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Welcome

Custom PC Issue 228

/ FROM THE EDITOR

Innovation central

Custom PC has been a fan of mini-ITX ever since the old days, when the first mini motherboards based on weedy VIA EPIA CPUs were being snapped up by modders – there's one built into a model car in our very first issue in 2003, and I also really like this month's Readers' drives scratch build (see p110), which is based on an even smaller motherboard design from ASRock.

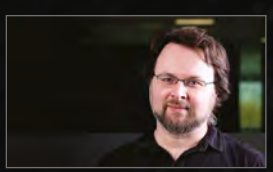
Having limitations forces you to innovate, and while there's still plenty of innovation going on in the ATX PC space, it's in the mini-ITX arena where you see all the really interesting ideas. Take a look at our mini-ITX motherboard Labs on p36 and you'll see all sorts of new ideas, from stacked PCB arrangements to M.2 ports on the backs of motherboards and vertical add-on boards to provide SATA ports. Packing all the gear needed by the average PC enthusiast onto a 170 x 170mm PCB requires some serious thinking, and that makes for some refreshing ideas.

There's also a huge variety of mini-ITX cases available in tall, short, wide and narrow designs. Squeezing a fully featured PC with a graphics card into the volume of a shoebox (or less) isn't easy, particularly when it comes to cooling.

While this makes for some really interesting ideas, however, it can be a bit of a minefield to navigate, particularly if you're new to the field. Your choice of case will also affect your choice of cooling and hardware, and the case you think looks best may well not have all the features you want.

That's why we've accompanied this month's mini-ITX motherboard Labs with a full feature (see p74). It takes you through the various different case designs and the hardware you can use with them, while also showing you how to build a killer gaming PC in Phanteks' gorgeous Evolv Shift XT chassis.

You'll be surprised what you can achieve in such a small case if you follow our guide. A full-sized graphics card and top-end CPU isn't out of the question, and neither is liquid cooling. If your only expansion card is a GPU, and you don't have a large stack of hard drives, there's no reason why your next PC can't be a dinky mini-ITX rig that has all the performance you could want. CPC



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CUSTOM PC

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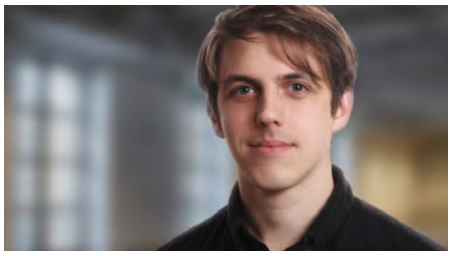

RICHARD SWINBURNE / VIEW FROM TAIWAN

PCI-E 5 SSDs ARE COMING

Storage speeds will soon hit 12GB/sec, but Richard Swinburne asks if you'll be able to notice the difference

At Computex this year, Phison showed the first PCI-E 5 SSD controller in action on an upcoming Asus ROG X670E Hero motherboard with an AMD Ryzen 7000-series CPU. Phison's new E26 SSD controller recorded a whopping 12.5GB/sec sequential read speed, and a sequential write speed a smidge over 10GB/sec. When compared to the peak ~7GB/sec sequential speeds of the fastest PCI-E 4 SSDs, it's clearly a huge upgrade.

The SSD was connected directly to the CPU for maximum performance, but you won't need to buy the most expensive X670E chipset to get a PCI-E 5 SSD socket. AMD has committed to having at least one PCI-E 5 M.2 socket on all its motherboard chipsets, whether it's X670E, X670 or even the mainstream B650. These next-gen SSDs will also be bigger than their predecessors – PCI-E 5 SSDs will measure 25mm wide (2580), instead of the 22mm (2280) used now.

Apacer and Zadak have announced SSDs using the Phison E26 controller for later this year, which gives us a good insight into availability. Those brands aren't typically a first choice on most people's shopping lists, but Phison should supply the chip to other partners as well.

Phison's demo did let slip one area with no performance gains, however. Its 4K single-queue-depth result – a typical workload for a home/gaming PC – was just 62MB/sec, which is pretty much the same as an average PCI-E 3 SSD. It remains to be seen if real-world speed will see a boost, but it's unlikely to be as revolutionary as the headline numbers suggest.

For example, a 1st-gen Intel Optane 900p drive, which launched in 2017, might only produce 2.5GB/sec sequential speeds, but its 4K single-queue-depth performance is around 220MB/sec – over 3.5x faster than the new PCI-E 5 drives. Sadly, we won't see another Optane drive out of Intel, and alternative technologies, such as spin-torque (STT), ReRAM or other phase-change storage products aren't materialising either. It's a bit frustrating that five years later, standard SSDs still haven't caught up with Optane in some essential metrics. That might soon change though.

> Its new 3D NAND uses external and internal controllers

At its recent investor day conference, Micron announced a new 232-layer 1Tb TLC 3D NAND chip. In comparison, the most advanced 3D NAND today has a maximum count of ~160-176 layers. Micron noted that its new 3D NAND uses a combination of external and *internal* controllers for data storage. Micron clarified that it's building a micro SSD controller into the NAND chip itself, offloading low-level functions, such as wear levelling and garbage collection, from the main SSD controller, freeing the latter to focus on user-centric work.

Micron explained that its design uses a wide bus inside each NAND chip, so it could efficiently handle its own operations and external requests, while the bus between the NAND and the main SSD controller is now narrower, owing to the reduced traffic. This reduces request latency, which boosts overall performance, and it improves power efficiency, because the data self-management never leaves the NAND chip. At a time when even PCI-E 4 SSD controllers are frequently temperature throttling under heavy load, this is a very welcome design change.

The Phison demo did use Micron TLC NAND, but not the new 232-layer variety. It's also unknown whether Phison's controller can use Micron's new NAND either, given that the E26 controller is already heading into production, and Micron's latest 3D NAND has only just been announced. However, this may be addressable in firmware updates, or perhaps 2nd-generation PCI-5 SSDs will demonstrate better real-world results beyond the headline numbers. 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

MYTHS AND LEGENDS

Tracy King takes on some of the pernicious myths about gaming, from addiction to games causing depression and violence

Someone recently asked me if I'd ever written a short guide to gaming myths, the sort of thing you could show to naysayers and fearmongers. I've tackled each of these topics at length in previous columns, whenever there has been new studies or evidence, but here are some handy quick talking points.

First up is the most common myth: that video games cause violence. This one is dangerous because it distracts from looking for the actual causes of shootings. Gaming is the most popular hobby, so yes, you will probably get some overlap with the 'commits violent crime' population. This is also true of, say, people who read Harry Potter, but no one is claiming Voldemort causes violence.

The teenage killer population is so tiny, and the gamer population so large, you'll get overlap just as you do for film and TV ('video nasties' were blamed for violence before games). You could just as easily argue that because 99.99 per cent of gamers do not shoot up schools, gaming actually has a positive influence.

> Currently the science says that games do not cause violence

But what does the evidence say? It's difficult to study because, again, the population of killers is very small, but currently the science says that games do not cause violence. Nor is there good reason to think they do, when there are so many other factors in the lives of killers.

The next myth is that games are addictive. This one is a bit more complicated than it used to be, because of loot crates. Gambling addiction is real, and gambling is heavily regulated because of it. Certain aspects of some games, such as loot crates, could be considered psychologically similar to gambling (and some countries are beginning to regulate them as such), but that is not the same as saying video games are addictive.

Nobody says a grand master is addicted to chess, because chess is seen as intellectually stimulating, but it is just a game that has a different cultural history to, say, Starcraft. If I bet on the outcome of chess, or play a chess variant where I pay for the chance of an upgraded rook, some gambling psychology might apply and my risk of developing a compulsion from which I can't walk away could increase. But currently there is no consensus on even the definition of video game addiction, or how to diagnose it.

The third myth is that gaming causes depression. Nobody knows for sure what 'causes' depression, but it's not plausible to claim that someone without mental health issues can develop them simply from playing games, any more than they could from binge-watching Netflix.

There is some evidence that gaming actually improves mental health, because it can be social and fun, but people experiencing depression may also retreat into virtual worlds as a distraction (this has happened to me and I credit gaming with helping, not exacerbating).

It may be reasonable to say that depressed people game more, but it's less reasonable to say people who game more become depressed.

Currently, the evidence says games don't cause depression, but staying up all night gaming (or reading, watching TV or listening to music), or lying on the sofa all day avoiding exercise might not be helping if you're already low.

Games get blamed for personal problems and societal ills because games are still relatively new and are perceived as mainly for young people. Once that's no longer true (gaming rigs in retirement homes are coming to a future near you!), the bogeyman will disappear and a new one will take its place. 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

8PACK LAUNCHES TOP-END MINI PC

OCUK's resident expert overclocker 8Pack has put his name to a new top-end small form factor PC, which features custom water-cooling gear and high-end components. As standard, the Meteoroid MK2 features a Ryzen 9 5900X and a GeForce RTX 3080 Ti, along with an Asus ROG Crosshair VIII Impact mini-DTX motherboard, 64GB of 3600MHz DDR4 memory and 5GB of solid state storage.

Meanwhile, the water-cooling system comprises a pair of 360mm radiators and custom distribution plates, complete with 8Pack branding. The water-cooled graphics card has also been shifted so that it sits under a Plexiglas window in the top of the chassis, giving you a view of the coolant flowing through it.

All the gear is housed in an acrylic chassis, which Overclockers says has been custom designed in-house, although it's clearly been influenced by Parvum's acrylic case designs. Not surprisingly, it doesn't come cheap, with the standard spec coming in at £7,800 inc VAT. For more information, visit **custompc.co.uk/Meteoroid**

THERMALTAKE UNVEILS MID-SIZED TOWER

Thermaltake has just revealed a new mid-sized flavour of its glass-fronted Tower chassis design, fitting in between the massive Tower 900 and the mini-ITX Tower 100. Like the other Tower models, the Tower 500 shifts around the interior from the usual case design, so that the motherboard is directly facing the front of the case, with 4mm tempered glass windows on the front and sides providing an unobstructed view of the insides.

The right-hand side panel can also be flipped 180 degrees, so you get mesh next to the area by the motherboard rather than glass, with room to mount a 360mm radiator. An optional 3.9in LCD panel kit can be fitted to the bottom front of the Tower 500, providing information such as real-time system data, or you can customise it with your own GIFs.

The Tower 500 is available in black and white options, which are available for £199 inc VAT from **scan.co.uk** now.

CHERRY RELEASES ULTRA LOW-PROFILE TACTILE SWITCH

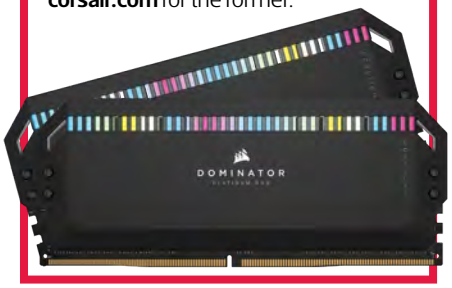
Mechanical keyboard switch maker Cherry is adding a new model to its line-up of low-profile key switches. The new Ultra Low Profile (ULP) Tactile is designed to offer a similar feel to the company's full-sized MX Brown switches, but in a low-profile form that can be used in laptop keyboards and slim desktop designs.

Unlike the already released ULP Click, the ULP Tactile doesn't make a clicking sound as it actuates, but still gives you a tangible feeling of actuation as you press the key. The new ULP Tactile has a total travel of 1.8mm, with the switching point sitting at 0.8mm.

Meanwhile, either RGB or single-colour LEDs are mounted directly under the switch, with Cherry saying it evenly illuminates the keycap, with options for programmable per-key lighting.

CORSAIR DDR5 HITS 6600MHz

Corsair has introduced a new top speed to its Dominator Platinum RGB offerings, with 6600MHz kits now joining the parade. The high-speed modules have 32-39-39-76 timings and all the usual benefits of Corsair's Dominator Platinum RGB design, including 12 individually addressable Capellix LEDs. The 6600MHz memory is available in 32GB (2 x 16GB) and 64GB (2 x 32GB) kits, with prices starting at £395 inc VAT from **corsair.com** for the former.



Rumour control

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

INTEL RAPTOR LAKE HITS 6GHz

Twitter tech gossiper **@OneRaichu** claims that one of Intel's forthcoming 13th-gen 'Raptor Lake' CPUs may have a top turbo frequency of 6GHz. The rumour followed an update to Intel's Extreme Tuning Utility on 21 June, which added support for some new features under the heading 'Future Platform(s) Support'.

The list included 'per-core OC TVB,' 'package OC TVB' and 'Efficient TVB', with TVB standing for Thermal Velocity Boost – Intel's tech that speeds up all a CPU's cores when thermal headroom is available.

RTX 4000-SERIES SPECS LEAK

Apparently leaked specs of Nvidia's forthcoming GeForce RTX 4000-series GPUs have been shared by regular tech Twitter leaker **@kopite7kimi**. He claims that the RTX 4090 will be based on the AD102-300 GPU, and will come with 16,384 FP32 CUDA cores, a 386-bit memory interface and 24GB of GDDR6X memory.

Meanwhile, he says the RTX 4080 will be based on the AD103-300 chip, with 10,240 CUDA cores and 16GB of memory and a 256-bit memory interface. Finally, he claims that the RTX 4070 will be based on the AD104-275 chip, and will feature 7,168 CUDA cores and come with 10GB of GDDR6 memory.

Reviews

ATX CASE

KOLINK OBSERVATORY Z MESH ARGB / £120 inc VAT

SUPPLIER overclockers.co.uk

As an up-and-coming manufacturer that's looking to muscle in with long-time players, Kolink has been getting progressively better at making cases. It's a strong supporter of mini-ITX, so you might want to take a look at its mini cases if you liked this month's feature and group test, but we're focusing on ATX here with the Observatory Z Mesh ARGB.

At £120 inc VAT, it's up against a number of cases offering good airflow and RGB lighting costing noticeably less money, such as the Cooler Master MasterBox 500 at around £100, while Antec's recent options such as the NZX700 cost even less money. Thankfully, Kolink has dialled up the Observatory Z Mesh ARGB's credentials to help justify the extra outlay, including the addition of four PWM 1,500rpm 120mm digital RGB fans in the package, as well as a multi-channel lighting controller.

The controller can hook up to a USB 2 header to provide software control too, but if you'd rather avoid that, you can control the lighting using buttons on the front panel or any 3-pin RGB controller, including 3-pin headers on your motherboard. The quality of the lighting is often a place where cheaper gear suffers, but we were suitably impressed by the vibrancy and accuracy of the Kolink's colours, which diffuse through the semi-opaque fan blades via the central hub, as well as the outer ring.

They also look particularly bright when viewed through the glass side window, which lacks any tinted coating. The fans have their cables threaded behind the motherboard tray, but you'll need to hook them up to the included controller yourself. The actual 4-pin fan cables will need to be connected to your motherboard, though, as the hub only deals with lighting.

In terms of size, the case's width of 24.5cm means it's quite chunky, even though both the depth and height are well under 50cm. However, this does open up the interior, enabling it to offer some serious hardware support. There's space in the front for 360mm or 420mm radiators, equating to three 120mm or 140mm fans, as well as 280mm or 360mm models in the roof, or two 140mm fans or three 120mm models. This is excellent for a case of this size and price.

There's a good deal of clearance in the roof and front section too, with room in the latter behind the fans to easily house 60mm-thick radiators. As well as ample radiator support, the case can also house E-ATX motherboards, and sports 180mm of CPU cooler clearance and 380mm of graphics card clearance, with a support included to help large cards from sagging. One minor niggle is that the rear vents are simply small horizontal cut-outs, rather than a highly

SPEC

Dimensions (mm)
245 x 465 x 495 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black

Weight
9.7kg

Front panel
Power, reset, 1 x USB 3.2 Gen 2 Type-C, 2 x USB 3, 2 x USB 2, stereo, mic, LED control

Drive bays
5 x 2.5in / 4 x 3.5in

Form factor(s)
E-ATX, ATX, micro-ATX

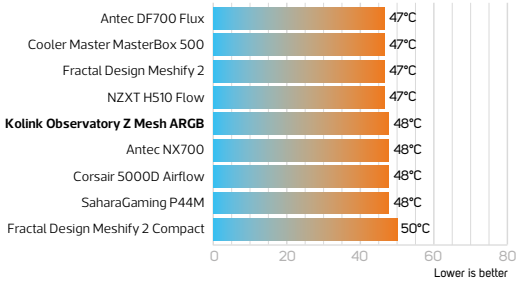
Cooling
3 x 120mm / 3 x 140mm front fan mounts (3 x 120mm fans included), 1 x 120mm / 140mm rear fan mount (120mm fan included), 3 x 120 / 2 x 140mm roof fan mounts (fans not included)

CPU cooler clearance
180mm

Maximum graphics card length
380mm

TEMPERATURE RESULTS

CPU DELTA T



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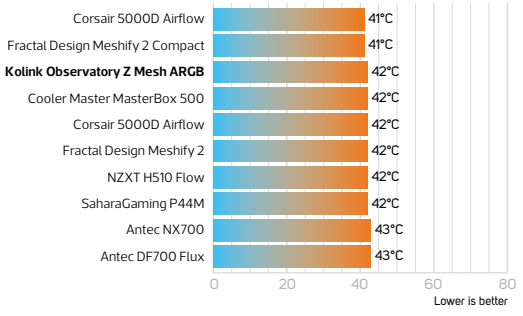


efficient hexagonal pattern, which may impact on airflow, even if it does look quite eye-catching.

The case feels well made too, and definitely more premium than Antec's recent efforts. They were solid enough, but the Kolink Observatory Z Mesh ARGB weighs 3kg more than the Antec DF700 Flux, for example, despite having a similar size, which gives you an idea of the additional materials involved. However, the glass side and front panel proved to be extremely stiff when removing them for the first time, so be prepared to heave them open.

Once inside, you'll find that the roof has a magnetic dust filter to prevent detritus falling into the case, with another catering for the PSU. However, the front mesh acts as its own filter, meaning you need to pull off the front panel in order to get at the fan mounts too.

There's a generous count of four hard disk mounts as well – they're spread across the rear of the motherboard tray and the storage tray under the PSU cover. Alternatively, you could store up to five 2.5in drives in these mounts too. The case's width means there's plenty of clearance between the motherboard tray and side panel too, plus there are lengthy Velcro ties included to gather cables together.

Meanwhile, the front panel offers loads of connections, including four Type-A USB ports, two of which are USB 3, plus a USB 3.2 Gen 2 Type-C port as well. There are power and reset buttons, audio jacks and a button to control the RGB lighting on this panel too.

Performance

The Kolink's fans proved to be extremely quiet at full speed, and if anything, we'd have liked to see a few more hundred RPM on offer from them to create a little extra cooling headroom. Despite having four fans, the temperatures didn't quite match the best results we've seen, but with all the cases in the graphs having similar mesh designs with several included fans, the results were very close.

The Observatory Z Mesh ARGB managed a CPU delta T of 48°C, which was noticeably cooler than the Fractal Design Meshify 2 Compact, but the louder, more powerful fans in the Antec DF700 Flux managed to knock an extra degree off at 47°C. The GPU delta T of 42°C was slightly better than the Antec case, but the Fractal Design Meshify 2 Compact and Corsair 5000D Airflow were slightly cooler. Either way, there's not much in it.

Conclusion

This is a solid and highly flexible case in terms of both air and water cooling. The RGB fans look fantastic and they're quiet as well. The only issue is that there aren't really any stand-out features, such as the removable roof with the Fractal Design Meshify 2 Compact, or the Antec DF700 Flux's superb value. However, if you want a capable case for a high-end system that looks great out of the box, but costs just £120, the Kolink Observatory Z Mesh ARGB absolutely does the job.

ANTONY LEATHER

VERDICT

Kolink continues to improve its case designs, with this affordable, flexible and capable case.

GREENWICH OBSERVATORY

+ Good cooling
+ Excellent water-cooling support
+ Reasonable price

TOILET ROLL TELESCOPE

– Not many other stand-out features
– Panels are tough to remove
– Could do with more powerful fans

COOLING **25/30**

FEATURES **15/20**

DESIGN **25/30**

VALUE **17/20**

OVERALL SCORE **82%**

ATX CASE

NZXT H7 FLOW / £120 inc VAT

SUPPLIER overclockers.co.uk

FLOW CHART

+ Good cooling
+ Excellent water-cooling support
+ Reasonable price

FLOW TEST

– Not many other stand-out features
– Fans are quiet but underpowered
– No microphone port

While NZXT has been dipping its toes into the pools of peripherals and motherboards recently, it's better known for its cases and its ATX line-up has just received a refresh recently with a trio of new models. The range caters for three different markets, with the two cheaper models offering high-airflow or closed-panel designs, while the top-end model offers all-glass panels, as well as software control. We're looking at the high-airflow model this month, which is the £120 H7 Flow.

It comes in either black or white, and it's reasonably compact, measuring 50cm tall and 48cm deep, while its width of 23cm enables the case to offer 185mm of CPU cooler clearance. The graphics card clearance stands at 400mm, but while there's no vertical GPU mount in the case, NZXT's recent flurry of launches included a universal vertical mount, and with three PCI-E slots to shift dual-slot GPUs away from the side panel, it's probably a better option than a fixed mount anyway.

As its name suggests, the H7 Flow also has a large mesh on its front panel and in the roof section, so it's geared towards offering high airflow with low fan speeds. There are a few useful features on the case's exterior, such as tool-free side, front and roof panels that simply pop into place. There's also a removable front fan mount, which you can detach in order to fix fans and radiators to it, rather than having to do it awkwardly inside the case. There are dust filters all around the interior too, with the roof part sitting under the main panel and held in place using magnets.

Meanwhile, the front panel is a basic affair, with a pair of USB 3 ports, a USB 3.2 Gen 2 Type-C port and a single audio jack output for a headset. However, that means there's no microphone input, so you'll need to use your motherboard or sound card's own input or a USB headset in order to be able to talk to people. The H7 Flow's exterior is otherwise unblemished, while the H7 Elite and H7 have extra vents in their side panel to boost cooling, due to them lacking a vented front panel.

Out of the box, the three cases' fan arrangements differ too, with the H7 and H7 Flow offering front and rear 120mm fans that spin up to 1,200rpm, while the H7 Elite includes four larger 140mm fans. The roof and front fan mounts can house up to 360mm radiators, with the front section also able to house up to three 140mm fans, and with space for 60mm-thick radiators, making it an excellent case for water-cooling systems or AIO liquid coolers.

If you're looking to add a bunch of hard disks, sadly there's just the basic two 3.5in mounts in a removable cage in the base of the case, which can also be used for 2.5in SSDs, in addition to four dedicated mounts for the latter behind the motherboard tray and on top of the PSU cover.

The H7 Flow also offers decent cable-routing options. If you detest cable ties and prefer large Velcro straps then you're in luck, as the H7 Flow has two large cable runs equipped with Velcro ties to secure the usual cables, such as the 24-pin ATX connector, PCI-E cables and any other wires at the front of your case. There are Velcro ties at the top and to the rear edge of the motherboard tray too, and the positions of cable-routing

SPEC

Dimensions (mm)
230 x 480 x 505 (W x D x H)

Material
Steel, plastic, glass

Available colours
Black, white

Weight
10.05kg

Front panel
Power, 1 x USB 3.2 Gen 2 Type-C, 2 x USB 3, stereo

Drive bays
2 x 2.5in/3.5in, 4 x 2.5in

Form factor(s)
E-ATX (up to 272mm) ATX, micro-ATX

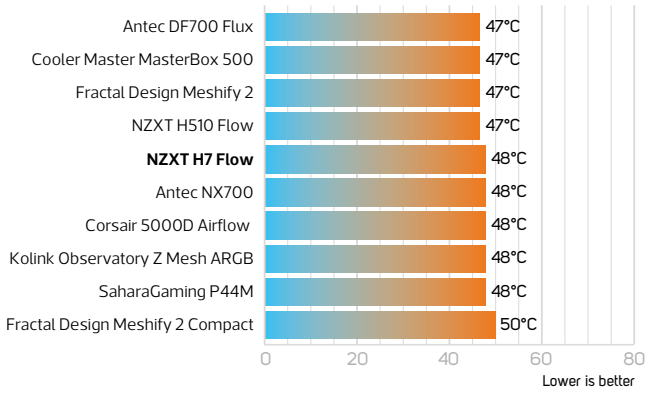
Cooling
3 x 120mm/3 x 140mm front fan mounts (1 x 120mm fan included), 1 x 120mm/140mm rear fan mount (120mm fan included), 3 x 120/2 x 140mm roof fan mounts (fans not included)

CPU cooler clearance
185mm

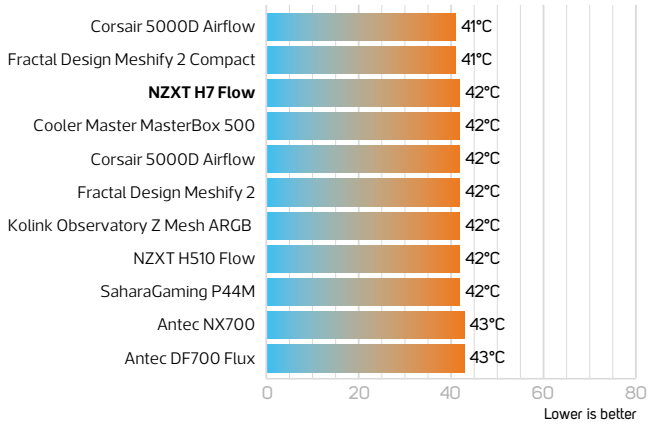
Maximum graphics card length
400mm

TEMPERATURE RESULTS

CPU DELTA T



GPU DELTA T



holes have been well considered. There's a routing hole at the top of the motherboard tray that runs for around 10in to cater for motherboards that have sockets in various places, such as most AMD Threadripper TRX40 models.

However, it's a shame the case doesn't have full E-ATX support, with the width limit set at 272mm. The main holes at the front of the case have a large cover to hide them as well. Overall, it's an easy case to keep tidy, with plenty of stowage for excess cables, lots of anchor points and cable ties. Build quality is also excellent throughout, with minimal panel gaps and all the parts fitting snugly together.

Performance

With the fans peaking at a speed of 1,200rpm, they're not particularly powerful, so it wasn't a surprise to see the H7 Flow return middling results with the CPU and GPU delta temperatures. However, the flip side is that it's extremely quiet, even with the fans at full speed. The CPU delta T of 48°C was on par with the Antec NX700 and Corsair 5000D Airflow, while the Antec DF700 Flux, Fractal Design Meshify 2 and Cooler Master MasterBox 500 were a little cooler. However, the NZXT was a couple of degrees cooler than the Fractal Design Meshify 2 Compact.

The GPU delta T sat at 42°C after our testing, which again is in the middle of the results and lacks the clout of cases such as the Corsair 5000D Airflow, while just pipping the Antec DF700 Flux and Antec NX700 to the post, albeit by just a single degree.

Conclusion

At a price of £120 inc VAT, the NZXT H7 Flow is well priced given what's on offer, which is just as well, as the competition is fierce. The Fractal Design Meshify 2 Compact sports a similar specification and a removable roof section that helps to set it apart, but with slightly reduced radiator and storage support, and lower CPU cooler clearance. Corsair's 5000D Airflow costs £20 more, but does offer an even better basis for a water-cooled PC, although it doesn't include more fans or storage mounts.

Overall, then, the H7 Flow is an attractive, well-priced case with good cooling and massive potential for expansion in terms of both air cooling and water cooling. We'd have liked to see full E-ATX motherboard support, although the 272mm width limit does cater for most large PCBs. The lack of a microphone front panel jack, and limited room for hard drives, may be an issue for some people, but not if you're using a USB headset and SSDS. It also lacks stand-out features compared with the competition, but this is otherwise a great case for the money.

ANTONY LEATHER

VERDICT

An excellent, attractive ATX case that's also well priced.

COOLING **25/30**

FEATURES **15/20**

DESIGN **26/30**

VALUE **18/20**

OVERALL SCORE **84%**

GAMING CHAIR

BACKFORCE ONE / €553 inc VAT (~£471 inc VAT)

SUPPLIER backforce.gg

BACKED UP

+ Good seat padding
+ Solid build quality
+ Pleasant fabric finish

BACKED DOWN

– Lack of adjustability
– Insufficient lumbar support
– Stiff castors

The latest gaming chair to find its way into our lab is a little different from the norm. Rather than clearly being made by the exact same company but rebadged, as is the case with some prominent chair manufacturers, the Backforce uses a different manufacturer to most of these brands and has quite a few features that set it apart from their chairs.

The overall aesthetic is familiar though. The seat is reminiscent of the racing/bucket seat styling seen on many gaming chairs, with an integrated headrest, high shoulder supports and a seat with raised sides.

We tested the 'OG' all-black version, so the styling is muted, but other options add coloured highlights to the shoulder fins, headrest, slashes in the lower back padding and various other areas of the seat.

The OG version is also all-fabric, whereas other colour versions incorporate some faux leather elements. You can also add custom-stitched, Velcro-attached patches to the tops of the shoulder fins, for showing off your gamer tag.

Around the back of the seat, it uses a fixed hard plastic shell that means there's no adjustment for lumbar support or the headrest, as is common with gaming chairs. There's also a sunken circle in the plastic, just below the headrest. Here, you can add an included RGB-illuminated module that again lets you add your gamer branding to the back of the chair.

The general lack of adjustment in the seat means that, despite being rated for sitters of between 4ft 11in and 6ft 3in, as a 6ft 2in tester, I found it didn't really fit my frame. In particular, the lack of lumbar support meant I was forced into a slightly hunched position, while the diagonal-patterned shoulder padding section prodded into the top of my back.

The armrests also didn't rise far enough to meet my arms, or reach over the desktop while in a normal sitting position. I resorted to adding a cushion behind my lower back for more lumbar support, but this then exposed the lack of seat length adjustment.

Our 5ft 2in tester had more luck, with the headrest aligning better, the seat proving sufficiently deep and the armrests providing good support – the padding on them is softer than on several gaming chairs too. Backforce also offers the One Plus, which includes seat depth adjustment, and upholstered, more adjustable armrests.

One universal positive is the seat padding, which is sufficiently soft and supportive, and rolls off on the front edge, so it doesn't dig into the underside of your legs. Many gaming chairs get even this basic feature wrong.

The chair also offers height adjustment and a recline feature. The tension of the latter can be adjusted via a knob on the right, and the chair can be locked in position by a knob on the left side. It's not the slickest, most easy-to-reach system but it works okay.

Meanwhile, the recline feature doesn't offer a particularly relaxing and supportive position – the seat doesn't tilt enough along with the back – but it works without having to rest your feet on a footrest to keep them held up, which is more than can be said for some gaming chairs.

Overall build quality is very good, with the whole chair being very sturdy, and the base and gas lift not wobbling at all. The castors are a bit stiff though – you won't win any office chair races riding this steed.

Conclusion

It's good to see a new face and genuinely different design in the gaming chair space, but the Backforce One still suffers from several of the same problems that blight its competitors. Namely, comfort levels are relatively poor for the high price, and there's not enough adjustability where it matters, particularly regarding lumbar support. The build quality of the Backforce One is excellent, though, plus there are lots of different colour options and it's considerably more comfortable than some gaming chairs.

EDWARD CHESTER

VERDICT

A solid gaming chair, but many conventional office chairs offer better comfort for the price.

COMFORT 15/25
DESIGN 18/25
FEATURES 22/25
VALUE 18/25
OVERALL SCORE 73%

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SUPPLIER amazon.co.uk

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+ Excellent overall performance
+ Plenty of features
+ Wired and wireless modes

FULL TO BURSTING

– Not all that light
– Slightly odd shape
– Divisive styling

The new Roccat Burst Pro Air takes the small and lightweight design of the Burst Pro and adds a wireless connection. It also includes a translucent body packed with RGB lighting, a stated 100-hour battery life, water resistance, Nvidia Reflex compatibility and a 19,000 DPI sensor, putting this rodent right at the forefront of mouse technology.

For all its features, though, it's the design of this mouse that's likely to tempt or dissuade most users – as is often the case with gaming mice, given the subjective nature of mouse shape and styling. In particular, it's this mouse's narrow-fronted, flared rear shape that will make or break it.

When using a fingertip grip, we found our fingers tended to slide slightly towards the narrow front and down the sides. Not only did we find this made for a less secure grip than mice shapes that guide your fingers into a central divot (via a front that flares out slightly), but this design also makes the Burst Pro Air slightly back heavy. The whole mouse isn't that light by today's standards either at 81g. Plenty of wireless alternatives dip well below 70g these days.

What's more, the shape of the rear doesn't have particular advantages for other grip styles. Claw grip suffers from the same issues as fingertip grip, while there's not enough overall bulk to make for a relaxed palm grip. The size and shape of the mouse works a little better for smaller hands, but while many companies are now embracing producing two sizes of flagship mouse, there's only one size of the Burst Pro Air.

Another potentially contentious design decision is the styling and the RGB lighting. The whole central top section of the mouse is translucent and backlit by several RGB zones. It's an impressive display, but it strays some distance from the sleeker designs favoured by many mice and mice users.

Elsewhere, though, the Burst Pro Air consistently impresses. Up front is a USB Type-C socket for charging the mouse, plus you can also run the mouse via its lightweight USB cable. Up top, the selection of buttons is typical, with left, right, middle, back and forward buttons, plus a top-mounted DPI button.

There are no additional buttons, but the standard buttons all fall easily to hand and have a precise, light action, plus the switches are rated to last 100 million clicks. Likewise, the scroll wheel is light, with a very grippy rubber cover and distinct scrolling notches, for precise control in games. Meanwhile, the underside has a slider for switching the mouse between standard wireless mode, Bluetooth and turning off the mouse. Alongside this is a profile button and a useful storage space for holding the wireless dongle.

Tracking performance from the company's Owl-Eye 19K optical sensor is flawless, as is the wireless performance. Nvidia's Reflex technology uses software optimisation to reduce overall system latency between clicking a mouse button and seeing the result on-screen. It doesn't make for a revolutionary change to gaming performance, and it only works with certain games, but it's one more flag in the cap of this mouse.

SPEC

Weight
81g

Dimensions (mm)
58 x 120 x 38 (W x D x H)

Sensor
Roccat Owl-Eye 19K (based on the PixArt PAW3370) optical, 19,000 DPI, 50G acceleration, 400 IPS

Buttons
6 (left, right, middle, forward, back, DPI)

Cable
1.8m, lightweight braided

Extras
RGB lighting

Conclusion

The Roccat Burst Pro Air's style and shape is less appealing to us than those of several competitors, but these are highly subjective factors. Otherwise, the Burst Pro Air delivers in spades, with excellent performance, great battery life and some useful extra features, all for a decent price.

EDWARD CHESTER

VERDICT

A potentially divisive design, but the Burst Pro Air otherwise offers excellent overall performance and decent value.

DESIGN 12/20
FEATURES 18/20
PERFORMANCE 28/30
VALUE 22/30

OVERALL SCORE 80%

GAMING HEADSET

AUSTRIAN AUDIO PG16 AND PB17 / £130 inc VAT

SUPPLIER game.com

VIENNA

+ Smart styling
+ Excellent sound quality
+ Light, compact design
+ Decent value

THIS MEANS NOTHING TO ME

− Not the most comfortable
− Cable too short
− No volume control

Austrian Audio is a relatively new entrant to the professional audio space, founded by former AKG engineers after that company closed its original Austrian facilities. The new brand has now entered the headset space with the introduction of the PB17 business headset and PG16 gaming headset.

The two headsets are physically identical, other than the grey (pictured) or red highlights on each one, plus the PG16 comes with a licence for the company's spatial audio software. Like Razer's equivalent software, it uses THX Spatial Audio technology to provide virtual surround sound for your stereo headphones. As we've come to expect from THX Spatial Audio software, it works very well.

The design is minimalist, with no RGB lighting or much in the way of extra features. The slim headband has a memory foam-padded central section, with telescoping arms for fit adjustment, plus they fold inwards to make the headset more compact for transporting – a fabric bag is included for carrying them.

The earcups spin on the ends of the arms and can pivot in and out too. They have a closed-back design with deep memory foam padding. The whole headset weighs 265g, which is fairly light – the Corsair Virtuoso, for instance, weighs 100g more.

This overall combination should offer decent comfort, but we encountered a couple of issues. The first is that the earcup padding pushed a little harder on the arms of our glasses than some alternatives. The exact effect will depend on the arm design of your glasses, but we noticed a relatively quick onset of discomfort.

Despite this, the overall fit is a touch loose too, putting more weight on the narrow headband than usual, further causing slight comfort issues with longer use. It's far from a bad showing, but it's not the most comfortable headset we've used.

We also found the 1.4m detachable cable to be a bit short for desk use. It's only just long enough to reach on-desk audio devices, and would struggle to reach around the back of many PCs. Having the cable plug into the right earcup, while the microphone is on the left earcup, also makes for a confusing break with convention. An on-headset volume control would have been handy too.

Meanwhile, the microphone is on a rotating and bendable arm but isn't removable. Its quality is adequate for chat but not for professional recording. The integral foam wind blocker is a welcome addition though.

Where this headset really shines is in the sonic performance of its headphones. Overall detail is superb, reproducing every subtle in-game footstep or musical intricacy. The reasonably flat sound profile also ensures there's no exaggerated bass or treble, providing a realistic presentation. The headset can produce those tones, but they're not forced on you. This results in a less bombastic sound than some headsets, but if you're after detail and accuracy, it delivers in spades. The closed-back design also blocks out external noise well.

SPEC

Dimensions (mm)
205 x 180 x 80 (W x D x H)

Weight
265g

Audio config
Stereo and virtual surround

Headphone frequency range
12Hz-24kHz

Sensitivity/sound pressure level
113dB

Mic frequency response
Not stated

Mic sensitivity
Not stated

Cable
1.4m (3.5mm combi jack to 3.5mm combi jack)

Battery life
N/A

Extras
3.5mm combi jack to 2 x 3.5mm jack adaptor (for separate mic and headphone), spatial audio software for the PG16, cloth carry bag

Conclusion

A clear sound profile makes these headsets excellent for those seeking accuracy in their music listening and clarity in the reproduction of in-game details. The smart-looking, compact and folding design also makes them practical to move around. However, the cable is a bit short for desk use, there's no volume control, comfort isn't the best and the highly detailed presentation won't suit those who prefer a bassier tone.

EDWARD CHESTER

DESIGN 16/20
FEATURES 14/20
SOUND QUALITY 32/40
VALUE 16/20

OVERALL SCORE 78%

VERDICT

Excellent clarity and decent value, but there are a few comfort and practicality issues.

GAMING LAPTOP

ASUS ROG ZEPHYRUS M16 GU603ZW / £2,499 inc VAT

SUPPLIER laptopsdirect.co.uk

The Zephyrus M16 is the latest laptop to bridge the gap between conventional 15.6in portables and huge 17.3in machines. This Asus laptop gets off to a great start with a mature, robust aluminium chassis, and its 2kg weight and 20mm thickness significantly undercut the Asus ROG Strix Scar 15. Impressively, it's no wider either.

The slim design still houses meaty components. There's a GeForce RTX 3070 Ti, with its 8GB of memory and 5,888 CUDA cores, albeit with a 100W power limit that hits 120W with Dynamic Boost. Those are decent figures, but they pale next to the 125W and 150W settings of the chunkier Asus Scar 15. The M16 also has a Core i9-12900H CPU alongside 32GB of 4800MHz DDR5 memory and a 2TB SSD with rapid read and write speeds of 7,035MB/sec and 5,108MB/sec. In those latter two areas, the M16 doubles the Scar's capacities.

That's good hardware for such a slim laptop, and the M16 is decent in other practical areas. The keyboard's buttons are solid, fast and have 1.7mm of travel. Its trackpad is fine as well, but any gamer should use a USB mouse instead.

On the right-hand edge, the M16 has a full-sized USB 3.2 Gen 2 port and a microSD card reader, while on the left-hand side, you'll find another USB port, Type-C port and Thunderbolt 4 sockets and an HDMI 2b output. You can also get connected via Gigabit Ethernet, dual-band 802.11ax Wi-Fi and Bluetooth 5.2. The M16 also has a webcam with Windows Hello support, which the Scar omitted.

This specification will sate most gamers, but there are some areas where the M16 is found wanting. The Scar has 2.5Gbps Ethernet and an HDMI 2.1 output, for example, as well as a firmer, crisper keyboard with per-key RGB LEDs rather than single-zone lighting.

