.

On socket AM4, you use the stock backplate along with a mounting plate, specific mounting screws and thumbscrews on top. Intel's LGA115x and LGA1200 sockets all require an included backplate for use with similar components, and the LGA2066 mount ditches the backplate, with the mounting screws attaching directly to the CPU socket.

It's all blissfully straightforward, although you'll need to source an additional dozen of 6-32 screws if you want to add a second row of fans.

Phanteks has included pre-applied thermal paste to the contact plate, but also includes a spare tube for reapplication should you upgrade.

We initially thought that Phanteks had supplied the wrong PWM splitter cable in our sample, as only a 2-way cable was included with the pump and you have to deal with four connectors. As it happens, one connector is for the pump and the fans can actually daisy-chain themselves together, so they only require a single extension cable to hook up to the splitter cable, which is all included in the box.

Another nifty addition is the set of three tube clips. These act like PSU cable combs and create neat tubing runs, which is a great feature, as it stops the tubes flailing around. They even have small cut-outs for the PWM extension cable, so you can keep that tucked away too. With 40cm tube lengths, you have enough tubing to comfortably mount the radiator in the front fan mounts of most cases too.

Three Phanteks 120MP fans are included, which can spin at up to 2,200rpm and they certainly dish out a lot of air at full speed. They were pretty noisy too, though, so you'll likely want to tweak your motherboard's fan response curves to ensure they only hit their peak speed in extreme conditions.

SPEC

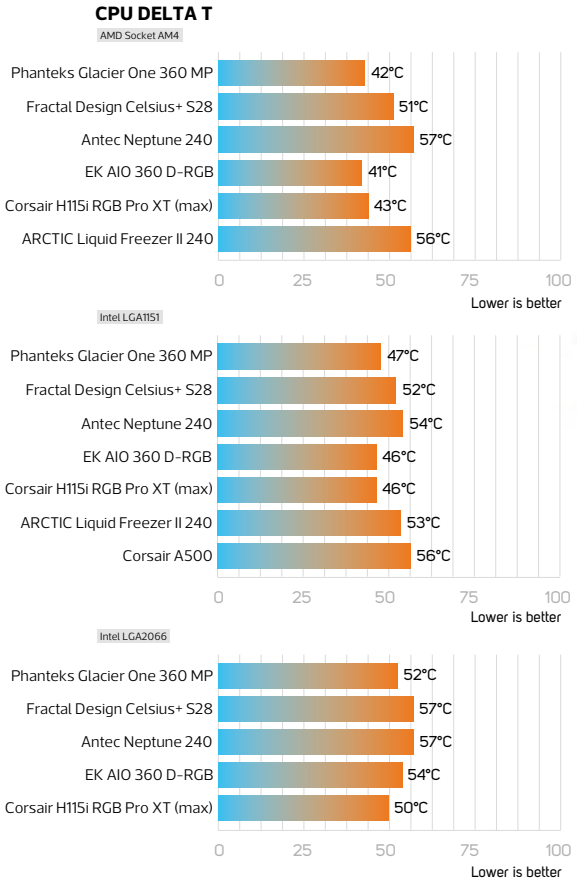
Compatibility
Intel: LGA1200, LGA115x, LGA2066, LGA2011; AMD: Socket AM4, AM3/+, AM2/+, FM2/+, FM1, TR4, TR4X

Radiator size with fans (mm)
120 x 394 x 52 (W x D x H)

Fans
3 x 120mm

Stated noise
34dBA

TEMPERATURE RESULTS



With a claimed static pressure of 3.41mm/H20, they should offer decent performance on the included 360mm radiator too. The latter is nothing special, being a typical Asetek unit measuring 27mm thick and 394mm long – it's suspiciously similar to the one included with the Cooler Master MasterLiquid ML360 Mirror TR4 we reviewed on p16.

Performance

A CPU delta T of 42°C put the Glacier One 360 MP near the top of the stack in our Socket AM4 system, where it was pitched against an overclocked 8-core Ryzen 7 1700 – only the EK AIO 360 D-RGB achieved a better result. The Phanteks bettered the monstrous Corsair H115i RGB Pro XT on its maximum fan speed setting too, although at full speed, the pump made a noticeable mid-to-high-pitched whine, so you'll definitely want to tune it back under low to medium loads.

In our Core i9-9980XE LGA2066 system, the Phanteks managed a delta T of 52°C, which again was enough for second place behind the Corsair H115i RGB Pro XT and it also bettered the EK AIO 360 D-RGB while offering a huge amount more cooling than the ARCTIC Liquid Freezer II 240 and Antec Neptune 240. Finally, our LGA1151 system with an overclocked Core i5-9600K saw it come within a degree of the top spot, but comfortably beating the Fractal Design Celsius+ S28. Only the EK and Corsair coolers were better, but barely so.

Conclusion

Phanteks has got a lot right with the Glacier One 360 MP. The tube clips are ingenious and will massively improve the look of your PC. In addition, the daisy-chain fans halve the number of cables you need. The fans don't sound ear-splitting at full speed, but they're potent enough to deal with extreme heat loads, while the large radiator enables good cooling at lower fan speeds.

The pump is a little on the noisy side, especially at full speed, but other components will likely drown out this noise under load anyway. Finally, the RGB-enabled pump housing is an attractive touch, if more of a bolt-on item, although the fact there's no software control means the likes of Corsair and NZXT do offer slightly more for your cash. If you're content to tweak the settings in your motherboard's EFI, though, and prefer the other aesthetic tweaks and features Phanteks provides, the Glacier One 360 MP is a good buy at a reasonable price.

ANTONY LEATHER

VERDICT

Some unique and interesting features and decent cooling, but it doesn't quite wow us enough to get our top award.

LGA115x

COOLING 35/40

FEATURES 16/20

DESIGN 17/20

VALUE 16/20

FITTING Easy

OVERALL SCORE 84%

AM4

COOLING 35/40

FEATURES 16/20

DESIGN 17/20

VALUE 16/20

FITTING Easy

OVERALL SCORE 84%

LGA2066

COOLING 36/40

FEATURES 16/20

DESIGN 17/20

VALUE 16/20

FITTING Easy

OVERALL SCORE 85%

MINI-ITX CASE

KOLINK ROCKET V2 / £140 inc VAT

SUPPLIER overclockers.co.uk

The original Kolink Rocket wowed us with its tiny size and ability to house some of the biggest graphics cards available, while offering good cooling for the latter. It was well built and made almost entirely from aluminium, which did sadly also bump up the price. However, not only is the new Kolink Rocket V2 £20 currently cheaper than its predecessor, but it's a more grown-up case in a few areas too. It's bigger in every dimension than the original, now spanning several centimetres of extra width and nearly 3cm in height.

The extra dimensions mean even better graphics card support, catering for up to 330mm-long cards that occupy up to 2.9 slots. The latter figure means that coolers bigger than dual-slot models are supported, but there are only two PCI-E slots on the rear panel, so very few cards will be too big. To support these cards, both side panels are vented, although the actual vented areas lack dust protection and remain the same size as before, despite the case and panels being bigger than the originals.

The exterior is made up almost entirely of a single U-shaped piece of aluminium, which suspends the main case chamber in a separate container, allowing for small recesses to sit above and below it. As such, while there are two fan mounts, you can't actually see them, as they exhaust into these recesses. The downside, of course, is that airflow will be restricted, as it has to bend around 90 degrees.

The side panels are fiddly to install, and the need for eight screws means it's not a quick process to perform upgrades and tweaks. The panels also didn't fit quite flush in some areas either, with noticeable gaps, although the gaps aren't visible from more than a few feet away.

Meanwhile, the underside is held aloft by small metal-clad circular feet with rubber bases that look very swish, and the front section is illuminated by a bright blue LED-backed power button. Beneath this sits a single USB 3 port, as well as a Type-C USB port. The latter uses a Type-C connector on its cable too, so you'll need a proper Type-C header on your motherboard to use it. There are no audio ports or a reset button though.

Like its predecessor, the Rocket V2 is limited to SFX and SFX-L power supplies, and the PSU is mounted on a removable bracket at the front of the case that points the fan at the side panel. A power extension lead then connects to your PSU and hooks it up to a standard kettle-lead female port at the rear of the case. Even using an SFX-L PSU will give you plenty of room above the ports for cables, although you'll need to take care that none of them fouls the 92mm fan in the roof.

The latter is an upgrade over the 80mm model in its predecessor, especially as there are even 92mm all-in-one

SATURN V

+ Ultra-compact case
+ Attractive appearance
+ Space for high-end GPUs

FIREWORK

– Limited cooling possibilities
– Average use of space
– Poor CPU cooler support

SPEC

Dimensions (mm)
150 x 350 x 270 (W x D x H)

Material
Aluminium

Available colours
Grey

Weight
2.6kg

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

Drive bays
2 x 2.5in

Form factor(s)
Mini-ITX

Cooling
1 x 92mm roof fan mounts (1 x 92mm fan included), 1 x 80mm base fan mount (fan not included)

CPU cooler clearance
63mm

Maximum graphics card length
330mm

liquid coolers floating around now. However, we'd prefer to see a couple of 120mm mounts in the roof instead, which would allow for more potent coolers or better airflow, especially as there's just 63mm of CPU-cooler clearance. While Kolink doesn't mention it, there's also an 80mm fan mount in the base of the case beneath the graphics card, which allows for a slim 80mm fan to boost airflow – that's an upgrade we certainly recommend, especially given their low price.

Meanwhile, the graphics card connects to the motherboard by way of a riser cable and, like the Phanteks Evolv Shift 2 on p24, it's only PCI-E 3-compatible. You can still use PCI-E 4 motherboards and graphics cards with it, but you'll need to fix your primary graphics slot to PCI-E 3 mode in your motherboard's EFI, as not doing so can cause stability issues.

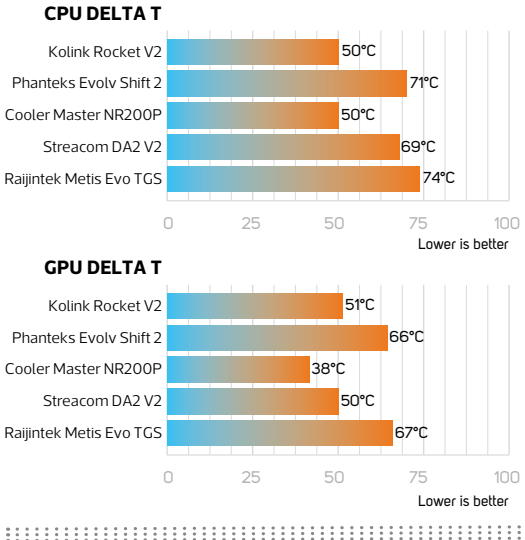
For storage, there are no 3.5in hard disk mounts, so if you want mass storage, you'll need to invest in an expensive large SSD, an external drive or a NAS. There are two 2.5in SSD mounts located in the bowels of the case, but like the side panels, they're not particularly easy to access once the drives are installed.

There are a few factors we'd change about the interior design as well, such as getting rid of the lower exterior shell, and lowering the motherboard and PSU. As it is, the case is unnecessarily tall. The fact the motherboard tray stretches from top to bottom means there's no option to include larger fan mounts there, when some simple tweaks would open up the case to much better airflow and liquid-cooling options.

Performance

The Rocket V2's CPU delta T of 50°C is actually very good, thanks to the large vent sitting right up against our low-profile CPU cooler, allowing it to draw cool air straight into its heatsink. This air is then expelled out of the roof, but we did suspect some recirculation was occurring, with warm air from the cooler leaving the side panel at the front of the case and being drawn back in again.

TEMPERATURE RESULTS



The GPU delta T was also very good at 51°C – only the Cooler Master NR200P, with its fans pointing directly at the GPU, fared noticeably better. The Kolink case also offers much better thermals than the Phanteks Shift 2 and Raijintek Metis Evo TGS in their out-of-the-box configurations.

Conclusion

Externally, the Kolink Rocket V2 is sleek, attractive and very compact – it would undoubtedly look great on top of your desk. Its price seems rather steep in the face of excellent and very flexible cases such as the Cooler Master MasterCase NR200P, but ultimately you're paying for the premium materials and more compact design.

Internally, though, it's very restrictive thanks to a complete lack of 120mm fan mounts and just 63mm of CPU cooler clearance. While you can comfortably house a monster graphics card in the Rocket V2, you can't say the same for your CPU. In fact, we'd have concerns about using any CPU with more than six cores, and we wouldn't recommend overclocking either.

Kolink does have a potential answer in the form of the Rocket Heavy, which we hope to test soon. For now, though, unless you're looking for a very specific layout or feature set, there are more flexible compact mini-ITX case options.

ANTONY LEATHER

VERDICT

A great-looking ultra-compact case made from premium materials, but some of its design aspects need a rethink.

COOLING 27/30

FEATURES 15/20

DESIGN 20/30

VALUE 15/20

OVERALL SCORE 77%

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MINI-ITX CASE

PHANTEKS EVOLV SHIFT 2 GLASS / £100 inc VAT

SUPPLIER overclockers.co.uk

The original Phanteks Evolv Shift really demonstrated why many of us have a soft spot for small form factor cases. It was good-looking and sleek, plus it had a unique design and looked great on your desk. However, its cooling left a lot to be desired and Phanteks even released a version with mesh rather than glass side panels to improve airflow. The same is true for the latest version – the Evolv Shift 2, which thankfully costs about the same at around £100, but has been tweaked in several areas to boost its credentials.

Firstly, the front and rear aluminium panels have been reworked and now secure using thumbscrews, so they no longer have the annoying habit of popping off when you lift the case. The side vents are larger too, stretching from nearly top to bottom and have larger perforated holes.

The biggest change to the entire case is found here too, with the rear panel now sporting a large grille pattern to boost airflow. A 140mm digital RGB fan is included to shunt air out of the case through this panel, and a second mount below it can offer a home to a 120mm fan or radiator, or a 140mm fan.

However, due to the way the PSU now sits, it's no longer possible to mount a second radiator in the base of the case. A third fan mount exists beneath the main chamber out of sight, and can be accessed by popping off the base. All this doesn't change much from the design of the original case, except that rear vent.

Meanwhile, the CPU cooler height limit is still restrictive at 85mm, even if it's better than the original case's 82mm. The graphics card clearance has also fallen from 350mm to 335mm with the new case, although this is long enough for all but the most massive graphics cards.

Installing graphics cards is made easier too, as the PSU mount has been tweaked to have either SFX or SFX-L PSUs mounted on their side rather than facing downwards. This also improves cable management, as modular PSUs' connectors faced upwards in the previous case, and it was a very tight fit between them and the mid-section plate that sat above them.

The GPU mount is also adjustable, and allows you move the graphics card back and forth depending on its width, with up to 150mm clearance. You can also reverse your card should you wish to make better use of its cooler design or show off its backplate.

Phanteks has included a higher-quality riser cable with the Shift 2 as well, although this isn't PCI-E 4-compatible, so if your motherboard and graphics card support it, you'll need to force your motherboard's primary graphics slot into PCI-E 3 mode in the EFI or your display driver will go haywire.

The front panel has also been moved and the pair of USB 3 ports now sit at the base of the case. They're embedded in a small plate that sits in the pop-off bottom section, rather than sitting in the mesh of the front panel's side section. The Shift was always a case you'd sit on your desk rather than the floor, so this change perhaps makes it a little easier to access the ports, as well as allowing the mesh in the front panel to extend further. There are no audio ports, though, and it's a shame there's no Type-C USB port either, as the case certainly looks like it should include one.

SPEC

Dimensions (mm)
170 x 274 x 490 (W x D x H)

Material
Aluminium, steel, glass

Available colours
Black, grey

Weight
6.8kg

Front panel
Power, 2 x USB 3

Drive bays
1 x 3.5in, 2 x 2.5in (additional 2 x 2.5in with adaptor)

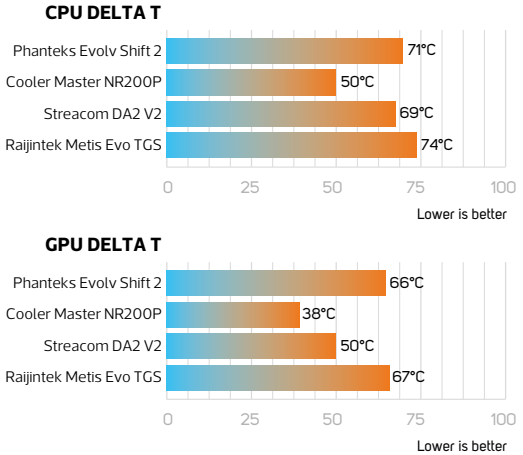
Form factor(s)
Mini-ITX

Cooling
2 x 120/140mm side fan mounts (1 x 140mm fan included), 1 x 120/140mm base fan mount (fan not included)

CPU cooler clearance
85mm

Maximum graphics card length
335mm

TEMPERATURE RESULTS



The power button sits in the same place, though, at the top of the case, adjacent to a button that controls the integrated digital RGB lighting. The lighting extends to the fan and power button out of the box, but Phanteks includes connectors for you to hook up its own extensive range of RGB paraphernalia.

Meanwhile, the roof of the Shift 2 hinges open to reveal the I/O panel of your mini-ITX motherboard, meaning you're forced to route the cables through a small hole at the rear. In practice this can prove a little awkward, as removing a single cable can be tricky if you have lots of USB peripherals.

The cables then flow out of the top of the rear of the case like a ponytail, so you'll need to place it at an angle on your desk to make sure they're not visible. It's clearly a case that would benefit from dishing out various signals over a single Thunderbolt port (see p98) to cut the number of cables. Finally, the storage system hasn't changed much since the original case. You get a single hard disk mount and you can fit up to four 2.5in SSD mounts, with two included out of the box and two more available using an optional bracket.

Performance

The Evolv Shift 2 Glass' CPU delta T of 71°C is slightly disappointing given that the 140mm fan and new rear vent are near the CPU. Comparatively, the Cooler Master NR200P with its additional fans and better airflow knocked 21°C off this temperature.

The Streacom DA2 V2 was also a little cooler despite including no fans, but ultimately, the Shift 2 is designed for all-in-one (AIO) liquid coolers rather than low-profile air coolers. The GPU delta T of 66°C was also poor, with the NR200P dropping this figure by 28°C. The rear 140mm fan was extremely quiet, though, which perhaps hindered the cooling.

Conclusion

While the Glass version of the Phanteks Evolv Shift 2 looks fantastic, despite the improved airflow, we'd still be reluctant to build a high-end PC inside it unless you add an extra fan and use an AIO liquid cooler. Even then, thermals are poor and overclocking would likely be out of the question.

The solution, then, would be to opt for the Air version of the case with its vented side panels. They don't have the lustre of glass, but your PC's components will thank you for it and you'll still have a great-looking PC on your desk. Overall, the Shift 2 is definitely worth considering, given its striking looks and ultra-small footprint, but you'll need to plan your system carefully to make the best use of its unusual thermal arrangement.

ANTONY LEATHER

VERDICT

A stunning case that's an improvement on its predecessor, but some thermal issues remain.

TEMPERED GLASS

+ Attractive design
+ Improved cooling
+ Reasonably priced

TEMPERED EXPECTATIONS

− No USB 3.1 Type-C support
− Poor cooling compared with the best-performing small cases
− Limited CPU cooler height support

COOLING **17/30**

FEATURES **16/20**

DESIGN **27/30**

VALUE **18/20**

OVERALL SCORE **78%**

WIRELESS GAMING HEADSET

RAZER BLACKSHARK V2 PRO / £180 inc VAT

SUPPLIER razer.com

The BlackShark V2 Pro is one of Razer's most premium headsets, boasting just the sort of high-end feature set you'd expect for its £180 asking price. It has a wireless connection, surround sound and top-of-the-line headphones, so there's plenty going on.

As well as lots of features, this is also a great-looking headset. All black and almost completely devoid of any flashy design extras – even the Razer logos on each earcup are shiny black on matt black – it's both a stylish yet modest-looking headset, which has more of a feel of form following function than many other gaming designs.

The design is in many ways quite simple too. The headband is a single-piece affair, with an adjustment system that just involves the two metal wires of the earcup holder sliding smoothly in and out of the headband. The lack of detent adjustment does mean the headset tends to slide loose over time, but rarely enough to be a problem – a quick tweak once every few hours is sufficient.

Comfort is decent too. That headband is deeply and softly cushioned, while the earcups have reasonably deep, squishy padding. They also provide just enough grip to help to take the middling 329g weight of the headset.

For physical features, you get a fairly modest selection, with the left earcup being home to the lot. Here you'll find the volume dial that sticks straight out the side of the headset, along with a 3.5mm analogue jack input, the micro-USB charging port (shame it's not USB Type-C), the microphone mute button and the power button. Sitting forward of all this lot is the socket for the bendable microphone.

It's a simple selection but it's very easy to use, with all the controls falling easily to hand and the volume control in particular providing just the right balance of accessibility without being too easy to knock. We also like that it has a detent halfway through its travel, making it easy to quickly dial in a mid-range volume level.

Meanwhile, the microphone has a decent length arm and comes with a slip-on foam wind sock. It's fairly easy to bend into position, although it springs back to being straight a little more than some designs. It offers unexceptional recording quality, although it's adequate for voice comms.

The headphones' audio quality is more exceptional. The 50mm drivers offer well-balanced sound, with strong but not overwhelming bass, and plenty of top-end detail without shrillness. It lends itself well to the majority of music genres and game types. For sheer sonic quality, they're the sort of step up you'd expect from a headset at this price.

Install Razer's software (with an annoying signup and login required), and you can also switch between the default stereo configuration and THX Spatial Audio. It's a shame the headset doesn't have a hardware button for switching modes, but the Spatial Audio does sound great, noticeably improving spatial awareness and directionality in games.

JAWS

+ Stylish, practical design
+ Great sound quality
+ Comfortable

SHARKNADO

– Expensive
– Headband loosens over time

SPEC

Audio config
Stereo and THX Spatial Audio

Frequency range
12-28,000Hz

Sensitivity/sound pressure
100db

Mic frequency response
100-10,000Hz

Mic sensitivity
-42dBV/Pa

Weight
329g with mic

Battery life
Up to 24 hours

Extras
Detachable mic, 1.3m analogue cable, wireless dongle, micro-USB charging cable

Conclusion

The BlackShark V2 Pro doesn't come cheap, but it delivers the sort of premium experience you'd expect in just about every area. It looks great, it's comfortable, it offers high-end sound quality, excellent virtual surround performance and has a simple but well thought out selection of features. The microphone quality is nothing special and the headband does loosen over time, but we didn't find either of these issues to be major drawbacks in games.

EDWARD CHESTER

DESIGN/COMFORT 17/20
FEATURES 16/20
SOUND QUALITY 33/40
VALUE 14/20
OVERALL SCORE 80%

VERDICT

A classy gaming headset with a premium price, there's plenty of reason to snap up the BlackShark V2 Pro if you can afford it.

WIRELESS GAMING HEADSET

CORSAIR HS70 BLUETOOTH / £99 inc VAT

SUPPLIER corsair.com

The latest addition to Corsair's gaming headset line-up includes both analogue wired input and Bluetooth connections, making the HS70 Bluetooth ideal for use with a gaming laptop, a console gamepad's audio port or a mobile device via Bluetooth.

The design of the HS70 Bluetooth is all but identical to the company's HS60 headsets (such as the HS60 Haptic reviewed in Issue 209), with the main difference being the addition of wireless support. This means it retains the same simple but stylish look and solid build quality.

Less welcome is the fact that the HS70 Bluetooth has the same level of comfort as the HS60. The headband has fairly shallow, not overly soft padding, so it doesn't do a particularly good job of distributing the weight of the headset. The clamping force of the headset is also quite strong and there's not much give in the earcup holders to accommodate the curve of different-shaped heads. Thankfully, the earcup padding is reasonably deep and the headset does at least stay firmly put, despite its relatively hefty 361g weight.

For features, you get a power button on the back edge of the right earcup, while the left earcup is home to the other bits and pieces. There's a socket for the detachable microphone that's covered by a rather pointless rubber bung, then a 3.5mm analogue audio input jack, the USB Type-C charging port (a decent upgrade over the micro-USB socket used in Razer's far more pricey BlackShark V2 Pro), a microphone mute button and a volume wheel.

All the controls fall to hand without being too easy to accidentally knock, and we particularly like the volume wheel. It's a conventional analogue wheel rather than a digital one, so it's easy to set and forget, while you're also able to adjust it quickly when needed.

In the box you get a detachable, bendable microphone, a foam sock for the microphone, a 1.5m analogue audio cable and a 1.8m USB Type-C cable. It's a simple but entirely adequate selection for a headset of this type, although notably you don't get a wireless dongle – if your PC doesn't already have Bluetooth, you can only use this headset via its analogue wired connection. We had no issues connecting the headset to a variety of devices via Bluetooth, with it delivering clear and delay-free audio both to the headphones and from the microphone, and its wired connection worked great with consoles too.

In terms of sound quality, the headphones produce a reasonably clear and powerful sound, although it's one that's very much muddied by an overly strong bass presence. It makes for quite a fun, engaging listen in games, but some clarity is lost and it can be a bit distracting at times. A slightly more even sound profile would be preferable here.

Meanwhile, the microphone is flexible and easy to bend into position, plus it holds that position, unlike some models. Its quality is sufficient for voice comms, but its narrow frequency response makes for a fairly boxy sound.

Conclusion

The Corsair HS70 Bluetooth is a solid option for laptop, mobile and console use. It's easy to connect to such devices and provides adequate audio quality. However, it's not the most comfortable headset to wear, and its bass-heavy sound is a little overdone.

EDWARD CHESTER

SPEC

Connections
USB Type-C (charging), 3.5mm stereo, Bluetooth

Audio config
Stereo

Frequency range
20-20,000Hz

Sensitivity/sound pressure
109dB

Mic frequency response
100-10,000Hz

Mic sensitivity
-40dBV/Pa

Weight
361g

Battery life
30 hours

Extras
Removable mic, USB Type-C and 3.5mm analogue cables provided

VERDICT

Well built and easy to use, this is a decent console-centric gaming headset, but it's not without its foibles.

BLUEBIRD

+ Good battery life
+ Stylish design
+ Easy console and mobile connectivity

BLUEBEARD

– Not very comfortable
– Very bass-heavy sound
– Not suited for PCs without Bluetooth

COMFORT **14/20**

FEATURES **16/20**

SOUND QUALITY **30/40**

VALUE **15/20**

OVERALL SCORE **75%**

LIGHTWEIGHT GAMING MOUSE

ROCCAT BURST PRO / £50 inc VAT

SUPPLIER roccat.com

FIREWORK

- + Compact ambidextrous shape
- + Very light
- + Won't get full of dust
- + Excellent gaming performance
- + Affordable

WATER MAIN

- − Not ambidextrous button layout
- − Uneven RGB lighting

Costing £50 inc VAT, Roccat's Burst Pro isn't quite what you'd call cheap, but in a world of seemingly simple gaming mice going for upwards of £70, this new ultra-lightweight gaming rodent is a relatively affordable option. In accordance with its modest price, you don't get a lot of extra features, but there's plenty of the latest technology and trends in mouse design included here.

The headline figure for this mouse is its weight. It tips the scales at just 68g, putting it right up against the lightest mice around, such as the Glorious PC Gaming Race Model O and Endgame Gear XM1 (both reviewed in issue 195). It couples this weight with a design that incorporates the new trend for perforating the chassis of the mouse with hexagonal holes to save weight. Here, though, Roccat has skinned over those holes with a translucent layer, so the mouse still has a smooth surface but you can see the holey structure below.

Roccat has tried to highlight this structure by adding RGB lighting inside the mouse, creating a backlit effect. It looks okay, with the rear portion of the mouse being clearly illuminated, but the lighting is rather uneven across the rest of the mouse. You also get an RGB-lit scroll wheel, and you can add effects and sync up both lighting zones via Roccat's software.

The mouse's shape is ambidextrous and relatively compact, with an overall length of 120mm and width of 58mm. This makes it ideal for fingertip grips for all hand sizes, while those with small hands could use a palm or claw grip. In comparison, the Glorious PC Gaming Race Model O is 8mm longer and nearly 8mm wider.

Although ambidextrous in shape, the Burst Pro doesn't have extra buttons for left-handed users. Instead, you get just the basic selection of left, right and scroll-wheel click at the front, back and forward on the left side, and a single DPI button behind the scroll wheel. For right-handed users, it's a sensibly laid out selection, with all the buttons proving easy to reach without being too easy to hit accidentally. The scroll wheel also offers a clear detent scroll system, and it's easy to press its button without nudging the scrolling.

The two main left and right buttons use Roccat's Titan optical switches, which are rated for a whopping 100 million clicks and, like other optical switches, claim to have a faster response than metal-contact switches that require a short debounce delay. In practice, we haven't been able to tell the difference between optical and metal switches, but overall the Burst Pro's buttons do feel very responsive.

Likewise, the Roccat Owl-Eye optical sensor provided flawless tracking performance.

A modern-style lightweight, highly flexible cable trails from the front of the mouse, ensuring you don't get any annoying push-back from the cable in the heat of battle. The very large gliding pads on the underside also do their job very well.

SPEC

Weight
68g

Dimensions (mm)
120 x 58 x 39 (W x D x H)

Sensor
Roccat Owl-Eye optical - 16,000 DPI, 50g acceleration, 400ips

Buttons
Six (left, right, scroll wheel, back, forward, DPI)

Cable
1.8m, lightweight braided

Extras
RGB lighting

Conclusion

The compact shape, sensible button layout and light weight of the Roccat Burst Pro make for an excellent high-performance gaming mouse. It's agile, responsive and precise. A bulkier, more contoured mouse such as the Razer DeathAdder V2 Pro (see Issue 210, p28) is more comfortable for daily desktop use, but its relative bulk isn't so great for fast-paced gaming. If fast-paced gaming is your priority then the Roccat Burst Pro is a superb, affordable gaming mouse, and it won't get full of dust either.

EDWARD CHESTER

VERDICT
A fantastic addition to the raft of excellent lightweight gaming mice.

DESIGN 17/20
FEATURES 15/20
PERFORMANCE 28/40
VALUE 27/30

OVERALL SCORE
87%

FREE CHILLBLAST AERO RGB GAMING MOUSE

WITH A 12-MONTH SUBSCRIPTION TO CUSTOM PC

SPEC

- **Sensor** PixArt PAW3327DB
- **DPI levels** 800,1,600, 2,400, 3,200, 4,800 and 6,200
- **Switches** Huano (10-million click lifetime)
- **RGB lighting** 11 modes switchable
- **Software programmable** Supports macro for all buttons
- **Polling rate** 125, 250, 500 and 1000Hz switchable
- **Tracking speed** 220 inches per second
- **Acceleration** 30G
- **Weight** 72g
- **Ascended cord** Light and flexible
- **Dimensions (mm)** 67 x 128 x 38 (W x D x H)

WORTH £40

Custom PC APPROVED

Our generous pals at Chillblast are kindly offering an award-winning Aero RGB gaming mouse (see Issue 208, p33) to anyone who takes out a 12-month UK subscription to **Custom PC** magazine.

Designed in Poole, Dorset, by Chillblast's team of gaming experts, the Aero RGB is designed for competitive gaming. Its honeycomb mesh design retains incredible strength, while allowing ventilation to keep your palm cool and fresh. Meanwhile, its carefully optimised 72g weight is ideal for gamers who want the fastest possible reaction times.

The PixArt PAW3327DB sensor allows for high DPI levels, while the all-Huano switches provide longevity and a tactile click response. Chillblast's braided, ascended cord also means you're never impeded by the cable, while support for horizontal acceleration of up to 30G means even professional esports players will never overwhelm its tracking hardware.

A plethora of customisation also awaits in the software, where you can program sensitivity, polling rate, recordable macros and RGB lighting effects. The Aero RGB is an awesome weapon for your favourite MOBA, FPS or strategy title.

SUBSCRIBE TODAY!

Chillblast

£45 for 12 months – UK ONLY use code **CPCMOUSE**

01293 312182

custompc.co.uk/chillblast

Mouse will be delivered within 28 days of signing up for subscription. Limited quantities available. This subscription gift will be awarded on a first come first served basis.

AMD B550 GAMING PC

CCL BLADE / £1,499 inc VAT

SUPPLIER cclonline.com

CCL's Blade combines AMD and Nvidia hardware, with the bulk of the parts made by MSI, including the case, CPU cooler and PSU. More conventionally, MSI makes the GeForce RTX 3060 Ti graphics card. It's based on Nvidia's newest and most affordable Ampere chip, and the MSI Ventus 2X OC raises its 1665MHz boost clock by 30MHz.

It's paired with an AMD Ryzen 5 5600X, which has six SMT-enabled cores, alongside base and boost speeds of 3.7GHz and 4.6GHz. Two 8GB sticks of Corsair DDR4 RAM run at a pacey 3600MHz, and storage comes from a 1TB PCI-E 4 Corsair MP600 SSD. The aforementioned MSI A650GF PSU is also modular and has an 80 Plus Gold certification.

Meanwhile, the MSI B550-A Pro motherboard has two spare memory slots, free 16x and 1x PCI-E slots, and a vacant M.2 connector, but neither the second 16x PCI-E slot nor the spare M.2 connector support PCI-E 4. It has Gigabit Ethernet but no Wi-Fi and it only has entry-level Realtek ALC887 audio.

The board has no RGB LEDs and bland heatsinks too, but it does offer some extra connectors for fans and lighting. At the rear, it has a USB 3.2 Gen 2 Type-A and a Type-C connector, plus two full-sized 3.2 Gen 1 ports, but the other ports use the slower USB 2 standard and there's no optical S/PDIF or faster USB 3.2 Gen 2x2.

It's all housed in MSI's MAG Vampiric 100R mid-tower chassis. The front panel has a meshed area with a solid, matt black plastic section, separated by RGB LEDs that match the lighting elsewhere. Build quality is decent, and the top of the chassis has one USB 3.2 Gen 1 port and two USB 2 connectors, but no USB Type-C.

The case has a button for changing the RGB LED colours, but it didn't work on our machine. On the inside, the cabling is neat and components are accessible, but this case measures just 390mm deep and 457mm tall. That's ideal for fitting this PC into smaller spaces but the dimensions, along with the front-mounted radiator for the CPU cooler and the double-height graphics card, leave the interior cramped.

CCL's £1,499 system squares up against this month's Wired2Fire Predator, which includes the same CPU alongside a 3060 Ti with a higher overclock. The Wired2Fire has slower memory and no PCI-E 4 SSD, but it's £100 cheaper than the CCL. There's also last month's Chillblast Fusion Commando 3060 Ti, which paired the 3060 Ti with a Ryzen 7 5800X and 32GB of RAM. At the time of writing, the Chillblast still costs £1,499 inc VAT, although supply issues may mean price increases.

The CCL has a decent warranty. It's a three year deal that covers parts and labour with collect and return service.

SPEC

CPU
3.7GHz AMD Ryzen 5 5600X

Motherboard
MSI B550-A Pro

Memory
16GB Corsair Vengeance RGB Pro 3600MHz DDR4

Graphics
MSI GeForce RTX 3060 Ti 8GB

Storage
1TB Corsair Force MP600 PCI-E 4 M.2 SSD

Networking
Gigabit Ethernet

Case
MSI MAG Vampiric 100R

Cooling
CPU: MSI MAG CoreLiquid 240R with 2 x 120mm fans; GPU: 2 x 90mm fans; rear: 1 x 120mm fan

PSU
MSI MPG A650GF 650W

Ports
Front: 1 x USB 3.2 Gen 1, 2 x USB 2, 2 x audio; rear: 1 x USB 3.2 Gen 2, 1 x USB 3.2 Gen 2 Type-C, 2 x USB 3.2 Gen 1, 4 x USB 2.0, 1 x PS/2, 6 x audio

Operating system
Microsoft Windows 10 Home 64-bit

Warranty
Three years parts and labour collect and return

Performance

In Shadow of the Tomb Raider and Doom Eternal at 1080p, the RTX 3060 Ti delivered 99th percentile minimums of 61fps and 201fps, and it even managed 38fps in Metro Exodus. The new Nvidia card proved capable at 2,560 x 1,440 too – its minimum hit 30fps in Metro and was faster in other games. There's enough power to play games on a 1080p or 1440p display with ray tracing. The downside is that the Wired2Fire and Chillblast machines are both faster.

The CCL's Ryzen 5 5600X scored an overall of 240,790, which is easily enough to avoid game bottlenecks and handle everyday workloads, photo editing and mainstream streaming. However, the Wired2Fire's was faster in our application benchmarks, and the Chillblast's Ryzen 7 5800X scores beyond 280,000, making it the better choice for content creation. At least the CCL's CPU is bolstered by the PCI-E 4 SSD, which delivered superb read and write speeds of 4,995MB/sec and 4,288MB/sec.

