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Maybe Intel was panicking about the threat of Ryzen. Maybe it realised it couldn't just keep churning out the same CPUs every year. Whatever the reason, Intel has rushed forward the launch of its brand-new Coffee Lake CPUs. It's a move that brings the firm's mainstream desktop chips up a level, adding two more cores across the range, and banishing the dual-core desktop CPU to the bottom end. You can now pick up an overclockable quad-core Core i3 CPU for £159 inc VAT, and the Core i5 and Core i7 chips all now feature six cores.

We've reviewed three of the new CPUs (see p20), as well as looking at the best memory to accompany them (see p23), and showing you how to overclock them (see p26). Plus, we also have a full Labs test of Z370 motherboards (see p42).

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**CPC78**



BEN HARDWIDGE / FROM THE EDITOR

# THE ROUTER LIMITS

Upgrading your network might not be exciting, but it massively reduces tech rage, argues Ben Hardwidge

**W**hile it's always tempting to upgrade to the very latest tech gear, I have a general policy on upgrades in an attempt to temper any irrational impulses that might leave my bank account barren. The policy is simple: upgrade when a product's shortcomings start to really annoy me, not because I just want the latest stuff for the sake of it. It's a policy that's pushed me to prioritise faster and more capacious SSDs over new CPUs, for example. My quad-core Core i7's shortcomings annoy me sometimes, but not nearly as much as running out of fast solid-state storage.

At the top of my current annoyance list is my home network. Wherever I sit in my house, you can guarantee that my laptop, iPhone or iPad will irrationally decide to connect to the wrong bit of it. If I'm downstairs, it will seemingly look at the available network options, and choose the upstairs range extender that only has one bar of range available.

If I'm upstairs, it will connect to the downstairs router, and I'll only realise after looking at the loading circle of doom in the middle of the screen for a while. I constantly have to muck about in the Wi-Fi settings to get an Internet connection. On a scale of annoyance and irritation, it's up there with getting my jeans' belt holes stuck on door handles, or hearing Liam Gallagher doing, well, just about anything.

Of course, it's difficult to even think about networking gear without stifling a yawn. It just connects stuff together, and if you do it right, it connects stuff together in a way that isn't really irritating. I know Asus and Netgear have both attempted to

make Wi-Fi routers look like stealth bombers, but they're still basically boxes that connect stuff together. You don't get excited about a new wireless router in the same way that you get excited about a new graphics card.

But it's important to overcome those feelings sometimes. Tweaking your home network and upgrading your networking gear can make a big difference to your home computing life, often much more so than other, more exciting tech gear.

A good place to start is our Wi-Fi tips and tricks feature on p92, in which we outline some ways you can boost your Wi-Fi range without resorting to buying new kit. However, my next tech upgrade is undoubtedly going to be a new mesh router (see p52). Having a series of powerful nodes set up around my home will not only give me a better signal everywhere in the house, but I also won't have to faff around in the Wi-Fi settings on my devices any more. A mesh network presents itself as a homogenous whole—you don't need to connect to a range extender separately.

The next upgrade after the router will be a new, faster NAS box to replace my aging Synology DS112j. Sexy, huh? The whole lot will likely cost me over £500, and that's a difficult cost to justify for a few boxes that allow stuff to connect to each other and access a hard drive. It's not as if I can even put them proudly on display so I can show them off to my mates. In the name of reducing irritation, though, and improving the way I use tech at home, it will all be worth it. Often the most worthwhile upgrades aren't the most exciting ones, but the ones that make the biggest difference to the way you use technology. **GPC**

It's up there with getting my jeans' belt holes stuck on door handles

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RICHARD SWINBURNE / VIEW FROM TAIWAN

# THE TIM ISN'T WORKING

It's time for Intel to stop putting cheap thermal paste between the core and heatspreader on unlocked CPUs, argues Richard Swinburne

**W**hen Intel first started adding heatspreaders to its processors with the Pentium 4, it sensibly soldered the aluminium plate to the CPU silicon underneath, which always provided an excellent bond and thermal transfer. However, when Ivy Bridge arrived five years ago, Intel did a low-key switch-out and decided to swap its solder for bog-standard thermal paste (TIM). It was irritating on its usual desktop processors, but at least the high-end desktop (HEDT) CPUs still used solder, until now.

As you may have read, Intel's latest premium Skylake-X CPUs on its X299 HEDT platform also now feature thermal paste rather than solder. It's a decision that's caused nothing but problems.

Temperatures – especially when over-clocking – are going through the roof. The latest eighth-generation Coffee Lake CPUs are hitting the thermal trip on high-end coolers when all cores are overclocked, let alone pushed beyond their maximum boost frequencies. Overclockers and enthusiasts are 'affectionately' calling Intel's TIM various names from 'toothpaste' to 'pigeon poop'. It's killing Intel's reputation among enthusiasts, and reducing the appeal of these unlocked CPUs.

Delidding the heatspreader is now becoming a very attractive option. By removing the aluminium plate, cleaning off the stock thermal paste and replacing it with better-performing alternatives, enthusiasts are seeing their CPU temperatures drop by tens of degrees Celsius. Such a large drop in temperatures is especially important if you have a Skylake-X CPU with many cores and very high power draw when it's overclocked.

Intel's excuse for shifting to TIM is that soldering causes microfractures in the silicon, because of the difference in the expansion coefficients of the different materials used in the chip,

solder and heatspreader – silicon, tin and aluminium. As the CPU goes through heat/cooling cycles during its everyday use, these metals expand and contract at different rates, causing stress.

That may well be true, but if that's the case then replacing the solder with cheap, inefficient thermal paste isn't the correct solution in a premium, enthusiast CPU – not when using decent-quality thermal paste (which, let's face it, isn't massively expensive) clearly makes a huge difference to temperatures.

Besides, I believe Intel is overstating the problems with using solder. After all, we've had soldered CPUs for around 15 years (2001 to 2016) now, and how many Intel processors can you

remember having to return? How many people are still rocking overclocked (and soldered) Core i5-2500Ks from 2011? Typically, your motherboard will give up before the CPU.

AMD is also continuing to solder all its processors, and there aren't forums full of enthusiasts reporting premature deaths of AMD CPUs. To me, it looks like a non-issue.

If I were to put on my cynical hat, I'd wonder if, by pushing enthusiasts to delid their processors, you also get overclockers to clearly void their warranties, reducing the CPU manufacturer's own liability potential further, and saving even more money on the odd return from too exuberant voltage use.

Yet Intel is still happy to charge extra money for these unlocked, premium-priced processors. What's the point of buying an unlocked CPU if there's still a chance of it throttling with a £100 cooler attached to it?

Intel either needs to use solder in *all* its K and X-series processors or at least use decent thermal paste in the first place. At a minimum, Intel needs to introduce an easily detached heatspreader. If you sell overclockable CPUs, you need to support them properly. **GPC**

Overclockers and enthusiasts are calling Intel's TIM 'toothpaste' and 'pigeon poop'

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



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TRACY KING / SCEPTICAL ANALYSIS

# GAMING FOR SCIENCE

Tracy King enthuses about a new crop-saving project powered by protein folding puzzle game, Foldit

**R**emember ‘ Frankenfoods ’? That weird period of time in the late 1990s when some people were trying to scaremonger everyone into avoiding genetically modified crops? The name never made sense to me, because as everyone on the Internet will leap to tell anyone who doesn’t know, Frankenstein is the name of the doctor.

GMOs should have been called Frankenstein’s Monster Munch, or something. Anyway, the name was as ridiculous as the concept, which is that science shouldn’t use science to improve crops, despite people having tinkered with breeding out undesirable traits in food since forever.

Fortunately, the public has broadly accepted that genetically modifying crops is good, and can improve yields, lower prices and even prevent entire nations from starving. Although there’s still scepticism (which is fine – informed debate must always be encouraged), there’s an extraordinary amount of ongoing research into making crops pest or blight-resistant, which is where we PC gamers can help.

You may already know Foldit (<https://fold.it>); I wrote about it in this column a couple of years ago. It’s a game in which the player competes against others to ‘fold’ a protein chain into an optimal space. It’s hard to describe in words, but imagine you had a Tetris screen full of Tetrominos that are jumbled up and wedged in rather than placed neatly in their rows and columns.

Your job is to click, drag and rearrange them to fit into the smallest space possible. It’s a rough analogy, but to add to the fun of the puzzle solving, you get a real-world solution. In 2011, home gamers successfully revealed the structure of an HIV enzyme and potential areas for drugs to attack it.

It’s funded by Mars, because it’s costing the firm a fortune in lost peanuts

And now, Foldit is back, and it wants our help solving a crop problem. Or rather, a mould problem, which is way more serious than it sounds. This particular mould first came to attention in 1960s England, when thousands of turkeys died. Eventually the cause was traced to a mould called *Aspergillus flavus*, which was infecting turkey feed imported from Brazil.

The feed was made from peanuts, which are especially susceptible to this type of mould, along with corn, wheat and other staple crops. If animals eat this stuff, it gets into milk, goes along the entire food chain and causes stunted growth in children and even liver cancer in adults.

In 2004, 125 people died in Kenya from ingesting the mould. It’s serious, and it isn’t going away. The best way to deal with it is to genetically modify the crop to be resistant, which requires folding CGI protein structures.

So, there’s a real-world problem that needs solving, and we can help solve it by playing a puzzle game. This particular iteration of Foldit is being funded by Mars, because it’s costing the firm a fortune in lost peanuts. While I’d like to be cynical, and say that Mars is funding it because M&Ms and Snickers are at stake, if that’s why this study gets funded and saves lives then I’m not fussed.

I do actually really like peanut M&Ms, so frankly it’s a bonus. I’ve read through the terms and conditions and the results are going to be public domain, although as someone points out in the comments, significant R&D investment will need to be made once a solution is found, so maybe I’ll regret being so cavalier about Mars’ involvement if it tries to patent ‘saving lives and peanuts’, but I’m really not worried at this stage. **RPC**

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



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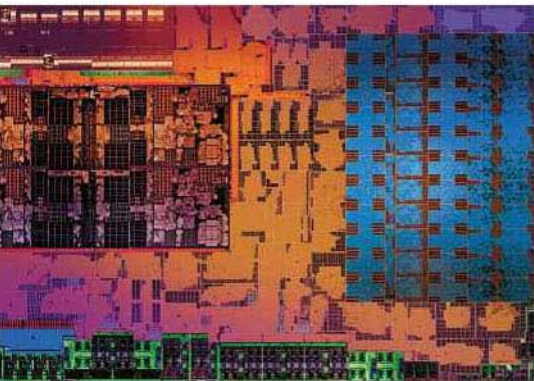
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# Incoming

We take a look at the latest newly announced products



## First Ryzen APUs appear

AMD has just unveiled its very first 'Raven Ridge' APUs to be based on its new Zen CPU architecture and Radeon RX Vega GPU tech. The Ryzen 7 2700U and Ryzen 5 2500U are quad-core CPUs, but they also support AMD's Simultaneous Multithreading (SMT) tech, so they can execute eight threads simultaneously.

The Ryzen 7 2700U has a 2.2GHz base clock (up to 3.8GHz turbo), and also has a 1300MHz GPU with ten compute units, equating to 640 stream processors. Meanwhile, the Ryzen 5 2500U has a 2GHz base clock (up to 3.6GHz turbo), and features an 1100MHz GPU with eight compute units.

According to AMD, both chips have a nominal TDP of around 15W, and the integrated GPU has enough power to play games such as League of Legends, Overwatch, CS:Go and Dota 2 at 1080p, while also maintaining an ultra-light laptop form factor. Asus, Acer, Dell, HP and Lenovo are all named as launch partners.

## Nvidia releases GeForce GTX 1070 Ti

Nvidia has just released a new GPU to bridge the gap between its GeForce GTX 1070 and 1080. Based on Nvidia's GP104 Pascal chip, the new GeForce GTX 1070 Ti is effectively a GeForce GTX 1080 with a single streaming multiprocessor (SM) disabled, giving the GPU a total of 2,432 stream processors. At stock speed, the GTX 1070 Ti has a base clock of 1607MHz, with a typical boost frequency of 1683MHz. The card's 8GB of GDDR5 memory is clocked at 4GHz (8GHz effective).

As a point of comparison, the vanilla GTX 1070 cuts five SMs from the GP104 architecture, giving you just 1,920 stream processors, meaning the 1070Ti should be much closer to the GTX 1080 in terms of performance. Pricing is closer to the GTX 1070 though. A GTX 1070 Ti card currently goes for £419 inc VAT on [www.scan.co.uk](http://www.scan.co.uk), compared to £370 inc VAT for a GTX 1070 or £489 inc VAT for a GTX 1080. Look out for a full review of the GTX 1070 Ti in our next issue.



## Synology upgrades home NAS range

Synology has updated several of its home NAS models, adding more powerful hardware.

The new single-bay DS118 picks up from the DS116 (see Issue 171, p50), adding a 1.4GHz 64-bit quad-core CPU, compared with the 1.8GHz dual-core chip in its predecessor. The DS118 also sports 1GB of DDR4 memory and Synology claims it offers encrypted sequential read speeds of over 110MB/sec. The DS118 also has support for 10-bit H.265 4K video transcoding on the fly.

The latter feature is supported by the DS218play, which has two drive bays but otherwise similar specs to the DS118. Finally, the DS218j (pictured) offers a cutdown, dual-bay box, with a dual-core 1.3GHz CPU and 512MB of RAM. Prices start at £158 inc VAT for the DS118.



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# Letters

Please send us your feedback and correspondence to [letters@custompcmag.org.uk](mailto:letters@custompcmag.org.uk)

## Missing RGB connection

I was reading the article in Issue 161 about building your dream PC, as I'm about to take the plunge and water-cool my PC, using the same EKWB EK-FB Asus R5-E10 Monoblock RGB Edition waterblock. I noticed on the front page of the mag, showing the final build, that the RGB connector from the CPU Monoblock isn't connected to the motherboard's Aura connector. What did you connect it to?

**DAVID ORD**

**Antony:** Good spot, David! There's actually a simple explanation. While I shot the PC for the front cover, I connected the waterblock cable to an external RGB controller. I did that so I could change the lighting colour without a screen, keyboard or mouse attached to the PC, and we went through several colours during the photo shoot before we found one we liked!

I didn't have to do the same with the Corsair fans, as they have a separate physical controller, but the motherboard needs to be controlled in the EFI or software, which is impossible without those peripherals. Controlling the waterblock from the nearby RGB header on the motherboard works fine, though, and I connected it to that header in the guide, so you'll be fine if you follow the guide, rather than the cover photo.

## Coffee Lake availability

It was interesting to read your editorial (see Issue 171,



**We connected our waterblock cable build to an external RGB controller for photography, but you'll want to hook it up to the Asus Aura RGB header**

p8) on the need, or lack of it, for the new Intel Coffee Lake CPUs for gaming, and I can't say that I disagree. Even more informative was James Gorbold's take on the same product (on p114), where he seems to imply that Intel has been resting on its laurels for the past ten years, and has now woken up to the

fact that AMD has finally got its act together with its new Ryzen CPUs.

What did make me grin, though, was James' comment on the virtual unavailability of Intel's new baby

and the implied long lead time before they will become available. I say 'grin' because, flipping over to the back page of the magazine revealed a full-page advertisement for the very company that James works for, seemingly saying that these same unavailable CPUs are in the company's new 3XS systems. I wonder what the lead time is?

**FRANK EVERETT**

**James:** As I wrote in my column last month, it's unfortunate that one of Intel's most compelling products was available in such tiny quantities for the original launch on 5 October. As a tech enthusiast who has been waiting years for a major step forwards, like this one from Intel, it's particularly frustrating.

As you will no doubt not be surprised to hear, Coffee Lake CPUs sold out within hours of launch, particularly the Core i7-8700K and Core i5-8600K. This situation makes for a real challenge when deciding what message to employ in an advert in a print publication such as *Custom PC*. Being such a major new tech launch, we couldn't ignore it, but at the same time, we were well aware that, for most customers, it would be case of pre-ordering Coffee Lake rather than clicking Buy on our website and receiving their order the next day. Plus, by its nature of being a print publication, we had to design the ad in question over a week before the launch of Coffee Lake.

As such, while the advert highlighted that the new CPUs were launching, we believe in being upfront with customers. In the ad in question, we deliberately avoided using language such as 'now available', and on our own website we've clearly marked Coffee Lake PCs and CPUs as 'pre-order' and, where possible, provided an indicated delivery



## COMPETITION WINNER

Congratulations to Ian Matthews, who won our MSI competition in Issue 169. We'll arrange to have your bundle of MSI goodies sent to you soon!





It's still a beast of a machine, but it just doesn't have that same awesome look

date. At the time of writing, the stock situation with Coffee Lake remains uncertain and I foresee it being challenging for some time yet.



### Total recall

I've subscribed to **CPC** for many months now. For my son's birthday, I bought him the water-cooled PC Specialist mini-ITX PC, based on your recommendations. It arrived, and it was a beautiful PC – the best I've ever seen! Sadly, though, less than a month after buying it, PC Specialist recalled it (apparently the case had a risk of exploding?), so we had to send ours back.

They rebuilt the PC in another case and sent it out. Although it's still a beast of a machine, unfortunately it just doesn't have that same awesome look. They did kindly refund the difference for the case, but it meant my poor son had to be without his birthday present for a few weeks.