Also, while the M16 has a 165Hz display, the Scar runs its 15.6in panel at 240Hz. The model we've reviewed (GU603ZW-K8015W) costs £2,499 too, which makes it £100 pricier than the Scar.

SPEC

CPU
2.5GHz Intel Core i9-12900H

Memory
32GB 4800MHz DDR5

Graphics
Nvidia GeForce RTX 3070 Ti 8GB

Screen
16in 2,560 x 1,600 IPS 165Hz

Storage
2TB Samsung PM9A1 M.2 SSD

Networking
Gigabit Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5.2

Weight
2kg

Ports
1 x Thunderbolt 4/USB Type-C/DisplayPort, 1 x USB 3.2 Gen 2 Type-C, 2 x USB 3.2 Gen 2, 1 x audio, 1 x HDMI 2b, 1 x microSD

Dimensions (mm)
355 x 243 x 20 (W x D x H)

Operating system
Windows 10 Home 64-bit

Warranty
One year parts and labour return to base

PERFORMANCE

The M16's RTX 3070 Ti is a good mainstream chip, but its power limit holds it back. At 1080p, the M16 delivered decent 99th percentile frame rates of 44fps and 48fps in Assassin's Creed Valhalla and Cyberpunk 2077 respectively, but those figures declined to 34fps and 30fps at the laptop's 2,560 x 1,600 native resolution.

You'll get noticeable slowdown at this resolution unless you compromise on graphics settings. More evidence on the M16's limited pace comes from Metro Exodus – the M16's 2,560 x 1,600 average of 38fps improved to 45fps with High ray tracing and DLSS enabled, but you'll need to really hack down the settings to achieve a consistent 60fps frame rate. The situation was better in Doom Eternal, where the M16 averaged 218fps and 149fps at its two resolutions – this machine can definitely cope with less demanding games at high frame rates.

There's clear air between the M16 and the Scar, though, which shows the compromise involved with buying a slim gaming laptop. The Scar delivered 1080p 99th percentile results of 52fps and 57fps in Assassin's Creed, for example.

This is no surprise given the GPU's power draw performance. In the M16's default Balanced mode, the GPU used 80W, but deploying Turbo mode saw that figure rise to between 100W and 110W. In that mode, the M16's 2,560 x 1,600 Metro Exodus average jumped from 38fps to 46fps, and its Doom Eternal score improved from 149fps to 166fps. There are gains to be made here, even if those scores still can't match the Scar.

We observed a similar situation in application benchmarks. The M16's overall RealBench system score

ZEUS

- + Slick, sleek design
- + High-quality, high-resolution 165Hz display
- + Crisp, fast keyboard
- + Decent mainstream gaming performance

CRONUS

- – Too hot and often too loud
- – Thicker rivals are comfortably faster
- – Better value available elsewhere

of 262,476 shows it's quick enough to handle mainstream content creation, editing and multi-tasking, but the Scar scored 291,826 with the same CPU. In the M16's Balanced mode, the CPU's P-Cores topped out at 2.4GHz in a multi-threaded benchmark and in a single-threaded test, they hovered between 4.3GHz and 4.6GHz, with neither speed close to the chip's theoretical peaks. Using the Turbo mode saw the rig's overall score only improve to 268,646.

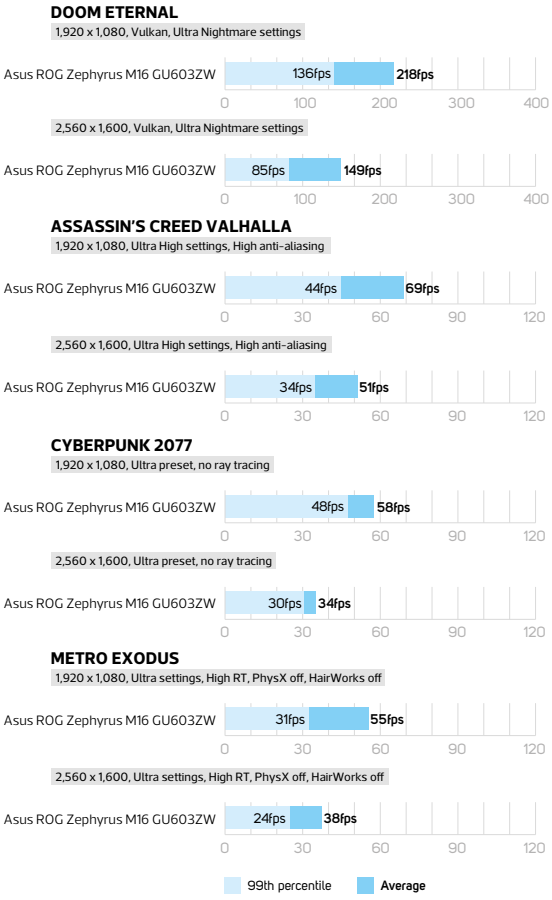
That Turbo mode does deliver a bit of extra performance, but the downside is noise and heat. In Turbo mode, when running games or tough single-threaded workloads, the M16 is louder than most laptops, the processor nearly hit 100°C before throttling and the metal around the keyboard became too hot to touch. The M16 produced moderate noise in its Balanced mode, but the exterior exhibited similarly overwhelming heat. Not surprisingly, the larger Scar was cooler and quieter.

If the heat and noise do become unbearable, the M16's Silent mode is decent – it runs games at speeds that hover between 40fps and 60fps while keeping down noise levels down. Arguably, though, that negates the point of a high-end gaming laptop entirely.

The M16 was inconsistent in battery tests too. Its gaming lifespan of one hour, six minutes is underwhelming, but it did last an excellent eight hours when playing a movie and four hours during a work test. Those latter scores are decent, but you'll want to stay connected to the mains for any gaming.

On the plus side, the display is excellent. The 16:10 aspect ratio and 2,560 x 1,600 resolution deliver crisp imagery and extra vertical room when compared with 16:9 rivals, and the contrast ratio of 1,221:1 combines with a peak brightness of 476cd/m^2 for superb vibrancy and punch. The delta E of 2.43 is good, the display renders almost 100 per cent of the sRGB and DCI-P3 gamuts, and the 165Hz refresh rate is fine for mainstream gaming. The speakers are great too – they sound loud and balanced, with serviceable bass.

BENCHMARK RESULTS



65,048
GIMP IMAGE EDITING

752,023
HANDBRAKE H.264 VIDEO ENCODING

204,954
HEAVY MULTI-TASKING

262,476
SYSTEM SCORE

CONCLUSION

That 16in display is great, and elsewhere the Zephyrus supplies solid mainstream performance in a slim, light design with a satisying keyboard and good connection options. There's no denying that the slim chassis creates issues though. The M16 is hotter, louder and slower than the chunkier 15.6in Scar – and it's pricier too. If you'd prefer a svelte gaming laptop, you'll have to accept those compromises, but your money will go further on a machine with a chunkier chassis that allows the components to breathe.

MIKE JENNINGS

PERFORMANCE 20/25
DESIGN 19/25
HARDWARE 22/25
VALUE 19/25
OVERALL SCORE 80%

VERDICT

This slim, light and smart laptop has decent pace and a great screen, but it's hot and loud in operation.

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- GIGABYTE Z690 GAMING X DDR4
- 16GB Corsair VENGEANCE RGB PRO 3600MHz
- 8GB NVIDIA GEFORCE RTX 3070 Ti
- 1TB PCS PCIe M.2 SSD
- 2TB SEAGATE BARRACUDA HDD
- Windows 11 Home

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PCSpecialist

INTEL Z690 GAMING PC

CYBERPOWER HYDRO-X INFINITY RTX / £4,699 inc VAT

SUPPLIER custompc.co.uk/CPHX

CyberPower's Hydro-X Infinity RTX has a massive price tag of £4,699, which is about as expensive as PCs get before you head into dream PC territory, and that's no wonder when you consider the components. This machine pairs a beefy Intel Core i9-12900KS CPU with an overclocked Nvidia GeForce RTX 3090 Ti GPU.

The MSI-made graphics card runs its boost clock at 1920MHz rather than the conventional 1860MHz, and the GPU packs 10,752 stream processors and 24GB of GDDR6X memory. Meanwhile, Intel's top-of-the-line Alder Lake chip has eight Hyper-Threaded P-Cores that theoretically peak at 5.4GHz, or 5.5GHz with Thermal Velocity Boost.

The rest of the hardware is suitably muscular, with 32GB of dual-channel DDR5 memory running at 4800MHz and a 2TB Kingston Fury Renegade PCI-E 4 SSD with impressive read and write speeds of 7,106MB/sec and 6,801MB/sec. It's all powered by an MSI MPG A850GF, which is a fully modular 80 Plus Gold PSU with an 850W power rating – no issues there.

Meanwhile, the serious-looking MSI MAG Z690 Tomahawk motherboard sports huge black heatsinks and no RGB LEDs. It has three 16x PCI-E slots, one of which supports PCI-E 5, and three of its four M.2 slots use PCI-E 4. The PCB also serves up decent Realtek ALC4080 audio, while networking comes from 2.5Gbps Ethernet and dual-band 802.11ax Wi-Fi. The rear I/O panel is solid too, with a USB 3.2 Gen 2x2 Type-C port that rattles along at 20Gbps, and there are three USB 3.2 Gen 2 Type-A ports and four slower ports.

CyberPower's rig has an imposing specification, but this isn't the only recent system we've seen in this price range. Scan's £4,899 3XS Torrent Ti used an RTX 3090 Ti and a marginally slower i9-12900K, but it had 64GB of 5200MHz DDR5 memory. It had a better motherboard too, but it only had an air cooler on the CPU, compared with the CyberPower's brilliant hard-tube custom water-cooling system.

That's a highly potent cooling system for just the CPU, but our tests have shown the Core i9-12900KS to be a toasty customer, and this custom loop will be able to cool it properly. The GPU isn't water-cooled, but on the plus side, that means you can easily upgrade the graphics card at a later date. CyberPower has also added RGB LED lighting strips, and the machine's eight case fans glow with coloured illumination – the interior looks fantastic.

All this gear is housed in a Corsair 7000D Airflow chassis. It measures 600mm tall and 550mm deep, so it's huge, and it has impeccable build quality and mature looks. Both the side panels are hinged, the roof and front panels pop free, and CyberPower has kept the interior tidy.

You get a decent warranty as well, with two years of the all-important parts and labour cover, plus a further three years labour only, including six months of collect and return service. The Scan is better here, though, offering three years of parts and labour cover, and a year of on-site repairs.

SPEC

CPU
3.4GHz Intel Core i9-12900KS

Motherboard
MSI MAG Z690 Tomahawk WiFi

Memory
32GB Corsair Vengeance 4800MHz DDR5

Graphics
MSI GeForce RTX 3090 Ti 24GB

Storage
2TB Kingston Fury Renegade M.2 SSD

Networking
2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5.2

Case
Corsair 7000D

Cooling
CPU: 2 x Corsair Hydro-X XR7 360mm radiators, Corsair Hydro XD5 RGB pump/reservoir, Corsair Hydro XC5 waterblock, 7 x 120mm fans; GPU: 3 x 90mm fans; rear: 1 x 120mm fan

Ports
Front: 4 x USB 3.1, 1 x USB 3.2 Gen 1 Type-C, 1 x audio; rear: 1 x USB 3.2 Gen 2x2 Type-C, 3 x USB 3.2 Gen 2, 2 x USB 3.2 Gen 1, 2 x USB 2, 1 x optical S/PDIF, 5 x audio

Operating system
Windows 11 Home 64-bit

Warranty
Two years parts and labour, plus three years labour only. Six months collect and return, then return to base

HERCULES

+ Awesome water-cooling system
+ Superb content creation performance
+ Fast in games

HYDRA

- CPU still can't hit peak speed
- Very high price
- Noticeable fan noise

PERFORMANCE

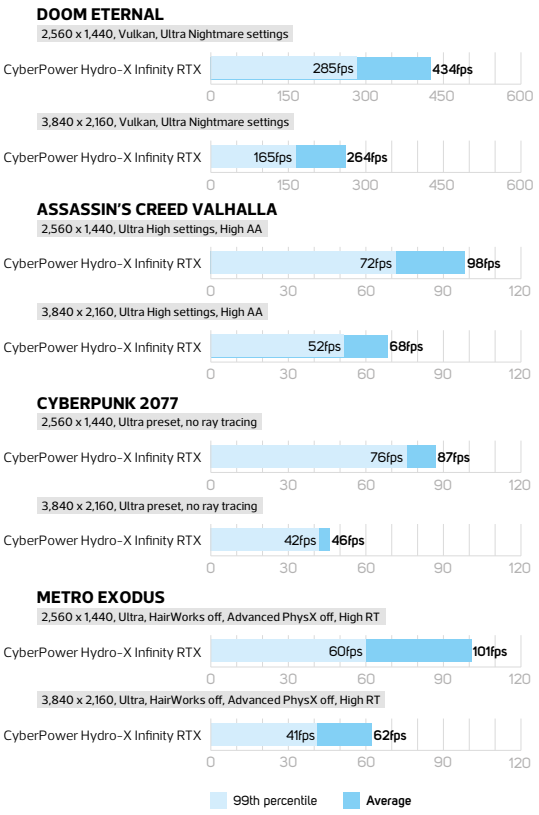
With its huge cooling system and top-end CPU, CyberPower's PC overhauled the Scan in application benchmarks. The i9-12900KS scored 82,455 in our image editing test, which stresses single-threaded performance, and 1,165,921 in our heavily multi-threaded Handbrake benchmark – a 12.5 per cent improvement on the Scan in the first test and a 5.5 per cent gain in the second.

That said, even this monster cooling system couldn't enable the CPU to get beyond 5.2GHz in our benchmarks, and it still peaked at 77°C during stress tests, which is right at this CPU's thermal limit. Also, while the CyberPower is never ruinously noisy, it's consistently audible when idle, and it's louder in gaming and multi-threaded tests. If you play loud music, use a headset or have your PC hidden away behind a desk, it's not an issue, but this system isn't suitable for near-silent working conditions. Scan's PC might not have the sheer CPU grunt or high-powered cooling system, but it's quieter.

Where this PC does excel, though, is in games. In our 4K Assassin's Creed Valhalla benchmark, the Hydro-X returned a 99th percentile of 52fps with an average of 68fps, and its 264fps average in Doom Eternal at 4K is superb – you can easily play undemanding games at 4K on monitors with high refresh rates.

There's room to enable ray tracing at 4K too, with the CyberPower averaging 62fps in Metro Exodus with High ray tracing, and it will be even quicker with DLSS enabled. The only game where the CyberPower struggled at 4K was Cyberpunk 2077 but, to be fair, all systems struggle with this test, and you'll be able to get it running if you drop the settings a little. Comparatively, the CyberPower was marginally slower than the Scan in many tests, but only by a couple of frames per second here and there.

BENCHMARK RESULTS



CONCLUSION

CyberPower's Hydro-X Infinity RTX offers sensational application and gaming speed, along with a great-looking water-cooling system. Given the cost of the latter, and the superior CPU, it's a better buy than the pricier Scan. The only disappointments are that even a custom water-cooling loop with two radiators can't free up the toasty Core i9-12900KS to hit its peak boost clock, and it's also a bit noisy. The price is also astronomical, of course, but buying the very fastest components always demands a premium, and CyberPower has housed them in a well-built, good-looking and very fast machine.

MIKE JENNINGS

VERDICT

Fantastic performance and an awesome water-cooling system, but you pay a premium for these top-line components.

PERFORMANCE **25/25**

FEATURES **23/25**

FEATURES **23/25**

VALUE **19/25**

OVERALL SCORE **90%**

INTEL Z690 GAMING PC

CCL HORIZON 5 INTEL RTX 3080 GAMING PC / £1,889 inc VAT

SUPPLIER custompc.co.uk/CCL3080

CCL's Horizon 5 Intel RTX 3080 Gaming PC uses Nvidia's veteran Ampere GPU, but there's still plenty to like about the aging 10GB GeForce RTX 3080 – it packs an impressive 8,704 stream processors into its core. What's more, in this machine, the MSI card overclocks the boost core from 1710MHz to 1740MHz.

Alongside that GPU Intel's mid-range Core i5-12600K Alder Lake CPU, featuring six Hyper-Threaded P-Cores with a top boost speed of 4.9GHz, along with four energy-efficient E-Cores. That's a perfectly decent CPU for gaming, and CCL has also specced up 16GB of 3200MHz DDR4 memory and a 1TB SSD. The drive in our test system is a WD Blue SN750 with mid-range read and write speeds, but at retail, CCL has swapped in a Samsung 980 that will be a bit faster.

Meanwhile, the reassuringly familiar Corsair RM750x power supply delivers 80 Plus Gold certification and modular design, and CCL offers one of the best warranties you'll find from any British builder, with three years of on-site service covering both parts and labour.

You get a half-decent motherboard too, which includes Intel's top-end Z790 chipset. Its primary 16x PCI-E slot supports PCI-E 5, and you get an impressive trio of 2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi and Bluetooth 5.2. The board has a generous total of four M.2 connectors, all with PCI-E 4 support, and elsewhere, this unassuming PCB has a Thunderbolt header and a great rear I/O panel. There's a super-fast USB 3.2 Gen 2x2 Type-C connector here, alongside seven other, slower ports. You'll need a pricier board for DDR5 support, but this is an excellent mainstream motherboard.

It's all housed in a Lian Li Lancool II chassis, which is sturdy and solid, and this Snow edition includes striking white panels. Two hinged panels on each side of the case make internal access easy, and throughout the chassis, you'll find room for three hard disks and four 2.5in drives. Extra shrouds around the back hide cables, and CCL's building is consistently tidy.

The radiator for the Corsair Hydro H100x CPU cooler sits in the roof and doesn't impede the motherboard, while the case's three intake fans sit in a removable bracket, so they can easily be swapped for different cooling hardware. There's room for larger graphics cards to be installed, and the bottom of the motherboard is easily accessible. Meanwhile, buttons on top of the chassis alter the RGB LEDs, and the top-mounted I/O panel includes a Type-C connection. The only absence here is fan control, which you'll find on Lian Li's Performance version.

Gaze around the market and CCL's machine offers good value. You won't get an equivalent specification from Chillblast, PC Specialist, Ebuyer or Wired2Fire without spending north of £2,000. Scan and Gladiator offer PCs with the RTX 3080 and Core i7 CPUs for £1,899, but they both have weaker cases and CPU coolers, and Scan's rig has an entry-level motherboard.

SPEC

CPU
3.7GHz Intel Core i5-12600K

Motherboard
Asus TUF Gaming Z690-Plus WiFi D4

Memory
16GB Corsair Vengeance RGB Pro SL 3200MHz DDR4

Graphics
MSI GeForce RTX 3080 10GB

Storage
1TB WD Blue SN570 M.2 SSD, 2TB Seagate Barracuda hard disk

Networking
2.5Gbps Ethernet, dual-band 802.11ax Wi-Fi, Bluetooth 5.2

Case
Lian Li Lancool II Mesh RGB Snow Edition

Cooling
CPU: Corsair Hydro Series H100x with 2 x 120mm fans; GPU: 3 x 90mm fans; front: 3 x 120mm fans; rear: 1 x 120mm fan

Ports
Front: 2 x USB 3.2 Gen 1, 1 x audio; rear: 1 x USB 3.2 Gen 2x2 Type-C, 1 x USB 3.2 Gen 1 Type-C, 2 x USB 3.2 Gen 2, 4 x USB 3.2 Gen 1, 1 x optical S/PDIF, 5 x audio

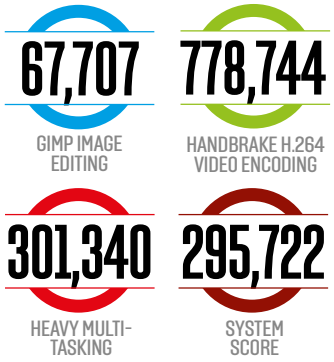
Operating system
Windows 11 Home 64-bit

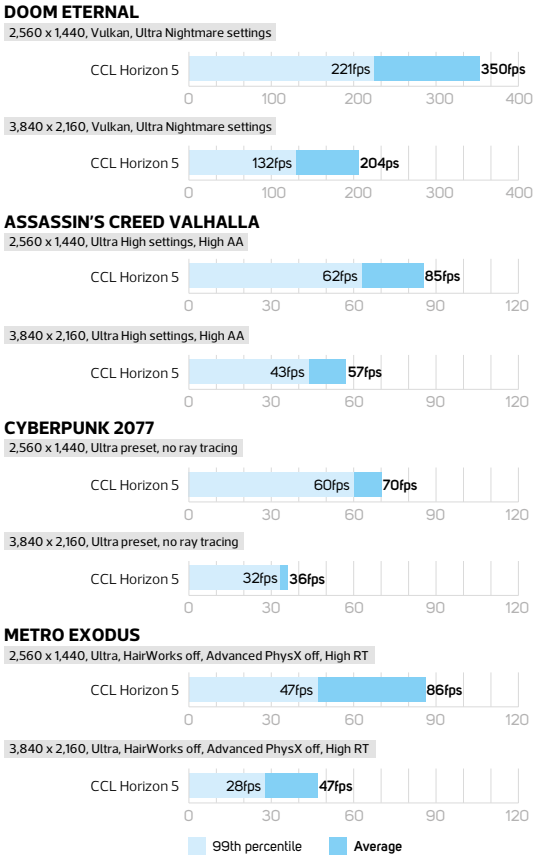
Warranty
Three years parts and labour on-site

PERFORMANCE

The GeForce RTX 3080 makes this sub-£2,000 PC great for gaming at 2,560 x 1,440. It didn't drop below a 99th percentile of 60fps in Cyberpunk 2077 and Assassin's Creed Valhalla, and it only dropped down to 57fps in the former at the Medium ray-tracing preset with DLSS enabled. Its average of 85fps

BENCHMARK RESULTS





in Metro Exodus with High ray tracing is a great result too. Meanwhile, the 350fps average in Doom Eternal shows that this machine has plenty of power for playing undemanding games on monitors at high refresh rates.

It's not so strong at 4K, where you really benefit from stepping up to the much pricier GeForce RTX 3080 Ti – the CCL dropped down to a clunky 28-32fps in Cyberpunk 2077 and Metro Exodus, although it still maintained decent pace in Assassin's Creed Valhalla and a great 204fps average in Doom Eternal. You'll be able to play some games at 4K on this machine, but you'll need to drop the graphics settings to run demanding games at this resolution.

Meanwhile, the Core i5-12600K is adept with everyday workloads, including multi-threaded content creation, and it won't bottleneck games. Its RealBench system score of 295,722 comfortably outpaces similarly priced machines we've seen based on AMD Ryzen 5 5600X and Ryzen 7 5700X chips.

The CCL's only underwhelming result was a comparatively sluggish 67,707 in the image editing test, which stresses single-threaded performance, but the CCL clearly has enough CPU power to handle games.

The relatively modest CPU also ensures that the CCL is a decent thermal performer. The Horizon 5 is never loud – even during the trickiest stress tests, this rig's fan noise was modest. The GPU delta T of 48°C is great, and the CPU's peak of 38°C is similarly impressive. During all-core tests, the processor ran at its expected speed of 4.5GHz, but it never got beyond 4.7GHz in single-threaded benchmarks (it should hit 4.9GHz), which partly explains its slightly poor image editing result.

ZERO DAWN

+ Great 2,560 x 1,440 gaming performance
+ Versatile case
+ Excellent warranty

ZERO HOPE

– CPU slower than usual
– Lacks consistent 4K gaming ability

CONCLUSION

CCL's system supplies solid performance inside an attractive, accessible chassis. It offers great value for the gaming performance on offer, and it has a top-notch warranty. If you'd like more processing power, you can find Core i7 machines elsewhere at this price, but not with this level of GPU power, and if you want more gaming power, you'll have to spend significantly more money. If you're looking for the fastest gaming performance you can get for under two grand, CCL's system is a well-balanced mid-market choice.

MIKE JENNINGS

VERDICT

CCL's Horizon 5 offers great gaming performance for the price, and it's bolstered by a superb warranty.

PERFORMANCE 21/25
DESIGN 21/25
HARDWARE 21/25
VALUE 24/25
OVERALL SCORE 87%

Custom kit

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

SAMSUNG T7 SHIELD / £252.97 inc VAT (2TB); £137.98 inc VAT (1TB)

SUPPLIER scan.co.uk

The Samsung T7 Shield is another solid entry in the field of external SSDs using USB 3.2 Gen 2 to combine previously unthinkable speeds with resilient cases. The case has a rounded rectangular shape with grooves down the sides, as well as a lightly rubbery surface that makes it comfy to carry and easy to grip.

In the case of the T7 Shield, unless you're hovering over a particularly deep pool or up a very high ladder, dropping it won't matter anyway, as it has an IP65 rating against dust and water, and can endure a 3m drop.

A sequential read speed of 1,090MB/sec and write speed of 1,039MB/sec are exactly what you would expect for a drive of this type (and even faster than Samsung's claims), so you can throw your files on it at great speed, or even use it as a portable games drive without being monstered by loading times.

It's on the cheaper side for a drive of this type, and it's very cheerful as well – this is a fast and tough-as-nails external SSD.

Greased ●●●●● Lightning

ARCTIC BREEZE / £14.17 inc VAT

SUPPLIER amazon.co.uk

The ARCTIC Breeze is a USB desk fan that features the same kind of 92mm fan you usually expect to see inside a PC. The construction is solid, there's a heavy base and you get a 1.8m cable, so you can plug it in reasonably far away. Meanwhile, the fan itself sits atop a bendy metal neck, which allows you to aim it where you like. There's no guard, though, so watch those fingers and stray cables.

Power is controlled with a dial on the base, and at the lowest setting of 800rpm, the Breeze is very quiet, to the extent that the sound is barely audible over an air-cooled PC, sounding like just another instrument in the orchestra. At full power, it reaches 1,800rpm and is loud enough to be irritating. Somewhere in the middle is fine. In terms of pushing air around, the Breeze does a surprisingly good job for its size. It's not substantial enough to cool a whole room, but it's good enough for a desk.

Easy ●●●●○ Breezy

LITETOUR DESK CORD ORGANISERS / £7.99 inc VAT

SUPPLIER amazon.co.uk

The evolution of the humble cable tie continues apace with a new incarnation by LiteTour. These cable ties have a flat base with a strip of double-sided tape to anchor them to any given surface; they then use a plastic loop with a ladder-like design to lock the cables in place onto the base. This style of loop offers an immediate and very helpful advantage over regular cable ties, which is that they can be adjusted back and forth, and even reopened once locked, without damaging them.

Locking the loop with the wires in place can be fiddly compared with a regular cable tie, though, and you'll want to tie up the cables first, then attach the base to the solid surface, as doing it the other way round gets fiddly. For fastidious folks, each of the 50 cable ties is also numbered from one to ten, so if you want your cables to be tidied in order, you can put your cable ties in order, so your order is in order.

Fast ●●●●○ Fastidious

COOLER MASTER CONNECT STAND / **£24.99** inc VAT

SUPPLIER amazon.co.uk

The Connect Stand is a handy cooling platform for networking devices that may benefit from more cooling power than they get as standard. The Connect Stand itself is an open-ended stand that measures 74mm high, 295mm long and 170mm wide. It mounts one of Cooler Master's 120mm Sickleflow Reverse Edition fans in the top, and you then place whatever device you want onto the mesh on top of it. Stability is provided by square rubber feet that keep it in place.

For some people, such a stand may seem entirely unnecessary, but if you've ever felt a top-end router or cable modem while it's working like a serf through a pitiless summer, you'll know that such a device could potentially benefit from some extra cooling power, particularly if it's shut away in a cupboard with restricted airflow.

You place the device you want to cool on top of the stand, plug in the USB cable that powers the fan (which thoughtfully has a pass-through port on the back, so it doesn't use up a USB port), and then your device gets the benefit of being lifted off the surface and getting a cool breeze up through its underbelly. The fan is quiet, outputting 22dBA at 1,200rpm, and does the job well. Most networking devices won't need this extra cooling, but if you have a high-powered router in a location with restricted airflow, this little stand provides some extra airflow without making a racket.

Hot ●●●●○ **Cool**

BOOMPODS SOUNDCLIP / **£24.99** inc VAT

SUPPLIER amazon.co.uk

The Soundclip from Boompods is an answer to the question: 'No really, are you sure you haven't attached a Bluetooth speaker to everything?' In a world of suction cups, magnets (and, of course, feet) being used to keep Bluetooth speakers in place, the Soundclip uses a big rubbery loop on its back. Boompods calls it a clip, but it's more like a belt loop. Either way, it works, insofar as it lets you loop the Soundclip onto any object that can accommodate it.

The unit itself is a round, curved speaker, with a comfy pebble shape. It weighs a featherweight 153g, but packs enough battery capacity for seven hours of run-time. As well as a speaker, the Soundclip also functions as an Amazon Alexa compatible device, and can be connected to your home network with an app for remote use, as well as making and receiving phone calls. The sound quality is good, clear and punchy enough for general use. The silicon strap that forms the clip covers the micro-USB port that's used for charging, and also helps to provide an IPX6 waterproof rating. It's a handy mobile alternative to an Echo Dot.

Clip ●●●●○ **Loop**

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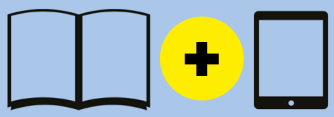

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How we test

MOTHERBOARDS

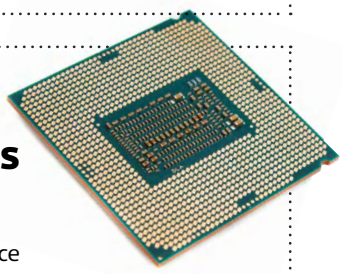
TEST PROCESSORS

- **Intel LGA1700** Intel Core i5-12600K
- **Intel LGA1700 mini-ITX** Intel Core i7-12700K
- **AMD AM4** AMD Ryzen 9 5900X

Common test hardware between our test rigs includes a WD Red SN750 SSD, plus a WD Black SN850 SSD to test the speed of M.2 ports, and an Nvidia GeForce RTX 3070. We use 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz DDR4 RAM, or 32GB (2 x 16GB) of Corsair 5200MHz Dominator Platinum DDR5 RAM.

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 6 on Windows 11. We also test each board's M.2 ports, and record the noise level and dynamic range of integrated audio using RightMark Audio Analyzer.

PROCESSORS



TEST MOTHERBOARDS

- **Intel LGA1700**
  Asus ROG Maximus Z690 Apex
- **Intel LGA1200** MSI MEG Z490 Ace
- **AMD AM4 APU** MSI MPG Gaming B550 Carbon WiFi
- **AMD AM4** MSI MEG X570 Unify

Common gear includes a 2TB Samsung 970 Evo SSD and Nvidia GeForce RTX 3070 FE graphics card. For LGA1700 CPUs, we use 32GB (2 x 16GB) of Kingston Fury 5200MHz DDR5 RAM and a Thermaltake Toughliquid Ultra 360 CPU cooler. For other systems, we use 16GB (2 x 8GB) of Corsair Vengeance RGB Pro 3466MHz RAM and a Corsair Hydro-X water-cooling loop, with two XR5 240mm radiators, an XD3 RGB reservoir and an XC7 RGB waterblock.

We use the latest version of Windows 11 with security updates, plus the latest BIOS versions and drivers. We record results at stock and overclocked speeds, and tests include our RealBench suite, Cinebench, Far Cry 6 and Dirt 5.

For games, we record the 99th percentile and average frame rates either using the game's built-in benchmark or Nvidia FrameView. Finally, we note the idle and load power draw of the whole system, using Prime95's smallfft test with AVX disabled.

MONITORS

We test image quality with an X-Rite iDisplay Pro colorimeter and DisplayCal software to check 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 response time with an Open Source Response Time Tester, and use Blur Busters' ghosting UFO test to check the sharpness of a display in high-speed motion.

CPU COOLERS

We use CoreTemp to measure the CPU temperature, before subtracting the ambient air temperature from this figure to give us a delta T result, which enables us to test in a lab that isn't temperature controlled. We use Prime95's smallest FFT test with AVX instructions disabled to load the CPU and take the temperature reading after ten minutes.

For the Intel LGA1200 system, we take an average reading across all eight cores, and for the LGA1700 system, we take an average reading across both the P-Cores and E-Cores. AMD's CPUs only report a single temperature reading, rather than per-core readings, so we list what's reported in CoreTemp.

TEST KIT
Fractal Design Meshify C case, 16GB of Corsair Vengeance RGB Pro memory, 256GB Samsung 960 Evo SSD, Corsair CM550 PSU.

INTEL LGA1700
Intel Core i9-12900K at stock speed, Asus ROG Maximus Z690 Apex motherboard.

INTEL LGA1200
Intel Core i9-11900K at stock speed with Adaptive Boost enabled, MSI MEG Z590 Ace motherboard.

AMD AM4
Ryzen 7 5800X overclocked to 4.6GHz with 1.25V vcore, or Ryzen 5 5600X overclocked to 4.6GHz with 1.25V vcore on low-profile coolers, MSI MEG X570 Unify 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, using an AOC U28G2XU monitor.

TEST KIT

AMD Ryzen 9 5900X, 16GB (2 x 8GB) of Corsair Vengeance RGB Pro SL 3600MHz DDR4 memory, Asus ROG Strix B550-E Gaming motherboard, Thermaltake Floe Riing 240 CPU cooler, Corsair RM850 PSU, Cooler Master MasterCase H500M case, AOC U28G2XU monitor, Windows 10 Professional 64-bit.

GAME TESTS

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

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

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

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

POWER CONSUMPTION

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

CUSTOM PC AWARDS

EXTREME ULTRA

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

PREMIUM GRADE

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

PROFESSIONAL

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

APPROVED

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

CUSTOM KIT

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

CUSTOM PC REALBENCH

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

GIMP IMAGE EDITING

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

HANDBRAKE H.264 VIDEO ENCODING

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

LUXMARK OPENCL

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

HEAVY MULTI-TASKING

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

LABS TEST

Little mix

Antony Leather tests ten of the latest mini-ITX motherboards, for both Intel and AMD platforms, to find the best options for building a mini PC

How we test

This month we're taking a look at ten mini-ITX boards, catering for current Intel and AMD CPUs at a range of budgets. We have boards based on Intel's B660 and Z690 chipsets for Intel's 12th-gen CPUs, as well as ones that use AMD's B550 and X570 chipsets, which are compatible with AMD's Zen 3 Ryzen 5000-series CPUs.

We've tweaked out test gear this month to focus on using powerful CPUs at stock speed, rather than overclocking them. We're using Intel's Core i7-12700K and AMD's Ryzen 9 5900X, which don't yield significant performance benefits with manual overclocking, and doing it increases CPU heat and causes VRMs to run much hotter too. Both of these hot spots are a bad idea in a mini-ITX system, which is why we've instead focused on stock speed results.

Apart from the two CPUs, our test kit includes an Nvidia RTX 3070 Founders Edition graphics card, and 16GB of 3466MHz Corsair Vengeance RGB Pro RAM, or 32GB of Corsair 5200MHz Dominator Platinum DDR5 memory for DDR5-enabled motherboards.

As some of the motherboards in this month's Labs test only have one M.2 slot, we've used a WD Black SN850 SSD with a Windows 11 installation to test the speed of M.2 ports, rather than an empty SSD, so all the results are comparable.

We use the latest motherboard BIOS versions, plus Windows and driver updates. All the motherboards are tested on a Barrow Rhopilema test bench with full custom water-cooling systems, including two 240mm radiators and a Laing DDC pump to eliminate any cooling bottlenecks.

We'll be looking at VRM and M.2 temperatures, as well as motherboard layouts, features and performance. To test M.2 heatsink performance, we run back-to-back runs of CrystalDiskMark's entire battery of tests to record the peak M.2 temperature. We also use RightMark's Audio Analyzer software to measure the dynamic range, noise level and total harmonic distortion of the on-board audio. Other tests include our RealBench suite of performance benchmarks, Far Cry 6, Cinebench R23's single and multi-threaded tests and total system power consumption measured at the wall.

Finally, our scores are based on a weighted calculation, including performance, features and value, with the overall score being the sum of those three values.

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AMD B550 MOTHERBOARD

ASROCK B550 PHANTOM GAMING-ITX/ax / £200 inc VAT

SUPPLIER scan.co.uk

AMD's B550 chipset is two years old now, but its longevity means the likes of the ASRock B550 Phantom Gaming-ITX/ax are still doing the rounds. As a board we first reviewed back in 2020, it hasn't fallen in price much, still stubbornly staying around the £200 mark, maybe shedding a tenner or two over that time. Thankfully, there are now plenty of options when it comes to Socket AM4 with mini-ITX, but let's see how the Phantom Gaming fares now.

It gets off to a good start with its wide open CPU socket area, which means cooler compatibility is far better than some other boards on test – even the large pump sections and mounting brackets included with the ARCTIC Liquid Freezer II and NZXT Kraken coolers fitted fine. Meanwhile, the 8-phase power delivery system is cooled by a large heatsink on the I/O shroud, but this still saw VRM temperatures measured at a peak of 55°C with our Ryzen 9 5900X under load, which was one of the warmer results on test.

ASRock has managed to shoehorn USB 3.2 Gen 2 compatibility into the board's Type-C header and Type-C port on the rear I/O panel too. Its X570-based bigger sibling might sport Thunderbolt 3, but it lacks a Type-C header, and other boards on test cut back one or both ports to slower and less powerful baseline USB 3 speeds too. It comes up a little short on the number of Type-A ports, though, with just five in total, although they're all at least USB 3 or faster.

There are just three audio ports on this rear panel, with no optical output, but you do at least get Realtek's ALC1220 codec, unlike some other boards. You get the usual 4 SATA 6Gbps ports too, all of which are right-angled to the PCB. Unlike this board's more expensive sibling, it also provides 802.11ax Wi-Fi, 2.5 Gigabit networking and a pair of M.2 ports. The PCI-E 4 M.2 port on the top side of the board is equipped with a heatsink, which kept our SSD to a reasonable temperature of 60°C, while the one underneath the PCB is left to fend for itself, while also being limited to PCI-E 3.

Performance in our benchmarks didn't yield any shortfalls or benefits over the rest of the field, and the ASRock coped well with the mighty Ryzen 9 5900X. Audio performance was decent, with a noise level of -101dBA and dynamic range of 101dBA. On the downside, ASRock's software and EFI are rather clunky and feel very dated – it's a shame they're not up to the standard of the board itself.

Conclusion

Unless you're desperate to get Thunderbolt support on your mini system, the B550 Phantom Gaming-ITX/ax is definitely the better of the ASRock Socket AM4 mini-ITX motherboards on test this month. However, while it has a solid feature set, other manufacturers' B550 boards we've tested are better in a few ways, either being cheaper, providing more features or offering better EFIs and software. As a result, unless you find this board in a cracking deal as Socket AM5 approaches, it's best to give it a miss.

SPEC

Chipset AMD B550

CPU socket AMD Socket AM4

Memory support 2 slots: max 64GB DDR4 (up to 5400MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1220

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

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

Ports 4 x SATA 6Gbps, 1 x M.2 PCI-E 4, 1 x M.2 PCI-E 3, 1 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 1 x USB 3.2 Gen 2 Type-C header, DisplayPort, HDMI, 3 x USB 3, 3 x surround audio out

Dimensions (mm) 170 x 170

PHANTOM TOLLBOOTH

+ USB 3.2 Gen 2 Type-C port and header
+ Modern feature set
+ Spacious CPU socket area

PHANTOM MENACE

– Few USB ports
– Poor EFI and software
– More expensive than competition

VERDICT

A solid enough effort, but it lacks the features needed to justify its current price.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
31/35	23/35	25/30	79%

AMD X570 MOTHERBOARD

ASROCK X570 PHANTOM GAMING-ITX/TB3 / £250 inc VAT

SUPPLIER overclockers.co.uk

Available since the launch of AMD's Zen 2 CPUs, the ASRock X570 Phantom Gaming-ITX/TB3 is quite old in the grand scheme of the Socket AM4 timeline, and it's painfully obvious that this motherboard hasn't aged well either. Compared with the Asus ROG Strix X570-I Gaming, it's lacking in a number of features. For a high-end board that costs £250, it only has one M.2 port, for example, and it's only equipped with four USB ports too.

Admittedly, the X570 Phantom Gaming-ITX/TB3 is the only B550 or X570 mini-ITX motherboard on test to feature Thunderbolt support, so it's likely ASRock assumed you'd be using fancy hubs and other Thunderbolt peripherals instead of USB ports. The early X570 boards that came on the market, including this one, also lacked features we take for granted now, such as Type-C headers, so you're out of luck if your case has a USB Type-C port on its front panel.