The CCL's biggest performance issue comes in thermal tests. When gaming, the Blade is louder than most systems,

BENCHMARK RESULTS

70,445 GIMP IMAGE EDITING

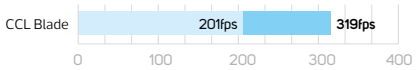
563,610 HANDBRAKE H.264 VIDEO ENCODING

300,571 HEAVY MULTI-TASKING

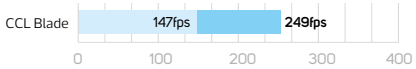
240,790 SYSTEM SCORE

DOOM ETERNAL

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

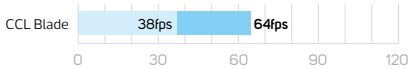


2,560 x 1,440, Vulkan, Ultra Nightmare settings

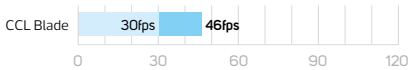


METRO EXODUS

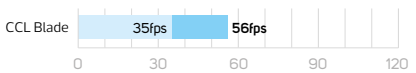
1,920 x 1,080, Ultra, HairWorks off, Advanced PhysX off, Ultra RT



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

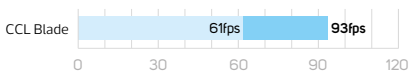


2,560 x 1,440, Ultra, HairWorks off, Advanced PhysX off, Ultra RT, DLSS

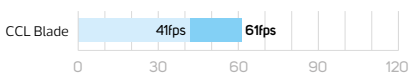


SHADOW OF THE TOMB RAIDER

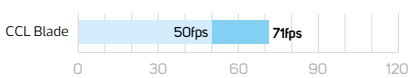
1,920 x 1,080, Highest settings, High ray-traced shadows, TAA



2,560 x 1,440, Highest settings, High ray-traced shadows, TAA



2,560 x 1,440, Highest settings, High ray-traced shadows, DLSS



99th Percentile | Average

SWITCHBLADE

- \+ Good gaming speed
- \+ Fast PCI-E 4 SSD
- \+ Small, tidy chassis
- \+ Decent warranty

SWITCHBOARD

- – Better CPUs available
- – Noisy
- – Entry-level motherboard

including the Wired2Fire. The racket mainly comes from the GPU fans and the CPU cooler, and it likely doesn't help that the PC's intake fans feed straight into the CPU cooler's radiator.

Tweaking the GPU fan settings didn't help either – dropping the fan from its default 90 per cent speed to 70 per cent made it quieter, but its peak boost clock speeds dropped. It ultimately depends on your requirements, but dialling down the noise means sacrificing performance. It's also possible to talk to CCL during the build process – the company would undoubtedly be able to install a different graphics card, albeit with some potential added cost.

The processor's highest delta E of 51°C was achieved during a single-core test – and here, the system matched the noise levels recorded during intensive gaming, just with most of the noise coming from the CPU cooler. In a multi-core test, the delta E of 46°C was decent and the noise levels were lower, likely thanks to lower all-core boost speeds.

Conclusion

CCL's system delivers solid gaming pace alongside a decent CPU and a fast SSD, and those factors make it a capable mid-range option for mainstream gaming and applications. The Wired2Fire is faster, quieter and it offers a better case for £100 less, though, giving it a better overall balance, while the Chillblast's Ryzen 7 CPU makes it a better buy if you'll be tackling tougher multi-threaded workloads.

MIKE JENNINGS

VERDICT

Decent gaming pace, but it needs a faster CPU and quieter operation at this price.

PERFORMANCE **20/25**

DESIGN **18/25**

HARDWARE **20/25**

VALUE **20/25**

OVERALL SCORE **78%**

AMD B550 GAMING PC

WIRED2FIRE PREDATOR

/ £1,399 inc VAT

SUPPLIER wired2fire.co.uk

Wired2Fire's Predator relies on an Nvidia GeForce RTX 3060 Ti and an AMD Ryzen 5 5600X, which means it squares up against this month's CCL Blade (see p30). Impressively, though, the Predator undercuts its rival by £100. The RTX 3060 Ti in this machine is made by MSI – just like the card inside the CCL – but the Gaming X Trio model is a larger card with three fans, and its original boost clock of 1665MHz is overclocked drastically to 1830MHz.

Meanwhile, the 6-core AMD Ryzen 5 5600X CPU runs at its stock base and boost speeds of 3.7GHz and 4.7GHz, and it's paired with 16GB of Corsair DDR4 memory running at a middling 3000MHz. The 1TB Intel 665p SSD is spacious and faster than a SATA drive, but it's not a PCI-E 4 drive. The PSU is decent too – it's a modular Kolink 700W unit with an 80 Plus Gold certification. It's certainly a good spec at this price, but the CCL has the bonus of a PCI-E 4 SSD and faster memory.

It all connects to an MSI MPG B550 Gaming Plus motherboard, which has bigger heatsinks and more LEDs than the board in the CCL, but the boards are otherwise similar. The Wired2Fire has free memory slots, free 16x and 1x PCI-E slots, and a spare M.2 connector, but the secondary 16x PCI-E and M.2 connectors don't support PCI-E 4, just like the CCL's board. Neither board has ALC1220 audio either, although the CCL's board does include an optical S/PDIF connector.

Wired2Fire's machine uses an MSI Gungnir 100R chassis. It's a mid-tower case from the same range as the CCL's chassis, but it goes further in important areas. It has a USB Type-C port and faster type-A ports, and its button for changing the lighting works properly. The tempered glass side panel is bolstered by tempered glass at the front, rather than mesh, and storage upgrading is easier thanks to two 2.5in drive mounts. The Gungnir also offers rubber grommets around its cable-routing holes and a fan synchronisation board.

In addition, the Gungnir measures 40mm longer than the CCL's case, so the interior isn't as cramped. This extra length, plus the inclusion of the Cooler Master CPU cooler's radiator in the roof, not the front, means there's room for three intake fans and the longer graphics card. The only downside here is the cabling around the back, as Wired2Fire's building is untidy here.

Wired2Fire's machine is protected by a five year labour warranty with two years of collect and return and parts coverage, which is decent for the money.

The Wired2Fire and CCL machines are closely matched, but both also compete with last month's Chillblast Fusion Commando 3060 Ti. That machine used the 3060 Ti and a better Ryzen 7 5800X CPU alongside 32GB of memory. That PC costs £1,499 at the time of writing, although the price may increase due to supply issues.

Performance

Wired2Fire's more aggressive GPU overclock pays off in gaming benchmarks, where it consistently beats the CCL. In our tough Metro Exodus 1080p test, the Wired2Fire's 99th percentile minimums were always better, and the Predator was a few frames per second quicker in Shadow of the Tomb Raider. It also maintained its advantage at 2,560 x 1,440, and it marginally outpaced the Chillblast.

SPEC

CPU
3.7GHz AMD Ryzen 5 5600X

Motherboard
MSI B550 Gaming Plus

Memory
16GB Corsair Vengeance LPX 3000MHz DDR4

Graphics
MSI GeForce RTX 3060 Ti 8GB

Storage
1TB Intel 665p M.2 SSD

Networking
Gigabit Ethernet

Case
MSI MPG Gungnir 100R

Cooling
CPU: Cooler Master MasterLiquid 240 with 2 x 120mm fans; GPU: 3 x 90mm fans; front: 3 x 120mm fans rear: 1 x 120mm fan

PSU
Kolink Enclave 700W

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

Operating system
Microsoft Windows 10 Home 64-bit

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

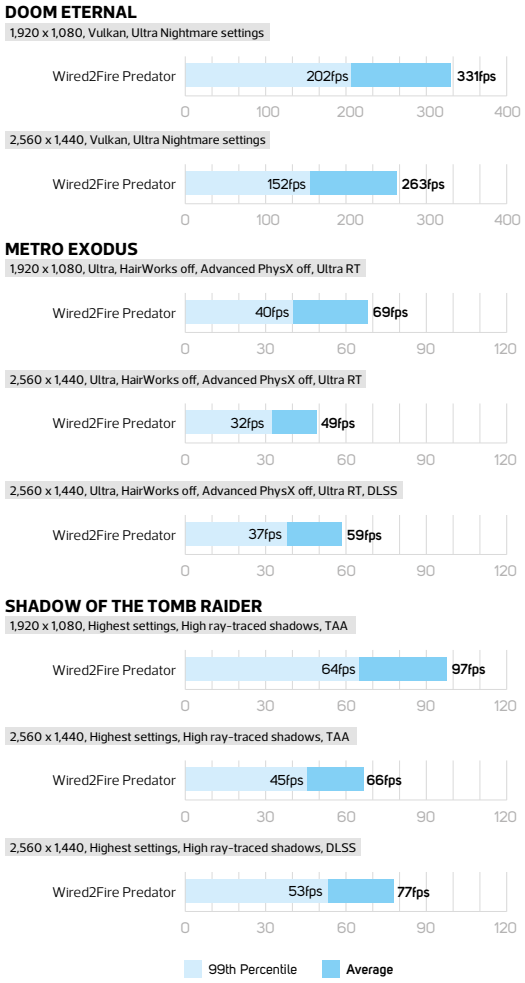
The Predator will happily play games at 1080p with ray tracing, and if you enable DLSS, it's quite happy at 2,560 x 1,440 as well. The Wired2Fire's pace can be partially explained by the GPU overclocking – the Predator's graphics core always ran beyond 1900MHz, while the CCL's GPU usually ran between 1830MHz and 1860MHz.

The Ryzen 5 5600X performs well too. The Wired2Fire's overall benchmark result of 247,389 is a solid score that creeps ahead of the CCL, despite the latter's faster memory. On the downside, the SSD's read and write speeds of 2,113MB/sec and 1,988MB/sec are mediocre compared with the CCL's PCI-E 4 drive, but those results are good enough for everyday use and you won't notice much difference outside of large-scale file transfers. Also, bear in mind that the Chillblast is better still for content creation – its Ryzen 7 CPU scored 284,689 in our benchmarks.

The Wired2Fire is a decent thermal performer too. When gaming, the fan noise is quite high-pitched, but the volume is moderate, easy to mask and more pleasant than that of both the CCL and Chillblast machines. A full-system stress test saw the noise increase, but it was still quieter than the CCL, and the noise levels remained moderate during single and multi-threaded CPU benchmarks.

Clock speeds remained decent too, with the GPU frequency proving aggressive and the CPU hitting its turbo peak with no throttling. The graphics core's delta T of 45°C was good too. The only minor issue was the CPU's peak delta T of 67°C, which is a little high, but that was only attained during a stress test and you'll only hit those temperatures if you're pushing the chip hard, which is very rare in most use cases.

BENCHMARK RESULTS



70,400
GIMP IMAGE EDITING

586,985
HANDBRAKE H.264 VIDEO ENCODING

304,293
HEAVY MULTI-TASKING

247,389
SYSTEM SCORE

Conclusion

The Wired2Fire and CCL machines are similar, but the Predator beats its rival in important areas. It's faster, quieter, has more features and it's £100 cheaper. You don't get a PCI-E 4 SSD, but the rest of the spec is great for the money. If you want a capable, affordable all-round PC for mainstream gaming and work, the Wired2Fire is superb – we'd only recommend spending more on the Chillblast if you need the extra CPU power.

MIKE JENNINGS

PREDATOR

+ Fast in games and applications
+ Quieter than competitors
+ Spacious, smart case
+ Solid warranty

COMMANDO

– Rivals have better CPUs
– No PCI-E 4 SSD
– Untidy cabling at the back

VERDICT

An impressively affordable all-rounder that outpaces and undercuts its competition.

PERFORMANCE	21/25
DESIGN	21/25
HARDWARE	20/25
VALUE	21/25
OVERALL SCORE	83%

Custom kit

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

TILE SLIM / £24.99 inc VAT

SUPPLIER thetileapp.com

The Tile Slim is the bigger, flatter brother of the Tile series of key ring tracking devices. The Slim is shaped like a slightly chunky credit card, so it can fit in a wallet. The Tile Slim runs off a battery with a three-year lifespan, so in that way it could be seen as disposable, but three years for an inexpensive tracking gizmo is a pretty decent run. The Slim is also rated as waterproof for up to 30 minutes in 1m of water, which ought to be enough for most situations.

Setup is easy and the Tile App is highly polished and simple to use on Apple or Android devices. It allows you to activate an alarm on your Tile Slim with your phone, or make your phone ring with the Tile Slim if needed, within a range of 60m. Past that, the app also tracks your Tile Slim's current and previous locations using a map, so you'll have the address of the last place it had a connection. Also, because the Tile uses Bluetooth and not its own GPS, it needs either your phone or another phone running the Tile App to ascertain its location, so while the Tile Slim is reliably able to tell you where you last had it within range of your phone, it's not going to give you running reports of its adventures if it gets left in a vehicle or stolen. This limitation aside, it's a smooth implementation of some very smart technology.

Where? ●●●●● **There**

NZXT PUCK / £20.47 inc VAT

SUPPLIER amazon.co.uk

The NZXT Puck looks weird at first, being a sort of black, square doughnut. It also feels weird – it looks like it's solid but it feels hollow and rubbery. Also adding to the weirdness is the fact that it breaks in half and contains a remarkably powerful magnet.

So what does it actually do? In simple terms, you stick it to the side of your PC case using the magnet inside it and you can hang your headset on it. It's a simple idea that borders on brilliant, taking the unused real estate on the side of a windowless case and making it useful in a way that looks cool in an oddball minimalist way.

You can also split the Puck in half and wrap cables around each end, with the cables tucked into the body. There are fewer practical uses for this kind of cable-tidying system, but it looks pretty clever. The Puck offers a clever and efficient way to clear up your desk clutter with minimal fuss.

Donald puck ●●●●○ **Daffy puck**

JONKUU 20000mAh POWER BANK / £16.49 inc VAT

SUPPLIER amazon.co.uk

A 20,000mAh power bank with built-in cables, the Jonkuu wobbles on that tricky tightrope between svelte and convenient portable phone chargers on one side, and the big bricky lads that will keep your devices running for days on the other. The end result is rather messy.

The Jonkuu weighs 470g, so you're not going to forget you're carrying it. Plus, in the spirit of adding almost random extra features, it also doubles as a torch thanks to a couple of bright LEDs in the front. The array of cables (lighting, micro-USB, USB Type-A and USB Type-C) tucked into the belly of the device are easily accessible and stowed, but awkwardly short, although there are also micro-USB, USB Type-A and USB Type-C ports, so you can plug in an alternative charging cable.

If you want power for days and you don't want to worry about losing cables or additional parts, the Jonkuu charges quickly and does everything you'd expect, while also being a torch for some reason. However, it's a bit too much of a brick for a portable power bank.

Another brick ●●●○○ **In the wall**

NIAGUOJI 7-PORT USB HUB / **£18.98** inc VAT

SUPPLIER amazon.co.uk

The Niaguoji is a 7-port USB 3 hub that tries to combine a sleek, compact design with a relatively huge number of ports. The result is a kind of death by a thousand cuts, as the miniaturisation of the device impacts on its form and function in unforeseen ways. The USB ports are mounted sideways rather than on the top of the device, and each one has a light indicating power, as well as an individual on/off switch.

This is an interesting approach, but it's soon apparent why it's not favoured by most hubs – having the ports in a horizontal line, rather than a vertical one, means the cables and devices being connected need to be narrow enough to fit, and even then, they still won't have much space.

The default cable for the Niaguoji is quite short at around 60cm, and there's no way to attach or secure the hub to a surface, so it's tricky to set up tidily and is likely to be dragged around by competing connections. In addition, while it has a socket for a 5V power plug, one isn't supplied and it could really use it with this many ports.

The Niaguoji's large number of ports in such a small device renders it crowded and near impossible to neatly employ. A case where less would have been more.

7 Deadly sins ●●●●○ **7 Wonders**

JAMSWALL GAMEPAD / **£21.99** inc VAT

SUPPLIER amazon.co.uk

The Jamswall is a multi-function pad aimed principally at the Nintendo Switch, although it's also compatible with Android devices and Windows PCs, with Bluetooth and USB Type-C connections available. While the Jamswall is very Switch-like, with a Nintendo-style colour scheme, the layout is very close to that of an Xbox pattern pad, with the notable difference being the lack of analogue shoulder buttons.

This means the Jamswall offers cleaner inputs for fighting games and platformers that just want click-and-go buttons, but it's not ideal for driving games, or other sims where you'd use the shoulder triggers granularly.

Sadly, the Jamswall also doesn't plug and play instantly with all its intended devices, and you'll need to keep the manual handy as a reminder of which buttons to press to get it to connect properly. The Jamswall works well as a cheap alternative Switch pad, and it will do the job as a PC or Android control pad, plus it's sturdy and comfortable to use, but it's rather wanting as a straight-up PC pad.

Jam tomorrow ●●●○○ **Jam today**

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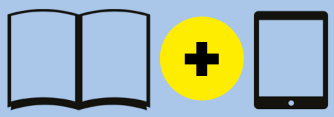

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Graphic content

Ben Hardwidge puts AMD and Nvidia's latest GPUs through their paces in some of the latest games, including Cyberpunk 2077 and Assassin's Creed: Valhalla

How we test

We've introduced a couple of new game benchmarks this month. First up is Cyberpunk 2077 (see p65), which is a high-profile and challenging game for even the latest GPUs. We run our own custom benchmark, which incorporates a 60-second drive around Night City recorded with FrameView.

We run it at the Ultra preset with no ray tracing, and with the Medium Ray Tracing preset on Nvidia GPUs – the game currently doesn't support ray tracing on AMD GPUs. You ideally want a 99th percentile result above 45fps with an average above 60fps.

Our second new test is the epically awesome Assassin's Creed: Valhalla. We run the built-in benchmark at the Ultra High preset with resolution scaling at 100 per cent, recording the results with FrameView. A 99th percentile result above 35fps, with an average over 45fps, will do the job.

Meanwhile, we've kept our Doom Eternal benchmark. It's an undemanding game, but it scales superbly with more GPU power, making it great for monitors with a very high refresh rate. Again, we record the frame rate with FrameView. We've also kept our Metro Exodus benchmark, although we now run it with and without ray tracing, and we've dropped the latter from Ultra to High. In addition, we've included ray-tracing results from Shadow of the Tomb Raider.

All the tests are conducted on a Core i7-8700K test rig with all cores overclocked to 4.8GHz. Finally, we measure the total system power consumption of the whole test rig at the mains, while the GPU goes through three runs of our Metro Exodus ray-tracing benchmark at 2,560 x 1,440. We record the peak power draw of the whole system.

Our rasterisation score rates performance of standard game tests without ray tracing, with the latter getting a separate score with a lower weighting – this is to reflect the fact that many of the latest games don't have ray-tracing support, although it's becoming widespread. We rate the importance of features such as DLSS, FidelityFX and SLI in our features score. We also incorporate a value score, and the overall figure is the sum of all the separate scores.

Contents

NVIDIA GEFORCE RTX 3060 Ti / £369 inc VAT

SUPPLIER nvidia.com

With similar performance to the GeForce RTX 2080 Super for under half the price, the GeForce RTX 3060 Ti has proved extremely popular. So much so, in fact, that stock has dried up with little hope of replenishment on the near horizon, as James Gorbold outlines on p114. As with all the Nvidia GPUs on test this month, the board-partner cards from retailers cost more than the Founders Editions, with RTX 3060 Ti cards going from £450 inc VAT on **overclockers.co.uk**

The stock situation is a real shame, because £369 is a fantastic price. If you can afford it, the GeForce RTX 3070 is worth the extra cash, as it properly opens up 2,560 x 1,440 gaming with loads of eye candy. However, if you can't find the extra money (and you're prepared to wait for stock to trickle into stores), the GeForce RTX 3060 Ti is a good buy, with no current-gen competition in this price bracket.

OUT OF SPACE

- \+ Performs like RTX 2080 Super
- \+ Solid 1,920 x 1,080 performance
- \+ Fantastic price

OUT OF STOCK

- – Lacks shading power
- – Struggles at higher resolutions
- – Severe stock shortage

SPEC

Graphics processor Nvidia GeForce RTX 3060 Ti, 1410MHz base clock, 1665MHz boost clock

Pipeline 4,864 CUDA cores, 80 ROPS

RT cores 38 (2nd-gen)

Tensor cores 152 (3rd-gen)

Memory 8GB GDDR6, 14GHz effective

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 448GB/sec

It's based on the same GA104 Ampere GPU found in the RTX 3070, but with 38 Streaming Multiprocessors (SMs) enabled, compared to 46 on the RTX 3070. That gives you a total of 4,864 CUDA cores, along with 38 2nd-gen RT cores and 152 3rd-gen Tensor cores.

It also comes with 8GB of GDDR6 memory and, as with the RTX 3070, it has an effective clock speed of 14GHz and it's attached to a 256-bit wide memory interface, giving you a total memory bandwidth of 448GB/sec.

The end result is a GPU that's brilliant for gaming at 1,920 x 1,080, which sounds like more of a job for a budget GPU, but the RTX 3060 Ti can do it properly with ray tracing enabled. Without DLSS, it coped fine with Metro Exodus and Shadow of the Tomb Raider at 1080p with ray tracing enabled, and it managed to run the latter well at 2,560 x 1,440 as well.

The RTX 3060 Ti started to struggle in Cyberpunk 2077, though, where it couldn't quite meet our 60fps target at 2,560 x 1,440 with ray tracing and DLSS, although it wouldn't take much tweaking in the settings to get it there, and the game was still playable.

Our rasterisation tests also proved challenging for this comparatively low-price graphics card. Again, all the results at 1,920 x 1,080 are fine, but the 2,560 x 1,440 results are a mixed bag.

Assassin's Creed: Valhalla is perfectly playable, but the frame rates are a fair way behind all the other cards, for example, and its Cyberpunk 2077 performance is disappointing at this resolution.

If you're happy to tweak the settings a bit, you could get this card running most games at 2,560 x 1,440 without sacrificing much graphical bling, but the RTX 3070 gives you more breathing space. As you'd expect, the RTX 3060 Ti can't cope with 4K gaming beyond Doom Eternal, but that's hardly an issue in this price league.

Conclusion

If it's ever back in stock at its retail price, the GeForce RTX 3060 Ti is a bargain. The RTX 3070 gives you more breathing space at 2,560 x 1,440, especially in Cyberpunk 2077, and offers more in terms of bang per buck. However, that's not much use if you're at the limits of a tight budget, and it's great to see performance on a level with the RTX 2080 Super for such a cheap price. However, the pitiful stock levels mean this card is practically a non-starter at the moment.

VERDICT

Lets you enable loads of eye candy at 1080p, and copes well in some games at 2,560 x 1,440, but there's no stock.

RASTERISATION	RAY TRACING	OVERALL SCORE
26/40	10/20	75%
FEATURES	**VALUE**	
9/10	30/30	

NVIDIA GEFORCE RTX 3070 / £469 inc VAT

SUPPLIER nvidia.com

We'll admit that it's hard to rate the current crop of GPUs when price is such an important factor and supply is all over the place. We've listed the official **nvidia.com** price of £469 inc VAT for the RTX 3070 above, but the more realistic board-partner prices start from around £530 inc VAT at retailers.

That still makes it a fair bit cheaper than the Radeon RX 6800 in terms of retail prices, and the GeForce RTX 3070 is at least turning up in limited quantities, unlike the practically non-existent Radeon RX 6800 (see p114).

Assuming that stock does become more widely available, and you can find a GeForce RTX 3070 for £530 inc VAT, it's definitely worth buying, as this card crosses the threshold into 2,560 x 1,440 gaming at decent frame rates. Where it really excels is with both ray tracing and DLSS enabled, where you get the beautiful shininess of ray tracing, while still maintaining reasonable frame rates.

Its 55fps 99th percentile and 65fps average in Cyberpunk 2077 at these settings are fine, as is its respective 46fps 99th percentile and 70fps average in Metro Exodus. It can even play Shadow of the Tomb Raider at these settings without dropping below 67fps. It doesn't cope so well in Cyberpunk 2077, but it's fine in our other ray-tracing tests.

The downside is that its raw shading power can't quite keep up with the Radeon RX 6800 in terms of rasterisation performance. Its Assassin's Creed: Valhalla average was 11fps behind the Radeon at 2,560 x 1,440, and it was 7fps behind in Metro Exodus.

The RTX 3070's frame rates at this resolution are all still playable though – its 56fps average in Cyberpunk 2077 doesn't quite meet our preferred 60fps target, but it's still perfectly playable. Where it starts to struggle is at 4K, dropping well back from the rest of the field, often with unplayable results, but then you can't expect to run every game at 4K on a £530 card.

Part of the reason for this is that the RTX 3070 is based on a different GPU and memory system from the RTX 3080 and 3090, which are based on Nvidia's top-end GA102 Ampere GPU. The RTX 3070 uses the smaller GA104 chip, and it also has one Texture Processing Cluster (TPC) disabled, so you lose two Streaming Multiprocessors (SMs) compared with a fully enabled chip. The end result is a chip with 5,888 CUDA cores, along with 46 2nd-gen RT cores for ray tracing.

Meanwhile, the RTX 3070 has 8GB of GDDR6 memory, rather than GDDR6X, and it's attached to a 256-bit wide memory interface. It runs at 1750MHz (14GHz effective), giving you a total bandwidth of 448GB/sec – that's substantially narrower than the RTX 3080 and 3090, and lower than the Radeon RX 6800's 512GB/sec, but it's still fine for the RTX 3070's target resolution of 2,560 x 1,440.

Conclusion

If the GeForce RTX 3070 Founders Edition ever becomes properly available at **nvidia.com** at £469 again, then it would be a no-brainer, but even at £530, it's worth waiting for stock to arrive at retailers.

It can't quite catch the Radeon RX 6800's raw shading frame rates, but its support for DLSS means you can run games with ray tracing at 2,560 x 1,440, including Cyberpunk 2077, and it maintained decent frame rates in all our test games at this resolution. If you're looking to play the latest games at 2,560 x 1,440 with ray-tracing bling enabled, this is the card to get if you can find one.

SPEC

Graphics processor Nvidia GeForce RTX 3070, 1500MHz base clock, 1725MHz boost clock

Pipeline 5,888 CUDA cores, 96 ROPS

RT cores 46 (2nd-gen)

Tensor cores 184 (3rd-gen)

Memory 8GB GDDR6, 14GHz effective

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 448GB/sec

FORCE OF NATURE

+ Ray tracing at 2,560 x 1,440 with DLSS
+ Decent shading power at 2,560 x 1,440
+ Great value

FORCE OF HABIT

– RX 6800 XT has more shading power
– Struggles at 4K
– Hard to find

VERDICT

The best-value mid-range GPU, enabling ray tracing with DLSS at 2,560 x 1,440 and still having decent shader performance.

RASTERISATION	RAY TRACING	OVERALL SCORE
28/40	12/20	77%
FEATURES	VALUE	
9/10	28/30	

AMD RADEON RX 6800 / £600 inc VAT

SUPPLIER overclockers.co.uk

Let's start with the big shock, which is that AMD's £600 Radeon RX 6800 actually managed to beat the GeForce RTX 3090 in Assassin's Creed: Valhalla at 1080p. This game is clearly well optimised for AMD's GPUs, but that's still astonishing. There's clearly a decent amount of shader power on offer here.

The Radeon RX 6800 sits at the bottom of AMD's 'Big Navi' stack, using the same Navi 21 GPU as its bigger siblings, but with just 60 of its Compute Units enabled. That gives you 3,840 stream processors and 60 corresponding Ray Accelerators. What's more, you also get the same memory system as even the flagship Radeon RX 6900 XT, with 16GB of GDDR6 memory running at 16GHz effective, giving you a total memory bandwidth of 512GB/sec.

That 16GB of memory is arguably wasted on this card though. Its GPU doesn't have the power to run the settings that would require so much memory, and it also bumps up the price of the card. Not that the price can be nailed down anyway, as stock is practically non-existent.

The Radeon RX 6800 costed £530 inc VAT from **scan.co.uk** when we first reviewed it, and the cheapest listed price we could find now was £600 inc VAT on **overclockers.co.uk**, but realistically, you're looking solely at eBay scalper prices for this card at the moment.

SPEC

Graphics processor AMD Radeon RX 6800, 1815MHz game clock, 2105MHz max boost clock

Pipeline 3,840 stream processors, 96 ROPS

Ray Accelerators 60

Memory 16GB GDDR6, 16GHz effective

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 512GB/sec

That's a different situation from the GeForce RTX 3070, which might also be sold out at the moment, but is still arriving at retailers and system builders in limited quantities, with prices currently starting from around the £530 mark for board-partner cards.

In terms of performance, the Radeon RX 6800 has some decent raw shading power under its belt, beating the GeForce RTX 3070 in all our non-ray-traced game tests at every resolution. Its 60fps average in Cyberpunk 2077 at 2,560 x 1,440 with Ultra settings is a great result, as is its 82fps average in Assassin's Creed: Valhalla at the same resolution, where it's even ahead of Nvidia's GeForce RTX 3080.

As with the other Radeons on test this month, the RX 6800's problem is ray tracing. On the one hand, it's great to see AMD implementing this feature in hardware, but there's no support for it in Cyberpunk 2077 as yet, and the Radeon RX 6800 was behind the GeForce RTX 3070 in nearly every ray-tracing test. What's more, the RTX 3070 can get an extra helping hand here by enabling DLSS.

On the plus side, the Radeon RX 6800 is capable of playing some games with ray tracing, and the non-DLSS results aren't far off those from the RTX 3070. Its 1,920 x 1,080 results are fine here, and its 72fps average in Shadow of the Tomb Raider at 2,560 x 1,440 is a great result. With just a little bit more ray-tracing power, and some help from a hardware-accelerated scaling feature such as DLSS, AMD could be onto a winner.

RADEON RX 6800	GEFORCE 6800
+ More shader power than RTX 3070	– Could do with similar feature to DLSS
+ Great Valhalla performance	– Extremely limited stock
+ 16GB of memory	– No ray tracing in Cyberpunk 2077

Conclusion

If you can find one for a reasonable price, the Radeon RX 6800 is a decent GPU, especially if your priority is getting the fastest raw frame rates. Its ray-tracing performance isn't bad either – it's behind the RTX 3070, but not by a huge amount. Where the RTX 3070 has the upper hand is with its support for DLSS to improve frame rates, its generally lower price and it's better availability. The GeForce RTX 3070 gets our vote in this price bracket, but there's not much in it.

VERDICT

Great shading power for the money, but the severe lack of stock and disappointing ray-tracing performance make the GeForce RTX 3070 a better buy.

RASTERISATION	RAY TRACING	OVERALL SCORE
30/40	11/20	74%
FEATURES	VALUE	
6/10	27/30	

AMD RADEON RX 6800 XT / £680 inc VAT

SUPPLIER overclockers.co.uk

AMD's Radeon RX 6800 XT got off to an awesome start when we fired up Assassin's Creed: Valhalla. We looked sceptically at our test rig, and ran the tests several times, but there's no mistaking it – this £680 card can outperform the GeForce RTX 3090 at not just 1,920 x 1,080 but also 2,560 x 1,440 in this game and it's not far behind it at 4K. That's an incredible achievement at this price. If Assassin's Creed: Valhalla is your main time sink, this is a cracking card if you can find one.

And therein lies the rub – there aren't any. Stock of all new GPUs is pretty dire at the moment, but the situation for the Radeon RX 6800 XT is particularly bleak, as James Gorbold outlines on p114. That's a shame, because it's a decent GPU if you're not bothered about ray tracing.

RADEONICS

- \+ Awesome rasterisation performance
- \+ AMD can make high-end GPUs again!
- \+ Brilliant for Assassin's Creed: Valhalla
- \+ 16GB of memory

RADIONICS

- – No equivalent of DLSS
- – Seriously limited stock
- – No ray tracing in Cyberpunk 2077
- – Can't catch RTX 3080 in ray tracing

SPEC

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

Pipeline 4,608 stream processors, 128 ROPS

Ray Accelerators 72

Memory 16GB GDDR6, 16GHz effective

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 512GB/sec

If you want fast frame rates at 1,920 x 1,080, it outperforms the RTX 3080 in all our tests, including Cyberpunk 2077, clocking up an average of 419fps in Doom Eternal (just 6fps behind the RTX 3090). It holds its own at 2,560 x 1,440 too, with its 99th percentile result in Metro Exodus being 8fps higher than that of the RTX 3080. It can't catch the RTX 3080 in Cyberpunk 2077 at this resolution, but its average of 69fps is still a great result in this game.

As with all the Radeon RX 6000-series GPUs, the 6800 XT is based on AMD's Navi 21 GPU, and in this case, it has 21 Compute Units enabled, giving it 4,608 stream processors and 72 Ray Accelerators. It also has 6GB more memory than the GeForce RTX 3080, although it's GDDR6 rather than GDDR6X, and it's attached to a 256-bit memory interface. This gives it a total memory bandwidth of 512GB/sec, compared to 760GB/sec on the RTX 3080 – a boost that's arguably more important than the 6GB of extra memory in current games.

The main problem (other than stock scarcity) is that while the Radeon RX 6800 XT does at least support ray tracing, it's not as quick as the RTX 3080, it doesn't support it at all in Cyberpunk 2077 (at least, not yet) and there's no equivalent of DLSS to help improve performance.

In most cases, the Radeon RX 6800 XT's 99th percentile results are pretty good in our ray-tracing tests, so you won't notice significant slowdowns, but the RTX 3080 maintains much faster averages. In both Shadow of the Tomb Raider and Metro Exodus at 2,560 x 1,440, for example, the RTX 3080's average is 16fps faster, and the gap widens further when you enable DLSS on the RTX 3080.

Conclusion

The main problem for the Radeon RX 6800 XT is its severely limited stock. We know it's hard to find RTX 3080 cards too, but Radeon RX 6800 XTs are much scarcer. If you had a realistic prospect of picking up one, we could make a good case for choosing one over the RTX 3080 if you wanted the best rasterisation frame rates for the money – it's a fantastic card for exploring the epic scenery in Assassin's Creed: Valhalla.

Even then, that would be the only case though. The RTX 3080 is significantly quicker at ray tracing, and the benefit of DLSS gives it a further performance boost. It's good to see AMD back in the high-end GPU race again, but the Radeon RX 6800 XT doesn't quite do enough to be competitive on all fronts.

VERDICT

Awesome rasterisation performance, but the Radeon RX 6800 XT struggles to keep up with the RTX 3080 in ray tracing and stock is severely scarce.

RASTERISATION	RAY TRACING	OVERALL SCORE
35/40	13/20	76%
FEATURES	VALUE	
6/10	22/30	

NVIDIA GEFORCE RTX 3080 / £649 inc VAT

SUPPLIER nvidia.com

Nvidia's GeForce RTX 3080 landed with a sonic boom last year, boosting ray-tracing performance well beyond its Turing-based predecessors, including the mighty RTX 2080 Ti, and significantly improving raw shading power too. Nvidia CEO Jensen Huang confidently assured owners of Pascal GPUs that it was now safe to upgrade, and it's been sold out since day one.

James Gorbold has an update on the stock situation on p114, and while supply still can't meet demand, cards are still arriving, with pre-orders gradually trickling out to customers. That's not ideal, but it's better than the situation with the latest Radeon cards.

In terms of specs, the RTX 3080 is based on the same GA102 GPU as in the RTX 3090, but with one Graphics Processing Cluster disabled. This gives it 8,704 CUDA cores, and reduces the width of the memory interface from 384-bit to 320-bit. However, it still comes with GDDR6X memory, giving you a total bandwidth of 760GB/sec. The downside is that there's only 10GB, compared to 16GB on the Radeon RX 6800 XT, although this doesn't seem to massively affect performance in current games.

As with the RTX 3090, the Founders Edition of the RTX 3080 has a reasonable price of £649 inc VAT from **nvidia.com**, but the more realistic price for board-partner cards from retailers is around £800 inc VAT. Even so, this is still half the price of the RTX 3090 at retail, and with limited available competition, it's worth paying if you can afford it.

That's because the RTX 3080 is a ray-tracing performance monster, with performance that's closer to the RTX 3090 than the cheaper RTX 3070. With DLSS enabled, it didn't drop below 61fps in Cyberpunk 2077 at 2,560 x 1,440, and its average of 75fps in Shadow of the Tomb Raider at 4K with High ray-traced shadows and DLSS is superb – that's 20fps ahead of the 3070, but only 9fps behind the 3090.

What's more, in our ray-traced tests without DLSS, the RTX 3080 regularly outperformed the significantly pricier Radeon RX 6900 XT. On the downside, it still doesn't have quite enough power to run Cyberpunk 2077 without DLSS beyond 1080p, but it's significantly ahead of the RTX 3070 in this game.

The other downside, of course, is the competition from the Radeon RX 6800 XT, which wasn't a factor when we first reviewed the RTX 3080. The former isn't as quick at ray tracing, and it doesn't have DLSS, but it has more raw shader power. In Assassin's Creed: Valhalla, the RTX 3080's average is around 8fps slower than the Radeon 6800 XT at 2,560 x 1,440, for example. The RTX 3080 is quicker in Cyberpunk 2077 without ray tracing, though, and the margins here aren't enormous.

Conclusion

At half the price of the RTX 3090, the RTX 3080 offers superb bang per buck. Its ray-tracing performance at 2,560 x 1,440 is superb, and it can cope with some 4K gaming with ray tracing if you enable DLSS too. While the Radeon RX 6800 XT often has the edge in games without ray tracing, the margins aren't huge, and stock of the Radeon RX 6800 XT is so rare, it might as well not exist. If you can find one, and you have the money, the RTX 3080 is absolutely the card of the moment.