Anyway, on the Elite list in the latest issue, I noticed you still recommend this water-cooled mini-ITX PC by PC Specialist, even though it was taken off the website a month after **Custom PC** reviewed it. I thought I'd better let you guys know, as it can be annoying scrolling through many pages of a website for something you can't find.

I love **Custom PC**, by the way. You guys do an awesome job, and I'm learning a lot, which also means I'm still able to have some

meaningful dialogue with my computer-maniac teenage son!  
**VINCENT LOATES**

**Ben:** Thanks for bringing this to our attention, Vincent – we had no idea! That's a shame – the PC Specialist LS-Surge was a fine-looking PC, as you said, but I'm glad you at least received a working PC and some money back. We'll take it off the Elite list now. **GPG**

**PC Specialist's LS-Surge is no longer available to purchase**

### WHEN'S THE NEXT MAG COMING OUT?

Issue 173 of **Custom PC** will be on sale on Thursday, 7 December, with subscribers receiving it a few days beforehand. Before anyone asks, yes, this will also be the issue with the mince pie megatest!



## Twitter highlights

Follow us on Twitter at @CustomPCmag

**Lassar1982** Hurry up with the new issue already. I need to read about Coffee Lake.

**Ben:** Turn to p19!

**PBallard1984** Do you have any plans to move some content online? Such as recording of custom builds and 'how to' videos?

**Ben:** We don't, no. These days, we only really have the resources to make a magazine, and that's what we're best at doing.

**QwertyDesignUK** I wish subscribers received the standard mag cover. These specials are rubbish IMO.

**Ben:** We're open to change. We decided to do the special subs cover many years ago, to give our subscribers a special product that showed off the full photography without writing on it. If most of our subscribers would rather



have the standard cover, though, then we're happy to change it back. If you're a subscriber, let us know your preference, either via Twitter or via email at letters@custompcmag.org.uk

**jimmee\_mac** I have a few Dell Optiplex 3040 micro PCs. Any possible way to get some decent gaming from them? They have Core i5 CPUs and 4GB of RAM.

**Ben:** That largely depends on your definition of 'decent' – the Optiplex machines are primarily designed for business use, taking up

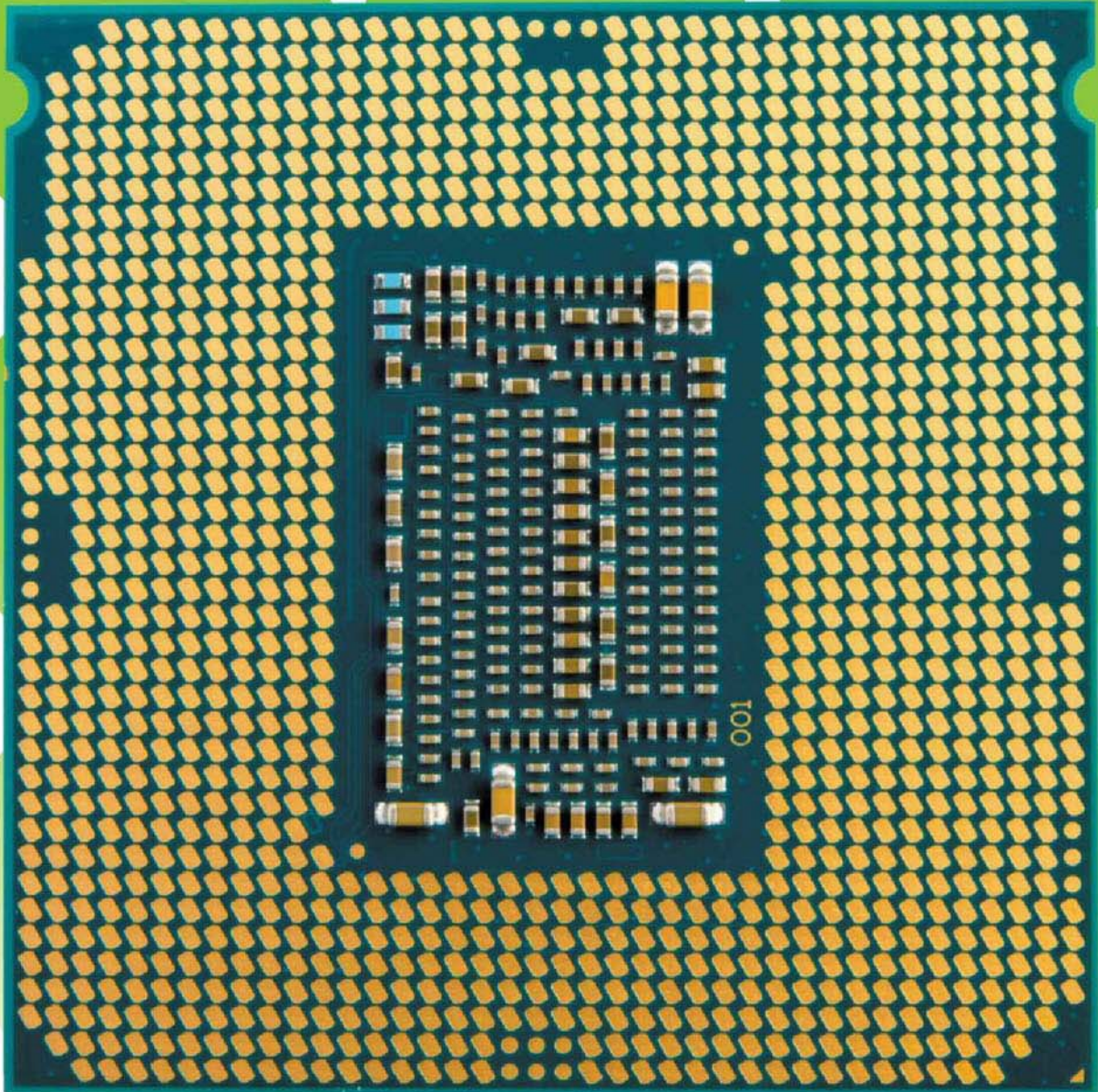
minimal space and not offering much room for expansion. You should be able to upgrade the RAM to 8GB with a second, matching DIMM, but the main factor for gaming will be the graphics card (the Core i5 CPU will be fine for basic gaming). The 3040 relies on integrated graphics, and while its motherboard has a 16x PCI-E slot, you'll only be able to fit a half-height card, which severely limits your options.

I've not actually taken one of these machines apart myself, but your best bet is to open it up yourself, and see how many expansion slot spaces are on offer. If there's another free space next to the 16x PCI-E slot, you should be able to install a half-height GeForce GTX 1050 Ti card (MSI makes one – £150 inc VAT from [www.scan.co.uk](http://www.scan.co.uk)). That will enable you to play most games at 1080p at decent settings.

Send your feedback and correspondence to [letters@custompcmag.org.uk](mailto:letters@custompcmag.org.uk)

# Reviews

Our in-depth analysis of the latest PC hardware



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Coffee Lake benchmark results p24 / How to overclock Coffee Lake p26 /  
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# Inside Intel Coffee Lake

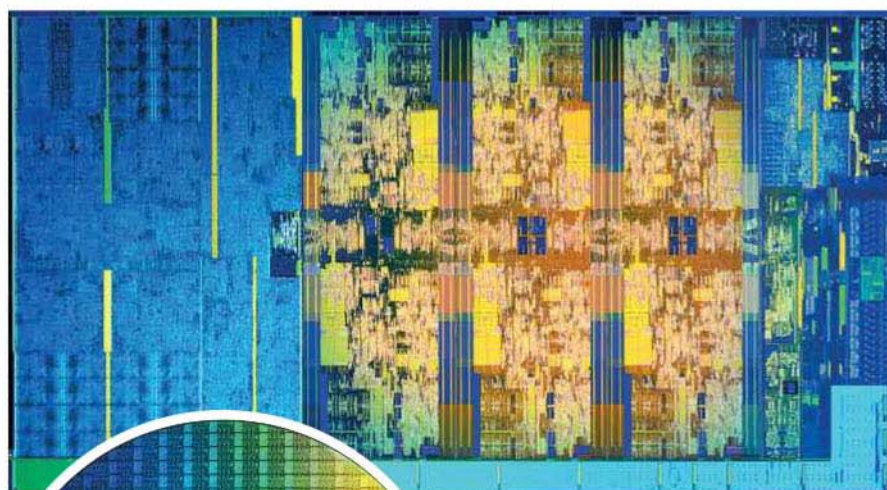
**D**espite the huge changes in the number of cores in Intel's latest mainstream CPU line-up this time around, with core boosts for every Core i3, Core i5 and Core i7 desktop CPU, Coffee Lake offers comparatively little in the way of architecture changes or chipset improvements. The biggest talking point is that Coffee Lake CPUs aren't backwards compatible with previous LGA1151 sockets. In other words, if you own a Z170 or Z270 motherboard, you're out of luck if you want to drop a Core i7-8700K into your motherboard.

## No backwards compatibility

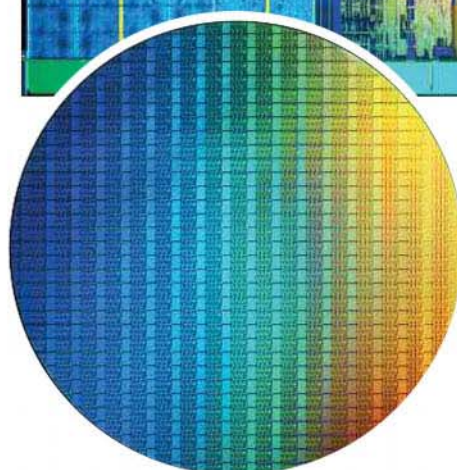
Similarly, older CPUs aren't compatible with the new Z370 motherboards either, and this situation has caused a fair bit of commotion among enthusiasts due to the fact that the sockets are practically identical. Both sockets have 1,151 pins, the notches are in the same place and Kaby Lake CPUs will even physically fit into the new socket. However, you'll be met with failed boots and black screens if you try.

The close proximity of the January 2017 launch of Kaby Lake and October 2017 Coffee Lake launch, along with the physically identical socket, resulted in many people incorrectly assuming that Coffee Lake would be backwards compatible. As it turns out, Kaby Lake is the last CPU core architecture to land on Z270, which means that anyone who invested in a Z270 motherboard recently can understandably feel a little short-changed.

Sadly, it's not a situation that can be altered with a simple BIOS update fix either. With their additional CPU cores, Coffee Lake CPUs require extra power, and this power is being fed through numerous activated pins in the CPU socket that were previously dormant. As a result, the pin assignment of the LGA1151



**A Coffee Lake die, showing six cores in the middle and a massive load of cache on the left**



**A Coffee Lake wafer. Intel now calls the manufacturing process 14nm++**

socket has changed, making it incompatible with older CPUs.

Additionally, in a recent interview with bit-tech, Asus revealed that it's technically possible for a Z270 board to support a Coffee Lake CPU, but that it would require an upgrade to the management engine, as well as BIOS update. According to Asus, however, Intel has locked down compatibility. The company also hinted that the tweaked socket's new power-delivery capabilities

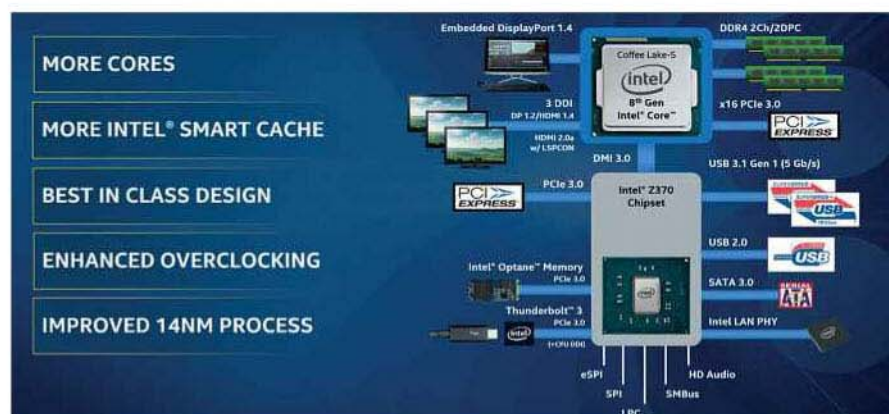
might also be useful for CPUs with more cores in the future.

## Small change

Meanwhile, the integrated graphics remains the same under the hood, except for a small bump in clock speed and a name change to UHD Graphics. The chipset doesn't have any major changes either, and despite some early rumours pointing at more PCI-E lanes, Z370 actually has the same number of lanes as Z270, with 16 lanes for graphics cards.

Coffee Lake CPUs are all manufactured on a 14nm process, and while that's technically the same node size as Kaby Lake, Skylake and Broadwell, Intel now calls the process 14nm++ to highlight the fact that the process has been refined three times. This refinement usually means we can expect higher clock frequencies and perhaps even better overclocking too, while Intel in theory has better yields. The downside, is that we now haven't had a mainstream CPU die shrink for four generations.

As well as core boosts across the range, with all Core i3 desktop CPUs now sporting four cores, Core i5 CPUs sporting six cores and Core i7 CPUs offering six cores and Hyper-Threading, the L3 cache amounts have also increased. The Core i7-8700K has a hefty 12MB of L3 cache, the Core i5-8600K has 9MB and the Core i3-8350K has 6MB. The latter is particularly interesting, since it means that this £160 (inc VAT) processor now has an almost identical specification to the previous Core i5-7600K, which currently costs around £50 more.



**The Z370 chipset's capabilities are practically identical to those of its predecessor**

**ANTONY LEATHER**

INTEL LGA1151-V2 PROCESSOR

Intel Core i7-8700K / £380 inc VAT

SUPPLIER [www.scan.co.uk](http://www.scan.co.uk)



We managed to push our sample to 5GHz using a vcore of just 1.25V

**T**en years ago, Intel wowed us with the new Core architecture, putting an end to AMD's AMD64 competition with a huge leap in efficiency. There's no big architectural leap this year from Intel, but Intel is taking the more logical and long-awaited step of boosting core counts to combat competition from AMD's Ryzen CPUs. The Core i7-8700K is the new flagship of its mainstream CPU platform, sporting six cores and 12 threads, along with 12MB of L3 cache – all 50 per cent boosts compared with the Core i7-7700K.

The only place its predecessor has an advantage is in base frequency, with the Core i7-7700K sitting at 4.2GHz and the Core i7-8700K starting at a much lower 3.7GHz. However, while the older Kaby Lake CPU might edge out the new kid on the block in a couple of stock speed specifications, the new 6-core CPU can still boost to fairly high frequencies, reaching 4.7GHz on a single-core boost.

As with all Coffee Lake CPUs, the Core i7-8700K sports an integrated graphics processor in the form of Intel's UHD 630, which is identical to that in the Core i7-7700K apart from name and a small clock speed boost. The new CPU does have a slightly higher TDP – 95W compared to 91W – but it's when overclocking that you'll really notice the additional heat and power use.

We managed to push our Intel engineering sample CPU to 5GHz using a vcore of just 1.25V with most of the boards we tried this month, but temperatures quickly rose and

total system power consumption regularly went well over 200W, sometimes up to 250W depending on the board; there's a lot of variation here while board manufacturers fine-tune their products. Even so, the fact that the new 6-core CPU appears to lose very little in overclocking headroom to its 4-core predecessor is remarkable.

It resulted chart-topping scores in many tests, and while AMD still has the upper hand at stock speed in heavily multithreaded tests such as Handbrake and Cinebench R15, the Core i7-8700K managed to beat them in the former and come within 100 points or so in the latter once overclocked, thanks to a huge advantage in clock speed. It was also the best-performing CPU in the multi-tasking test at stock and overclocked speeds, and came away with chart-topping results in the system score and Ashes of the Singularity game tests too.

AMD's Ryzen 7 chips are still faster in Cinebench, though, and the Core i7-8700K was bettered by the Ryzen 7 1700X in Cinebench at

stock speed and when overclocked, and in our Handbrake video encoding test, only beating the AMD CPU here once overclocked. The Ryzen 7 1700, which is cheaper still, also offered some tough competition when overclocked, but AMD's own 6-core CPUs were a long way behind Intel thanks to their lower clock speeds. To be fair, though, AMD's 6-core CPUs undercut the 8700K by around £150 too.

**Conclusion**

The Core i7-8700K is not only hugely fast in some tests, but it's never far from the top of the graphs, whether it's at stock speed or when overclocked. It's an awesomely quick all-rounder that's also superb in games, and does well in both lightly threaded and heavily multithreaded software.

AMD still offers better value if multithreaded applications make up the majority of your PC's tasks, but if you'll be performing a range of tasks on your PC, the Core i7-8700K is a better bet and a huge amount quicker than its predecessor in most tests too.

ANTONY LEATHER

**/SPECIFICATIONS**

**Base frequency** 3.7GHz

**Turbo frequency** 4.7GHz

**Core** Coffee Lake

**Manufacturing process** 14nm

**Number of cores** 6 x physical (12 threads)

**Hyper-Threading** Yes

**Cache** 12MB L3 cache, 1.5MB L2 cache

**Memory controller** Dual-channel DDR4, up to 2666MHz

**Packaging** Intel LGA1151-v2

**Thermal design power (TDP)** 95W

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

**SPEED** 48/50     **FEATURES** 14/15     **VALUE** 27/35

**OVERALL SCORE**  
**89%**

**VERDICT**  
An awesomely quick CPU across the board, and with plenty of overclocking headroom too.

## INTEL LGA1151-V2 PROCESSOR

# Intel Core i5-8400 / £209 inc VAT

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

**S**adly, what's likely to be the sweet spot Coffee Lake CPU, the 6-core, multiplier-unlocked Core i5-8600K, still hasn't hit the shelves at the time of writing, and we were unable to get hold of a sample from either Intel or retailers. Instead, we had to make do with a multiplier-locked Core i5-8400 sample that came direct from Intel. However, it still offers six cores, which can all boost up to 3.8GHz, while up to four cores can boost to 3.9GHz and a single core can boost to 4GHz. It also offers 9MB of L3 cache, which is 1MB more than the Core i7-7700K.