There's no M.2 heatsink either, with the single M.2 port located on the rear of the PCB instead. As such, it wasn't surprising to see our PCI-E 4 SSD's temperature rocket to nearly 80°C in under a minute, so we suggest adding a third-party heatsink or opting for a cooler-running PCI-E 3 model.

The CPU socket areas is also unusual, as ASRock opted to have Intel mounting holes rather than Socket AM4 ones, in order to accommodate the 10-phase power delivery system. This at least means that AIO liquid cooler compatibility is reasonable, even if ARCTIC's Liquid Freezer II pump still can't fit.

However, the towering VRM and chipset heatsinks mean that clearance for low-profile air coolers is abysmal. In addition, the noise from the chipset heatsink fan can become quite audible and, unlike the Asus ROG Strix X570-I Gaming, there's no monoblock available for it that removes the fan. The VRMs were relatively cool at 56°C, but the Asus board was noticeably cooler.

The ASRock's fan also spun up noticeably under high loads, although in games and less demanding tasks, it didn't really make much noise. For your own case fans, there are three 4-pin headers, which is typical of most mini-ITX boards. There's also RGB lighting arranged in a strip on the underside of the PCI-E slot, plus 3-pin and 4-pin RGB headers too.

Meanwhile, ASRock's EFI and software are very basic, but combined they do allow you to take control of your fans and carry out overclocking relatively easily. Performance was decent across the board, and the ASRock handled our Ryzen 9 5900X well. Its standout result was the audio, though, with its Realtek ALC1220 codec offering a noise level of -109dBA and dynamic range of 109dBA.

SPEC

Chipset AMD X570

CPU socket AMD Socket AM4

Memory support 2 slots: max 64GB DDR4 (up to 4533MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1220

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

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

Ports 4 x SATA 6Gbps, 1 x M.2 PCI-E 4, 2 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Thunderbolt 3/Type-C, 2 x USB 3, DisplayPort, HDMI, 3 x surround audio out

Dimensions (mm) 170 x 170

THUNDERBOLT AND LIGHTNING

+ Thunderbolt support
+ Smart design
+ Reasonable AIO liquid cooler compatibility

VERY VERY FRIGHTENING

- Only one M.2 port
- Only four rear Type-A USB ports
- No modern EFI fan control suite

Conclusion

While it might look dashing and different, the ASRock X570 Phantom Gaming-ITX/TB3 is left wanting in a number of areas, which is a shame, as its smart design, Thunderbolt support and good audio quality are the makings of a decent motherboard. Sadly, with just one M.2 port, a tiny amount of USB Type-A ports and poor air cooler compatibility, there are plenty of better options this month, with both the Asus ROG Strix B550-I Gaming and MSI MPG B550I Gaming Edge WiFi offering better packages for less money.

VERDICT

A typically outlandish ASRock design with a unique layout, but there are too many shortcomings.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
28/35	17/35	19/30	64%

AMD B550 MOTHERBOARD

ASUS ROG STRIX B550-I GAMING / £180 inc VAT

SUPPLIER cclonline.com

With a £20 price reduction since we first reviewed it a while ago, the Asus ROG Strix B550-I Gaming is now even more attractive, especially as it's now £120 cheaper than its X570 sibling too. This board give you an 8+2 power phase design and the same aesthetics as the Asus ROG Strix X570-I Gaming, but there's no snazzy RGB lighting and there's only one fan rather than two helping to cool the VRMs.

There's a pair of M.2 ports as well, but only the top one supports PCI-E 4, with a second PCI-E 3 connector located on the underside of the PCB. The M.2 temperature with our PCI-E 4 SSD was just 54°C under load, which was the second lowest on test, although the VRM temperature was measured at 57°C with our IR probe; while well away from any throttling issues, this was 10°C warmer than the result from the ROG Strix X570-I Gaming.

One feature that's sadly lacking on that board is a Type-C header on the PCB, which weren't included with many X570 motherboards. Thankfully, you get one here, but it only supports USB 3, and isn't a high-speed option, unlike the full-fat USB 3.2 Gen 2 Type-C port on the rear I/O panel. The USB Type-A port count is pitiful too, though, at just four, which will mean plenty of owners heading to Amazon to look for USB hubs.

On the plus side, this board uses the Realtek ALC S1220A codec, which offers decent performance and you also get 802.11ax Wi-Fi and 2.5 Gigabit Ethernet, with the latter trumping the standard Gigabit networking on the pricier Asus board too.

It also has a rare feature in the form of a thermal probe input, which allows you to set the input temperature for fan speed control to your thermal probe's reading in the EFI, or in Asus' software.

This is particularly useful if you use a coolant probe and control your radiator fans using the coolant temperature rather than the CPU temperature, which helps to cut noise levels. This feature has been removed form Asus' Z690 offering this month too. You get the usual four SATA 6Gbps ports as well, but sadly only a run-of-the-mill total of three fan headers.

Performance in games and content creation was on par with the rest of the field, but the audio performance was a cut above, with the noise level of -105dBA and dynamic range of 106dBA being second only to the ASRock X570 Phantom Gaming-ITX TB3 and Asus ROG Strix X570-I Gaming.

AGED GRACEFULLY

+ Great VRM and M.2 cooling
+ Reasonable price
+ Excellent EFI

FOSSILISED

- Only four USB ports
- Only three fan headers
- No on-board RGB lighting

SPEC

Chipset AMD B550

CPU socket AMD Socket AM4

Memory support 2 slots: max 64GB DDR4 (up to 5100MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel SupremeFX S1220A

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

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

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

Dimensions (mm) 170 x 170

Conclusion

With the B550 chipset being released a while after X570, the Asus ROG Strix B550-I Gaming has the edge in some areas over the pricier Asus ROG Strix X570-I Gaming. It has a USB Type-C header, which is common in cases these days, and an improved layout with its SATA ports all on the edges of the PCB. Its VRM fan was quieter too, but best of all is that it costs £120 less. If you're on a tight budget, this is the mini AM4 board to buy, but it's worth saving for the Asus ROG Strix X570-I Gaming, as it has more USB ports, cooling-running components and attractive RGB lighting.

VERDICT

A decent B550 board for a good price, although it's now showing its age a little.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
32/35	28/35	29/30	89%

AMD X570 MOTHERBOARD

ASUS ROG STRIX X570-I GAMING / £288 inc VAT

SUPPLIER cclonline.com

While those with deep pockets might be tempted by the Asus ROG Crosshair VIII Impact if their case could squeeze a longer mini-DTX motherboard into its innards, the Asus ROG Strix X570-I Gaming is your best bet for a premium motherboard that sticks within the 170 x 170mm confines of mini-ITX. Despite its age, you still won't see much change from £300 if you buy this top-end mini board.

Its total of ten power phases are cooled by a huge array of heatsinks and fans, which also run down to the M.2 port and chipset, and there's a decent amount of clearance around the CPU socket area. However, the fans can ramp up their speeds in warm environments and become audible, and sadly, there's no way to control them. The Asus did offer the lowest VRM temperature on test of just 47°C, but it's no wonder that EK offers a monoblock for the board that allows you to remove the fans completely.

Another issue is the lack of a USB Type-C header, which is common on X570 boards, although some cases do offer the ability to use a USB 3 header to power a Type-C port. Still, it's a bitter pill to swallow at nearly £300, especially as other cheaper boards have them. We can't deny its looks, though, and with an RGB-enabled M.2 heatsink, it's a very attractive board for sure. That M.2 heatsink covering the top PCI-E 4 M.2 port isn't just for show either, as it kept our SSD below a peak of 52°C.

There's a second M.2 PCI-E 4 port on the underside of the PCB as well, which is the main reason to opt for this board over the ASRock X570 Phantom Gaming-ITX TB3. The rear I/O panel is far busier than on the Asus B550 board as well, with seven Type-A ports, three of which support USB 3.2 Gen 2, as does the USB Type-C port here.

There's no 2.5 Gigabit Ethernet, though, so you'll have to make do with just one Gigabit network port, although you do at least get 802.11ax Wi-Fi and Realtek S1220A audio. The performance from the audio was excellent with a dynamic range of 107dBA and noise level of -106dBA, although this board didn't really set itself apart from the cheaper competition in our gaming or content creation benchmarks.

Like its ROG Strix B550-based sibling, the board sports a thermal probe input, allowing you to control your radiator fans using coolant temperature if you use a coolant probe, which is very handy. However, we'd like to see Asus improving the sensitivity when switching to other inputs for fan control, as they can be clunky.

SPEC

Chipset AMD X570

CPU socket AMD Socket AM4

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

Expansion slots One 16x PCI-E 4

Sound 8-channel ROG SupremeFX S1220

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

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

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 3 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 3 x USB 3, HDMI, DisplayPort, 3 x audio jacks

Dimensions (mm) 170 x 170

KING KONG

+ Attractive RGB lighting
+ Excellent design and cooling
+ Plenty of features

KING PRAWN

- No way to control chipset fans
- No USB Type-C header
- Expensive

Conclusion

With ample cooling, decent CPU socket clearance and most modern features, the Asus ROG Strix X570-I Gaming remains an excellent choice for an AMD Ryzen mini-ITX PC. Its main shortcomings are simply due to age, which means its competitors suffer the same issues, such as a lack of a Type-C header, below-average networking and a need for fans to cool the chipset and VRMs. Asus will no doubt be the company to beat with Socket AM5, but if you're sticking with Socket AM4, this is the premium option to buy unless you need a USB Type-C header.

VERDICT

Still the Socket AMD mini-ITX king, although it's showing its age now.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
33/35	32/35	25/30	90%

AMD B550 MOTHERBOARD

GIGABYTE B550I AORUS PRO AX / £167 inc VAT

SUPPLIER scan.co.uk

The Gigabyte B550I Aorus Pro AX costs around £30 less than it did at launch, but can it now offer the allure of the more expensive boards on test, or has Gigabyte cut too many features from the list? Let's start with the M.2 heatsink, which is a vast improvement on the non-contact design of Gigabyte's X570 board (see p42), but the large top heatsink doesn't actually make contact with the SSD. Instead, there's a smaller heatsink beneath it.

Quite why Gigabyte separated the two is beyond us, as its Z690 board (see p47) has just has one big slab that offers excellent cooling via your case's airflow. Still, the peak M.2 SSD temperature of 58°C was decent. The VRMs were also kept chilly. With an 8-phase power delivery, they were kept at a peak of 51°C, which was the second coolest result on test.

The Gigabyte has three fan headers, albeit with one being a tiny proprietary port that requires an included adaptor to connect to a fan. Gigabyte's fan control section in the EFI and it's software are excellent too, with plenty of adjustments available, although the software is a bit clunky for overclocking and other tasks.

Sadly, there's no USB Type-C header on the motherboard, which is a shame given that all the other B550 boards on test this month include one.

The rear I/O panel at least offers a USB 3.2 Gen 2 Type-C port, but it's a shame the board can't cater for cases that have full Type-C support. Type-A ports are a bit thin on the ground too, with just five of them, but there are boards with fewer this month so we can't be too harsh.

Arguably, the best feature of this board is the wide-open CPU socket area. Unlike Gigabyte's B660 offering this month, there's no heatsink at the top, and every cooler we tested fitted fine, including ARCTIC's Liquid Freezer II with its huge mounting plates. As you'd expect from a B550 motherboard, you get 802.11ax Wi-Fi and 2.5 Gigabit Ethernet as well as Realtek ALC 1220 audio. There's the full complement of four SATA 6Gbps ports too, as well as HDMI and DisplayPort outputs should you want to use an APU with on-board graphics.

Meanwhile, a handy feature is Q-Flash Plus, which is Gigabyte's answer to USB BIOS Flashback, allowing you to update the EFI without having a compatible CPU. This could be useful if you end up with a second-hand model that has an old BIOS, and you have a shiny new Ryzen 7 5800X3D it doesn't support.

Audio performance was good, with a noise level of -103dBA and dynamic range of 103dBA. There wasn't much difference in the performance results between all these boards in our benchmarks, but the Gigabyte did managed to top the charts in Cinebench and Far Cry 6, and it's on par with the rest of the field.

CHILLED OUT

+ Good VRM and M.2 cooling
+ Good software and EFI-based fan control
+ Spacious CPU socket

HOT TEMPERED

− Heatsink design could be better
− Could do with more USB ports
− No USB Type-C header

SPEC

Chipset AMD B550

CPU socket AMD Socket AM4

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

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1220

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

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

Ports 4 x SATA 6Gbps, 1 x M.2 PCI-E 4, 1 x M.3 PCI-E 3, 1 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 4 x USB 3, 2 x HDMI, DisplayPort, 3 x surround audio out

Dimensions (mm) 170 x 170

Conclusion

Even though the Gigabyte X570-I Aorus Pro WiFi is cheaper, we'd still take the B550I Aorus Pro AX over it. It offers better VRM and M.2 cooling as well as faster networking and more fan headers too. In this price range, it's a toss-up between Gigabyte, Asus and MSI's B550 motherboards, depending on your priorities, and this is a great board if you have a really limited budget.

VERDICT

A solid B550 mini-ITX motherboard that doesn't shed too many features for the price.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
32/35	26/35	28/30	86%

AMD X570 MOTHERBOARD

GIGABYTE X570-I AORUS PRO WIFI / £140 inc VAT

SUPPLIER cclonline.com

When you spot an X570 motherboard retailing for significantly less money than its B550 counterpart, you know something isn't quite right and our initial misgivings about the Gigabyte X570-I Aorus Pro WiFi have been proved correct – this is a board that hasn't stood the test of time particularly well. Its design is in stark contrast to that of Gigabyte's own excellent Z690 motherboard on test this month too, and even Gigabyte's own B550I Aorus Pro AX. Still, at £140, it could be a bit of a bargain, especially with the inclusion of AMD's top-end X570 chipset.

Our main issue with this board the first time we reviewed it was the lack of a heatsink making contact with an SSD in the top M.2 slot. There's a small fan above it blowing onto the chipset heatsink below, but this simply isn't doesn't have enough power to effectively cool a hot-running SSD.

Our PCI-E 4 test SSD quickly topped 70˚C in our stress test in this board, for example, compared to a peak of just 58˚C with the Gigabyte B550I Aorus Pro AX, which also shaved a few degrees off the VRM temperature. While this board can handle high-end CPUs, you'll need to rein in your SSD's spec and avoid any high-speed PCI-E 4 drives that are likely to get too toasty in the tight confines of a mini-ITX chassis.

Despite having some of the best fan control software we've seen, as well as an excellent EFI fan control suite, Gigabyte also seems to have forgotten that you actually need to have fan headers to power your fans too. This board has just two of them, which is going to mean buying splitter cables if you have to contend with more than two fans.

The number of Type-A USB ports is also low compared with the competition, with five instead of the usual seven, although at least all the ports on this board are either USB 3 or USB 3.2 Gen 2. Thankfully, the clearance around the CPU socket area is excellent, as you only need to contend with the M.2 and I/O shroud heatsinks here.

As with most X570 boards, there's no Type-C header on this board, but there is a USB 3.2 Gen 2 Type-C port on the rear I/O panel. This panel is mostly similar to the one on the B550 model, with 802.11ax Wi-Fi antennae connectors, video outputs and audio ports for the Realtek ALC1220 audio. However, the Ethernet connection is only Gigabit rather than 2.5 Gigabit. The audio performance was good, though, with a dynamic range of 103dBA and noise level of -103dBA, and benchmark results elsewhere were on par with the competition as well.

SPEC

Chipset AMD X570

CPU socket AMD Socket AM4

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

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1220-VB

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

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

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 1 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 4 x USB 3, 2 x HDMI, 1 x DisplayPort, 2 x surround audio out

Dimensions (mm) 170 x 170

COMPETITIVELY PRICED

+ Spacious CPU socket area
+ Good EFI and software
+ Decent audio performance

SUSPICIOUSLY CHEAP

– Only two fan headers
– M.2 cooling not particularly effective
– Only five Type-A USB ports

Conclusion

If you can manage with just two fan headers, five USB ports, poor SSD cooling and a lack of a Type-C header, the Gigabyte X570-I Aorus Pro WiFi might be for you if you're looking to save some money. The Gigabyte B550I Aorus Pro AX is better for a little more money, while the Asus ROG Strix X570-I Gaming represents the best that the X570 chipset can provide in a mini-ITX form factor, albeit for double the price.

VERDICT

A temptingly cheap price for an X570 board, but there's a long list of shortcomings.

PERFORMANCE 29/35 | FEATURES 21/35 | VALUE 27/30

OVERALL SCORE 77%

Wireframe

Join us as we lift the lid on video games

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AMD B550 MOTHERBOARD

MSI MPG B550I GAMING EDGE MAX WIFI / £190 inc VAT

SUPPLIER ebuyer.com

When it comes to mini-ITX motherboards, MSI is often late to the party, if it even turns up at all. We're still waiting for its Z690 offering, which is set to arrive in the next month or so, but it missed the X570 party altogether. Instead, we had to make do with the MPG B550I Gaming Edge WiFi, and now the new version, which has the word 'MAX' in its title.

However, the only differences between these two boards appear to be that the newer one ships with a later BIOS version to support the latest CPUs, while fixing a glaring issue with the original, which was a hidden clear-CMOS header. This was bizarrely located under the I/O shroud and required you to remove the motherboard from the case to access it. Conversely, the MPG B550I Gaming Edge MAX WiFi now includes a clear-CMOS button on the I/O panel, so if you do get stuck after some overclocking, you won't have a mission on your hands.

Unlike a number of recent mini-ITX motherboards, the PCB on display here is spacious, with no VRM heatsink at the top of the board and a low-riding M.2 heatsink at the other end. The heatsink has a fan embedded inside, but unlike some boards, you can control its speed in the EFI (it otherwise responds to chipset temperature). We found it only spun up under extended heavy loads, but seeing as the peak temperature was already 62°C, we suggest either leaving it alone or setting a constant speed, so there's at least some airflow.

There's a second M.2 port on the underside of the PCB too, although it only offers PCI-E 4 support. Similarly, we were pleased to see a USB Type-C header on the PCB, although it's only USB 3 rather than USB 3.2 Gen 2. The latter is reserved for a lone Type-C port on the rear, which is accompanied by a mediocre total of five Type-A ports. Every other feature is present and correct, though, including 2.5 Gigabit Ethernet, 802.11ax Wi-Fi and Realtek ALC1200 audio, along with the usual count of three 4-pin fan headers.

Meanwhile, the power delivery comes from eight phases and is cooled by a large topside heatsink and smaller metal plate on the underside. This did a decent job of cooling the VRMs, which peaked at 54°C, so there's plenty of headroom here. There's no RGB lighting as standard, but you do get a 3-pin RGB header. There's no 4-pin header, though, so if you want to add some RGB pizzazz, make sure you get the right gear.

Finally, benchmark results were solid across the board. Even the audio results of -103dBA noise level and 103dBA dynamic range were slap bang in the middle of the results this month.

Conclusion

As an entry level mini-ITX board that covers all the essentials, the MSI MPG B550I Gaming Edge MAX WiFi is a good choice. It could do with some more USB ports, but it also offers a couple of extras over the cheaper Gigabyte B550I Aorus Pro AX. It can't quite beat the Asus ROG Strix B550-I Gaming in this price bracket, but there's not much in it.

MAX

+ Good M.2 and VRM cooling
+ USB Type-C header
+ Speed-adjustable chipset fan

VECNA

- Type-C header is only USB 3
- Average number of USB ports
- No 4-pin RGB headers

SPEC

Chipset AMD B550

CPU socket AMD Socket AM4

Memory support 2 slots: max 64GB DDR4 (up to 4600MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1200

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

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

Ports 4 x SATA 6Gbps, 1 x M.2 PCI-E 4, 1 x M.2 PCI-E 3, 1 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 1 x USB 3 Type-C header, 2 x USB 3, 2 x USB 2, HDMI, 3 x surround audio out

Dimensions (mm) 170 x 170

VERDICT

A balanced motherboard with nearly all you need to build an affordable mini Ryzen rig.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
32/35	28/35	28/30	88%

INTEL Z690 MOTHERBOARD

ASUS ROG STRIX Z690-I GAMING WIFI / £373 inc VAT

SUPPLIER scan.co.uk

Our initial review of the Asus ROG Strix Z690-I Gaming WiFi was glowing, as it sported a mighty feature set and an imposing PCB crammed with even more goodies than previous generations. However, it still won't leave you with much change from £400, so can it still justify that price in the face of cheaper competition?

Its triple-stacked array of M.2 ports and audio circuitry is built into a heatsink system that passively cools both of its PCI-E 4 M.2 ports, with our PCI-E 4 SSD maxing out at 54°C, and this idea has been copied to some extent by Gigabyte with its Z690I Aorus Ultra Plus. The Gigabyte board trumps the Asus in a couple areas too, with more fan headers and on-board RGB lighting, plus both boards offer USB 3.2 Gen 2 Type-C ports and headers.

The Asus board is the only one to offer full Thunderbolt 4 support, though, and with a pair of ports on the back too. This does push up the price tag, but it enables you to add Thunderbolt devices such as hubs and 10 Gigabit network controllers.

Meanwhile, the 11-phase power circuitry is cooled by a large fan-assisted I/O shroud heatsink, along with a second heatsink at the top linked by a heatpipe. With a VRM temperature of 51°C after dealing with our Core i7-12700K at full load for ten minutes, it was the coolest Intel board on test, so it will have no issues dealing with a Core i9-12900K either.

Move around the back and, you'll find a rear I/O panel with a reasonable count of seven Type-A USB ports, two of which are USB 3.2 Gen 2. There's also a clear-CMOS button, 2.5 Gigabit Ethernet port and aerial mounts for the 802.11ax Wi-Fi. Audio is provided by Asus' Supreme FX 7.1 system which is based on Realtek's ALC4080 codec, and the board's three minijacks cater for line-out, microphone and line-in functions.

You may have spotted a vertical PCB in the photo too. This is where Asus has located the four SATA 6Gbps ports, along with RGB headers and even the front panel connectors. If you want to remove it, there's a second power button header on the PCB. Sadly, though, the extra paraphernalia has resulted in Asus ditching the thermal probe header, which was useful for controlling fan speeds according to coolant temperature in custom water-cooling loops.

The Realtek ALC4080-based audio performed excellently, with a dynamic range of 118dBA and noise level of -118dBA, alleviating your inability to add a discrete PCI-E sound card. Its audio was better than the Gigabyte Z690I Aorus Ultra Plus too, and the Asus topped all of the Intel benchmark charts apart from Cinebench, albeit by small margins.

Adding coolers to the board can prove a challenge, though, as the CPU socket is cramped. This meant out ARCTIC Freezer Liquid II cooler was unable to fit, and using NZXT's hefty Kraken Z53 required us to use low-profile memory too. However, smaller cooler blocks from Corsair and EK fitted fine.

SPEC

Chipset AMD X570

CPU socket AMD Socket AM4

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

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC1220-VB

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

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

Ports 4 x SATA 6Gbps, 2 x M.2 PCI-E 4, 1 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 4 x USB 3, 2 x HDMI, 1 x DisplayPort, 2 x surround audio out

Dimensions (mm) 170 x 170

Conclusion

It might be pricey, but if money is no object and you must have the best Z690 mini-ITX board you can buy, the Asus ROG Strix Z690-I Gaming WiFi ticks nearly every box ,and its added premium features ultimately justify its high price.

ROG

+ Attractive design
+ Excellent M.2 and VRM cooling
+ Innovative layout

RAG

- No thermal probe input
- Cramped PCB
- Expensive

VERDICT

One or two small niggles, but this is ultimately a fantastic mini Z690 motherboard.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
33/35	34/35	21/30	88%

INTEL B660 MOTHERBOARD

GIGABYTE B660I AORUS PRO DDR4 / £200 inc VAT

SUPPLIER scan.co.uk

Overclocking Intel's 12th-gen CPUs doesn't always yield decent gains, particularly at the high end, so if you plan on running one at stock speed, you don't need to fork out for a Z690 motherboard. The Gigabyte B660I Aorus Pro DDR4 costs significantly less than its Z690 siblings, and it uses DDR4 memory, cutting down the price of building a total system compared with using DDR5.

It's also equipped with a decent array of features despite its price. There's a large M.2 heatsink, which kept our PCI-E 4 SSD to a peak temperature of 60°C and well away from throttling. The heatsink is attached via a heatpipe to a large aluminium I/O heatsink shroud and a further heatsink at the top of the board too. The VRM temperature was still a little toasty, though, with our ten-minute load test seeing our Core i7-12700K drive the temperature to 67°C.

There's a standard total of three 4-pin fan headers too, two of which require the use of adaptors included in the box, as Gigabyte has miniaturised them on the PCB to save space. Impressively for one of the cheaper boards this month, it also includes a generous count of seven Type-A USB boards and a USB 3.2 Gen 2 Type-C port on the I/O panel. However, you don't get a full-fat Type-C header – the one on this board only offers USB 3 credentials, rather than the higher speed and power of USB 3.2 Gen 2 or Gen 2x2.

Another shortcoming is the lack of M.2 ports. There's a single PCI-E 4 M.2 port, but you'll need to reach for SATA devices and the included four SATA 6Gbps ports for more storage capacity. Thankfully, networking is solid, with 802.11ax Wi-Fi and Intel 2.5 Gigabit Ethernet supported.

Performance was mostly on par with the other boards on test, but the Realtek ALC897 audio was a little below the standard presented by the other two Intel boards, with a dynamic range of 95dBA vs 100dBA and 118dBA for the more expensive boards. The video encoding and Cinebench multi-threaded results were a tad lower too, but not by a concerning margin.

However, the board's layout did pose some issues from a cooling point of view, mainly due to the close proximity of the M.2 heatsink and top VRM heatsink to the CPU socket. The area was too small to accommodate large AIO liquid cooler pump sections, such as that on the ARCTIC Liquid Freezer II 240 RGB, so you'll need to opt for a cooler with a smaller mounting mechanism, such as the EK's ALC AIO liquid coolers.

Conclusion

The Gigabyte B660I Aorus Pro DDR4 offers a reasonable feature set, and includes ample cooling for your M.2 SSD and VRMs. It's more than up to the task of dealing with a high-end CPU, even under extended loads. A second M.2 port, USB 3.2 Gen 2 Type-C header and a more spacious CPU socket would be the icing on the cake, and we'd like to see better integrated audio too.

However, if you're on a tight budget, it's still a solid base for a 12th-gen Intel mini-ITX PC if you don't plan to overclock your CPU.

SPEC

Chipset Intel B660

CPU socket Intel LGA1700

Memory support 2 slots: max 64GB DDR4 (up to 5333MHz)

Expansion slots One 16x PCI-E 4

Sound 8-channel Realtek ALC897

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

Cooling Three 4-pin fan headers, VRM heatsinks

Ports 4 x SATA 6Gbps, 1 x M.2 PCI-E 4, 2 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2 Type-C, 3 x USB 3, 2 x USB 2. 1 x USB 3 Type-C header, DisplayPort, HDMI, 3 x surround audio out

Dimensions (mm) 170 x 170

BUSY

+ Attractive design
+ Effective M.2 and VRM cooling
+ Decent number of USB ports
+ Reasonable price

CROWDED

– Only one M.2 port
– Cramped CPU socket area
– Type-C header is only USB 3

VERDICT

A couple of niggles, but this is still a good choice if you want a solid sub-£200 mini-ITX board for Intel's 12th-gen CPUs.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
29/35	22/35	29/30	80%

INTEL Z690 MOTHERBOARD

GIGABYTE Z690I AORUS ULTRA PLUS / £280 inc VAT

SUPPLIER box.co.uk

As its predecessor has now been recalled, the Gigabyte Z690I Aorus Ultra Plus is now the company's flagship Z690 board for mini PCs. It gets off to a good start price-wise, as it costs nearly £100 less than the Asus ROG Strix Z690-I Gaming WiFi, and comes in both DDR4 and DDR5 flavours.

Gigabyte has gone for a double-stacked PCB and heatsink array for its M.2 SSDs, which is a far cry from the poor effort with its X570 sibling this month. The large heatsink on top makes direct contact with the M.2 SSD beneath, which benefits from an underside thermal pad, cooling both sides.

There's a second M.2 port beneath this arrangement, although only the top side is cooled with a heatsink. It's worth noting that neither port supports SATA-based M.2 SSDs, but our PCI-E 4 SSD was kept at 51°C under load, which was even cooler than the Asus ROG Strix Z690-I Gaming WiFi.

If you look just above the 16x PCI-E 5 graphics slot, you'll see that the top PCB in the aforementioned stack also sports a Reset button, 3-pin RGB header and a small proprietary port for one of several 4-pin fan headers, with adaptors for these included in the box. This brings the total number of fan headers to four. Less impressive is the number of SATA 6Gbps ports, though, with Gigabyte cutting these to two, although to be fair, it's rare that there are more storage mounts in most mini-ITX cases anyway.

Sadly, there's no Thunderbolt support, which is present on the Asus board. You do get a super-fast USB 3.2 Gen 2x2 Type-C port on the I/O panel, though, and a Gen 2 Type-C header on the PCB, so it's slightly more forward-thinking than its B660-based sibling. As you'd expect at this price, you also get 802.11ax Wi-Fi and 2.5 Gigabit LAN.

However, the board has a slightly odd audio arrangement, with just a single output and input jacks on the rear I/O panel. Meanwhile, the front panel audio connector is tucked away under the I/O shroud, and connects to your case's cable using a cable of its own.

Meanwhile, the VRMs have 13 power phases and the heatpipe-linked heatsinks kept them to a maximum temperature of 51°C with our Core i7-12700K under full load for ten minutes. Socket clearance was slightly better than average too, and we managed to slot an NZXT Kraken Z53 pump section into the area, albeit using low-profile DDR5 memory. We'd suggest using a cooler with a smaller waterblock/pump unit, though, such as those from Corsair or EK.

Audio performance was good, if not spectacular, from the Realtek ALC4080 codec, with a dynamic range of 95dBA and noise level of -99dBA. It also managed to edge out the other two Intel boards on test in Far Cry 6's 99th percentile frame rate, and both Cinebench tests, albeit not by much.

Conclusion

It might not have the lavish feature set of the Asus ROG Strix Z690-I Gaming WiFi, but the Gigabyte Z690I Aorus Ultra Plus packs a punch and will leave you with change from £300. Just beware that it only has two SATA ports, lacks Thunderbolt and has a slightly cramped CPU socket area.

STACK OF PCBS

+ Four fan headers
+ Excellent M.2 and VRM cooling
+ Reasonable price

STACK OF LAUNDRY

- No Thunderbolt support
- Cramped CPU socket area
- Only two SATA ports

SPEC

Chipset Intel Z690

CPU socket Intel LGA1700

Memory support 2 slots: max 64GB DDR5 (up to 6400MHz)

Expansion slots One 16x PCI-E 5

Sound 8-channel Realtek ALC4080

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

Cooling Four 4-pin fan headers, VRM heatsinks

Ports 2 x SATA 6Gbps, 2 x M.2 PCI-E 4, 3 x USB 3.2 Gen 2 Type-A, 1 x USB 3.2 Gen 2x2 Type-C, 4 x USB 3, 2 x USB 2, 1 x USB 3.2 Gen 2 Type-C header, DisplayPort, HDMI, 1 x audio out

Dimensions (mm) 170 x 170

VERDICT

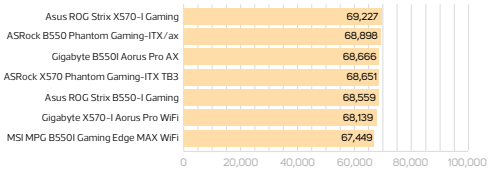
A well-featured sub-£300 motherboard for Intel's latest CPUs, as long as you're aware of its limits.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
33/35	29/35	27/30	89%

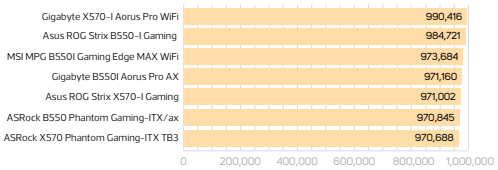
MINI-ITX MOTHERBOARDS BENCHMARK RESULTS

AMD SOCKET AM4

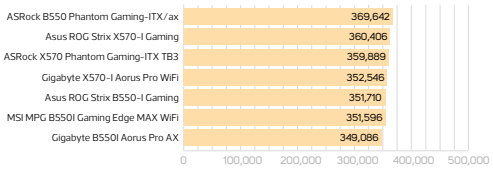
GIMP IMAGE EDITING



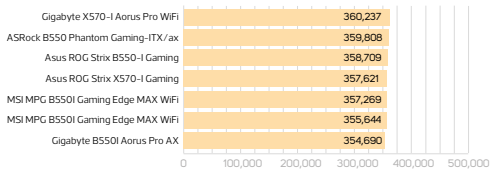
HANDBRAKE H.264 VIDEO ENCODING



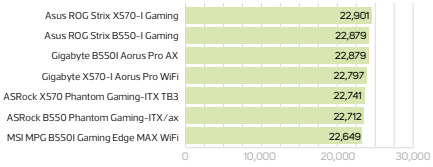
HEAVY MULTI-TASKING



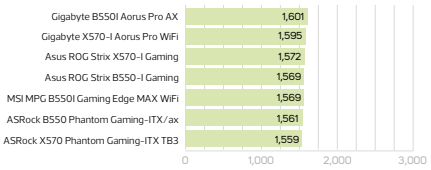
SYSTEM SCORE



CINEBENCH R23 MULTI-THREADED

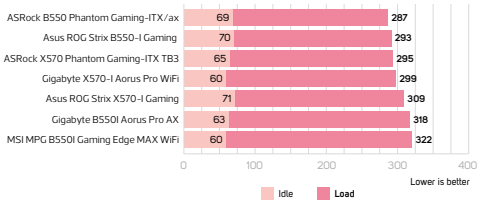


CINEBENCH R23 SINGLE-THREADED



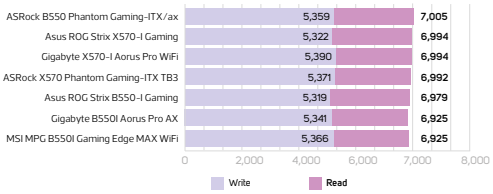
TOTAL SYSTEM POWER CONSUMPTION (WATTS)

Stock speed, Windows desktop / Prime95 smallFFT



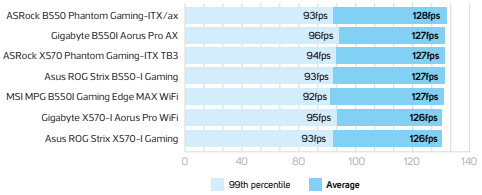
M.2 SPEED (MB/SEC)

CrystalDiskMark, sequential 32-queue depth



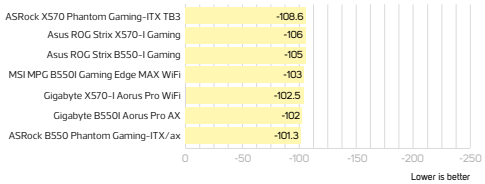
FAR CRY 6 (FPS)

1,920 x 1,080, Ultra settings



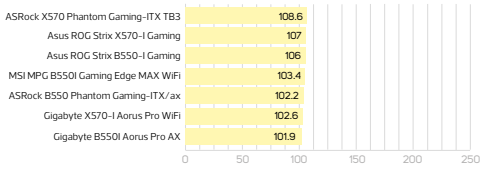
AUDIO NOISE LEVEL (DBA)

RightMark Audio Analyzer 24-bit, 192kHz



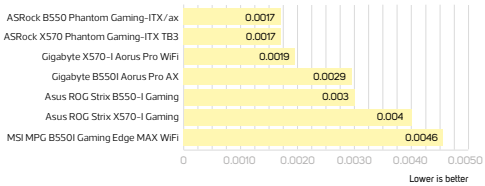
AUDIO DYNAMIC RANGE (DBA)

RightMark Audio Analyzer 24-bit, 192kHz

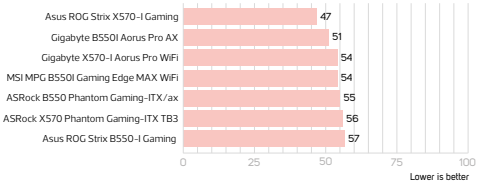


AUDIO TOTAL HARMONIC DISTORTION (PER CENT)

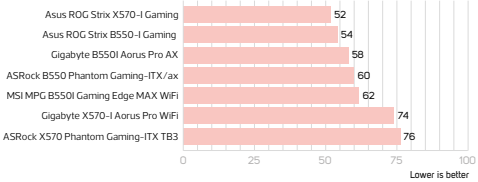
RightMark Audio Analyzer 24-bit, 192kHz



VRM TEMPERATURE (°C)



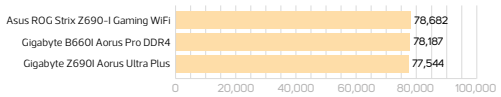
LOWEST M.2 TEMPERATURE (°C)



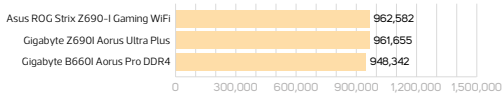
MINI-ITX MOTHERBOARDS BENCHMARK RESULTS

INTEL LGA1700

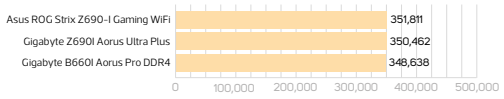
GIMP IMAGE EDITING



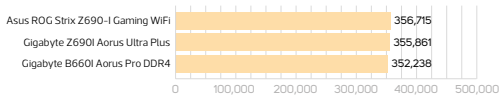
HANDBRAKE H.264 VIDEO ENCODING



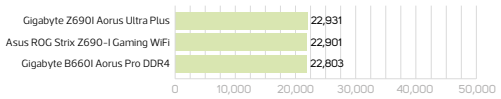
HEAVY MULTI-TASKING



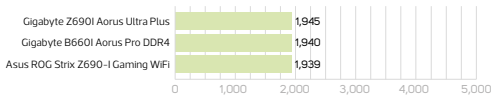
SYSTEM SCORE



CINEBENCH R23 MULTI-THREADED

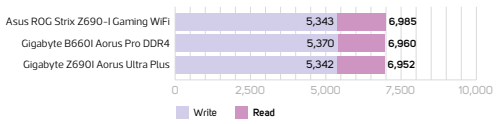


CINEBENCH R23 SINGLE-THREADED



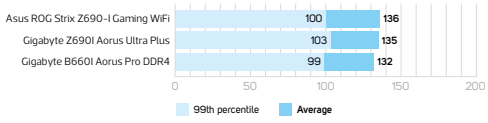
M.2 SPEED (MB/SEC)

CrystalDiskMark, 32-queue depth



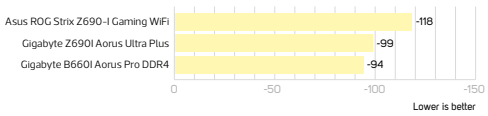
FAR CRY 6 (FPS)

1,920 x 1,080, Ultra settings



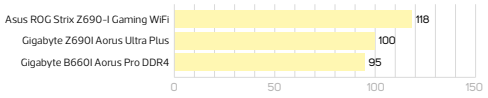
AUDIO NOISE LEVEL (DBA)

RightMark Audio Analyzer 24-bit, 192kHz



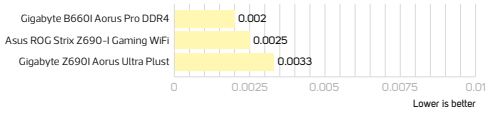
AUDIO DYNAMIC RANGE (DBA)

RightMark Audio Analyzer 24-bit, 192kHz



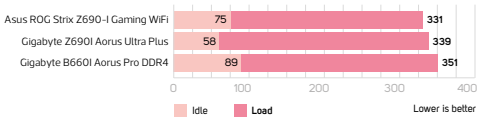
AUDIO TOTAL HARMONIC DISTORTION (PER CENT)

RightMark Audio Analyzer 24-bit, 192kHz

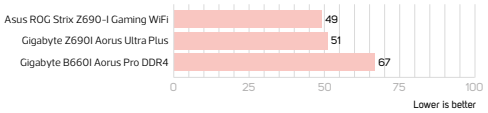


TOTAL SYSTEM POWER CONSUMPTION (WATTS)

Stock speed, Windows desktop / Prime95 smallFFT



VRM TEMPERATURE (°C)



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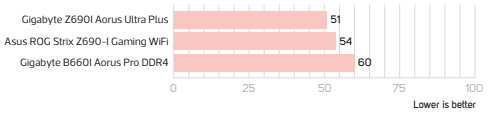

LABS TEST

Get a grip

A keyboard and mouse isn't the only option for gaming on your PC, and you'll want a gamepad for some titles such as Elden Ring. **Edward Chester** puts nine gamepads to the test

How we test

The trusty mouse and keyboard combo has long been the go-to choice for gaming on PCs, but they're not ideal for every game. Whether you need the analogue control that's ideal for racing games and flight sims, or just want a more comfortable lounge-gaming experience, a gamepad is often a better choice.