SPEC

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

Pipeline 8,704 CUDA cores, 96 ROPS

RT cores 68 (2nd-gen)

Tensor cores 272 (3rd-gen)

Memory 10GB GDDR6X, 19GHz effective

Memory interface 320-bit

Card interface 16x PCI-E 4

Memory bandwidth 760GB/sec

AMPED UP

+ Great ray-tracing performance
+ Capable of some 4K gaming
+ Faster ray tracing than RX 6900 XT
+ Half the price of RTX 3090

DAMPED DOWN

− Radeon RX 6800 XT often quicker at rasterisation
− Limited availability
− Only 10GB of memory

VERDICT

The RTX 3080 hits the sweet spot right in the bullseye, with fantastic ray-tracing performance and plenty of shader power for half the price of the RTX 3090.

RASTERISATION	RAY TRACING	OVERALL SCORE
33/40	16/20	81%
FEATURES	VALUE	
9/10	23/30	

AMD RADEON RX 6900 XT

£1,200 inc VAT

SUPPLIER overclockers.co.uk

It's been the best part of a decade since AMD had a GPU that could compete with the best Nvidia has to offer, but with some help from AMD's rich Ryzen revenue, as well as a new GPU architecture, it's now *almost* there. We say 'almost' because the current flagship of AMD's 'Big Navi' GPU line-up, the Radeon RX 6900 XT, can't keep up with the GeForce RTX 3090.

All of AMD's current Radeon RX 6000-series GPUs are based on the same Navi 21 GPU, but with different numbers of compute units enabled. In the case of the Radeon RX 6900 XT, you get 80 of them, and they each come with one of AMD's Ray Accelerator units for real-time ray tracing in games.

The result is a whopping count of 5,120 stream processors. You don't get a clock speed advantage over the Radeon RX 6800 XT, though, with the quoted game clock (the frequency at which the card is likely to run in games) of 2015MHz matching the Radeon RX 6800 XT. The latter card also has a slightly higher quoted maximum boost clock.

There's no memory advantage either. Like the other Radeon RX 6000-series cards, you get 16GB of GDDR6 memory attached to a 256-bit memory interface and running at 16GHz (effective). This marks a difference from Nvidia's approach, where the RTX 3080 and 3090 come with faster GDDR6X memory and much higher memory bandwidth, though with only 10GB of memory in the case of the 3080.

AMD also makes a seemingly bizarre claim about the Radeon RX 6900 XT, which is that it draws the same 300W of power as the Radeon RX 6800 XT, meaning you get a performance advantage for free in terms of power draw. We were sceptical, but lowering the boost clock frequency seems to indeed have done the trick here. Our test system drew 421W from the mains with the Radeon RX 6900 XT installed – just 3W more than the 418W with the Radeon RX 6800 XT.

In terms of performance, the Radeon RX 6900 XT is seriously powerful when it comes to raw shading power. It tops 1080p and 2,560 x 1,440 performance charts in Assassin's Creed: Valhalla, and it beats the RTX 3090 at 1,920 x 1,080 in Metro Exodus and Doom Eternal too.

You don't buy a £1,200 card to play games at 1080p, though, and the RTX 3090 is still generally quicker at higher resolutions, particularly in Cyberpunk 2077. That said, the RTX 3090 is much more expensive.

As with the other AMD GPUs, where the Radeon RX 6900 XT struggles is in ray tracing. It can't do it at all in Cyberpunk 2077 yet, and it's slower than the cheaper RTX 3080 in our other ray-tracing tests. Plus, with no hardware-accelerated equivalent to Nvidia's DLSS mode, there's no way to significantly boost this performance either.

Conclusion

If you're not fussed by ray tracing, and you can't quite run to the cost of the GeForce RTX 3090, you won't be disappointed by the Radeon RX 6900 XT – it's a really fast GPU in our standard game tests and it's surprisingly power-efficient as well. However, while it's great to see AMD competing at the top end again, the Radeon RX 6900 XT can't beat the RTX 3090 at higher resolutions, its ray-tracing performance is behind the RTX 3080 and there's no equivalent of DLSS. To make matters worse, stock is severely scarce and it's very expensive.

SPEC

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

Pipeline 5,120 stream processors, 128 ROPS

Ray Accelerators 80

Memory 16GB GDDR6, 16GHz effective

Memory interface 256-bit

Card interface 16x PCI-E 4

Memory bandwidth 512GB/sec

BIG NAVI

+ Superb Valhalla frame rates
+ Amazing rasterisation performance
+ Decent power efficiency

BIG BROTHER

– Severely limited stock
– No DLSS equivalent
– Ray tracing slower than RTX 3080
– Expensive

VERDICT

Fantastic rasterisation performance, but this scarce card can't catch the cheaper RTX 3080 in ray tracing and it's too expensive.

RASTERISATION	RAY TRACING	OVERALL SCORE
37/40	14/20	72%
FEATURES	VALUE	
6/10	15/30	

NVIDIA GEFORCE RTX 3090 / £1,399 inc VAT

SUPPLIER nvidia.com

In normal times, the most remarkable aspect of the GeForce RTX 3090 would be its stunning performance, but in these silly times it's the fact that there's actually some stock available. Yes, real graphics cards inside real boxes on real shelves! At the time of writing, **scan.co.uk** even had stock of three models.

On the downside, they're massively pricey. The £1,399 price for the Founders Edition on **nvidia.com** is expensive enough, but the cards from board partners at retailers (the ones you might actually be able to buy) typically go for at least £200 more. Is it worth it? Not in terms of bang per buck, no, but if you really want the fastest gaming GPU available, then this is the one.

The monstrous price is backed up by some standout specs, including a huge 24GB allocation of GDDR6X memory running at 19.5GHz (effective), and it's attached to a 384-bit interface, resulting in an overall memory bandwidth of 936GB/sec, which isn't far off 1TB/sec.

Meanwhile, the GPU itself is based on the same GA102 Ampere chip as the RTX 3080, but with 82 streaming multiprocessors enabled, each with a 2nd-gen RT core for ray tracing and four Tensor cores for features based on Nvidia's deep-learning tech, such as DLSS. You end up with a huge total of 10,496 CUDA cores in this chip, making for a formidably powerful parallel processing machine.

The GPU clock speeds are slightly lower than those of the RTX 3080, but there's not much in it, with a stock boost clock of 1695MHz compared to 1710MHz on the RTX 3080. One other feature worthy of note is that the RTX 3090 is the only GPU from Nvidia's current Ampere line-up to support the company's dual-GPU SLI technology, although declining game support and compatibility issues mean we'd stay well away from it.

Not surprisingly, Nvidia's flagship monster generally lays waste to the competition at high resolutions, topping the tables in all our 4K tests. One interesting anomaly, though, was Assassin's Creed: Valhalla at 2,560 x 1,440 and 1,920 x 1,080, where the top two Radeons were quicker. It's also the only GPU on test to manage a frame rate above 40fps in Cyberpunk 2077 at 4K, and you can even get a respectably playable 45fps 99th percentile and a 53fps average at 4K with Medium ray tracing if you set DLSS to Balanced.

Disappointingly, though, even this top-end GPU can't cope with this game with the Ultra ray-tracing preset in Cyberpunk 2077, dropping down to a clunky 24fps, which only increased to a 33fps 99th percentile with DLSS on the Quality preset. In our other ray-tracing tests, however, the RTX 3090 copes at 4K, especially if you give it a helping hand by enabling DLSS. Its 78fps average in Metro Exodus with High ray tracing and DLSS enabled is a superb result.

On the downside, it also consumes a lot of power, with our test rig drawing 567W from the mains with the RTX 3090 installed.

Conclusion

The GeForce RTX 3090 might be ridiculously expensive, and it also has the highest power draw on test by a large margin, but it's also clearly the best GPU for 4K gaming. If you have the money, and you want the best of the best, then this is the card to buy. That said, the bang per buck is poor here, and it's disappointing that such an expensive GPU still can't play Cyberpunk 2077 at the top settings. CPC

VULKAN

- \+ Barnstorming performance
- \+ Some stock available
- \+ Best 4K gaming GPU available

TRIBBLE

- – Still struggles with Cyberpunk 2077 at 4K
- – Cheaper Radeons often faster in Valhalla
- – Extremely expensive

SPEC

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

Pipeline 10,496 CUDA cores, 96 ROPS

RT cores 82 (2nd-gen)

Tensor cores 328 (3rd-gen)

Memory 24GB GDDR6X, 19.5GHz effective

Memory interface 384-bit

Card interface 16x PCI-E 4

Memory bandwidth 936GB/sec

VERDICT

This outrageously priced GPU still struggles with Cyberpunk 2077 at 4K, but it's undoubtedly the current performance king if you can afford it.

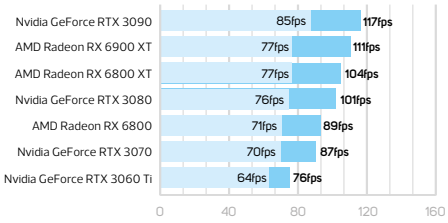
RASTERISATION	RAY TRACING	OVERALL SCORE
38/40	19/20	78%
FEATURES	VALUE	
10/10	11/30	

GRAPHICS CARD LABS RESULTS

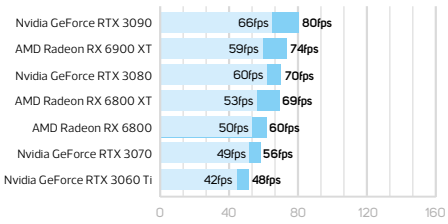
STANDARD GAME TESTS

CYBERPUNK 2077

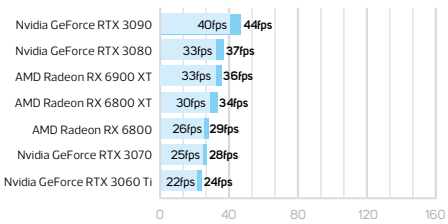
1,920 x 1,080, Ultra preset



2,560 x 1,440, Ultra preset

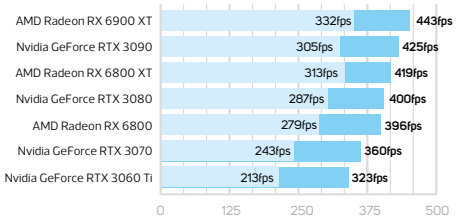


3,840 x 2,160, Ultra preset

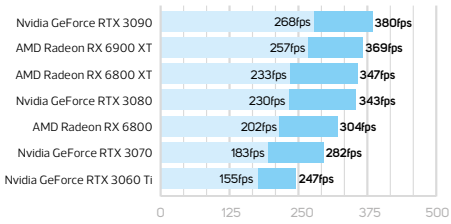


DOOM ETERNAL

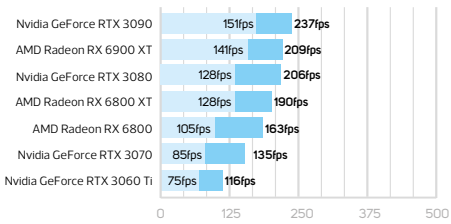
1,920 x 1,080, Ultra Nightmare settings



2,560 x 1,440, Ultra Nightmare settings

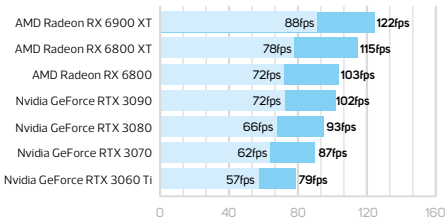


3,840 x 2,160, Ultra Nightmare settings

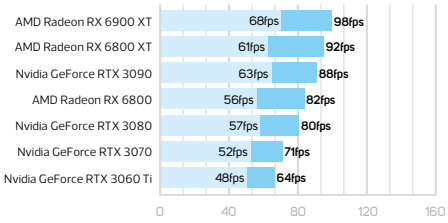


ASSASSIN'S CREED: VAHALLA

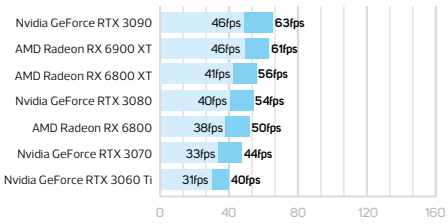
1,920 x 1,080, Ultra high settings, High AA



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

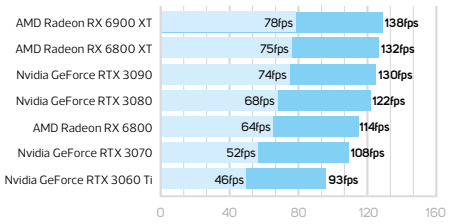


3,840 x 2,160, Ultra high settings, High AA

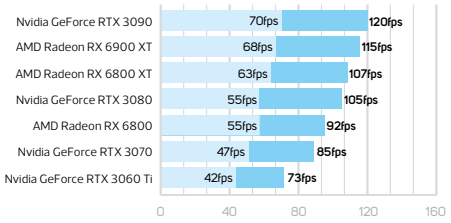


METRO EXODUS

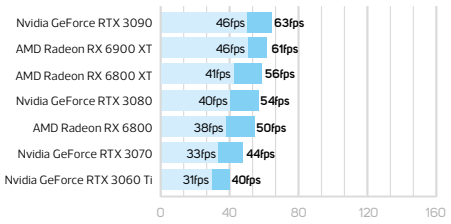
1,920 x 1,080, Ultra settings, PhysX off, Hairworks off



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



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



99th percentile Average

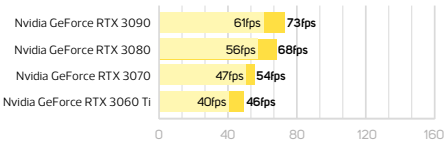
99th percentile Average

GRAPHICS CARD LABS RESULTS

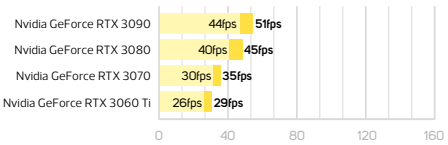
RAY TRACING

CYBERPUNK 2077

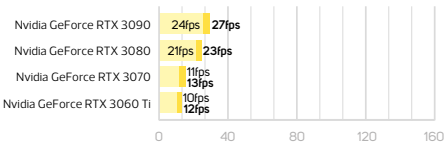
1,920 x 1,080, Medium ray tracing preset



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

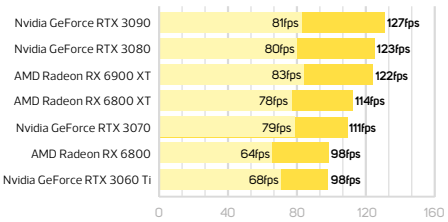


3,840 x 2,160, Medium ray tracing preset

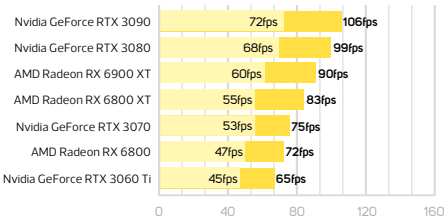


SHADOW OF THE TOMB RAIDER

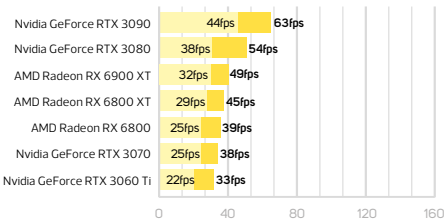
1,920 x 1,080, Highest settings, High ray-traced shadows, TAA



2,560 x 1,440, Highest settings, High ray-traced shadows, TAA

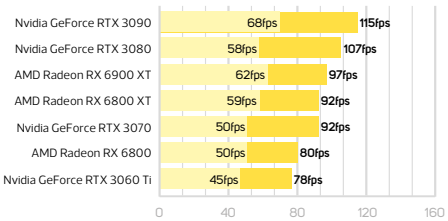


3,840 x 2,160, Highest settings, High ray-traced shadows, TAA

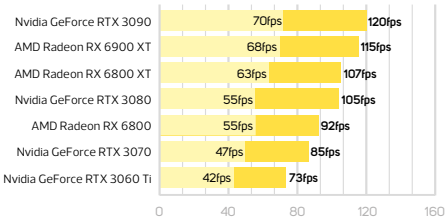


METRO EXODUS

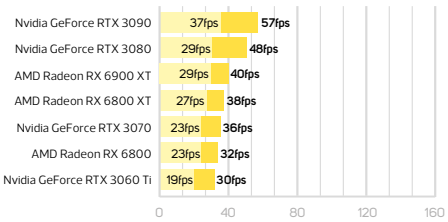
1,920 x 1,080, Ultra settings, High RT, PhysX off, Hairworks off



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



3,840 x 2,160, Ultra settings, High RT, PhysX off, Hairworks off



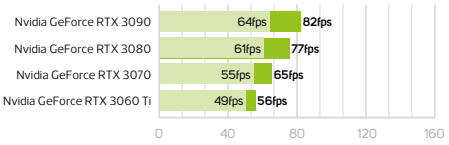
99th percentile Average

GRAPHICS CARD LABS RESULTS

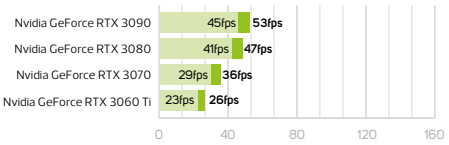
RAY TRACING AND DLSS

CYBERPUNK 2077

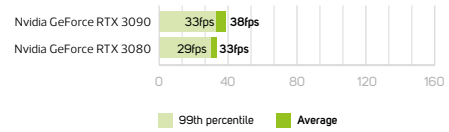
2,560 x 1,440, Medium ray tracing preset, DLSS Balanced



3,840 x 2,160, Medium ray tracing preset, DLSS Balanced

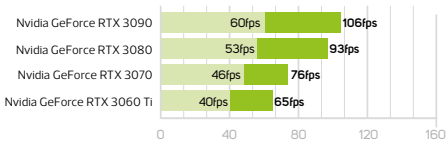


3,840 x 2,160, Ultra ray tracing preset, DLSS Quality

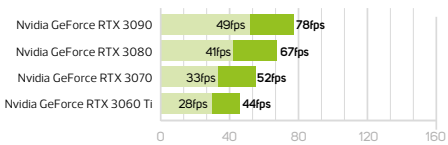


METRO EXODUS

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

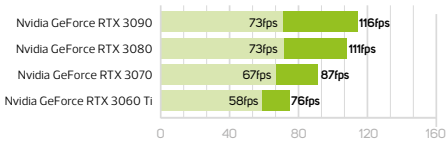


3,840 x 2,160, Ultra settings, High RT, PhysX off, Hairworks off, DLSS

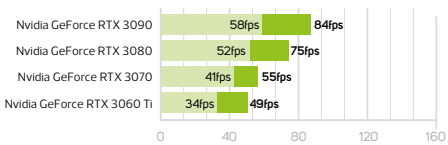


SHADOW OF THE TOMB RAIDER

2,560 x 1,440, Highest settings, High ray-traced shadows, DLSS

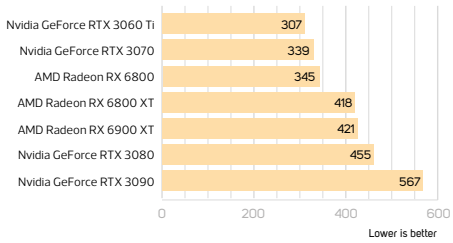


3,840 x 2,160, Highest settings, High ray-traced shadows, DLSS



POWER CONSUMPTION

LOAD TOTAL SYSTEM POWER CONSUMPTION (WATTS)



LABS TEST

Sitting pretty

Essential gaming accessory or expensive gimmick? **Edward Chester** puts six of the most popular gaming chairs to the test

How we test

Gaming chairs have come in for a bit of stick since they first started appearing a few years ago. All style and no substance with overinflated price tags is the general cynic's refrain, but what's the reality of the situation? Are they worth buying or are you better off with a premium office chair?

We've tested six gaming chairs priced between £225 and £429 inc VAT, which may sound like a lot compared with the bargain basement bottom warmers you'll find in your local office supplies store. However, the step up in features and quality is huge, even for the cheaper chairs on test. Sturdy bases, recline support, headrests, ample padding, adjustable armrests and wheels that actually roll are the sort of features you'd expect to cost the better part of £200, even on no-name office chairs.

Aesthetically, there's a clear theme to all the gaming chairs on test, with a car-racing bucket seat vibe running throughout the models. Several brands throughout the industry are also all made by the same manufacturer, so they have strikingly similar features – all the chairs on test here appear to use one of two recline systems, for instance.

So while some chairs do have unique features, what largely differentiates the various models on test is the choice of materials, colours and extra features, such as the adjustability of the armrests, plus of course, the price.

To test each chair, we first assessed the ease with which you can unpack and assemble them (they were all easy and very similar to assemble). Then, over the course of a couple of weeks we spent a minimum of one day sitting in each chair, getting to know how it felt initially and after a long sitting session.

All the adjustments were tested, and we did plenty of wheeling around as well. We also compared them with two more conventional office chairs we had to hand, the Herman Miller Aeron (£1,000 inc VAT) – widely regarded as the king of office chairs – and an Ergo-Task Fully Loaded mesh-backed office chair (£184 inc VAT).

Contents

AKRACING CALIFORNIA / £349 inc VAT

SUPPLIER scan.co.uk

While the AKRacing California is built and designed in much the same way to the other chairs on test, it's specifically designed for smaller users, up to a height of 5ft 6in. A quick spy of its colour options – white, pink and light blue – and it's clear the target audience is more the stereotypical idea of a 'girl gamer' than children or other smaller users, but ultimately colour preference is personal and the core experience will suit anyone on the petite side.

Putting that petiteness into numbers, while most of the chairs on test have backrests that are 88-90cm tall, the California is just 77cm tall. The usable length of the seat is also just 45cm rather than the 48-50cm of the larger models. The latter measurement, in particular, may not sound like much of a change, but in practice, it can make all the difference for those with shorter legs.

After all, the difference in total height between people is accumulated through the whole body, so a 3cm difference in just the length of your femur is quite substantial. Our 5ft 2in tester confirmed that the overall proportion was much better than the other chairs, allowing for a more comfortable leg position, and the headrest cushion naturally sat at a more comfortable height.

Indeed, thanks to the general lack of adjustment in the seat heights and lengths in these bucket-seat designs, this chair highlights the importance of paying attention to the recommended height range when choosing a chair. Most manufacturers offer two or three sizes, with the largest often billed as being for wider users as well as taller ones, but it's the height that will be the key difference for many users.

In terms of core features, the California is a mid-range chair of this type, as its price suggests, and it uses a polyurethane (PU) leather for easy wipe-clean maintenance. Choosing a bright white chair such as our review sample is surely asking for trouble, regardless of how easy it is to clean, but the PU material is certainly better than a bright white fabric in this respect.

Elsewhere, the California offers the same sort of feature set as the other cheaper chairs on test. Specifically, the recline mechanism is a basic one that can lock in a fully upright position or swing freely, but you can't lock it in a reclined position. The balance of the recline isn't great either, with it proving near impossible to just tilt back into a recline without putting your feet on an object to counteract your weight.

Either that or you need to lower the backrest to push back your centre of gravity. This is an area where the Herman Miller office chair shows why it costs so much, offering a very easy recline system, although the Ergo-Task chair doesn't recline at all.

You also get more basic castors that don't roll as well as more expensive options, simpler armrests that offer 'only' height adjustment of the support arm and forward, back and rotation movement of the rest pad. Like all the chairs on test, gas-lift seat height adjustment and sprung backrest angle adjustment are included as well.

Meanwhile, lumbar and head support are provided by cushions that hang onto the chair via elastic straps. It's a slightly clunky system that has us concerned for the longevity of the elastic, but the cushions are comfortable and the lumbar support is easy to adjust.

Conclusion

The AKRacing California is potentially ideal for smaller gamers. Its proportions are a better fit than 'one size fits all' chair designs and it's a solid, well-built unit. Potentially divisive colour options and a basic tilt mechanism are factors to consider though.

DREAMIN'

- \+ Ideal size for smaller users
- \+ Smart mostly white finish
- \+ Decent feature set for the price

WINTER'S DAY

- – Limited recline system
- – Odd selection of colourways

VERDICT

An ideal design for smaller gamers, although there's room for improvement and the colour options are potentially divisive.

COMFORT	DESIGN	OVERALL SCORE
18/25	15/25	73%
FEATURES	VALUE	
20/25	20/25	

AKRACING MASTERS SERIES PREMIUM / £429 inc VAT

SUPPLIER scan.co.uk

MASTERFUL

- + Best seat padding on test
- + Sensible lumbar cushion size
- + Plenty of features

AMATEURISH

- − Clunky faux carbon fibre design
- − Slightly restrictive seat wings
- − Headrest is rather slippery

Although AKRacing's Masters Series Premium offers plenty of features and function for its price, there's one crucial area where we immediately weren't taken with it, which is its styling. With the faux carbon fibre look of this version of this chair, plus its prominent white-on-black AKRacing logos, silver car-style wheel hubs and pointless plastic AKRacing logos on the otherwise solid metal base, the Master Series Premium is among the most egregiously 'gamer'-styled chairs on test. However, the attractiveness of styling and appearance are all in the eye of the beholder, so we'll leave further musings on the colour combinations to you.

As one of the pricier chairs on test, the Master Series Premium has the sort of feature set you would expect, with a costly wipe-clean PU leather covering and an uprated recline system being the key draws. The latter offers the ability to lock the chair in a reclined position, so you aren't constantly wobbling back and forth, trying to balance. It's also much better balanced, so you can recline by just leaning back. Comparatively, with the cheaper systems, you need to push up with or support your legs in order to get the chair to recline.

The overall effect is one of a generally premium feel, and there are some specific areas that we particularly like. The 4D armrests (sideways slide is added) have a nicer shape and softer material than the ones on the Corsair and noblechairs models, though it's still a relatively hard foamy plastic. The armrests also don't wobble as much as those chairs, though they lack a locking system for the armrest rotation and sliding movements, so they can move if you lean on them.

The seat of this chair is also the pick of the bunch in terms of padding. It's much deeper-feeling and softer than the other chairs on test, with a longer, better-contoured and padded drop-off at the front to reduce the feeling of digging into your legs at the front of the chair.

It's still not as deep as that of the Ergo-Task Fully Loaded, nor as perfectly cushioning as the mesh of the Herman Miller Aeron, but it's ample for all-day sitting. Where the seat is less well suited to some gamers is with its modest width and steep sides. While it's one of the longest in terms of usable seat depth (50cm), it's only 39cm wide at its front and the wings jut straight up, so you feel them dig into you unless you're sat really quite straight-legged. The same is true of the hip wings that have just a 33cm gap – this isn't a chair for wider people.

Unlike the slightly cheaper noblechairs HERO, you don't get a built-in, adjustable lumbar support with this chair, but instead rely on a lumbar cushion. It's a sensibly modest size – although, like most of the other chairs on test, it's still a bit too big. Also, once it's strapped in, it's surprisingly easy to slide it up and down to adjust its placement. The same is true of the headrest, although here it's less welcome, as it tends to slide too far down – the one on the noblechairs HERO stays in place better. On a chair this expensive, a more mechanical, longer-lasting system would be nice.

Conclusion

This is a pricey chair that thanks to its – shall we say – divisive styling, is put on the back foot from the off. However, its best-in-class seat padding, generally solid build quality and ample feature set certainly help to pull it back, and other colours are available too. This is the most comfortable of all the gaming chairs on test in which to sit, and for that reason alone it's still worth considering if that's your absolute top priority.

VERDICT

Styling questions aside, this is a very comfortable gaming chair.

COMFORT	DESIGN	OVERALL SCORE
23/25	15/25	78%
FEATURES	VALUE	
22/25	18/25	

CORSAIR T3 RUSH / £250 inc VAT

SUPPLIER corsair.com

The Corsair T3 Rush may be one of the cheapest seats on test this month, but in many ways it punches well above its weight, with the most obvious win being its design. The company offers just three colour options for this particular model, with charcoal, grey/charcoal and grey/white available, and they all have an understated classiness to their styling that many of the other chairs on test fail to bring to the table, or indeed your computer desk.

As well as the fabric colouring, the attractiveness of the design is also down to aspects such as the choice of a simple black plastic set of legs and matching wheels – there's none of the flashier 'gamer' touches seen on some of the models on test this month. Even Corsair's logo is fairly subtle.

What's more, the fabric finish of this chair feels really pleasant. It's finer and softer than the Nitro Concepts chair, and it's our clear favourite of the coverings on test in terms of touch. However, it won't be as easy to keep clean as the PU leather coverings found on some of the pricier chairs tested this month.

Further helping this chair's cause is its rather neat lumbar support cushion. It has a plush covering, it's much larger than most other chairs' lumbar supports and it doesn't use straps. Instead, the idea is it can just sit, wedged at the base of the seat, or you can cinch it up a bit once you've sat down. It's able to do this and still be comfortable because it's made of super-squidgy memory foam. It puts all the other lumbar support cushions to shame with its sheer kidney-hugging snugness.

Letting the side down on the comfort level are two factors though. The first is that the seat just feels rather hard – it's perhaps the firmest on test. Thankfully, though, the seat does a reasonable job of alleviating this hardness by having a more comfortable shape than the likes of the Nitro Concepts S300.

The other problem is the particularly harsh wings, specifically those on the sides of the backrest. I have relatively wide hips for a slim 6ft 2in man, but I still wouldn't expect a chair of this type to dig into my hips. A shallower angle or just a few extra centimetres of width would make all the difference here. This really goes to show that using a racing seat for an office chair isn't ideal. There are no sideways forces being slung at you to make the support wings useful and they otherwise only serve to restrict your sitting options.

Meanwhile, the main area that shows up the relatively low price tag on this chair (other than the lack of PU leather), is the inclusion of a more basic type of recline system, which is identical to that on the AKRacing California and Nitro Concepts S300. It technically does offer recline, but it's not well balanced and it can't be locked in a reclined position.

Meanwhile, the armrests are of the 4D type, with a sideways sliding motion, but they're particularly hard and wobbly with a weird-looking checker pattern. We actually preferred the more basic armrests on the Nitro Concepts S300.

Conclusion

The Corsair T3 Rush is a good value gaming chair that offers a solid balance of features for its comparatively low price. The chair covering and colour schemes in particular are excellent, as is the lumbar support cushion. However, the seat is slightly too firm and the side wings are a little restrictive. This chair would also be improved with a better recline mechanism, but this would up the price considerably. If you can't afford to spend big money, this is a decent gaming chair for the price.

RUSH

- \+ Classy design
- \+ Super squishy lumbar support cushion
- \+ Good value

DRUM SOLO

- − Overly hard seat padding
- − Side wings too constricting
- − No height adjustment for lumbar support

VERDICT

The best-looking chair in its class, and it offers good value too, but check your hip width before taking the plunge.

COMFORT	DESIGN	OVERALL SCORE
15/25	22/25	79%
FEATURES	VALUE	
18/25	24/25	

NITRO CONCEPTS S300 / £225 inc VAT

SUPPLIER overclockers.co.uk

Nitro Concepts is the low-cost sibling brand of noblechairs, offering gaming chairs in the range of £160-£250 inc VAT. The S300 is the top-of-the-line model, with the very slightly cheaper X1000 offering essentially the same features but in a flatter seat shape suited to larger sitters. Meanwhile, the cheaper C100 is a much more basic chair with fixed – though rather lusciously padded – armrests.

The most obvious feature you miss here over the pricier chairs on test is the more sophisticated recline system. Like the AKRacing California and Corsair T3 Rush, it limits you to either a locked upright position or free-floating recline, with the latter being badly balanced and requiring leg support or raising of the arms behind the head to sustain a tilt (depending on your body weight and shape, to an extent).

The other main tick-box feature you don't get is a leather or PU leather finish. Instead, you get a fabric covering, which is the only material available, although many colour options are on offer. It's a fairly coarse weave but not enough to be an irritant to bare legs or elbows.

It also feels tough enough to withstand plenty of abuse, but it inevitably won't be as spill-resistant as leather and PU leather coverings. On the plus side, it's warmer to the touch than those alternative materials on first sitting.

You don't get so-called 4D armrests here either. The ones on the S300 'just' go, down, forwards and back, as well as rotating from side to side – sideways sliding isn't available. Ironically, this has allowed Nitro Concepts to actually provide by far the best-looking and best-feeling armrests of the group.

They're still a bit on the hard side, but they're softer than the others on test and they have a simple, smooth, rounded-off shape. It also means the armrests are secure, with none of the annoying rattle and play in some of the '4D' armrests.

Another cheaper element is the quality of the castors, which noticeably don't glide as smoothly and easily as the other chairs on test. Otherwise, build quality is solid enough – this is still a clear step up from flimsy basic office chairs.

The chair's shape has the more aggressive style, with pronounced wings on the sides to prevent you from falling foul of those Gs you'll be pulling. However, unlike the Corsair T3 Rush and AKRacing Masters Series Premium, the wings aren't so pronounced as to prod into my relatively modest frame.

The flat of the seat measures 39cm at the front and 32cm at the back, while the narrowest part of the backrest is 32cm. These are similar dimensions to those two aforementioned chairs, but the gentler slope of the wings relieves any pressure.

Letting the side down on the comfort front is the shortness and slightly raised front edge of the seat. It measures 48cm from front to back, which is only 2cm shorter than the longest seats, but because the front edge rises slightly, and because the padding isn't all that soft, it slightly digs in under your thighs. Similarly, the lumbar support cushion is terrible. It's overly hard, with far too steep a profile, and it ends up jutting into your back rather than gently supporting it. The little elasticated head cushion is fine though.

Conclusion

In many ways, the Nitro Concepts S300 seems like quite a bargain at its price of just £225 inc VAT. If you're not fussed about having a chair that can tilt back easily, the core spec delivers most of the rest of the key features found on far more expensive models. However, under the surface, there are plenty of areas where the cost cutting shows. That said, it still offers decent value. It's just a shame the main event – the seat cushion – isn't all that comfortable.

VERDICT

A decent-value gaming chair option, but it's worth paying the extra money for more comfort.

COMFORT	DESIGN	OVERALL SCORE
12/25	16/25	67%
FEATURES	VALUE	
15/25	24/25	

NITROUS OXIDE

+ Solid build quality
+ Low cost
+ Decent armrests

OXIDATION

- Not that comfortable
- Basic recline system
- Castors don't glide smoothly

NOBLECHAIRS HERO BLACK EDITION / £419 inc VAT

SUPPLIER overclockers.co.uk

SUPERHERO

- + Sleek design
- + Solid build quality
- + Decent overall comfort
- + Built-in lumbar support beats cushions

HERO COMPLEX

- – Seat too firm
- – Neck pillow feels cheap at this price

As one of the most expensive chairs on test – and with perhaps the heaviest box – the noblechairs HERO Black Edition comes with high expectations, and thankfully delivers on several of them. This is a large-format chair, made for taller, wider folks. The backrest rises to 90cm, and although the seat measurements have the same 32cm to 39cm central sitting area as most other chairs on test, the wings are almost non-existent, so you can sit comfortably on the full 52cm width of the seat.

Similarly, the shoulder wings have only a very modest bump to them, so your shoulders don't feel restricted or pushed forwards. Perversely, though, the hip wings are still quite pronounced and not a lot wider than those of some of the other chairs on test, measuring 32cm at the backrest and 42cm at the tips of the wings, so those with wide wastes may feel a little hemmed into this chair.

The overall effect, though, is of a chair that allows a little more room to manoeuvre compared with some, with room to spread out into a comfortable pose (unlike the AKRacing Masters Series Premium). The open shoulder wings in particular allow for a better 'shoulders-back' posture.

The built-in lumbar support also helps a great deal. While noblechairs does also include an elastic-strapped lumbar cushion that's rather too firm, many people will find they can do away with it in favour of the built-in support. That said, it's not a very pronounced support. Tighten the knob on the side of the chair and the back of the chair in that area firms up, but it's nowhere near the exaggerated support of lumbar cushions. We still found it sufficient for our needs though.

For neck support, this chair relies on a separate pillow, which at this price does feel a bit cheap – a sturdy mechanical system would be better here. Nonetheless, for this 6ft 2in tester, the cushion did sit perfectly, and it feels pleasant and squishy with a soft plush finish.

For overall features, this chair is a cut above most of the other chairs on test in several ways. For starters, it has the more sophisticated tilt system found on the AKRacing Masters Series Premium, so you can more easily lean back and lock yourself in that position. You also get fully adjustable armrests that, while a little wobbly, offer a significant improvement over the Corsair chair in particular and have a slightly smarter look, although they're still a bit too hard.

In terms of styling, the simple all-black look works well, and although the main material is a little colder to the touch than fabric, the Hybrid-PU leather (a tougher blend of vinyl and polyurethane) of this Black Edition soon warms up and we didn't find it too sweaty (of course, testing in the middle of winter isn't a great indicator in this regard). The chair is also available with some genuinely good-looking game brand tie-in designs – Fallout and Doom fans take note.