Like the Core i5-8600K, it lacks Hyper-Threading, so you only have six threads, but the core count has been boosted by 50 per cent compared with the likes of the Core i5-7400, while the TDP still makes this CPU an attractive proposition for a low-power, high-performance PC, thanks to a TDP of just 65W. At £209 inc VAT, it does cost a fair amount more than the Core i5-7400, though, which currently costs around £160, albeit with a 2-core deficit.

As with the Core i-8350K (see p22), the competition from AMD puts the Core i5-8400 in an interesting position. The Ryzen 5 1600X costs around the same price, but offers six more threads thanks to Simultaneous Multithreading, while the awesome, overclockable 6-core Ryzen 5 1600 costs significantly less at £180 inc VAT.

With all the CPUs running at stock speed, the Core i5-8400 was much quicker than any AMD CPU in the image editing test, and a match for the Ryzen 7 chips in our game test too. It got a bit of a bloody nose from AMD in multi-threading, though, with the Ryzen 5 1600 and 1600X being noticeably faster in the video encoding test and in Cinebench. These leads were extended even further after overclocking, and the AMD chips also came close to matching the Intel CPU's gaming performance when overclocked too.

Multi-tasking was the Core i5-8400's forte, with it achieving the fourth highest score on test, bettered only by the overclocked Core i7-7700K and Core i7-8700K. Overall, the Core i5-8400's system score of 150,772 was in the same league as the AMD Ryzen 5 6-core CPUs, making it rather poor value for money compared with the Ryzen 5 1600 once the latter was overclocked. The Intel chip was very power-frugal by comparison, though, with our whole test system drawing just 121W from the mains under load.



It was much quicker than any AMD CPU in our image editing test

### Conclusion

Intel's latest multiplier-locked Core i5 CPU is far from a Ryzen killer, despite a 50 per cent core count boost over its predecessor. Its low turbo boost frequencies mean it's hampered compared with the Core i7-8700K and overclocked Core i3-8350K, and it only gains any advantage in lightly threaded tests. When overclocked, the cheaper Ryzen 5 1600 was also faster overall, and significantly so in heavily multi-threaded tests.

The main issue for the Core i5-8400, though, is that there are no H or B-series chipset motherboards available yet, and this situation doesn't look as if it will be remedied until 2018. If you're not overclocking, you could build a cheap 6-core system using the Core i5-8400 with one of these chipsets. Currently, though, you'll have to opt for an expensive Z370 motherboard for it, while there are much cheaper options for AMD's CPUs. If you can't afford the Core i7-8700K, but still want a 6-core Intel CPU, we suggest waiting until next month, when we'll hopefully be reviewing the Core i5-8600K and Core i7-7800X.

ANTONY LEATHER

### /SPECIFICATIONS

Base frequency 2.8GHz

Turbo frequency 4GHz

Core Coffee Lake

Manufacturing process

14nm

Number of cores 6 x

physical

Hyper-Threading No

Cache 9MB L3 cache, 1.5MB

L2 cache

Memory controller Dual-

channel DDR4, up to

2666MHz

Packaging Intel LGA1151-v2

Thermal design power

(TDP) 65W

Features Turbo Boost 2,

FMA3, F16C, SHA, BMI /

BMI1+ BMI2, AVX-512,

AVX2, AVX, AES, SSE4a,

SSE4, SSSE3, SSE3, SSE2,

SSE, MMX

SPEED  
44/50

FEATURES  
12/15

VALUE  
23/35

OVERALL SCORE  
79%

### VERDICT

A lack of cheaper motherboards leaves the Core i5-8400 in no-man's-land, with AMD's Ryzen 5 CPUs offering better value.



INTEL LGA1151-V2 PROCESSOR

Intel Core i3-8350K / £159 inc VAT

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

**O**f all the new 14nm Coffee Lake CPUs, the Core i3-8350K is the one that has the potential to shake up the market, both in terms of competition for AMD and when compared with its predecessor, the Core i3-7350K. It's essentially a very similar CPU to the Core i5-7600K, yet it costs less than the Core i3-7350K's launch price, and also costs significantly less than the Core i5-7600K's current price.

As a result, the old Core i5 could be utterly redundant less than a year after its launch. The Core i3-7350K only sported two Hyper-Threaded cores too, and while it was overclockable, the

lack of cores hurt it in many benchmarks, making it poor value and a bit of a disappointment.

The Core i3-8350K, though, has four cores – double that of the old Kaby Lake Core i3, and it has the same 6MB cache as the Core i5-7600K, as well as a 200MHz higher base frequency at 4GHz, compared to 3.8GHz. The Core i5-7600K did have a higher turbo frequency, but

that's irrelevant if you're overclocking.

Price-wise, the Core i3-8350K is an exact match for AMD's Ryzen 5 1500X, AMD's quad-core CPU with simultaneous multi-threading, which enables it to execute eight threads simultaneously, compared to the Core i3-8350K's four threads. At stock speed, the fight will be interesting; the AMD CPU has more threads and more cache, while the Intel CPU has higher frequencies and slightly better single-core prowess.

Overclocking proved to be particularly fruitful for the new Core i3 too, as we managed to push it to a massive 5.1GHz. We had to push the vcore right up to 1.34V to make this clock speed stable, but temperatures were well within limits. We tested a retail CPU for this review too, rather than an engineering sample.

Intel is usually dominant in the image editing test, so it was no surprise to see the Core i3-8350K enjoying a 10 per cent lead over the Ryzen 5 1500X, although the Core i5-7600K was also slightly quicker still, thanks to its ability to turbo-boost. Once overclocked, though, the tables were turned, as the Core i3-8350K was the fastest CPU on test in the image editing benchmark, with a massive lead over the AMD CPU.

Video encoding and Cinebench saw the Ryzen 5 1500X enjoy a stock speed lead, but the raw clock speed of the Intel CPU's overclock saw it regain the lead in the video encoding test, and come within 50 points of the AMD chip in



It was the fastest CPU on test in the image editing benchmark

Cinebench too. Overall, the Core i3-8350K was slightly slower than the AMD CPU at stock speed, but just as quick or quicker when overclocked, while also outperforming the Core i5-7600K in some tests too. However, AMD's 6-core Ryzen 5 1600 is still a threat in this price league, offering much better multi-threaded performance for just £20 more.

**Conclusion**

The Core i3-8350K is a fantastic sub-£200 CPU that's hugely overclockable. It's a match for the Core i5-7600K, despite costing much less money, and it also better the similarly priced Ryzen 5 1500X. The only exceptions are at stock speed in multi-threaded tests, where the AMD CPU was much quicker, but the Core i3-8350K quickly makes up ground once overclocked; it's also faster in games and single-threaded work. The 6-core Intel CPUs offer far more multi-threaded grunt, as does AMD's Ryzen 5 1600, but if you'll mainly be using your PC for gaming, the Core i3-8350K is the CPU for you.

ANTHONY LEATHER

**/SPECIFICATIONS**

**Base frequency** 4GHz

**Turbo frequency** N/A

**Core** Coffee Lake

**Manufacturing process** 14nm

**Number of cores** 4 x physical

**Hyper-Threading** No

**Cache** 6MB L3 cache, 1MB L2 cache

**Memory controller** Dual-channel DDR4, up to 2400MHz

**Packaging** Intel LGA1151-v2

**Thermal design power (TDP)** 91W

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

<b>SPEED</b> 43/50	<b>FEATURES</b> 13/15	<b>VALUE</b> 34/35
<b>OVERALL SCORE</b>		
90%		
<b>VERDICT</b>		
A great budget gaming CPU with massive overclocking headroom – it's essentially a Core i5-7600K with a massive price cut.		

# What's the best memory for Coffee Lake?

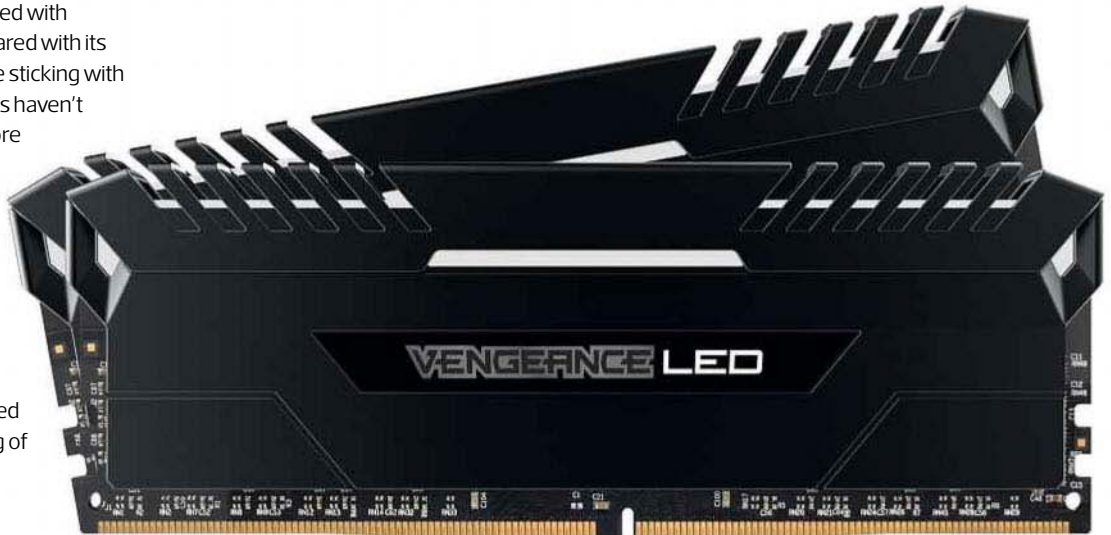
**V**ery little has changed with Coffee Lake compared with its predecessor. We're sticking with DDR4 memory, and the CPUs haven't changed much apart from core counts and cache levels. However, memory prices have risen considerably in the past few months, with your average premium 16GB kit costing around £170 inc VAT for 3200MHz modules, compared to just over £110 when we first looked at Kaby Lake at the beginning of the year.

This begs the question of whether the sweet spot has shifted. Is 3200MHz still worth buying at this price, or is the performance gain so little between that and a 2400MHz kit that you can potentially save some cash? Also, how much could you save by dropping down to 8GB from 16GB, and would the performance sacrifice be worth it?

Firstly, let's look at prices for the four speed ranges we tested this month. We used 2400MHz, 2666MHz, 3000MHz and 3200MHz kits, and the price difference between them is still relatively small. For example, a 16GB kit of Corsair Vengeance LPX memory costs £160 inc VAT. Stepping up to 2666MHz with similar timings costs around the same at £165 inc VAT, and you pay just a couple of pounds more for 3000MHz.

To get to 3200MHz, you only need to spend just over £170 inc VAT, meaning there's barely £10 difference between kits separated by 800MHz. Going above 3200MHz still demands a much bigger premium, though, with the cheapest 16GB 3466MHz kit we could find costing just under £200 inc VAT.

It's clear, then, that 3200MHz is still the sweet spot in terms of price, but with prices well north of their position a few months ago, you can save £80 by dropping down from 16GB to 8GB if you're on a really tight budget. For your typical £1,000-plus PC, it's still worth going for 16GB. We regularly see our PCs using more than 8GB with a few browser tabs open, along with a photo editor. If you have limited funds, that's £80 that could be better spent on a faster graphics card, and even now most games won't benefit from more than 8GB of RAM, as long as you don't



**A 16GB 3200MHz dual-channel memory kit is the current sweet spot for Coffee Lake systems**

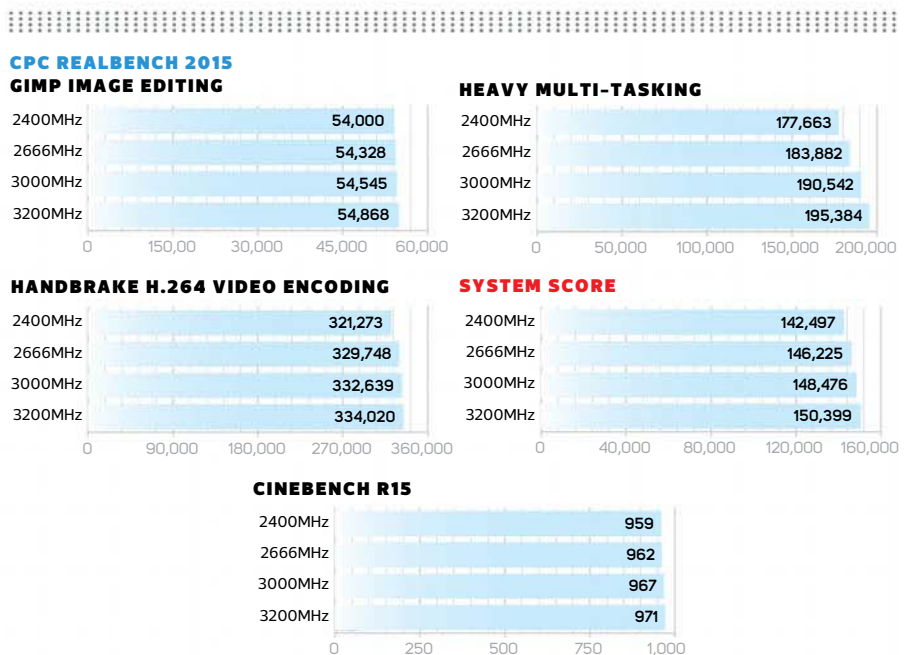
have any other big software packages, or lots of browser tabs, open at the same time.

In terms of speed, our results paint a similar picture to the one we saw with Kaby Lake in January. We used an Intel Core i5-8400 along with a 16GB kit of 3200MHz Corsair Vengeance LED memory. By moving from 2400MHz to 3200MHz, you gain around a 2 per cent boost in performance in photo editing, 4 per cent in video encoding and 10 per cent in multi-tasking, with our system's overall score increasing by 6 per

cent just down to the memory speed. Rendering saw less of a boost, with the Cinebench R15 score rising from 959 to 971.

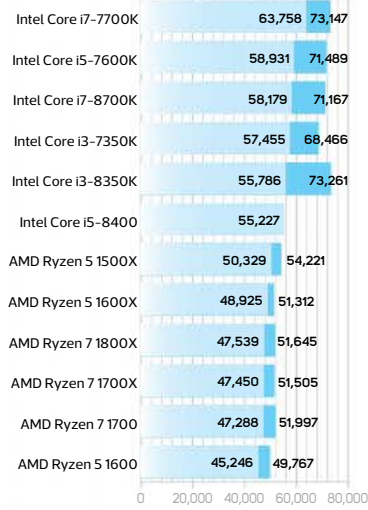
The overall score also highlights that there are diminishing returns, with the score rising more between the two lowest frequencies than the two highest frequencies, so opting for memory faster than 3200MHz will offer poor value. As a result, our ideal Coffee Lake memory would run at 3200MHz, and if you can afford it, make it a dual-channel 16GB kit.