There are plenty of options, with all the official controllers for the major games consoles being supported to some degree on PCs, plus there are many third-party options too. However, not all controllers are created equal, so there's plenty to consider.

For a start, one feature that we consider essential, and that the likes of the Nintendo Switch Pro controller lacks, is analogue triggers. They're needed for accurately controlling features such as accelerating and braking in racing games, and have many other uses too. It's for this reason we've omitted this otherwise solid controller from this test.

The second biggest distinction between some controllers is whether they're wired or wireless. Wireless options are more expensive, and you may need to jump through a few hoops to get them working on your PC, as you may need to buy a Bluetooth adaptor. Controllers that use Bluetooth can also be used with mobile devices.

Another consideration is the style of controller, with the main divide being between the shape and control layout of Xbox 360/One/X controllers and PlayStation DualShock/DualSense controllers. The former are bulkier, and the left thumbstick is positioned above the D-pad, while the latter tend to be smaller with two analogue sticks in the middle. It's largely personal preference as to which layout you may prefer.

Beyond these core feature differences, there are plenty of other factors to consider. Build quality is a huge one, with premium controllers often feeling better-made than their cheaper counterparts, and including more precise-feeling controls – the analogue sticks can especially suffer in cheaper controllers. Extra features, such as additional buttons and switches for different modes, can come in useful too.

We tested our gamepads across a variety of games, concentrating on racing games, flight sims and first person shooters, to see how the most sensitive parts of the controllers – the analogue controls – held up.

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LOGITECH F310 / £23 inc VAT

SUPPLIER currys.co.uk

As one of the cheapest fully featured (analogue triggers and thumbsticks) gamepads on the market, the Logitech F310 understandably lacks the finesse of some of the pricier competitors on test this month, but still gets the basics done. However, its design certainly leaves no doubt about its low-cost status. The combination of the two-tone blue and black shell, its generally lightweight, hollow feel and jewel-like ABXY buttons have a distinct toy-like quality to them.

The lightness comes in part from the fact that there are no haptic feedback motors, plus the fact it's a wired-only controller, so there are no batteries adding to its mass. Its cable is also tethered and measures 1.8m long, which is ample for desk use but will be a bit short for sofa use with a living room PC.

This is a robustly built controller, though, with no amount of aggressive gripping and twisting eliciting the slightest creak or bend. Instead, it's in the crispness of its buttons and the smoothness of its analogue controls that the F310 shows its cheapness.

For example, the analogue sticks are stiffer than most and take more force to start moving, making it difficult to use them accurately, particularly around the crucial central area where accurate small movements are so important. The analogue triggers are also quite stiff and have a relatively short throw, again making accuracy an issue.

The upshot is that the F310 isn't great for more demanding analogue control such as for playing competitive first-person shooters. They're an upgrade on keyboard control for racing games and flight sims, where any sort of analogue control is better than none, but better-quality controllers will give you markedly more finesse.

Along with its full complement of digital and analogue controls, there's also a switch on the rear for swapping between DirectInput and XInput modes. DirectInput is the older standard used for games in Windows, with XInput being the more modern version. As such, this otherwise basic controller is an ideal choice for those seeking a single basic controller that they can use with a host of games old and new. Because of this simple switch system, installation is completely plug-and-play too, so there are no driver or compatibility hurdles to overcome. It just works.

Meanwhile, a button on the front of the controller lets you switch between flight and racing modes. This switches the default assignments of the D-pad and left thumbstick so that the D-pad controls movement, and the thumbstick controls POV for sports mode, and vice versa for racing mode.

In terms of ergonomics, it's very reminiscent of older Sony DualShock 3 controllers, with very small, steeply sloped grips and its two analogue sticks positioned in the middle. It works fine if you're holding the controller in a conventional manner, with your thumbs on the sticks/D-pad, and index and middle fingers on the bumper buttons and triggers.

However, it's far from the most comfortable pad we've used. The deep grooves on the back into which your fingers nestle make it awkward for alternative grip styles, such as claw grip, for example. The relatively long distance between the top edge of the controller and the ABXY buttons makes using different grip styles more difficult too.

SPEC

Weight 295g

Connections Tethered USB cable

Features DirectInput and XInput switch

Battery N/A

F18

+ Full range of controls for low price
+ Sony DualShock-style layout
+ DirectInput and XInput modes

HORNET

− Cheap look
− Slightly awkward shape
− Clunky analogue controls

Conclusion

The Logitech F310 is a basic controller, with no rumble motors, no wireless mode and a generally cheap quality to its buttons and analogue controls. Its shape and colour scheme are also distinctly toy-like. However, it gets the job done, and its analogue controls are sufficiently fine-grained to make for an improvement for racing games and flight sims over a keyboard. Its DirectInput and XInput modes also make it quite versatile. If you're on a really tight budget, it does the job, but you'd be better off spending just a few more quid.

VERDICT

Cheap and cheerful, there's a lot to like about the Logtiech F310, although there are better bargains to be found.

DESIGN	FEATURES	OVERALL SCORE
12/20	20/30	70%
PERFORMANCE	VALUE	
22/30	16/20	

MICROSOFT XBOX ELITE WIRELESS CONTROLLER SERIES 2 / £145 inc VAT

SUPPLIER microsoft.com

Microsoft's Xbox Elite Wireless Controller Series 2 offers an across-the-board upgrade over the standard Xbox Wireless Controller. It includes premium build quality touches, such as a metal D-pad and rubber grips, and you get extra buttons in the form of rear paddles. There are also customisation options, including swappable D-pad and thumbsticks. Plus, if all that isn't enough, there's also a charging dock, carry case and many replacement parts included in the box.

In terms of the pad's overall design, it's essentially identical to the conventional Xbox Wireless Controller, so any preference for DualShock-style or Xbox-style controllers, in terms of shape and button placement, applies as usual here. Instead, it's in the extras that you'll notice the difference between the Xbox Elite Wireless Controller Series 2 and the standard pad.

For a start, while it's a subtle factor, the clean black and grey colour scheme looks to our eyes just a little bit classier than the multi-coloured ABXY buttons of a standard controller. Meanwhile, build quality is noticeably improved in all areas.

The grips have a textured rubber surface that provides improved purchase, while the whole device just feels much better-quality in your hand. The D-pad and additional back paddles are also made from solid metal, so they have a reassuring heft and a cold, steely feel under your fingers.

As for those extras, the D-pad pops off, so you can use a round omnidirectional version or a conventional cross-style one. The thumbsticks also pull off and you can opt for standard or classic designs (which differ only by their surface finish). Alternatively, you can opt for a dome or a tall stick – in theory, taller sticks are better for accuracy, while shorter ones are better for quick movements. Your mileage may vary, but the inclusion of these options mean you can give them a go and see which ones work best for you.

Meanwhile, the paddles on the underside magnetically attach to the buttons and provide true hair trigger response for your middle and ring fingers. It's a really well implemented system, although the buttons are very easy to press, and some gamers may prefer buttons that require a slightly more solid press to activate, such as the ones on the Scuf Instinct Pro (see p57). The latter also offers considerably more colour options than the Xbox Elite Wireless Controller, which is basically only widely available in black.

A headphone jack is included too, along with a profile switch and hair-trigger switches for each trigger. These shorten the throw of the triggers, making it easier to tap them rapidly.

You also get an internal rechargeable battery that's good for 40 hours of play time. The overall result of all these tweaks is a controller that's more comfortable to hold and considerably more capable than the basic Xbox One controller. In a large part, it still feels like an indulgence than an essential upgrade, but those extra paddle buttons could be a deal maker for some games.

Conclusion

The Xbox Elite Wireless Controller Series 2 is a superb-quality, premium gamepad. It delivers just about every upgrade you could imagine over a standard Xbox controller. It has more buttons, offers customisation options, has an internal battery and it looks great too.

That's all very nice, but there's no getting around the price. At £145 inc VAT, it costs almost three times the price of the standard controller. If you have plenty of money to spend, this is the best wireless PC controller you can buy, as long as you don't want the customisable colour options of the Scuf Instinct Pro.

SPEC

Weight 435g

Connections USB Type-C with 2.7m cable and charging dock

Features Swappable D-pad (two included) and thumbsticks (six included), removable rear paddle buttons (four paddles included), thumbstick tension adjustment

Battery Internal rechargeable (40 hours average per charge)

ELITE

+ Great build quality
+ Lots of extra buttons
+ Customisable
+ Rechargeable battery

ALIGHT

– Very expensive
– Limited colour options

VERDICT

A worthy all-round upgrade over a standard Xbox controller, but it certainly comes at a price.

DESIGN	FEATURES	OVERALL SCORE
18/20	28/30	84%
PERFORMANCE	VALUE	
28/30	10/20	

MICROSOFT XBOX WIRELESS CONTROLLER / £50 inc VAT

SUPPLIER overclockers.co.uk

Now known simply as the Xbox Wireless Controller, the official gamepad that ships with Microsoft's latest Xbox Series X and S consoles is essentially the same as the Xbox One controller that came before it. In many ways, it can be considered the de facto choice for a PC gaming controller thanks to Microsoft's excellent support for it in Windows. You don't have to leap through any of the hoops involved with hooking a Sony DualSense controller up to your PC, for instance.

Software support aside, though, it's also just a very good controller. Microsoft has been steadily honing its controller design and the latest update sees almost no change from the Xbox One design – the fact that Sony's latest controller looks more like the Xbox controller shape than ever before is testament to the quality of design. It's just a very comfortable shape to hold in your hand.

The build quality of this gamepad is surprisingly good too, considering its relatively modest price. It's a solid unit with smooth, reliable control movements and plastics that don't feel cheap, unlike the Logitech F310, Thrustmaster Dual Analog 4 and even the MSI Force GC20. The well-dampened triggers also make almost no noise when you press them, which is another example of this controller's feel of quality.

Another crucial upgrade over cheaper controllers is the inclusion of a wireless connection, with one of the only major upgrades of this latest iteration being the inclusion of a USB Type-C port for wired connection, instead of the micro-USB port that was used before. Moreover, the port can also be used for charging, as long as you buy a compatible battery pack (£20 inc VAT from **xbox.com**). Otherwise, you need to use a pair of AA batteries, which you install by removing a compartment on the back.

The wireless connection is Bluetooth-based, so the controller will also connect to other Bluetooth devices such as mobile phones. There's a dedicated pairing button on the back for getting it connected to your chosen device.

Other smaller updates include the addition of a Share button on the front face for taking screenshots and captures (although you can also reassign it), along with a new circular hybrid D-pad and a textured surface to the triggers, bumpers and back surface.

The textured surface on the back is welcome, but the trigger and bumper surface changes aren't game changers – all the other gamepads on test make do with triggers with smooth surfaces and we didn't find them any worse to use. The D-pad change is a welcome one, though, providing easier diagonal movement than the previous controller, and without compromising the clear up/down/left/right feel of the cross design.

Microsoft offers its latest controller in five colour options of black, white, blue, red and a fluorescent green Electric Volt option, which is reminiscent of the original Xbox green. Otherwise, you don't get any customisation options, with no removable faceplates, thumbsticks or other features. The range of colours available is a considerably better showing than the black or white only options of the Sony DualSense though.

Conclusion

Microsoft's de facto standard Xbox controller remains a great option for PC gamers. Its design makes it comfortable to hold, its controls are accurate and its compatibility with Windows games is excellent. There are few frills here, such as custom colour combos, replaceable parts or motion controls, but the core experience is top-notch and you get the option of a few different official colour choices as well. With solid build quality and a modest price, it's easy to recommend if your priorities are ease of use and compatibility.

TEXTURED

- \+ Great Windows compatibility
- \+ Wireless connection
- \+ Range of colour options

SLIPPERY

- – Rechargeable battery is optional extra
- – Few frills

SPEC

Weight 232g without batteries (282g with batteries)

Connections USB Type-C and Bluetooth

Features Charge-over-USB, Share button

Battery AA or rechargeable battery pack (40 hours average per charge)

VERDICT

The latest official Microsoft Xbox Wireless controller remains a solid choice for PC gaming, with a comfortable design and great Windows compatibility.

DESIGN	FEATURES	OVERALL SCORE
18/20	22/30	82%
PERFORMANCE	VALUE	
26/30	16/20	

MSI FORCE GC20 V2 / £27 inc VAT

SUPPLIER ebuyer.com

The MSI Force GC20 is a wired alternative to an official wireless Xbox controller. For roughly half the price of the real deal, you lose battery power and a headset connection, but you gain swappable D-pad covers, rubber grips, multiple input modes and a removable cable that also lets you hook up the gamepad to Android devices.

In terms of basic design, the Force GC20 is a direct spin on the formula for the Xbox 360/One controller, with it sporting the same basic shape and button layout. There are some subtle differences though. For starters, the grips are slightly shorter, more rounded and don't come to quite such a sharp point as those of the latest Xbox Series X controller, so they feel a little like a hybrid between a DualSense and an Xbox controller.

The sides also have a patch of grippy rubber on their outer edge, where the grips nestle into the meat of your palm. Despite being such a small patch, it's surprisingly effective at helping to keep the gamepad secure in your hand.

The standard Xbox-style button layout feels pleasantly familiar when you start gaming, but the buttons aren't as good quality as those on the official Microsoft controller. They're comfortably a step up from the Logitech and Thrustmaster budget controllers on test this month, but they lack that final bit of crispness that comes with the official options (let alone the premium controllers). The metal D-pad feels too slippery as well, although the circular alternative is much better.

Meanwhile, the thumbsticks offer smooth, accurate movement that's head and shoulders above the cheaper options on test, and comparable with the official gamepads. However the analogue triggers lack the smoothness of more premium models.

As we mentioned earlier, if you remove the main cable, you can alternatively plug in a supplied micro-to-micro-USB cable that you can then connect to Android phones, for example. However, given that most new Android phones are USB Type-C these days, you'll probably need a further adaptor to get connected, making it feel like a Bluetooth controller would be an easier option overall.

The controller can run in four different modes, indicated by a row of LEDs on the front. The default mode provides standard XInput signals, or you can switch the controller to two different DirectInput modes and an Android mode. The two DirectInput modes allow you to use either the analogue stick or D-pad. You also get vibration motors for haptic feedback, which the cheaper controllers on test don't include.

While these extra features are welcome at this price, and make up for the disappointing feel of the buttons, the big caveat here is that if you're just after a controller for use with standard PC games, they don't really add much. In comparison, the PowerA Spectra Infinity does a far better job of providing genuinely useful features for PC/console use, plus it has superior build quality and only costs a few pounds more.

Conclusion

The MSI Force GC20 is a decent, low-cost wired alternative to an official wireless Xbox controller. It's well made, with decent analogue sticks, and a few extra features with the rubber grips and multiple connection modes. However, it could do with an update to use a USB Type-C cable and it lacks the headset connections of some alternatives, which are really handy for sofa gaming. This is a solid enough gamepad for the money, but for just a little extra outlay, the PowerA Spectra Infinity is a far better bet.

SPEC

Weight 205g

Connections Wired-only with micro-USB socket, 2m main cable and 30cm mobile cable included

Features Four modes (2 x DirectInput variations, XInput and Android)

Battery N/A

BANG UP TO DATE

+ Decent-quality analogue controls
+ A few extra features
+ Low price

BANG OUT OF ORDER

− Lacks finesse of official options
− Dated micro-USB socket
− No headset connections

VERDICT

A clear step up in quality from the very cheapest units, but you don't have to spend much more to get an even better experience.

DESIGN	FEATURES	OVERALL SCORE
14/20	22/30	70%
PERFORMANCE	VALUE	
20/30	14/20	

POWERA SPECTRA INFINITY XBOX SERIES X / £35 inc VAT

SUPPLIER amazon.co.uk

PowerA has been creating fully licensed Xbox controllers for many years, offering colourful designs, extra buttons and generally more choice than the official controllers, while maintaining impressively low prices. As a case in point, this Spectra Infinity Xbox Series X controller includes three RGB lighting zones, multi-level trigger locks, dual rumble motors, headset input with microphone mute and volume control, and extra rear buttons, yet it costs just £35 inc VAT.

Despite packing such a huge number of features into the package for such a low price, the Spectra Infinity doesn't want for anything when it comes to build quality, at least in terms of heft. Despite being a wired-only controller, it weighs the same as a standard Xbox controller (with batteries) and it feels like it's built like a tank, with buttons that have a precise, crisp feel to them too – they're a far cry from the cheaper-feeling buttons of the Logitech and Thrustmaster options on test this month.

The thumbsticks feel good too, with a light yet smooth resistance. They're just a touch lighter in use than those on a standard Xbox controller but they still feel relatively easy to use accurately. The analogue triggers, on the other hand, do feel a bit too light. We find stiffer triggers make it easier to accurately dial in functions such as accelerator control, but you could get used to this lighter feel with practice.

Slide the trigger controls on the underside over one notch and the trigger travel distance moves from roughly 10mm to about 7mm, while sliding the control fully over results in the trigger travel dropping to about 5mm. The latter still isn't quite what we'd called a truly hair trigger feel, but it tightens up the response a bit.

Also on the underside are the two extra buttons, which fall neatly under your middle fingers when using a conventional grip, but are difficult to reach if you're using any alternative grip. They offer a well-balanced feel, though, with a small travel distance making for a quick response, but without the hair-trigger feel of the Xbox Elite Series 2 controller's paddles.

Meanwhile, the inclusion of a headset socket is a really useful addition that elevates this controller far above any of the cheaper units on test this month, while the volume/mute control on the front even adds features that you won't find on a standard Xbox controller.

Really, then, it's only the fact that this is a wired controller (and a heavy one at that) that puts it at all behind official Xbox units. The micro-USB socket at the back is sunken so that the provided cable stays firm and secure, and the cable's 3m length is ample for most applications. It would be good to have a USB Type-C socket instead of micro-USB though.

This specific Spectra Infinity model also features RGB lighting that surrounds all the buttons and the edge of the controller. It's a bit much for our liking when it's in full flow, but there are masses of other options of this controller available, including plain solid colour models available in black, red, khaki green, blue and white, to name just a few.

SPEC

Weight 282g

Connections Wired-only with micro-USB socket, 3m cable included

Features Three-zone RGB lighting, three-level trigger locks, two extra rear buttons

Battery N/A

RESPECTED

- \+ Excellent build quality
- \+ Useful extra features
- \+ Fantastic value

SUSPECTED

- – Wired only
- – Micro-USB rather than USB Type-C
- – Slightest loose-feeling triggers

Conclusion

Although we found the analogue triggers of this controller a little lacking in resistance, and the extra RGB lighting wasn't quite to our taste, there's also a lot we liked about it, especially for the price. It's packed with features, including extra rear buttons and headset volume controls, and it's very well built. It's a touch heavy considering it lacks wireless, but it's hard not to be bowled over by the quality of this controller for this price.

VERDICT

A stunningly low price for the quality and features on offer, even if it's a touch heavy and lacks a wireless connection.

DESIGN	FEATURES	OVERALL SCORE
16/20	26/30	82%
PERFORMANCE	VALUE	
22/30	18/20	

RAZER WOLVERINE V2 CHROMA / £130 inc VAT

SUPPLIER razer.com

While Razer has produced wireless gamepads in the past, such as the DualShock-alike Raiju Tournament Edition (reviewed back in Issue 191), the reptilian peripheral maker currently only offers wired gamepads. Moreover, it only offers a single model, but which is available in two different variants. The Wolverine V2, then, is an official Xbox licensed controller, with the Xbox logo on its front, and it sports the standard Xbox thumbstick layout. However, it actually sports a slightly different shape from the official controller, and both versions include quite a few extras.

The standard model (currently £70 inc VAT from **currys.co.uk**) includes two additional buttons next to the triggers and bumper buttons. It also has a couple of sliders on the underside for converting the triggers to a hair trigger mode. Meanwhile, the Chroma version on test here adds two extra buttons on the underside for your middle and ring fingers, along with interchangeable thumbstick caps.

The extra features are very useful, with the extra bumper buttons being a seemingly obvious addition that few other gamepads have ever included. The hair triggers aren't quite as precise as the name suggests – like most such modes, they just shorten the throw of the triggers, so the buttons still feel quite mushy – but they work well enough.

The extra buttons on the rear are our least favourite of the implementations of this feature this month though. The simple vertical stack of one button above the other in the centre of the rear feels quite difficult to reach. It's good to have them, and they will work well if you have large hands, but other implementations feel more natural in your hand.

Another factor that sets both the standard Wolverine V2 and the Chroma version apart from the competition is that both pads have Razer's 'Mecha-Tactile' buttons. These feel lighter and more clicky than typical gamepad buttons, giving a more mouse button-like feel.

They do feel precise and crisp in action – although not revolutionary – and Razer claims a three million activation lifetime, which is impressive.

Back to the shape of the Wolverine, and it feels a little like a combination of an older Sony DualShock 4 and an Xbox Series X controller. The grips have the same thicker, rounder ends of the DualShock, as compared to the pointy Xbox-style grips. Otherwise, it largely feels as comfortable to use as a standard Xbox controller, and the rubber coating on the grips secures the pad well in your hand too.

So far so good for the Wolverine V2, but its main drawback is its wired-only connection. While a plentiful 3m cable is included in the box, for the prices Razer is asking for both versions, being limited to always using a wire is a significant downside. For PC use, it's certainly not essential to go wireless but it's a slight inconvenience, plus the lack of a Bluetooth connection means you can't use it for mobile gaming.

Combine this omission with the limitation of only two colour options – black or white – and fairly limited options for customisation elsewhere, and the Wolverine V2 doesn't leap out as great value. The RGB lighting strip that wraps around the controller does look great though.

Conclusion

The limitation of being wired-only makes the Wolverine V2 Chroma a tough sell given its premium price. Other high-end controllers that include wireless connections, such as the Microsoft Xbox Elite Series 2 and Scuf Instinct Pro, feel better made. Still, there's also a lot to like with this controller, thanks to its extra buttons, comfortable shape and responsive Mecha-Tactile switches.

SPEC

Weight 270g

Connections USB Type-C (3m cable included)

Features Hair Trigger Mode with trigger stops, two remappable multi-function buttons, Mecha-Tactile buttons and D-pad, four rear buttons

Battery N/A

ADAMANTIUM CLAWS

+ Good build quality
+ Plenty of extra buttons
+ Cheaper than premium wireless models

SUBORDINATE CLAUSE

– No wireless connection
– Rear buttons awkward to reach
– Very high price

VERDICT

A excellent-quality, wired-only gamepad, but it's a pricey option.

DESIGN	FEATURES	OVERALL SCORE
16/20	24/30	74%
PERFORMANCE	VALUE	
24/30	10/20	

SCUF INSTINCT PRO / £200 inc VAT

SUPPLIER scufgaming.com

Scuf Gaming hasn't been around that long but it's revolutionised the gamepad market in this short time. Not only did it bring us the innovation of paddle switches on the back of gamepads – as seen on this example and the Xbox Elite controller – but it patented them too, meaning any gamepad that uses rear controls has had to license the idea from Scuf. No wonder Corsair snapped up the company a few years back.

The company's bread and better, then, is premium gamepads (variants on the latest Xbox controller, as well as DualShock 4 and DualSense versions) that incorporate rear buttons and many other extras, as well as fully customisable colour schemes. The result is the sort of sky-high price you see at the top of this page.

The Instinct (Xbox variant) is available in either Standard (from £170 inc VAT) or Pro versions (from £200 inc VAT), with both including four rear paddle buttons – two each per side, for use by the fingers of each hand. They also include a profile switch for switching between three button-remapping configurations, interchangeable thumbsticks and a removable faceplate. The Pro version adds switchable triggers to swap between long-throw analogue mode and hair-trigger digital modes and a rubberised grip area.

INSTINCTIVE

+ Masses of features
+ Fantastic build quality
+ Loads of custom colour options

SCUFFED

– Very high price

SPEC

Weight 280g

Connections USB Type-C and Bluetooth

Features Four rear paddle buttons, profile switch, interchangeable front panels and thumbsticks, instant triggers

Battery AA

Opt for a standard black colour scheme and you'll get those starting prices, but add different colour options and the price ramps up. Change the colour of every component and you'll add £49 inc VAT to the price, while a further £10 inc VAT will get you the removal of vibration – a downgrade in immersion but potentially useful for professionals not wanting to be distracted.

The pricing is a bit alarming, even compared with the price of the Xbox Elite controller, but the cost is largely justified. Build quality is superb – despite the various interchangeable elements, there's not the slightest bit of wobble or flex. Small touches such as the magnetic battery cover are great too.

The design is very much akin to a standard Xbox controller, so in terms of comfort and grip styles, it reaches the same heights, but it feels like a serious step up. The Instinct Pro's rubber grips also make for a really secure purchase that's ideal for situations when many of your fingers are engaged with operating buttons rather than holding the controller.

Meanwhile, the usefulness of the rear paddles can't be overstated for certain games. While many gamers resort to using alternative grip styles to efficiently access more buttons at once, with four extra buttons on the rear, there's seldom a need to make such compromises, so your thumbs never need to leave the thumbsticks.

The rear button setup is a little different to the Xbox Elite controller though. Here, the rear buttons are most naturally activated by your middle finger and require a reasonable amount of travel to activate. Comparatively, the official Elite controller's buttons sit under your middle and ring fingers and are hair triggers. The latter is better for the most efficient control, while the Instinct is a little more forgiving of accidental finger flicks.

In terms of connections, you get wireless and wired options, with a USB Type-C port at the rear for the latter. Like the official Xbox controllers, it uses AA batteries and doesn't charge them in-device. Also, bear in mind that The Scuf Reflex is one of the few licensed alternatives to the Sony DualSense, if you prefer that design of gamepad.

Conclusion

The Scuf Instinct Pro is certainly expensive, even considering its build quality, features and customisation options. As such, it's hard to really say it its price is fully justified. However, it categorically does feel every bit like the best gamepad you can buy, and that title comes at a premium.

VERDICT

Superb build quality and control accuracy, loads of features and colour options aplenty, for a price.

DESIGN	FEATURES	OVERALL SCORE
18/20	28/30	84%
PERFORMANCE	VALUE	
28/30	10/20	

SONY DUALSENSE

/ £50 inc VAT

SUPPLIER scan.co.uk

Like the DualShock 4 before it, the Sony DualSense immediately bumps up against a major issue when it comes to use on a (Windows) PC, which is that Sony hasn't produced official Windows drivers to give the controller full native support. The controller will work if you just plug it straight into your PC, but instead of providing support for the modern XInput system used in modern games, it only offers DirectInput support, as used in older games. Plenty of games will still support it but many others won't.

Thankfully, there are two workarounds. Firstly, you could only play games on Steam. Thanks to Valve adding in native XInput emulation, any games it hosts will work with controllers that still use the DirectInput system, such as the DualSense.

The second workaround is to use emulation software such as DS4windows (**custompc.co.uk/DS4Windows**) to convert the DirectInput signals to XInput. Just load the software, run it in the background and it will provide full support for all Windows activities, even enabling you to use the DualSense's touchpad as a normal laptop touchpad, so you don't need a separate mouse in a living room PC setup.

There's one final caveat to using this controller on a PC, which is that even with full emulation, the haptic feedback and adaptive triggers (the key additions of this controller over the DualShock 4) only work when connected via a cable and not via Bluetooth. Plus, they only work in a handful of games.

When they do work, though, they really do elevate this controller above any other. Each step your character takes in Deathloop, for instance, is accompanied by a gentle haptic buzz that changes with the terrain or your pace. It genuinely adds an extra level of immersion. Meanwhile, the changing resistance of the triggers revolutionises the feel of accelerating and particularly braking in racing games.

Elsewhere, the evolution of the DualShock controller design, from a rather small, uncomfortable shape to a fuller, rounded design akin to that of the Xbox controller, continues with the DualSense. The sides have filled out and are more rounded compared with the DualShock 4, the grips taper to a finer point at the back and the top section with the touchpad has grown too. It makes for a supremely comfortable controller that surpasses even the latest Xbox controller for general comfort and versatility of grip.

Build quality is also excellent, with an attractive smooth plastic on the top surface and a lightly speckled pattern on the underside for better grip. The controls all feel sturdy and precise too. You don't get the absolute crispness of button response you get on premium gamepads but they're distinct enough to provide good feedback.

Up front is a socket for your headphones, which is a really useful addition for sofa gaming with your PS5 but this doesn't work on PCs, sadly. A built-in speaker can also take over voiceover duties, though, providing a further sense of immersion.

A built-in battery means the DualSense is easier to charge than an Xbox controller too, but changing the battery is a pain. The new Xbox controller's option of AAs or a rechargeable unit is more versatile.

Conclusion

The fantastic adaptive triggers and haptic feedback really elevate the DualSense above most other controllers for sheer gaming immersion. Add in the fantastic comfort levels, superbly accurate controls and a design that works well with a variety of grip styles and you have a truly fantastic controller. You have to jump through hoops to make it work properly on your PC but the results are worth the effort.

SPEC

Weight 280g

Connections USB Type-C and Bluetooth

Features Touchpad, adaptive triggers, built-in speaker

Battery Built-in rechargeable, up to 12 hours per charge

COMMON SENSE

+ Fantastic haptic feedback and adaptive triggers
+ Integrated touchpad
+ Great build quality and comfort

NONSENSE

− Requires third-party software to work in Windows
− No option to swap battery
− Headphone socket doesn't work on PC

VERDICT

Feature-rich, stylish, comfortable, precise and decent value. It's a pain to get working on a PC, but it's worth the effort.

DESIGN	FEATURES	OVERALL SCORE
18/20	26/30	86%
PERFORMANCE	**VALUE**	
26/30	16/20	

THRUSTMASTER DUAL ANALOG 4 / £18 inc VAT

SUPPLIER box.co.uk

With a price of just £18 inc VAT, the Thrustmaster Dual Analog 4 is among the cheapest gamepads you can buy that still includes two analogue sticks. Drop to a lower price and you'll be confining yourself to controllers with just a D-pad and ABXY buttons, and that style of gamepad isn't much use for the games that benefit most from using a pad for gaming on a PC.

Inevitably, such a low price comes with a few compromises. For a start, the Dual Analog 4 lacks analogue triggers. We omitted the Nintendo Switch Pro controller from our tests for the same reason but that's because it's a £60 inc VAT controller that commits the same sin, whereas an £18 price tag makes it a more acceptable compromise for this modest option.

Elsewhere, you also miss out on any buzzing-motor haptic feedback, making this a particularly light gamepad at just 132g not including the cable. The cable itself is also fixed and measures a modest 1.9m long, so while it will easily reach the back of a PC at a desk, it will struggle for living room duty on the sofa.

Other issues include the D-pad feeling mushy and indistinct. The buttons lack a clear click or step when pressed, instead offering a stiff, linear movement. This makes it very bad for games that require rapid, precise button mashing, such as in beat 'em ups, or even in complex boss battles. It will just about do the job for adjusting your point of view in a flight sim, though, for instance.

SPEC

Weight 132g without cable (243g with cable)

Connections Tethered USB cable

Features Two analogue sticks, two bumper buttons, two digital triggers, D-pad and four action buttons

Battery N/A

The other buttons mostly fare better, with them at least offering a more defined pressing action than the D-pad. However, the bumper buttons annoyingly hinge from the outer edge, rather than their inner edge, so it's not enough to simply tap the outside edge to activate them. Instead, you have to reach further, over the hinge point, in order to press them.

Meanwhile, the all-important analogue thumbsticks are usable, providing a basic amount of fine-grained control for mimicking steering a car or controlling the flight stick of a plane, but they're not great for more demanding control. Trying to play a first-person shooter was not fun with this controller.

The overall design is quite compact, with small hand grips that require you to wrap your fingers much further round them than the fuller designs of more premium controllers.

It's better than the Logitech F310 in this respect, though, with that controller's particularly short, steep grip design. The modest size, slim shape and button layout that has the buttons quite near the edges also works surprisingly well for alternative grip styles.

Build quality is also perfectly sturdy enough, with no flexing or creaking when stressed. The textured plastic surface also feels quite good in the hand. It's certainly not a premium feel, but there are no sharp edges or obvious other such concerns you may have with a very cheap unit.

One final point of caution is that this controller only supports the older DirectInput system so, as with the Sony DualSense, you'll have to use a remapping app to make it work with more modern games.

DUAL WIELDING

+ Comfortable design
+ Very light
+ Two analogue sticks for low price

DUELLING WEIRDLY

− Low-quality analogue controls
− Terrible D-pad buttons
− DirectInput only

Conclusion

With its two analogue sticks, the Thrustmaster Dual Analog 4 delivers the bare minimum for a gamepad that you might want to use with a PC. However, its lack of analogue triggers, poor D-pad quality and odd bumper button design means it struggles to make a convincing case for itself. You only have to spend £10-£15 more to get a vastly better experience, so it's well worth saving for a little longer. CPC

VERDICT

Cheap but not very cheerful, you're better off spending a touch more to get a much better controller.

DESIGN	FEATURES	OVERALL SCORE
12/20	18/30	62%
PERFORMANCE	VALUE	
18/30	14/20	

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.

8-core system with integrated graphics

8-core CPU, basic gaming

Needs a micro-ATX or ATX case. We recommend a 450W 80 Plus Bronze power supply. See Issue 218, p76 for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	AMD Ryzen 7 5700G	scan.co.uk	**#218** p20	£280
CPU COOLER	AMD Wraith air cooler included with CPU	N/A	**#218** p20	£0
GRAPHICS CARD	AMD Radeon RX Vega 8 integrated into CPU	N/A	**#218** p20	£0
MEMORY	16GB (2 x 8 GB) Corsair Vengeance LPX Pro 3200MHz (CMK16GX4M 2B3200C16)	scan.co.uk	**#218** p78	£62
MOTHERBOARD	Asus TUF B450M-PLUS II (micro-ATX) with BIOS flash	awd-it.co.uk	**#218** p78	£90
STORAGE	500GB WD Blue SN570 (M.2 NVMe)	scan.co.uk	**#222** p20	£44
		Total £476		

1,920 x 1,080 gaming

6-core CPU, 1080p gaming

Needs an ATX case. We recommend a 500W 80 Plus power supply. See Issue 224, p76 for an example build guide.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12400F	cclonline.com	**#227** p51	£164
CPU COOLER	ARCTIC Freezer i13X	scan.co.uk	**#224** p76	£20
GRAPHICS CARD	AMD Radeon RX 6600 XT	overclockers.co.uk	**#228** p90	£360
MEMORY	16GB (2 x8 GB) Corsair Vengeance LPX DDR4 3200MHz (CMK16GX4 M2B3200C16)	scan.co.uk	**#224** p76	£62
MOTHERBOARD	Gigabyte B660 Gaming X DDR4 (ATX)	scan.co.uk	**#224** p50	£141
STORAGE	1TB WD Blue SN570 (M.2 NVMe)	scan.co.uk	**#222** p20	£73
		Total £820		

UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3070	nvidia.com	**#228** p90	£469
SWAP STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£103

2,560 x 1,440 gaming system

10-core CPU, 2,560 x 1,440 gaming and ray tracing

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

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i5-12600K	cclonline.com	**#227** p56	£269
CPU COOLER	ARCTIC Liquid Freezer II 240 RGB (240mm AIO liquid cooler)	scan.co.uk	**#226** p49	£80
GRAPHICS CARD	Nvidia GeForce RTX 3070	nvidia.com	**#228** p90	£469
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£71
MOTHERBOARD	Gigabyte Z690 Gaming X DDR4	scan.co.uk	**#222** p46	£200
STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£103
		Total £1,192		
UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	ebuyer.com	**#166** p54	£86

Mid-range gaming system

10-core CPU, smooth 2,560 x 1,440 gaming and ray tracing, some 4K gaming

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	Intel Core i5-12600K	cclonline.com	**#227** p56	£269
CPU COOLER	ARCTIC Liquid Freezer II 240 RGB (240mm AIO liquid cooler)	scan.co.uk	**#226** p49	£80
GRAPHICS CARD	Nvidia GeForce RTX 3080 10GB	overclockers.co.uk	**#228** p90	£740
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX 4M2C3200C16)	scan.co.uk	**#221** p76	£71
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	scan.co.uk	**#222** p48	£240
STORAGE	1TB ADATA XPG GAMMIX S50 Lite	cclonline.com	**#215** p43	£103
		Total £1,503		
UPGRADES				
ADD SECONDARY STORAGE	Western Digital Blue 4TB	ebuyer.com	**#166** p54	£86

Core component bundles cont ...

4K gaming system

12-core CPU, 4K gaming and ray tracing

Needs an ATX case with room for a 360mm all-in-one liquid cooler. We recommend an 850W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i7-12700K	cclonline.com	**#227** p59	£380
CPU COOLER	Corsair iCUE H150i Elite LCD (360mm AIO liquid cooler)	scan.co.uk	**#226** p78	£250
GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	nvidia.com	**#226** p78	£1,050
MEMORY	16GB (2 x 8GB) Corsair Vengeance RGB Pro 3200MHz DDR4 (CMW16GX4M2 C3200C16)	scan.co.uk	**#226** p78	£71
MOTHERBOARD	MSI MAG Z690 Tomahawk WiFi DDR4	scan.co.uk	**#226** p78	£240
STORAGE	2TB WD Black SN770	box.co.uk	**#226** p78	£220
	Total £2,211			
UPGRADES				
ADD SECONDARY STORAGE	4TB Western Digital Blue	ebuyer.com	**#166** p54	£86

Content creation system

16-core CPU, 1,920 x 1,080 gaming

Needs an E-ATX case with room for a 360mm all-in-one liquid cooler. We recommend a 750W 80 Plus Gold power supply.

COMPONENT	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
CPU	Intel Core i9-12900K	cclonline.com	**#227** p62	£556
CPU COOLER	Corsair iCUE H150i Elite LCD (360mm AIO liquid cooler)	scan.co.uk	**#226** p78	£250
GRAPHICS CARD	AMD Radeon RX 6600 XT	overclockers.co.uk	**#220** p53	£360
MEMORY	32GB (2 x 16GB) Corsair Dominator Platinum RGB 5200MHz DDR5 (CMT32GX5M2 B5200C40)	scan.co.uk	**#221** p76	£290
MOTHERBOARD	MSI MEG Z690 Unify	scan.co.uk	**#222** p50	£520
STORAGE	2TB WD Black SN850	scan.co.uk	**#215** p49	£230
	Total £2,206			
UPGRADES				
SWAP GRAPHICS CARD	Nvidia GeForce RTX 3080 Ti	nvidia.com	**#221** p48	£1,050
ADD SECONDARY STORAGE	4TB Western Digital Blue	ebuyer.com	**#166** p54	£86

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.