Letting the comfort side down slightly, though, is the hardness of the actual seat. We understand that offering firm support is better than providing too much soft padding, but there's a balance to be struck, and this chair feels surprisingly hard. The AKRacing Master Series Premium is notably softer.

Conclusion

You do expect to get a lot of chair when you fork out £420 inc VAT for it, and the noblechairs HERO Black Edition largely delivers on that expectation. It's big, wide and has plenty of features. It's a shame the seat padding isn't a little softer and better contoured, but the built-in lumbar support and decent reclining system are big plus points here, as is the classy styling.

VERDICT

Plenty of features and solid build quality make for a superb gaming chair, although the seat could be a little softer.

COMFORT	DESIGN	OVERALL SCORE
19/25	22/25	81%
FEATURES	VALUE	
22/25	18/25	

VERTAGEAR SL5000 SPECIAL EDITION / £329 inc VAT

SUPPLIER box.co.uk

With its middling price, the SL5000 offers just the sort of mid-range feature set you'd expect, but you'd be forgiven for thinking it was a pricier chair from its design. The dark blue PUC (this time a polyurethane and PVC mix) leather marries really well with the black fabric material and yellow stitching to create a surprisingly stylish overall look. The Corsair T3 Rush still just takes the overall crown in this regard, to our eyes, but this is a clear step up from several other options.

That step up in quality and price is also reflected in the costlier use of PUC leather, which is why the SL5000 is a more expensive option than the Corsair and Nitro Concepts chairs on test this month. However, the upgrades don't extend to the tilt mechanism, which is of the more basic variety. It will lock upright and tilt back but won't lock in a tilted position. Also, the tilt isn't well balanced and raises the front of the chair in an awkward manner.

The fancier 4D armrests are present and correct, though, offering side-to-side sliding along with height, rotation and forward and back slide adjustment. Like all the chairs on test, we do wish they'd drop a bit lower, though, so you can drop them almost completely out of the way. You also get good-quality castors and an attractive, muted-looking black aluminium base and wheels. In other words, the price of this chair is bang on for its selection of features, as compared with the other chairs on test.

One feature this chair offers that you won't find in any of the other chairs on test, though, is RGB lighting! For a cool €300 (approximately £265 inc VAT) you can equip the plastic-lined holes in the back of the chair with RGB frames. For the same amount of money, you can also get an RGB-equipped base, with lights under the arms and even in the rims of the wheels. They're both battery-powered and sync with your PC, and a charger is included, but boy, that is quite the price. We didn't get to try these additions, so we can't comment on their ease of installation or quality.

As for comfort, the SL5000 is a mid-sized chair for those up to 6ft 4in in height and weighing up to a hefty 120kg. However, we'd be a little surprised if someone of that weight would be fully comfortable in this chair, as it has quite aggressive side and leg wings. Like the AKRacing Master Series Premium, the latter really constricts how wide-legged you can sit. It's not uncomfortable but it limits your options a bit.

The seat padding is good, though, offering a gentler base than the slightly harsh Corsair and Nitro Concepts chairs. The neck pillow is good too, with its cosseting plush finish, but the lumbar pillow is a bit aggressive for our liking. It also doesn't include straps for adjusting its height.

One extra addition for American buyers is that if you order direct from Vertagear, as well as specifying a colour (several variations on black with another highlight colour are available), you can also choose a type of castor. For an extra $5, you can get locking wheels or larger 3in wheels while $10 gets you locking 3in wheels. Sadly, however, UK buyers are limited to just the standard wheels.

VERTICAL

- \+ Stylish dark blue design
- \+ Good seat padding
- \+ Solid build quality

VERTIGO

- – Basic tilt system
- – Quite restricted leg space

Conclusion

The Vertagear SL5000 is a solid mid-sized gaming chair that makes for a particularly attractive option in its midnight blue colour scheme. It has plenty of attractively muted design details and offers a comfortable overall sitting experience. Its lumbar cushion isn't the best, though, and its middling price makes it feel a little more disappointing that it only offers a basic tilt system. CPC

VERDICT

An attractive colour scheme and overall comfort make this a decent mid-range gaming chair, although it's a shame you don't get a better reclining system.

COMFORT	DESIGN	OVERALL SCORE
18/25	22/25	76%
FEATURES	VALUE	
17/25	19/25	

How we test

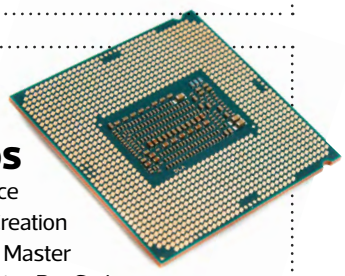
MOTHERBOARDS

TEST PROCESSORS

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

Our test gear comprises a GeForce RTX 2070 Super Founders Edition and a 2TB Samsung 970 Pro SSD (or a PCI-E 4 1TB Corsair MP600 SSD on X570 and TRX40 boards). We also use Corsair Vengeance RGB 3466MHz DDR4 RAM – a 16GB dual-channel kit for mainstream systems, and a 32GB quad-channel kit for HEDT systems. All CPUs are cooled by a Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock.

We test with our RealBench suite and Far Cry New Dawn on Windows 10 Home 64-bit. We also test the board's M.2 ports, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer. Where possible, CPUs are overclocked and benchmarked again.



PROCESSORS

TEST MOTHERBOARDS

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

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

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

MONITORS

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

CPU COOLERS

We measure the CPU temperature with 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.

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

Intel Core i7-8700K overclocked to 4.8GHz on all cores, 16GB of Corsair Vengeance LED 3000MHz DDR4 memory, Gigabyte Z370 Aorus Gaming 5 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 FrameView.

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

Metro Exodus Tested at Ultra settings with High ray tracing, and with Advanced PhysX and HairWorks disabled. We run the game's built-in benchmark, and report the 99th percentile and average frame rates.

Shadow of the Tomb Raider Tested at the Highest settings preset with High ray-traced shadows, with both TAA and DLSS if it's supported. We run the built-in benchmark and record the 99th percentile and average frame rates with OCAT.

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	scan.co.uk	**#194** p20	£144
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	£78
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	awd-it.co.uk	**#204** p74	£79
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£58
		Total £359		

Budget gaming system

6-core CPU, 1080p gaming

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 2600	scan.co.uk	**#189** p46	£165
CPU COOLER	ARCTIC Freezer 7 X	scan.co.uk	**#202** p20	£18
GRAPHICS CARD	AMD Radeon RX 5600 XT	scan.co.uk	**#204** p74	£283
MEMORY	16GB (2 x8GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M2Z 3200C16)	scan.co.uk	**#204** p74	£78
MOTHERBOARD	Asus TUF B450M-Plus Gaming (micro-ATX)	awd-it.co.uk	**#204** p74	£79
STORAGE	500GB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£58
		Total £608		

UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3060 Ti	nvidia.com	**#211** p39	£369
SWAP STORAGE	1TB WD Blue SN550 (M.2 NVMe)	scan.co.uk	**#204** p24	£95

Entry-level RTX 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 (see Issue 210, p74 for an example build guide).

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 5 5600X	scan.co.uk	**#209** p30	£310
CPU COOLER	Antec Neptune 240	scan.co.uk	**#204** p16	£80
GRAPHICS CARD	Nvidia GeForce RTX 3070	nvidia.com	**#211** p40	£469
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	**#210** p74	£89
MOTHERBOARD	MSI MPG B550 Gaming Carbon WiFi (ATX)*	cclonline.com	**#210** p74	£200
STORAGE	1TB Gigabyte Aorus NVMe Gen4 M.2 SSD (M.2 NVMe)	scan.co.uk	**#210** p74	£155
	Total £1,303			
UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£95

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

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	scan.co.uk	**#208** p16	£444
CPU COOLER	Antec Neptune 240	scan.co.uk	**#204** p16	£80
GRAPHICS CARD	Nvidia GeForce RTX 3080	nvidia.com	**#211** p43	£649
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	**#210** p74	£89
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	£160
	Total £1,712			
UPGRADES				
SWAP CPU	AMD Ryzen 9 5900X (12 cores)	overclockers.co.uk	**#208** p18	£600
ADD SECONDARY STORAGE	Western Digital Blue 4TB	overclockers.co.uk	**#166** p54	£95
SWAP CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	**#185** p82	£125

***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	overclockers.co.uk	#208 p18	£600
CPU COOLER	Corsair H100i RGB Platinum (240mm AIO liquid cooler)	scan.co.uk	#175 p20	£125
GRAPHICS CARD	Nvidia GeForce RTX 3090	nvidia.com	#208 p24	£1,399
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3600MHz (CMW16GX4M 2Z3600C20)	scan.co.uk	#210 p74	£89
MOTHERBOARD	MSI Prestige X570 Creation (E-ATX)*	overclockers.co.uk	#193 p48	£440
STORAGE	1TB Samsung 980 Pro	ebuyer.com	#208 p52	£214
	Total £2,867			
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	overclockers.co.uk	#166 p54	£95
SWAP CPU	AMD Ryzen 9 5950X (16 cores)	overclockers.co.uk	#209 p31	£860

***This motherboard will 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	scan.co.uk	#199 p44	£202
MEMORY	32GB (4 x 8GB) Corsair Dominator Platinum RGB 3600MHz	scan.co.uk	#197 p20	£261
MOTHERBOARD	ASRock TRX40 Taichi (E-ATX)	overclockers.co.uk	#198 p44	£470
STORAGE	1TB Samsung 980 Pro	ebuyer.com	#208 p52	£214
	Total £2,551			
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3070 (2,560 x 1,440 gaming with real-time ray tracing)	nvidia.com	#211 p40	£469
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	£280
AMD B550 (AM4 budget)	Asus ROG Strix B550-I Gaming	scan.co.uk	#206 p44	£200
AMD X570 (AM4 mid-range)	Asus ROG Strix X570-I Gaming	overclockers.co.uk	#198 p20	£290

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	overclockers.co.uk	#206 p18	£90
PREMIUM	NZXT H1	scan.co.uk	#201 p24	£299

CPU coolers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE	Noctua NH-D9L	amazon.co.uk	#143 p17	£48

ATX cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Phanteks Eclipse P300 Glass	overclockers.co.uk	#176 p28	£55
BUDGET QUIET	be quiet! Pure Base 500	scan.co.uk	#196 p24	£70
SUB-£100	be quiet! Pure Base 500DX	scan.co.uk	#202 p39	£99
COMPACT	Fractal Design Define 7 Compact	overclockers.co.uk	#203 p32	£99
MID-RANGE	Phanteks Eclipse P600S	overclockers.co.uk	#202 p44	£139
SUB-£150	Fractal Design Define 7	overclockers.co.uk	#204 p18	£140
PREMIUM	Phanteks Enthoo Evolv X	overclockers.co.uk	#187 p24	£215

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD X399 (TR4)	ASRock X399M Taichi	scan.co.uk	#179 p28	£320
AMD B550 (AM4)	MSI MAG B550M Mortar	ebuyer.com	#204 p42	£145

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Fractal Design Focus G Mini	scan.co.uk	#180 p46	£47
MID-RANGE	Fractal Design Define Mini C	scan.co.uk	#161 p26	£70

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ROUTER (WI-FI 6)	TP-Link Archer AX6000	overclockers.co.uk	#196 p57	£280
MESH ROUTER (WI-FI 6)	Asus AiMesh AX6100	amazon.co.uk	#196 p54	£340
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	#196 p58	£60
SINGLE-BAY NAS BOX	Synology DS118	box.co.uk	#174 p34	£155
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	#200 p22	£154
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	#174 p34	£199

Monitors

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

Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144HZ, TN, 1,920 X 1,080, F, G	AOC G2590FX	scan.co.uk	#190 p53	£178
24IN, 144HZ, VA, 1,920 X 1,080, F	AOC C24G1	amazon.co.uk	#191 p28	£174
25IN, 240HZ, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	currys.co.uk	#209 p57	£329

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	£2,499
43IN, 120HZ, VA, 4K, F, G	Asus ROG Strix XG438Q	amazon.co.uk	#205 p39	£1,079

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	£215
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	£470

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	£49
BUDGET TKL MECHANICAL	HyperX Alloy FPS Pro	amazon.co.uk	#201 p46	£62
MECHANICAL	Corsair K68 RGB	scan.co.uk	#181 p53	£90
OPTICAL ESPORTS	Asus ROG Strix Scope RX	overclockers.co.uk	#209 p43	£125
MECHANICAL MMO	Corsair K95 RGB Platinum	overclockers.co.uk	#164 p26	£180
PREMIUM MECHANICAL	Corsair K70 Mk.2 Low Profile	scan.co.uk	#193 p56	£150
PREMIUM TKL MECHANICAL	Asus ROG Strix Scope TKL Deluxe	scan.co.uk	#202 p24	£140
LUXURY MECHANICAL	Razer Hunstman Elite	box.co.uk	#193 p59	£185
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	£100
WIRELESS	Corsair Dark Core RGB Pro	amazon.co.uk	#202 p25	£90
PREMIUM WIRELESS	Razer Deathadder V2 Pro	scan.co.uk	#210 p28	£130
ULTRA LIGHTWEIGHT	Roccat Burst Pro	roccat.com	#211 p28	£50

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
PREMIUM RACING WHEEL	Fanatec CSL Elite PS4 Starter Kit	fanatec.com	**#202** p49	~£497
GAMEPAD	Microsoft Xbox One Wireless Controller	amazon.co.uk	**#191** p56	£54
BUDGET FLIGHT STICK	Logitech Extreme 3D Pro Joystick	currys.co.uk	**#207** p52	£34
FLIGHT STICK	Thrustmaster T.1600M FCS HOTAS	thrustmaster.com	**#207** p56	£140

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET STEREO	Roccat Elo X Stereo	argos.co.uk	**#210** p56	£40
STEREO	Epos | Sennheiser GSP 300	eposaudio.com	**#210** p54	£89
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	**#204** p50	£154
PREMIUM WIRELESS	Razer BlackShark V2 Pro	razer.com	**#211** p26	£180

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Edifier R1280DB	cpc.farnell.com	**#192** p57	£100

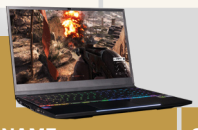
Non-gaming keyboards

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	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	Wired2Fire Predator	AMD Ryzen 7 5800X	Nvidia GeForce 3060 Ti	wired2fire.co.uk	**#211** p32	£1,399
8-CORE GAMING	Chillblast Fusion Commando 3060Ti	AMD Ryzen 7 5800X	Nvidia GeForce 3060 Ti	chillblast.com	**#210** p34	£1,500
8-CORE RTX 3080 GAMING	PC Specialist Obsidian I	Intel Core i7-10700KF	Nvidia GeForce RTX 3080	pcspecialist.co.uk	**#209** p40	£2,081
10-CORE RTX 3080 GAMING	CyberPower Infinity 910 RTX	Intel Core i9-10850K	Nvidia GeForce RTX 3080	cyberpowersystem.co.uk	**#208** p42	£2,465
WATER-COOLED 16-CORE GAMING	Scan 3XS Absorbere	AMD Ryzen 9 5950X	Nvidia GeForce RTX 3090	scan.co.uk	**#209** p46	£5,407
DREAM PC	Scan 3XS Barracuda	Intel Core i9-10980XE OC to 4.3GHz	Nvidia GeForce RTX 3090	scan.co.uk	**#145** p58	£13,815



Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
THIN AND LIGHT GAMING	Asus ROG Zephyrus G14 GA401IV	AMD Ryzen 9 4900HS stock speed	Nvidia GeForce RTX 2060 Max-Q	14in 2,450 x 1,440 IPS 60Hz	overclockers.co.uk	**#202** p28	£1,800
GAMING	Chillblast Phantom 17	Intel Core i7-10875H stock speed	Nvidia GeForce RTX 2070	17.3in 1,920 x 1,080 IPS 144Hz	chillblast.com	**#197** p53	£1,760
HIGH-PERFORMANCE GAMING	Lenovo Legion 7i	Intel Core i7-10875H stock speed	Nvidia GeForce RTX 2080 Super Max-Q	15.6in 1,920 x 1,080 IPS 144Hz G-Sync	laptopsdirect.co.uk	**#208** p40	£2,050

RICK LANE / INVERSE LOOK

FOCUS POCUS

The best games have a specific idea and unwavering dedication, argues Rick Lane

What makes a great video game? There are many reasons why a game might turn out mediocre or worse, ranging from bugs and technical issues to imbalanced mechanics or poorly implemented design. Similarly, there are lots of ways a game might stand out, such as having a distinctive art style, such as Limbo, or introducing a new mechanic, such as Watch Dogs Legion.

These features don't necessarily make a game great, however. A game can be bug-free and execute its design well, and still only be a satisfactory experience at best, such as Crysis 2. Limbo and Watch Dogs Legion might be enjoyable, but they wouldn't occupy the virtual hall of fame.

If you step back and look across the medium generally, great games usually focus on a single idea and dedicate the experience to elaborating on it in as many ways as possible. The original Doom is exclusively about one activity – shooting demons in the face. Aside from movement, shooting is really the game's only mechanic. What makes it a timeless experience is how every element of the design feeds back into making that simple action as thrilling and satisfying as possible.

The weapons, enemies and the level structures are designed to test you in new and surprising ways. That's why Doom is remembered as the watershed moment for the FPS genre over Wolfenstein 3D. Although Wolfenstein was the progenitor of the genre, from a design perspective, it's a much flatter experience that doesn't explore its core mechanic in quite the same way. It's good, but it feels like a prototype compared with Doom.

> A game can be bug-free and execute its design well, and still only be satisfactory at best

The key here is design focus, not simplicity. The design attitudes that made Portal such an incredible game are the same behind Deus Ex's landmark experience, even though one game is vastly more complex than the other from a mechanical perspective.

Portal focuses on exploring its unique portal mechanic, through an array of carefully crafted puzzles infused with a light comic story that's drip-fed as a reward for completing those puzzles. By comparison, Deus Ex focuses on giving the player as much agency as possible. This necessitates a broader scope and more layered systems, but it's all driven towards a single goal.

Even massive open-world games can have a singular design focus, which is often the factor that distinguishes them from other, lesser open-world games. With Skyrim, for example, the design focus is player freedom, which the game pursues relentlessly through systems, world design and character progression.

Even its modding tools are a part of this focus, offering a powerful yet accessible system that enables players to extensively customise their experience. Meanwhile, The Witcher 3 chooses narrative as the focus of its open world, making its exploration rewarding through dozens of carefully crafted, relatable human fairy tales.

Like all art, the best games take on an idea or a subject, and commit themselves to investigating it, through art, systems and design. When it comes to the best of the best games, it's all a matter of focus. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

Cyberpunk 2077 / £39.99 inc VAT

DEVELOPER CD Projekt RED / **PUBLISHER** CD Projekt RED

Cyberpunk 2077 is a game of dizzying highs and disappointing lows. At its best, it's a glimpse into the future of open world games, with next-generational visuals, phenomenal environment design, and storytelling that combines Hollywood-level production values with CD Projekt Red's penchant for human, emotive storytelling.

At its worst, Cyberpunk struggles to keep up with the past, with underbaked core systems, tedious RPG mechanics, antiquated open-world design and a general sense that the game isn't quite finished. On PC, it offers a decent experience but it isn't even close to being the revolution that the game's marketing would have you believe.

Players assume the role of V who, depending on how you create your character, can either be a counterintelligence agent working for the Arasaka corporation, a Street Kid trying to survive in the district of Heywood, or an out-of-town Nomad running contraband across the border. Whichever starting Lifepath you choose, V invariably ends up living as a small-time 'Edgerunner', a general-purpose thug working various kinds of jobs for 'Fixers' across Night City.

While Cyberpunk's story is officially told in three acts, it's really a tale of two halves. The first sees V and his partner Jackie Welles gearing up for an ambitious job to steal some cutting-edge tech from Arasaka, Night City's biggest corporation. The second half deals with the fallout from the heist, as V is drawn into conspiracies and circumstances far larger and stranger than he anticipated.

The story is generally excellent, with missions ranging from prowling through back alleys performing Chandler-style detective work, to dazzling high-concept scenarios, such as attempting a clandestine rendezvous with an Arasaka during a glittering parade. Yet it's in the smaller, more intimate moments where Cyberpunk truly shines.

CD Projekt Red has already demonstrated its talent for storytelling and dialogue in its Witcher games, and this is easily where Cyberpunk is strongest, providing a charismatic cast of thugs, thieves, assassins and others trying to get by in Night City. Highlights include Jackie Welles, your charismatic companion for the early game with a heart as big as his biceps, and Panam, an ex-Nomad who initially comes off as abrasive, but will no doubt be one of your favourite characters by the game's end.

Then there's Johnny Silverhand, the AI construct of a former rock star and terrorist lodged inside V's head like a particularly stubborn bit of pork gristle. Played by Keanu Reeves, Silverhand pops up in almost every quest (both main and side) to offer his distinctly anarchic and misanthropic perspective on

CYBERPUNK

+ Incredible visuals and tech
+ Compelling story
+ Some excellent side-quests

CYBERCLUNK

– Dreadful character progression
– Mediocre stealth
– Open world design is old-fashioned
– Bugs
– Performance issues

situations. Silverhand is a fantastic storytelling device, adding dynamism to every scene and bringing the narrative into general play, rather than limiting it to cutscenes and specific dialogue sequences.

All this drama takes place against the backdrop of Night City, which offers some of the most arresting virtual architecture you'll ever see. It's a place of dizzying density and verticality, with vast, glittering skyscrapers clustered together in districts such as Kabuki and Japantown, each building covered in shimmering neon billboards. It's a surprisingly varied cityscape too.

The Northside District is the city's industrial zone, where smoke-billowing factories and vast oilfields turn the city's skies to a smoggy bronze. Travelling to the City's southern tip, meanwhile, will bring you to Pacifica. Once intended as a holiday resort for the city's elite, its hotels and shopping malls have long since been abandoned, now playing home to gang turf wars.

Night City is a place that's both wondrous and horrifying, so dense and dazzling that simply walking around it admiring the sights feels like a worthwhile activity. This is just as well, as the actual activities that CD Projekt has designed often underwhelm.

Cyberpunk's problems begin with pacing. Most of the game's meatier side-missions don't appear until around two thirds of the way through the main story, comprising a half-dozen or so 'mission chains', each revolving around a specific character such as Panam or police detective River Ward. These are largely excellent, lengthy and involved side-stories that help you get to know both Night City and the character involved. Yet, while each story takes several hours to complete, there's only a handful of these side-stories. This makes the game feel oddly small, with certainly nothing like the scope of The Witcher 3.

Beyond these more in-depth side missions, the rest of Night City's activities boil down to 'gigs', cookie cutter distractions that have populated open-world games for over a decade. There are several flavours. One may involve stealing an object from a secure location, while others may require you to extract a person from another secure location. Aside from a couple of outliers, such as doing battle with amped up 'Cyberpsychos', most gigs feel functionally the same, and have little of the personality that CD Projekt generally infuses into its games' optional quests.

The reason for this is not entirely down to mission design, however. By far, Cyberpunk's biggest problem is that its role-playing systems simply aren't very good. The key inspiration for Cyberpunk's mechanics is Deus Ex, with the game offering

a similar combination of shooting, sneaking and hacking as its primary modes of play.

As a first-person shooter, Cyberpunk is enjoyable enough, with guns that rival Call of Duty for their sense of weight and power. Highlights include a bolt-action sniper rifle so chunky that cocking it is like reloading a tank shell, and Johnny Silverhand's pistol, which tears basketball-sized chunks out of enemies and has one of the coolest reloading animations we've ever seen.

Sadly, the combat is undermined by an overemphasis on stats, meaning your weapon selection is based purely on numbers rather than how a weapon actually functions and feels. Worse, the loot system is so overgenerous that picking up a new gun loses any significance. Cyberpunk is by no means the only RPG with this problem, but it's particularly egregious in CD Projekt's game.

Stealth is less well served. It's a basic crouch-to-sneak affair with only one non-lethal takedown ability – a chokehold so shoddily animated it looks like you're giving enemies a gentle hug from behind. You can install a mod to make your weapons non-lethal, but since silenced weapons generally won't knock out enemies outright, it's little use as an aid to sneaking. Fortunately, stealth is rescued from being completely tedious by Quickhacks, a range of smaller abilities that let you disable security cameras, distract enemies and even temporarily blind them on the fly (some Quickhacks can also be used in combat).

The problem with Quickhacks is they don't go far enough. There's only a handful of Quickhacks, which is nowhere near sufficient to support 40+ hours of gameplay, while many only serve functions that would be standard fare in another game. One Quickhack basically lets you 'whistle' at enemies to distract them, which most people can do without the help of advanced computer software.

This issue with Quickhacks gets to the core of Cyberpunk's problems, namely that character progression is terribly designed. At first glance, the skills system seems abundant with possibilities. There are multiple skill categories, each of which has two separate branches that include at least a dozen different upgrades. Yet nearly all of them offer tiny, incremental stat boosts that barely make any difference to your experience. The most exciting skill you can pick up in the stealth tree is the ability to throw a knife.

Cyberware is even more disappointing. Cyberware is Cyberpunk's equivalent to Deus Ex's augmentations, key

upgrades that are supposed to lend you wildly different powers. But again, nearly all of them revolve around incremental stat upgrades.

The only meaningful Cyberware implants are those for your arms and legs. The former offers a range of new attack types, while the latter improves your ability to jump. This is genuinely useful, although not exactly revolutionary.

All of this means that, from a play perspective, Cyberpunk generally underwhelms. There are other issues too, including an array of bugs and performance issues, ranging from relatively innocuous glitches such as NPCs floating in the air, to game-killing issues such as the frame rate dropping ridiculously if you use the menus.

Yet even if these issues are fixed, it won't change the fact that, at its core, Cyberpunk is an oddly inert experience that's nowhere near as enjoyable as Square Enix's recent Deus Ex games.

This is not to say that Cyberpunk is without merit. The story is worth experiencing. The larger side-quests are worth pursuing.

The city that CD Projekt has built is worth exploring. Nonetheless, Cyberpunk 2077 represents a significant step backwards from the dizzying highs of The Witcher 3, with a deeply flawed design for which no amount of technical wizardry and compelling writing can compensate.

RICK LANE

/ VERDICT

Cyberpunk's technical wizardry dazzles, and its storytelling satisfies, but the underlying game is disappointingly hollow.

OVERALL SCORE

60%

GEARS 5: HIVEBUSTERS / £15.99 inc VAT

DEVELOPER The Coalition/ **PUBLISHER** Microsoft

GEARS

- \+ Prettiest Gears yet
- \+ Spectacular set pieces
- \+ Packs a lot into a small package

TEARS

- – Inconsistent characterisation
- – Combat pacing issues
- – Unbalanced abilities

Creating a single-player origin story for a multiplayer mode might seem like the height of hubris, but Hivebusters proves to be a thoroughly entertaining addition to Gears (of War) 5. A Gears campaign in miniature, Hivebusters is designed as an introduction to the main game's Escape mode, which sees players working together to infiltrate and destroy a Locust Hive. It tells the story of that mode's three main playable characters, Keegan, Lahni and Mac, as they embark on their very first Hivebusting mission across the tropical Galangi islands.

Hivebusters packs an impressive amount of variety into its three-hour campaign. The opening mission sees your squad stranded on one of the tropical islands, the vibrant colours and lush vegetation of which are a far cry from the original trilogy's festival of brown.

Later, a mission to recon an abandoned underground COG facility culminates in your squad riding a lava flow on a giant, reinforced vault door.

It's every bit as spectacular and ridiculous as you'd expect from Gears of War, and the lighter, more tongue-in-cheek storytelling from Gears 4 and 5 makes a welcome return. Your three soldiers are a motley bunch. The underachieving Keegan is still a corporal despite 25 years of service to the COG, while Mac is a foul-mouthed Scot who views rules and regulations in the same way a strongman views a steel bar.

Unfortunately, while the characters are fun, the script isn't always consistent in representing their relationships. One minute they act like old friends, while the next they barely seem able to stand one another. The character arcs aren't exactly subtle either. The final mission might as well have each character say 'I HAVE LEARNED AND GROWN FROM MY EXPERIENCE' for all the nuance with which it's delivered.

Combat is little changed from that seen in Gears 5, being snappy, bloody and satisfying. Some missions struggle to maintain a good rhythm, however. The aforementioned lava-surfing mission is visually incredible, but it isn't all that interesting from a play perspective.

More broadly, Hivebusters' combat suffers as a consequence of its multiplayer origins. As is now expected in cooperative multiplayer, each character has a unique skill that gives them an edge in combat. In a single-player, these skills make the game too easy. Keegan's ammo replenishing ability means you never risk running low on ammunition, so powerful weapons such as the Torque Bow can be carried through entire levels.

That said, going wild with Gears' arsenal is undeniably fun, and Hivebusters is an appropriate place for bending the rules. Given the rarity of action-packed linear shooters these days, it would be unfair to rag on Hivebusters for providing too many opportunities to blow up stuff.

RICK LANE

/ VERDICT

Hivebusters is a fun, if rather choppy, extra slice of Gears action.

OVERALL SCORE

70%

HALO 4 / £6.99 inc VAT (~~£29.99~~ inc VAT for Master Chief Collection)

DEVELOPER 343 Industries / **PUBLISHER** Microsoft Studios

The Master Chief Collection's staggered arrival on PC completes with the release of Halo 4. The first Halo title developed by 343 Industries rather than Bungie, it's generally considered the series' weakest entry. However, while it's flawed in certain areas, Halo 4 offers one of the series' more interesting storylines.

It's more personal than earlier games, with Master Chief searching for a way back to Earth after being stranded in space at the end of Halo 3. The story mainly concerns Chief's relationship with Cortana, his AI Companion who is suffering from the virtual equivalent of dementia, which can only be remedied by getting back to Earth.

It's a surprisingly intimate and emotive narrative thread, sadly undermined by a couple of issues. The first is Cortana's bizarrely sexualised new design, visually objectifying her where the writing seeks to do the opposite.

The other problem is the story's broader arc, which introduces a new enemy called the Didact, a painfully tedious 'foolish mortals!' type of self-appointed god. The Didact forms part of a baffling new lore branch for Halo; frankly, this is too dull to bother figuring out whether or not it makes any sense.

Although the story struggles to reconcile its two halves, the individual missions are thoroughly entertaining. The campaign kicks off with a daring escape from Chief's stranded spaceship, including a magnificent Zero-G shooting section. Other highlights including escorting the Mammoth – a gigantic, railgun-equipped military crawler – through hostile territory, and the Chief's desperate attempt to defend a space station from an all-out assault by the Didact's forces.

Where Halo 4 stands out from previous games, however, is in the feel of the combat. 343 does a lot of work to 'ground' Halo's gunplay, making it feel weightier and more propulsive. Classic weapons, such as the Battle Rifle and Needler, are given better audio/visual feedback, and there are several punchy new weapons, including a semi-automatic DLR, a heavy machine gun and a mightily powerful railgun.

Halo 4 also introduces a new enemy type, the Prometheans. Unfortunately, this is Halo 4's main weak spot, as the Prometheans are neither as aesthetically nor mechanically engaging as either the Covenant or the Flood. One particular frustration is their ability to heal themselves using a floating drone that's extremely difficult to shoot down. That said, their new range of weapons is a welcome addition to Halo's arsenal, considerably expanding loadout options in multiplayer.

Speaking of which, alongside the familiar competitive multiplayer, Halo 4 also introduces Spartan Ops, an extensive four-player co-op campaign, the plot of which ties into the main Halo 4 story. It rounds off an ultimately fine FPS package, and a surprisingly satisfying send-off for the Master Chief Collection on PC.

RICK LANE

DLR

- \+ More character-focused story
- \+ Diverse, well-crafted campaign
- \+ Satisfying combat

DNR

- – Tedious broader arc
- – New enemy type a bit dull

/ VERDICT

Don't be fooled – the 'worst' Halo in the series is really not that bad at all.

OVERALL SCORE

78%

REALITY CHECK

Medal of Honor's Omaha Beach mission ought to be an amazing experience in VR. **Rick Lane** sees if Above and Beyond can live up to expectations

REVIEW

MEDAL OF HONOR: ABOVE AND BEYOND / £44.99 inc VAT

DEVELOPER Respawn Entertainment / **PUBLISHER** EA

Medal of Honor: Above and Beyond seems like a dream come true for VR. A full-length, classic WWII shooter developed by FPS maestro Respawn Entertainment (whose founders, Jason West and Vince Zampella, created both Medal of Honor: Allied Assault and the original Call of Duty), all designed to showcase the potential of VR. Above and Beyond is easily the most exciting VR project since Half-Life: Alyx. What could possibly go wrong?

Sadly, the answer is 'quite a lot'. Although there's much to admire about Above and Beyond's ambition, it never approaches the quality of Half-Life: Alyx. From scripting and pacing issues, to a design attitude that favours scope and spectacle over detail and player experience, Above and Beyond never quite satisfies as much as you expect.

The game puts you in the boots of an American soldier known simply as 'Lieutenant' who, after being wounded while fighting in North Africa, is recruited to the OSS (the precursor to the CIA) and tasked with a set of increasingly dangerous and daring missions. It's basically a VR remix of Allied Assault, taking you to many of the same locations, including its own variant of the Omaha Beach landing.

One of the more immediate issues with Above and Beyond is that it takes ages to get going. Before you commence your first mission, you must wade through an involved tutorial (including a surreal segment where an army doctor takes you through your VR setup), followed by an extensive briefing sequence, and finally, the Quartermaster area where you can experiment with weapons and equipment. There's also little continuity between these areas, with each one separated by a loading screen.

This issue is compounded by the first mission, where you team up with the French Resistance to destroy a compromising list of its agents held by the Gestapo. It's an exciting premise, marred by the fact you can barely walk 20 paces without stumbling into a briefing or dialogue segment.

These are always gated off from actual play, bookended by a fade-to-black that hinders the flow of the game. These segments are also inconsistent regarding what the player is allowed to do within them. Sometimes you can move around a bit, picking up objects and interacting with the environments. At other times you can only stand still and listen, which always feels weird in VR.

This would be less of a problem if the dialogue was well written, but that's sadly not the case. Above and Beyond has a bizarre tone, seemingly unable to decide whether it's serious WWII fiction, or a knockabout action caper such as Kelly's Heroes. Unlike Allied Assault, Above and Beyond often seems unwilling to buy into its own fiction, always looking for a joke or a tongue-in-cheek nod, intended to make its characters more endearing, but often spoiling the atmosphere instead. Your squad makeup doesn't always help either. Sarge – your grizzled, WWI veteran companion, is convincing enough, but Ollie – an underage British medic who looks like Harry Potter – seems entirely out of place in a crack OSS outfit.

After stumbling through the first mission, the game begins to improve. The second

mission involves parachuting into Germany to rescue a fellow agent by springing her from a train en route to Berlin. Here, individual levels become longer and more closely resemble a first-person shooter – there's a couple of standout moments, including a tense crawl through a German bunker, and the assault on the train itself.

As an FPS, Above and Beyond is competent, if rather uninspired. Handling the period weapons such as the M1 Garand and MP40 in VR show the game at its strongest, with all weapons having authentic priming and reloading mechanics. The bolt-action rifles such as the Kar98k are particularly satisfying to use, although they're also the most difficult weapons to wield efficiently. Intriguingly, Above and Beyond is one of the few VR shooters in which you can effectively shoot from the hip. Most weapons use tracer rounds, letting you guide shots more easily toward their targets, especially with submachine guns.

Not all the weapons are great, however. Sniper rifles are unusable unless you switch the scopes to Realistic, which requires you to pull the scope right up to your eye. Grenades are especially disappointing. They take ages to explode, and are underwhelming when that explosion actually happens. Part of the problem is that enemies have no death animations, folding like puppets with their strings cut when they're killed.

While the core shooting is adequate, the game struggles during more elaborate set-pieces. The second mission starts with you manning the guns of a bomber, but you can't actually grip the controls for these weapons properly, making aiming extremely tricky.

The third mission, meanwhile, returns to Omaha beach, the mission that made Allied Assault's name and arguably kickstarted the second generation of the FPS genre. You'd think this would be an unparalleled experience in VR, but sadly it isn't a patch on the 2002 version. The deafening roar of D-Day experienced in Allied Assault is oddly muted here, while the atmosphere is interrupted by out-of-place orchestral swells and yet more fade-to-black cutscenes that kill the tension.

Unlike Half-Life: Alyx, which polishes three or four key mechanics to a brilliant sheen, Above and Beyond simply takes on too much, resulting in a decidedly uneven experience. In some areas the game looks incredible, while in others it appears a decade old.

There are further issues too. The file size is monstrous, taking up 170GB in total. In fact, the game is extremely demanding across the board, struggling to perform at a decent frame rate on even a GeForce RTX 2080 Super. The multiplayer offers a surprisingly engaging VR deathmatch, but good luck finding someone else who is playing it.