**ANTONY LEATHER**

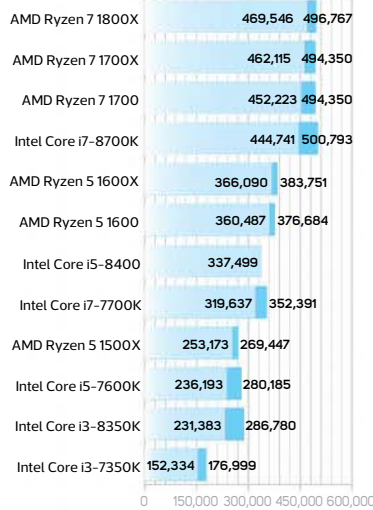


# Intel Coffee Lake benchmark results

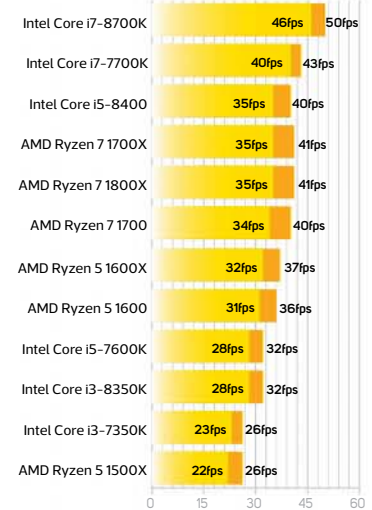
## CPC REALBENCH 2015 GIMP IMAGE EDITING



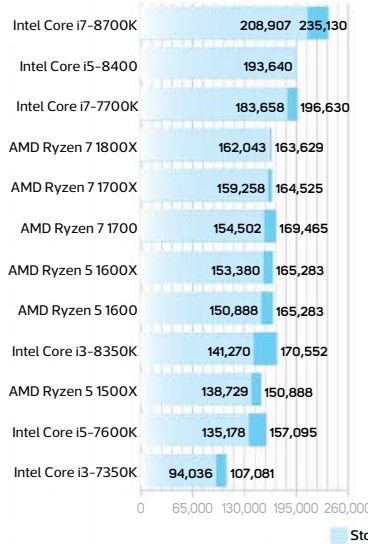
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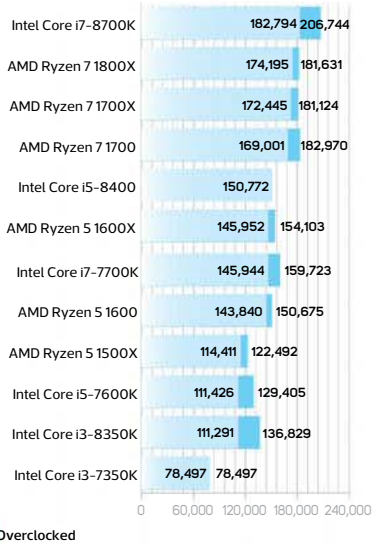
## STOCK SPEED ASHES OF THE SINGULARITY: ESCALATION



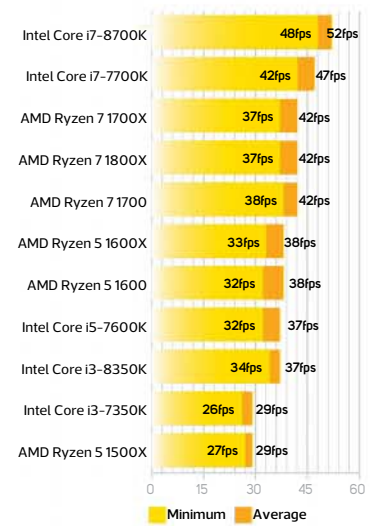
## HEAVY MULTI-TASKING



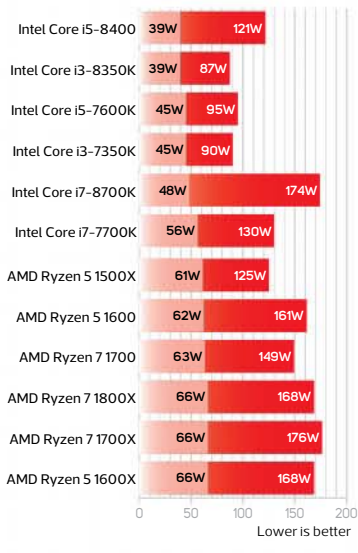
## SYSTEM SCORE



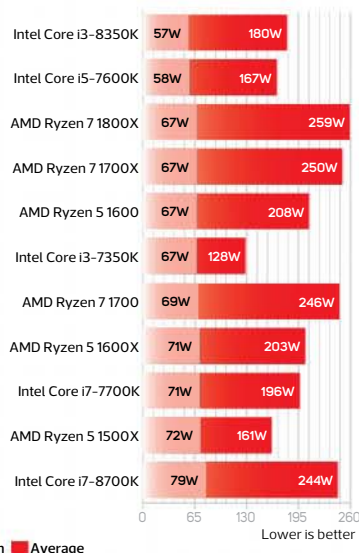
## OVERCLOCKED ASHES OF THE SINGULARITY: ESCALATION



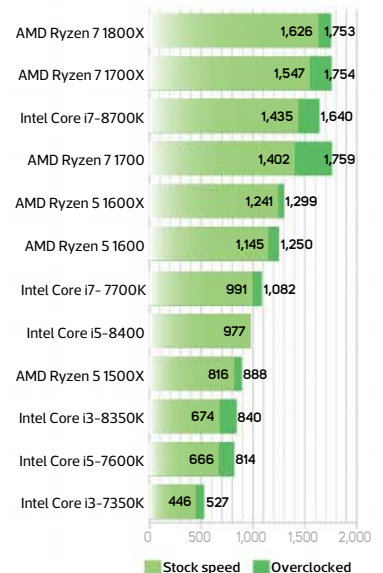
## STOCK SPEED TOTAL SYSTEM POWER CONSUMPTION



## OVERCLOCKED TOTAL SYSTEM POWER CONSUMPTION



## CINEBENCH R15





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# Overclocking Coffee Lake

In terms of how you go about overclocking Intel's latest Coffee Lake CPUs, the method hasn't really changed compared with overclocking a Kaby Lake CPU. You still have a 100MHz base clock, a CPU multiplier and you need to deal with similar voltage ranges. The difference, of course, is that with more cores, you'll have to contend with more heat.

Core i3 CPUs have brought the biggest change in this respect, where the TDP has risen from 60W for the Core i3-7350K to 90W for the Core i3-8350K, thanks to a doubling in the number of cores.

At stock speed, these CPUs are easily tameable, but we've found the 6-core Core i7-8700K draws quite a bit more power than the Core i7-7700K, and generates more heat too, which is to be expected when it has 50 per cent more cores under the heatspreader.

We've found 5GHz to be a reasonably easy target for the Coffee Lake CPUs we've tested so far. Our Core i7-8700K is an engineering sample from Intel, and we got it up to 5GHz using a vcore between 1.25V and 1.32V,

depending on the motherboard; more recent EFIs on Z370 boards have seen the required voltage to be closer to the former figure.

However, we've heard from a number of retailers that 5GHz isn't always possible on the Core i7-8700K, with 4.8GHz being a more realistic frequency on some retail samples. Temperatures quickly become an issue too, since Intel is again using thermal paste and not solder between the CPU core and heatspreader. However, we're also dealing with more cores, and therefore many more fast-switching transistors, concentrated in the same amount of space as a Kaby Lake CPU package.

Our Core i3-8350K sample, however, was a retail CPU, so we're a little more confident about its performance and overclocking headroom being indicative of other retail samples.

That's great news, as we managed to get our chip to 5.1GHz, albeit with a fairly high vcore of 1.34V. Still, our all-in-one liquid cooler easily dealt with the temperature, and none of the cores went beyond 85°C.

## Set XMP profile

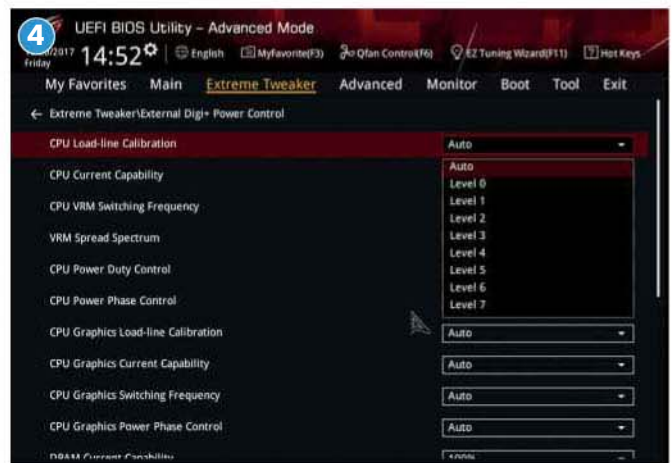
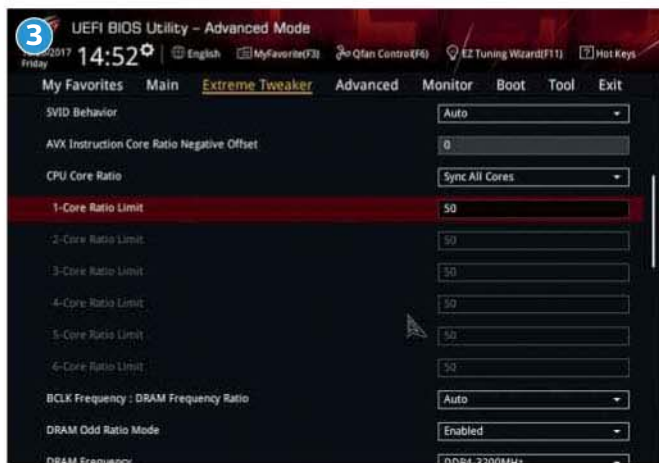
Whichever Coffee Lake CPU you're using, start by applying the XMP profile in your motherboard's EFI **1** to set the correct memory speed; in our case, this happened to be 3200MHz.

This setting will also apply the correct memory timings. The XMP profile setting is usually found in the Extreme Tweaker section on Asus motherboards, the MIT section on Gigabyte motherboards or the OC section on MSI motherboards.

## Set vcore

We'll be applying a fairly simple fixed vcore in this guide, but you can conservatively experiment with adaptive and offset modes if you want to reduce power consumption as much as possible.

We haven't needed more than 1.35V to get either of our K-series CPU samples to 5GHz, so that's a good starting point from which to work back **2**. You might need to switch the EFI's CPU voltage setting to manual mode in order to set the vcore.



## Set multiplier

Find the CPU core ratio setting and put 48 into the field. We'll start with 48, and then hopefully you'll be able to raise this figure to 50, but aim for 4.8GHz first, in case the CPU-buying lottery didn't land you with a particularly overclockable chip.

## Apply loadline calibration

While we only had to set the correct frequencies and vcore on the MSI and Asus motherboards we tested this month, Gigabyte's boards seemed to love a helping of loadline calibration, which suggests they suffer from vdroop. However, they then required the lowest vcore on test, as well as having very frugal power consumption. Consider applying loadline calibration if you're using a Gigabyte board, or if you're having problems getting your CPU to 5GHz.

## Using software instead of the EFI

Alternatively, you can use your motherboard's software to overclock the CPU from within Windows, which can save you a huge amount of time. However, it's still worth applying the XMP profile in the EFI. Make sure you tell the software to apply the overclock to all cores. There's usually fan control software too, which can help you to fine-tune your system's fans to keep your overclocked CPU cool without making too much noise.



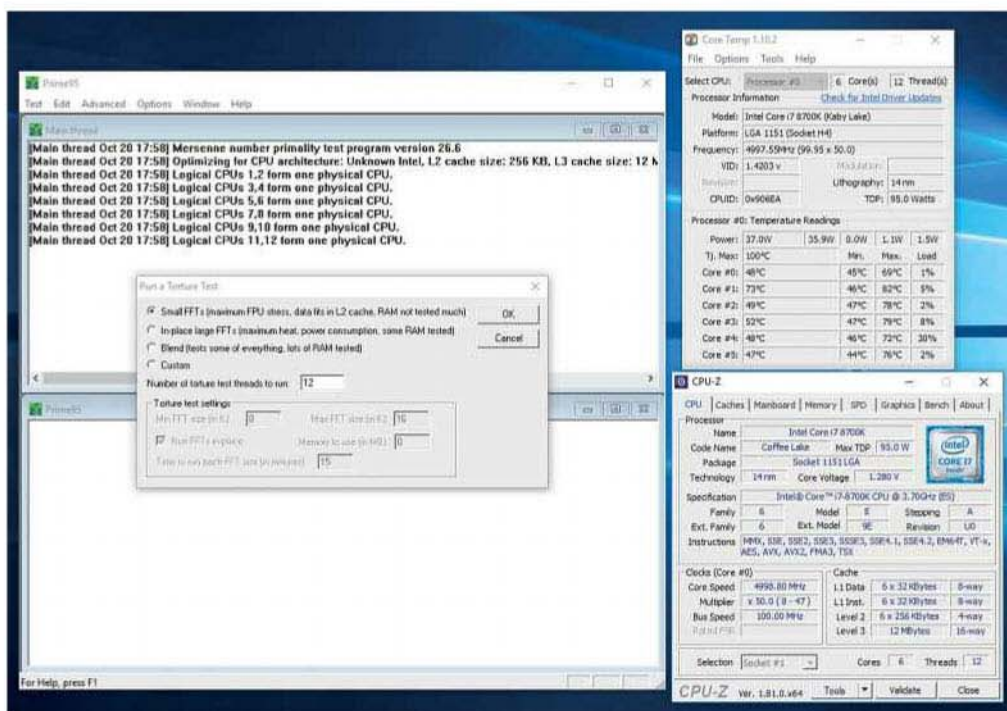
You can use Windows software to overclock your CPU

## Stress testing

There are two parts to stress testing. Firstly, you need to make sure your CPU cooler can handle the temperatures from the increased frequency and voltage, and then you need to assess whether the voltage is high enough for the overclock to be stable. Start by downloading CoreTemp ([www.alcpu.com](http://www.alcpu.com)), CPU-Z ([www.cpuid.com](http://www.cpuid.com)) and Prime95 ([www.mersenneforum.org](http://www.mersenneforum.org)).

Check your overclock has been applied using CPU-Z, and use CoreTemp to monitor

temperatures. Run the smallfft test in Prime95, and check the core temperatures while it's running. Any temperature above 85°C is a tad warm for an everyday overclock, especially if you're testing in colder months. A 15-minute run of Prime95 can be a good indicator of stability too. If your temperatures are acceptable, it's also worth running the video encoding and multi-tasking tests in our RealBench test suite ([www.asus.com/campaign/Realbench](http://www.asus.com/campaign/Realbench)) as well as having a few gaming sessions to make sure.



Stress-test your CPU, while monitoring the core temperatures, to make sure your overclock is stable

If your system is all stable, head back into the EFI and increase the multiplier a notch. Rerun the benchmark and temperature tests again until you encounter stability issues, then knock back the multiplier to the previous stable setting. In our case that was 5GHz for the Core i7-8700K and 5.1GHz for the Core i3-8350K, although your mileage may vary.

Don't leave the voltage at 1.35V, as you can likely cut it back. Drop it by 0.02V (from 1.35V to 1.33V), then rerun the benchmarks to test stability. When you encounter issues, raise the voltage again by the same 0.02V amount and retest your system. You should find that you can reduce the voltage to well below 1.3V, which will mean your CPU will run cooler, draw less power and be less likely to suffer in the long run.

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- Corsair RMX 650W Power Supply
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- LED monitor is not included but optional
- Mouse and keyboard are not included but optional



HD 7.1



Optional



Optional

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Mouse and keyboard are not included but optional

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16GB DDR4 2400Mhz HyperX Black Memory  
500GB Samsung® 850 EVO SSD  
2TB 7200rpm SATA III 6.0Gb/s HDD  
8GB MSI NVIDIA GeForce GTX 1070 Video Card  
NZXT Source 340 Gaming Case  
CoolerMaster® 600W Power Supply  
CoolerMaster® Master Liquid Lite 120 Cooling System  
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### Infinity X55



#### Windows 10 Home

**Intel® Core™ i5-7600K Processor**  
MSI® Z270-A PRO Mainboard  
8GB DDR4 2400Mhz HyperX Fury Memory  
2TB 7200rpm SATA III 6.0Gb/s HDD  
3GB MSI Nvidia® GeForce® GTX 1060 Video Card  
CoolerMaster® Master Box 5 Gaming Case  
CoolerMaster® 500W Power Supply  
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GAMING LAPTOP

# MSI GS43VR Phantom Pro / £1,499 inc VAT

SUPPLIER [www.scan.co.uk](http://www.scan.co.uk)

**T**he MSI GS43VR is one of the smallest gaming laptops we've seen recently, and it's also not ridiculously overpriced, with a respectable mid-range price tag of £1,499 inc VAT. The dinky machine uses a 14in screen, and flaunts the design tropes that we've seen on numerous other MSI laptops. The lid has the familiar MSI Dragon Gaming logo, and the interior has a red keyboard backlight and red metal around the trackpad.

Fitting in with the red theme, the status lights and power buttons are also coloured red, and the chassis panels are made from glossy brushed aluminium. Meanwhile, the back of the GS43VR features a couple of vents that eject air through red slats. The MSI GS43VR

Phantom Pro looks decent, and it's relatively lithe: for a gaming laptop too. Its body weighs just 1.8kg, and it only measures 23mm thick.

Those figures mean you'll barely notice the MSI when it's sitting in a bag or a backpack, and they also mean that the MSI undercuts one of its key small-screen gaming rivals – the Alienware 13 (see Issue 168, p38), which has a thickness of 26mm

thick and weighs in at a comparatively hefty 2.6kg.

The Alienware is chunkier, but it beats the MSI in terms of build quality. The Alienware is rock-solid, but the MSI's wrist-rests have noticeable flex in them, and any squeeze on the lid causes screen distortion on the Windows desktop. We'd definitely protect the MSI with a case or a sleeve. The Alienware arguably looks better too, although that's largely a matter for personal taste. The MSI's familiar gaming laptop design is fine, but the Alienware has RGB LEDs, matt

gunmetal aluminium chassis parts, fewer visible seams and a smarter hinge.

Meanwhile, the MSI keyboard is the usual chiclet variety seen on most current gaming laptops, and the GS43VR's implementation is broadly fine: its keys have enough travel, they're comfortable and the base is solid. That's good for typing, but closer examination reveals a slightly wobbly key action and buttons that are a little on the light side. It's not a massive issue, but a more solid action would be preferable for gaming.

The Alienware's keyboard is better in this respect. It's one of few recent gaming laptops we've seen with traditionally shaped, heavier keys, with additional travel and a firmer base, all of which are better suited for gaming than a light chiclet keyboard. Like the Alienware, though, the MSI also suffers from spongy and



underwhelming touchpad buttons. They're fine for working on the train, but you'll want a proper mouse for gaming.

Meanwhile, it's business as usual on the inside. The Pascal-based GeForce GTX 1060 has 1,280 stream processors and 6GB of memory. It's clocked to 1404MHz and can reach a boost peak of 1670MHz. It's well suited to 1080p gaming, which makes it a good fit for this laptop with its 1080p screen. The Alienware had the same GPU, but paired it with a 2,560 x 1,440 screen, limiting the games you can play at top settings at the screen's native resolution.