Mini-ITX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
Intel Z690 (LGA1700)	Gigabyte Z690I Aorus Ultra Plus	box.co.uk	**#228** p46	£280
Intel B660 (LGA1700)	Gigabyte B660I Aorus Pro DDR4	scan.co.uk	**#228** p47	£200
AMD X570 (AM4)	Asus ROG Strix X570-I Gaming	cclonline.com	**#228** p40	£288
AMD B550 (AM4)	Asus ROG Strix B550-I Gaming	cclonline.com	**#228** p39	£180

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
ALL-PURPOSE	Cooler Master MasterBox NR200P	scan.co.uk	**#206** p18	£100
TOWER	Ssupd Meshlicious	overclockers.co.uk	**#225** p51	£100
HIGH AIRFLOW	Fractal Design Torrent Nano	scan.co.uk	**#225** p45	£120
PREMIUM	Streacom DA2 V2	quietpc.com	**#214** p51	£203

Other components

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
LOW-PROFILE CPU COOLER	Noctua NH-L12S	scan.co.uk	**#219** p54	£55
SFX POWER SUPPLY	Phanteks Revolt SFX 750W	overclockers.co.uk	**#228** p74	£130

ATX cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET RGB	Antec DF700 FLUX	cclonline.com	**#214** p26	£80
SUB-£100 AIRFLOW	Corsair 4000D Airflow	scan.co.uk	**#222** p56	£90
COMPACT	Fractal Design Meshify 2 Compact	scan.co.uk	**#215** p20	£100
HIGH AIRFLOW	Fractal Design Meshify 2	scan.co.uk	**#212** p45	£140
SUB-£150	Fractal Design Define 7	scan.co.uk	**#204** p18	£147
PREMIUM HIGH AIRFLOW	Fractal Design Torrent RGB TG	scan.co.uk	**#225** p20	£220
LUXURY	Corsair iCUE 5000T RGB	scan.co.uk	**#224** p22	£350

Micro-ATX

Motherboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD B450 (AM4)	Asus TUF B450M-PLUS II	awd-it.co.uk	**#218** p76	£80
AMD B550 (AM4)	MSI MAG B550M Mortar	scan.co.uk	**#204** p42	£130

Cases

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET	Kolink Citadel Mesh RGB	overclockers.co.uk	**#218** p26	£63

Networking

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET ROUTER	Belkin RT3200-UK	currys.co.uk	**#216** p52	£130
ROUTER	Asus RT-AX68U	scan.co.uk	**#216** p51	£177
MESH ROUTER	Asus ZenWiFi AX Hybrid XP4	amazon.co.uk	**#226** p59	£266
WI-FI ADAPTOR	TP-Link Archer TX3000E	overclockers.co.uk	**#196** p58	£60
DUAL-BAY NAS BOX	Synology DS220j	box.co.uk	**#200** p22	£154
DUAL-BAY MEDIA NAS BOX	Synology DS218play	box.co.uk	**#174** p34	£202
2.5 GIGABIT DUAL-BAY NAS BOX	QNAP TS-231P3	box.co.uk	**#212** p25	£240

Monitors

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

Up to 25in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
24IN, 144HZ, IPS, 1,920 X 1,080, F, G	AOC 24G2U	cclonline.com	#214 p28	£159
25IN, 240HZ, IPS, 1,920 X 1,080, F, G	Acer Predator XB253Q	box.co.uk	#209 p57	£205
25IN, 360HZ, IPS, 1,920 X 1,080, F, G	Asus ROG Swift PG259QN	ebuyer.com	#212 p20	£659

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	£180
27IN, 240HZ, IPS, 1,920 X 1,080, F, G	Asus TUF Gaming VG279QM	ebuyer.com	#209 p60	£276
27IN, 165HZ, VA, 2,560 X 1,440, F, G	AOC CQ27G3SU	box.co.uk	#223 p45	£249
27IN, 240HZ, TN, 2,560 X 1,440, F, G	AOC AG273QZ	overclockers.co.uk	#202 p27	£570
27IN, 240HZ, IPS, 2,560 X 1,440, F, G	Alienware AW2721D	dell.com	#212 p21	£699
28IN, 144HZ, IPS, 3,840 X 2,160, F, G	AOC U28G2XU	amazon.co.uk	#221 p29	£569

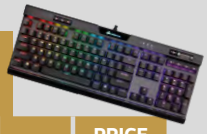
Over 28in

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
31.5IN, 60HZ, VA, 3,840 X 2,160, F	iiyama ProLite XB3288UHSU	scan.co.uk	#205 p43	£370
32IN, 144HZ, VA, 2,560 X 1,440, F, G	iiyama G-Master GB3266QSU	scan.co.uk	#224 p30	£345
32IN, 165HZ, IPS, 2,560 X 1,440, F, G	LG UltraGear 32GP850	overclockers.co.uk	#220 p38	£350
34IN, 144HZ, IPS, 3,440 X 1,440, W, F	iiyama G-Master GB3461WQSU	overclockers.co.uk	#206 p53	£450
34IN, 144HZ, IPS, 3,440 X 1,440, W, F, G	LG UltraGear 34GN850	overclockers.co.uk	#206 p55	£650
38IN, 144HZ, IPS, 3,840 X 1,600, W, F, G, HDR	LG UltraGear 38GN950	overclockers.co.uk	#208 p30	£1,200
32IN, 144HZ, IPS, 3,840 X 2,160, F, G, HDR	Asus ROG Swift PG32UQX	scan.co.uk	#218 p54	£3,299

Non-gaming

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
27IN, 75HZ, IPS, 2,560 X 1,440, F	LG 27QN880	amazon.co.uk	#210 p26	£340

Peripherals and audio



Gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET TKL	SteelSeries Apex 3 TKL	currys.co.uk	#221 p59	£40
OPTICAL ESPORTS	Asus ROG Strix Scope RX	amazon.co.uk	#209 p43	£70
MECHANICAL TKL	NZXT Function MiniTKL	cclonline.com	#226 p32	£100
MECHANICAL MMO	Corsair K95 RGB Platinum	scan.co.uk	#164 p26	£180
PREMIUM TKL MECHANICAL	Corsair K70 RGB TKL	scan.co.uk	#214 p31	£150
PREMIUM MECHANICAL	Corsair K70 RGB Pro	overclockers.co.uk	#225 p30	£160
PREMIUM WIRELESS MECHANICAL	Razer BlackWidow V3 Pro	overclockers.co.uk	#208 p60	£180

Gaming mice

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	NZXT Lift	scan.co.uk	#226 p32	£40
FIRST-PERSON SHOOTER	Glorious PC Gaming Race Model O	overclockers.co.uk	#215 p57	£50
AMBIDEXTROUS	Razer Viper 8K	currys.co.uk	#215 p59	£50
MULTI-BUTTON	Roccat Kone XP	roccat.com	#225 p60	£80
WIRELESS	Razer Viper Ultimate	currys.co.uk	#217 p54	£63
PREMIUM WIRELESS	Razer DeathAdder V2 Pro	scan.co.uk	#210 p28	£96
ULTRA LIGHTWEIGHT	Asus TUF Gaming M4 Air	overclockers.co.uk	#227 p36	£38
PREMIUM LIGHTWEIGHT WIRELESS	Logitech G Pro X Superlight	currys.co.uk	#217 p52	£109

Peripherals and audio cont ...

Game controllers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
RACING WHEEL	Logitech G29 Driving Force	currys.co.uk	#202 p50	£241
BUDGET GAMEPAD	PowerA Spectra Infinity Xbox Series X	amazon.co.uk	#228 p55	£35
MID-RANGE GAMEPAD	Sony DualSense	scan.co.uk	#228 p58	£50
PREMIUM GAMEPAD	Scuf Instinct Pro	scufgaming.co.uk	#228 p57	£200
BUDGET FLIGHT STICK	Logitech Extreme 3D Pro Joystick	currys.co.uk	#207 p52	£36
FLIGHT STICK	Thrustmaster T.16000M FCS HOTAS	scan.co.uk	#207 p56	£115

Gaming headsets

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET STEREO	Roccat Elo X Stereo	scan.co.uk	#210 p56	£40
STEREO	Epos | Sennheiser GSP 300	amazon.co.uk	#210 p54	£50
WIRELESS	Corsair Virtuoso RGB Wireless	ebuyer.com	#204 p50	£146
PREMIUM WIRELESS	Razer BlackShark V2 Pro	scan.co.uk	#211 p26	£162

Speakers

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
STEREO	Edifier R1280DB	overclockers.co.uk	#224 p59	£110

Non-gaming keyboards

CATEGORY	NAME	SUPPLIER	ISSUE	PRICE (inc VAT)
WIRELESS 84-KEY ELECTRO-CAPACATIVE	Niz Mini 84 Pro	keyboardco.com	#220 p29	£165
BUCKLING SPRING MECHANICAL	Unicomp New Model M	keyboardco.com	#219 p26	£129

PCs and laptops

Pre-built PC systems

CATEGORY	NAME	CPU	GPU	SUPPLIER	ISSUE	PRICE (inc VAT)
AMD APU PC	Wired2Fire Ultima Ryzen Gamestation	AMD Ryzen 5 5600G	Integrated AMD Radeon RX Vega 7	custompc.co.uk/W2F	#222 p36	£709
BUDGET GAMING	Wired2Fire Phoenix Intel – Powered by MSI	Intel Core i5-12400F	Nvidia GeForce RTX 3060	custompc.co.uk/Phoenix	#224 p38	£1,136
QUIET GAMING	Gladiator Nocturnal	Intel Core i5-12600K	Nvidia GeForce RTX 3070	custompc.co.uk/Nocturnal	#225 p36	£1,799
MID-RANGE GAMING	CCL Horizon 5 Intel RTX 3080 Gaming PC	Intel Core i5-12600K	Nvidia GeForce RTX 3080 10GB	custompc.co.uk/CCL3080	#228 p28	£1,899
4K GAMING	PC Specialist Magnus Pro K500	Intel Core i7-12700K	Nvidia GeForce RTX 3080 Ti	custompc.co.uk/MagnusPro	#225 p34	£2,499
WATER-COOLED ULTIMATE PERFORMANCE	CyberPower Hydro-X Infinity RTX	Intel Core i9-12900KS	Nvidia GeForce RTX 3090 Ti	custompc.co.uk/CPHX	#228 p26	£4,699

Laptops

CATEGORY	NAME	CPU	GPU	SCREEN	SUPPLIER	ISSUE	PRICE (inc VAT)
BUDGET GAMING	Lenovo Legion 5 Pro	AMD Ryzen 7 5800H	Nvidia GeForce RTX 3070 Laptop	16in, 2,560 x 1,600 IPS 165Hz G-Sync	custompc.co.uk/Legion5Pro	#222 p32	£1,499
ULTRA PORTABLE GAMING	Razer Blade 14	AMD Ryzen 9 5900HX	Nvidia GeForce RTX 3070 Laptop	14in 1,920 x 1,080 IPS 144Hz	custompc.co.uk/Blade14	#220 p40	£2,120
MID-RANGE GAMING	Asus ROG Strix Scar 15 G533ZW	Intel Core i9-12900H	Nvidia GeForce RTX 3070 Ti Laptop	15.6in 2,560 x 1,440 IPS 240Hz	custompc.co.uk/AsusScar15	#227 p40	£2,399
HIGH-SPEED GAMING	Alienware x17 R2	Intel Core i7-12700H	Nvidia GeForce RTX 3080 Ti Laptop	17.3in 1,920 x 1,080 IPS 360Hz G-Sync	custompc.co.uk/AlienwareX17	#227 p38	£3,184

RICK LANE / INVERSE LOOK

FIFA FALL OUT

EA's split from FIFA marks the end of an era, but its significance is superficial, says Rick Lane

FIFA is one of those games that's so massive it exists inside its own orbit. Like Minecraft, Fortnite and League of Legends, you don't hear it discussed much in general games discourse, because it's always been there. It would be like having a conversation about the sky – it isn't going anywhere, so what's the point?

Today we're having a conversation about the sky, however, because it appears to have fallen in. After 30 years, publisher Electronic Arts has cut ties with FIFA, after the two organisations came to loggerheads in negotiations over the renewal of the licence. EA will continue to publish annual football games, but now under the (awkward) name of EA Sports FC. FIFA, meanwhile, intends to create its own line of football games.

On the face of it, this is momentous. FIFA has dominated sports games for three decades, despite frequently offering an inferior play experience to Konami's Pro Evolution Soccer. The official branding has carried the series through many difficult times, making it fair to ask 'What is FIFA without, well, FIFA?'.

It turns out the answer is 'quite a lot'. For EA, the main advantage of the FIFA licence wasn't the brand itself, but the access it provided to all the other official licences for teams, cups, leagues, players and so on. Over the years, however, the publisher has built its own relationships with these individual organisations.

As EA said in its statement regarding the split: 'Our unique licensing portfolio of more than 19,000+ players, 700+ teams, 100+ stadiums and 30 leagues that we've continued to invest in for decades will still be there, uniquely in EA Sports FC. That includes exclusive partnerships with the Premier League, LaLiga, Bundesliga, Serie A, the MLS – and more to come.'

In addition, the competition is no longer there. Konami's Pro Evolution series has spent at least the past five years in a relegation battle, culminating in one of the biggest embarrassments in recent video game history. Last year, Konami ditched the Pro Evolution brand and launched 'eFootball 2022', which released in such an unfinished state that it was the worst-reviewed game on Steam for months. FIFA, meanwhile, isn't perfect by any means, but it's leaps and bounds ahead of eFootball, even after a year of updates.

> The split is more an indicator of EA's confidence

The split is more an indicator of EA's confidence than anything else. The company is able to rely on the strength of its own branding in EA Sports and Ultimate Team – the hugely profitable club-building element of EA's football games that's now as recognisable as FIFA itself.

The biggest challenge is marketing the name change, which EA can presumably do with the money it saves from ditching the FIFA licence. It's likely that EA Sports FC will be safe in its dominance of sports gaming for the next few years. The question is whether FIFA's rival plans are a threat. FIFA claims it's 'engaging with publishers, studios and investors' to create a 'major new simulation football title' by 2024.

That's extremely ambitious, and FIFA's first stab is unlikely to match the quality of EA's output, as Tracy King discussed in Issue 227. The obvious gambit is to partner with Konami and attempt to reverse the fortunes of eFootball under the FIFA brand. If it would work is debatable, but it would be another fascinating twist in this decades-long rivalry. CPC

Rick Lane is Custom PC's games editor @Rick_Lane

King Arthur: Knight's Tale / £31.99 inc VAT

DEVELOPER NeoCoreGames / **PUBLISHER** NeoCoreGames

The most interesting aspect of King Arthur: Knight's Tale is that it's possibly the greyest game ever made. A real-time tactics experience that sees you play as Arthur's nemesis Mordred, it pitches itself as a grim and gruelling dark fantasy take on Arthurian Legend.

The game takes place after the mythical Battle of Camlann, during which Arthur and Mordred kill each other in a duel. In Knight's Tale, both men are returned to life by the Lady of the Lake, but Arthur's resurrection goes wrong, turning him into a disfigured monster who blights the land of Albion. The Lady then turns to Mordred, tasking him with rebuilding Camelot and re-establishing the Round Table in order to take down the now evil Arthur.

Knight's Tale is strongest in its tactical combat. Unlike most tactics games, Knight's Tale's battlefields have little cover for your warriors, wizards and rogues to hide behind. Instead, your units must rely on their armour to protect them. Mordred and other warrior-class units are able to withstand significant amounts of damage, thereby acting as mobile cover for your ranged units.

Alongside this are a couple of other decent ideas. Rebuilding Camelot involves upgrading the castle to unlock training and healing facilities for your knights, as well as shops to furnish them with superior equipment. There's also a built-in choice and consequence system that affects your relationship with other members of the Round Table.

Sadly, the whole endeavour is undermined by a litany of broader design issues. Stylistically, Knight's Tale is astonishingly dull. NeoCore conflates 'dark' with 'drab', painting its world in a sickly blend of greys, browns and greens.

Pacing is also an issue. Every aspect of the game, from individual actions to the quests themselves, takes too long to resolve, with NeoCore padding out quest length by making you repeat every objective three times. Moreover, the entire first act – around 15 hours in length – sees you fighting bandits and zombies in an identikit series of swamps. Occasionally, it sends you to a castle or a village, but they're still wrapped in the game's oppressively dun aesthetic.

What's more, the story falls completely flat due to a truly insipid script. Every character is written with the subtlety of an advertising billboard. The Lady of the Lake, for example, comes off as a complete idiot rather than a scheming mastermind. Mordred, meanwhile, can be played either as a redeemed hero or an enduring villain, but there's no arc to either of those choices. He's either the noblest knight who ever lived, or a bloodthirsty maniac.

If any one of these problems were fixed, there might be enough to King Arthur: Knight's Tale to make it worth investigating at a discount. As it stands, however, there are too many better tactics games to make this dismal medieval slog worth your time.

RICK LANE

KNIGHT'S TALE

+ Novel armour mechanic
+ Rebuilding Camelot is a nice idea

KNIGHT'S FAIL

- Visually ugly
- Badly written
- Sluggish pacing

/ VERDICT

The only Knight's Tale worth your time is the film with Heath Ledger in it.

OVERALL SCORE

48%

Dorfromantik / **£10.99** inc VAT

DEVELOPER Toukana Interactive / **PUBLISHER** Toukana Interactive

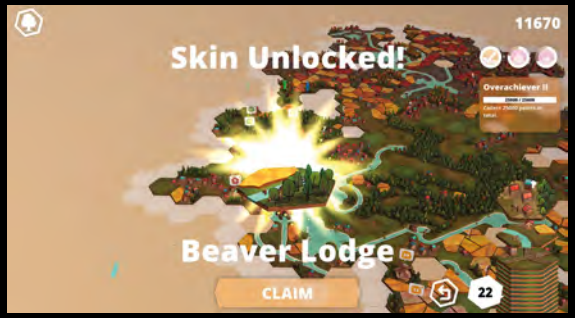
Games can be exciting, spectacular, challenging, complex, frightening, emotional, amusing and creative, but they're rarely designed specifically to be relaxing. By their very nature, they rely on attention and reaction to work. Relaxation, meanwhile, generally doesn't involve attending or reacting to anything, unless it's a waiter bringing you another pina colada, or the press of a masseuse's palm into a particularly tight knot of muscle.

Dorfromantik is different. This light and fluffy blend of strategy and puzzling is the closest you'll get to virtual relaxation without someone giving you a shoulder rub as you play. It combines a gentle yet surprisingly involved tile-building game with gorgeous artwork and serene audio design.

It's essentially a jigsaw puzzle that you make up as you go along. Each game starts by offering you a pile of hexagonal tiles, representing little chunks of landscape. Taking each tile in sequence, you can place them on the board however you choose. Ideally, however, you want as many sides of the tile as possible to match with its surroundings. You want fields to connect to fields, forests to forests, buildings to buildings and so on. If you can match all six sides of the tile with its surroundings, the game adds an extra tile to your stack, letting you play for longer.

The ultimate goal of Dorfromantik is to get the highest score possible, trying to keep the game going as long as you can by adding extra tiles to your stack. This may seem difficult, as placing a perfect tile isn't easy, but there are several other factors at play in a round of Dorfromantik.

First, it's rare you'll have to match all six sides at once. Typically, you'll only need to match two or three sides at any given time, as most tiles are placed at the edge of the



board (which automatically generates additional spaces to place new tiles). Moreover, alongside gaining single tiles for perfect placements, you can also earn extra tiles by completing quests.

There are two kinds of quests in Dorfromantik. There are standard quests, which task you with clustering together a certain number of tile objects in an area, such as houses or trees. Then there are 'flag' quests, which require you to close off an area with non-matching tiles so no further matches can be made. Completing either of these quest-types rewards you with five additional tiles, making them the easiest way to bulk out your tile deck and extend the game.

In this way, what appears to be a simple tile-matching game gradually evolves into a more elaborate puzzle. The layers of complexity don't end there either. You can also group quests together so that, for example, all of the trees on the map contribute to one big payoff. But beware! Although some quests require a minimum number of newly placed trees, others demand a precise amount, and going over that number will result in you failing the quest.

Then there's the shifting nature of the tiles themselves. Early game tiles tend to be uniform blocks of fields, trees, houses and so on. However, as the game progresses, a single tile can have multiple landscape types on it, meaning you need to think more carefully about where to place it. In addition, certain tiles, such as river or railway tiles, can only be placed next to other river or railway tiles, limiting your building possibilities in certain areas.

This may sound like a lot to think about, but in practice, it's a straightforward set of rules to remember, and Dorfromantik carefully guides you through them with a comprehensive tutorial level. Moreover, you quickly learn to intuit where tiles should be placed, which tiles should be used to contribute to quests, and which should be used to provide a perfection bonus by filling gaps in the board.

Dorfromantik also constantly provides a drip-feed of rewards. Not only do you get extra tiles for completing quests, but there are also broader challenges tracked across multiple games, the completing of which earns you brand new tiles, such as windmills, river boats and castle ruins.

These tiles don't massively alter the game, but they do broaden your opportunities for placing tiles, and contribute to the more aesthetic pleasure of creating a pastoral landscape. Indeed, it's common to lose yourself in Dorfromantik for long stretches of time, only to notice with surprise just how much larger your board has become since you started playing.

It's remarkable how much pleasure Dorfromantik squeezes out of such simple ideas, although there are a few pieces in its puzzle that don't fit so well. On some of the busier tiles, it can be hard to discern which type of landscape lies along each edge, for example. Similarly, the highlights for where you should place tiles to close off flag quests are often too subtle, and it's annoying when you waste a tile closing off a flag quest, only to discover there are more gaps you need to fill.

More broadly, there's a case to be made that the end of your game is too dependent on luck. You have no choice over which tiles you place, and the game sorts them randomly. This means a run of bad tiles can end some games in a way that feels premature. This isn't a massive problem, as the game isn't about creating one massive map, but it could also easily be resolved by giving the player a few chances to pick specific tiles from the stack.

All the above applies specifically to Dorfromantik's Classic mode, but there are several other modes designed for more tailored experiences. These include Creative mode, which gives you infinite tiles, Quick mode, which challenges you with getting the highest score out of a small handful of pieces, and Hard mode, which ups the complexity of individual tiles for a sterner puzzling challenge.

However you choose to play, Dorfromantik is a delight, capable of fitting neatly into a lunchtime play session, or eating up entire evenings with its gentle self-perpetuating jigsaws. What's more, it only costs just over a tenner, a bargain price for arguably the best puzzle game of the year, an essential counterpart to the thrill and bombast of bigger-budget titles.

RICK LANE

JIGSAW

- \+ Gentle, captivating puzzle design
- \+ Gorgeous pastoral aesthetic
- \+ Extremely chilled vibes

HACKSAW

- – Some minor UX issues
- – No control over tile dispensation

/ VERDICT

More relaxing than a long bath, Dorfromantik is a beautiful light strategy puzzler.

OVERALL SCORE

88%

GALACTIC CIVILIZATIONS 4 / £39.99 inc VAT

DEVELOPER Stardock / **PUBLISHER** Stardock

GARDEN WORLD

+ Visually impressive
+ Lots of variety
+ Many refined systems

LIFELESS ROCK

– No killer features
– Poor tutorial
– Annoying research system

/ VERDICT

With lots of minor changes but little that's radically new, Galactic Civilizations 4 is a serviceable universe simulator.

OVERALL SCORE

68%

As with every other game in the series, Galactic Civilizations 4 sees you attempting to wrest control of the galaxy as the spacefaring race of your choice, through a turn-based mixture of colonisation, conquest, trade and diplomacy. While it looks superficially similar to its predecessors on the surface, however, Stardock has made a bunch of changes to how this new game plays.

Firstly, victory is no longer bound to a specific condition. Instead, every activity you do in the game contributes to an umbrella victory condition known as Prestige. This means you can dabble in a bit of everything on offer, from researching new tech to building your interstellar military. You can also earn big prestige points by completing specific story quests, which replace the set campaigns seen in previous games. This lets you experience the 'story' with any race you like.

Changes have also been made to how planets and the galaxy as a whole works. The map is no longer a single group of stars, but is split into clusters connected by the galactic equivalent of motorways. Meanwhile, you no longer need to directly manage every planet you colonise. Instead, you only assume direct control over a planet to which you assign a governor, letting you prioritise the most resource-abundant planets as Core Worlds. Colonies left ungoverned will then funnel their resources to the nearest Core World.

These changes have varying significance on the game, but none of them could be described as a killer feature that make it a must-play game. It lacks a distinctive hook to pull in players, such as Stellaris' focus on questing and storytelling, or Crusader Kings' emphasis on character interrelationships.

There are also a couple of new features that don't completely work. The newly added tutorial (in the form of a robot known as Space Clippy) is woefully inadequate for a game this complex. Moreover, the way research gives you a random selection of technologies from which to choose can make it difficult to pursue the specific tech you actually want.

That said, nothing in Galactic Civilizations 4 is especially broken either. It's a perfectly adequate and enjoyable Space 4X game, offering a huge number of interesting technologies to discover, a robust diplomacy system, intriguing colony expansion and development, and loads of different ship types to build.

It also looks tremendous and features countless races to play, ranging from evil squirrel pirates to sentient robots that don't require food to proliferate. Galactic Civilizations 4 might never go supernova, but this also means it doesn't collapse into a black hole that sucks everything around it into oblivion. Like the space shuttle, it may not be as exciting or innovative as more modern rockets, but it's a dependable workhorse nonetheless.

RICK LANE

THE STANLEY PARABLE: ULTRA DELUXE / £19.99 inc VAT

DEVELOPER Crows Crows Crows / **PUBLISHER** Crows Crows Crows

The Stanley Parable: Ultra Deluxe is an expanded reimagining of 2013's The Stanley Parable, which itself was an expanded reimagining of the 2011 mod, The Stanley Parable. If that sounds ridiculous, then you're in the right frame of mind to read a review of this magnificently irreverent comedy caper.

The premise and overarching structure of Ultra Deluxe is broadly the same as the 2013 version. You play a man named Stanley, whose life working in a nondescript office building is subject to a running commentary by an unseen narrator. One fateful day when Stanley's co-workers disappear, Stanley takes it upon himself to discover their fate. Coming to a room with a pair of parallel doors, the narrator instructs Stanley to take the left path, whereupon you can choose to follow the narrator's instructions, or defy them.

The rest of the game follows this pattern, giving you branching choices that lead to increasingly bizarre situations. The narrator responds to your decisions in wildly different ways, variously acting as your friend, nemesis, business partner, therapist, co-conspirator, victim and so on. Defy him at one point in the story, and he might try to reconcile with you, attempting to create a game more suited to his tastes. Defy him at another, and he might simply try to kill you.

The Ultra Deluxe version significantly expands the number of story permutations, all of which are as chaotic, hilarious and wryly allusive as the original game. One path self-referentially explores the dreaded cash-in expansion pack phenomenon, while another muses on the treacherous power of nostalgia, and the gulf between critic and user reviews. One of the funniest paths focuses entirely on the humble 'skip dialogue' button, transforming a simple quality-of-life feature into an apocalyptic time-hopping epic.

Alongside introducing whole new paths, Ultra Deluxe also adds alternative endings to all existing paths, via a new item – the Reassurance Bucket. Equipping this bucket and carrying it through the game changes the story threads of each path, with the narrator switching focus from his relationship with Stanley, to Stanley's relationship with the bucket.

It's an amusing gag, but it doesn't quite succeed in eliminating The Stanley Parable's biggest problem, which is that seeing all the different paths and endings involves replaying a lot of the same content. The game tries to tackle this issue in other ways too, such as slightly changing the opening area and the narrator's starting lines every time you revert to the beginning, but this isn't quite enough to stave off a creeping sense of repetition.

Still, The Stanley Parable more than makes up for this with its creativity, humour and remarkable ability to seemingly anticipate every action you can possibly take. It remains one of the finest comedy games ever made, and the additions in Ultra Deluxe only make it more enjoyable.

RICK LANE

PARABLE

+ A fantastic comedy game
+ Ingeniously expanded
+ Free bucket

PARASITE

– Can get repetitive

/ VERDICT

The Stanley Parable's second overhaul is so good, we can't wait for the next one in 2031.

OVERALL SCORE

90%

REALITY CHECK

Rick Lane brings news of virtual assassins and has space school lessons in this VR roundup

REVIEW

COSMONIOUS HIGH

DEVELOPER Owlchemy Labs / **PUBLISHER** Owlchemy Labs

Cosmonious High is a VR sandbox with tonnes of sand, but not enough box. Owlchemy Labs' colourful VR adventure sets a new standard for dynamic VR interactions, but it struggles to structure them into entertaining challenges. The result is a game that, while undeniably fun, ultimately squanders its considerable potential.

Cosmonious High puts you in the role of Prismi, a cheerful alien creature embarking on its first day of space school. The game sees you visiting various classrooms throughout the school, undertaking different activities under the watchful eyestalks of your extra-terrestrial teachers.

By far the most impressive aspect of Cosmonious High is its wide array of interactions. At a base level, Prismi can conjure multiple powers from its hands, such as the ability to shoot water, fire and wind, and even a power that lets you alter the size of objects.

In addition, each classroom brings its own myriad abilities. For example, Chemosophy class sees you creating various compounds out of base liquids, producing materials such as Bouncium, which makes any object springy, and Stickium, which causes items to attach to one another.

Almost every object in the game's world will respond to your actions. If you spray water at a character's face, for example, they'll spit it back out. Liquids can also be placed into beakers, mugs and other vessels, and carried around. Indeed, any object or power discovered in one room can be transported to other areas of the school to help solve puzzles.

The problem with Cosmonious High is that those puzzles simply aren't that interesting. You'll use your water powers to put out fires, and your size-altering abilities to unblock passages, but the challenges never extend beyond one or two steps. Worse, many of the game's systems are barely used at all. All those cool materials you create in Chemosophy have little practical function whatsoever.

Combined with the game's kaleidoscopic colour scheme, soft-play environment designs, and cheerful-verging-on-patronising characters, Cosmonious High feels overwhelmingly like a game designed for small children as an entry-level VR experience. There's nothing inherently wrong with this idea, but VR headsets across the board aren't rated as suitable for children under 12 years of age.

In other words, the whole game feels designed for an audience that's technically not allowed to play it. Moreover, Owlchemy already nailed entry-level VR experiences through its previous games, Job Simulator and Vacation Simulator. Not only were they brilliantly fun, but they also made better use of their built-in systems than Cosmonious High.

It's a shame, because Cosmonious High has the potential to be one of the best VR games ever made. As an exploration of VR's interactive possibilities, it's unparalleled – no other VR game is this inventive. But it simply doesn't do anything with those inventions, resulting in a fun, but ultimately frivolous missed opportunity.

LESSON

+ Incredibly interactive world
+ Experimentation is fun

LESSEN

– Sorely lacks structure
– Juvenile presentation
– Made for an audience that can't play it

VERDICT

Cosmonious High is a VR nursery with lots of cool toys but no real point to any of it.

OVERALL SCORE

60%

NEWS

WALLACE AND GROMIT: THE GRAND GETAWAY

Stop-motion icons Wallace and Gromit are coming to Meta Quest 2 next year, in a collaborative project between Aardman, Meta and developer Atlas V. Dubbed a VR 'experience', Wallace and Gromit: The Grand Getaway sees Wigan's most famous duo off on that most British of excursions, the summer seaside holiday.

Like all beach holidays in Britain, it's doomed to go wrong, as Wallace gets his dates mixed up and must cross the country in just half an hour, resulting in a calamitous malfunction of his latest invention, the Auto Caddy.

There's little specific information about how The Grand Getaway will play, but the framing of it as an 'experience' implies it will be a fairly light affair. What is certain is that Wallace will be voiced by Ben Whitehead, who replaced the late Peter Sallis after he retired from the role in 2010.

Aardman's Managing Director Sean Clark says the game will combine 'engaging storytelling with emerging technologies to offer fans a totally immersive experience', adding that 'for loyal fans of Wallace & Gromit, this will be real-wish fulfilment territory'.

It's difficult to know how to feel about seeing Wallace and Gromit in VR. While we'd never say no to another Wallace and Gromit adventure, the idea of seeing a life-sized Wallace is faintly terrifying. In any case, you'll be able to traumatise yourself with the sight of a human-sized plasticine northerner sometime in 2023.

NEWS

ASSASSIN'S CREED: NEXUS

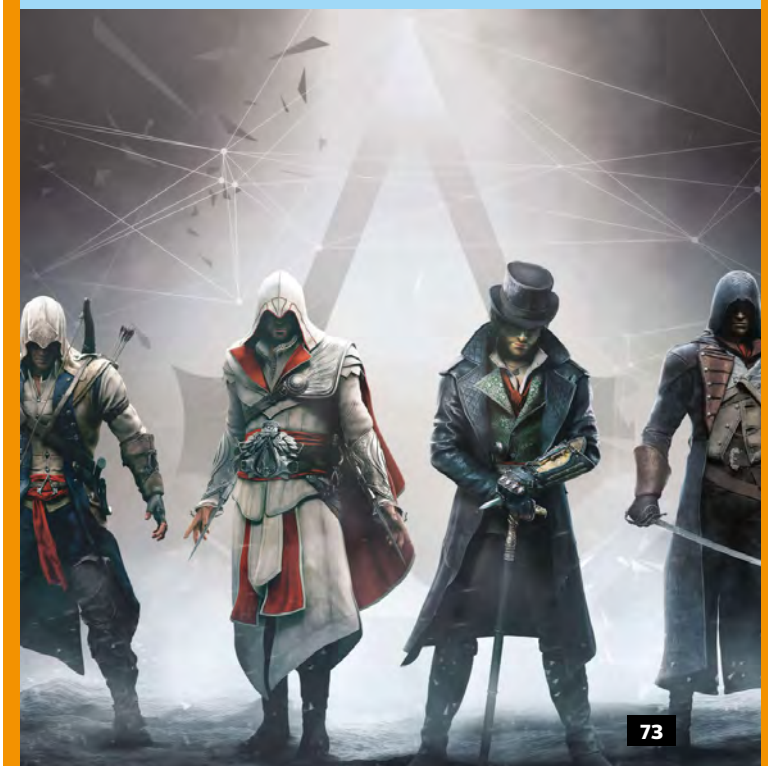
A build of Ubisoft's Assassin's Creed VR project has reportedly leaked online, revealing a game called Assassin's Creed: Nexus, which will apparently offer a time-hopping adventure across many different historical periods.

Footage showed an interactive menu framed around the game's in-fiction Animus machine, essentially Assassin's Creed's own VR device that lets its characters access their 'genetic memories'. The footage also includes a description of one of the game's missions, The Sword of Ezio, which sees Assassin's Creed II's protagonist return to his family home of Monteriggioni to help his sister Claudia with a problem.

The broader game will apparently see players inhabiting multiple assassins from across the series. The specific characters aren't confirmed, although given the game's reported 16 missions, Ubisoft could potentially include all the major characters from the series, as well as making Nexus a substantial VR offering.

The game also seems to be mechanically varied. Combat will be a familiar timing-based affair, with players using weapons such as swords, throwing knives, crossbows and the series' signature hidden blade. Other systems include pickpocketing, lock picking, climbing and, of course, stealth.

Ubisoft hasn't confirmed or denied the authenticity of the leak, but one source of the leak, the gaming website Exputer, has reported credibly on leaks in the past, including a build of the PS5 game Horizon: Forbidden West, which leaked several weeks ahead of the game's debut. CPC



BUILD A MINI PC

THERE'S NEVER BEEN A BETTER TIME TO BUILD A MINI-ITX PC. ANTONY LEATHER GIVES YOU HIS TOP TIPS ON HOW TO PICK THE BEST HARDWARE AND BUILD THE PERFECT MINI SYSTEM, AND HOW TO PUT IT ALL TOGETHER

With more great compact cases than ever before, along with a huge range of CPUs, graphics cards and small SFX PSUs from which to choose, there's never been a better time to downsize your desktop and build yourself a little PC that can do it all.

If your only expansion card is a single graphics card, and you use on-board audio or an external audio device, then you're likely wasting a lot of desk space. It's also true that you don't need to skimp on gaming or content creation performance when you're building a mini-ITX PC any more. There are plenty of powerful graphics cards that fit in small cases, and many of the latter cater for chunky triple-slot graphics cards too.

Not only that, but the latest small SFX PSUs now offer well over 700W of power, which is plenty for a high-end system. Most mini-ITX cases have decent water-cooling support too, allowing you dip your toes into the world of AIO liquid coolers or custom water cooling despite not having a massive ATX case.

This month we'll not only be showing you how to build a mini-ITX PC from start to finish, but we'll also be offering our top tips on choosing the right hardware, taking you through the differing case designs and covering both air and water-cooled options.

WHY USE MINI-ITX?

There are a variety of reasons why people switch from ATX systems to mini-ITX. The key benefit is, of course, the reduction in volume of a mini-ITX case compared with an ATX tower. They not only occupy less space, but they also have significantly smaller footprints on your desk. This means you can reclaim desk or floor space, and without sacrificing performance either. If you don't need any discrete expansion cards beyond your graphics card, there really isn't any reason why you can't opt for mini-ITX.

Variety is another reason why some enthusiasts prefer mini-ITX. By its nature, it's a challenging format in terms of case and motherboard design, and for these reasons, there tends to be far more variation between case and motherboard designs than you see with typical ATX hardware. Motherboards tend to have heatsinks in different locations, have a wide variety of specifications and some even trade off cooler compatibility, so they can squeeze more hardware onto the PCB.

Cases are especially varied too, with a huge array of designs and sizes, ranging from designs that are friendly to both air and water cooling, to ones that specifically focus on one cooling method or the other. Some cases offer super-small footprints, while others focus on minimising volume. Plus you also get the usual mixes of glass, aluminium and steel panels, and the impact of ventilation and airflow design can be particularly pronounced in such a small case. Basically, mini-ITX makes PC building interesting and fun, and perhaps more of a challenge.

MINI-ITX MYTH BUSTING

There are plenty of naysayers when it comes to mini-ITX systems, but a lot of their claims are rooted in the past, and have either been solved with current hardware or have vastly improved.

Motherboard designs vary wildly, which in turn has an impact on cooler compatibility

Even two sandwich-style cases can look completely different, as we can see here with the Phanteks Shift XT and NZXT H1 V2

The first myth is that you can't build a mini-ITX PC that's as powerful as an ATX PC. This is wrong in nearly every way. All current mainstream desktop CPUs, and even Intel's LGA2066 high-end desktop CPUs, are compatible with at least one mini-ITX motherboard. Even a GeForce RTX 3090 Ti card can squeeze into many mini-ITX cases, and can be powered by the latest SFX PSUs too.

There are exceptions, of course. For example, most mini-ITX cases will struggle to house large CPU air coolers. Mini-ITX cases are generally limited to 280mm radiators or smaller too, simply because making room for a 360mm radiator would make the case too large. Otherwise, though, a mini-ITX PC can be every bit as powerful as an ATX system.

Another myth is that mini-ITX PCs are more difficult and time-consuming to build. This can be true in some cases, but recent additions to the mini-ITX scene mean this is largely a non-issue. For example, if you want an easy mini-ITX ride, working with NZXT's H1 V2 is easier than with any other mini case we've tested. Its cables are pre-routed, its AIO liquid cooler is preinstalled and its included SFX PSU is already installed as well.

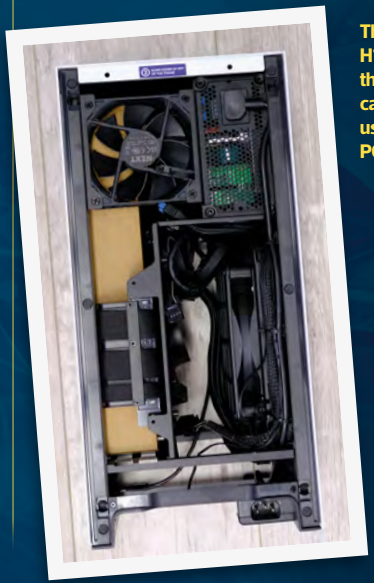
Cable tidying can be an issue in some smaller cases too, but the shorter cable sets included with SFX PSUs help here, and some manufacturers even offer extra short cable kits to cater for situations where the PSU is planted right next to your hardware. You can also create your own cables to custom lengths using companies such as CableMod (**cablemod.com**).

It's easy to forget that mini-ITX is still a niche form factor, despite its increased popularity, but another myth that ties into this fact is that mini cases, PSUs and hardware are more expensive than their full-sized counterparts. This can be true, but not throughout the industry. At the time of writing this feature, the Asus ROG Strix B660-F Gaming WiFi cost £250 inc VAT, while the ROG Strix B600-I Gaming would set you back £245 inc VAT, for example.

Yes, you get more ports with the larger board, but in terms of how much you need to spend to get a ROG Strix motherboard with otherwise similar features, the two boards cost the same price. Downsizing in this case won't cost you more money, and if you want to go with mini-ITX, you've already made the decision to live with two DIMM slots and a single PCI-E slot anyway.

We'll admit, though, that SFX PSUs generally bag you less power for the same cash, and mini-ITX cases are rarely cheaper than ATX cases in a similar range.

Even the largest graphics cards can fit inside mini-ITX cases, such as this GeForce RTX 3090 Ti installed in a Ssupd Meshlicious



The NZXT H1 is one of the easiest cases to use for mini PC building

Make sure your CPU cooler and graphics card fans will be located near mesh panels

PCI-E riser cables are used to connect a graphics card to your motherboard's PCI-E slot in sandwich-style cases, or in cases with vertical graphics card arrangements

BE WARY

While there are plenty of unfair mini-ITX myths doing the rounds, it's still not a perfect form factor. In addition to cooler compatibility and limited hard disk space, which we'll discuss in more detail in a moment, there are a few issues that anyone taking the plunge with a small PC needs to consider.