Ultimately, Medal of Honor: Above and Beyond is simply more trouble than it's worth. If you want to play an immersive and engaging WWII shooter, you'd be better off with the original Allied Assault, or even Call of Duty: WWII if your eyes can't handle looking at 2002-era visuals. It's a real shame, as it has all the right components for a successful operation, but when it comes to execution, Above and Beyond is AWOL. GPC

ABOVE & BEYOND

- \+ Proper VR FPS campaign
- \+ Many spectacular moments
- \+ Fun weapon handling and base shooting

BELOW & BEHIND

- – Terrible pacing
- – Tonally off
- – Disappointing enemy behaviour
- – Technically demanding

VERDICT

Despite some standout moments, Above and Beyond suffers from overambition and a lack of attention to detail.

OVERALL SCORE

57%

WATER-COOL YOUR PC ON A BUDGET

ANTONY LEATHER SHOWS YOU HOW TO BUILD A CUSTOM LIQUID-COOLING SYSTEM FOR THE SAME PRICE AS A HIGH-END ALL-IN-ONE LIQUID COOLER

Water-cooling your PC is a great way to make it look better, run quieter and cool your hardware more effectively. It's easier than ever to water-cool your PC too, as the standardisation of components has made connecting them together a simple process with little need to stress over fittings and tube sizes. There are hundreds of components available, covering every CPU socket and nearly every graphics card, and the latest reservoirs and pumps now include mounting kits that enable you to secure them to radiators, fan mounts or your case itself, so nearly any PC case can house a custom water-cooling system.

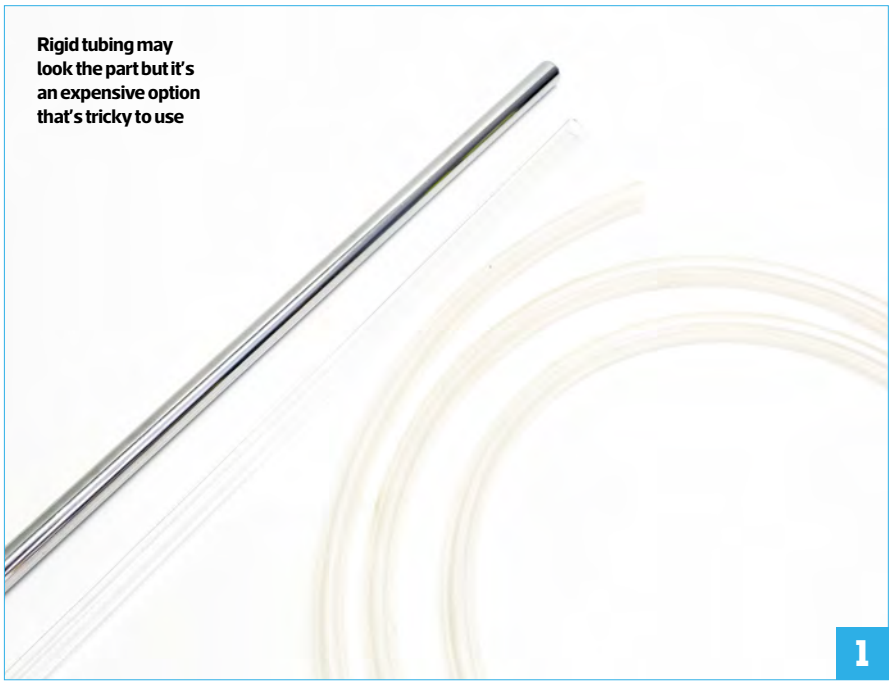
However, it's easy to lose sight of some of the benefits of water-cooling that don't stem from the aesthetic. Improved cooling and lower noise are real boons when it comes to owning a high-end PC, as they mean you can overclock your PC without fear of things overheating under extended heavy loads. A noisy PC is never pleasant either, so being able to silence your graphics card and CPU means that even monster PCs can be whisper-quiet.

That's not what manufacturers always concentrate on, but it's what got most of us here at **Custom PC** into water cooling in the first place. It benefits big and small PCs alike and allows us to overclock and tinker to our heart's content. Of course, water-cooled PCs usually look good too, but this is an area that has massively outgrown the noise and thermal factors, and adds a huge amount to the cost of a water-cooling system.

Custom-designed reservoirs and pumps, flashy nickel-plated waterblocks and rigid tubing look great, but they come with a high price tag due to their complex, expensive manufacturing. Some CPU waterblocks alone cost upwards of £150, outstripping the cost of some entire high-end AIO liquid coolers. Similarly, those fancy combined pump and reservoir units may look nice and show off your coolant, but they can also set you back £150 or more.

Meanwhile, flavour-of-the-moment rigid tubing offers no benefit in cooling or noise reduction either, but it can be hugely expensive, costing many pounds per metre, while premium fittings can cost more than five pounds a piece, demanding as much as many low-end liquid coolers for a full set.

All this means that if you opt for the most luscious, premium components, you won't be getting much change from £400, even if you just water-cool your CPU. That's a huge amount of money just for a bit of eye candy and while we can't deny that your PC will look great and these components will likely outlast most other components in your PC, it's



Rigid tubing may look the part but it's an expensive option that's tricky to use

1

2

Fancy fittings can quickly drive up the overall cost of a water-cooled rig

Price comparison

Alphacool brass tubing *£11 for 40cm*

Alphacool acrylic tubing *£21 for 3m*

Cheaper option: Alphacool flexible tubing *£11 for 3m*

Cost saving for an entire loop *Up to £40*

CUSTOM RESERVOIRS AND PUMPS, FLASHY NICKEL-PLATED WATERBLOCKS AND RIGID TUBING LOOK GREAT, BUT THEY HAVE HIGH PRICE TAGS

a hurdle that will put off many people. At the very least, those with smaller budgets should definitely make their money count elsewhere first such as getting a better graphics card, CPU or bigger SSD.

However, it might surprise you to know that not all water-cooling hardware costs so much and we haven't always had to fork out many hundreds of pounds to water-cool our PCs. In fact, there's still plenty of hardware out there that will allow you to do just that and for less than the price of some high-end AIO liquid coolers too.

As well as simply opting for less flashy (figuratively and literally) hardware, there are other ways to cut costs as well, such as ditching coloured pre-mixed coolant and opting for less expensive manufacturers. If you're not as fussed about the latest bling-laden hardware and your priorities are great cooling and low noise as well as a bragworthy water-cooled PC then this guide is for you.

1 RIGID VS FLEXIBLE TUBING

Without doubt, ditching rigid tubing is one of the quickest and easiest ways to save money on your water-cooling loop. Yes, it looks great, but it can be hideously expensive. Even clear acrylic tubing can set you back many pounds a metre. Plated metal tubing can be even worse, retailing for as much as £10 a foot, meaning you can be looking at a bill of a hundred pounds just for the tubing.

All this and rigid tubing is a major pain to deal with, sucking up cost in terms of the time it takes to build. It's tricky enough with straight runs and can take a huge amount of time when you need to make complicated bends. Such tinkering can be half the fun, of course, but time is also money, and rigid tubing isn't an efficient option in this regard.

This is where flexible tubing comes in. It costs less than £10 for metres of the stuff – certainly enough to build even a high-end PC with multiple waterblocks or radiators.

You don't need any of the extra tools to deal with it either. Best of all is that it's so easy to use. You can attach one end to one component, offer it up to the next, cut it to length and you're done.

Instead of spending an entire weekend heating and bending tubing, you can do the same task in less than an hour with flexible tubing. It comes in different colours as well as clear, so you can still show off your coolant and there's even black rubber tubing too.

Alphacool's flexible tubing is cheap, easy to use and still shows off your coolant. Unlike rigid tubing, you may even be able to reuse it if you upgrade your PC and, done well, it can still look good in a water-cooled PC and we saved £40 compared with brass or some acrylic rigid tube kits.

2 CHEAPER FITTINGS

Fittings are another area that can be prohibitively expensive. The likes of Bitspower and Corsair certainly offer some amazing-looking chrome-plated fittings, but just a single angled joint can cost over £20, while packs of four or six straight fittings won't leave you with much change from £60. Again, there's no denying that they're very attractive. You can customise colours, they come in attractive packaging and generally get you excited when you handle them. The same is true whether you opt for fittings catering for hardline tubing or flexible tubing.

There are premium and more affordable options for each, with some needing £50 or more to complete a full water-cooling loop. Spending more than five pounds a fitting isn't the way to go, though, if you're looking to water-cool your PC without spending a fortune. Thankfully, plenty of manufacturers such as Alphacool and Barrow have fittings that are cheap enough to kit out a well-planned loop with the minimum of components for less than £25.

Opting for a utilitarian-looking pump/reservoir combo over a flashier unit can save you a lot

3

Price comparison

***Corsair Hydro XF hardline fittings** £25 for four, £50 for eight*

***EK Quantum Torque flexible tube compression fittings** £40 for six*

***Cheaper option: Barrow 6 x 13/10mm flexible tube compression fittings** £21 for six*

***Cost saving for an entire loop** £29 compared with hardline fittings, £19 compared with premium flexible tube fittings*

If you hunt around you can find cheap fittings. Barrow and Alphacool are particularly strong here, with compression fittings for flexible tubing available around £20 for a pack of six. If you decide to go with rigid tubing, they also offer reasonably priced rigid tube fittings as well. In any event, you'll be saving around £30 compared with premium hardline rigid tube fittings and around £20 over premium flexible compression tube fittings.

3 USE A COMBINED PUMP AND RESERVOIR

It used to be the case that a reservoir would be a separate item to the pump. This was in the early days of pumps such as the Laing DDC and D5, when combining a pump and reservoir was beyond the capabilities of water-cooling companies. Eventually, it was discovered that the pump tops could be tweaked to offer better flow rates, so opening up the pumps and creating acrylic tops became common and it wasn't long till someone made a bigger top to include a reservoir. That has spiralled into large tube reservoirs with integrated pumps and these days all manner of reservoir shapes offer integrated pumps.

This can save money too. You need less tubing and fewer fittings, as there's just a single inlet and outlet for both components, and fewer parts are needed to mount them to your case. However, there is a downside, which is that the extra R&D and materials, as well as the intricate and unique nature of the part that joins the pump and reservoir, mean that they can be much more expensive than the separate components. Most include RGB lighting too that further pushes up the cost.

Thankfully, it's still possible to buy a combined pump and reservoir that both saves space and cuts costs for a fraction of the price of the most expensive units and for dealing with a single radiator plus one or two waterblocks, they're plenty powerful enough too.

Price comparison

***EK-Quantum Kinetic FLT DDC** £170*

***Cheaper options: Barrow SPB17-TM 960LPH or Alphacool Eisstation VPP** £70*

***Cost saving** £100*

We found two popular combined pump/reservoirs from Barrow and Alphacool that both offer a significant saving over more premium options. Both retail for around £100 less than a premium pump and reservoir combination, meaning for just £70, you can get both a pump and reservoir added to your loop.

The Barrow SPB17-TM 960LPH uses the company's own version of the popular DDC pump with a combined high-performance pump top and reservoir. It includes a filter as well as a speed control dial, so you can fine-tune its speed-to-noise ratio to your liking.

The Alphacool Eisstation VPP is a little on the chunky side but uses a larger reservoir to accommodate Alphacool's version of the D5 pump, which can often be tuned to lower noise levels than DDC-style pumps.

Another option would be Alphacool's Eisbaer Solo, which costs even less, although its pump is maybe not up to the task of dealing with a loop with more than two waterblocks and a single radiator.

YOU NEED LESS TUBING AND FEWER FITTINGS, AS THERE'S JUST A SINGLE INLET AND OUTLET FOR BOTH COMPONENTS

Not all pumps are created equal, but cheaper units are still adequate for the vast majority of systems

4

4 SHOP AROUND FOR YOUR PUMP

Water-cooling manufacturers will often sell their own versions of popular Laing DDC and D5 pumps. They may be reduced power versions or have slightly different housings or circuitry, but in general, they offer similar cooling performance, even if they have reduced flow rates.

Often, the only reason to opt for a more premium option is you plan to make a monster water-cooling system with several radiators and numerous waterblocks.

As they use the same housings and fittings as the Laing D5 and DDC, these aftermarket pumps fit aftermarket pump tops and reservoirs too.

Most will mention either D5 or DDC in the title, which gives the game away. The stock version of the Laing DDC retails for around £65, but switching to Barrow's alternative bags you the pump, a metal heatsink and housing, high performance pump top and combined reservoir for just £5 more.

Some pumps are just cheaper too. For instance, the likes of the EK Quantum Intertia D5 with aftermarket top retails for over £100, with the official D5 pump on its own usually not leaving you much change from £70. In comparison, Alphacool's VPP755 D5-style pump can be had for less than £65 with a pump top. Meanwhile, the Alphacool Eisstation VPP is just £70 with its combined reservoir or £45 on its own.

Price comparison

EK Quantum Intertia D5 *£130*

Cheaper option: Alphacool VPP755 *£70*

Cost saving *£60*

Alphacool's VPP755 and Barrow's SPB17-T V2 are far cheaper alternatives to D5 and DDC pumps respectively and while they're lower-power versions, they still have more than enough grunt to deal with a CPU and GPU-cooling loop with a large radiator. Opting for one of them can save you up to £60 compared with a premium pump and top combination.

5 DITCH THE RGB

While RGB lighting is great for illuminating your PC and colour-matching components to your colour scheme or light effects, it's not a free feature. Those LEDs and controllers cost money, whether it's with fans, waterblocks or reservoirs, and this is partly why some flashier products are a lot more expensive.

There are plenty of other reasons to ditch the RGB, though, such as having fewer cables to deal with and not tying yourself into a particular RGB connector ecosystem, allowing you to chop and change components without having to worry about yet another compatibility consideration.

RGB lighting also doesn't add much to coloured or pastel coolant and you can often jazz up your PC with a single cheaper LED strip than opting for expensive RGB-enabled components. A good example is EK's Quantum Velocity RGB waterblock. It's available in both RGB and non-RGB versions with the latter costing nearly £20 more.

6 USE CHEAPER WATERBLOCKS

There's no doubt that some waterblock manufacturers slap hefty premiums onto their components and the sleek mounting mechanisms, RGB lighting, nickel plating and intricate, high-performing internals all add up to waterblocks that won't leave you with much change from £100, with some costing even more, even for just a CPU waterblock.

Our chosen block this month, though, is Barrow's Micro Jet LRC 2.0 RGB and as it's name suggests, it sports RGB lighting, but also manages to cram in attractive nickel plating and a simple mounting mechanism for just £31. This shaves over £52 off the price of the likes of the EK-Quantum Velocity D-RGB, which will set you back over £80.

Price comparison

EK-Quantum Velocity D-RGB *£83*

Cheaper option: Barrow Micro Jet LRC 2.0 RGB *£31*

Cost saving *£52*

The Barrow Micro Jet LRC 2.0 RGB might not have the swagger of more premium branded waterblocks, but it does the job, looks good, has nickel plating and even RGB lighting and costs just £30.

RGB waterblocks and fans can look amazing but add hugely to the cost without adding cooling benefit

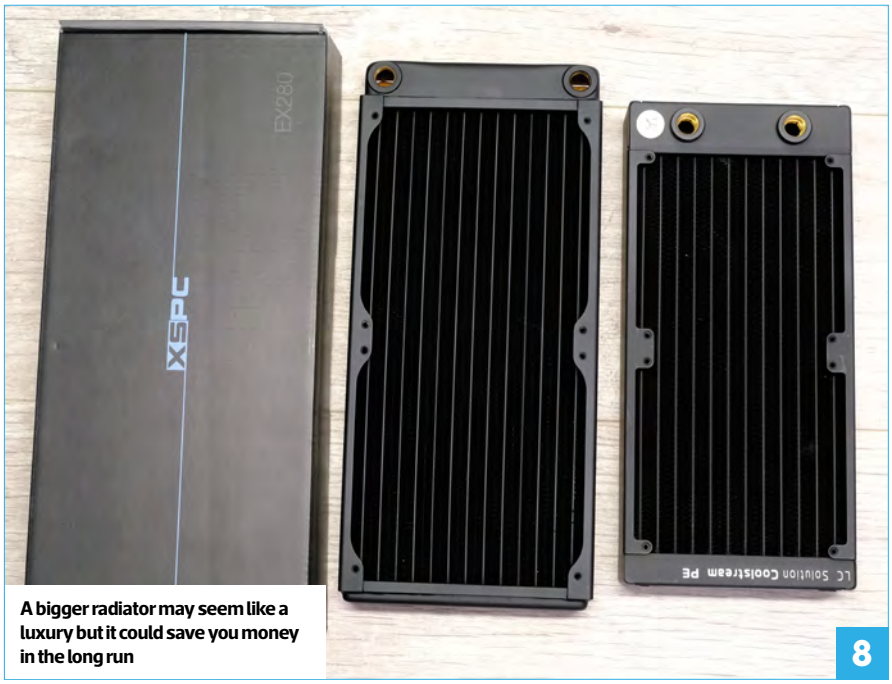
5

Cheaper waterblocks may lack a little in the looks department but still deliver where it counts

6

Good-quality fans are important for a low-noise system, but you don't need to splash the cash on RGB

7



A bigger radiator may seem like a luxury but it could save you money in the long run

8

7 USE INEXPENSIVE FANS

As well as ditching RGB lighting from your core water-cooling components, your fans should also be a target for cost-saving. RGB lighting mounts up here too and in spectacular style if you throw in some digital RGB LEDs and controllers.

For example, Corsair's high static pressure ML140 fans won't cost you much more than £10 a fan and can spin up to a monstrous 2,000rpm, which is more than flexible enough to cope with a water-cooling system. However, the RGB lighting version of the fan costs more than twice as much and if you want the full RGB control kit, you're looking at an eye-watering £71 for just two fans. That's nearly four times as much for fans that will do an identical job in terms of cooling and noise.

Needless to say, opting for cheaper fans can be a great way to save yet more cash on your water-cooling system and the more fans you buy, the more money you save compared with premium RGB models.

There's also performance to consider. You'll want fans with high static pressure for your radiator and these usually demand a premium. We've opted for Corsair's ML140 Pro fans with our build this month and they're tried and tested radiator fans. However, if you shop around, there are even cheaper models available with reasonable static pressure that could potentially save you a few more pounds on a set.

Price comparison

Corsair ML140 Pro RGB dual pack *£71*

Cheaper option: ML140 Pro *£31*

Cost saving *£52*

8 PLAN AHEAD TO SAVE MONEY

Gone are the days when you can pick up a cheap dual-fan radiator for less than £35 and you're now looking at £40-50 even for a 240mm model. This means that the radiator will likely be one of the more expensive parts of your water-cooling loop and for this reason, you have some important decisions to make.

If you'll just be water-cooling your CPU or GPU, then for mainstream desktop CPUs, a 240mm model will be all you need. However, that's not enough to deal with an overclocked CPU and graphics card, should you want to add the latter to the loop at a later date. This means that building in some extra cooling capacity to your loop with a bigger radiator will mean you won't have an expensive upgrade bill later on.

Planning ahead for future upgrades doesn't cost as much as you think. Even the cheapest 240mm radiators cost at least £40 and are quite skinny too, limiting their cooling potential.

It's called water cooling for a reason – even cheap deionised water will do the job, with a splash of anti-corrosion additive

9

CORSAIR'S HIGH STATIC PRESSURE ML140 FANS WON'T COST YOU MUCH MORE THAN £10 A FAN AND CAN SPIN UP TO A MONSTROUS 2,000RPM

For just £16 more, you can grab a 280mm radiator that can be fitted with two 140mm fans, which will not only mean your initial system will be whisper-quiet, but you'll have the benefit of having enough extra cooling capacity to plumb in your graphics card at a later date without the need to add a second radiator.

For example, The XSPC EX280 is the cheapest 280mm radiator we found and costs just £56, which is much cheaper than premium models while you'll be looking at £40 for a cheaper, thinner 240mm radiator. However, the total cost of two 240mm radiators will be £80, so you're potentially saving nearly £25 by building in some headroom at the start instead of adding a second radiator later.

The EX280 is 36mm thick, too, so it adds nearly a centimetre to the overall volume as well as offering its much larger surface area overall. Combined, it makes for a significant bump in cooling capacity. You just need to make sure your case can house it, with a dual 140mm fan mount and enough depth clearance for the thicker radiator and a single row of 140mm fans.

9 USE DEIONISED WATER WITH ADDITIVE

Coolant has come a long way in recent years and the latest pastel coolants from the likes of Mayhems look fantastic and come with all the additives you need for a near maintenance-free water-cooling system. The downside is that it can cost more than £10 a litre, with Corsair charging £15 for the same amount of its pre-mixed coolant. If you're using large reservoirs and radiators, you may find you need two bottles.

There's an easy way to save money here and that's to use deionised water. It costs a fraction that of fancier coolant, with a 5l container going for under £5 from the likes of Euro Car Parts and Halfords, where it's called battery top up water.

You'll be needing an anti-corrosion and anti-biological growth additive too, but this can be found in concentrated form for around £5 and is enough to treat nearly 10l. From here, you can either be happy in the knowledge you have more than enough coolant to last for several refills for less than a tenner, or you can add a coloured dye to it for a little more flair.

Price comparison

Corsair Hydro X coolant *£15 for 1l*

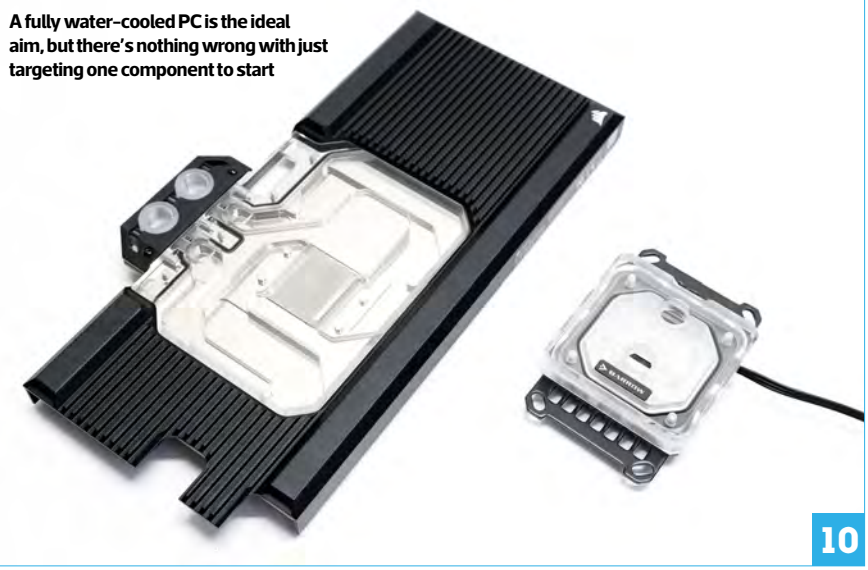
Cheaper option: 5l of deionised water with EK Cryofuel clear additive *£9 for 5l*

Cost saving *£13 per litre*

10 JUST WATER-COOL YOUR CPU OR GPU

Water cooling certainly has its benefits, but you should never do it just for the sake of it if your wallet has limits. For this reason, you should carefully consider which components you want to water-cool. You may already have a beefy CPU cooler that's plenty cool and quiet

A fully water-cooled PC is the ideal aim, but there's nothing wrong with just targeting one component to start



10

Some all-in-one liquid coolers are expandable, providing perhaps the easiest option for custom water-cooling a system

11

enough to handle your overclocked pride and joy, but your graphics card is the one making your ears bleed when you're gaming. This can be especially true if your graphics card has a blower-style fan, but thankfully, that may also mean it has a reference design PCB that has plenty of options when it comes to water-cooling it.

Never be afraid to just water-cool your graphics card and don't feel the need to spend more on blocks, tubing and fittings to unnecessarily water-cool your CPU. You can always add it to the loop at a later date and not doing so could save upwards of £50 off your total bill. Equally, if you find those rendering sessions mean your PC is painful to sit next to as your CPU cooler morphs into a mini jet engine to deal with the heat, you'll likely want to pick your CPU as the first candidate for some liquid cooling.

11 EXPAND AN AIO COOLER

If you already have an all-in-one liquid cooler, then you may already have a way to cut the cost of a liquid-cooling system. Older models have barbs inside the tubing, meaning you can use appropriate-sized tubing to create a custom water-cooling loop, keeping the pump section to save on purchasing a new pump and waterblock. However, there have been plenty of models designed with expansion in mind, with removable G1/4in fittings and even quick-disconnect fittings in the tubing that allow you to connect additional components.

IT'S MAYBE NOT AS ATTRACTIVE AS EVEN A BASIC CUT-PRICE WATER-COOLING SYSTEM WITH CLEAR FLEXIBLE TUBING, BUT IT DOES THE JOB

If you like the idea of an expandable AIO liquid cooler then Alphacool is the brand to go for, as it has several options. Its Eisbaer 360 sports a large 360mm radiator, three 120mm fans and a combined pump, waterblock and reservoir.

There's a quick-disconnect fitting in the middle of one of the tubes, meaning you just need to buy the other ends of those connectors, some tubing and a graphics card waterblock to plumb your GPU into the loop. It's maybe not as attractive as even a basic cut-price water-cooling system with clear flexible tubing, but it does the job and will leave you with change from £110 with the option of adding more components to your loop with a minimum of fuss.

12 ESSENTIAL COMPONENTS AND TOOLS

We still consider some tools to be essential for putting together a water-cooled PC, to avoid leaks and other mishaps. The first is a proper tube-cutting tool. Scissors often create uneven cuts in flexible tubing, meaning they can be prone to leaks, as they don't sit in the compression fitting properly. A cutting tool such as the XSPC heavy-duty hose cutter

12

There are simply some areas where you can't scrimp, and some sort of leak tester is one of them

BUDGET WATER-COOLED SYSTEM SPEC

Tubing
Alphacool flexible tubing
£11 inc VAT
watercoolinguk.co.uk

Fittings
Barrow 6 x 13/10mm flexible tube compression fittings
£21 inc VAT
watercoolinguk.co.uk

Pump
Barrow SPB17-TM 960LPH
£70 inc VAT
watercoolinguk.co.uk

CPU waterblock
Barrow Micro Jet LRC 2.0 RGB
£31 inc VAT
watercoolinguk.co.uk

Fans
2 x Corsair ML140 Pro
£30 inc VAT
overclockers.co.uk

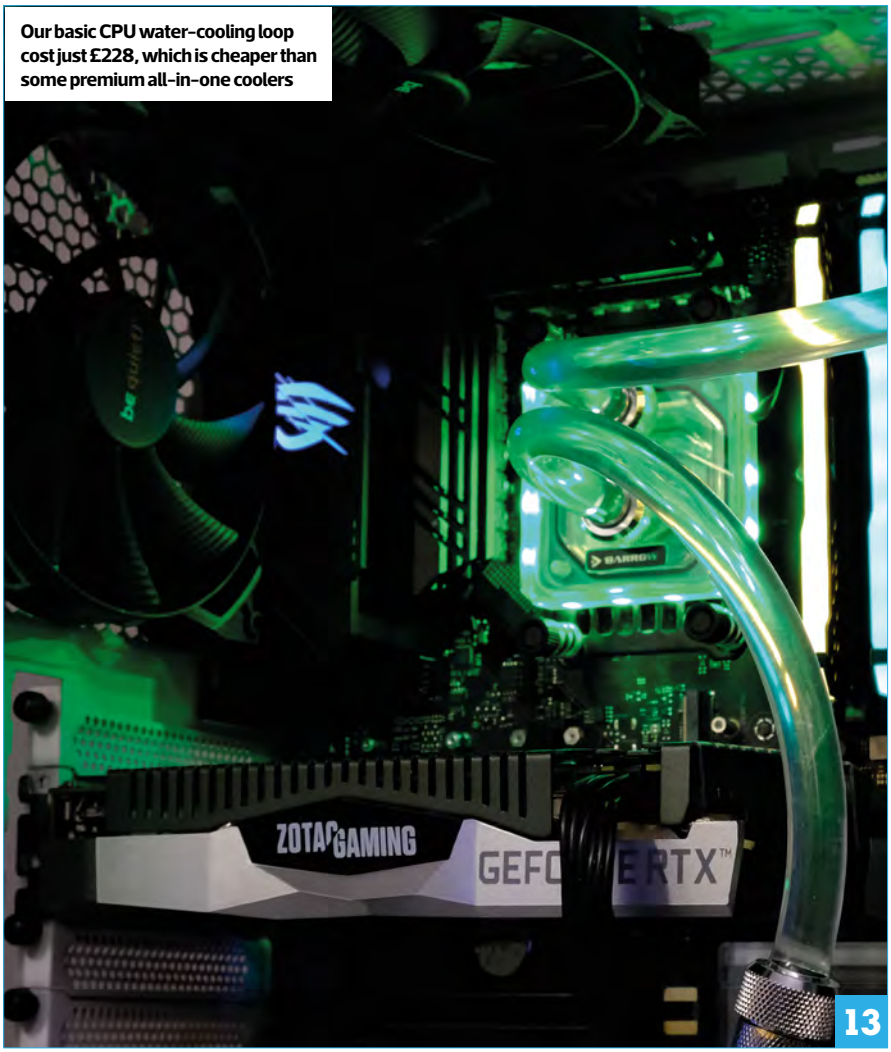
Coolant
5l deionised water +
EK Cryofuel clear additive
£4 + £6 inc VAT
Halfords + scan.co.uk

Radiator
XSPC EX280
£55 inc VAT
watercoolinguk.co.uk

Total
£228 inc VAT

costs less than £10 and will ensure dead straight cuts every time.

The second is a leak tester. Several companies have made them recently, but the cheapest on offer is the Barrow GJQM-01 system leak tester. It works in much the same way to others we've seen such as EK's model, but costs a few pounds less. Just plumb it into your system before filling with water and you can ensure all your joints are air and thus watertight, ready for coolant.



Our basic CPU water-cooling loop cost just £228, which is cheaper than some premium all-in-one coolers

13

13 OUR SYSTEM

We picked some of the components discussed above to build our own budget custom water-cooling system and compared it with the best-performing cooler from last month's AIO CPU cooler Labs test – the Deepcool Gammaxx GTE V2.

Firstly, we fine-tuned our water-cooling loop, so the pump was running at around a third of its full speed using its speed controller. Here it was quiet, but the flow rate didn't impact temperatures. It managed a CPU delta T of 54°C using an Asus ROG Strix B550-E Gaming motherboard and Ryzen 9 5900X overclocked to 4.5GHz at 1.25V.

We also switched the fans to half speed and didn't see temperatures rise, so there's plenty of wiggle room in this regard. Combined, the fans and pump made just a gentle thrum that was hardly noticeable outside the case. By comparison, even at full speed, the Deepcool Gammaxx GTE V2 could only manage a CPU delta T of 71°C and was far louder too.

Compared with the cost of a typical water-cooling kit with premium components, our budget build saves over £250, while even putting together a custom kit yourself made from premium components is likely to cost you over £200 more.

And yet this cheaper option still makes for a potent water-cooling loop that's a match for any AIO liquid cooler and can easily be expanded. It also still makes for a smart, if not entirely awe-inducing PC interior with plenty of room left over to add RGB lighting and other flashier components elsewhere. CPC

VULKAN

DEEP DIVE

THE OPEN SOURCE AND CROSS PLATFORM GRAPHICS API, VULKAN, HAS JUST RECEIVED RAY-TRACING SUPPORT. MARK SIMPSON GUIDES US THROUGH THE IMPLICATIONS FOR GAME DEVELOPMENT AND WHAT WE CAN EXPECT IN TERMS OF GAMING PERFORMANCE

OpenGL enjoyed a 22-year run in the graphics application programming interface (API) space as the sole viable alternative to DirectX on PCs, and the only viable option on non-Microsoft platforms. Then came Metal in 2014, and Vulkan just two years later, both of which completely shattered the mould when it comes to driving modern GPUs on modern systems. A few years on and, while the Apple-exclusive Metal remains as such, Vulkan is now absolutely everywhere as the lingua franca for GPU programming, available on all sorts of devices, from your phone to the most powerful gaming PCs. Let's dive into its initial development, how it works, and what the future holds for the Khronos GPU programming powerhouse.

The birth

The evolution of real-time 3D graphics acceleration has been driven in large part by the evolution of the APIs used to drive the GPUs we all use. The hardware is nothing without the software, and 2014 saw the start of a tectonic shift in how programmers were asked to drive the GPU. Cast to one side were the programmer-friendly, higher-level APIs that provided an easier path for programmers to draw something on the screen but that made it harder to get the most performance from hardware. In their place came a new era of more explicit APIs that provide a much more granular, so-called 'closer to the metal' view to enable programmers to squeeze out every ounce of performance.

Metal, Vulkan and DirectX 12 are the three competing mass-market public APIs that allow you to drive the GPU in this new explicit way. Metal is Apple's API that's primarily designed for use with its own operating systems and devices. Vulkan is the standard bearer outside the more closed Apple, Windows and Xbox ecosystems and it's everywhere, from the PC to the Nintendo Switch, Raspberry Pi and the myriad mobile and embedded platforms largely powered by Android. If you want to draw something on the screen and you're not on a PC or an Apple device, Vulkan is what you need to use.

However, it wasn't always clear that would be the case. When Apple announced Metal in 2014, Khronos, the stewarding organisation made up of representatives from the hardware and software solar system that orbits modern GPUs, stopped the bus on OpenGL and examined whether it was fit for continued purpose. Microsoft did the same with DirectX, and both camps took a long hard look at what Apple had done with its API, offering programmers much more direct control over what happens on the GPU, and set about finding a way to offer the same.

Programmers were forthright in their support for this new way to drive the GPU after Metal was announced, asking both Khronos and Microsoft to look at a similar kind of programming model. Yes, they said, it might mean more work for them, but the payoff is more than worth it – better 3D performance for the end user and more control for programmers.

But what should any new API look like? Apple had split from Khronos before creating Metal, so Metal itself wasn't an option for

Yes, this really is the official Vulkan logo, made up of stylised versions of classic 3D programming test models such as the Utah teapot

a standards-based alternative to DirectX. It did give Khronos a target, though, so the technical group inside of Khronos got started. Google proposed that Khronos took its in-development graphics API, whose name is still a secret, but it was focused on too narrow a domain of devices and wasn't quite close-to-the-metal enough.

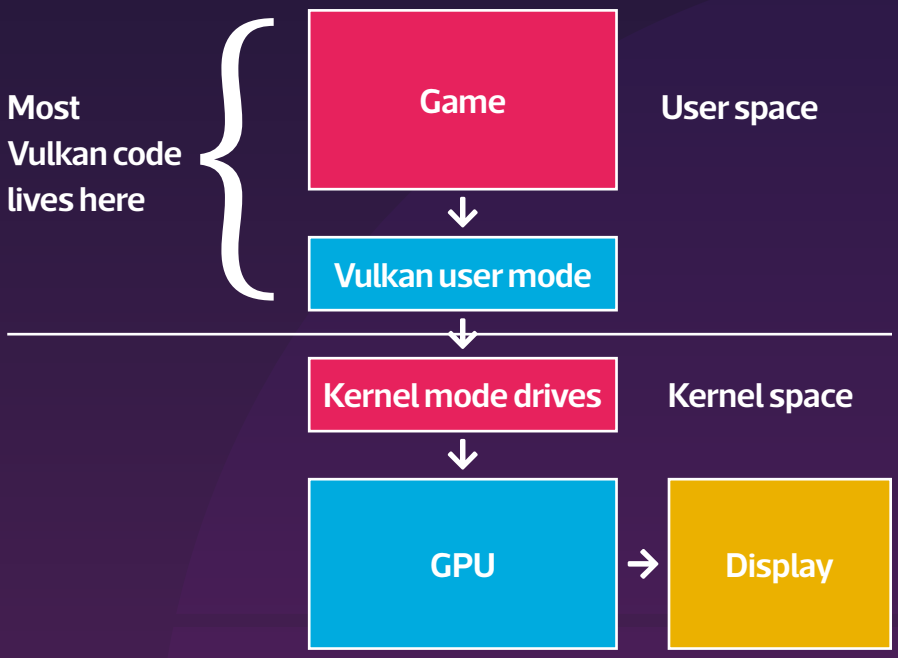
Then AMD stepped in and donated Mantle, its own proprietary low-level graphics API for its Graphics Core Next (GCN) GPU microarchitecture, and the deadlock was broken.

The benefits of Mantle were clear: it was a production-ready API, having shipped in multiple PC games at the time of its donation, and it was designed for a modern GPU microarchitecture in GCN. Not every GPU looked like GCN, but GCN worked in a way that was general enough that Mantle was a fine starting point for an idea that could be adapted to suit other GPUs, including those from arch-rivals Nvidia and Intel. It even looked good to the mobile GPU companies, despite their use of quite different – predominantly tile-based – GPU architectures.

So, with an agreed base on which to start, and AMD waiving all copyright and patent claims, the team got to work on moulding Mantle into the successor to OpenGL that the graphics industry thought it needed.

The aim? To provide high-performance graphics on a wide variety of platforms and not be bound to OpenGL's slow-moving and difficult-to-adapt legacy.