The GPU is accompanied by a Core i7-7700HQ CPU, which runs at its usual speed of 2.8GHz with a turbo peak of 3.8GHz. You also get a healthy 16GB allocation of 2400MHz DDR4 memory. The CPU and RAM are the same spec you'll find in the Alienware 13, but the MSI definitely has better storage. The GS43VR has a 256GB Samsung SM951PCI-E NVMe SSD and a 1TB hard disk, while the Alienware had no hard drive, only offering a slower 256GB Toshiba NVMe SSD.

The GS43VR is governed by MSI's usual gaming laptop software. Dragon Center is the main utility, and it contains system monitoring modules and tweaking options. It's possible to add 200MHz to the GPU core and 350MHz to the memory clocks for a couple of extra frames per second in games, and fan speeds can be tweaked. It's also possible to tone down clock speeds and fan pace. Meanwhile, TrueColour is used to choose different screen modes, and



Its body weighs just 1.8kg, and it only measures 23mm thick

**/SPECIFICATIONS**

**CPU** 2.8GHz Intel Core i7-7700HQ

**Memory** 16GB 2400MHz DDR4

**Graphics** Nvidia GeForce GTX 1060 6GB

**Screen** 14in 1,920 x 1,080 IPS

**Storage** 256GB Samsung SM951 SSD, 1TB hard disk

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

**Weight** 1.8kg

**Ports** 2 x USB 3, 1 x mini-DisplayPort, 1 x HDMI, 1 x Gigabit Ethernet, 1 x SDXC, 2 x audio

**Dimensions (mm)** 345 x 245 x 23 (W x D x H)

**Extras** Windows 10 Pro 64-bit

**Warranty** Two years parts and labour return to base



the Nahimic utility contains speaker-tweaking options. The Music mode is the default, but it has an underwhelming treble and a tinny high end.

The Movie option is no better – it ramps up the bass, but it sounds indistinct and overwhelming.

Nahimic's Strategy and Role-playing options dial down the bass until it feels toothless. Surprisingly, the best option is the FPS mode, which has the most defined mid-range and a clear high end. It's our pick of the audio modes, but the sound is still a long way short of the Alienware. Then again, you don't generally expect fantastic audio from a laptop, and you can always use a headset with it anyway.

### Performance

The MSI outpaced the Alienware by slim margins in games. It was a frame per second or two quicker in Fallout 4 and Deus Ex, and its 60fps minimum in The Witcher 3 is a great result.

The MSI's GeForce GTX 1060 GPU will easily play any game at the screen's native 1,920 x 1,080 resolution at top settings, and the processor is similarly competent.

Again, the MSI a little quicker than the Alienware in our RealBench test suite, which meant an overall score of 103,584 – around 8,000 more than the Alienware machine. That's enough CPU power to avoid games bottlenecks, and cope with tough productivity tools and even streaming. It's helped by the SSD, which delivered read and write scores of 2,203MB/sec and 1,249MB/sec. Neither result is record-breaking, as the drive is an OEM drive rather than a fully fledged 960-series drive, but both results still beat the Alienware's SSD.

The lightweight MSI didn't deliver any surprises in battery tests though. Its 61Wh battery is 15Wh smaller than the Alienware's power pack, and it lasted for around 65 minutes in a game benchmark – 30 minutes short of the Alienware.

- 1 A Samsung NVMe SSD and a 1TB hard drive are both included in this small machine
- 2 A healthy 16GB allocation of 2400MHz DDR4 memory is included
- 3 The chassis panels are made from glossy brushed aluminium

#### CPC REALBENCH 2015

##### GIMP IMAGE EDITING



##### HANDBRAKE H.264 VIDEO ENCODING



##### LUXMARK OPENCL



##### HEAVY MULTITASKING



##### SYSTEM SCORE



INTEL REFERENCE STANDARD: 90.5%

SPEED  
22/25

DESIGN  
20/25

HARDWARE  
21/25

VALUE  
23/25

OVERALL SCORE  
**86%**

#### FALLOUT 4

1,920 x 1,080, Ultra Detail, TAA



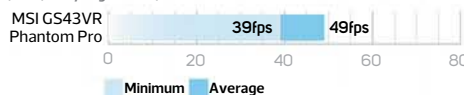
#### THE WITCHER 3: WILD HUNT

1,920 x 1,080, High Detail, Nvidia HairWorks off



#### DEUS EX: MANKIND DIVIDED

1,920 x 1,080, Very High detail, DX11



### VERDICT

Solid gaming pace in a lightweight package that's far cheaper than the competition.



You'll get better longevity by toning down the screen brightness, but the GS43VR will never manage a lengthy gaming session without plugging it into the mains.

Also, while the MSI was quiet when idle, running a gaming stress test saw the CPU and GPU reach delta Ts of 72°C and 62°C. The former figure is higher than that of the Alienware, and the base became hotter than the Alienware's exterior, although the temperature was never problematic. Adding a CPU stress test saw the delta Ts jump by 2°C and 3°C respectively, and caused the base to become a little warmer. The MSI was never loud and never too hot, unlike some of MSI's previous GS-series laptops we've reviewed, but the Alienware's components were cooler and the machine had a chillier outside too.

Meanwhile, the MSI's 1080p IPS panel delivered solid benchmark results. Its black point and brightness level of 0.29cd/m<sup>2</sup> and 302cd/m<sup>2</sup> are good, and they deliver a contrast ratio of 1,041:1 – enough to ensure vivid and well-defined colours. The colour temperature and delta E figures

of 7,271K and 0.24 are both good too, and the panel renders a reasonable 86.6 per cent of the sRGB colour gamut.

Uniformity was mediocre, but not so bad that you'll notice it during games. Don't bother with the alternative screen modes either – the default sRGB option is the best. It's a good screen with ample quality for games and movies, but again, the Alienware is better.

That pricier machine had a 2,560 x 1,440 OLED panel with a perfect black point, huge contrast and 100 per cent sRGB coverage. Those figures mean deeper black shades, more vivid tones throughout and a broader range of colours that can be rendered.

### Conclusion

MSI's GS43VR Phantom Pro combines the GTX 1060, i7-7700HQ and a solid 1080p screen to build a small, lightweight gaming laptop that offers good gaming pace in any current title. That's solid, but the mid-range price means the keyboard and battery life are mediocre, and the MSI's aesthetics and build quality can't compete with the Alienware, which also has a better screen.

The Alienware has more finesse, then, but it also costs around £350 more, and the MSI doesn't make any significant mistakes – it's slimmer, lighter and hundreds of pounds cheaper than its rival, plus its 1080p native screen resolution is better suited to the GPU. If you're looking for a svelte, fast and good-quality laptop, but can't run to the cost of the Alienware 13, the GS43VR is a fine option.

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## ATX CASE

## Fractal Design Meshify C / £90 inc VAT

SUPPLIER [www.scan.co.uk](http://www.scan.co.uk)

**S**olid front panels might give a case a smart, more refined look, but their cooling is never going to be as good as with a full mesh front panel. Even in cases with huge side vents, such as Corsair's Crystal Series, the air still has to bend through 90 degrees before it enters the chassis, which has an impact on cooling efficiency. Fractal Design's classic cases, such as the Define Series, have championed this side vent approach, but the new Meshify C goes back to basics with a full mesh front panel, as well as including a tinted tempered glass side panel that secures using thumbscrews.

The front panel has angular mesh that makes a change from the usual flat mesh, but it can look a little odd from certain angles – a bit like your foot has met with it and bent it out of shape. However, it definitely helps to break up the look of the front section.

The mesh panel is removable for cleaning too, but you need to remove the entire front panel to extract it, which is a bit of a pain. There's also a large full-length dust filter on the underside, which is easier to remove, plus a magnetic mesh in

the roof, so while the case promotes a high-airflow design, dust shouldn't be a problem.

The Meshify C is also fairly compact, measuring just over 40cm deep, but it rises to a height 453mm on top of rubber-based chrome feet. As a result, you get a reasonable amount of room in the roof for installing radiators in the twin 120/140mm vacant fan mounts – the half-height models used in most all-in-one liquid coolers won't cover your motherboard at all.

Thanks to the top fan mounts being offset away from the motherboard, it should be possible to install a 60mm-thick radiator here as long as your motherboard's VRM heatsinks aren't taller than 40mm. The front panel is equally water-cooling-friendly, with three 120mm (two 140mm) fan mounts and the ability to house corresponding radiators.

There's a removable plate in the top of the full-length PSU cover too, which opens up the base to allow triple 120mm-fan radiators to slide down in front of the PSU, and there's headroom for 60mm-thick radiators here too, with space for a double 140mm-design.

Two 120mm Dynamic X2 GP-12 fans are included – one in the front and one in the rear – for a balanced out-of-the-box airflow arrangement. They can reach up to 1,200rpm, which is reasonable, and they definitely dish out a lot of airflow. Of course, the downside to a mesh front



panel is that the fans are a little more audible. While they were noticeable, though, our graphics card and CPU coolers we far louder, with the case fans producing a pleasant, low thrum, plus you can hook up these fans to your motherboard and tune them down if necessary. The front fan sits directly in front of the graphics card too, which will help to keep it cool.

The Meshify C is an all-steel chassis with a smattering of plastic, but it's solid and well made. The cable routing is excellent too, with a large recess running down the front and large Velcro ties for gathering the major cables together. This setup works very well, and the grommet-covered routing holes run nearly from the top to the bottom, so it never feels crowded. There's also a pair of holes in the top of the motherboard tray for routing radiator fans and the 8-pin CPU power connector, so the case design is very well thought out.

You won't be installing any RAID 5 hard disk arrays in the Meshify C, as there are only two 3.5in mounts, located in the base in solid steel trays, but you do get three dedicated 2.5in mounts, while the 3.5in mounts can also house SSDs. Sadly, none of these mounts is tool-free though – you'll even be dealing with screws to install SSDs. The rest of the SSDs mounts are found in a single tray that sits behind the motherboard.

If you'll be air-cooling your CPU then there's a decent 172mm clearance for heatsinks, which is more than enough for most of the biggest heatsinks, such as Noctua's NH-D15. Meanwhile, the graphics card length limit sits at 315mm with the front fan installed, but will be reduced if you install a radiator in the front section.

### Performance

The Meshify C's CPU delta T of 54°C is reasonable, but it was beaten by several cases we've previously tested by a

The Meshify C's GPU delta T was surprisingly low at just 46°C

### /SPECIFICATIONS

**Dimensions (mm)** 217 x 409 x 453 (W x D x H)

**Material** Steel, plastic, glass

**Available colours** Black

**Weight** 7.9kg

**Front panel** Power, reset, 2 x USB 3, stereo, mic

**Drive bays** 3 x 2.5in, 2 x 2.5/3.5in

**Form factor(s)** ATX, micro-ATX, mini-ITX

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

**CPU cooler clearance** 172mm

**Maximum graphics card length** 315mm

1

A removable plate opens the base to allow triple 120mm-fan radiators to sit in front of the PSU

2

The grommet-covered routing holes run nearly from the top to the bottom

3

The front panel's angular mesh makes a change from the usual solid front panels we see



couple of degrees, and is likely to be influenced by the rear fan performance. The Fractal Design Define S was a little cooler, despite having a closed front panel, but it's a larger case that also has two larger fans.

The Meshify C's GPU delta T was surprisingly low at just 46°C, though, which is likely due to the single blower fan on our reference graphics card being placed right next to the front intake fan. This temperature was the lowest result of any case we've seen recently, although using a third-party graphics card with a larger, multiple-fan cooler would likely see the results even out a little.

### Conclusion

The Fractal Design Meshify C offers good cooling, decent build quality, a tempered glass side panel and some useful features, as well as excellent water-cooling support.

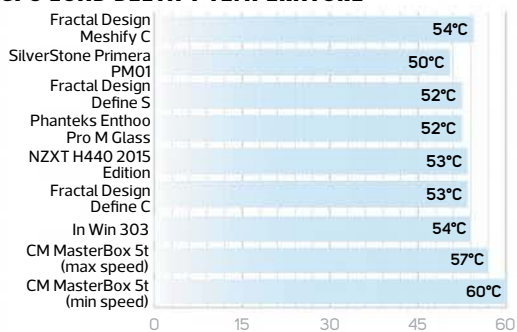
However, it doesn't quite match the likes of the Phanteks Enthoo Pro M Glass in terms of aesthetics.

Despite costing the same amount of money, the latter offers more drive bays, E-ATX support and is even more water-cooling-friendly.

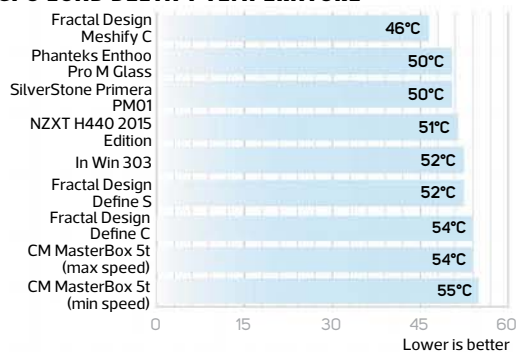
These aren't necessarily deal breakers though – if looks aren't a top priority, and you want a well-built chassis with loads of graphics card airflow, a decent design and excellent cable routing, the Meshify C is still well worth considering.

ANTONY LEATHER

#### CPU LOAD DELTA T TEMPERATURE



#### GPU LOAD DELTA T TEMPERATURE



COOLING  
26/30

FEATURES  
14/20

DESIGN  
26/30

VALUE  
17/20

OVERALL SCORE  
**83%**

#### VERDICT

Great cooling, solid build quality and excellent cable routing, but it lacks visual pizzazz and features compared with the competition.

# Custom Kit

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

## Mousebean Ergonomic Hand Rest / **£9.48** inc VAT

Having a wrist rest built into a mouse pad can sometimes cause a few problems, usually to do with the moving position of the mouse relative to the fixed position of the pad. The Mousebean aims to bypass these problems by attaching the wrist rest directly to the mouse itself. It solves the positioning problems of a fixed wrist rest, but it introduces some new problems too.

The biggest is that there's no satisfactory way to attach it. No adhesive is supplied, and glue is recommended – applied to a flexible rubber pad. However, it's still not ideal, especially if you have a high-end and/or oddly shaped mouse and you don't want anything stuck to it. If you're willing to glue the Mousebean to your mouse, though, you can sit your hand comfortably on the rest and then use your mouse as normal, without the rest getting away from you. It feels a little crude to use at first, but it does provide the same support as a wrist rest with a better range of motion. The implementation could be much better, but the idea is good.



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



## Anker PowerCore Speed 20000QC Power Bank / **£69.99** inc VAT

While it may share some visual characteristics with the mysterious alien obelisks in 2001, the Anker PowerCore is much easier to figure out. Boasting a capacity of 20,000mAh, the PowerCore Speed 20000QC delivers a large capacity (we generally got around six full charges with our test smartphone) in a relatively compact shape without any fuss or fanfare. There's a micro-USB input for charging and two USB ports for output, one of which is a 24W Qualcomm USB 3 Quick Charge port.

As a result, the charging speed is very fast, being comparable to a mains adaptor. The PowerCore also has a good shape for travel – it's not lumpy, there are no sharp corners and it includes a bag to stow it and its cables. The minimalist design extends to the capacity indicator, there's a button on the side and four lights indicating remaining charge. The only current downer is the ridiculous price of £70, when it should (and did until recently) cost half that amount, but it's well worth picking up if the price drops again.



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

## Power Pen /

**£24.99** inc VAT

Cramming as many tools as possible into a pen-sized object, at least one of which is a writing implement, looks like a good idea, although it can be tricky to pull off. The Power Pen is a pen that functions as a stylus, and it also contains a battery and USB connector, so it can act as a charge bump for a phone.

The Pen connects to micro-USB or Lightning via a supplied internal adaptor. With only 700mAh, you're only getting a fraction of a phone's full capacity, but that could still be important as a last resort. The biggest problem, though, is the size and shape of the pen. The need for a USB port to charge it means it's big, and the battery makes it relatively heavy. The Power Pen manages to do all the jobs in its remit, but it doesn't do them particularly well.



SUPPLIER [www.firebox.co.uk](http://www.firebox.co.uk)





## Netgear Mini Wi-Fi Range Extender/

**£14.99** inc VAT

The Netgear Mini Wi-Fi Range Extender plugs into a wall socket and acts as a wireless hub, connecting you to your original wireless network via its own wireless network. You're not directly extending your original Wi-Fi network, as you might by installing a bigger antenna; instead you're spinning off a second network from the first with this device as the hub.

If you can't afford a full Wi-Fi mesh system (see p52), this range extender works well if your Wi-Fi router signal struggles to go through ceilings or walls, and simply boosting the original signal won't cut it. Setting up the device is easy enough if you follow the instructions, but the antennae on the device mean you will need to give it more room than a standard plug. It only supports 802.11n too, with a maximum quoted speed of 300Mb/sec, but that's fine if you're just using your smartphone in bed. It's also smaller than your average range extender, and surprisingly affordable and effective to boot.



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



## PowerUp 3.0 Smartphone Controlled Plane/ **£39.99** inc VAT

The PowerUp 3.0 allows you to make paper aeroplanes that you can control with your smartphone. You get a Bluetooth-controlled motor and rudder assembly that you can build into paper aeroplanes, as well as some printed templates for plane designs, plus further plane types available online. You just need some paper and tape to get you underway.