Firstly, the limited volume in mini-ITX cases means that there's very little margin for error when it comes to cooling. You need to pay careful attention to airflow and where your CPU and GPU coolers will be getting their air supply. For this reason, unless you're water-cooling your hardware, glass panels sat next to your GPU or CPU coolers are a bad idea, which is why most new mini-ITX cases are equipped with mesh panels, or at the very least, have mesh panel options. You'll need to be prepared to make sure every fan mount is occupied in order to ensure sufficient airflow too.

Other issues with cooling include limited clearances. Few mini-ITX cases offer support for CPU air coolers taller than 150mm, for example, which is the starting point for most ATX cases. In fact, many fall well short of even this height, meaning that in many cases, you'll need to opt for liquid cooling to cope with high-end CPUs, and pay careful attention to CPU cooler height limits if you want to use a low-profile cooler.

Graphics card clearances can vary wildly between cases too. You'll need to check that your chosen case has room for enough slot brackets if you card uses more than two. Also, the maximum supported length of graphics card can vary, not just between cases, but also between the same case's different configurations.

For instance, the popular Ssupd Meshlicious has several internal configurations that can allow for better water-cooling support, but can drastically reduce graphics card length limits.

Another potential issue is PCI-E riser cables. These are often used in sandwich style cases, where the graphics card sits back to back with the motherboard, linked to the PCI-E slot via a ribbon cable.

Unfortunately, many cases that use these setups only include PCI-E 3 riser cables, and using one of these if your motherboard and graphics card are PCI-E 4-enabled can result in system instability.

You can either upgrade to a PCI-E 4 riser cable or force your motherboard into PCI-E 3 mode in the BIOS.

Finally, you need to be wary of noise. A mini-ITX case typically sits on your desk, while many ATX cases end up on the floor under your desk. Also, due to their size and shape, mini-ITX machines often bring their innards closer to you than an ATX tower, so you can still access its front I/O ports and so on. This means that, to your ears, even if the same hardware were inside it and every other factor was equal, it would seem to be louder than an ATX case in the same location. If you're noise-sensitive then you'll need to think about ways to keep the decibels to a minimum.

If you use a short graphics card, the Ssupd Meshlicious can house it horizontally instead of vertically, making room in the base for hard disks

LOW-PROFILE CPU COOLERS

The biggest issue mini-ITX system owners face is cooler compatibility, and not just when it comes to cases. Motherboard heatsinks have become larger over the years, in order to cope with ever more powerful CPUs and chipsets. Combine these large heatsinks with all the elaborate ways of cramming as much onto the PCB as possible, such as vertically stacked audio and M.2 arrangements, and space around the CPU socket can end up being pretty tight.

The main issue here is with low-profile air coolers. The CPU socket on a mini-ITX motherboard sits closer to the memory and I/O shield than on ATX motherboards, and while the resulting shorter PCB traces can be beneficial – for instance, with memory overclocking – it can result in some low-profile CPU coolers not being able to fit.

What's more, compatibility varies between motherboards, so one low-profile cooler could work on one motherboard, but not on another, depending on how many heatsinks and other bits and pieces sit around the CPU socket. Thankfully, some CPU cooler

An example of the CPU cooler compatibility lottery is Noctua's NH-L12S, which fits fine on Gigabyte's X570i Aorus Pro WiFi (top), but doesn't stand a chance on ASRock's X570 Phantom Gaming ITX/TB3 (bottom)

Using an M.2 SSD is a great way to cut cable numbers, as it connects straight to the motherboard, and 2TB models can now cost under £150

manufacturers, such as Noctua, have made the effort to see which of its coolers are compatible with specific motherboards.

The low-riding NH-L12S, for example, shows up as not being compatible with any of Asus' recent Intel-based mini-ITX boards, due to it fouling the I/O panel shroud or chipset coolers. Reddit and PC forums are also a good place to check which coolers are compatible with which boards. The key factor here is that if you intend to use a low-profile air cooler, you'll need to make sure it fits your chosen motherboard before buying it.

Using an SFX PSU (top) will free up a considerable amount of space compared to using an ATX PSU (bottom)

WHAT ABOUT ALL MY HARD DISKS?

In general, mini-ITX cases aren't great for those of us that need plenty of hard disks. Many cases offer at least one 3.5in mount, which isn't bad considering there are usually just two in many ATX cases these days. However, there are plenty of cases that offer support for two or more hard disks. This is often as a compromise for other hardware, but if housing multiple hard disks is a priority then they do exist.

However, there are good reasons to ditch your hard disks, and even 2.5in SSDs too. The latest M.2 SSDs are not only quicker than SATA SSDs and hard drives, but they also require no cables, making your cable tidying easier and improving airflow. Flash storage still isn't great value for mass storage, but we spotted several 2TB NVMe SSDs available for just £140 at the time of going to press, meaning you could get 4TB for under £300.

The best option for those that need more storage is to use a NAS box. This will allow you to add as much storage as you like, but will also cut noise levels (and heat) from hard disks' spinning platters and seeking heads, while also cutting down the number of cables cluttering up your mini PC's interior.

Slim fans can squeeze into places full-sized fans can't

SFX PSUs

Many mini-ITX cases support ATX PSUs; at first glance, these might seem like an attractive idea, given it will save you having to invest in a smaller SFX PSU if you already have a decent PSU in your ATX system that you can transplant. However, there are several reasons why doing this is a bad idea.

Firstly, space is at a premium in mini-ITX cases, and having a PSU that occupies more than is necessary will make your life harder. An SFX PSU is significantly smaller than an ATX model, and your PC will be tidier, cleaner and easier to manage as a result of using it.

SHORTENED PSU CABLES

Opting for SFX PSUs comes with another benefit too. They typically include shorter cables than ATX power supplies, as you simply don't need lengthy cables in such a small case. Using an ATX PSU with standard cables will only result in a huge amount of slack to tidy away in a case that's already suffering from limited cable stowage space.

There are also shortened cable sets available for some SFX PSUs, further reducing slack in particularly small cases.

SFX PSUs usually come with shorter cables than their ATX counterparts

Glass side panels look great, but you need to ensure there's enough airflow to deal with the heat

CableMod (**cablemod.com**) is a custom PSU cable manufacturer that offers shorter cables for a variety of PSUs, but its most useful feature is its custom cable service, where you can specify the length of individual cables, so they fit your case and hardware perfectly.

SLIM FANS

It's important to use every fan mount in your mini-ITX case in order to maximise airflow and get the heat out of the case. This may be tricky in some situations, as some hardware configurations will get in the way of fan mounts, while standard-height fans can look unsightly and end up fouling cables.

This is where slim fans come in. They're around 10mm thinner than standard fans, which can make the difference between being able to fit a fan in your mini system or not. They're available in 120mm and 140mm flavours, and can look neater than standard-height fans too, although they typically offer slightly reduced airflow and static pressure.

CUSTOM WATER COOLING

With mini-ITX cases often suffering from reduced CPU cooler clearance, and glass panels hampering air-cooled graphics cards next to them, water-cooling your mini-ITX hardware can actually be very beneficial. It can result in high-end CPUs being cooled more effectively, as radiators offer more cooling capacity than low-profile air coolers. In the case of your graphics card, it also

Small combined pump and reservoir units, such as EK's FLT 80, are ideal for water-cooling systems in mini-ITX cases

means you can mount it vertically to show off through a glass side panel, or it can just make your PC quieter in games.

Water cooling can deal with heat more effectively than air cooling in such tight confines. Low-profile air coolers, and most graphics cards, tend to dump heat into the case, relying on its airflow system to get rid of the warm air. Conversely, AIO liquid coolers and custom loops will transport the heat to a radiator that can then expel it straight out of the case.

There are plenty of water-cooling components that are specifically designed to make your life easier in small form factor systems too. Slim radiators work in much the same was as slim fans, in that they're thinner than standard radiators.

Typical radiators are usually around 30mm thick as a minimum, but slim radiators are just 20mm thick, shaving a centimetre off their required clearance. Combined with slim fans, you need just 35mm of clearance to actually fit an actively cooled radiator into

Alphacool's new line of slim radiators can are available in sizes for both 120mm and 140mm fans

Using a slim radiator and slim fan shaves 2cm off the clearance compared with standard-height models

your case, opening up the world of water cooling to cases that would otherwise have to be air cooled.

In addition, they may allow you to install additional radiators to boost your system's cooling capacity and reduce noise as a result. Only two manufacturers make slim radiators – XSPC and Alphacool, and the latter has just released a range of new models that not only include 120mm variants, but 140mm variants too, giving us the first 280mm slim radiators.

EK's new Quantum Velocity 2 combines a pump, reservoir and waterblock in one unit, making it much easier to water-cool any PC

Thunderbolt can be useful for adding features to mini-ITX motherboards

Being able to combine a pump and reservoir into one space is also clearly very advantageous when water-cooling a mini-ITX PC, and the likes of EK's FLT reservoirs and Alphacool's Rise Flat models take up barely any more space than a couple of 120mm fans, and they use powerful DDC or D5 pumps mounted to compact reservoirs. EK's FLT 80 is our pick of the bunch, being the smallest combo yet and offering plenty of inlets and outlets.

Another very useful gadget is a combined pump, waterblock and reservoir. These are rare, but BarrowCH's LRC 2.0 and EK's recently announced Quantum Velocity 2 Kinetic DDC 4.2 combine all these features into a single unit, meaning you only then have to find a place for your radiators if you're just cooling your CPU, which makes your tube runs far simpler too.

THUNDERBOLT SAVES THE DAY

The main drawback of mini-ITX is the lack of expansion slots. If you're using a discrete graphics card then you won't easily be able to add a second PCI-E device. There

Thunderbolt accessories include 10 Gigabit Ethernet adaptors

are a couple of options here, including M.2 adaptors such as the Innodisk EGPL-T101, which can turn an M.2 port into a 10 Gigabit Ethernet port.

However, an easier way to add devices such as this to your mini-ITX PC is with Thunderbolt. It's still a rare feature on mini-ITX motherboards, but thankfully, ASRock offers it on its Z690, B550 and X570 Phantom gaming motherboards, and Gigabyte's Z590i Vision D supports it too.

Using a Thunderbolt 3 or 4 hub enables you to add a host of adaptors and extra ports to your PC. For example, OWC's 10 Gigabit adaptor plugs straight into a Thunderbolt port should you need a networking upgrade. There are plenty of Thunderbolt-based external storage options too.

CASE LAYOUT VARIATIONS

There's a huge variety of mini-ITX case layouts available, and they all serve different purposes. It's important to realise that while you may find some styles of designs more attractive than others, the style of case you choose will have a significant impact on a case's ability to house certain hardware, and can also affect cooling.

TRADITIONAL LAYOUT

With a graphics card facing the bottom of the case and connected directly to a vertically mounted motherboard, traditional layouts usually offer the best CPU air cooler clearance of any mini-ITX design. Popular cases here include the Cooler Master NR200P, which offers more than 150mm of CPU cooler clearance. The downside is that their radiator support can be limited unless, like the NR200P, it has a flexible layout with a vertical graphics card mount as an option. They also tend to be quite wide, with much larger footprints than some designs.

Cooler Master's NR200P

SANDWICH LAYOUT

With a PCI-E riser cable connecting the motherboard and graphics card, which sit back to back, a sandwich layout frees up space above and below the core components for radiators, and also allows the graphics card to sit vertically. This means the graphics card can be placed close to mesh panels, or offer a more aesthetically pleasing look from the side, but using glass panels with this type of case can negatively impact cooling.

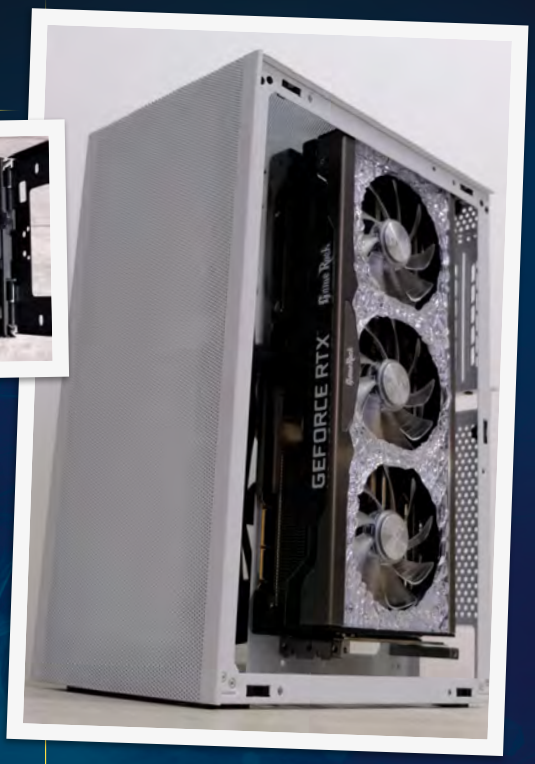
CPU cooler height is also very limited, as the motherboard sits far closer to the side panel than in an ATX case, again meaning mesh panels are a good idea for air-cooled systems. AIO liquid coolers and custom water cooling loops are often much better options than air cooling in these cases, especially for your CPU. The motherboard is often inverted too. Popular cases here include the Lian Li Q58, Raijintek Ophion series, and those from Sliger, Geeek and Dan Cases.

Phanteks' Evolv Shift XT from above

VERTICAL SANDWICH LAYOUT

These cases are similar to the standard sandwich layout, but with the graphics card mounted vertically and the motherboard I/O panel usually located in the top or bottom of the case. This style of design can result in extremely small case footprints, as well as flexible case designs. Popular cases here include the Phanteks Shift series, Ssupd Meshlicious and NZXT H1, with some cases offering decent water-cooling support, thanks to their large mesh panels and the use of small SFX PSUs.

NZXT's H1 V2



Ssupd's Meshlicious

FLEXIBLE LAYOUTS

Due to the above designs being quite inflexible, focusing on improving one feature at the expense of another, a popular party trick of many modern mini-ITX cases is to have multiple layout options. These options might allow a graphics card to switch from being directly connected to a motherboard, to using a riser cable to sit in a different orientation. Or they might be able to use more storage devices by boosting the number of 2.5in and 3.5in mounts, or shift hardware around to make more space for radiators.

For example, the Cooler Master NR200P comes with a riser cable that allows the graphics card to sit vertically, clearing space in the base of the case for a radiator and allowing additional fans to be fitted in the roof, with the option of mounting the radiator in the side of the case too.

The Ssupd Meshlicious goes even further. It supports both ATX and SFX PSUs, and if you use the latter, you can install a graphics card up to four slots wide. It has both vertical and horizontal graphics card mounts, with the latter requiring short cards that, combined with the use of an angled riser cable, clears space for two hard disks to be installed beneath it.

10 TOP TIPS FOR BUILDING A BETTER MINI-ITX PC

1 KEEP CABLES TO A MINIMUM

A fully modular PSU, whether it's SFX or ATX, is highly recommended to keep cable numbers to a minimum. We also recommend using M.2 SSDs rather than 2.5in models or 3.5in hard disks, as this will cut cable numbers, potentially improving airflow, reducing the clutter in your interior and making cable tidying easier.

2 REDDIT AND FORUMS ARE YOUR FRIENDS

The Internet can be a huge help when building a mini-ITX PC. Compatibility with coolers, radiators and graphics cards isn't very well documented with many manufacturers, but you may well be able to find someone who has tried the same combination of components you're considering and has either failed or been successful.

The small form factor PC subreddit is a great place to start and we can highly recommend the mini-ITX case list there (**custompc.co.uk/itx-reddit**).

3 CONSIDER LIQUID OR CUSTOM WATER COOLING

If your dream mini-ITX case has limited CPU cooler clearance, or airflow-killing glass panels next to your graphics card, all is not lost. Liquid cooling can remove the need for masses of airflow, and instead shift the cooling requirements to a radiator that can be positioned in the case's fan mounts. Boosting cooling this way will enable you to increase your system's capacity to deal with heat and can also make it quieter.

4 PUT CASE LAYOUT AHEAD OF AESTHETICS

Mini-ITX cases are often very specialised, and with the exception of highly flexible models, you should pick the best case for your hardware. For example, if you don't want any form of liquid cooling, but want a high-end CPU and GPU, it's inadvisable to opt for a sandwich-style case with limited CPU cooler clearance, or one that has a glass panel sitting right next to your graphics card's cooler.

5 AVOID GLASS PANELS

Glass gives you a great view of your hardware, but while ATX cases can make do with large front and roof vents to provide airflow, side ventilation is also extremely important in small cases, in order to lower internal temperatures and allow vertically mounted graphics cards to breathe. Nearly all mini-ITX cases have mesh panels on at least one side panel, and some manufacturers also offer optional mesh panels to replace glass or otherwise solid panels.

6 BEWARE OF MOTHERBOARD AND COOLER COMPATIBILITY

Low-profile coolers come in all shapes and sizes, and unfortunately many haven't been designed with modern high-end mini-ITX motherboards in mind. They can foul heatsinks, I/O shrouds and other components, so research which coolers are compatible with your motherboard before you reach for your wallet.

You can occasionally install slim fans and radiators in places that can't accommodate normal-sized models

SFX PSUs are considerably smaller than ATX PSUs

7 WATCH OUT FOR PCI-E 3 RISER CABLES

If your motherboard and graphics card are PCI-E 4-compatible then you need to make sure the riser cable included with your case, if it has one, is PCI-E 4 too. If it isn't, your PC will suffer stability issues unless you force your system to operate in PCI-E 3 mode in the EFI.

8 USE AN SFX PSU

Even if your case has ATX PSU compatibility, it's still worth using an SFX PSU. They save valuable space, making the building process much easier. They also have shorter cables, so you don't have miles of slack to tidy later.

9 SLIM FANS AND RADIATORS CAN MAKE A DIFFERENCE

If you've ever wanted to install a radiator in a tight spot, but found there's just not enough clearance, slim fans and radiators are really handy. Combining the two can shave up to 20mm off the total height of a fan and radiator combination, making them far more amenable to squeezing into small gaps than normal-sized models.

10 FILL EVERY FAN MOUNT

A vacant fan mount is heresy in a mini-ITX case, as it's vitally important to make use of all of them to boost airflow. More fans don't necessarily mean more noise either. In fact, shifting more air with several low-spinning fans sounds quieter than one fan spinning at high speed shifting the same or less airflow. If your hardware makes using standard fans in some mounts impossible, slim fans can often enable you to occupy every fan mount in your case to maximise airflow.

HOW TO BUILD A KILLER MINI GAMING PC

WE TAKE YOU THROUGH THE COMPONENTS NEEDED TO ASSEMBLE A CRACKING 2,560 x 1,440 GAMING SYSTEM, AND SHOW YOU HOW TO PUT IT ALL TOGETHER

OUR MINI-ITX SHOPPING LIST

CPU
Intel Core i7-12700K
£377 inc VAT
▶ cclonline.com

Building a mini-ITX PC doesn't have to be about compromise, but equally there's no point opting for overly hot-running hardware that's hard to cool in the confines of a small case. For this reason, we've opted for Intel's Core i7-12700K Alder Lake CPU, which offers huge gaming and content creation performance, thanks to its eight performance-focused P-Cores and four power-efficient E-Cores, but isn't quite as power-hungry and hot-running as the top-end Core i9-12900K, which is overkill for most people's needs anyway.

MOTHERBOARD
Gigabyte B660I Aorus Pro DDR4
£200 inc VAT
▶ scan.co.uk

Manual overclocking doesn't benefit the high-end CPUs in Intel's line-up, so there's little point opting for an expensive motherboard with a Z690 chipset, particularly for a mini system that makes overclocking difficult anyway. As such, we've chosen Gigabyte's B660I Aorus Pro DDR4 motherboard, which costs just £200 and uses DDR4 memory, which is much cheaper than DDR5 memory and has little impact on performance.

This board will also still enable our chosen CPU to boost to its full turbo speeds. However, bear in mind that this board only has one M.2 port, so you'll want to consider an alternative board if you need more than one M.2 drive.

CASE
Phanteks Evolv Shift XT
£160 inc VAT
▶ overclockers.co.uk

With decent airflow, support for a 240mm AIO liquid cooler and achingly good looks, the Phanteks Evolv Shift XT is a droolworthy mini-ITX case, even if it's not the smallest or most flexible mini chassis available.

Handily, it also has a PCI-E 4 riser cable included in the box, so it's already compatible with the latest motherboards and graphics cards without having to force them to run in PCI-E 3 mode.

Alternatively, it's also well worth considering the Ssupd Meshlicious and Cooler Master NR200P for your mini-ITX build. These cases have more flexible designs than the Phanteks Shift XT, and are also water-cooling-friendly, while also offering smaller footprints.

GRAPHICS CARD
Gigabyte GeForce RTX 3070 Ti Vision OC 8G
£690 inc VAT
▶ scan.co.uk

Our chosen Phanteks Shift XT chassis has ample room in its interior to accommodate a large graphics card, so there's no need to be restricted to a graphics card with a small PCB and single-fan cooler.

In fact, in this situation, it really pays to get a graphics card with a large cooler, in order to keep your card's temperatures in check in the close confines of a mini-ITX case.

However, we advise against using an Nvidia Founders Edition RTX 3000-series card in a mini system, unless you've thoroughly researched your case's airflow system, as these cards' flow-through coolers are often at odds with the specialised airflow systems found in mini-ITX cases.

We've chosen the triple-fan Gigabyte GeForce RTX 3070 Ti Vision OC 8G, which looks fabulous, offers stunning performance in games at 2,560 x 1,440, has decent ray-tracing performance, and can even manage smooth frame rates at 4K in some titles, especially with DLSS enabled.

POWER SUPPLY
Phanteks Revolt SFX 750W 80 Plus Platinum
£130 inc VAT
▶ overclockers.co.uk

There are plenty of high-power SFX power supplies available at the moment, and we've chosen Phanteks' new 80 Plus Platinum-rated Revolt SFX 750W unit for our build this month.

It has plenty of connectors, it runs quietly and its excellent efficiency rating will minimise the contribution of gaming sessions to your electricity bill. Importantly, it has plenty of power on tap for our chosen components, as well as some headroom for future upgrades

CPU COOLER
EK EK-AIO 240 Basic
£83 inc VAT
▶ scan.co.uk

Rather than opt for a low-profile air cooler, due to the restricted CPU cooler clearance in the Phanteks Shift XT, we've picked an AIO liquid cooler with the biggest radiator we could fit into this case. The EK-AIO 240 Basic offers enough cooling to keep our Core i7-12700K in check, and it will get rid of the heat straight through the case's roof vent. Its compact pump is small enough to fit on even the most space-cramped CPU sockets too, which can't be said for the ARCTIC LF II 240 RGB or NZXT Kraken Z53 RGB.

SOLID STATE DRIVE
2TB WD Black SN770
£170 inc VAT
▶ ebuyer.com

Our chosen mini-ITX motherboard only has one M.2 port, so we've gone with a 2TB solid state drive, in the form of the WD Black SN770, in order to maximise storage capacity. With its PCI-E 4 interface, it offers blazing sequential read and write speeds of around 5,000MB/sec, and its M.2 interface means it won't clutter the interior with extra cables.

BUILDING THE PC

IF YOU'VE ONLY EVER BUILT ATX PCs BEFORE, DOWNSIZING CAN PRESENT SOME CHALLENGES. HERE'S OUR STEP-BY-STEP GUIDE TO BUILDING OUR GAMING PC, WITH THE ASSUMPTION THAT YOU ALREADY KNOW THE BASICS OF PC BUILDING

1 INSTALL CPU, MEMORY AND COOLER MOUNT

You need to always aim to install as much hardware as possible on a mini-ITX motherboard before you fit it into your case. You'll have limited room to work once it's installed, so fit the CPU, memory and cooler-mounting components now.

2 INSTALL M.2 SSD

The solid state drive needs to sit under the motherboard's heatsink, which will help to keep it cool. Remove the protective wrap on the thermal pad, fit the SSD and then reinstall the heatsink on the motherboard.

3 CONNECT 8-PIN EPS CPU POWER CABLE

Accessing the motherboard's 8-pin EPS CPU power connector can be tricky once the motherboard is installed in the case, so grab the cable from the PSU box and plug it into your motherboard now. You'll then just need to hook up the other end to your PSU later, once the rest of the system is built.

4 REMOVE CASE PANELS

The Phanteks Shift XT allows you to remove its exterior panels in order to get better access to the interior. This is especially useful for installing the motherboard and AIO liquid coolers, so do it now.

5 INSTALL MOTHERBOARD

Now install the motherboard into the Phanteks Shift XT. Use the screws provided with the case, lifting the PCI-E riser cable out of the way for now.

6 CONNECT FRONT PANEL CABLES

The front panel header is thankfully easy to access, so you can leave this alone until the motherboard is installed. You only need to deal with the power switch, USB 3 and USB Type-C headers in this case.

7 CONNECT PCI-E RISER CABLE

Now connect the PCI-E riser cable to the motherboard. In this case it's pre-installed, so you just need to plug it into the PCI-E slot on the motherboard.

8 INSTALL GRAPHICS CARD

The graphics card slots neatly into its own compartment, but needs to slot into the other end of the PCI-E riser cable. Ensure the two are properly connected by looking underneath the graphics card.

9 FIT FANS TO RADIATOR

You want to mount the fans so that they push air through the radiator and out of the roof, with the fans positioned as shown. The screws included with the cooler need to pass through the fan mounting tray in the top of the case, which is removable, and then through the fans before securing to the radiator.

10 SECURE FAN MOUNT

With the radiator installed, replace the fan mount on the roof of the case. It's a tight squeeze for one of the tubes, but there's a small recess in the motherboard tray that allows it to fit.

11 CONNECT COOLER CABLES

The cooler has a single 4-pin PWM

cable providing power to the pump and fans, so attach this to the CPU header on your motherboard.

12 INSTALL PUMP SECTION

With the radiator and fans secured, and the cooler's cables connected, apply thermal paste to the CPU in a thin cross-shape from corner to corner, and then install the cooler's pump/waterblock section. Position it so that the tubes are under the least amount of stress, which in this case has the tube connectors facing the I/O panel.

13 INSTALL PSU

Connect the SATA, PCI-E, 8-pin EPS and 24-pin ATX connectors to the PSU, and fit it into the case so that the PSU fan faces towards the side panel.

14 CONNECT POWER CABLES

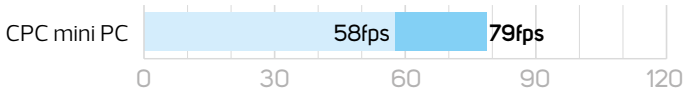
Connect the power cables to the motherboard, graphics card and, finally, the SATA connector for the case's RGB lighting if you're using it.

RESULTS

78,629	924,785	335,828	343,421
GIMP IMAGE EDITING	HANDBRAKE H.264 VIDEO ENCODING	HEAVY MULTI-TASKING	SYSTEM SCORE

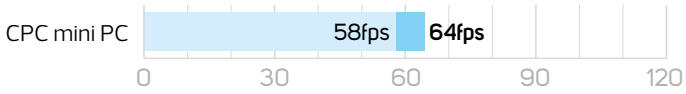
ASSASSIN'S CREED: VALHALLA

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



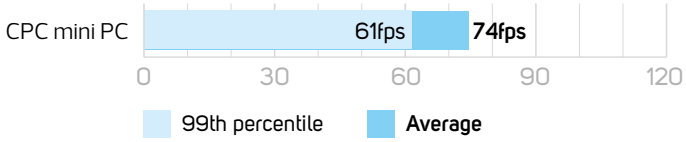
CYBERPUNK 2077

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

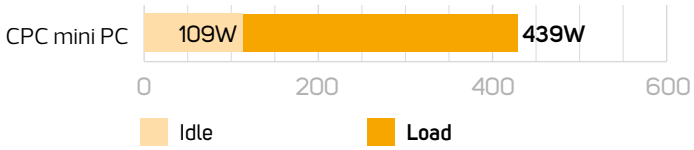


WATCH DOGS: LEGION

2,560 x 1,440, Ultra settings



TOTAL SYSTEM POWER CONSUMPTION



Our mini PC managed to produce a RealBench system score of 343,421, which was actually a tad faster than the same CPU in our 4K gaming PC in Issue 226. It also managed a silky-smooth 99th percentile frame rate of 58fps at 2,560 x 1,440 in Assassin's Creed: Valhalla, the same in Cyberpunk 2077 and 61fps in Watch Dogs: Legion.

The peak GPU temperature of 72°C was a tad on the warm side compared with an ATX case, but that's mostly due to the case having a sandwich-style design and not completely playing ball with the pass-through fan on our RTX 3070 Ti GPU. The CPU temperature topped out at 81°C with an ambient of 24°C when running Cinebench R23, so it's well away from any thermal throttling and you'll see much lower temperatures than this in games.

Finally, the peak power consumption in games was 439W, so there's plenty of headroom for upgrades and, as this figure represents less than 60 per cent of our PSU's maximum output, the PSU fan doesn't spin up too much either. CPC

INSIDE AMD FIDELITYFX *SUPER RESOLUTION 2*

AMD HAS REWORKED ITS FSR UPSCALING TECHNOLOGY, BRINGING IMPROVED IMAGE QUALITY AND PERFORMANCE IN ORDER TO COMPETE WITH NVIDIA'S DLSS. EDWARD CHESTER TESTS OUT THE NEW TECHNOLOGY

With the visual demands of modern games getting ever greater, and screen resolutions going ever higher, the brute force approach to graphics rendering is becoming less viable for many situations. That's why in recent years we've seen a significant increase in the use of resolution scaling (upscaling) to allow games to still show all the latest eye candy, such as ray tracing, without frame rates plummeting when running on high-resolution screens.

Scaling new heights

Resolution scaling is where a game engine renders the 3D portion of the game at a lower resolution than the one set in the game, and stretches that image to fill a higher-resolution screen, before then applying post-processing effects – such as film grain, chromatic aberration and on-screen blood splatters – and adding the game's heads up display (HUD).

It's basically like running a game at a lower resolution, but without ending up with a blocky-looking, oversized HUD and menu system. And because the latter are generally only rendered in 2D, they require a fraction of the processing power of the 3D scene behind them, despite being rendered at full resolution. The ability to apply some post-processing effects at the higher resolution also helps maintain a sharper-looking image compared with just running a game at a lower resolution.

That's the theory of resolution scaling, but there are many different techniques. For a long while, most of them offered fairly poor image quality – the step down from running at native resolution was very obvious – but the arrival of Nvidia's Deep Learning Super Sampling (DLSS) changed all that.

The first iteration of DLSS wasn't all that successful, but DLSS 2 has been a revelation. It offers impressive image quality in many instances, and at high quality settings can even improve image quality over running at native resolution, thanks to it replacing and doing a better job than the temporal anti-aliasing (TAA) used in many games to smooth out jagged edges. It manages this feat thanks to it using not just the visual information from the current rendered frame to upscale the image – known as spatial scaling – but also information from past frames.

By combining the past frames with object movement data from the game, the renderer can essentially add back information that is lost by initially rendering at a low resolution. This use of past data for upscaling is known generally as temporal scaling/upscaling.

DLSS 2 isn't perfect, as the temporal comparison can break down if the player moves too quickly. Plus, like any resolution scaling, it works best at high resolutions. Nonetheless, it's still a very capable technique. The only major problem is that it's exclusive to

Native resolution without AA (left) vs native resolution with TAA (middle) vs FSR 2 at its Quality setting (right)

FSR 1 (left) on Ultra Quality mode looks far worse than FSR 2 (middle) and DLSS 2 (right) on Quality mode

Nvidia graphics cards, and only RTX cards at that. All of which has compelled AMD to come up with its own resolution scaling technique called FidelityFX Super Resolution (FSR).

FSR 1

AMD's first attempt to create a rival to DLSS wasn't really a direct competitor, as it didn't include the temporal comparison of DLSS 2. Instead, FSR 1 is a spatial scaling technique that first stretches the image then uses an edge-detection algorithm to selectively sharpen certain portions of the image.

It works surprisingly well, outperforming more basic scaling techniques in some games we tried. Moreover, it gained significant traction thanks to it being a completely cross-platform system that can work on any graphics card. Over 75 games had implemented it, or announced upcoming support for it, between its June 2021 arrival and the announcement of FSR 2 in March this year.

Nonetheless, the stage was set for AMD to come up with an even better technique that could truly rival DLSS 2, which it's hoping to achieve with FSR 2.

FSR 2

FSR 2 is a complete rework of FSR that now includes a temporal comparison element, just like DLSS 2. Each initially rendered frame is compared with the previous frame and combined with motion vector data to tell the algorithm how far every part of the image has moved. Crucially, though, where DLSS 2 takes advantage of the Tensor cores in Nvidia's RTX graphics cards to accelerate the scaling process, making it exclusive to those cards, FSR 2 works on conventional graphics stream processors, using any GPU architecture.

Another key distinction between FSR 2 (and DLSS) and FSR 1 is that the new technique operates earlier in the graphics pipeline and replaces the need for TAA. The older technique dealt with the fully rendered frame after any AA – whether TAA or otherwise – had already been applied to it, leaving only the very final post-processing and HUD to be added after upscaling.

The lack of a reliance on specialised processing cores, such as Nvidia's Tensor cores, exposes the fact that FSR 2 doesn't rely on any sort of machine learning to inform its upscaler. However, even Nvidia has admitted that DLSS 2 doesn't really do any machine learning on the fly – as it did with DLSS 1 – the Tensor core requirement is mainly down to Nvidia simply choosing to use them rather than *needing* to use them.

Using FSR 2

As with other resolution scaling techniques, FSR 2 needs to be baked into the game you're playing and can't be enabled via a graphics driver. However, given the widespread support for FSR 1, we expect FSR 2 to receive a similarly speedy uptake. At the time of writing, three games have already implemented FSR 2 (Deathloop, God of War and Farming Simulator 22) and a further 16 games have support incoming.

EACH INITIALLY RENDERED FRAME IS COMPARED WITH THE PREVIOUS FRAME AND COMBINED WITH MOTION VECTOR DATA

FSR 1 looks terrible on its Performance mode (left) but FSR 2 (middle) and DLSS 2 (right) look remarkably good

Within games that support FSR 2 you'll find there are up to four detail levels available – Quality, Balanced, Performance and Ultra Performance. These will render the game at an ever-lower starting resolution as you move from the highest setting to the lowest.

The exact resolution will vary depending on the output resolution (the resolution of your monitor), so for a 4K screen the Quality setting will render at 2,560 x 1,440, while for a 2,560 x 1,440 screen, the game will render at 1,706 x 960. Using the Performance setting, a 4K screen will render at 1,920 x 1,080 and the 2,560 x 1,440 screen will render at just 1,280 x 720. These are almost identical ratios to equivalent DLSS 2 settings, with just the Balanced setting of each tending to differ slightly (sometimes DLSS 2 uses a slightly higher render resolution, sometimes FSR 2 is slightly higher).

In general, any upscaling algorithm works best when starting with as high a render resolution as possible, so it's for this reason that the FSR 2 Ultra Performance setting will often not be implemented, and it's also why Nvidia recommends the DLSS 2 Ultra Performance mode is only used in conjunction with 8K output resolutions.

FSR 2 adds one further option with which users can tinker, which is a sharpness slider. This changes the degree to which the upscaler applies a 2D sharpening filter to the final image. Just the right amount of sharpening can be crucial to tighten up the image, but too much and there can be an unnatural quality to the final image. In Deathloop, the sharpening slider was set to its maximum by default and we did find it a little aggressive. Turning it down to five out of ten felt a little more natural looking but we've stuck with the default 10 setting for our test shots.

FSR 2 image quality

We used Deathloop to test FSR 2, as it's not only the first game to implement the technology, but it also supports DLSS 2, FSR 1 and has optional TAA for use when gaming at native resolution – some games force TAA on when gaming at native resolution, which can make some image quality comparison tricky. TAA is forced on in this game when using FSR 1 though.

Our test system included an AMD Ryzen 5 3600X, 16GB of Corsair Dominator 3600MHz DDR4 RAM and an Nvidia GeForce RTX 2060. Using the latter card enabled us to test DLSS and FSR on the same card, and it also represents a good example of the sort of card that could potentially benefit from upscaling with a game such as Deathloop. At native resolution with all in-game settings set to maximum, it delivered a just-about-playable frame rate of 31fps.

FSR 2 COPED SLIGHTLY BETTER THAN DLSS 2 AT MAINTAINING A SHARP IMAGE AND MINIMISING GHOSTING

FSR 2 (top) copes better with fast motion than DLSS 2 (bottom) in our tests, with less ghosting and a crisper image

Images were captured initially with the player stood still, then we also tested for any visual artefacts while moving. We captured screenshots for the latter while walking forward with a fixed view (see above) and moving the mouse side to side (see below).

Starting off with a comparison of FSR 1 and FSR 2, it's like night and day even at the highest quality setting. The amount of detail FSR 2 manages to retain in the arm of the crane in our test shots is so much higher. Meanwhile, the anti-aliasing on the wired fences is much smoother with FSR 2. If both options are available, it's clear which to use from a visual perspective.

Trying the Performance modes reveals a starker difference. The detail in the rocks behind the crane is almost completely lost with FSR 1 and the fences look a complete mess, but with FSR 2 they still look impressively smooth.

DLSS 2 suffers considerably from horizontal ghosting, while FSR 2 seems to cope better. Native resolution without TAA is the sharpest though

Performance comparison

Upscaling mode	Minimum (fps)	Average (fps)	Maximum (fps)
Native resolution	25	31	33
FSR 1 Ultra Quality	30	34	35
FSR 1 Quality	32	37	38
FSR 1 Balanced	28	39	40
FSR 1 Performance	32	40	42
FSR 2 Quality	28	34	35
FSR 2 Balanced	17	37	38
FSR 2 Performance	29	37	38
DLSS 2 Quality	28	37	38
DLSS 2 Balanced	29	37	39
DLSS 2 Performance	30	39	40

DLSS 2 and FSR 2 have very similar performance characteristics, but DLSS 2 holds a small lead

Moving on to comparing FSR 2 against native resolution and there are two key factors to note. The first is just how little detail you lose when opting for FSR 2 on its Quality setting. There are only mere hints of detail loss here and there, although certainly the aggressive sharpening algorithm helps to provide the illusion of more detail.

The second notable factor is the poor default TAA implementation in this game. It fails miserably to retain any detail in the wire fences and generally softens the image considerably. Because of this, FSR 2 in Quality mode consistently looks better than at native resolution when TAA is enabled. Without TAA, there are jagged lines everywhere but you do retain that extra sharpness.

When it comes to FSR 2 vs DLSS 2, both implementations are very similar. The more aggressive sharpening filter makes FSR 2 pop a little more but DLSS 2 arguably has a slightly more natural-looking, softer presentation. DLSS 2 also does a better job with the wire fences, retaining more detail and a more realistic smoothness. This general impression held up in moving images too, with DLSS 2 better minimising the pixel flicker from the fences as you move around.

These broader points largely held true in Performance mode too, with both DLSS 2 and FSR 2 looking very similar and both proving impressive at retaining detail. However, DLSS 2 pulled further ahead in its ability to reduce pixel flicker on fine detail, such as overhead wires and wire fences.

As for our moving gaming tests, we were surprised to find FSR 2 coped slightly better than DLSS 2 at maintaining a sharp image and minimising ghosting. While there is distortion above the edge of the barrier in our test shots with FSR 2, there's less fully discernible ghosting, whereas the DLSS 2 shot looks softer and there are clear ghost images of the barrier above it. FSR 2, DLSS 2 and TAA all lost significant sharpness compared with native resolution with no AA too.

FSR 2 performance

We compared every possible iteration of resolution scaling available in Deathloop for the fixed 3,440 x 1,440 resolution of our test monitor, and our results were interesting. The most striking takeaway was the relatively modest performance uptick of all the upscaling modes.

With a starting point of 31fps at native resolution, the maximum frame rate, we achieved without dropping to a lower resolution or changing in-game detail settings was 40fps using the terrible-looking FSR 1 Performance mode. Meanwhile, FSR 2 and DLSS 2 were all but tied on 37fps and 39fps using their respective Performance modes.

That's still a roughly 20 per cent gain in frame rate but considering the Performance modes use a resolution half that of native resolution, it's not quite the performance uplift for which you might have hoped. However, these are early tests on just one game, and we fully expect to see greater variance in frame rate across different games at different resolutions.

Looking more closely at how DLSS 2 and FSR 2 compared, there was an average 4.6 per cent higher frame rate for DLSS 2 over FSR 2. This seems to tally with the fact that DLSS 2 can take advantage of the otherwise unused Tensor cores in an Nvidia RTX GPU to accelerate some of the DLSS 2 processing, whereas FSR 2 is taking up more performance from the main stream processors.