Driver stack



The basic modern GPU driver stack sees APIs such as Vulkan sit between the game code and the GPU driver

THIS EXTENSION CAPABILITY IS AN ASPECT THAT SETS VULKAN APART FROM METAL AND DIRECTX 12 AND GIVES IT A POWERFUL ADVANTAGE

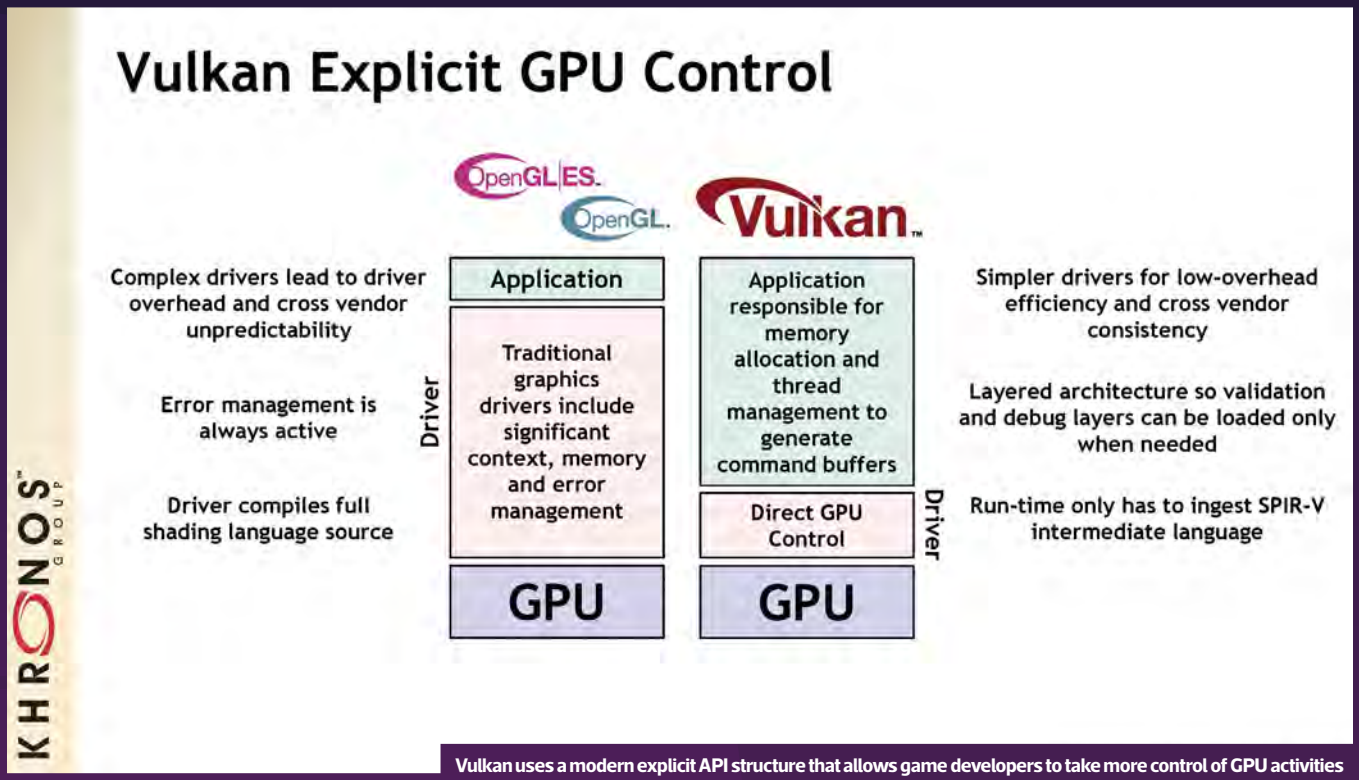
The evolution

Vulkan has been moulded and shaped in myriad ways in the time since Mantle formed its starting point, with GPU hardware vendors joining forces with programmers to steer its course. That collaborative process is difficult to understate in this brave new world of lower-level graphics APIs. In contrast, traditional graphics APIs have been designed by either the platform vendor in concert with GPU vendors, in the case of DirectX, or by an outside committee in the case of OpenGL. However, Khronos realised that a broader collaboration would be necessary in the age of Vulkan.

Why? Because Vulkan is a completely different abstraction over the inner workings of the GPU compared with OpenGL or DirectX 11, exposing much more of the inner workings of the machine to the programmer. That means the design of the API must take real-world application performance into account. Apple designed Metal's API behind closed doors, but Apple had real-use cases in mind when it designed Metal, and a very strong and experienced team to help shape it. Khronos doing the same for Vulkan is responsible in no small part for its success to date.

The upshot is that Vulkan sits at around the right position on the spectrum from completely explicit control of the GPU through to total abstraction and easy programmer productivity. There's a point on that spectrum before which most working 3D graphics programmers won't be able to pick it up and wield it properly, while beyond that it will have too heavy an impact on performance.

Lately, the work put into the API has been around modernising it to keep pace with DirectX 12, which has recently led the way in terms of pushing the boundaries of what an API will let the programmer do on the GPU, and what hardware features are exposed. The big tentpole feature is ray tracing, and recently Vulkan gained its own



Vulkan uses a modern explicit API structure that allows game developers to take more control of GPU activities

take on hardware ray tracing in a new set of extensions.

This extension capability is an aspect that sets Vulkan apart from Metal and DirectX 12 and gives it a powerful advantage. Whereas those APIs are monolithic, Vulkan has the concept of a core API that all implementations (such as graphics cards) must support in order to be considered compliant. Then, on top of the core API are extensions, which an implementation can expose via its Vulkan driver, to tell the calling application what extra features are present.

An extension doesn't have to increase the surface area of the API (the amount of possible code with which a programmer has to interact) and give the programmer more work, but many of them do require more complexity and ray tracing is one of them. Practically speaking, ray tracing in Vulkan is shipped as a number of extensions, each adding a distinct feature to the core API to enable ray tracing.

Why implement it that way rather than one monolithic extension specification? There's a number of ways to implement hardware-accelerated ray tracing, and splitting the specification into multiple extensions lets different hardware vendors expose it in the right way for their implementation. That means there's a little extra work for the programmer who wants to use it, but that power of extensibility is core to Vulkan's ethos and in practice, one of its most powerful attributes.

The key outcome of this extension-driven evolution is ubiquity. Because the core API is so small, even tiny GPUs can implement the specification in full. Then, as you walk up the device capability curve and hardware has more inherent features and performance, Vulkan allows the implementation to expose those areas.

In DirectX 12, in particular, it's much more all or nothing in terms of what an implementation has to provide, so DirectX 12 is necessarily more demanding of the underlying hardware.

This choice limits the applicability of DirectX 12 to cheaper or lower-power devices, for instance, whereas Vulkan can be supported across all manner of devices, great and small. Support ranges from tiny microcontrollers with GPUs measuring under 1mm^2 in silicon, all the way to the giant gaming GPUs you're used to reading about in these pages. In between, you'll find it driving the GPUs in a huge range of devices, from cars and mobile phones, to Google Stadia and the Nintendo Switch.

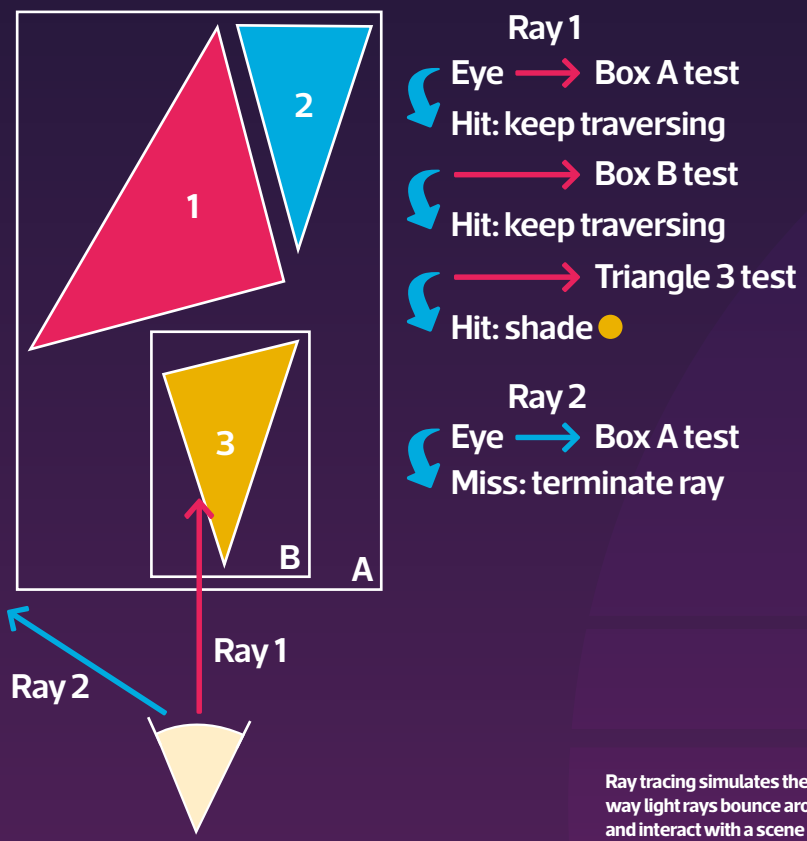
Quick refresher on graphics APIs

If you've got this far without really understanding the definition of a graphics API, here's the whirlwind tour. In contrast to CPUs, which implement a particular instruction set that software compilers know how to target, GPUs are driven at a higher level by a standard application programming interface or API. That means each GPU is free to implement its own instruction set and supporting microarchitecture, all hidden by that upper API layer. This approach has allowed GPUs to evolve much more freely than CPUs over the past 25 years, with different instruction sets and microarchitectures used to provide the same core set of GPU functions to software.

Between the API and the hardware sits the GPU's driver and shader compiler. The former tells the GPU how to set itself up in order to execute the API, while the compiler determines exactly what shader programs to run to draw on the screen, turning a high-level shader program into the GPU's internal instruction set that the programmer never gets to see.

So, when a game makes a Vulkan API call, it's calling on code in the GPU's Vulkan driver, which translates it, so it can be understood by the GPU on the fly. Comparatively, when

Ray tracing



Ray tracing simulates the way light rays bounce around and interact with a scene

WHEN YOU FIRE A BUNCH OF RAYS AT THE SCENE, YOU CAN CHECK FIRST FOR INTERSECTION WITH THE WHOLE CAR'S BOUNDING BOX

a game makes an API call to run something on the CPU, it's already in a format the CPU can understand with no translation required at runtime because it already happened when the game was compiled. Performing compilation at runtime has a performance cost, but graphics APIs trade that for the GPU vendor having the freedom to constantly innovate in the underlying hardware.

Explicit APIs

We've already mentioned that Vulkan, DirectX 12 and Metal are part of a new class of graphics API that's closer to the metal, and the common terminology to group those is 'explicit'. This means the API is explicit about what will happen on the GPU when you send it a command, with very little underlying driver contortions, deferred execution or any other hidden magic happening. Of course, it's not possible to completely eliminate some abstraction, as GPUs aren't uniform across every vendor, but the core idea is that when the programmer asks the GPU to do something via the API, it does it when and how a programmer intended.

One crucial way in which more control is provided is that the API allows programmers to manage the whole GPU schedule, managing the order in which operations are performed on the GPU, which is critical for getting the best performance out of any given hardware and software combination. In the prior API regime, such as OpenGL and DirectX 9-11, there was a lot more hidden management happening after the game had submitted its graphics API calls, making the whole GPU programming system a lot more difficult to understand, resulting in a lot more per-vendor variation.

In turn, debugging and performance optimisation was a lot more complex for the developer. It can get very complicated to write a good DirectX 11-class rendering system that's fast in a cross-vendor manner and works well on every GPU. Explicit APIs are designed to make almost all of that problem go away.

There are three key ideas in explicit APIs that give them that property. The first is that the APIs force you to pre-determine and record up-front all the commands and GPU states required to execute a draw. That means the GPU driver gets to see the end-to-end view of everything the programmer intends for that draw. Knowing all the GPU states required and the transitions between them is important for performance, since changing state on a GPU (such as switching from executing one type of instruction to another) often causes stalls in the graphics pipeline.

The second is that the programmer is in complete control of memory. All memory allocation, use, sharing, copying, moving and transitioning is handed over to the programmer. So, for example, if you don't explicitly tell the API that you're now done with the piece of memory you allocated for a texture, and it can be used for another job, the GPU driver can't step in and sort that out for you under the hood.

The third is that explicit control over the GPU schedule to which we alluded earlier. The API itself can't reorder commands, move draws around or defer them for later, which it could legally do in non-explicit APIs. If you could disassemble a modern DirectX 11 driver, you'd see a surprising amount of code devoted to working out the best order in which to run the command it had been given. All of that goes away with explicit APIs such as Vulkan.

Those three pillars that define an explicit GPU API make the driver smaller and faster, because there's less code required to perform all the old under-the-hood trickery of non-explicit APIs. The engineers inside GPU companies joke that the greatest trick explicit APIs ever pulled was convincing game developers to write the guts of a GPU driver for each game, so the GPU vendor doesn't have to do it.

Ray-tracing primer

One of the key new additions to Vulkan that has got people discussing it again is the arrival of cross-platform ray-tracing extensions.

But before we delve into the specifics of how Vulkan does ray tracing, let's remind ourselves how ray tracing works.

Ray tracing is the act of tracing a ray from a viewpoint (source point) in the scene to the destination, to figure out what the source point can see. When the ray hits an object, surface and so on, it can return information to the source about what it just hit, and optionally bounce off somewhere else and keep going further into the scene. It's essentially a description of how light bounces off objects and into our eyes or a camera, except in reverse – the light rays are traced from our view, not the light source. This model for describing the lighting of a scene can result in much higher-quality rendering than the conventional technique used in most existing games, known as rasterisation, because it much more closely approximates the physical properties of light bouncing around a scene.

The problem with ray tracing is performance: it's massively computationally intensive, which is why it has taken this long to add even a small amount of real-time ray-tracing capability to very high-end modern GPUs. Movie makers such as Pixar may have been using ray tracing to create stunning-looking 3D animation for decades, but they employ rendering systems consisting of thousands of high-end GPUs and/or CPUs and each scene may take minutes, hours or even days to render.

Vulkan ray tracing

With Nvidia having driven development of ray tracing in DirectX 12, it was no surprise that Nvidia was one of the proposers of a ray-tracing specification for Vulkan. There were competing proposals though. For instance, Imagination Technologies also had a proposal based on its OpenRL shading language and API. Nvidia's proposal was chosen, though, primarily because DirectX 12 had a similar API, and any approach that eases developer effort in porting from one graphics API to another is valuable. The result is different to what's in DirectX 12, both because of the development process and the fact that Vulkan addresses more than just desktop-class GPUs.

The universal applicability for the ray-tracing requirements of Vulkan was the driving force for it ultimately being implemented as a trio of extensions (plus two related helper instructions), rather than one all-encompassing one.

Those extensions provide a common data structure for the GPU to use while ray-tracing, called an acceleration structure, and two programming models for firing rays into the structure.

Acceleration structure support

Before building up a model of how ray-tracing hardware acceleration is provided by Vulkan, let's get ray-tracing acceleration structures baked into our thinking, since it's a common concept for both programming models.

Let's say you have a load of triangles on screen and you want to fire a ray from one of the pixels on the screen (that represents the camera) in a particular direction and find out what it hits. That action forms the core of all ray tracing. It's easy to imagine, because you have a lot of those pixels and because the GPU is a parallel machine, that you might want to fire a lot of rays at the same time. In order to help the GPU optimise how it fetches the triangles against which to test the ray, the GPU builds another representation of the triangles in the scene in order to make it easier to test rays against them. That alternative representation is called the acceleration structure.

Imagine you have a scene that includes a model of a car. The acceleration structure defines a box around the whole car — ideally the smallest possible box that covers the extents of the model — and then inside that box it has further boxes that define subsections of the car. So, one box might contain the front portion of the car, another the middle and one more for the rear. Within each of those boxes you might then have further, even smaller boxes around the wheels, the wing mirrors or each car seat. In this way you can build up a hierarchical structure of boxes that define ever smaller portions of the car. These boxes are called bounding boxes.

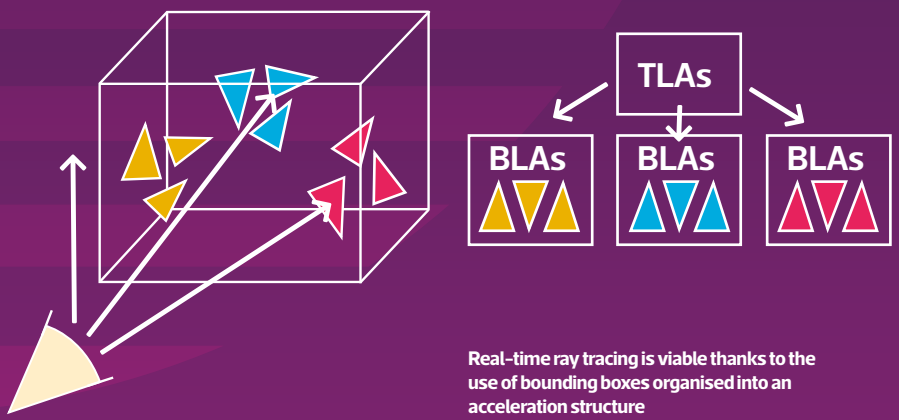
Now, when you fire a bunch of rays at the scene you can check first for intersection with the whole car's bounding box. If a ray misses, you don't need to do any further checks for any of the smaller bounding boxes (and triangles in those boxes), but if a ray hits it then moves on to being checked against the next level down of bounding boxes. In this way you can quickly drill down to only having to check a small portion of the scene's triangles for intersection with the rays.

This easy-check system is the main enabler for high-performance ray tracing and you can't implement a fast parallel system for ray tracing without it. Knowing you don't need to continue, or conversely, that the rays all hit the box together, makes it more efficient to traverse the scene's hierarchy of boxes before working on the triangles at the bottom level. That way, for many rays in parallel, you can fetch the common boxes, or bottom-level geometry, to test them all in parallel against the same data. That's the core idea behind a ray-tracing acceleration structure.

Ray-tracing acceleration structures

Top-level acceleration structures (TLAs) contain pointers to BLAs

Bottom-level acceleration structure (BLAs) contain pointers to triangles



Real-time ray tracing is viable thanks to the use of bounding boxes organised into an acceleration structure

Ray tracing pipelines

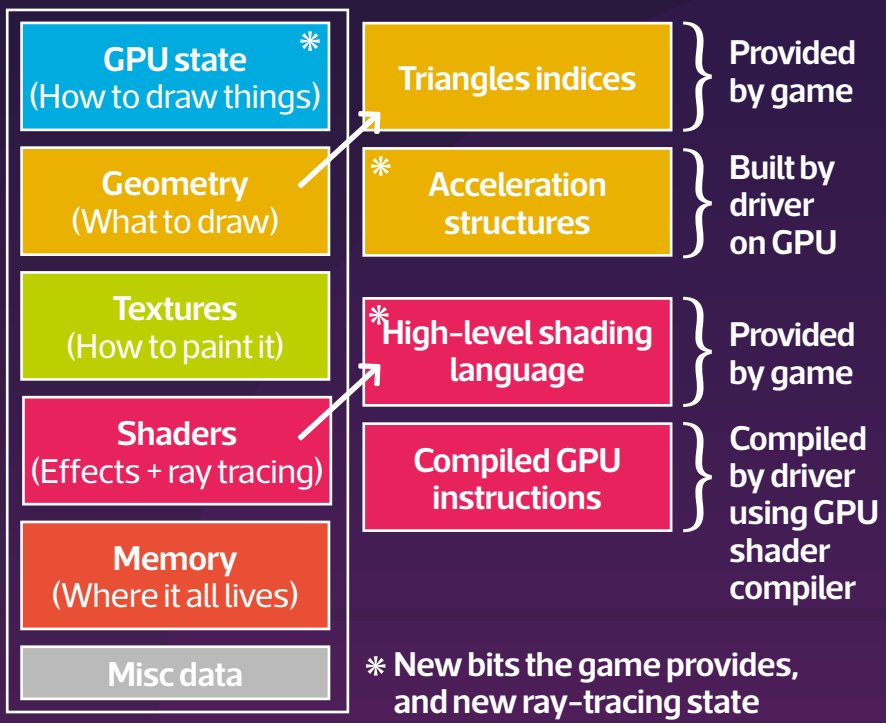
The first ray-tracing programming model proposed by Nvidia is sometimes called 'full ray pipelines', but more commonly just 'ray tracing pipelines'. First added to DirectX 12 and functionally mirrored in Vulkan via the 'VK_KHR_ray_tracing_pipeline' extension, it adds an explicit ray-tracing pipeline with which developers can interact, and a set of explicit shader types for them to write. It's quite a complicated programming model for the programmer to conceptualise and fit into the Vulkan method, because it's not like any other part of the Vulkan API in how it works and how it interacts with the GPU. The way the programmer uses ray-tracing pipelines also removes some of the more explicit control over the GPU schedule that we mentioned before, defining where events happen on the GPU timeline.

With ray-tracing pipelines — and this is common to both Vulkan and DirectX 12 — the programmer sets up a full description of how to launch a set of rays, including describing, up-front, what should happen as the rays hit the acceleration structure. All the ray-tracing work is scheduled in an explicit ray-tracing shader stage that stands apart from the existing vertex and pixel shaders.

Using full ray pipelines means writing special ray-tracing-specific shaders that control the ray tracing into the acceleration structure. So, when a ray hits or not, and depending on how it hits, a specific shader is selected from the set provided up-front by the programmer. If the ray misses, a 'miss' shader is run. If it hits, a 'hit' shader is selected to run. It complicates the scheduling model quite a bit and adds a lot of extra work for the programmer, so a much simpler model was proposed.

Ray queries

The simpler model is called ray queries in Vulkan, defined by the 'VK_KHR_ray_query' extension, but you'll also see it commonly called 'inline ray tracing'. Instead of having a separate ray-tracing shader stage and special ray-tracing shaders, ray tracing instead becomes a job the programmer can do from any of the existing shader stages, and they can add ray tracing to existing shaders. That means the programmer can more easily add ray tracing to a renderer that already exists, without the overhead of having to write code to drive yet another discrete shader stage.



Ray tracing fundamentally interrupts some of the conventional graphics pipeline flow, making it a complex feature to add

So, if the programmer wants to add ray-traced shadows, for instance, it can take an existing set of pixel shaders that already include shadow rendering and fairly easily modify them to include ray-tracing calculations. This placement of the ray-tracing function into an existing GPU schedule also makes it much easier for the programmer to profile, debug and understand.

Splitting the programming model

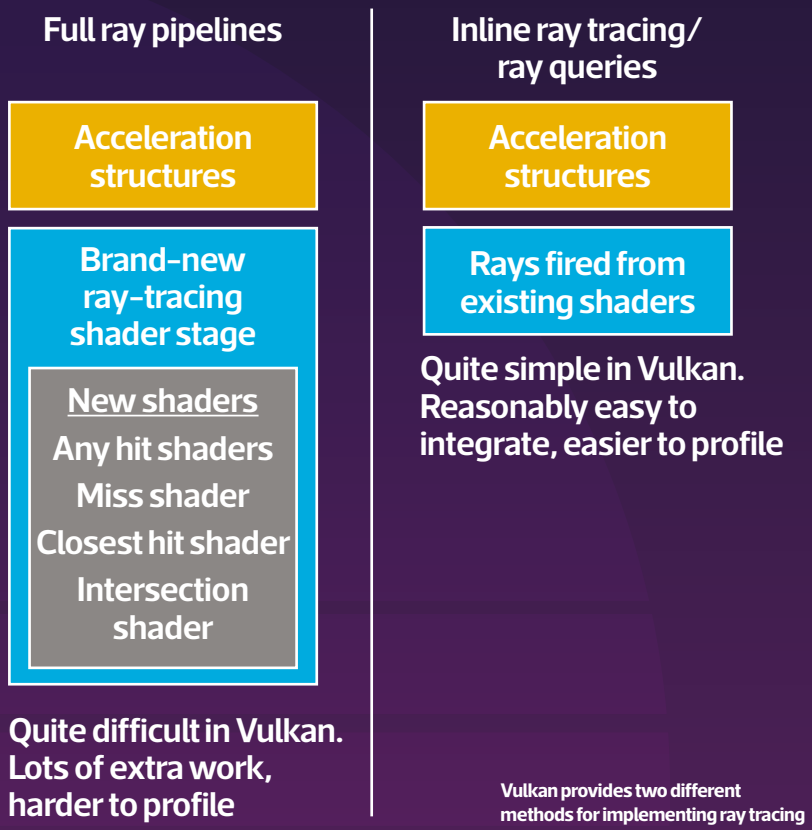
That split of the programming model, to allow the developer to use the more heavyweight ray-tracing pipeline model or the lighter, simpler ray query model, gives the developer flexibility to choose what's right for them. It also confers the same ability to the hardware vendors that need to implement acceleration in their GPUs and then expose that via the model or models that work for them in their Vulkan driver. Mobile vendors shipping an implementation using Linux or Android are likely to only bring along the ray query model, whereas vendors of bigger, desktop-class GPUs are likely to bring along both.

What does this mean for the uptake of either programming model by developers using Vulkan, or indeed DirectX 12 with its similar split model approach? We think it's much more likely that developers are going to pick the lower-overhead and lower-friction inline ray-tracing model, at least to start, with simple-to-develop effects such as ray-traced shadows and reflections. When a level of comfort with the API is established, and supporting GPU market share and performance is adequate, developers might favour the more complex ray pipeline model, but that's still unlikely. Explicit APIs are hard enough to use already, so simplicity tends to win where new API features are concerned. Don't expect anywhere near a majority of new games to use ray tracing on the desktop for years yet, since it's still early days, even with the simpler model available.

What's accelerated by hardware?

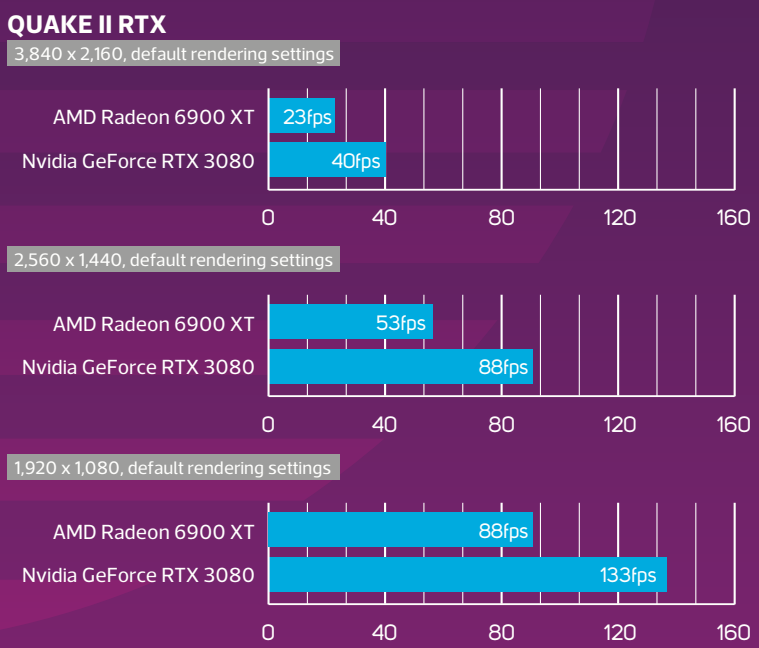
The Vulkan ray-tracing specification stipulates very little regarding what must be implemented in hardware, because there are many hardware solutions to the same

Ray-tracing programming models



Vulkan provides two different methods for implementing ray tracing

NVIDIA JUST HAS A LOT MORE RAY-TRACING PERFORMANCE AVAILABLE IN ITS PRODUCTS, WITH AMD STILL FOCUSING MORE ON RASTERISATION



problem. As such, there's a wide spectrum of solutions, depending on the requirements for the processor to which they're attached.

For instance, Nvidia has been clear that it accelerates the testing of a ray against a box or a triangle to see if and where they hit, and that it also has hardware to help manage the traversal of the acceleration structure. In contrast, AMD only has the ray-testing part in silicon, with the acceleration structure management and traversal running as a 'software' implementation via a compute shader with the driver's help.

This is just one way in which AMD's implementation lags behind that of Nvidia, although the larger part of the performance deficit we've seen in previous ray-tracing tests is simply down to Nvidia's ray-tracing acceleration hardware being able to perform more ray intersection tests per clock cycle.

Quake II RTX performance

To get a taste of what Vulkan's new support for ray tracing will mean for ray-tracing performance on existing hardware, we fired up one of the first games to add support for the new extensions: Quake II RTX. A small team at Nvidia developed the renderer, but engineers from AMD are also submitting patches to help improve the performance on their implementation in the future too.

Quake II RTX is fully ray-traced, with no rasterisation present in the renderer at all. That means it leans almost exclusively on the ray-tracing hardware, without using the rest of the GPU much at all.

We ran the game on both an Nvidia GeForce RTX 3080 (461.09 driver, 1440MHz base clock, 1710MHz boost) and a Radeon 6900 XT (20.12.2 driver, 2015MHz game clock, 2250MHz boost) at three different resolutions. The game was left on stock rendering settings and measurement was taken on a run through the first map.

At the two higher resolutions, the RTX 3080 has a roughly 1.6x performance advantage over the 6900 XT, showing off Nvidia's higher-performance ray-tracing tech. At 1080p, where there's more of a CPU limit in play, the gap drops to around 1.5x. This tallies with the large gaps seen in previous DirectX 12 ray-tracing tests, confirming that Nvidia's GPUs have an advantage in raw ray-tracing performance right now. AMD is still focusing more on rasterisation performance, for better or worse.

Spirit of Motion

Photo credit
Brad Hutchison
@hutchison15

JOSIAH FAST TAKES US BACK TO THE AGE OF AIRSTREAM WITH THIS GLORIOUS RETRO CUSTOM BUILD

This project came about because my dad started gaming in recent years. He had an older laptop he had been both gaming and working on, and it was in need of an upgrade. So, I wanted to build him a desktop computer that would let him play games at above 'low' graphic settings. The extra fun part of this build was that I wanted the specs and design to be a complete surprise for him.

Solidifying the concept and design of the Spirit of Motion was a multi-month process. I created lists of his favourite things, asked him some leading questions, and landed with a rough plan for an art deco era car's front grille with Candy Apple Red paint. He has always loved early automotive design and hotrod-era candy red paints. Combining these two was a welcome challenge. I started with numerous hand drawings in my notebook, and once satisfied with the shape, I moved to 3D modelling.

The design inspiration came most specifically from a 1938 Graham Spirit of Motion, an icon of 1930s automotive styling. For instance, despite significantly increasing the difficulty of manufacturing the case, I wanted to make the case wider at the top than the bottom to match that car's hood (bonnet) shape. This also lends the overall design a sense of motion, from the forward-leaning and rising shape.

I also thought it would be great if you could access the hardware like you would in a car as well, so the grille needed to lift like a car's hood. This led to the need to run the motherboard upside down to keep all the rear I/O as low as possible, as the hinge and mounts for the hood took a good deal of space on the rear of the case.

Start your engine (the frame)

I don't currently own a 3D printer, CNC mill, TIG welder, laser cutter, water jet cutter or metal brake, yet I needed them all to make this build a reality, and I couldn't afford to pay someone else to make all the parts for me. But where there's a will, there's a way.

I hired out the laser cutting, sheet metal work and water jet cutting to two local businesses. Along the back and bottom of the PC is a single sheet metal piece that I paid a metal works shop to laser cut, bend and powder coat in black with a light texture.

The grille is created with 25 unique pieces of aluminium, so I had to create that many unique 2D drawings for the water jet cutter. Pieces were cut from 1/4in, 3/8in and 1/2in aluminium plate. While those pieces were being made for me, I took off on building everything else.

There's a machine shop roughly 30 minutes away from where I live, so I visited the owner and struck a deal. I worked for him at his machine shop after work each day, and he would give me access to his CNC mill and TIG welder. I learned a tremendous amount from him and was able to use tools I'm unable to own myself.

The frame was one of the most critical components to this being a successful build. A large radiator would hang from the front of the frame creating a twisting force, the heavy grille would also hinge from the back of this frame creating a much greater twisting force, and all the computer hardware needed to be mounted and fit perfectly between those.

A 3D render of the original concept design for the Spirit of Motion

SYSTEM SPECS

Sponsors Nvidia and EVGA

Motherboard MSI B450M PRO-M2 Max

CPU AMD Ryzen 5 3600

RAM 16GB (2 x 8GB) G.Skill Trident Z 3600MHz

Storage 500GB Samsung 970 EVO and 1TB Samsung 860 EVO

Graphics card Nvidia GeForce RTX 2080 FE

Power supply EVGA SuperNOVA 750 G5

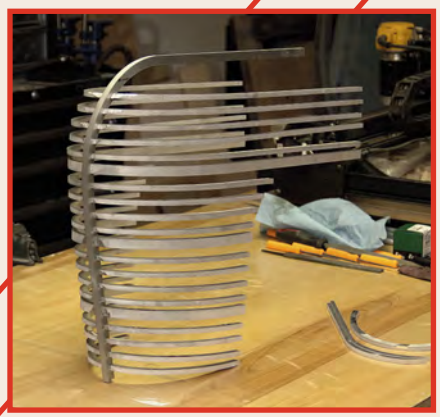
CPU Cooling Corsair Hydro H115i Pro

Reservoir EK-Quantum Kinetic TBE 160 DDC Body D-RGB - Acetal

Radiator EK-CoolStream PE 240

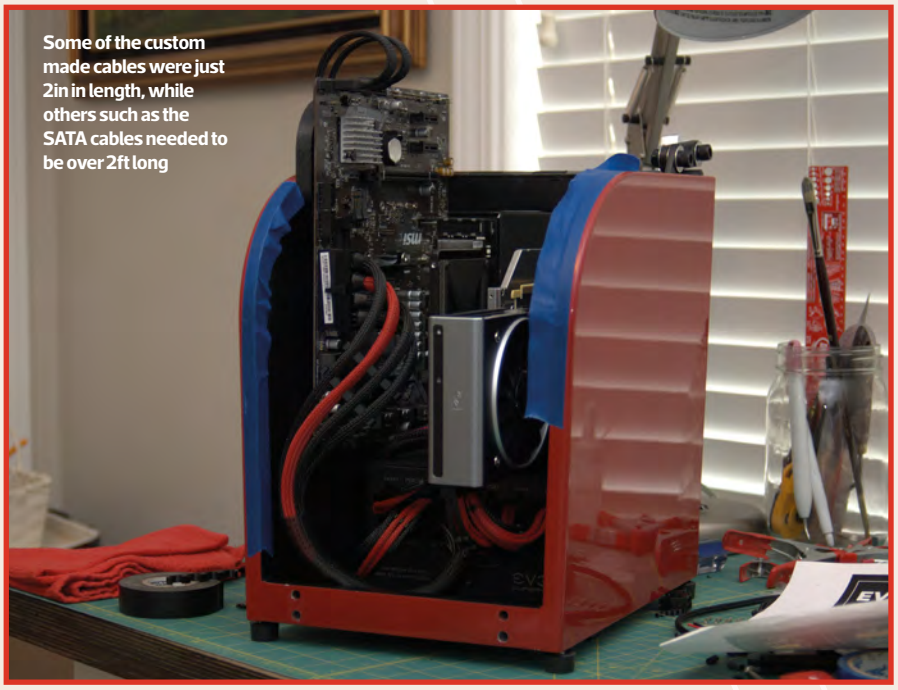
Fans Cooler Master MasterFan Pro 140 RGB

Miscellaneous LG Ultra Slim Blu-ray drive



The 25 unique water jet-cut aluminium pieces for the grille assembled for the first time

Hand filing was required for shaping the grille in delicate areas



Some of the custom made cables were just 2in in length, while others such as the SATA cables needed to be over 2ft long

BEFORE I COULD WELD, I SPENT DAYS POLISHING THE TOP AND BOTTOM SIDE OF EACH PIECE TO AN ALMOST MIRROR FINISH

So two side panels and two cross bars make up the frame that was CNC machined from 0.5in-thick 6061 aluminium plates. Because these side panels would show and be painted red, I couldn't use screws to join these pieces. The solution was fully TIG welding the frame. Using the same material, and while I had access to the CNC, I also did all the cutting, drilling and tapping I needed for several other mounts and brackets within the frame.

I picked up the water jet-cut pieces from the local business, and this is when it first began sinking in that I may have underestimated the amount of time it was going to take to create this solid aluminium grille. This was easily the most labour intensive and difficult part of the build. Naturally, it's also the feature that really sets it apart.

The assembly line

My grille design has each individual piece curving with the shape of the spine yet the water jet cuts material at a 90-degree angle. So I hand-shaped, with a saw and files, the front angle of every grille piece to fit perfectly into the grille's spine. I had to be extremely careful because there were no extra pieces, and the final finish for the grille is raw polished aluminium. There wasn't an opportunity to hide mistakes with fillers or paint.

Before I could weld, I spent days polishing the top and bottom side of each piece to an almost mirror finish. I did, however, finish the backs of each with a brushed finish, which saved me a ton of time and didn't compromise the aesthetic.