The app to control the aircraft is easy to use; you tilt the phone to control the rudder and touch the screen for the engine power. It takes practice, careful assembly and favourable conditions to get any decent control over the planes, but it's great when you succeed. The plus side of the planes being paper is that you can easily replace them after crashes, and the kit includes spare propellers, rudders and other components that might fall off or break. The PowerUp 3.0 is fun, but requires some effort to get the most out of it.



SUPPLIER [www.firebox.co.uk](http://www.firebox.co.uk)

## Posunitech USB Hub/

**£29.89** inc VAT

The Posunitech USB Hub doesn't mess around. It's a ten-port USB 3 hub that you can power from the mains, so you don't have to worry about overwhelming the port on your PC to which it's connected. The design is simple and there's surprisingly little to it; you just get a small box with lots of USB ports. There's also a power switch for each block of three, so you can turn them off without unplugging them, but otherwise, that's all there is to it.

There's a couple of nits to pick given the price though. The power cable could stand to be longer, and the box lacks any feet or anchoring mechanism, which means it tends to dangle at the whim of whichever device is attached to it.

However, if you want to hook up loads of USB 3 devices, this hub otherwise does a great job without taking up a lot of space.



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



Seen something worthy of appearing in Custom Kit? Send your suggestions to [editor@custompcmag.org.uk](mailto:editor@custompcmag.org.uk)

# How we test

## PROCESSORS

### INTEL LGA1151-V2



Intel LGA1151-V2 CPU

Asus ROG Maximus X Hero

16GB Corsair Vengeance LED 3200MHz DDR4

256GB Crucial MX100

Zotac GeForce GTX 1080 AMP! Edition

### INTEL LGA2066



Intel LGA2066 CPU

Asus ROG Strix X299-E Gaming

32GB Corsair Vengeance LED 3000MHz DDR4

256GB Crucial MX100

Zotac GeForce GTX 1080 AMP! Edition

### AMD AM4



AMD AM4 CPU

Asus ROG Crosshair VI Hero

16GB Corsair Vengeance LPX 3000MHz DDR4

480GB Crucial M500

AMD Radeon R9 390X

### AMD TR4



AMD TR4 CPU

Asus ROG Zenith Extreme

32GB Corsair 3000MHz Vengeance LED DDR4

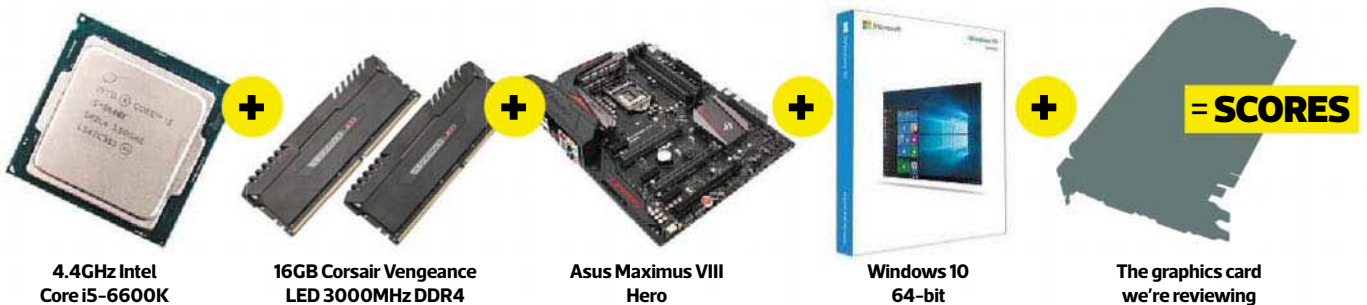
256GB Crucial MX100

Zotac GeForce GTX 1080 AMP! Edition

**TESTS:** We use Custom PC RealBench 2015, Cinebench and Ashes of the Singularity: Escalation, installed on Windows 10 Home 64-bit, and record the power draw of the test PC. These tests cover a broad range of performance characteristics, including image editing, gaming, video encoding and 3D rendering. We run all tests at stock speed and at the CPU's highest overclocked frequency.

## GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.



4.4GHz Intel Core i5-6600K

16GB Corsair Vengeance LED 3000MHz DDR4

Asus Maximus VIII Hero

Windows 10 64-bit

The graphics card we're reviewing

= SCORES

## CUSTOM PC REALBENCH 2015

### INTEL REFERENCE



Intel Core i7-4790K + 16GB of Corsair 2400MHz DDR3 + 240GB OCZ 150 + Asus Maximus Gene VII + Nvidia GeForce GTX 780 3GB = 100%

### AMD REFERENCE



AMD A10-7850K + 8GB of Corsair 2133MHz DDR3 + 256GB Plextor M5 Pro + Asus A88X-Pro = 100%

Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from [www.asus.com/campaign/Realbench](http://www.asus.com/campaign/Realbench)

## MOTHERBOARDS

### INTEL LGA1151-V2



Intel Core i7-8700K + Motherboard on test + 16GB Corsair Vengeance LED 3000MHz DDR4 + 500GB Samsung SSD 960 Evo + Zotac GeForce GTX 1080 AMP!

### INTEL LGA2066



Intel Core i9-7900X + Motherboard on test + 32GB Corsair Vengeance LED 3000MHz DDR4 + 256GB Crucial MX100 SSD + 500GB Samsung SSD 960 Evo + 2 x Asus Strix Radeon RX 480 8GB

### AMD AM4



AMD Ryzen 7 1700 + Motherboard on test + 16GB Corsair Vengeance LPX 3000MHz DDR4 + 500GB Samsung SSD 960 Evo + AMD Radeon R9 390X

### AMD TR4



AMD Threadripper 1920X + Motherboard on test + 32GB Corsair 3000MHz Vengeance LED DDR4 + 500GB Samsung SSD 960 Evo + 2 x Asus Strix Radeon RX 480 8GB

**TESTS:** We use Custom PC RealBench 2015 and Ashes of the Singularity installed on Windows 10 Home 64-bit, and also test the board's SATA and M.2 ports. We try to overclock every motherboard by overclocking our test CPU to its maximum air-cooled level.

## The Awards



### EXTREME ULTRA

Some products are gloriously over the top. These items of excellent overkill earn our Extreme Ultra award.



### PREMIUM GRADE

Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.



### PROFESSIONAL

Products worthy of the Professional award make you and your business appear even more awesome.



### APPROVED

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



### CUSTOM KIT

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



**TESTS:** By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test Deus Ex: Mankind Divided, Doom, Crysis 3, Fallout 4 and The Witcher 3: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

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## LABS TEST

# Coffee Lake motherboards

Antony Leather takes a look at six of the latest Z370 motherboards for Intel's Coffee Lake CPUs, from Asus, Gigabyte and MSI

### Contents

Asus ROG Maximus X Hero / p43

Asus ROG Strix Z370-E Gaming / p44

Gigabyte Z370 Aorus Gaming 7 / p45

Gigabyte Z370 Aorus Ultra Gaming / p46

Results graphs / p50

MSI Z370 Gaming Pro Carbon AC / p47

MSI Z370 Godlike Gaming / p48

## How we test

**A**s Coffee Lake CPUs aren't backwards compatible with Z270 motherboards, if you want to build a system using one of Intel's stunning new CPUs, you'll need to invest in a new Z370 motherboard. Thankfully, there's plenty of boards from which to choose, with all sizes and price ranges landing at launch, even if some of the CPUs and low-end chipsets are still on their way. We've chosen six boards, priced from £170 to £530 inc VAT, from three of the big manufacturers to see which ones are worth your cash.

As the Z370 chipset is for the most part identical to Z270, our test kit mostly uses the same kit as our Kaby Lake test gear. This setup includes 16GB of 3000MHz Corsair Vengeance RAM, a 512GB Crucial MX100 SSD with Windows 10 64-bit installed, plus an NZXT Kraken X42 all-in-one liquid cooler. We also use a Zotac GeForce GTX 1080 AMP! Edition graphics card and a Samsung 960 Evo M.2 SSD. The latter is used to get performance numbers for the motherboard's M.2 ports, and we also tap into the SSD's internal temperature sensor

to see how well any M.2 heatsinks perform under load, using back-to-back runs of CrystalDiskMark's entire battery of tests.

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, Ashes of the Singularity: Escalation for gaming and total system power consumption from the mains, measured at the Windows desktop and at load running Prime95's smallfft test.

# Asus ROG Maximus X Hero / £240 inc VAT

SUPPLIER [www.box.co.uk](http://www.box.co.uk)

**W**hile some Z370 boards are pricier than their Z270 equivalent predecessors at launch, Asus' ROG Maximus X Hero actually costs around the same amount of money. What's more, the new board appears to offer more features, rather than taking a machete to the specification list. The Maximus IX and X Hero look quite similar, but there are two clear aesthetic differences. The first is the inclusion of a nifty integrated I/O shield, and the other is a large heatsink for one of the two M.2 ports.

It's one of the better-featured boards on test this month, yet it doesn't cost that much more than some of the cheaper models on test. It has an enviable set of features compared with the less expensive boards too, including the full complement of overclocking and testing tools, from power, reset and clear-CMOS buttons to USB BIOS Flashback and an LED POST code display – all absent on the cheaper ROG Strix Z370-E Gaming. The latter does sport Wi-Fi, but while it's missing from our ROG Maximus X Hero model, Asus offers another Wi-Fi-equipped version.

Asus also sensibly includes a decent amount of fan headers near to the CPU socket, which are lacking on both of MSI's boards this month, and the Hero includes a 3A header to power water-cooling pumps, dishing out up to 36W, which is enough to power DDC and D5 pumps, albeit using a 3-pin to 4-pin Molex adaptor. There are thermal probe and water-cooling flow rate headers too, and while Asus' fan control system isn't quite as flexible as those of MSI or Gigabyte these days, there's still plenty of scope for using the ROG Maximus X Hero as a powerful fan control system.

The Hero only offers two M.2 slots, while the slightly more expensive Gigabyte Z370 Aorus Gaming 7 has three, but two will be enough for most people. The Gigabyte board does sport some incredible lighting, though, and both boards offer support for individually addressable RGB LED strips.

Both boards also have single M.2 heatsinks, located above the graphics card slot, which allowed for much lower temperatures than the heatsink-less boards on test. However, the larger heatsink on the ROG Strix Z370-E Gaming and lower-positioned heatsink on the MSI Z370 Godlike Gaming resulted in noticeably lower temperatures, although not any speed gains. Also, while the ROG Maximus X Hero's



## The Hero includes a 3A header to power water-cooling pumps

heatsink cut the load temperature of our Samsung 960 Pro by 12°C, the close proximity of the graphics card and memory meant that it was still 10°C warmer under load than on the MSI Z370 Godlike Gaming, where we used the outermost heatsink at the board's base.

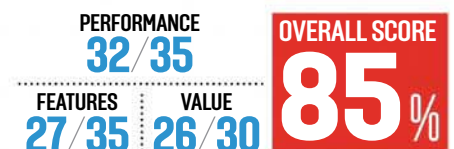
In terms of power consumption, the ROG Maximus X Hero was reasonably power-frugal at stock speed, but it had the highest overclocked idle power draw as well as higher load draw, despite using a lower vcore. Speaking of overclocking, the ROG Maximus X Hero managed to overclock our CPU to 5GHz with the joint lowest vcore on test of 1.25V, with temperatures easily tameable by our all-in-one liquid cooler.

Meanwhile, the EFI is up to Asus' usual high standards; our only issues are that the fan control section isn't quite as detailed as those on the MSI or Gigabyte boards, plus the M.2 PCI-E speed is set to 2x on one port as standard – you'll need to bump it up manually to 4x to get the full bandwidth.

### Conclusion

It's a shame Wi-Fi isn't included on the Hero as standard, but thankfully there's a Wi-Fi

version available too if you want it. Otherwise, though, the Asus ROG Maximus X Hero has decent overclocking abilities, and plenty of enthusiast features to make it well worth the extra cash over the cheaper boards on test this month.



### VERDICT

A fantastic Z370 motherboard with all the essential enthusiast features and decent overclocking abilities, all for a reasonable price.

### / SPECIFICATIONS

- Chipset** Intel Z370
- CPU socket** Intel LGA1151-v2
- Memory support** 4 slots: max 64GB DDR4 (up to 4133MHz)
- Expansion slots** Three 16x PCI-E 3, three 1x PCI-E 3
- Sound** 8-channel Realtek ALC1220
- Networking** Intel Gigabit LAN
- Overclocking** Base clock 40–650MHz, CPU multiplier 8–83x; max voltages: CPU 2.155V, RAM 2.4V
- Ports** 6 x SATA 6Gbps (Z370), 2 x M.2, 1 x USB 3.1 Type-A, 1 x USB 3.1 Gen 2 Type-C, 4 x USB 3, 1 x LAN, 5 x surround audio out, S/PDIF out.
- Dimensions (mm)** 305 x 244

# Asus ROG Strix Z370-E Gaming / £200 inc VAT

SUPPLIER [www.cclonline.com](http://www.cclonline.com)

**A**s with the ROG Maximus X Hero, Asus' ROG Strix boards are available in a variety of models, with the main differentiating features between the Z370-E Gaming here and the cheaper Z370-F Gaming being Wi-Fi support and different-coloured heatsinks. It might seem strange to include two very similar boards in your line-up, but Asus claims that many system builders prefer boards with no Wi-Fi, instead allowing the customer to choose a high-performance Wi-Fi card instead, or indeed use a wired network.

The silver heatsinks of the ROG Strix Z370-E make a pleasant change from the usual grey or black colour schemes though; plus, at £200, it's one of the cheaper boards to offer Wi-Fi. There's not too much going on in terms of RGB lighting when you turn on the board, except for the multi-LED tick-shaped array on the I/O shroud, which can dish out funky rainbow effects thanks to individually controllable LEDs. However, the board also includes three RGB LED headers, with one supporting individually addressable LED strips, as well as supporting Asus' Aura synchronised lighting system.

There isn't quite as much going on in terms of cooling and fan control as on the Maximus X Hero though. While you get the same number of fan headers, there's no high-current header for custom water-cooling pumps. Instead, you're limited to a 1A/12W header for all-in-one liquid cooler pumps. There are no water-cooling flow rate sensors either, but you get the same EFI and software fan control suites as on the Hero.

The ROG Strix Z370-E Gaming features the biggest M.2 heatsink on test as well, but only one SSD can make use of it. Even so, the load temperature of 51°C was the second lowest on test, despite our initial concerns that the graphics card's side vents might warm it up. That said, though, the smaller but similarly placed heatsink on the MSI Z370 Godlike Gaming managed an even lower temperature when dealing with our Samsung 960 Evo.

Not being a fully fledged ROG board, you also miss out on features such as USB BIOS Flashback and, unlike the Hero, there are no on-board overclocking or testing buttons and tools. However, MSI and Gigabyte's cheaper efforts on test lacked these features too. One area of concern, though, is the number of USB ports. Only five Type-A ports are located on the rear panel, so you'll need to make use of



The silver heatsinks make a pleasant change from the usual grey or black colour

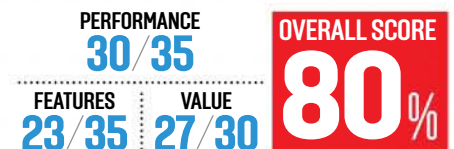
the numerous USB headers if you need more. Like all other boards on test, one of these headers is USB 3.1, although USB 3.1 still has limited uses at the moment.

As we tested this board soon after the Coffee Lake launch, we ended up using a relatively early EFI, which could explain the need to use a fairly high vcore of 1.31V to get our Core i7-8700K stable at 5GHz. Overclocked power consumption was high as a result, although the ROG Maximus X Hero was also quite greedy in this respect. The overclock saw the system score rise from 59,303 to 70,785, which are both mid-table results, but performance was very similar for all the boards anyway, and the board's audio and storage performance is similarly fine too.

## Conclusion

The ROG Strix Z370-E Gaming is a decent Z370 motherboard, but at £200 inc VAT, this board's main issue is lack of any stand-out features to differentiate it from the rest of the pack. The low M.2 temperatures are welcome

and Asus' EFI and software are excellent, but overall, the Gigabyte Z370 Aorus Ultra Gaming is a slightly better budget buy unless you really need on-board Wi-Fi.



## VERDICT

Great M.2 temperatures, but the limited number of USB ports and lack of stand-out features mean the Strix isn't quite an award winner at this price.

## SPECIFICATIONS

**Chipset** Intel Z370

**CPU socket** Intel LGA1151-v2

**Memory support** 4 slots: max 64GB DDR4 (up to 4000MHz)

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

**Sound** 8-channel Realtek ALC1220

**Networking** Intel Gigabit LAN, 802.11ac Wi-Fi

**Overclocking** Base clock 40-650MHz, CPU multiplier 8-83x, max voltages: CPU 2V, RAM 2.1V

**Ports** 6 x SATA 6Gbps (Z370), 2 x M.2, 1 x USB 3.1 Type-A, 1 x USB 3.1 Gen 2 Type-C, 2 x USB 3, 2 x USB 2, 1 x LAN, 5 x surround audio out, S/PDIF out.

**Dimensions (mm)** 305 x 244

# Gigabyte Z370 Aorus Gaming 7 / £258 inc VAT

SUPPLIER [www.scan.co.uk](http://www.scan.co.uk)

**W**hile some other boards on test haven't seen a price hike over their equivalent predecessors, the Gigabyte Z370 Aorus Gaming 7 does sadly cost around £20 more than the Z270 Aorus Gaming 7 cost at launch – a board that picked up our Premium Grade award back in January 2017's Z270 motherboard group test. The higher price also means that it's noticeably more expensive than Asus' ROG Maximus X Hero, which costs £240.