Conclusions

For several years, Nvidia has held a significant advantage over AMD thanks to its DLSS 2 technology, but with the arrival of FSR 2 AMD finally has an answer to this 'free performance' setting. FSR 2 looks fantastic – almost as good as DLSS 2. Both upscaling techniques can even offer image quality that's sometimes better than native resolution. Image quality in fast motion in both techniques suffers from a bit of ghosting, but it's only really of concern for competitive, faster-paced games.

DLSS 2 is still a little faster than FSR 2, but not by much, and the fact FSR 2 is available for just about any graphics card from the past ten years means it's a technology that can benefit everyone.

The fact it also works on Nvidia cards means AMD doesn't have a compelling argument for gamers buying one of its cards over one from team green, but at least buying an AMD GPU no longer means missing out on such a potentially huge performance-boosting feature. GPC

Which GRAPHICS CARD SHOULD I BUY?

*Now that GPU prices are starting to bear some semblance to normality again, **Ben Hardwidge** takes a look at the current market to tell you which GPUs should be on your shortlist*

1,920 x 1,080 GAMING

If you're only looking to play games at 1,920 x 1,080, or you're simply on a tight budget, the GPU market is still in a bit of a state. We sorely miss the days when you could buy a Radeon RX 570 for £150 and know it would do the job fine. That doesn't mean there are no options though – you just need to be careful.

Of course, this is made harder by the huge array of options available, and prices below the £400 mark are still a bit all over the place. Is it worth buying a second-hand GPU? Is an RTX 3050 better than an RTX 2060? Is the GTX 1660 still worth considering? There are so many questions, so let's take them on.

Buying second-hand

Be very wary if you're buying second-hand. Firstly, remember that any GPU you buy may have been pummelled to within an inch of its life in a cryptocurrency farm. Secondly, a lot of people are seemingly paying very silly prices for second-hand cards on eBay, when they could get new cards with a warranty for less money from an etailer now. Before you buy, check the price of the card new – don't get caught in a bidding war without doing your research – we found there was no point in buying any RTX cards on eBay at their current prices.

Let's start with the cheapest entry-level option that's worth buying, which is the GeForce GTX 1660 – these currently go for around £150 on eBay, saving you around £50 on the cost of buying one new. If you're on an extremely tight budget, this is the bare minimum spec you should consider.

A second-hand GeForce GTX 1660 is the bare minimum spec you should consider

The GTX 1660 is based on Nvidia's last-gen Turing architecture, so it doesn't have any of the RT cores for ray tracing, or the Tensor cores for deep learning, which are found on the RTX-branded Turing GPUs. As such, you won't be able to run any of the latest gaming features, such as ray tracing and DLSS.

You also won't be able to play the latest graphically demanding games at top settings, but you will be able to comfortably play them at lower settings, and you'll be fine in older and less demanding titles. We ran our old Battlefield V benchmark at Ultra settings on a GTX 1660, for example, and it averaged 79fps, which is absolutely fine.

If you can afford to stretch your second-hand budget a bit further, however, the bargain of the moment is AMD's last-gen Radeon RX 5700 XT, which currently goes for around £250 on eBay. Like the GTX 1660, it doesn't have any ray-tracing hardware, but it offers an awesome amount of raw shader power for the money. Compared with the GTX 1660, for example, it averages 135fps in the same Battlefield V test – that's 56fps quicker.

THE RADEON RX 5700 XT DOESN'T HAVE ANY RAY-TRACING HARDWARE, BUT IT OFFERS AN AWESOME AMOUNT OF RAW SHADER POWER FOR THE MONEY

We also ran some of our new game tests on the Radeon 5700 XT, and it produced some stunning results for the money. It averaged 253fps in Doom Eternal at 1,920 x 1,080, for example – you could even use this card on a monitor with a high refresh rate. It also averaged 76fps in Metro Exodus.

That's 12fps quicker than the GeForce RTX 3060, and for much less money. It even outperforms the GeForce RTX 3060 Ti in Assassin's Creed Valhalla. If you just want the fastest frame rates for the cheapest price, and you don't care about ray tracing, this is the

AMD's Radeon RX 5700 XT is the second-hand bargain of the moment, but try to find one without this reference cooler design

The aging GeForce RTX 2060 is cheaper and faster than the new RTX 3050 at current prices

second-hand card to buy – just make sure you buy a third-party card with a decent cooler, rather than a reference design with a noisy blower-style cooler.

What about the RTX 2060?

In the midst of a crisis where none of its latest GPUs could be bought, Nvidia rushed the aging GeForce RTX 2060 back out to market, which has created a bit of a confusing situation when it's up against the new cards. To make matters worse, there's also now an 8GB version with slightly more CUDA cores than the previous 6GB version. However, given that prices of the latter now border on the silly (they start from £330 inc VAT on **scan.co.uk**), the 6GB flavour is the one to consider if you're on a tight budget.

We've tested the RTX 2060 6GB in our current test suite, where it clocked up an average of 59fps in Metro Exodus, and it maintained a 47fps average in this game with High ray tracing enabled too, but only with a clunky 99th percentile result of 27fps. You can improve these results if you enable DLSS, but in all honesty, DLSS looks horrible at 1,920 x 1,080 – you'd be better off lowering some of the graphics settings instead. However, you only get 6GB of memory, so this GPU won't even run our Doom Eternal test at top settings.

Comparatively, the pricier RTX 3050 is significantly slower in Metro Exodus (48fps, or 40fps with ray tracing). The RTX 2060 is also slower than the Radeon RX 5700 XT, but it's a decent step up from the GTX 1660 in terms of shader power, averaging 110fps in Battlefield V. Also, while you can't get decent ray-tracing frame rates from this card in the latest demanding games, it can cope with it in some less demanding and older titles. For example, it averaged 55fps in Battlefield V with High ray tracing enabled.

AMD's Radeon RX 6600 XT remains the sub-£400 GPU king

Enough of the old GPUs already

We'll admit it's a bit hard to get excited about the prospect of buying a second-hand GPU, or a new one based on a last-gen architecture, so what are your best bets if you want a proper brand-new GPU?

For starters, forget any GPUs at the low end. The Radeon RX 6500 XT might look tempting, with its sub-£200 price tag, but these cards are based on the same Navi 24 chip used in AMD's low-end mobile GPUs. They only come with 4GB of memory, they have narrow 64-bit memory interfaces and they only have 1,024 stream processors. It speaks volumes that not a single card manufacturer has been brave enough to send one to us for review.

The GeForce RTX 3050 is a better option, coming with 8GB of memory, 2,560 CUDA cores and a 128-bit memory interface. However, in our tests the RTX 3050 is outperformed by the cheaper RTX 2060.

With the two new low-end options knocked out, that brings us to the GeForce RTX 3060 and AMD's Radeon RX 6600 and 6600 XT, with prices respectively starting from £300, £350 and £360 from **overclockers.co.uk**

If you can't afford to go above beyond £300, the Radeon RX 6600 is a decent option. It even outperforms the pricier RTX 3060 in Metro Exodus at 1080p without ray tracing, for example, averaging 66fps.

If you can afford to go a bit further, you're choosing between the GeForce RTX 3060 and Radeon RX 6600 XT, and it's the latter that gets our vote. It's the one sub-£400 GPU that hits our frame rate target (at least a 45fps 99th percentile and 60fps average) across most of our test suite.

At 1,920 x ,1080, it averages 79fps in Assassin's Creed Valhalla, even beating the GeForce RTX 3070. It also beats the GeForce RTX 3060 in our non-ray-traced Cyberpunk 2077 test, with a 59fps average compared to 58fps. You can even (at a push) enable ray tracing on it. The 6600 XT produced the same average of 54fps in Metro Exodus as the RTX 3060 with High ray tracing enabled, but its 99th percentile result of 35fps was faster than the RTX 3060's 32fps.

The RTX 3060 has superior ray-tracing power in newer games such as Cyberpunk 2077, but that point is largely moot, as it still only averaged 35fps (compared to 22fps for the Radeon RX 6600 XT). You can get a boost by enabling DLSS on the RTX 3060, but we don't recommend using these resolution scaling technologies at 1,920 x 1,080 anyway. The best new card you can buy for under £400 is the Radeon RX 6600 XT.

In summary

My budget is very limited
Second-hand Nvidia GeForce GTX 1660
~£150 *ebay.co.uk*

I want fast frame rates on the cheap
Second-hand AMD Radeon RX 5700 XT
~£250 *ebay.co.uk*

I want to buy new
Nvidia GeForce RTX 2060 6GB
£249 *overclockers.co.uk*

I'm happy to pay for the best
AMD Radeon RX 6600 XT
£360 *overclockers.co.uk*

2,560 x 1,440 GAMING

If you're looking to play games at 2,560 x 1,440 then you'll need a bit more GPU power in order to churn out all those extra pixels. Thankfully, the GPU market starts to get much less cluttered and complicated once you get beyond the £400 level, and it's been recently made much simpler by the fact that several of Nvidia's Founders Edition cards are now actually back in stock at **nvidia.com** at their original launch prices.

With a price of £469 inc VAT, the RTX 3070 is a no-brainer if you want to go beyond 1080p. It also leaves its little sibling, the RTX 3060 Ti, in rather a no man's land. There's no Founders Edition of the latter available on **nvidia.com** at the moment, and board partner cards at retailers currently start at £470 inc VAT on **overclockers.co.uk**, so you may as well buy the RTX 3070 Founders Edition.

The RTX 3070 is generally around 10 per cent quicker than the RTX 3060 Ti – both GPUs are based on the same GA104 chip, but the RTX 3070 has 46 of its streaming multiprocessors (SMs) enabled, compared to 38 on the RTX 3060 Ti. This gives it 5,888 CUDA cores, over the 4,864 in the 3060 Ti, and it also gives it eight more RT cores for ray tracing.

The RTX 3070 is also generally quicker than AMD's nearest competition, the Radeon RX 6700 XT and the new (identical but clocked up) Radeon RX 6750 XT, with the former currently starting at £470 inc VAT from **overclockers.co.uk**. The exception to this generalisation is Assassin's Creed Valhalla, where the Radeons have the upper edge, but the RTX 3070 still averages over 60fps in this game.

The RTX 3070 Founders Edition is a no-brainer now that it's back in stock at £469

Otherwise, the RTX 3070 is quicker across the board, and it also opens up the gateway to ray tracing. It averages 63fps in Metro Exodus at 2,560 x 1,440 with High ray tracing, compared to 47fps for the Radeon RX 6700 XT, and this increases to 71fps if you enable DLSS, which is worth doing once you hit 2,560 x 1,440.

Until this point, we'd previously been recommending Nvidia's newer GeForce RTX 3070 Ti, as the RTX 3070 was either out of stock or overpriced, but the re-establishment of both GPUs in Founders Edition cards changes this situation. There's not much difference between the RTX 3070 and the 3070 Ti, with just an extra two SMs enabled on the latter, giving you 256 extra CUDA cores, and the Ti card also has GDDR6X memory, rather than GDDR6.

That spec boost gives you a little more performance, but not a great deal – you're looking at an extra 4fps in Cyberpunk 2077 with Medium ray tracing and DLSS, or an extra 5fps in Metro Exodus with High ray tracing and DLSS. That's not much of a difference for an extra £90. Still, if you want a bit more performance, and you can't run to the RTX 3080, the RTX 3070 Ti is still a decent option.

Finally, we come to the ultimate card for gaming at this resolution, the RTX 3080. Sadly, the Founders Edition isn't in stock at **nvidia.com again**, but you can pick up a board partner card for £740 inc VAT from **overclockers.co.uk**. The 10GB version is all you need if you're gaming at 2,560 x 1,440, and it's a killer GPU. It will run Cyberpunk 2077 at 80fps with Medium ray tracing and DLSS, and it will only drop down to a 63fps 99th percentile.

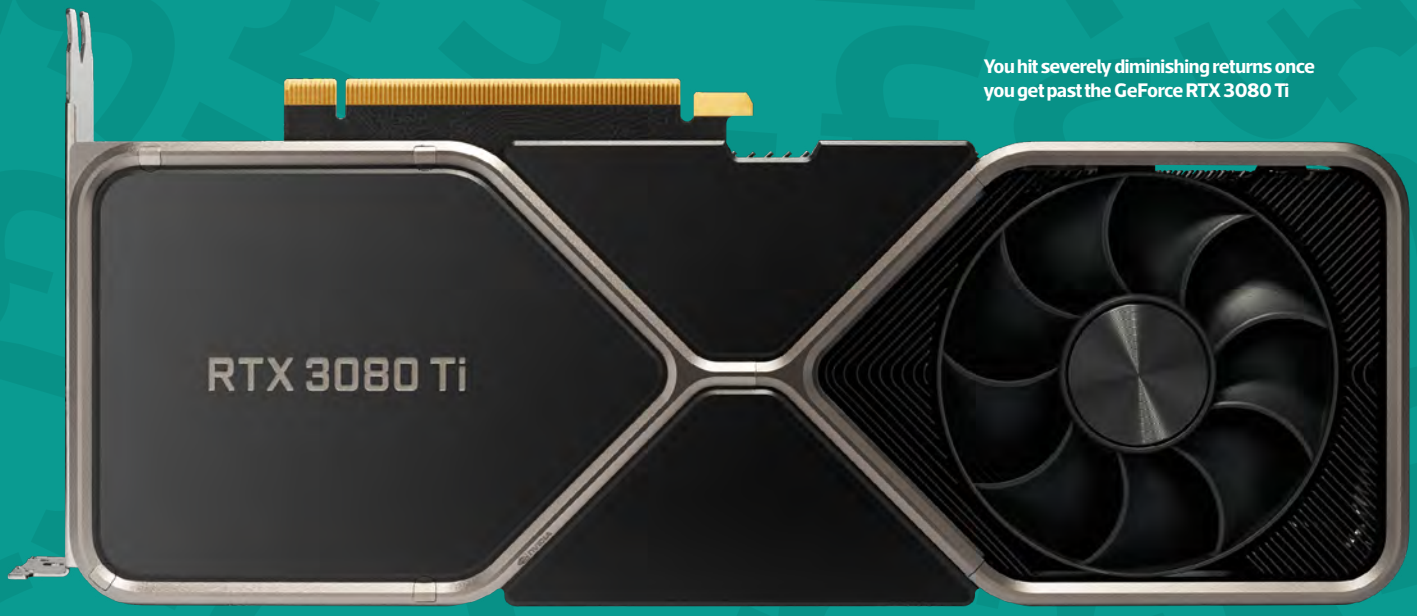
Add its superb 348fps average in Doom Eternal at 2,560 x 1,440 (the RTX 3070 Ti gets 300fps), and its 90fps average (with a 52fps 99th percentile) in Metro Exodus with High ray tracing and DLSS, and this is a fantastic GPU if you can afford it.

In summary

I want to go beyond 1080p
Nvidia GeForce RTX 3070
£469 *nvidia.com*

Give me a bit more power
Nvidia GeForce RTX 3070 Ti
£549 *nvidia.com*

Only the best for sir
Nvidia GeForce RTX 3080 10GB
£740 *overclockers.co.uk*



You hit severely diminishing returns once you get past the GeForce RTX 3080 Ti

4K GAMING

Finally, we come to the pinnacle of gaming resolutions, the mighty pixel space of 3,840 x 2,160. There aren't many graphics cards up to this job. In fact, even the £1,879 GeForce RTX 3090 Ti can't play Cyberpunk 2077 with Ultra ray tracing at 4K, even with DLSS enabled.

As we covered in our recent 4K gaming feature (see Issue 226, p78), you get the best 4K bang for your buck from Nvidia's GeForce RTX 3080 Ti. You can pick up the Founders Edition for £1,049 from **nvidia.com**, but board partner cards also currently go for the same price at **overclockers.co.uk**. Plus, unlike the RTX 3070 Ti, there's a substantial step up in spec between the RTX 3080 and the 3080 Ti.

It has 80 of its GA102 GPU's SMs enabled, giving it 10,240 CUDA cores, compared to 8,704 in the RTX 3080. Its 384-bit memory interface is also wider than the 320-bit interface on the RTX 3080, and it has an extra 2GB of GDDR6X memory.

The GeForce RTX 3080 Ti is the minimum-spec GPU that hits our frame rate target in Metro Exodus at 4K with high ray tracing enabled, averaging 74fps with a 47fps 99th percentile – that average is 10fps faster than the result from the standard RTX 3080. Its 227fps average in Doom Eternal at 4K is also a stunning result.

AMD's nearest competitor is the Radeon RX 6950 XT; like all the latest Radeons, this is faster than the equivalent GeForce GPU in Assassin's Creed Valhalla, but otherwise the RTX 3080 Ti is faster across the board at 4K.

Beyond this point, you get into severely diminishing returns. The RTX 3090 comes with a huge 24GB of memory, but only gives you an extra two SMs, so the performance impact on games is minimal (just 5fps in Metro Exodus at 4K with High ray tracing). Prices for the RTX 3090 start at £1,518 inc VAT on **scan.co.uk** – a lot of money for such a small boost.

THE GEFORCE RTX 3090 ONLY GIVES YOU AN EXTRA TWO SMs OVER THE 3080 Ti, SO THE PERFORMANCE IMPACT ON GAMES IS MINIMAL

Likewise, the RTX 3090 Ti gives you another two SMs on top of the RTX 3090, but costs £1,879 – that's an extra £830 over the RTX 3080 Ti, and it's only 7fps faster in Metro Exodus with High ray tracing. Unless you literally have money to burn, the RTX 3080 Ti is the 4K gaming sweet spot.

In summary

I want to play games at 4K
Nvidia GeForce RTX 3080 Ti
£1,049 *nvidia.com*

I love the smell of burning money
Nvidia GeForce RTX 3090 Ti
£1,879 *nvidia.com* 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

The Panic Playdate isn't your average handheld device, with its black and white display and hand-crank peripheral

REVIEW
Panic Playdate

Created through a collaboration between games publisher Panic and esoteric electronics concern Teenage Engineering, the Playdate is a handheld console. It's not your usual handheld console either. For starters, the Playdate's screen is black and white. Not shades of grey, but a simple 1-bit black and white 2.7in 400 x 240 panel. There's neither a back nor a front light, meaning it's usable only in a well-lit room or in sunlight – like Nintendo's original Game Boy range.

The standard bundle is just the console and a USB cable, with the protective case sold separately

However, it's also smart. The panel uses Sharp's Memory LCD technology, which means it draws very little power unless it's being actively updated. In fact, the Playdate's display is always on: when you're not playing, it doubles as a clock – a feature that will be enhanced with the planned launch of a desktop dock in the near future.

Most of the controls on the bright yellow console, which feels pleasingly robust in hand despite its small size, are standard fare. There's a 4-way direction pad to the left and two buttons to the right, with an optional flip mode to put the screen on the bottom and swap the D-pad to the right and the buttons to the left. There's also a menu button and a top power button with an RGB status LED.

Meanwhile, the single speaker sounds surprisingly clear, and makes a solid alternative to using the 3.5mm headphone jack found next to the USB Type-C charging and data port on the base. Weirdly, there's also a crank on the right-hand side – a metal and plastic crank, with a yellow handle, which hides in a small slot when it's not in use.

The crank is, effectively, the console's main selling point. While it might look like a device you'd use to charge the console in some kind of gaming emergency, it's actually an input device. The console can tell whether you're cranking it forwards or backwards and at what speed, while a sensor can also inform the game whether or not it's docked.

NEWS IN BRIEF

Seeed Studio opens UK warehouse

Hobbyist and embedded electronics specialist Seeed Studio (**seeedstudio.com**) has opened its first warehouse in the UK, offering dramatically improved delivery times and reduced costs compared with products shipped from its Chinese warehouses.

'Once you finalise your orders,' Seeed's Serna Liang explains, 'the purchases are sent from our UK warehouse and expected to be received in two to three working days with about $3-$8 [around £2.40-£6.40 ex VAT] shipping fees.' Only a subset of the company's products are available from the UK, but Seeed has indicated the range will grow over time.

Which brings us on to the games. Here, you'll need to temper your expectations. The console is powered by an STMicro STM32 microcontroller with a single Arm Cortex-M7F core running at 180MHz, plus an Espressif ESP32 added for Wi-Fi and Bluetooth connections. With just 4GB of non-expandable storage, you're not likely to see a Skyrim port any time soon.

The console's compact size makes it ideal for on-the-go gaming

The bundled games range from basic RPGs, such as Casual Birder, to a music-making sequencer

What you get instead is a 'season' of games from independent developers – 24 titles, provided at the rate of two a week for 12 weeks. The first two, Whitewater Wipeout by Chuhai Labs and Casual Birder by Diego Garcia, offer a taste of what to expect. They offer simple graphics, pick-up-and-play gameplay and clever use of the crank.

In Whitewater Wipeout, the crank controls the direction of your surfboard as you perform as many tricks as possible; in Casual Birder, the crank manages the focus of your camera as you try to win a bird-spotting competition and kick the 'bad birders' out of the village.

Not every piece of software in the first season is technically a game. Boogie Loops, one of the titles delivered in your second week of Playdate ownership, is a cutesy but surprisingly deep music sequencer with dancing pandas, pizza slices, rabbits and cacti.

You're not limited to just playing games either. Panic has published a full software development kit, allowing anyone – even, thanks to the simulator, those who don't have a Playdate themselves – to have a crack at writing their own software. For the less technically minded, a browser-based game development environment called Pulp offers a much lower barrier to entry.

The Playdate community has already released a number of packages for the console, ranging from commercial games to simple tools, such as a DTMF phone dialler, to a collection of productivity tools with a voice memo feature that taps into the console's on-board microphone.

The official software, however, still needs some work. The battery life is one concern, with overnight drain being higher than expected – a problem worsened by the console's fussiness with USB chargers – the review unit refused to accept a charger that works fine with other devices.

The biggest problem with the Playdate, though, is its price. At $179 US or $199 US for the one with the highly recommended magnetic protective cover (around £145 and £161 ex VAT respectively), the Playdate isn't cheap. Landed in the UK, you'll pay £222 inclusive of shipping and VAT – making it more expensive than the considerably more capable Nintendo Switch Lite.

If you have some cash spare, though, it's an undeniably delightful device – and it's the perfect size for on-the-go gaming. The Playdate is available to pre-order online from **play.date** now.

The case is overpriced but solidly built, and keeps the screen safe

UPDATE
MNT Reform

While component shortages have delayed shipments, the MNT Reform community is growing apace

The MNT Reform (reviewed in Issue 220) is more than just a laptop. It's a project driven by an aggressively open ethos, and with development that's both rapid and incremental – so much so that, less than a year since its first review, there's already been plenty of new activity to report.

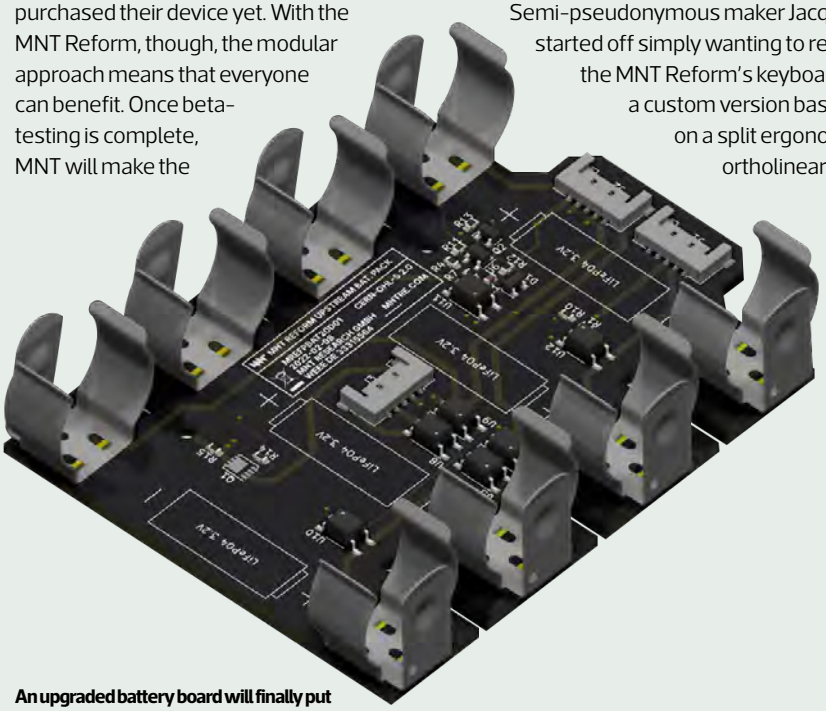
MNT Research hasn't been resting on its laurels since the original chunky, retro-style open-source laptop hit the market. In addition to a previously reported firmware update designed to work around the issue of batteries becoming too deeply discharged while the laptop is in a sleep state, company founder Lukas F. Hartmann has been investigating a hardware fix.

The result is a brand-new battery board, which includes per-cell monitoring in hardware. When the voltage drops to a minimum safe level, the batteries are completely disconnected from the system until they're recharged – a final and conclusive fix for the problem.

With a traditional laptop, that would be good news only for those who haven't purchased their device yet. With the MNT Reform, though, the modular approach means that everyone can benefit. Once beta-testing is complete, MNT will make the battery boards available for sale as a drop-in upgrade for existing Reform laptops – or, given the open nature of the project, you could also download the design files and have a crack at producing your own battery board.

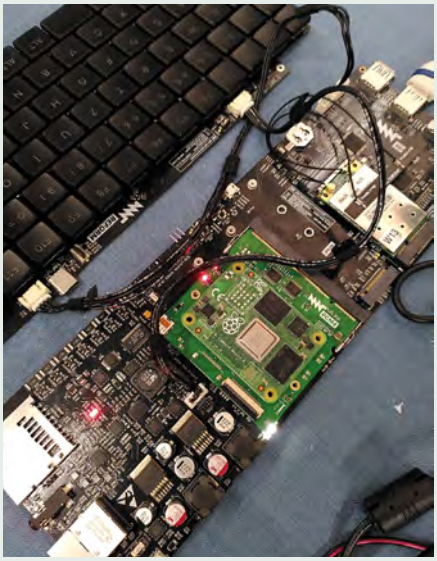
A laptop you can literally make yourself was always Hartmann's vision, but few people have actually attempted it. The kit form version of the Reform, which is sold at a discount over the pre-assembled units, is popular, but comes with the circuitboards already populated. PCB design files are readily available from MNT Research, but it's only in the past few months that someone has proven that they give you enough information to make your own PCB from scratch.

Semi-pseudonymous maker Jacqueline started off simply wanting to replace the MNT Reform's keyboard with a custom version based on a split ergonomic ortholinear layout.



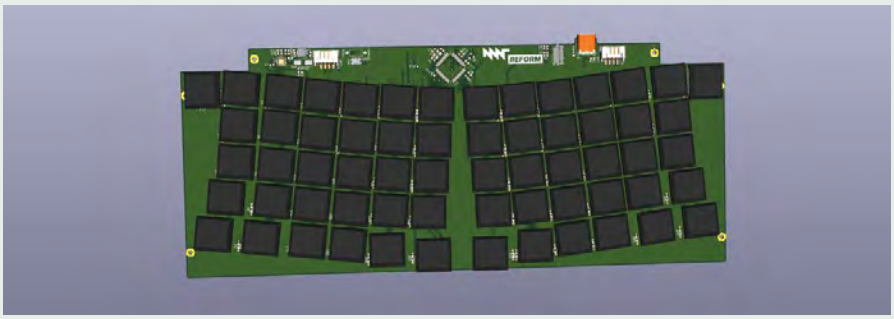
An upgraded battery board will finally put an end to deep-discharge problems

From there, the project spiralled. Jacqueline's finished Reform is a spin on the original design that not only encompasses a brand-new keyboard but also swaps out the power jack on the motherboard for a USB Type-C connector with Power Delivery support. It was built entirely from scratch using the board design files released by MNT Research.



A work-in-progress adapter aims to bring the Raspberry Pi Compute Module 4 to the Reform

Still in the prototyping stage, the Pocket Reform brings back the netbook form factor



The community has contributed a range of add-ons and respins, such as this ergonomic keyboard design

Others in the community have also been hard at work. There are work-in-progress projects for custom keyboard designs, as well as modifications for stowable external antennas for improved Wi-Fi range. There are also alternate operating system efforts, including a port of Plan 9 from Bell Labs, a classic and now open-source distributed operating system first developed in the 1960s.

Moving back to MNT Research itself, the battery board isn't the only upgrade in development. Hartmann and colleagues have also been working on the Reform Camera, a privacy-focused open-source webcam upgrade.

The team has also released robust metal side panels as alternatives to the thin plastic ones that originally shipped with the laptop. The trackball has undergone a series of revisions to improve its feel as well, including the addition of steel ball bearings for a smoother glide.

The company is also well into development of a smaller, netbook-like alternative machine dubbed the Pocket Reform. With a clamshell design likely to centre around a 7in display, as well as a compact ortholinear keyboard, the Pocket Reform is still in the prototype stage with no release date yet available.

On the software front, many highlighted bugs in our original review have been ironed out. A 3rd-generation operating system image was running through beta at the time of writing, designed to resolve several issues, including the problem of package manager updates often breaking customisations. It's expected to have launched by the time this issue hits the shelves.

There's still little news on the promised new system-on-module (SOM) designs, however. Occasional teaser images and benchmark tests are being shared of SOMs that offer everything from high-performance Arm cores with up to 16GB of RAM or carriers for Raspberry Pi 4 Compute Modules, to SOMs built around the free and open-source RISC-V architecture, but none of them has a release date attached. With that said, several SOMs appear to be in the final stages of development, which is good news for those who found the performance of the Reform's stock SOM disappointing.

The final update, sadly, is less positive. The ongoing component shortages affecting the entire electronics industry have resulted in stock problems. Many people who pre-ordered their machine after the original crowdfunding campaign are still waiting for their hardware a year later, and anyone ordering one now is warned to expect a wait time of six to nine months.

Those not put off by that fact can place an order on **mntmn.com** now, with prices starting at €1,099 (around £930 ex VAT) for the DIY kit version.

NEWS IN BRIEF

Framework Mainboard powers new custom builds

The Framework Mainboard, a single-board computer originally designed to power the Framework modular laptop, has begun appearing in impressive community builds, including the pictured machine based on a circular display. Created by Penk Chen, designer of the CutiePi tablet, the Mainboard Terminal (**github.com/penk/MainboardTerminal**) features a 5in circular screen and a custom mechanical keyboard. 'And yes,' its creator notes, 'it runs Spacewar!'

Richard Sutherland's Framedeck (**github.com/brickbots/framedeck**), meanwhile, is a portable machine inspired by the TRS-80 Model 100 and housed in a transparent laser-cut case. The Framework Mainboard is available to buy from **frame.work** now, priced from £399 (inc VAT).

Jacqueline's customised Reform includes a new keyboard and a revised motherboard with USB Type-C charging

REVIEW

From Vultures to Vampires

In Commodore: The Inside Story (reviewed in Issue 189), former Commodore UK managing director David Pleasance aimed to tell the tale of what happened within the (at the time) immensely successful computer maker to bring about its downfall. At least, that was the idea – instead, it served as an outlet for increasingly unbelievable and in no way corroborated personal anecdotes, plus a series of considerably more enlightening contributed chapters from the community.

From Vultures to Vampires: 25 Years of Copyright Chaos and Technology Triumphs Volume One 1995-2004, to give the follow-up its full title, is a very different book. Pleasance's name is still on the cover, but there's another one beneath it – Trevor Dickinson, who wrote the foreword in the original book.

The tonal shift is revealed within the first few pages. You'll find no first-hand accounts of trade show orgies or ill-advised drink-driving adventures; instead, you'll get a roughly chronological journey through the post-Commodore years, focused almost (but not quite exclusively) on the fate of the Amiga family of machines.

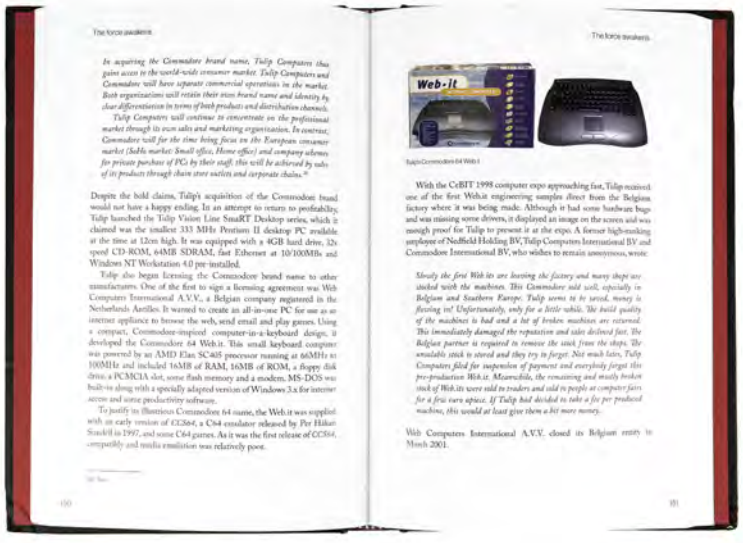
It's all factual in nature. Quotes both contemporaneous and newly obtained are cited, although the colour images sprinkled around the pages are left unattributed, and subjects were approached for comment and clarification, which Pleasance avoided for his original book.

It's also, at times, a little dry. From the off, nearly four pages are taken up by a cut-and-paste copy of Commodore's bankruptcy filing, and a fair chunk of the rest of the book is taken up by regurgitation of technical specifications for every Amiga and Amiga-like machine that followed Commodore's sales, splits and eventual demise.

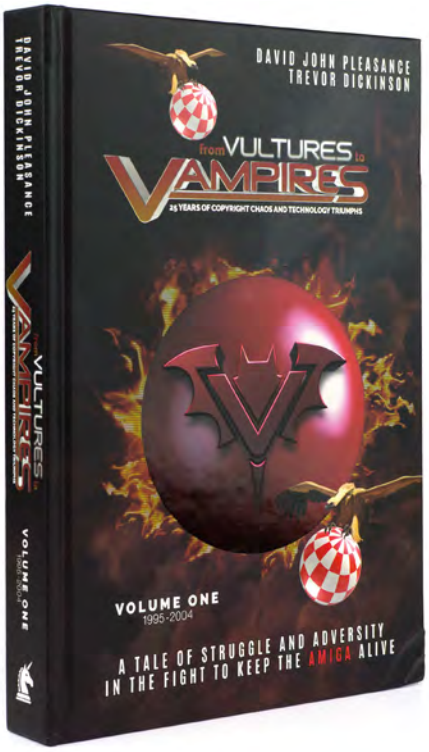
Having criticised Pleasance's original for its anecdotal nature, it feels churlish to ding Dickinson's follow-up for going in the opposite direction, but it's a shame a middle ground between the two styles couldn't have been found.

It's not all speeds-and-feeds, though, and there are fascinating stories to be found within the book. Examples go from a company's demise after investigations into its direct funding of terrorist activities, to the still ongoing arguments as to which of the various efforts to keep the Amiga alive into the 21st century are to be considered 'official'.

There's a bit of a bait-and-switch to the publication strategy, sadly. The title was originally crowdfunded as a single book, before its authors decided to split it into two volumes, and ask backers to buy the second book at only a slight discount. With unarguable leeway to cut down on the filler, there was almost certainly room to pack the whole story into a single book.



There aren't too many images inside, but what's included is reproduced in full colour on glossy paper



Originally proposed as a single book, From Vultures to Vampires is now two separate volumes

The book could also have benefited from an additional editorial pass. A smattering of typographical errors break the flow. Sensible Soccer is attributed to publisher Renegade rather than the better-known Sensible Software, which created it, and concepts relating to the Amiga's inner workings – such as the '2MB chip RAM barrier', a 'planar-to-chunky chip', and the concept of 'retargetable graphics' – are dropped into the text without explanation.

Ending on a clear cliffhanger – 'unfortunately,' the reader is told, 'it was about to get much worse' – it feels like a book that only those already deeply entrenched within the Amiga community will enjoy, although whether they'll enjoy it enough to splash out on both volumes remains to be seen.

From Vultures to Vampires Volume One is available from **blackwells.co.uk** now for £24.73 (zero-rated for VAT), a discount from its £35 recommended retail price. The second volume hasn't yet been published. CPC

Gareth Halfacree is a keen computer hobbyist, journalist, and author. His work can be found at freelance.halfacree.co.uk @ghalfacree

WIN

A FRACTAL TORRENT NANO RGB MINI-ITX CASE

If you're feeling inspired to get started on building a new mini system after this issue then you'll want to enter this month's competition, where we have an award-winning Fractal Design Torrent Nano RGB case up for grabs.

The Torrent Nano RGB is built to maximise cooling potential straight out of the box. Its main standout features include an unobstructed base intake, an open front grille and a Fractal 180mm Prisma AL-18 RGB fan, which has been custom-made to achieve maximum air cooling while maintaining controlled noise levels.

Other features include a removable top bezel, along with routing clips with cable ties, to make for easy installation and cable management. There's also a top-mounted aerodynamic PSU shroud with integrated ARGB effects, and the case's lights are all fully controllable by motherboards that support addressable RGB (5V).

Meanwhile, despite being space-optimised, the Torrent Nano can hold a three-slot graphics card up to 335mm long, and its seamless tempered glass panel has a bolt-free, top-latching mechanism.

SPEC

- **Motherboard compatibility** Mini-ITX, mini-DTX
- **Power supply support** ATX, max length 200mm
- **CPU clearance** 165mm
- **Graphics card clearance** 335mm, three slots
- **Included front fan** 180mm Fractal Design Prisma AL-18 RGB
- **Total fan mounts** 1 x 180mm, 4 x 140mm or 5 x 120mm (with included brackets)
- **Front panel** 1 x USB 3.1 Gen 2 Type-C, 2 x USB 3, audio jack

SUBMIT YOUR ENTRY AT **CUSTOMPC.CO.UK/WIN**

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Beware Socket AM5 cooler compatibility

Not a lot is known about Socket AM5 at the moment. We don't know exact CPU models or core counts, although it looks like 16 cores may be the limit, at least at first, and when I spoke to AMD's Robert Hallock recently, he suggested that 3D V-Cache might not appear at the launch of AMD's new socket either, but that we would be seeing it again.

However, one point that has been made clear is that coolers that are compatible with AMD's current Socket AM4 will fit on Socket AM5, and that there has been no change in Z-height for the new CPUs either, unlike Intel's Alder Lake CPUs.

I have, however, learned from waterblock manufacturer EK that Socket AM5 isn't going to offer cooler manufacturers and cooler owners an entirely easy ride. While the plastic brackets on current Socket AM4 boards will remain, giving coolers that use them a free pass for cooling Zen 4 CPUs, the same can't be said of those coolers that require the use of a backplate on the motherboard.

EK told me this month that the backplate will be fixed to the socket this time, rather than being detachable, as with Socket AM4.

This is similar to Intel's LGA2066 socket, meaning that the use of custom backplates won't be possible. This raises some significant problems, as plenty of air coolers, AIO liquid coolers and waterblocks require the use of a custom backplate to secure them to the motherboard.

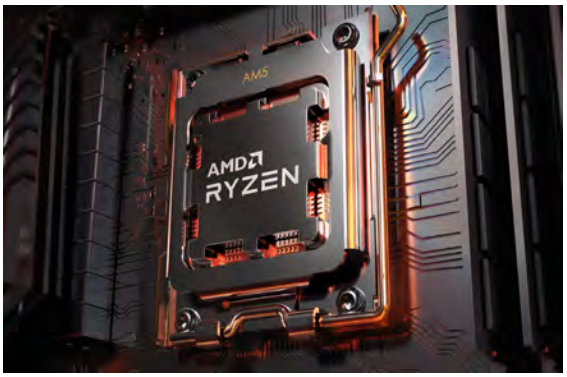
It remains to be seen if the CPU socket mounting holes will sit in the same place, and if the backplate itself is physically the same, with the same threads as the one used on current Socket AM4 motherboards.

Socket AM4 coolers that use the standard plastic mounting brackets will be compatible with Socket AM5

If it is, then there are a number of coolers that do currently make use of the included backplate rather than using their own designs.

If that's the case then two out of three situations will be okay. However, it's highly unlikely that any CPU cooler or waterblock that uses a custom backplate will cleanly fit to an integrated backplate on a Socket AM5 motherboard.

The fittings for these coolers vary significantly, with different screw lengths and screw threads, so if you're planning on jumping on the Socket AM5 bandwagon at launch, and the cooler you plan to use has a custom backplate, be prepared for some problems on day one. You'd also be well advised to check compatibility with your cooler's manufacturer nearer the time, as they'll probably offer adaptor kits if necessary.