Welding was an adventure and after only a couple of small fires, I had the lower section of my grille taking shape. Before welding the upper section of the grille I needed to attach the hinge and back plate. There was no way I was going to chance a misalignment of the grille. The hinge is a beefy piano hinge that I cut down to the exact width needed. I proceeded by drilling and countersinking holes in the hinge, drilling and tapping threads into the frame and backplate, and lastly mounting the hinge assembly. With that complete, I centred the grille to the frame and welded the remaining upper grille pieces to the backplate.

This next step was the only part of the build I didn't enjoy, as it was hours upon hours of sanding, grinding, hand filing, buffing and polishing. I needed to shape the entire outside surface to match the contour of the spine. This is a complex compound curved surface

Three pieces make up the hood of the PC, with the top piece also providing an exhaust for the PC

A favourite detail is the faux radiator cap for topping off that engine coolant

The hood ornament is a 3D-printed part disguised to look like metal

The rear of the PC was kept clean and stealthy so as to not distract from the rest of the design

that's extremely difficult to maintain without introducing flat spots or mistakes. Any error in the finish would be immediately noticed due to the light reflections off the eventual polished aluminium grille.

I primarily used an angle grinder and belt sander with very heavy grit sandpapers to tackle the initial heavy removal and rough shaping. As the form approached the correct shape, I used finer and finer sandpaper grits. To finish up the outside polish, I used a die grinder with a fine-fibre disk.

The sheet metal showed up from the local shop right on cue, as I needed it for mounting the hardware and some internal brackets. The pieces looked flawless. The finish was incredible. My excitement in getting ready to install this gorgeous piece of metalwork, though, was short-lived when I noticed I'd made a massive design flaw. I had forgotten to add the hole for my power supply fan. I was able to measure and mark where I needed the hole before carefully cutting it out with a jigsaw. It was painful sawing away at the part I had just paid a bunch of money to have made, but I'm glad it was something I could easily fix.

Because the case widens as it goes up, I designed and 3D-printed a bracket that would reorientate the motherboard to be truly vertical. There's another similarly made bracket that supports the optical drive and SSD that alters the hardware to make it vertical. I utilised an ultra-slim drive from a laptop and mounted it to be accessed at the case's rear.

The top portion that sits on the grille was 3D-printed in three separate pieces. The rear section is hollow to accommodate a fan and exhaust grille at the back of the system. The three printed pieces were prepped and glued together before I applied Bondo over the entire surface and sanded it smooth.

Detailing

I could write pages on the finer details of the build, so I'll just touch on some of my favourite features and why. I wanted this to have a show car-quality cherry red paint job but the budget afforded me three cans of spray paint from the local hardware store. The goal was then instead to imitate a show-quality automotive paint job with my three cans. Challenge accepted.

I started by priming everything with two to three coats. Once dry, this was wet-sanded before the metallic cherry red paint was applied. I wanted to simulate the visual depth you get with an expensive paint job, so I followed the red paint with around five coats of gloss clear coat. This would also give me enough thickness in my clear coat so that I could cut and buff the clear to be perfectly smooth. After drying many days to give the paint a chance to fully harden, I took to wet-sanding with 1,000-grit sandpaper followed by 1,500. Rubbing compound, polishing compound and a good wax coat finished it up.

I designed and 3D-printed the hood ornament in PLA plastic, sanded, primed, sanded more and painted the ornament to look almost exactly like the aluminium spine it is mounted to. Multiple people have thought (even in person) that the ornament is actually metal.

Custom wiring and sleeving came next, and was some of the most fun I've ever had. Some of the cables were mere inches long because of the way hardware was oriented. After not liking individual sleeved wires for my 24-pin cable, I tried grouping the wires into four bundles. The aesthetics were much less busy and I love how it turned out.

The radiator as a whole was another of my favourite features. The custom multi-piece aluminium mount is angled to perfectly match the grille contour. This also made it easy to see the radiator sitting behind the grille exactly like a real car. I finished the radiator off by designing and 3D printing a scaled down radiator cap that included a vinyl cut caution sticker.

The last fun feature is the power button itself. I'm a big fan of repurposing and reducing unnecessary waste when possible. While taking out some trash at work I noticed a piece of equipment sitting in the dumpster. An old air pillow machine with a shiny aluminium button right on the front that I knew would be the perfect power button for the Spirit of Motion.

Finish line

I'm pleased with the end result of Spirit of Motion. Limitations dictated a few unexpected design changes but ultimately, I wouldn't change anything. It was a labour of love from the beginning and I feel like the finished PC satisfies my goal of creating a one of a kind build specifically for my dad. Surprising him with the computer when it was complete and his reaction to seeing it is a memory I'll cherish for a very long time. CPC

GARETH HALFACREE'S

Hobby tech

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

REVIEW
Kobol Helios64

A compact yet powerful open-spec NAS, the Helios64 is flawed but still impressive

Kobol isn't a name that's likely to spring to mind in the network attached storage (NAS) market, but the Helios64 isn't the company's first product. Four years ago, Kobol released the Helios4, an open-spec Arm-based NAS in an eye-catching laser-cut acrylic chassis via crowdfunding site Kickstarter.

The Helios4 was a modest success, but lacked power and professionalism. That's where the Helios64 comes in. The acrylic chassis has been dropped in favour of an all-metal, surprisingly compact design with a magnetic front panel and five drive bays, while the board powering it offers a 6-core 64-bit processor, 4GB of RAM and a 16GB eMMC.

A wired backplane provides hot-swap abilities for five SATA drives

There are a couple of caveats, however. The first is that while the processor does indeed have six cores, they're not all equal. The Rockchip RK3399, a downgrade from the originally planned RK3399K, boasts two 1.8GHz Arm Cortex-A72 cores alongside four lower-power Cortex-A53, which top out at 1.4GHz. The second is that while there are indeed five drive bays compatible with 3.5in SATA drives, or 2.5in drives with a suitable adaptor, the first bay is shared with an on-board M.2 SATA slot, reducing the total drive capacity to four if the M.2 slot is in use.

These considerations aside, the Helios64 delivers on its promises. The five drive bays use eye-catching plastic sleds and offer true hot-swap capabilities through a cabled backplane arrangement. A design flaw, to be addressed in future manufacturing runs, does mean the sleds fit tightly into the rails – to the point that plastic is shaved off every time you insert them.

Supplied in kit form, the Helios64 is relatively easy to assemble. The most awkward part, tight drive rails aside, is handling the wiring loom for the SATA backplane. The kit even includes a small battery, which acts as an internal uninterruptible power supply (UPS), keeping the system running for over an hour

NEWS IN BRIEF

Carrier board revives old Spectrums

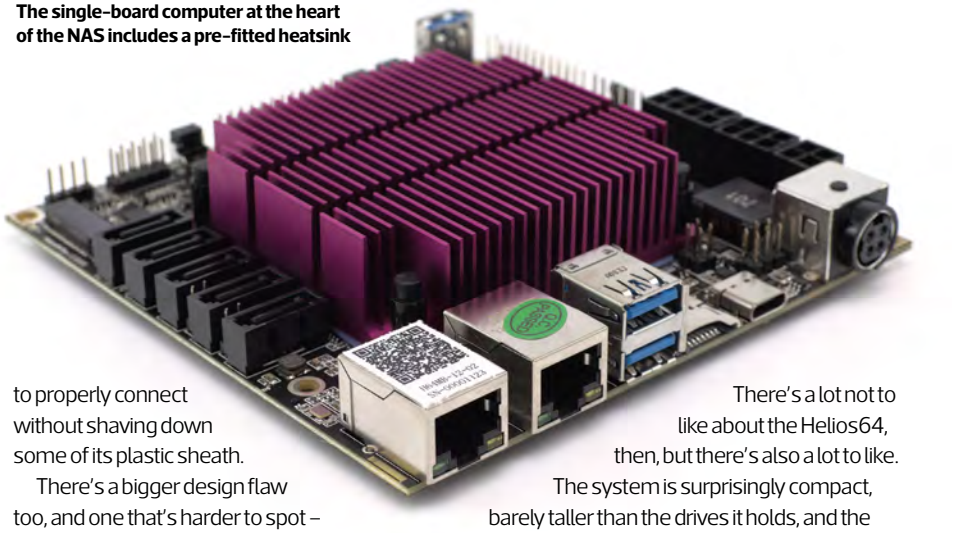
Retro computing enthusiast Alistair Carty is looking to bring long-dead Sinclair ZX Spectrums back to life with a case-compatible carrier board, which is designed to replace the motherboard with a Raspberry Pi Zero single-board computer. Designed to fit in original or reproduction ZX Spectrum cases, the board links to the original keyboard and offers an HDMI video output. Software isn't run natively, however, but on the Raspberry Pi Zero via the open-source FUSE emulator. The boards are being crowdfunded on **kickstarter.com**, priced at £20 for a bare PCB, £75 for a kit or £125 for a fully assembled board (all inc VAT.)

on loss of mains power. Software support for this feature, though, is still pending – at the time of writing, the official UPS tool was only capable of shutting down the system safely after a ten-minute period off the mains.

During assembly, though, it's hard to ignore a number of design flaws – none of them is critical, but they all niggle. The manufacturing process leaves rust on screw terminals, it's possible to short out the LEDs on the front panel, and the rear panel sits too proud of the ports to allow the bundled USB Type-C cable to properly connect without shaving down some of its plastic sheath.

A mesh front cover attaches via hidden magnets, and is removed to reveal the drive sleds

The single-board computer at the heart of the NAS includes a pre-fitted heatsink



There's a bigger design flaw too, and one that's harder to spot – the bundled board includes a Gigabit and a 2.5 Gigabit Ethernet port, but the 2.5 Gigabit port hasn't been properly wired. If it's connected to a Gigabit network, the port runs extremely slowly – the fix is to solder a bodge wire to ground, but while doing so fixes the flaw, it also immediately invalidates your warranty.

On the software side, Kobol has partnered with the community-driven Armbian project to put together two Linux builds, one based on Debian Linux and the other based on Ubuntu Linux. It's a smart move: Armbian is a growing distribution with a strong community behind it, and comes with the promise of continued updates.

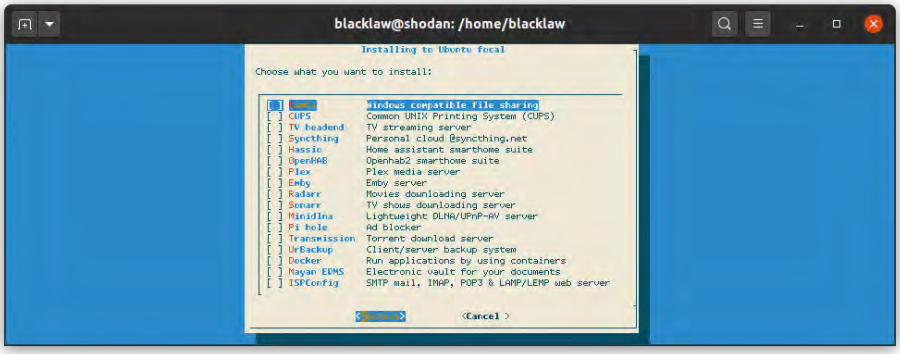
Sadly, the process is taking longer than anticipated. At the time of writing, the Helios64 Armbian port was still for testing only, with a number of bugs and missing features – the most recent of which saw the 2.5 Gigabit Ethernet port disappear from the list of available network devices altogether. Progress is being made, but it's unclear whether the software will be finished by the time the second manufacturing run kicks into gear.

There's a lot not to like about the Helios64, then, but there's also a lot to like.

The system is surprisingly compact, barely taller than the drives it holds, and the twin 80mm speed-controlled fans are near inaudible under general usage. Stability issues aside, the software is reasonably welcoming – of particular note is a configuration tool, which simplifies the installation of common server applications, such as Syncthing, MiniDLNA and OpenMediaVault.

Performance is a plus too, especially given its peak loaded power draw of 28W measured with two 6TB hard drives and a 240GB M.2 SSD installed. While it can't match even older x86 systems, such as HP's popular MicroServer N54L, on single-core performance, the six processor cores help it to edge out dual-core x86 systems in multi-threaded workloads. Also, the Armbian community is working on unlocking further performance by enabling access to the RK3399's hardware video encode and decode blocks.

At $295 US (around £218 ex VAT) from **kobol.io**, the Helios64 is a lot of machine for the money. If the first-batch flaws get fixed, the software is stabilised, you're happy with community-driven support and you don't need ECC memory, it's definitely worth a look.



The Armbian software includes a handy configuration tool for quick installation of common software

REVIEW

Keyboardio Atreus

Ultra-compact yet highly ergonomic, the Atreus design is sure to raise an eyebrow

For many people a keyboard is a device that comes bundled with a PC and requires no additional thought; for others, it's a purchase that requires some consideration and comparisons between layouts and switch types. For a smaller subset of this latter group, a keyboard is a device to customise, and for an even smaller group, a device to build from scratch.

Keyboardio was founded to bridge the gap between those last two groups. Taking existing open-source keyboard designs, the company raises money via crowdfunding to build commercial-grade implementations – offering the joy of an unusual keyboard without the hassle of building it yourself.

The Keyboardio Atreus is the company's version of the Technomancy Atreus, which was made available by designer Phil Hagelberg under the CERN Open Hardware Licence. Built as an alternative to the popular Ergodox, the Atreus has an unusual ultra-compact ergonomic layout – where a regular keyboard has anywhere from 104 to 110 keys, and a compact keyboard has 78 keys, the Atreus has just 44.

The secret is that the Atreus is a layered keyboard, meaning each key can be programmed with a particular function depending on which layer you're using.

In the default layer, the keys correspond to letters, and a subset of punctuation and control keys; in another layer, it's numbers and symbols; in yet another layer it's function and navigation.

Out of the box, the Atreus has three layers, although it can be configured with up to ten layers in total, while a handy laminated reference card can be marked up with dry-erase pens while you work to commit your customised layout to memory.

Configuration is handled by Chrysalis, an open-source package designed for keyboards running the Kaleidoscope firmware – including Keyboardio's earlier full-sized Model01. Kaleidoscope itself, meanwhile, is an Arduino sketch that runs on an ATmega32U4 microcontroller inside the keyboard, which is exposed via a single USB Type-C connector to the rear.

With just 44 keys, the Atreus is an ultra-compact design reliant on multiple function layers

A USB Type-C port is the keyboard's only external connection option

Chrysalis is, however, a work in progress: Keyboardio describes it as 'alpha quality software', although it proved stable in repeated testing. Its biggest drawback at the time of writing was an inability to customise certain features, in particular the keyboard's macro feature – those looking to program a macro need to edit the Kaleidoscope sketch directly, a process that, while not particularly onerous, isn't very user-friendly.

Like many keyboard makers, Keyboardio has opted not to offer Cherry-brand mechanical switches. Instead, the keyboard is fitted with a choice of Kailh switches: Box White, Box Brown, Box Red, Speed Silver, Speed Bronze, Speed Copper and Pro Purple. Unlike most keyboards, there are no international layout options, mainly because none of the 44 keys is localised. For those who are used to a layout other than the default QWERTY, whether it's AZERTY or QWERTZ or even Dvorak, it's easy enough to swap the caps around and configure the keyboard via Chrysalis.

The keyboard is available with a variety of hot-swap Kailh switch types

The unit on test was supplied with Box White switches fitted to hot-swap sockets. This means that swapping out one or more of the switches for a pin-compatible equivalent is as simple as removing the PBT cap and pulling firmly, with no soldering iron required.

An aluminium key plate and ABS plastic enclosure provide perfect stability, although there are no adjustable feet for those who prefer to type on an incline. Adapting to the keyboard requires more than getting used to it being completely flat against the desk too – the position of every single key is shifted compared with a traditional keyboard, even though it retains the standard QWERTY layout, and remembering which layer contains which symbol is a real challenge – the laminated reference card comes in handy here.

It's worth persevering though. As well as increasing your available desk space with its compact 243 x 100mm footprint, the Atreus is highly portable – doubly so if you splash out on the optional carry case, which has room for the keyboard in the main pocket and cables in the front. Only the lack of a wireless connection prevents the Atreus from being ideal for road warriors with a penchant for ergonomic mechanical keyboards, but adding a radio and battery would bloat the body considerably.

One key point in favour of the Atreus as a portable keyboard is how the firmware works. All customisations are saved onto the on-board microcontroller via Chrysalis, which is compatible with Linux on AMD64 and Arm, plus Windows and macOS. Once saved, the software is no longer required: connect the Atreus to any USB-compatible system and it will operate perfectly with all your customisations intact.

The Atreus is available from **keyboard.io** for $149 US (around £110 ex VAT) regardless of switch type; the carry case costs an additional $25 (around £19 ex VAT), while a wooden palm rest accessory adds $59 (around £44 ex VAT) to the total.

Every key can be remapped in the open-source Chrysalis software

An optional case is available for the road warrior

NEWS IN BRIEF

FUZE launches 89p Switch game bundle

Educational computing specialist FUZE has launched a low-cost package of games written in its eponymous programming environment for the Nintendo Switch, offering 27 titles for 89p. The games in the bundle are inspired by all sorts of titles, from Ring Fit Adventure to Robotron: 2084, Asteroids and Solitaire – plus an official port of Fast Food Dizzy. You can play each game, and also view its source code from the FUZE Player. Those who find the games enticing can program their own ones in FUZE4 Nintendo Switch, the on-device programming environment (reviewed in Issue 196). Both FUZE4 and the new FUZE Player are available now on the Nintendo eShop.

REVIEW

Retro Tea Breaks Vol. 1

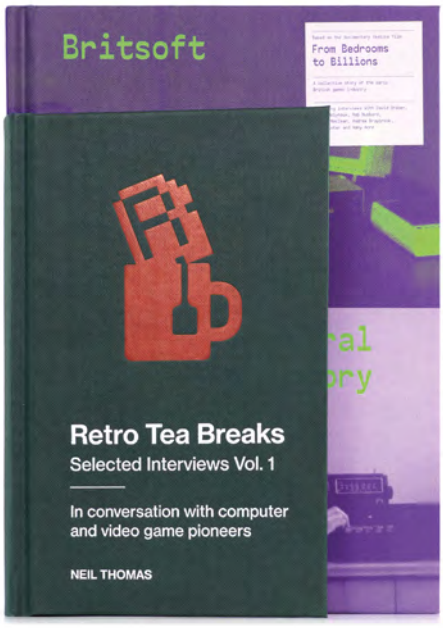
Neil Thomas' Retro Tea Breaks: Selected Interviews Vol. 1 is not a coffee table book, unless you have a particularly small coffee table.

While it's bound as a hardback, the book measures just 10.8 x 17.8cm, with Thomas claiming the compact printing is 'designed to be enjoyed on your commute as much as at home'. However, with over 400 pages, it's considerably thicker than the airport novel it otherwise mimics.

Retro Tea Breaks didn't start life as a book – its content is culled from interviews carried out for Thomas' YouTube channel RMC, formerly Retro Man Cave, in the Retro Tea Break section.

While the interviews have been lightly edited for clarity, and there's some bonus content, they're largely direct transcripts of the original interviews, retaining the same question-and-answer format.

In this respect, the book is comparable to Britsoft (reviewed in Issue 176), with the content for the former taken from interviews carried out for the documentary From Bedrooms to Billions. Where Retro Tea Breaks flows like a conversation, Britsoft took a more scattershot approach, although it offered considerably more content.



It's thick but compact, and considerably smaller than similar tomes such as Britsoft

Retro Tea Breaks also draws from a broader pool – rather than concentrating only on the pioneers of British gaming as in Britsoft, it traverses the globe with 14 interviews.

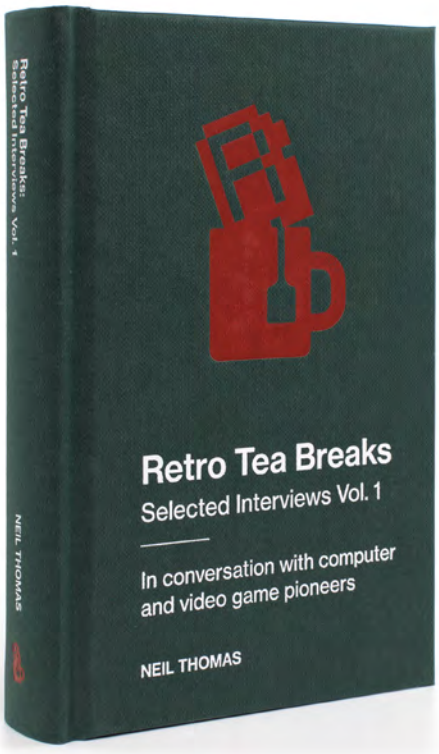
They cover a number of industry giants, including the Oliver twins Philip and Andrew, George 'The Fat Man' Sanger, Chris Sawyer, Richard Garriott, François Lionet and, surprisingly, Jon St. John, best known to gamers as the voice of Duke Nukem.

The interviews are as engaging on paper as in video form, and fans of vintage gaming will find plenty to enjoy. The only real catch is that the small format leaves little room for additions, and while the occasional footnote is welcome, the frequent box-out sections often break the flow by taking up an entire page or more by themselves.

While the book's primary focus is the interviews themselves, there's a smattering of black and white imagery too – all properly credited in an appendix at the rear. A small number of colour plates are found at the centre, along with a fold-out section that offers a timeline of game and software releases covered in the book. Rather disappointingly, though, it doesn't offer an exhaustive list of the work of each interview subject.

Each chapter opens with a custom pixel-art portrait by noted artist Stoo Cambridge, formerly of Sensible Software, who is himself interviewed in the book.

While the in-chapter representations are too small to enjoy, particularly as they lack any colour, they're reproduced in larger format on the rear of the centre fold-out section – that's a great idea for putting faces to names, and it's done in a way that also pays homage to the graphical limitations of the 16-bit era.



Collecting 14 interviews from the RMC YouTube channel, Retro Tea Breaks is a worthwhile read

As with many crowdfunded publications, though, the book would benefit from the eye of a professional editorial team. There's a number of typographical and grammatical errors throughout, and the positioning of footnotes is often bizarre – the AMOS programming language, as an example, is only given an explanatory footnote on its eighth mention.

It's easy to overlook these issues, though, given the engaging interviews. While nothing within can be taken as gospel – they're transcribed interviews made, in many cases, decades after the discussed events, and no effort has been made to fact-check or corroborate interviewees' claims – it still serves as an admittedly one-sided recounting of some fantastic tales from the early days of gaming.

Retro Tea Breaks Selected Interviews Vol. 1, ISBN 978-1-5272-6925-5, is available to purchase online now from **rmcretro.store** for £15 (VAT exempt). CPC

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at freelance.halfacree.co.uk @ghalfacree

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ANTONY LEATHER'S

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Why Thunderbolt is my new favourite tech

Thunderbolt hubs allow you to route nearly all your PC's cables through a single Thunderbolt cable, cutting clutter

If you'd asked me a year ago whether or not I'd be writing about Thunderbolt 3 in my first column of 2021, I'd have laughed at the remotest possibility. It's always seemed like Apple-centric, expensive and largely reserved for external storage – areas that don't really interest me for the most part.

Sure, it offers blistering transfer speeds, but USB 3 has been enough for me, especially as the latest portable SSDs can dish out up to 1,000MB/sec over USB 3 now anyway. However, following a few recent experiences, I'm considering it an essential feature for my future PC. This is down to a shedload of reasons, from reducing cable clutter to upgrading mini-ITX PCs and home network speeds. Here's why.

If you've read some of my columns here in **Custom PC**, you'll know that I'm a bit of a small form factor fan. I'm also still in the process of fine-tuning and modifying a home office I built a year ago, and that means dealing with cables – lots of them. The fewer cables I have to manage, the better. And yes, the one technology I haven't considered that interesting – Thunderbolt – is actually the answer here.

The current specification is Thunderbolt 3, which is soon to be replaced by Thunderbolt 4. Among other benefits, this update allows you to have several full-fat Thunderbolt ports on devices rather than just one. However, even Thunderbolt 3 amazed me recently when it solved several issues in one stroke.

Firstly, I was looking for ways to cut the number of cables trailing out the back of my PC. The rest of my new desk is super-clean, with a dash of RGB lighting and a slightly aging ultra-wide

Many motherboards come equipped with Thunderbolt 3 ports, including some mini-ITX models

monitor. However, all my tidying efforts are undone by the mass of cables emanating out the back of my small mini-ITX PC. There are at least ten of them, with one powering a hub that adds even more cables. You just can't hide them on a wide, open desk.

I've tried drilling little cable holes into the desk, but they only allow a certain number of cables through them before the look unsightly. I also have cables to power a couple of RGB lighting rigs I have in my video studio, so I guess I have more than the average person, but even six would be six too many when the PC sits on your desk and its rear end is in full view every time you walk in the room.

Thunderbolt can help here by way of a hub. A single cable can run from the Thunderbolt 3 port on your motherboard's I/O panel (or laptop), and from this sprouts a Gigabit LAN port, USB ports, an SD card reader, audio ports and video outputs. As the hub is powered, it can drive plenty of peripherals.

Hiding this hub under your desk means just a single data cable would need to come out of the back of your PC. Even if you need access to some of the ports on the hub, you can at least house it somewhere out of sight.

It's amazing, and the USB and LAN ports can run at full speed with no bottlenecks as well.

The second benefit is the ability to charge laptops. I'm forever leaving my laptop charger in my rucksack, and the need to unplug half a dozen cables each time I head out from a hotel gets tiresome very quickly. However, with a Thunderbolt 3 hub, you can connect a single cable to a compatible laptop, and it both charges it and dishes out all the above data streams – networking and USB. There's no need to fish around with charging or peripheral cables – it's one cable to rule them all. Sauron from Lord of the Rings would love it.

Finally, I've also been looking at beefing up my home networking speeds. As I use a mini-ITX PC, there's only so much storage you can fit inside it, and while I'm lucky enough to have a 2TB M.2 SSD, these drives offer poor value for mass storage when you're dealing with video editing. A NAS, then, is essential for me, especially as I can hide it away out of sight, but Gigabit speeds mean that dealing with 4K video files feels painfully slow.

There are 2.5 Gigabit LAN ports on most Z490 and B550 motherboards these days, but that's cutting-edge technology that most of us don't have yet, including me with my X570 motherboard. As my motherboard is mini-ITX, there's also no way to add a Thunderbolt card, as I have a graphics card in the only PCI-E slot.

However, Thunderbolt can come in handy here too. Using the Thunderbolt port on a motherboard (admittedly only ASRock and MSI have mini-ITX boards equipped with Thunderbolt 3), or an additional port on a Thunderbolt hub, you can connect a Thunderbolt-to-10-Gigabit adaptor, and have blazing fast networking that can move data around at 1GB/sec.

Thunderbolt is actually useful, then, whether you just want an easy way to charge your laptop or use it on the go, to cut cable clutter or add faster-then-Gigabit networking. Of course, I've not made the situation easy for myself by owning a mini-ITX PC, but if you have a spare PCI-E slot, then there are plenty of Thunderbolt 3 cards that will leave you with change from £70, meaning that upgrading your PC to Thunderbolt 3 isn't too expensive or even that difficult.

With all this in mind, I'll certainly be adding more brownie points to motherboard reviews when they include Thunderbolt 3. If you're in the market for a new motherboard or laptop, I can highly recommend factoring Thunderbolt into the equation if the above reasons matter to you. CPC

Thunderbolt 3 can support 10 Gigabit Ethernet adaptors, so you can upgrade your network without adding expansion cards to your PC

If you have a spare PCI-E slot, you can easily add Thunderbolt support with an expansion card

Antony Leather is Custom PC's modding editor @antonyleather

How to Water-cool a GeForce RTX 3080 FE

Antony Leather has received one of the first samples of EKWB's RTX 3080 FE waterblocks – here's how to install it

TOTAL PROJECT TIME / 3 HOURS

Nvidia's Founders Edition RTX 3080 cards are certainly unique-looking with their flow-through fans and distinctive coolers, but under all the luscious exterior lies a very odd-shaped PCB that has posed a challenge to water-cooling manufacturers.

What's more, Nvidia's cooler design for its own RTX 3000-series cards isn't straightforward when it comes to fitting waterblocks. This month we're taking a look at the RTX 3080 Founders Edition waterblock from EKWB and how to install it, with future guides looking at other models too. It's undoubtedly the most complicated GPU waterblock and stock cooler we've ever used, but we have some handy tips and tricks for you.

TOOLS YOU'LL NEED

GPU waterblock
overclockers.co.uk

Scalpel
Most hardware stores

Plastic pick
Most hardware stores

Work cloth or microfibre cloth
Most hardware stores

Thermal paste cleaner
overclockers.co.uk

Neodymium magnets
Most hardware stores

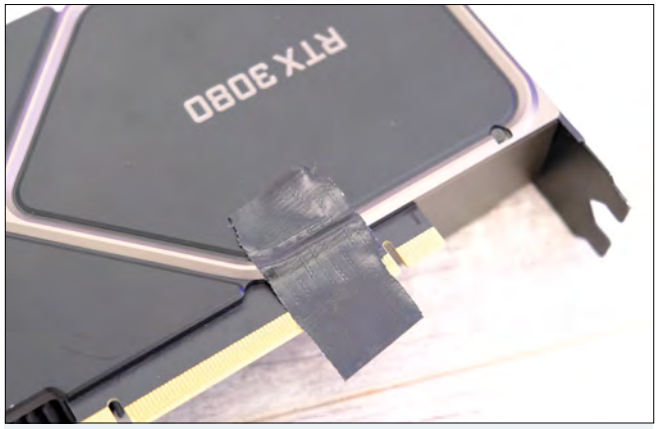
Small sealable Tupperware box
Most hardware store

Micro screwdriver set
amazon.co.uk

Duct tape
Most hardware stores

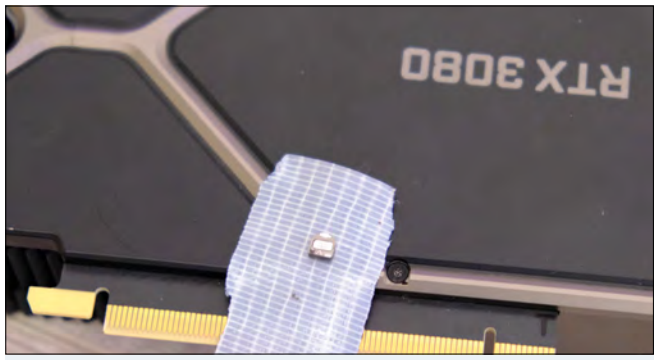
1 / CHOOSE WATERBLOCK

There's a few waterblocks available for the RTX 3080 Founders Edition, but always check compatibility first. There are waterblocks available for partner cards as well, but we've picked the Founders Edition model from EKWB.



2 / REMOVE MAGNETIC SCREW COVERS

The RTX 3080 Founders Edition isn't an easy card to disassemble. The fun begins with the removal of magnetic covers that hide screws securing the backplate to the cooler. There are several ways to do this, and the first to try is pressing duct tape onto them.

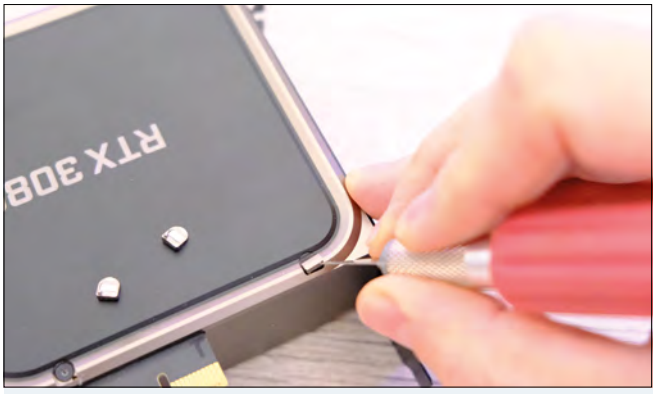


3 / REMOVE DUCT TAPE

The duct tape should lift the cover out of the recess. If it doesn't work first time, give it a few more tries from different angles with fresh pieces, and press firmly onto the covers first. The cover is a small section of plastic that looks like this.

4 / USE A MAGNET

Using a strong magnet can also work. You'll need a neodymium magnet for this job. Identify the right polarity to stick to the cover and gently lift it out of the recess.

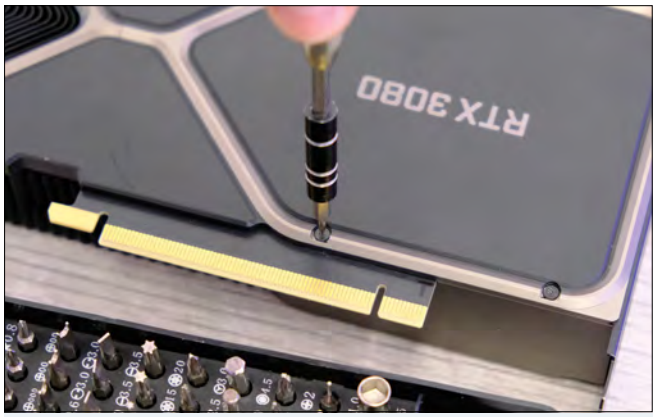


5 / USE A SCALPEL

If duct tape and magnets fail, then you'll need to physically pry the cover out of the screw. This is a last resort, as you can potentially scratch the cover, but it works well if you're careful. Place the side of the blade into the gap between the cover and GPU shroud, then lift the cover using the blade.

6 / USE A PART CONTAINER

There's a large number of screws to keep safe if you ever need to refit the cooler, so use a small sealed container to house them.



7 / REMOVE BACKPLATE SCREWS

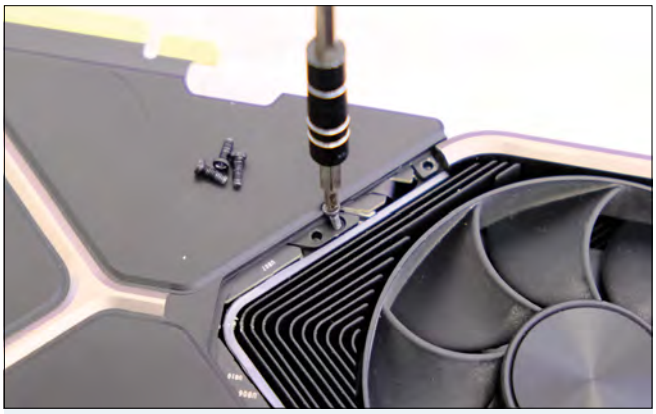
Now go ahead and remove the four screws that were under the covers. There's a variety of screw sizes and heads here, so you'll need a set of micro screwdrivers to deal with them all.

8 / LIFT CENTRE SECTION

The next step is to remove a centre section of the shroud near the flow-through fan. Use a plastic pick to lift this section away from the pointed end.

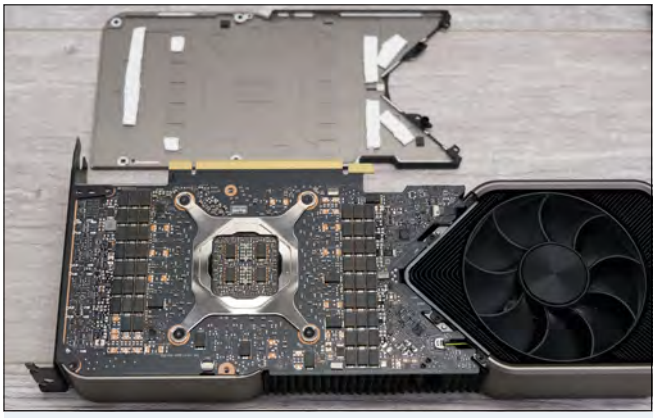
9 / REMOVE CENTRE SECTION

The section will lift, but is held in place with a push fitting. You'll need to lift it the rest of it away with your hand, taking care to lift it evenly and not at an angle.



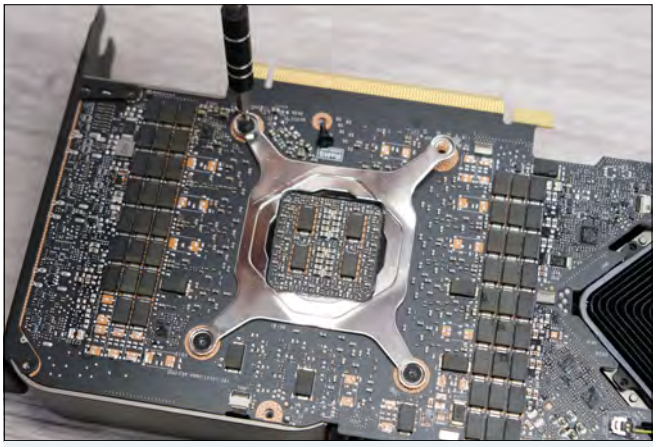
10 / REMOVE SCREWS

The centre section hides yet more screws that you'll need to remove. You'll need a small crosshead screwdriver to deal with them.



11 / LIFT AWAY BACKPLATE

The stock backplate can now be removed. To do this, lift it gently from one end. There are only a few small thermal pads holding it in place, so it should lift easily.