It does sport a few extra features, though, such as more fan headers, an extra M.2 port and the most amazing light show we've ever seen on a motherboard. There are also four headers for standard RGB LED strips, as well as strips with individually addressable LEDs. In addition to illuminated DIMM and PCI-E slots, the Z370 Aorus Gaming's chipset, VRM heatsinks and I/O shroud now also light up in full RGB glory. Plus, if that isn't enough, the board can also control Corsair's Vengeance RGB LED memory.

There are three M.2 ports, but only one of them is equipped with a heatsink; however, to be fair, only the expensive MSI Z370 Godlike Gaming offers more M.2 heatsinks. It's a similar heatsink to the others on test this month, with a slab of aluminium pressing on the M.2 SSD by way of a thermal pad.

However, the heatsink isn't really able to make use of your case's airflow, being stuck between the CPU socket, RAM and graphics card, which could be why it was only able to come within 6°C of the best result on test. This result was 9°C better than without the heatsink, though, so it's definitely worth using.

Sadly, this comparatively pricey board also lacks Wi-Fi, but it does have a pair of Gigabit LAN ports, as well as six USB Type-A ports on the rear panel, along with the usual USB 3.1 Type-C port in addition to the USB 3.1 header on the motherboard. It also has some great VRM cooling, with two massive heatpipe-equipped heatsinks, which are actively cooled by a small, fairly inconspicuous fan.

Thankfully, this fan can be controlled in Gigabyte's fan control software, which is excellent and offers more control than Asus' FanXpert4 software or EFI, with the ability to choose from a variety of thermal sources, including thermal probes and flow sensors, to control fan or pump speed. The Z370 Aorus Gaming 7 also has a 3A/36W fan header, which has enough grunt to power proper custom water-cooling pumps.



It offers the most amazing light show we've ever seen on a motherboard

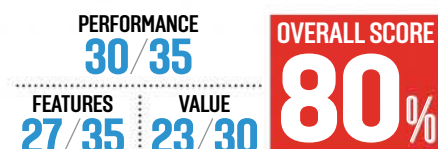
Meanwhile, if you like the convenience of being able to test your hardware out of the case as well as having POST code displays and clear-CMOS buttons, then you'll be pleased to know that all these features are present

We initially had issues getting the board stable with the vcore below 1.3V when overclocking, but applying the extreme loadline calibration profile fixed this issue, with the lowest stable voltage sitting at just 1.25V to get our Core i7-8700K to 5GHz. As a result, the Aorus Gaming 7 has the second lowest load power draw, at just 210W when overclocked, although it also recorded the lowest overclocked system score result, sitting at 203,582. Audio and SATA performance was below the rest of the pack in the graphs too, but the results are still good – most people won't notice the difference in real-world use.

## Conclusion

If you like illumination on your motherboard, the Z370 Aorus Gaming 7 is for you. It looks spectacular and completely outdoes the

competition in the lighting stakes, while the colour-neutral design helps colour matching to your own PC. The VRM fan and third M.2 port are perhaps a little unnecessary, but the specifications are otherwise spot on. It's only the high price that means this board just misses out on an award.



## VERDICT

Spectacular lighting and a great feature set, but it's a little too expensive compared with the competition.

## SPECIFICATIONS

**Chipset** Intel Z370

**CPU socket** Intel LGA1151-v2

**Memory support** 4 slots: max 64GB DDR4 (up to 4133MHz)

**Expansion slots** Three 16x PCI-E3, three 1x PCI-E3

**Sound** 8-channel Realtek ALC1220

**Networking** Intel and Killer Gigabit LAN

**Overclocking** Base clock 80-500MHz, CPU multiplier 8-127x; max voltages, CPU 1.8V, RAM 2V

**Ports** 6 x SATA 6Gbps (Z370), 3 x M.2, 1 x USB 3.1 Type-A, 1 x USB 3.1 Gen 2 Type-C, 5 x USB 3, 2 x LAN, 5 x surround audio out, S/PDIF out.

**Dimensions (mm)** 305 x 244

Gigabyte Z370 Aorus Ultra Gaming / **£170** inc VATSUPPLIER [www.novatech.co.uk](http://www.novatech.co.uk)

**T**hankfully, if you don't want to spend upwards of £200 inc VAT on a Z370 motherboard, there are plenty of cheaper examples available. Gigabyte's Z370 Aorus Ultra Gaming is a fine example, costing just £170 inc VAT. Like its more expensive sibling, the Z370 Aorus Gaming 7, it costs noticeably more than its Z270-based predecessor at launch. It's still the cheapest board on test by quite a margin, though, and Gigabyte hasn't cut too many corners to get the price down.

You get six fan headers on the Z370 Aorus Ultra Gaming, along with six SATA 6Gbps ports and even two M.2 ports. Neither of the latter sports a heatsink, so your M.2 SSD will be left to its own devices, but that shouldn't be a big deal if there's decent airflow in your case. There are no overclocking or testing tools either, but these features are still absent on the Asus ROG Strix Z370-E Gaming and MSI Z370 Gaming Pro Carbon AC, which cost significantly more money.

Despite the low price, Gigabyte has still managed to include a nifty lighting display too, with five independent zones, including the DIMM and PCI-E slots, plus the same four RGB LED headers as those you'll find on the more expensive Gaming 7 board, two of which support LED strips with individually addressable LEDs. You also get a decent amount of USB ports. There's a USB 3.1 header on the PCB and the rear panel offers a total of seven USB Type-A ports, one of which supports USB 3.1, courtesy of an ASMedia controller, which also gives you a Type-C port.

Of the six fan headers, three are located near the CPU socket, so rear and roof case fans plus CPU cooler fans shouldn't need to much faffing in terms of cable routing. Sadly, there's no high-current header for custom water-cooling pumps, but there's a dedicated header for lower power all-in-one liquid-cooler pumps.

Gigabyte provides the same EFI and software as its more expensive boards too, so you can take full advantage of the excellent fan control section in the EFI, as well as Gigabyte's System Information Viewer fan control software.

With no heatsinks to cool our Samsung 960 Evo M.2 SSD, its load temperature of 72°C was by far the warmest on test, but this temperature didn't result in lower speeds. If you're planning to use slower, SATA-based M.2 SSDs, you'll also need to note that one of



Despite the low price, Gigabyte has still managed to include a nifty lighting display

the M.2 ports only support PCI-E M.2 drives, so you'll only be able to use one of them.

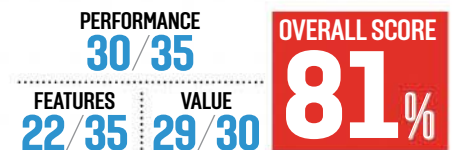
Next we came to overclocking, which proved to be an identical experience to that of the Z370 Aorus Gaming 7, with just a 1.25V vcore and turbo loadline calibration required to get stability at 5GHz with our Core i7-8700K. The system score at stock speed of 184,142 wasn't outstanding, nor was its overclocked score of 204,401, although neither are far off the fastest results.

Audio performance was also on a par with the rest of the field, thanks to the same Realtek ALC1220 codec being used, despite the cheaper price tag. Power consumption was also very low at stock speed and when overclocked, so Gigabyte has clearly got to grips with the new CPUs.

### Conclusion

Few corners have been cut to allow the Gigabyte Z370 Aorus Ultra Gaming to undercut the competition by around £30, which is a significant saving. It has solid

performance across the board, some excellent RGB lighting and plenty of ports, which means it offers better value than MSI or Asus' more wallet-friendly offerings this month. If you're on a tight budget, the Z370 Aorus Ultra Gaming is the board to buy.



### VERDICT

Solid performance and overclocking with some nifty lighting for a very good price.

### SPECIFICATIONS

**Chipset** Intel Z370

**CPU socket** Intel LGA1151-v2

**Memory support** 4 slots: max 64GB DDR4 (up to 4000MHz)

**Expansion slots** Three 16x PCI-E3, three 1x PCI-E3

**Sound** 8-channel Realtek ALC1220

**Networking** Intel Gigabit LAN

**Overclocking** Base clock 80-500MHz, CPU multiplier 8-83x; max voltages: CPU 1.8V, RAM 2V

**Ports** 6 x SATA 6Gbps (Z370), 2 x M.2, 1 x USB 3.1 Type-A, 1 x USB 3.1 Gen 2 Type-C, 4 x USB 3, 2 x USB 2, 1 x LAN, 5 x surround audio out, S/PDIF out.

**Dimensions (mm)** 305 x 244

# MSI Z370 Gaming Pro Carbon AC / £199 inc VAT

SUPPLIER [www.ebuyer.com](http://www.ebuyer.com)

**T**wo boards sit on the £200 mark this month – Asus’ ROG Strix Z370-E Gaming and MSI’s Z370 Gaming Pro Carbon AC, and these two models’ predecessors have been doing battle for a couple of generations too. Choosing between them is going to be trickier than ever now, though, as they’re both extremely similar in terms of features.

Both boards support Wi-Fi, but while Asus uses its own integrated Wi-Fi card, MSI has opted for an entirely discrete 1x PCI-E card with an Intel 8265NGW 802.11ac network adaptor installed on it.

This decision could be due to the fact that the rear I/O panel is a little busier than that of the Asus board with an additional two USB ports and PS/2 port, so there may not be room for antennae connectors.

Asus trumps MSI in the M.2 heatsink stakes, though, as the ROG Strix Z370-E Gaming offers a huge heatsink at the cooler, base end of the board, while the MSI board includes a rather skinny heatsink that has to be used in the top M.2 slot, which we’ve found to run warmer, as it’s next to the graphics card. Both M.2 ports support either PCI-E NVMe or SATA-powered M.2 SSDs, though, so if you want one SATA M.2 SSD for general data storage and one PCI-E SSD for your software and Windows, you can take your pick.

Like Asus, MSI has some fairly low-key RGB lighting on the PCH heatsink, I/O shroud and underneath the PCB itself, as well as the audio circuitry, but you get a smattering of RGB LED headers too. Both boards also sport a 10-phase CPU power design, along with six fan headers. Interestingly, MSI offers double the power of the ROG Strix Z370-E Gaming’s pump header, though, with up to 2A/24W available, which is enough to power most custom water-cooling pumps.

Combine this feature with an excellent fan control section in the EFI, where you can switch off fans under low heat loads, plus choose from numerous temperature inputs and control pump speed, and the Z370 Gaming Pro Carbon AC punches above its price tag here. All the usual ports are included too, including a USB 3.1 header plus Type-A and Type-C ports on the rear panel, although the Asus board has the bonus of an angled USB 3 header for tidy cable routing.

The two boards are even difficult to separate when it comes to performance. The



## The EFI’s excellent fan control section allows you to switch off fans under low heat loads

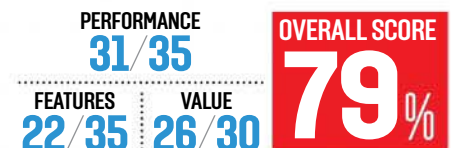
Z370 Gaming Pro Carbon AC gets top marks in the audio testing, topping both dynamic range and noise level results, but the ROG Strix Z370-E Gaming wasn’t far behind. The two were in spitting distance in our RealBench benchmark suite too, with barely 1,000 points separating their system scores at stock speed and when overclocked.

Both boards also managed average results when overclocking too; while they both managed to overclock our Core i7-8700K to 5GHz, each board needed a comparatively high vcore to get there. However, it was the Z370 Gaming Pro Carbon that won here, needing 0.03 volts less and with a much lower power draw.

### Conclusion

In performance terms, there’s very little between any of the boards this month, so if the Z370 Gaming Pro Carbon AC’s looks take your fancy, it’s a great if not standout choice. It competes with Asus’ similarly priced ROG Strix Z370-E on a solid footing too. However,

if you look further afield, the Gigabyte Z370 Aorus Ultra Gaming is £30 cheaper and has a similar feature set, while the Asus ROG Maximus X Hero costs an additional £40, but has tonnes of extras.



### VERDICT

A decent board with solid performance and features, but it doesn’t offer quite enough to stand out in this crowded market.

### /SPECIFICATIONS

**Chipset** Intel Z370

**CPU socket** Intel LGA1151-v2

**Memory support** 4 slots: max 64GB DDR4 (up to 4000MHz)

**Expansion slots** Three 16x PCI-E3, three 1x PCI-E3

**Sound** 8-channel Realtek ALC1220

**Networking** Intel Gigabit LAN, Intel 802.11ac Wi-Fi PCI-E card

**Overclocking** Base clock 98-593MHz, CPU multiplier 8-81x; max voltages: CPU 1.52V, RAM 2.2V

**Ports** 6x SATA 6Gbps (Z370), 2x M.2, 1x USB 3.1 Type-A, 1x USB 3.1 Gen2 Type-C, 4x USB 3.2x USB2, 1x LAN, 5x surround audio out, S/PDIF out.

**Dimensions (mm)** 305x244

MSI Z370 Godlike Gaming / **£530** inc VATSUPPLIER [www.scan.co.uk](http://www.scan.co.uk)

**U**nlike MSI's sub-£200 Z370 Gaming Pro Carbon AC this month, the company's other entrant is hoping your wallet hasn't been on a diet. The Z370 Godlike Gaming costs over £500, but while that's a rather obscene amount of money to spend on a motherboard, there's an awful lot to get excited about. This beastly E-ATX motherboard has every feature you could want from an enthusiast motherboard, outdoing the rest of the field this month in practically every department.

While the MSI Z370 Gaming Pro Carbon AC only has one M.2 heatsink and two M.2 ports, for example, the Z370 Godlike Gaming has three ports, each of which sports a heatsink. The lowest slot is out of the way of motherboard hot spots, and is able to make use of your case's airflow too, resulting in the lowest M.2 temperature on test. If you need more M.2 ports then a 16x PCI-E card with two additional ports is included too.

Other box accessories include a 45cm RGB LED strip, plus extension cables, a USB header hub, thermal probes and some custom-braided SATA cables too. Meanwhile, the PCB is packed with even more features, such as an 18-phase power delivery, on-board Killer Wi-Fi, extra power connectors for the CPU and PCI-E slots, plus the full complement of overclocking and testing tools. It's also a fan control powerhouse, with ten headers, along with a fantastic EFI fan control section. The dedicated pump header offers up to 24W of power, and the Godlike Gaming is also the only board on test this month to offer a U.2 port, although these ports aren't much use anymore.

The rear I/O panel sadly lacks an integrated shield, so the Asus ROG Maximus X Hero scores more points for aesthetics here. However, the Z370 Godlike Gaming offers a full-sized headphone audio jack, seven Type-A USB ports and, interestingly, it has three Killer Gigabit Ethernet ports.

The idea with the latter is that you can connect all three ports to your router or switch to provide three dedicated pipes for games, streaming or watching online content, while also using the on-board Wi-Fi as a wireless access point. Or you could show off and hog some extra ports at your next LAN gaming event. The board looks fantastic too, with some low-key spotlight-style lighting in various different zones, which can be controlled using MSI's Mystic Light software.



A 16x PCI-E card with two additional M.2 ports is included too

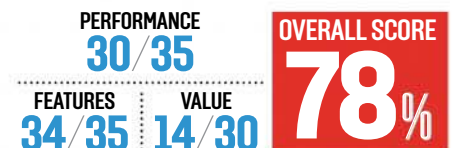
When it came to overclocking, the Z370 Godlike Gaming required just 1.25V to overclock our Core i7-8700K to 5GHz, and there was no need to fiddle with loadline calibration, unlike both Gigabyte boards on test. However, the MSI was quite power-hungry at stock speed, drawing 200W under load, and it also had the highest power draw once overclocked.

We suspect the high power draw was down to an early EFI being used, which might also explain the low stock speed benchmark results in our benchmarks, as once it was overclocked the MSI was on a par with the rest of the field. Storage and audio performance were solid too.

### Conclusion

If we had £500 to spend on a Z370 motherboard, the Z370 Godlike Gaming definitely has the gear to tempt us, especially when it comes to cooling and overclocking. You clearly hit diminishing returns after a certain point, and the Asus Maximus X Hero will cover most people's needs for less than

half the price. However, if you have the money, and you want to build the most feature-rich Coffee Lake system possible, then it's without doubt a fantastic board.



### VERDICT

An extreme Z370 motherboard with a humongous feature list, but also an equally massive price tag.

### / SPECIFICATIONS

**Chipset** Intel Z370

**CPU socket** Intel LGA1151-v2

**Memory support** 4 slots: max 64GB DDR3 (up to 4133MHz)

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

**Sound** 8-channel Realtek ALC1220

**Networking** 3 x Killer Gigabit LAN, Killer 802.11ac Wi-Fi

**Overclocking** Base clock 80-655MHz, CPU multiplier 8-83x; max voltages: CPU 2.155V, RAM 2.2V

**Ports** 6 x SATA 6Gbps (Z370), 1x U.2, 5 x M.2, 1x USB 3.1 Type-A, 1x USB 3.1 Gen 2 Type-C, 6 x USB 3, 3 x LAN, 6 x surround audio out, S/PDIF out.