AMD's new Socket AM5 will apparently use a backplate that's fixed to the motherboard

That said, the similar situation with Intel's new LGA1700 socket didn't result in a smooth transition, with adaptor kits suffering from poor availability at launch, and many manufacturers still not offering them or even compatibility information. We'll be updating you here with the latest news as we approach AMD's Socket AM5 launch.

Reduce your bills by undervolting

My needs from my main rig have changed quite a bit over the years. I've gone from massive water-cooled, overclocked behemoths that took up half my bedroom, to compact mini-ITX PCs that focus on space saving and low noise. The latter always involved custom water cooling, though, and that's not likely to change, as I like a quiet PC with plenty of headroom for beating the heat. However, I don't tend to do that much overclocking anymore.

As my current system sports a Ryzen 5000-series CPU, overclocking has been rather pointless too. There's more benefit from leaving many CPUs at their stock speed settings, rather than overclocking them, as their boost frequencies (especially at the higher end), are higher than what you'd achieve with a manual all-core overclock. You can tweak individual cores, of course, but this can be hugely time-consuming. However, there is a hidden benefit among all those overclocking settings, which is the ability to reduce the CPU voltage compared with stock speed.

This can apply to both stock speed and overclocked situations. With many CPUs pushed to their limits with high boost frequencies and vcores, reducing the voltage or power limit of a CPU can result in lower load temperatures compared with stock speed. Even overclocking the CPU, but reining in the voltage can have benefits, reducing its peak temperatures under load.

Dialling in these settings with a stock speed CPU can bring it within striking distance of smaller coolers too, potentially saving you money or allowing you to cool your CPU with a more modest cooler or even a smaller case. This also applies to graphics cards, where undervolting them can have big rewards in terms of reduced power consumption and thermals.

With today's electricity prices showing no signs of falling, undervolting or reducing your CPU's power limits can save on your electricity bill too. It's possible to shave over 100W of power from your PC's load draw – more if we're talking about a high-end system in situations that use both the CPU and GPU under heavy load.

Importantly, undervolting or reducing power limits doesn't always result in lower performance. Simply lowering the voltage that your CPU or GPU can use will mean it still adheres to its boosting algorithms, but the resulting lower temperature may enable it to boost further.

Of course, in some situations, messing around with voltages can kill any boosting algorithms, as your motherboard will think you're attempting a manual overclock. However, the latest boosting technologies from AMD and Intel, such as Precision Boost Overdrive 2 (PBO2) and Intel's granular per-core approach, allow you to adjust power limits and voltages without impacting on performance.

If you haven't tinkered with undervolting yet and, like me, nearly fell off your chair when you looked at your last electricity bill, it's worth taking a look. The places to start are manual undervolting with older AMD CPUs, and using PBO2 and its custom voltage curve with current AMD CPUs.

Meanwhile, Intel systems can offer plenty of flexibility, with motherboard EFIs often containing PL1 (long-term TDP) and PL2 (short-term maximum power draw) power limit controls.

These all offer quick and easy ways to adjust power, and in turn temperatures and power consumption, often with little to no drops in real-world performance. You can see a full guide to undervolting your hardware in our next issue. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Spray-paint your case

Antony Leather shows you how to transform your PC's look with your own choice of colour and paint effects

TOTAL PROJECT TIME / 48 HOURS

Spray painting offers a fantastic way to customise your PC, thanks to the huge array of colours and effects available with today's acrylic paints. All you need is a small space to work that's well ventilated, along with some protective gear, and you can give your PC a unique colour and finish that's colour-matched to your hardware and lighting.

Spray painting can be tricky to get right, though, and there are plenty of pitfalls that can ruin your day. Thankfully, with a few tips, as well as the right preparation, you can achieve a great finish even with basic gear. In this guide, we'll cover the process from start to finish, including dismantling and reassembling a case, cleaning and priming the surfaces, using effects paints, achieving a durable finish, and keeping you and your surroundings safe and paint-free.

TOOLS YOU'LL NEED

Acetone paint cleaner
vipgraffitipaint.co.uk

Drill and 3mm bit
Most hardware stores

Microfibre cloth
Most hardware stores

Frog Tape
Most hardware stores

Plastic greenhouse
amazon.co.uk

Respirator with P3 filters
amazon.co.uk

Rivet gun and rivets
amazon.co.uk

2K clear coat
ebay.co.uk

Spray paints, primer and clear coat
vipgraffitipaint.co.uk

1,000-grit sandpaper
Most hardware stores

Disposable gloves
Most hardware stores

1 / USE PROTECTIVE GEAR

Spray paint gets everywhere, so it's important to wear old clothes, protective gloves and goggles that enclose your eyes. It's unlikely the paint will wash out of clothes and you want to avoid getting it on your skin as much as possible.

2 / USE A RESPIRATOR

When painting small objects in a well-ventilated space, a painting face mask will suffice, but if you're spraying your whole case or using a sealed enclosure to contain paint, you'll need a respirator. It will allow you to spend extended periods around paint fumes and protect you for short periods against premium clear coats too.

3 / USE SEALED ENCLOSURE

Having a well-ventilated area is important to ensure fumes disperse, but spraying in the open will lead to dust and bugs getting trapped in the paintwork. Using a plastic greenhouse traps paint overspray and allows ventilation, but drastically reduces detritus drifting onto your painted surfaces, and it allows you to paint in all weathers.

4 / CLEAN YOUR NOZZLES

If you're reusing old spray can nozzles, or finishing up after this guide, use acetone or spray nozzle cleaner to remove dried paint. This can hamper the spray and cause droplets to form when spraying. After you're finished spraying, place the nozzles into a sealable container filled with acetone.

5 / CHOOSE COLOURS AND SURFACES

You can spray just the exterior surfaces of your case, masking the ones you don't want to paint, or go all out and coat the whole case. Don't rush into this – have a good think about it. Take your time and make sure you're happy with both the colour and areas you intend to spray.

6 / CONSIDER PAINT EFFECTS

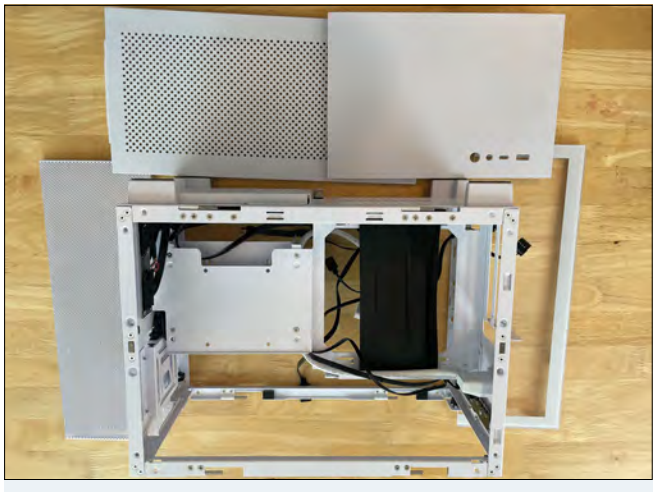
Paint effects range from metallic, which is usually included in many paint colours, all the way up to spray-on additives such as marble effects. These can jazz up your case's exterior compared with plain colours, but it can be tricky to work with effects you spray on after the colour coat.

7 / REMOVE RIVETS

Many cases are riveted together, and you'll need to drill out these rivets before proceeding, as it's far easier and more effective to spray your case if it's dismantled. This is an easy job, but you'll need access to a drill and 3mm drill bit, along with a rivet gun and replacement rivets.

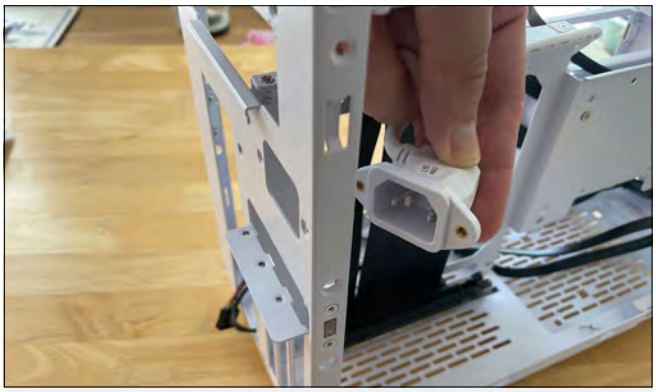
8 / REMOVE SCREWS

If you're lucky enough to be using a case that screws together, you're in for a much easier time. However, take note of the position of each screw, as they can differ in length, thread or head type, even on a single model of case.



9 / DISMANTLE CASE

You'll want to remove any drive bays, fans and front panels from the case so you're dealing with open sections of the case. Once all the appropriate screws and rivets are removed, detach all the panels, so they're free for you to paint.



10 / REMOVE FIXTURES AND FITTINGS

Any ports, PSU extensions, fan hubs or drive bays in areas you want to paint must be removed. These will be held in place with screws or rivets. It's best not to mask over them, as this can be tricky, time-consuming and often not very effective with such small parts.

11 / MASK UP SURFACES

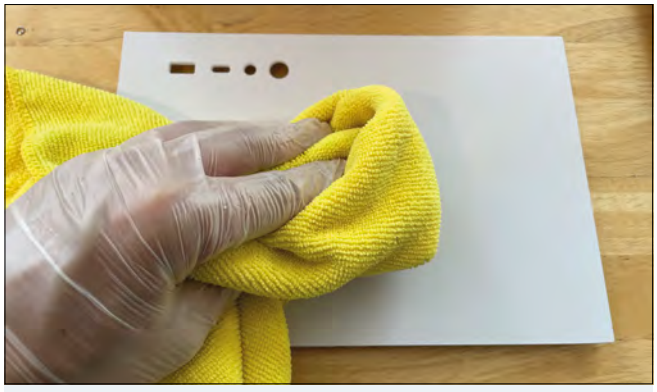
If you just want to spray the exterior of your case, or keep certain sections paint-free, you'll need to mask them. Use Frog Tape for this job, attaching white card or paper to the tape cover larger sections. If you want to create curved mask areas, it's best to use edging tape.

12 / CLEAN SURFACES

Use washing-up liquid and a sponge to clean all the surfaces you plan to paint, then rinse them thoroughly. This will remove any oils or other grime that could impact on the paint finish. You'll want to wear protective gloves from now on, in order to prevent oils from getting on your hands.

13 / SAND SURFACES TO PAINT

If your case has rough paint finishes, you'll need to sand them using 1,000-grit sandpaper first. This will even out any lumps and bumps, while also improving the paint finish. Rinse the area again with water after you've finished sanding.



14 / WIPE WITH A CLOTH

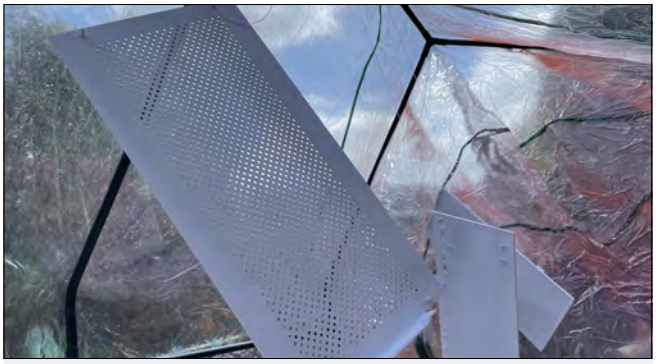
To aid the drying process after washing and rinsing, wipe down the case sections with a microfibre cloth. You can also suspend the parts in your spray area, but manually drying them will get you ready for painting much quicker.

15 / WARM PAINTS

A trick for spraying in colder months is to warm the paints first. Avoid placing them in an unheated shed or garage the night before, and place the cans in warm (but not hot water) for five minutes prior to spraying.

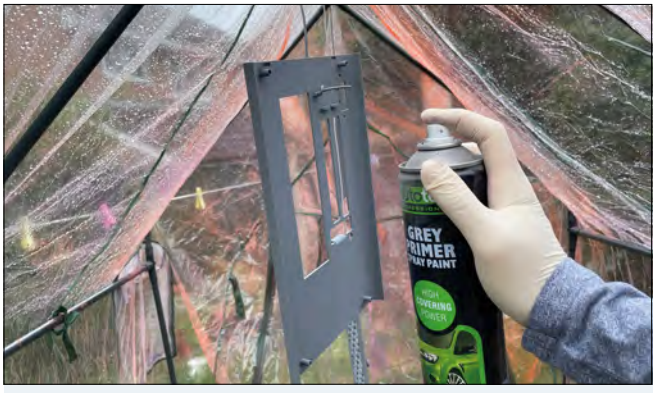
16 / PRACTISE USING PRIMER

Primer is generally cheaper than colour paint or clear coat, so it's good for practising your spray technique on a piece of spare cardboard first. You need to spray 20–30cm away from the surface, moving the can around 30cm per second over the surface from side to side, working your way across it.



17 / SUSPEND YOUR SPRAY SURFACES

We advise you to suspend your case parts vertically, so you can spray all the sides in one go. If they're sat on a surface, the paint can end up sticking the two surfaces together. Fishing wire or electrical wire fed through screw holes will allow you to suspend your panel without blocking the paint spray.



18 / USE PRIMER

Usually grey or white, primer acts to fill in small imperfections on surfaces, and provide a smooth base to which the colour coat can adhere. Apply as many coats as needed to make the original case colour no longer visible, then add one more.

19 / SAND PRIMER

Some primers leave a rough surface, especially in very warm conditions when they dry quickly. If the surface feels very coarse, use 1,000-grit sandpaper to lightly smooth it down once it's dry.

20 / TEST COLOUR COAT

The colour coat will come out of the can differently to the primer, so spray a little on some cardboard to practise first. Use the same method as we described for the primer in step 16 – if the paint starts running, move your hand faster or spray from further away.

21 / APPLY COLOUR COAT

Using the same method as step 16, cover the entire section with one coat, covering the primer completely – then allow it to dry for ten minutes before applying another coat. Three or four coats are needed to build up a solid, even colour over the whole surface. Don't be afraid to apply more coats, as conditions can impact coverage.

22 / APPLY EFFECTS COAT

You can now apply an effects coat if you want one. We're using marble effect spray. It's essential to practise first, as metallic or marble effects sprays can't be removed, so it's important to get it right first time. The marble effect required us to move the can more rapidly than the colour coat to create an even finish, using just two passes.

23 / REMOVE MASKING

As soon as you've finished spraying, remove the masking. Doing this while the paint is damp, and before you apply clear coat, prevents the finish from tearing or cracking when you remove the masking. If you want, you can reapply masking to prevent the clear coat settling on unwanted areas, but this isn't essential, as it's transparent.

24 / APPLY CLEAR COAT

Aim to spray clear coat only onto areas that need it, removing any overspray with paint cleaner later. Apply it in generous layers at the same speed and movement as the colour coat and aim for five layers, allowing coat each to dry for 30 minutes. Finally, leave it to dry for two days somewhere well ventilated before handling it.

25 / CONSIDER 2K CLEAR COAT

Standard clear coat can be soft, even when fully hardened, while 2K clear coat is applied in the same way and offers a more durable finish. It's more expensive and is nasty stuff, so you'll need to cover all skin and eyes, use a P3 filter respirator and only stay near the fumes for a few moments to apply it.

26 / INSERT NEW RIVETS

To replace rivets you drilled out earlier, you'll need new ones with heads the same size as the original case rivet holes, which are usually 3mm. Insert the thin tail of the rivet into a rivet gun, push the large head through the case sections and squeeze the trigger until the tail snaps off, leaving the rivet head behind.

27 / REASSEMBLE CASE

If your case screws together, go ahead and reassemble it. The gloss from modern clear coats is usually excellent, but you can use standard car polish to buff it if necessary. If you mess up any areas, or need to respray in future, paint remover spray can be used to remove the paint and clear coat so you can try again. CPC

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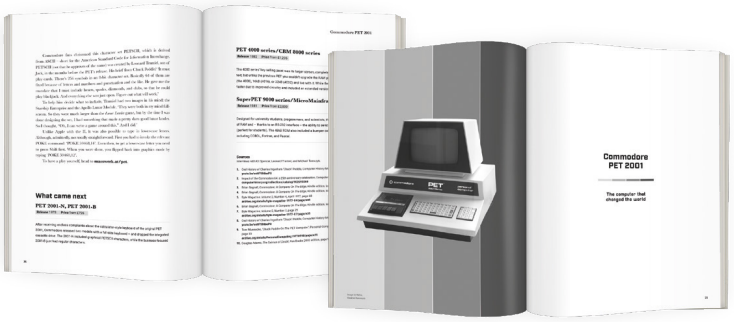

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Retro tech

INTEL 8086

Stuart Andrews looks at the story behind the stopgap CPU that helped to start a revolution

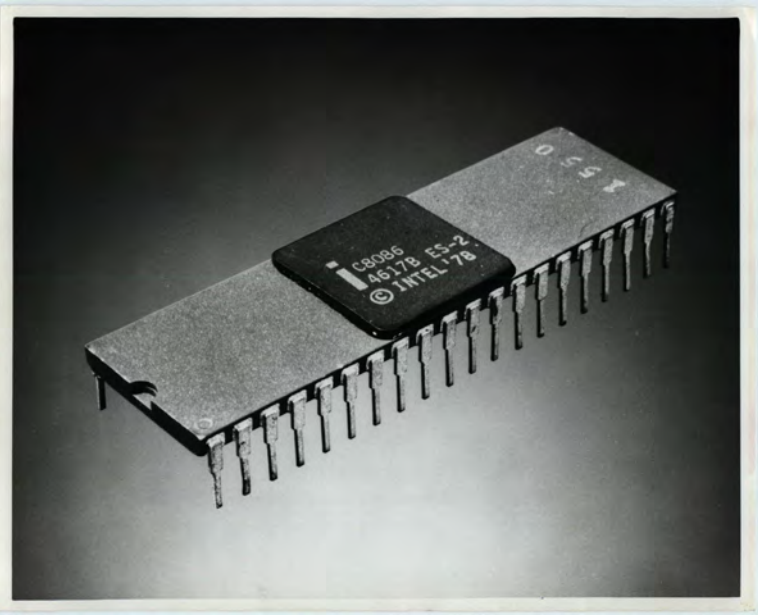
Amazingly, the most important chip in Intel's history – the chip that began the whole x86 line – was only intended to be a stopgap. In 1976, there were no personal computers as we know them today, only a range of specialist scientific tools, industrial devices, mainframes and microcomputers, which were slowly trickling down from big corporations and research institutions into the small business market.

At this point, Intel was just one of several major players in the emerging processor market. Its 8-bit 8080 microprocessor had made the jump from calculators and cash registers to computer terminals and microcomputers, and was the core platform for the big OS of the era, CP/M.

However, Intel had some serious competition. Zilog's Z80 was effectively an enhanced 8080, running a broadly compatible machine code with some added functions for processing strings. The Motorola 6800 had similar capabilities to Intel's chip, and was beginning to find favour with Altair and other manufacturers of early kit microcomputers. To make matters worse, both Motorola and Zilog were working on new 16-bit designs, the 68000 and the Z8000 respectively.

Intel was working on its own revolutionary 32-bit architecture, dubbed iAPX 432, but had run into some complex challenges. Development of iAPX 432 was taking Intel's team of engineers much longer than expected. The architecture spanned across three chips, and the process technology required to manufacture them was still years away.

What's more, the instruction set was focused on running new high-level, object-oriented programming languages that weren't yet mainstream; Intel's own operating system for



It didn't look anything special, but the 8086 CPU ended up founding a mighty dynasty of CPUs

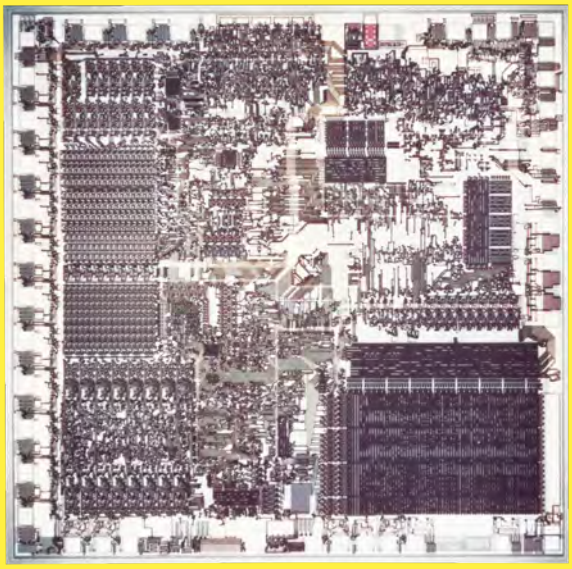
It couldn't merely address double the RAM, but a full 1MB of it

it was being coded entirely in Ada. Concerned that Zilog and Motorola could eat its market share before iAPX 432 even launched, Intel needed a new and exciting chip to hold its competitors at bay.

Intel had followed up the 8080 with its own enhanced version, the 8085, but this was little more than an 8080 with a couple of extra instructions to reduce its reliance on external support circuitry. Knowing it needed more, Intel looked to Steven Morse, a young software engineer who had just written a critical report on the iAPX 432 processor design, and asked him to design the instruction set for a new Intel processor. It had to be 8080-compatible and able to address at least 128KB of memory – double the maximum 64KB supported by the 8080.

DESIGNING THE 8086

Morse worked with a small team, including project manager Bill Pohlman and logic designer Jim McKevitt, to design and implement the new architecture. He typed specs and documentation through a text editor on a terminal connected



The die of the original 8086. It was one of the most complex processors of the time with over 29,000 NMOS transistors

to an Intel mainframe, even creating diagrams from ASCII characters to illustrate how the new CPU would work.

Meanwhile, Jim McKevitt worked on how data would be passed between the CPU and the supporting chips and the circuitry across the system bus. After the first couple of revisions, Intel brought in a second software engineer, Bruce Ravenal, to help Morse refine the specs. As the project neared completion, the team grew to develop the hardware design, and were able to simulate and test what would become the core of the x86 instruction set.

Left pretty much alone by the Intel management to work on an architecture Intel saw as having a limited lifespan, Morse and his team had freedom to innovate. The 8086 design had some clear advantages over the old 8080. It couldn't merely address double the RAM, but a full 1MB. Rather than handle 8-bit operations, it could manage 16-bit.

It had a selection of new instructions and features, including features designed to handle strings more efficiently and features designed to support high-level programming languages. It made up for one of the 8080's biggest shortfalls with hardware support for multiply and divide operations. The 8086 design made a coder's life easier.

However, Morse also took a new approach to processor design. As he told PC World in a 2008 interview, 'up until that time, hardware people did all the architectural design, and they would put in whatever features they had space for on the chip. It didn't matter whether the feature was useful or not'.

Instead, Morse looked at what features could be added – and how they could be designed – in order to make software run more efficiently. The 8086 made existing 8080 software run better, and was designed to work more effectively with the software and programming languages that were emerging, unlike both iAPX 432 and Zilog's Z8000.

What's more, the 8086 was designed to work with additional processors, co-processors and other components as the heart of a computer system. In the foreword to his book, The 8086 Primer, Morse talks of how 'the thrust of the 8086 has always been to help users get their products to market faster using compatible software, peripheral components and system support'. It was designed as the heart of 'a microprocessing family' with multiple processors supporting the CPU. This, in turn, made the 8086 a good fit as microcomputers evolved into PCs.

A STAR IS BORN

The 8086 was hardly an overnight success. The Z80 continued to cause Intel nightmares, appearing in more affordable business computers running CP/M. The most exciting processor in development in the late 1970s wasn't one of Intel's, but Motorola's 68000, which went on to dominate the workstation market, and create a new generation of home and business computers. Comparatively, the 8086 made it into some new microcomputers and terminals, plus a few more specialist devices, but it wasn't the market leader. In March 1979, frustrated by Intel's working culture, Steven Morse left the company.

Then, a few weeks after Morse left, Intel launched a revamp of the 8086: the 8088. The new chip was actually weaker; half its data pins were removed, so it could only send or receive 8 bits of data at a time. However, this meant it could work with existing 8-bit support chips designed for the 8080, and it didn't need as much complex circuitry to run. Given that the 8086 architecture was backwards compatible, and that Intel was investing heavily in support, building new versions of existing computers and devices around the 8088 became a no-brainer. At this point, Intel found out about a new project underway at IBM.

In 1980, an Intel field sales engineer, Earl Whetstone, began talking to an IBM engineer, Donald Estridge, about a top-secret project to develop a new kind of computer. Schedules were tight, meaning IBM needed to work with an existing processor, and Estridge faced a choice between the Zilog Z8000, the Motorola 68000, and Intel's 8086 and 8088.

Whetstone sold Estridge on the technical merits of the 8086 architecture and the lengths Intel would go to support it, while IBM's bean counters realised that the 8800 could help them keep costs down. IBM was already familiar with Intel, and was working with a version of Microsoft Basic that ran on the 8080.

A version of 86-DOS, sold as part of a Seattle Computer Products kit, would become the basis of Microsoft's MS-DOS. The project became the IBM PC 5150, or the original IBM PC, and because it used off-the-shelf hardware and Microsoft's software, it became the inspiration for an army of PC clones.

As they say, the rest is history. Had Intel focused down on iAX 432 and IBM had chosen Motorola, computing may have gone in a different direction. Intel was smart enough to double down on x86, moving on to the 286 and 386 CPUs and – eventually – abandoning what was supposed to be its flagship line. What's more, while the x86 architecture has now evolved beyond all recognition, even today's mightiest Core CPUs can still run code written for the lowly 8086. It started as a stopgap, but the 8086 has stood the test of time. CPC

Readers' drives

Piñasphere

Armed with a modified 3D printer, Jean Roberto De Iacovo created all the parts he needed to make the chassis for this stunning-looking scratch build

SEE THE FULL PROJECT LOG AT custompc.co.uk/Pinasphere

CPC: What inspired you to build this PC?

Jean: I wanted to see how far I could get with the design of a computer case. The standard that people picture in their mind when you talk about a PC is a boxy shape – apart from a few exceptions, most computer cases are based on a square shape.

This case had to be unique and sophisticated, so after choosing the split sphere as the main shape, I evolved it when I learned to play with Blender's mesh editing and icosphere generation. There are some nature-inspired elements when the case is closed, while the open-air configuration has a sci-fi techy look.

On the sides you can see these black wavy rings – I wanted them to look like the waves generated when you drop something in water. I was playing with the pinecone/pineapple motif for the dome at this time, so I thought this idea would work really well for the waves' crests too, albeit with a lot of tweaking.

The other half of the dome was also nature-inspired – it's based on filled honeycombs, and every hexagon is complex when you view it up close. This complexity also helps when it comes to making the printing layer lines less visible. The interior has more of a sci-fi look with lots of polygons. It's structurally similar to an aircraft frame – it's not a sphere, but a complex icosphere with geometric holes that help with airflow too.

CPC: How did you plan and design this build?

Jean: Usually I start my work with some quick pencil and paper sketches, but this one started with a Tinkercad sketch. I was testing various configurations with some 3D mock-ups I made of the hardware components on Tinkercad, then I thought that if I didn't install a GPU, and used an external PSU, I could try to make a split-sphere shape.

The first idea was to use a handcrafted metal frame made with 3mm-thick aluminium sheet. However, I'd also recently done some experiments with 3D printing to make a camera rig – during those experiments, I tested the strength of PLA and PETG, and concluded that PETG was strong enough to handle the stresses of the case.

CPC: You used 3D printing for the whole build. Tell us all about your process.

Jean: At first it was hard, but it would now be a much quicker process, I had to start planning it differently from a usual case mod, because I wasn't removing material but adding it. I did some tests with different small projects, so I could fine-tune the 3D printer settings.

/MEET THY MAKER

Name Jean Roberto De Iacovo

Age 40

Occupation Hotel receptionist

Location Italy

Main uses for PC 3D modelling, gaming, tablet drawing, video/photo editing, web surfing

Likes Hugs, arts, PCs, fitness, gaming, nature, Star Wars, Marvel, I could go on ... I'm also a petrolhead, but I like sporty electric vehicles too

Dislikes Bitter tastes, SUVs, racism, sexism

The software I used as a slicer for the prints was Ultimaker Cura 4.13, I found it intuitive from the start and it allowed me to fine-tune my prints. For example, I learned to set the Z-seam alignment to avoid having a visible line on the prints, and to set the retraction settings for different situations – you can basically tailor the settings around your needs. My workhorse 3D printer is a Creality Ender 3 Pro, which I've modded as it was too noisy for me. I've added a Creality Silent Mainboard, plus a 120mm fan for the PSU, and I also designed and printed the custom fan ducts for the printer with PETG, which enables me to use a dual 60mm Noctua fan setup instead of the standard 40mm fans.

It also has a direct extruder now – I had to reduce the retraction a lot more than expected, because the first prints with the new setup resulted in extruder clogging problems when printing with PETG.

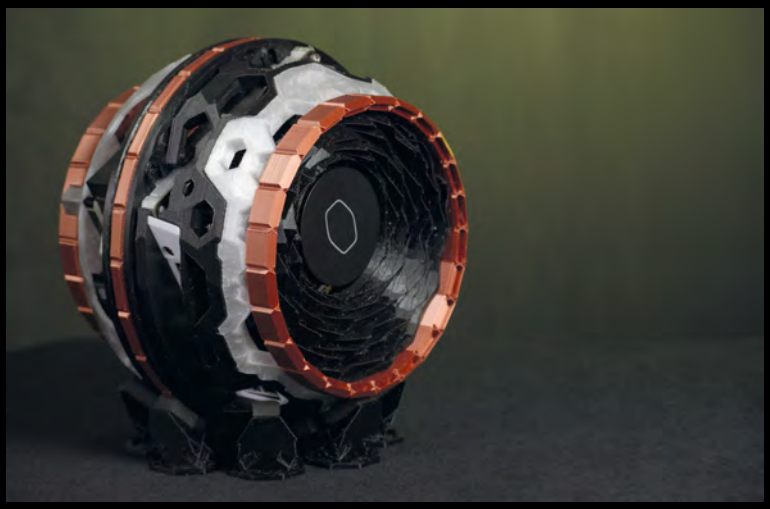
In total, Piñasphere is composed of 27 3D-printed parts. For the finishing touches, I used precision cutters, along with a lighter, to remove any excess material or stringing. However, once I'd got the filament temperatures right, I found that stringing was extremely limited. I also found that the orientation of parts during the printing process helped when it came to finishing. I purposely choose the base as the contact side between parts, as it's the side with which you have less control for the finish if you don't paint it afterwards.

One key point I learned is that getting the parts perfectly clean with precision cutters takes time and patience – make one mistake and you end up throwing away the printed part – it happened with an SSD frame I printed. The cleaning and levelling of the printer takes a bit of time too, but it solves the majority of problems that can occur during the printing process – printing at a slower speed also helps to avoid a lot of problems.

CPC: How do all the pieces fit together?

Jean: It's basically a super-sandwich structure – as with aircraft, some parts are simply pressed between the fastened layers. The parts are shaped so that they can only be assembled the correct way – even if it's just a different corner or hole, each part always has an aspect that helps for positioning. This structure enabled me to create a chassis with enough strength, but with minimal infill, so it minimises the weight and the amount of material used.

I then used stainless steel screws for fastening – the motherboard is secured using M3 screws with 10mm threaded brass inserts – you



can warm them up with a soldering iron then press them inside the 3D-printed parts. For the rest of the fastenings, I threaded the PETG with tools and used button-head M5 screws – the threaded sections are at least 10mm long. Meanwhile, the white domes simply snap into place on the motherboard side, and secure with a slight clockwise twist on the radiator side – no tools are needed here.

CPC: What tiny motherboard is that?

Jean: I used an ASRock X300M-STX motherboard. It was one of the smallest motherboards I could find that allowed me to use an AMD Ryzen 7 5700G. It can support up to 64GB of memory, and it has two M.2 SSD slots and two SATA ports for 2.5in SSDs, so it gives me ample room to upgrade memory and storage, which will help to keep this machine useful in the future, maybe as an office PC or server.

CPC: What challenges did the shape of the build present?

Jean: Honestly, if you think mostly about the shape and not the dimensions, it's relatively easy to make a PC with an unusual shape – the biggest challenge for me was leaving enough room inside the case for all the gear to work well. Another big challenge was presented by the two I/O panels – I'd decided that both of them were going to look like the front panel, placed in a recess of the dome, but I also had to leave some space for the power cord, and that's why the 'slice' is so long on that side.

CPC: What PSU did you use?

Jean: It's the external power supply that ships with the ASRock Deskmini X300.

It looks like a laptop power supply, and its output is 120W at 19V – it's rather small, so it was perfect for this PC, as it isn't a power-hungry monster.

CPC: How did you plan the cable routing?

Jean: All the cables are routed inside the middle ring, which also forms the main frame – it has lots of empty spaces in it for airflow and cable routing. The cables for the power switch, SSD activity LED and power LED are tucked under the motherboard, and they then go into the box that acts as hooks for the domes and also contains the power switch.

The radiator fan cable is hidden by the dome hook under the radiator – I made a routing canal for it – then it goes through the passage for one of the cooling tubes and stays hidden under the cooling tube on the motherboard side. The Wi-Fi antennae cables are hidden under the motherboard, and their connectors on the top of the motherboard are hidden under the M.2 SSD so you just can't see them. Lastly, the waterblock cables were laid under the waterblock's fastening 'wings'.

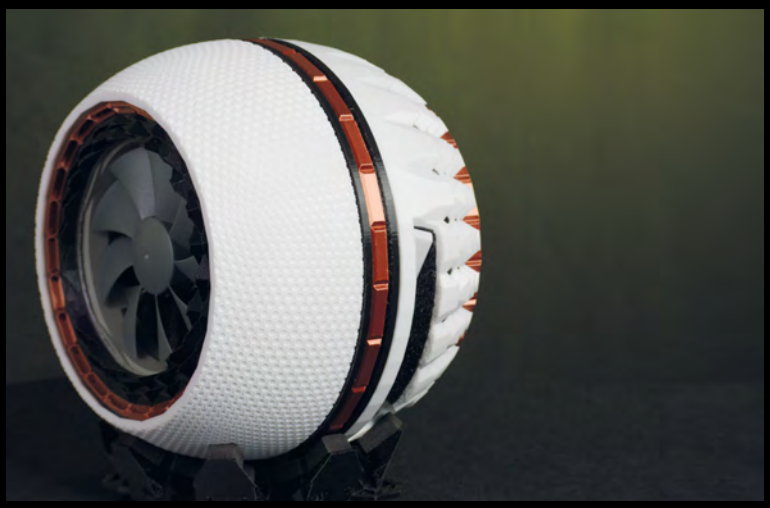
CPC: Tell us how the airflow system works.

Jean: This is one of the parts I like the most in my projects. After going through the radiator, the air goes through the middle channel, cooling the 2.5in SSD, then moves under the motherboard and exits from a 5mm gap between the motherboard and its support frame – it flows around almost the whole perimeter.

But the air isn't out at this point – the internal dome then guides it to move around the motherboard, so it cools the M.2 modules and motherboard VRM heatsink. There are also two holes on the side of the radiator, which relieve a bit of the counter pressure generated from the air moving inside the middle channel.

SYSTEM SPECS

CPU AMD Ryzen 7 5700G
GPU Integrated AMD Radeon RX Vega11
Storage 1TB Samsung 980 M.2 SSD, 250GB Samsung 860 Evo 2.5in SATA SSD
Memory 16GB (2 x 8GB) Corsair Vengeance 3200MHz DDR4 SODIMMs
Motherboard ASRock X300 M-STX
PSU 120W ASRock external PSU
Cooling Cooler Master MasterLiquid ML120L V2 AIO liquid cooler



CPC: How did you achieve the copper-coloured touches?
Jean: I wanted to add a warm colour to contrast against the white, and I originally considered using real copper rings. However, during the sketching phase, I wanted to add more reflective facets than you get on rings, so I printed them with a more complex shape. If I'd had a tonne of time, I could have handcrafted them, but this time I wanted to test myself and see what I could do with just 3D printing, so I bought some Giantarm Silk Copper Filament and the results didn't disappoint – they do give a premium vibe to the build.

CPC: What spec did you choose and why?
Jean: I wanted it to be able to do a bit of everything, but 3D editing was a must-have capability. I also wanted the machine to perform decently at 1080p gaming. With no room for a graphics card, the obvious choice was going for the best APU I could buy, and that was the AMD Ryzen 7 5700G – I love it; it's an excellent performer.

The build has 16GB of memory, because I was looking for the hardware during October and November, and it was on sale then. Corsair is a good brand, so I took my chance and bought it. I'll upgrade the RAM in the next few months, as the ASRock motherboard allows you to increase the shared video RAM up to 16GB if you have more than 32GB of system memory.

CPC: Did you come across any difficulties?
Jean: I think the biggest challenge was fine-tuning the printer profile for every filament. I had to reduce the printing errors that would be impossible to hide, as one of my objectives was to make the build look good without having to paint it. I got used to deep-cleaning the extruder, and I also bought a long stainless steel needle to purge every bit of filament residue out of it.

CPC: How long did it take you to complete this build, from start to finish?
Jean: After the learning about 3D editing phase, I would say three to four months. It would definitely take less time if I did it now.

CPC: Are you completely happy with the end result, or do you wish you'd done some of it differently in retrospect?
Jean: I'm absolutely happy – this was the first time I'd tried building a 3D-printed case, and before the final assembly, I wasn't 100 per cent sure how it would look. However, after I assembled it all together I had only one thought – 'WOW it's solid and looks really cool!' I really couldn't be happier. CPC

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Corsair Hydro X Series XC7 RGB CPU Water Block

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JAMES GORBOLD / HARDWARE ACCELERATED

WHAT HAPPENED TO OPTANE?

James Gorbold looks back at this innovative memory technology from Intel

3D XPoint, later rebranded as Optane, the memory technology joint developed by Intel and Micron, created a lot of headlines when it was revealed back in 2015. Rightly so in my opinion, as the technology promised to solve many of the limitations of both DRAM and NAND, delivering much higher density and performance than NAND without the cost and volatility of DRAM.

However, I think it's fair to call time on the technology now and relegate it to the 'failed idea' chapter of tech history, as it has indeed failed to deliver on its promise and has more or less disappeared from the market. A large part of the reason for this is that NAND technology has moved on, with much higher density types coming to market, such as QLC, TLC and 3D NAND. The proliferation of lightning-fast consumer M.2 and enterprise U.2 NVMe SSDs also took a lot of wind out of the sails of Optane.

The other factors impacting the success of Optane are more business-related, such as product positioning, Intel's position in the CPU market and Intel's change of strategic direction. Taking these in turn, the product positioning of Optane was always a bit muddled. As I've already mentioned, the first Optane consumer drives were made redundant by cheaper and faster M.2 NVMe drives. The second coming of Optane to the consumer market was a range of low-capacity drives that were designed to cache frequently used games and applications stored on the hard drive.

While these showed some promise, the combination of an Optane cache drive and hard drive was more expensive than a SATA SSD, and less flexible to boot. The final nail in the coffin for this series of caching drives was their limited compatibility – they only worked with select Intel chipsets and CPUs. Critically, they didn't work with entry-level chipsets and CPUs, the only part of the market where hard drives were still commonly used as OS drives.

Compatibility became even more of an issue from 2017 onwards when, after years in the doldrums, AMD made a strong comeback in the market with its Ryzen processors. As these continued to evolve and take market share from Intel, a drive that didn't work on an AMD platform had a far smaller market in which to play. As both a component reseller and system integrator, I can tell you that Scan sold diddly squat of these caching drives.

> Scan sold diddly squat of these caching drives

More recently Intel has very publicly divested itself of its memory business, selling its NAND division wholesale to SK Hynix, which continues to sell the products under the new Solidigm brand. While Optane wasn't included in that deal, in early 2021 Intel shut down its one and only Optane fab, as it apparently had a lot of unsold stock still to sell.

These will be enterprise Optane products, such as Optane DIMMs, but they probably won't be replaced when sold, as in a recent interview Intel CEO Pat Gelsinger stated, 'I never want to be in memory, you see I'm doing everything I can to exit our memory businesses.'

Micron, the other company involved in the development of 3D XPoint, hasn't done a huge amount with the technology either, releasing and discontinuing an enterprise SSD family and little else. With PCI-E 5 NVME SSDs just around the corner (as Richard Swinburne discusses on p8), I can't see either Intel or Micron bringing back Optane either. NAND, for now at least, will remain the dominant form of data storage for PCs for practically everything apart from cold archives. 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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