12 / REMOVE CORE SCREWS

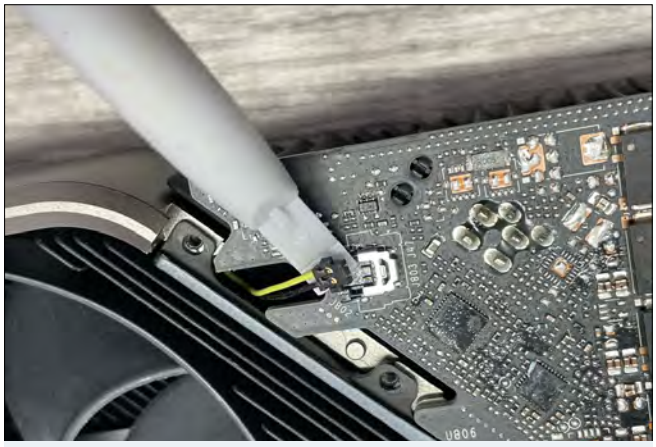
There are four screws around the GPU located in a metal brace. Remove these screws using the appropriate star tool from your micro screwdriver set.

13 / LIFT RIBBON CABLE LATCHES

There are two ribbon cables that you'll need to remove before you can lift out the PCB. These look like the one shown and you'll need to use a small flat-blade screwdriver to gently lift the black latch at the rear of the clip vertically.

14 / REMOVE RIBBON CABLE

Now use a small pick to pry out the ribbon cable. You need to be extremely careful here, so you don't damage the cable. Don't bend it too much – just lift it out of the container for now.

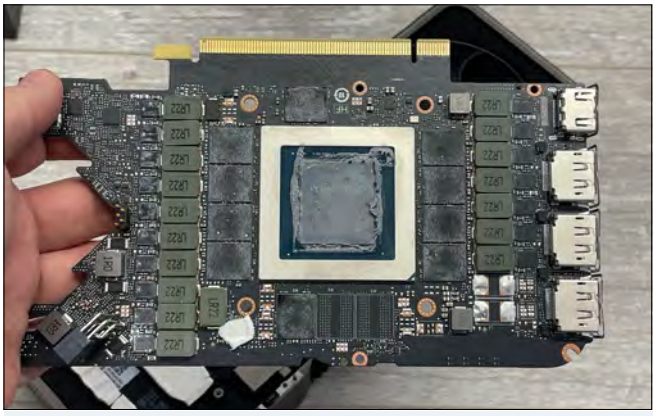


15 / REMOVE SECOND CONNECTOR

Next there's another small connector to unplug. This has yellow and black cables, and is located near the fan as shown. There's a small centre section that you can pry out backwards away from the metal shroud.

16 / REMOVE PCI-E BRACKET

EKWB includes a single-slot bracket with the waterblock, and you'll need to remove the stock bracket to fit it, and also to let you remove the stock cooler. You need to deal with a few screws here, and you'll need the appropriate star tool to remove them.

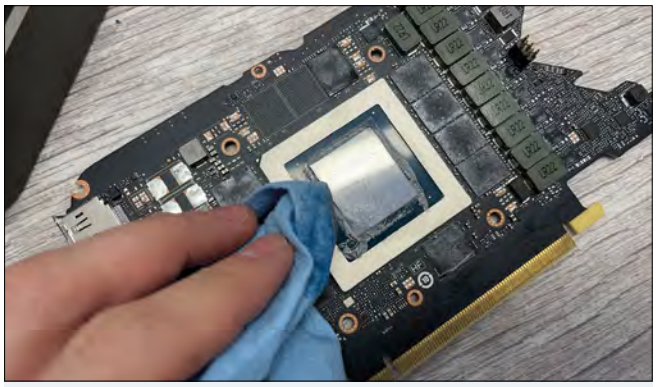


17 / LIFT PCB AWAY FROM COOLER

Finally, you should be able to lift the PCB away from the cooler, but double-check that all the aforementioned screws and ribbon cables are detached, especially if you feel any resistance.

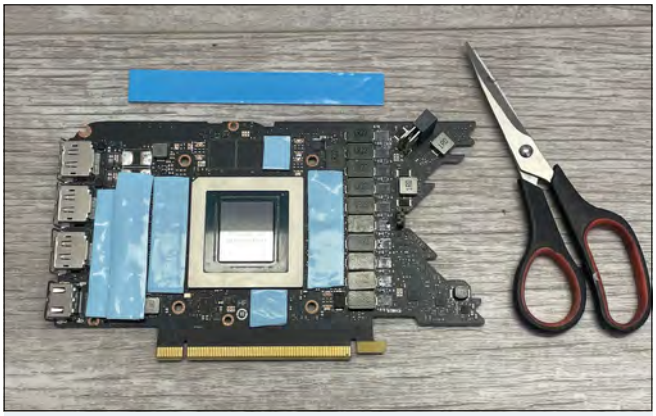
18 / REPLACE THERMAL PADS

With both the backplate and cooler removed, if any thermal pads are left behind on the PCB, use a small tool to gently remove them and place them back onto the cooler or backplate, so you can reassemble the card later if necessary.



19 / CLEAN GPU DIE

You'll need to clean any old thermal paste off the GPU before you fit the new waterblock, so use isopropyl alcohol or TIM cleaner to remove it, along with a microfibre or dense disposable work cloth.



20 / FIT MEMORY PADS

New thermal pads are included for the PCB in the waterblock box – start by using the waterblock's manual to locate the memory modules and cut the thermal pads to size to cover them.

21 / INSTALL ADDITIONAL PADS

You'll need to apply some other thermal pads to the top side of the PCB for the VRMs and other smaller hot spots, so you'll need to use the scissors more often here to trim the pads to size according to the instructions.

22 / REMOVE WATERBLOCK SECTIONS

The waterblock is equipped with a two-section backplate, and these sections need to be removed before you install the PCB. Remove the seven screws holding them in place and remove both parts.

23 / INSTALL PCB

Place the PCB GPU-down into the main waterblock section, lining up the four main holes with those on the waterblock and checking the other holes line up too. Now go ahead and secure the four silver mounting screws and washers.

24 / ADD BACKPLATE PADS

Sadly, you're still not done with thermal pads yet, as the backplate requires them too. Follow the instructions to cut them to size, so they can deal with the hot spots that will be cooled by the backplate sections.

25 / ATTACH NEW PCI-E BRACKET

Locate the new PCI-E bracket in the box, and place it between the backplate and PCB. The screws you use to secure the backplate will also screw through the bracket to hold it in place.

26 / SECURE BACKPLATE

The backplate uses crosshead screws, two of which will need to pass through the PCI-E bracket as well, so take care to line up all the parts correctly. You can then install the final piece of the backplate.

27 / DECIDE ON PORT DIRECTION

The waterblock uses rear-mounted ports, and you have the option of using the pre-fitted end piece with the ports facing the rear, or a second piece that allows you to point the ports at right angles. The choice here will depend on what works best for your specific cooling system, or indeed, the layout of your case. CPC

Folding@home

Join our folding team and help medical research

ACTIVE USER MILESTONES

USERNAME	POINTS MILESTONE
Dave_Goodchild	3,000,000,000
Simlec	3,000,000,000
kcanti	900,000,000
madmatt1980	800,000,000
sonic_vortex	600,000,000
BurnedFastfood	500,000,000
Little_Willie	400,000,000
Gwallace	300,000,000
Votick	300,000,000
Simlec	200,000,000
Neku	100,000,000
fatchef	100,000,000
Macrosb	100,000,000
Origami_Tsuki	90,000,000
Bedders	80,000,000
Jon_Simmo	80,000,000
Will_Walton	80,000,000
Liaw_Jun_Xian	80,000,000
peete	70,000,000
Count_Stex	70,000,000
TrekkieStu	60,000,000
GreenPig	50,000,000
YCDCN22	50,000,000
bytemarq	50,000,000
Curtis.Perdue	50,000,000
SgtDunk	50,000,000
AlSomething	30,000,000
CheeZee73	30,000,000
filreed	30,000,000
Glyn_Mason	20,000,000
G4zm4n	10,000,000
Pedro8888	9,000,000
leeoliver24	9,000,000
TheLimey	8,000,000
Drystan14	7,000,000
Pausanias828	7,000,000
StevieTM	7,000,000
JasperofBelper	5,000,000
Pennine_Lad	5,000,000
blotty	4,000,000
Parmesan	3,000,000
geofftswin	1,000,000
Wickermonkey	1,000,000
Wenna	900,000
mjgray87	800,000
Rabaks	500,000
PendragonOrion_ ALL_1Gpy...	500,000
Ian_Beales	400,000
ROric	400,000
iamannie	300,000

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	15,803,069	14,225,973,112
2	Desertbaker	8,574,859	3,484,073,159
3	tarka_dahl	6,814,967	1,502,000,165
4	Lordsoth	6,384,829	5,147,984,517
5	Slavcho	6,282,096	3,689,467,439
6	TrekkieStu	3,660,808	60,714,523
7	PC_Rich	3,599,385	6,458,439,084
8	BurnedFastfood	2,797,460	530,492,291
9	Votick	2,609,169	384,740,718
10	madmatt1980	2,576,073	842,061,644
11	kcanti	1,997,386	967,919,461
12	Bloo_Toon	1,722,422	350,879,133
13	Neku	1,674,775	127,893,872
14	Curtis.Perdue	1,607,229	59,006,613
15	GWallace	1,510,753	356,022,525
16	KevinWright	1,354,438	1,336,436,680
17	sonic_vortex	1,218,575	689,121,047
18	Little_Willie	1,212,112	417,640,073
19	gKitchen	1,200,903	168,719,769
20	Simlec	1,165,484	304,562,572

TOP 15 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	DocJonz	14,225,973,112	336,778
2	PC_Rich	6,458,439,084	164,321
3	Shirty	5,263,891,598	39,825
4	Lordsoth	5,147,984,517	179,555
5	Nelio	4,638,586,520	523,610
6	Slavcho	3,689,467,439	71,612
7	HHComputers	3,544,050,839	85,007
8	Desertbaker	3,484,073,159	66,371
9	Dave_Goodchild	3,055,362,845	159,790
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	Unicorn	1,753,462,654	57,079
14	daxchaos	1,637,104,710	41,302
15	Laguna2012	1,527,029,380	51,930

Retro tech

THE INTEL 486

Stuart Andrews recalls the mighty CPU that made the PC the ultimate powerhouse

The 486 went into development at an interesting time for Intel. The Intel 386 line had seen Intel snatch a victory from the jaws of a disaster, making up for the failure of Intel's new-fangled iAPX432 architecture with a mix of strong compatibility and great performance. Its design team, led by chief architect John Crawford, had dragged the 16-bit x86 architecture into the 32-bit era and kept Intel ahead of the pack.

But other manufacturers were moving fast. Arch-rival AMD was already developing its own 386 CPUs and only Intel's litigation was delaying their release. Cyrix was already producing Intel-compatible maths co-processors and was threatening to move into CPUs. Intel needed an awesome new product.

It combined a tighter, more streamlined pipeline with an integrated L1 cache

On the other hand, there was a lot of conflict within Intel – and within the computing community at large – over the future direction of processor architecture. Many felt that CISC (Complex Instruction Set Computer) architecture, as used in the x86 line, was a technological cul-de-sac; that performance would flatten out within a few years as Moore's law met fundamental barriers of computing.

They saw RISC (Reduced Instruction Set Computer) architecture as the future, using a smaller number of more versatile instructions and optimising the hell out of the architecture to drive performance. While one team at Intel worked on a successor to the 386, another was working on a new RISC processor that eventually became the i860. You probably haven't heard of the i860, which tells you a lot about how this situation played out.

In theory, the i860 should have trumped any 386 successor, but in 1985, Intel's CEO, Andy Grove, put John Crawford and hotshot architect Pat Gelsinger in charge of the design. Crawford and Gelsinger had already worked together on the 386 and shared a strong belief in the potential of the x86 and CISC architecture. Both felt that, while RISC had its advantages, a redesigned x86 chip could keep up.

What's more, it could do it without forcing big software publishers to redevelop their applications, rebuild operating

The 1st-generation 486 was twice as fast as a 386 with the equivalent clock speed. Image credit: Andrzej W K, own work, CC BY-SA 3.0

systems and optimise compilers. When you threw more transistors at the problem and increased their frequency, there was no reason why a CISC chip couldn't compete with a RISC CPU. Apply Moore's Law and keep increasing speeds, and a CISC chip might even crush it.

OPTIMISE THE PIPELINES!

Gelsinger and Crawford focused on delivering a processor that was fully 386-compatible and would build on the existing 32-bit architecture but would give you a massive increase in performance – at least double, clock for clock. They took inspiration from what was going on with the new RISC CPUs, paying particular attention to how instructions were loaded, organised, decoded and executed on the CPU.

The 2nd-generation DX2 chips doubled their predecessors' clock speed, a feat never replicated by any subsequent Intel CPU. Image credit: Henry Mühlpfordt, own work, CC BY-SA 3.0

THE RIVALS

If Intel's processor design teams put the 486 far ahead of the pack in terms of performance, its legal teams did a cracking job of suppressing any competition. However, eventually Cyrix and AMD won their legal fights, and 486 competitors began to appear. Cyrix's 486SLC and DLC processors, released in 1992, were particularly interesting.

Effectively a 386DX with a 486 instruction set and just 1KB of L1 cache, they still used a 32-bit bus and gave users a cheap halfway house – a 486DLC33 could run software at roughly the same speed as a 25MHz 486-SX. Not only were the processors more affordable, but they plugged into existing 386 motherboards, meaning the platform as a whole was cheaper.

I had one of these beauties in my first PC, and while it was noticeably less capable than my friend Brian's mighty 33MHz 486-DX, it could still run X-Wing, Ultimate Underworld II, Alone in the Dark and – eventually – Doom. Ultima VIII: Pagan? A bit more of a slideshow, but then it wasn't a great Ultima, so who cares?

AMD released its own 486 chips in 1993, and while they were late to the party, AMD made up for it with a repeat of a classic 386 performance trick. AMD's CPUs ran on a 40MHz bus, meaning that the, SX-40 and Am486DX/2-80 were slightly faster than the equivalent Intel CPUs.

Meanwhile, AMD's straight Am486 DX-25 and 33 and SX-33 gave you the same performance as Intel's equivalents at lower prices. AMD even released what it called the AM5x86-133 in 1995, which competed with the low-end Pentium 75 but was actually a 486 running on a 4x multiplier with a 33MHz clock.

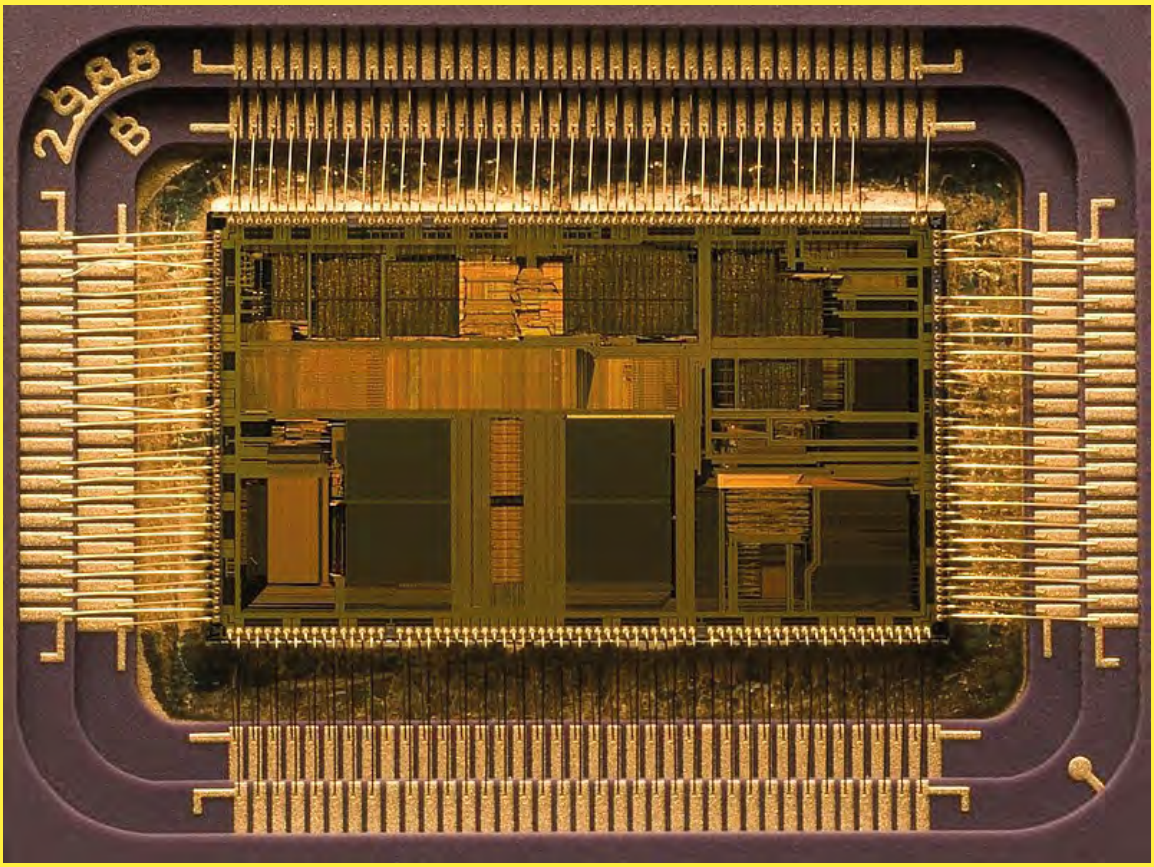
The big innovation was to combine a tighter, more streamlined pipeline with an integrated L1 cache – a first in a mainstream CPU. With 8KB of high-speed SRAM as a store for recently used instructions and data on the same silicon, the instruction pipeline could be fed with a consistent flow, enabling it to execute the simplest and most commonly used instructions at a sustained rate of one per clock cycle – an achievement that RISC devotees believed was beyond a CISC processor.

The new pipeline had five stages, although the first – the Fetch stage – wasn't strictly necessary for each instruction, as the CPU could fetch about five instructions with every 16-byte access to the cache. Once fetched, instructions went through two decoding stages, where they were organised and fed into the execution units. Here they were executed, and the results written back to registers or memory in a final write back stage.

The cache minimised any delay in loading data and instructions, and did such an effective job of caching data and instructions that the processor only had to go to system memory on roughly 5 to 10 per cent of memory reads. What's more, many 486 motherboards incorporated a secondary cache with 16KB or more of high-speed RAM, reducing latency even further. Meanwhile the two decoder stages enabled those instructions to be pipelined and processed more efficiently – with five instructions running through the pipeline, one would normally be processed with every clock cycle.

The result was a spectacular improvement in performance. On integer instructions – very much the meat and potatoes of computing at the time – the 486 was at least twice as fast as a 386 running at the same clock speed, and sometimes 2.5 times as fast. This meant the CISC-based 486 could hit similar levels of performance to the RISC-based i860, while still being compatible with all the existing x86 software. There was no need to rebuild or recompile – code developed for the 286 and 386 just worked.

With enough processing power to run it full-screen at a full VGA resolution, Doom became the 486-DX2's killer app



With over 1.2 million transistors, the 0.8micron 486-DX2 relied on Moore's Law and higher clock speeds to trash the theoretically superior RISC competition. Image credit: by Matt Britt, own work, CC BY-SA 3.0

At this point, floating point instructions weren't so commonly used, but here the news was just as good. Previous Intel processors had worked with optional, discrete maths co-processors, which handled all the floating point logic. These were expensive and not popular outside of business, as only a few major business applications, such as dBase, Borland Quattro Pro and Lotus 1-2-3, actually used a Floating-Point Unit (FPU). The 486-DX, however, integrated one directly onto the processor die, connected to the CPU by its own dedicated local bus.

OVERDRIVEN

The 486 marked another shift in Intel's tech and marketing strategy by embracing the whole idea of PC upgrades. As Intel released its clock-doubling DX2 and DX4 processors, it also released Overdrive versions designed to boost existing PCs. Some 486 Overdrive processors were simply replacement CPUs, plugging into the existing 168-pin socket and replacing, say, your 25MHz 486-SX with what was effectively a 50MHz 486-DX – albeit at an eye-watering cost of $549 to $699 US.

At this point, not every CPU could be removed from its socket, but luckily many 486 motherboards shipped with their own 169-pin upgrade socket, originally designed to fit a 487-SX maths coprocessor for 486-SX machines. Sneakily, the 487-SX was actually a fully functional 486-DX with an extra pin that told the motherboard to ignore the existing CPU, and the OverDrive chips just repeated the trick with some extra control circuitry with 50MHz and 66MHz 486-DX2 CPUs.

Doubling your speed was definitely tempting, and SX owners got a maths co-processor in the mix as well. And while Intel pushed the benefits with AutoCAD, WordPerfect and Corel Draw, the biggest sellers for OverDrive chips were undoubtedly games such as Strike Commander, Falcon 3.0 and Doom.

This meant there was less overhead in shifting data between CPU and FPU; this, combined with other optimisations, resulted in a significant improvement in floating point performance. Fast forward a few years, and Quake would require a CPU with a floating point unit, with the system requirements citing a 486-DX4 as the minimum. Today, it's impossible to imagine a CPU without an FPU, and that's thanks to the mighty 486.

Beyond this, differences from the 386 were relatively small. The 486 had a few extra 'atomic' instructions that sped up some basic operations, but nothing compared with the instructions added with the 80286 or 386. The 486 also didn't mess with the 386's memory model; it could still address 4GB of RAM across a 32-bit bus, with a protected mode that presented both real and virtual memory as one big pool. However, its improved Memory Management Unit performance meant it was much more efficient at shifting data between the system RAM, the CPU and the cache.

DOUBLE THE CLOCKS!

There was one final architectural change that was to have a major impact, even on today's PCs. Intel CPUs from the 8086 to the 1st-generation 486 ran at the same frequency as the external bus that connected all the core components together. This meant that the initial 486-DX processors, introduced in 1989-1990, ran at the same 20, 25 and 33MHz speeds as the I/O bus. Intel pushed speeds higher, releasing

Cyrix's low-cost 486 alternatives would work inside a 386 motherboard, making them the bargain Intel alternative of the day

a 50MHz 486-DX, but the 50MHz bus speed began to cause problems for components elsewhere on the bus.

Luckily, the 486 design team had an ace to play: it decoupled the CPU clock speed from the motherboard clock speed and enabled the CPU to run at double the system clock. This fired up the 486-DX2, launched in 1992, to run at internal speeds of 40MHz, 50MHz and even a staggering 66MHz, making the 66MHz 486-DX2 the RTX 3080 of its day in terms of its impact on gaming performance.

The 486-DX4, introduced two years later, went even further, tripling the bus speed to hit 75MHz and 100MHz; a staggering level of performance that trashed the available RISC competition. The team's confidence in the x86 architecture no longer looked misplaced.

WALLET-WHACKING POWER

So, the 486 launched with an undeniable advantage in performance in a market where – thanks to Intel's ace legal department – other x86 chip vendors had practically nothing. There was just one problem. While Intel had moved production down to a 1-micron process, it still had over 1.2 million transistors – a big step from the 275,00 in the original 1.5-micron 386. This made it a comparatively big chip and, partly thanks to its $250 million US R&D costs, also an expensive one.

At launch, the 33MHz 486DX alone cost around $950 US (nearly $1,900 in today's money), which was roughly three times the cost of the equivalent (and still pretty speedy) 386. A 486 PC cost users somewhere north of £2,000 (roughly £4,500 today). Intel's response – you guessed it – was to put out a cut-down, cost-conscious alternative, and 1991's 486-SX wasn't actually such a bad deal.

Games such as Strike Commander pushed the 486 architecture to its limits with advanced 3D texture mapping and Gouraud shading

When Intel tried the same trick with the 386, it released a hobbled version with a 16-bit data bus and slower clock speeds, but the 486-SX was basically a 486-DX with the FPU disabled. At the time, with so little software that supported the FPU, this wasn't much of an issue, and by the time the 486-SX was released, it only cost around $250 to $300 US.

THE 486 EFFECT

The power of the 486 was transformative at a time when the CPU was the biggest star of the PC show. Sure, it was supported by a platform where VGA and SVGA graphics cards were growing more powerful, and where standardisation around the VESA local bus and, later, PCI standards was opening up the PC for more powerful add-on cards. However, the 486's advances in integer and floating point performance arrived just at a point where advances in gaming graphics needed them most.

In the early 1990s, as prices dropped to more affordable levels, the 486 hit its peak. Just check out the games that emerged. Ultima Underworld and its sequel, Strike Commander, Wing Commander III, X-Wing, Ultima VIII: Pagan, IndyCar Racing and Alone in the Dark all launched between March 1993 and December 1994, and with their texture-mapped, Gouraud-shaded 3D graphics, these PC showcases needed all the processing grunt that they could get.

A few simulations, such as Spectrum Holobyte's Falcon 3 and Digital Image Design's TFX, even used the FPU. And then, of course, came Doom; a game that you could just about run on a 386 in a stamp-sized patch in the middle of the screen, but looked amazing running full-screen at the full VGA resolution on a 66MHz 486-DX2.

If all those other games had pushed the PC as the high-end gaming platform of the early 1990s, Doom confirmed it. Even when the PlayStation and Saturn consoles launched a few years later with their fancy-pants, hardware-accelerated 3D tricks, they still struggled to run Doom classic smoothly in full screen. The 66MHz 486-DX2 could do it on its own, simply using sheer number-crunching power. People saw it, liked it and pulled out their wallets. The idea of the PC as the real gaming powerhouse was born. CPC

Readers' Drives

Project Pac-Man

With some custom-made acrylic panels and boxes, Karl Patterson transformed this Pac-Man arcade cabinet into a water-cooled dual-loop gaming PC

CPC: So how did this project start? What inspired you to build this Pac-Man cabinet PC?
Karl: It all started when Intel UK asked me to come up with a retro-themed gaming PC, and I came up with the idea of a Pac-Man theme.

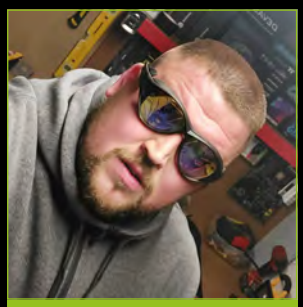
CPC: Where did you get the cabinet from, and how did you go about modifying it to suit your requirements?
Karl: It's based on the cabinet from a new 1Up machine (**arcade1up.com**), and I had to mod it in order to build my fully water-cooled PC in the bottom. First of all, I had to add a back and top panel inside the cabinet – the back panel housed my motherboard, and I used the top panel to run all my water-cooling pipes. I added a mirror-finish acrylic panel to the top, and a black gloss acrylic panel to the back, to give it a clean look.

CPC: It looks like there are two systems in there at first glance.
Karl: Yeah, this was my plan – to make it look there were two systems inside the cabinet, so that's why I went with mirrored acrylic for the top panel.

CPC: Did you make the Pac-Man cutout and pellets at the bottom of the cabinet?
Karl: Yes, I made them with my CNC machine – I already had the yellow acrylic to hand, and I thought they would be a nice touch at the bottom of the arcade cabinet. This bit was an afterthought really – I'd originally planned to just use black acrylic here, but I'm glad I went with the Pac-Man logo – it turned out really well and gives it a better all-round look.

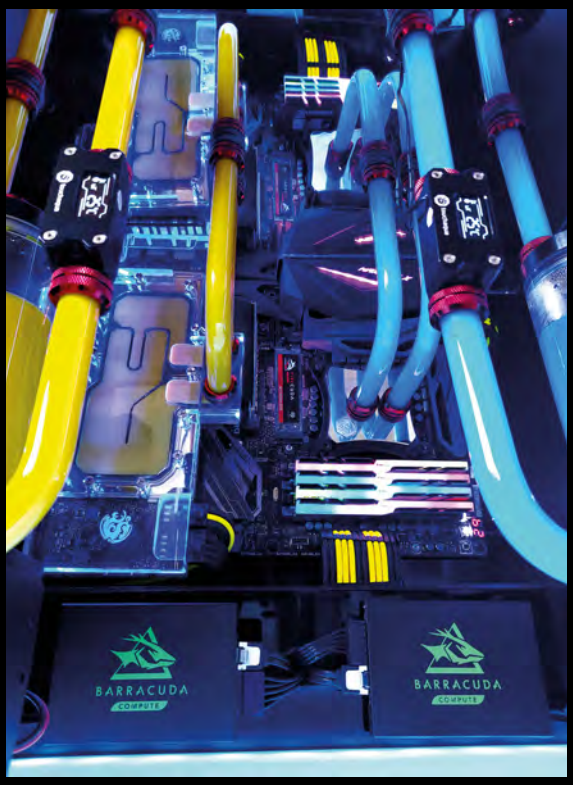
CPC: Can you still use those controls to play Pac-Man on the cabinet?
Karl: Yes, you can play Pac-Man on this arcade – I wanted to leave the arcade as standard – the PC is separate from this bit. The joystick and the controls all work as they should. My original plan was to remove the screen and replace it with a monitor for the PC, but when I bought the cabinet and set it all up, I decided to leave it all set up as a standard, fully functional Pac-Man machine.

CPC: So you can't play any of the latest PC games on the screen with the cabinet controls?
Karl: This is the question I get asked the most about this mod. Yeah, the bottom half of the cabinet is a fully



/MEET THY MAKER

Name Karl Patterson
Age 33
Occupation Plumber
Location Durham
Main uses for PC Gaming
Likes PCs, cars, bikes and technology
Dislikes Fish and salads



functional gaming PC, on which you can play any PC game – I have it set up to output to another monitor. The top half is for playing Pac-Man, so if you wanted, you could have someone playing a PC game on the monitor, while another person could play Pac-Man on the arcade controls at the same time.

CPC: Take us through the process of planning the water-cooling loops. Why did you go for a dual-loop approach and where are the radiators?

Karl: When I came up with the design for the water-cooling loops, I knew right away that I wanted a dual-loop setup in the system. I wanted one yellow loop and one blue loop, to match the Pac-Man colour theme perfectly.

The hard part was fitting it all in the cabinet. I had to relocate the radiators to the back of the cabinet, and then run all the pipes vertically, as I wanted the interior to look clean. I used hard tubing in the areas you can see at the front, but then used soft tubing at the back where it was out of sight – the latter choice made it easier for me to connect the tubing to the radiators, as there's very little room to work in the back of the cabinet.

CPC: What coolant did you use in each loop?

Karl: For the yellow coolant, I used Thermaltake's yellow C100 – it was the only yellow coolant I could find that was bright enough to match the yellow on the cabinet. For the blue, I used EK coolant, which also

matched perfectly with the colours in the cabinet, as I wanted the colours of the loops to tie in with the cabinet's theme.

CPC: The lighting in the bottom chamber is clear and bright, highlighting the gear inside, but you can't see individual LED strips anywhere – how did you do this?

Karl: Yeah, this is all thanks to a custom light box that I made – I used mirror-effect acrylic for the bottom, and opal acrylic for the top, then cut strips of black acrylic that are just a bit bigger than the LED strips I was using.

I glued the black acrylic strips around the edges of the mirror-effect acrylic panel, stuck all the LEDs to these black strips inside the box, then added the opal acrylic to the top of it. When it's all lit up it looks like one big light box – it uses RGB LEDs, so I could make the lighting any colour I liked, but I left it on white, as it fully lights up the cabinet.

CPC: It all looks amazing from the front, but how does it look at the back, and where does air get in and out?

Karl: At the back, where the radiators are located, I added vents in the sides of the cabinet, so you get plenty of ventilation. I'm running a pair of 240mm radiators in the back – one for each loop – with the power supply sitting between them. I would like to have used 360mm radiators instead, but I didn't have room for them in the back of the cabinet.

I made a custom light box, with mirror-effect acrylic for the bottom, and opal acrylic for the top

SYSTEM SPECS

CPU Intel Core i7-8086K

Graphics card Asus GeForce RTX 2080

Storage 500GB Seagate FireCuda 510 M.2 NVMe SSD, 2 x 500GB Seagate BarraCuda 120 SATA SSDs

Memory 32GB G.Skill Trident Z Neo 3200MHz

Motherboard Asus ROG Maximus X Hero

PSU 850W Thermaltake

Cooling Custom water-cooling system featuring Bitspower components and Thermaltake yellow C100 coolant, EK blue coolant

CPC: That's an immaculate cable-tidying job – where are all the cables hidden?

Karl: I made a box that I fitted under the motherboard, so I could run all my cables through to the back of the cabinet. As with the black acrylic strips I used to hide the LEDs, the idea was to hide all the cables as much as possible, as I wanted to create a clean look.

CPC: How long did it take you to complete this build, from start to finish?

Karl: I think the whole build took me around four months to complete, but I did have some issues getting hold of some of the parts for the build in that time.

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?

Karl: Yes, I'm very happy with how it turned out – the end result looks even better than I expected from my original ideas. CPC

WIN CORSAIR HYDRO X WATER-COOLING GEAR

To enter your rig for possible inclusion in Readers' Drives, your build needs to be fully working and, ideally, based in the UK. Simply send us a couple of photos on Twitter (@**CustomPCMag**) or Facebook (**CPCMagazine**), or email low-res ones to **ben.hardwidge@raspberrypi.com**. Fame isn't the only prize; you'll also get your hands on some fabulous prizes, courtesy of Corsair.

Corsair Hydro X Series XD3 RGB Pump/Reservoir C

WORTH £151

The Corsair Hydro X Series XD3 RGB Pump/Reservoir Combo features a high-performance DDC PWM pump, integrated RGB lighting and in-loop temperature sensor to drive even the most compact custom cooling systems. It has a high-performance Xylem DDC PWM pump controlled via PWM to deliver the perfect flow balance for your loop. There are also 16 individually addressable RGB LEDs, which light up the pump head to produce stunning, customisable lighting effects to match your build.

Corsair Hydro X Series XC7 RGB CPU Water Block

WORTH £70

The Corsair Hydro X Series XC7 RGB CPU Water Block combines premium construction, vivid RGB lighting and extreme cooling performance to become the centrepiece of your water-cooling loop. It has a nickel-plated copper cold plate and more than 60 high-efficiency micro-cooling fins, which efficiently draw heat away from your CPU, lowering operating temperatures and allowing for maximum overclocks. You can choose 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

STOCK SUPPLY UPDATE

James Gorbold reveals the inner workings of the industry as 2021 gets underway

The past few months have seen some fantastic new PC products launched, such as GeForce 30-series and Ryzen 5000-series. While both these launches have been plagued with supply issues on specific models, particularly the GeForce RTX 3060 Ti, 3080 and Ryzen 9 5900X, the vast majority of our pre-orders for the other models have now been fulfilled.

Sadly, with the inevitable lull in manufacturing and logistics over the Christmas and New Year period, there's still extremely little free stock available for customers to order. However, at least there's a glimmer of light at the end of the tunnel.

Unfortunately, the supply situation on the aforementioned three models is still pretty bleak. GeForce RTX 3060 Ti graphics cards remain effectively unavailable, so we haven't opened pre-orders, as it simply wouldn't be fair to take them when we can't provide customers an ETA for their card. The situation with the RTX 3080 is improving, and while there are still hundreds of launch-day pre-orders to be fulfilled, we've shipped out thousands of cards over the past few months and more cards are arriving every week.

> Supply of the Ryzen 9 5900X is still very bleak, with hundreds of pre-orders still yet to be fulfilled

One interesting side effect of the RTX 3080 shortage is that it reveals which brands command the most loyalty. For instance, most gamers would prefer to wait weeks or months for an A-brand card from the likes of Asus, EVGA or MSI than a much shorter wait for a B-brand card from the likes of Palit or PNY.

Unfortunately, the supply of the Ryzen 9 5900X is still very bleak, with hundreds of pre-orders still yet to be fulfilled. Scan has a direct relationship with AMD and both teams have been working hard to secure as much UK stock as possible, but the simple fact is there aren't any CPUs available and multiple forecast deliveries from AMD have now been pushed back. In fact, we haven't received any 5900X chips this year at all, and AMD currently isn't forecasting any deliveries for the whole of January.

The worst situation of all, however, remains Radeon RX 6000-series graphics cards. With next to no stock available at launch and barely a trickle arriving since, all three members of this family remain effectively in limbo with a handful of sales and zero pre-orders. I've said it before, and I'll say it again: AMD may as well have not have bothered.

The combination of unprecedented demand and COVID's impact on manufacturing and logistics will continue to have a long-tail effect on supply for the foreseeable future too. This makes the recent announcements at CES from AMD, Intel and Nvidia all the more sensitive. While action counts more than words, Nvidia at least acknowledged the supply issues in its keynote, but AMD's upbeat messaging glossed over the company's many challenges.

With new products on the horizon from both brands, it remains to be seen if they'll be available in significant numbers. The past few months have taught us to be excited, but cautious.

Intel is in a bit of a different situation from AMD and Nvidia, as its currently available CPUs from the 10th-gen Comet Lake family are freely available, even if demand has taken a tumble since the Ryzen 5000-series launch. Intel still has time to play with as well, as we're still a couple of months off the launch of its 11th-gen Rocket Lake CPUs. What's more, with CPU-veteran Pat Gelsinger making a welcome return to Intel as its new CEO, I'm expecting the company's situation to change for the better. 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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