**Dimensions (mm)** 305 x 272





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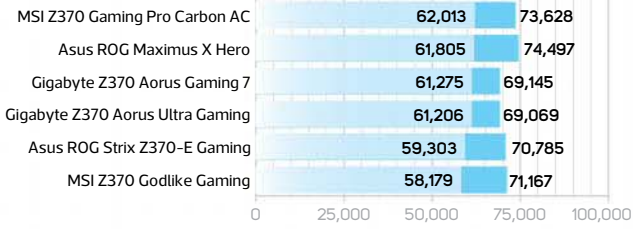
34" UltraWide curved monitor  
349X7FJEW



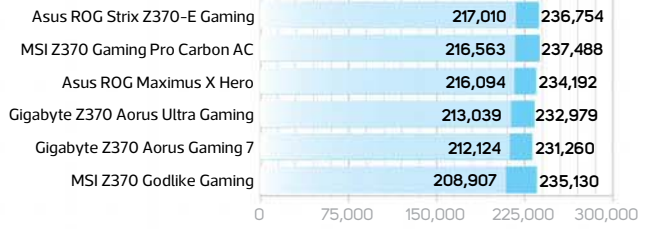
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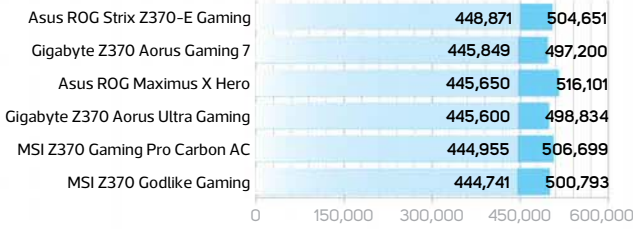
**CPC REALBENCH 2015  
GIMP IMAGE EDITING**



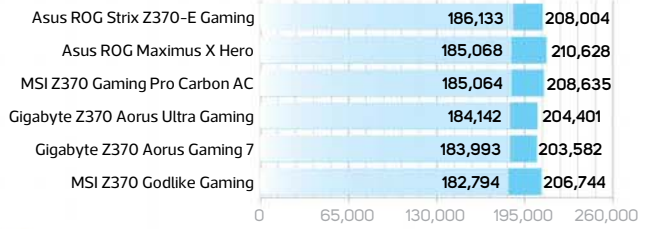
**HEAVY MULTI-TASKING**



**HANDBRAKE H.264 VIDEO ENCODING**



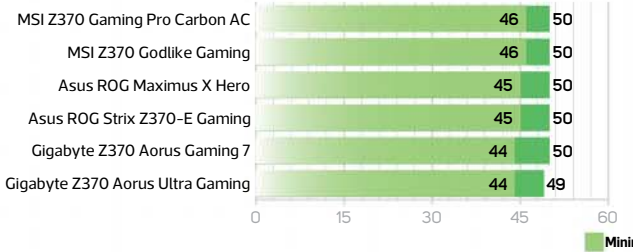
**SYSTEM SCORE**



Stock speed Overclocked

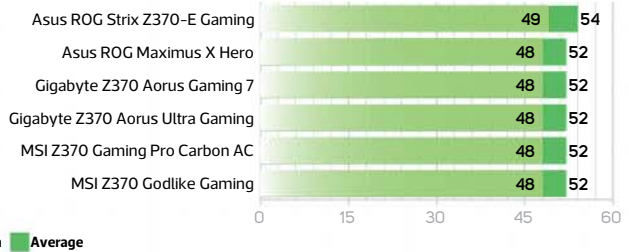
**STOCK SPEED ASHES OF THE SINGULARITY: ESCALATION (FPS)**

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



**OVERCLOCKED ASHES OF THE SINGULARITY: ESCALATION (FPS)**

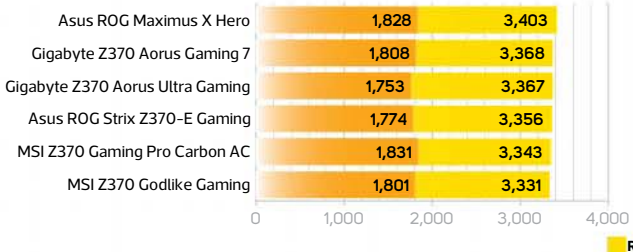
DX12 CPU benchmark, 1,920 x 1,080, High settings



Minimum Average

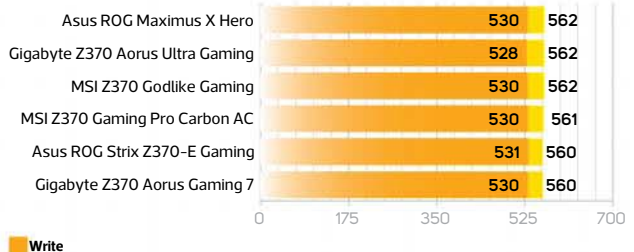
**M.2 SPEED (MB/SEC)**

CrystalDiskMark 32-queue-depth



**SATA 6GBPS SPEED (MB/SEC)**

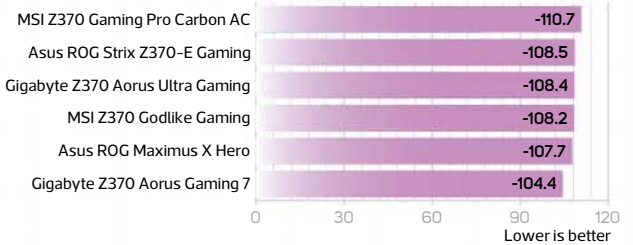
CrystalDiskMark 32-queue-depth



Read Write

**NOISE LEVEL (DBA)**

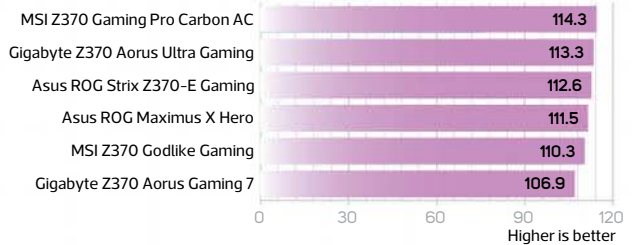
RightMark Audio Analyzer 24-bit, 192KHz



Lower is better

**DYNAMIC RANGE (DBA)**

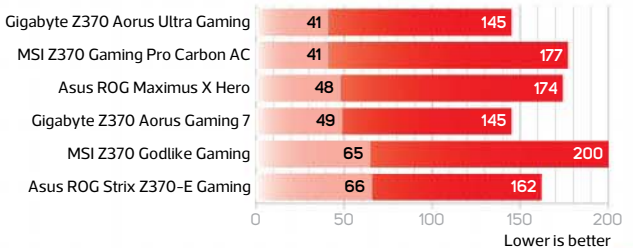
RightMark Audio Analyzer 24-bit, 192KHz



Higher is better

**STOCK SPEED POWER CONSUMPTION (WATTS)**

Windows Desktop / Prime95 smallfft

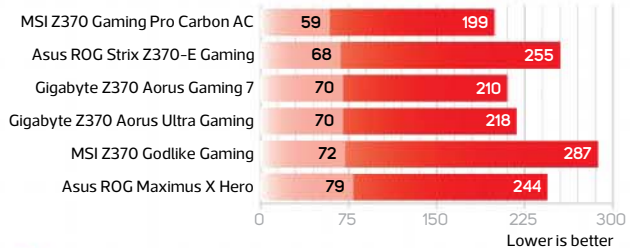


Lower is better

Idle Load

**OVERCLOCKED POWER CONSUMPTION (WATTS)**

Windows Desktop / Prime95 smallfft



Lower is better

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- 2x PowerBOOST
- 16+2 Power Phase
- Spectra LED Lighting



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- 11 GB GDDR5X
- 11.000 MHz Memory (352-bit)
- 3x DP 1.4 & 1x HDMI 2.0b & 1x DL-DVI
- Dual Fan IceStorm Cooling 2 Slots
- FREEZE Fan-Stop Tech
- 2x PowerBOOST
- 16+2 Power Phase
- Spectra LED Lighting



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- Super Compact
- 8.3-inch Length
- Dual Fan IceStorm Cooling 2 Slots
- 8+1 Power Phase
- Spectra LED Lighting



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## LABS TEST

# Another fine mesh

Find the best way to spread the Wi-Fi love with Edward Chester's roundup of the latest whole-home Wi-Fi systems

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## How we test

**A** few years ago, the Wi-Fi router market reached a plateau. With the latest 802.11ac standard, Wi-Fi speeds up-close didn't really need to get any faster for most practical uses. Instead, what matters most for many people now is range and consistency, which is where mesh routers, or whole-home Wi-Fi systems, come in. They use several access points, or nodes, that work together to spread out the Wi-Fi load.

In essence, they're like a network of Wi-Fi extenders but they differ in a couple of crucial ways. For a start, they're generally faster. Each node tends to be at least dual-band and uses multiple spatial streams to provide speeds that would rival a dedicated router.

The second benefit is that, despite using several bits of hardware working together, you don't need to individually name and manage all the different Wi-Fi bands. Instead, the entire network is presented as one continuous whole, and the router and nodes take care of connecting your devices in the fastest way possible.

Beyond these common features, though, these systems offer several different approaches. Some are designed to replace your existing router and completely take over networking duties, while others just take over Wi-Fi duties, piggybacking on an existing network. Some also consist of multiple identical units that can either work as a router or node, while others are specifically designed with a central router

and separate nodes. The best setup for you will largely depend on the layout of your house and the quality of your existing router.

To test the systems, we set them up in a three-storey, semi-detached house, with the main router (or first node) on the ground floor. From here, we tested the maximum Wi-Fi speed of the router on its own from a distance of 2m, as well as checking its Ethernet ports were up to speed. Then we tested again at one location on the middle floor (test 1) and two locations on the top floor (test 2 and test 3) to check for long-range performance. Then a second node was added on the middle floor and the tests repeated, before a final node (most of the kits consist of three nodes) was placed on the top floor and the tests repeated again.

# Asus Lyra / £380 incVAT

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

**T**he Asus Lyra is a powerful and versatile mesh Wi-Fi system that demands a suitably premium price. However, compared with similarly capable systems, it's a bit of a bargain for what you get in the box. It consists of three nodes, each of which has a powerful, tri-band 2x2 Wi-Fi system that can deliver a total of 2,200Mb/sec (400+867+867). Each node also includes two Ethernet ports that can be used to connect wired devices to the extended network.

Whichever node you choose to be the primary one that plugs into your modem or existing router, one of its Ethernet ports will have to be given over to this task and the system will automatically work out that it's being used for this purpose.

In theory, it should also be possible for Asus to add a wired backhaul feature. This is where, instead of the various nodes of the network connecting via Wi-Fi, they can be connected by Ethernet. It's great if you have a building such as a garage that's a fair distance from your house. You can lay a cable out to that building – using other technologies such as powerline networking, if need be – connect up a node and end up with a seamless single-network. However, Asus hasn't yet enabled this feature.

Another missing feature is USB, so you can't share hard drives or printers. It's a common feature on most normal routers, but it's been omitted on nearly all these mesh systems.

In terms of design, each node is a reasonably attractive circular device that measures 148 x 41 x 148mm (W x D x H) and has a simple matt white finish. The top appears uniform, but underneath you'll find a single RGB light that glows through to the top in a spotted pattern that covers the whole top surface. The light is useful for setup, and it looks good, but it can also be turned off.



## In theory, it should also be possible for Asus to add a wired backhaul feature

The nodes can be laid flat on their five little rubber feet, or wall-mounted using a couple of standard plastic sockets that clip over a screw head. As for other features, you get a reset button and a pairing button that's used to connect a new node, or reconnect existing ones that may have lost their connection.

Setup, as with most of these systems, is performed via an app, and although it suffers from a few too many translation errors, it's very easy to use. There's no signup required, no extraneous confirmation screens and generally no faffing. It just gives you clear instructions of what to plug in where, what lights to look for and what to do next.

Once the system has been set up, the app offers the same basic options as most other mesh systems. You can change the Wi-Fi name, add a new node, see a network map and check which devices are connected. A couple of features that some other rival

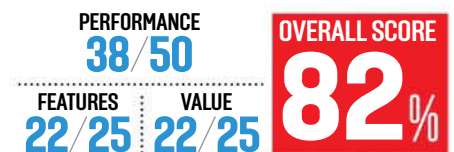
systems don't offer, though, are a guest network and basic parental control.

In terms of speed, the Lyra is fast up-close, but not class-leading. We can't push our test setup much beyond 500Mb/sec due to the receiver being used. The Lyra's 463Mb/sec peak doesn't push that limit but it's still fast.

Meanwhile, at long range, the Lyra comfortably beats the Google Wifi and trades blows with the BT system, both as a single unit, and when two and three nodes are used. However, it can't reach the speeds of the fastest devices on test, which is a little disappointing considering its price and the hardware that's inside each node.

### Conclusion

The Asus Lyra is a powerful mesh Wi-Fi system with great potential. However, its raw speed doesn't quite match up to expectations, and it doesn't have the features to compete with the other systems that demand such a high price. If Asus can improve its performance and add in wired backhaul, it will be a great, lower-priced alternative to the Linksys Velop, but at the moment, it's up against some tough competition.



### VERDICT

The Asus Lyra should, on paper, be a bargain considering its powerful hardware. However, its performance doesn't quite live up to expectations.



## BT Whole Home Wi-Fi / £200 inc VAT

SUPPLIER [www.currys.co.uk](http://www.currys.co.uk)

**B**T's Whole Home Wi-Fi kit is the cheapest system on test, but don't for a minute think that the low price is an indicator of low capabilities. While it isn't the fastest or most feature-rich kit on test, it provides solid performance for a great price. Just how low is its price? Well, at £200 inc VAT, the next cheapest system on test is the Google Wifi, which costs £230. However, the latter is a two-node system compared with the BT Whole Home Wi-Fi's three nodes. Nearly all the other three-node systems cost well over £300.

That cost-cutting has some limitations though. The Whole Home Wi-Fi kit is an extension system only, which must be used with an existing router, so you can't replace your whole router setup with it. If you already have a decent router, though, it's a great low-cost system for spreading Wi-Fi around your house.

You also miss out on any significant extras. There are no USB ports, there's just one Ethernet port on each node and there are no particularly clever software options, although wired backhaul is at least supported. Incidentally, all these extension systems allow you to add a network switch to the extended network, so you can still connect all your gear if you have lots of wired devices in one area.

The nodes themselves are all identical pearlescent white plastic discs that have a small BT logo in the centre. They're designed primarily to stand up on their built-in metal stands. However, if you do stand them up, the cables can sometimes be springy enough to pull the disc around and knock it over, which can get irritating.

Alternatively, you can wall-mount them via a single screw mount. If you do so, the non-removable stand makes the disc stick out at an odd angle, which seems strange at first, but it allows enough room for cables to plug into the node round the back. On the back of each node you'll also find buttons for power, reset and WPS, plus there's a really neat addition that's become a bit of a BT signature. A removable plastic tab has the default Wi-Fi settings and admin password on it, making it quick and easy to check these details once the node has been installed.

Setup of the Whole Home is really easy. BT's app is simple and straightforward and, because there are so few extra features here, it's also a quick process. Once the Whole Home has been set up, the app shows you which nodes are online, which devices are connected to them and the condition of their connection to the overall network.

You can also change the network name, adjust the brightness of the disc's LED, add another disc, change the admin password and pause Wi-Fi access. There are no parental controls, and there's no guest network option either – the Whole Home is as simple as it gets when it comes to home networking.

But while it may be simple, the Whole Home works superbly. Inside each disc is a powerful, dual-band 4x4 Wi-Fi setup that allows for up to AC2533 speeds (1733 + 800Mb/sec).

It didn't set any records from close range, although it did hold its own. It's not all that great if you use just one disc either. However, once you add in a second and third disc, this system is superb. It regularly sat mid-table with two discs set up, and on average, it was the fastest three-node system on test – a fantastic result for this price.

### Conclusion

The BT Whole Home Wi-Fi is the cheapest and simplest kit on test, but thanks to excellent performance and easy setup, it's a clear winner if you can't run to a full system that includes a router. If you don't need to replace your router and are looking for a solid way to get full-home Wi-Fi coverage for a reasonable price, the BT Whole Home Wi-Fi is easily your best option.



PERFORMANCE  
**44/50**

FEATURES  
**18/25**

VALUE  
**25/25**

OVERALL SCORE  
**87%**

### VERDICT

BT's aggressive pricing for its three-node Wi-Fi kit makes it the outstanding bargain of this group test.

# Google Wifi / £230 inc VAT

SUPPLIER [www.johnlewis.co.uk](http://www.johnlewis.co.uk)

**T**he Google Wifi is arguably the most well-known whole home Wi-Fi kit. The sheer clout of Google has put it front and centre of this new wave of products. However, fame doesn't necessarily equate to quality. Unlike most of the other mesh routers on test this month, Google is actively pushing the Google Wifi as a possible standalone router if you buy just a single unit. While all but the BT Whole Home can also function in this way, most of those companies are pushing their products as kits containing several units.

However, we advise you to dismiss this idea straightaway. While it's perfectly competent and powerful enough on its own to work as a basic router, the Google Wifi really doesn't make much sense as a standalone router. It lacks features, it's not that fast and at £129 inc VAT, it doesn't offer particularly good value for money for what's on offer either. Its ease of setup and app interface makes it a little tempting, but you can basically get a better standalone router for less money elsewhere.

Instead, it's the two-node kit priced at £229 inc VAT that will be the first Google Wifi kit you should realistically consider. This price makes it one of the cheapest mesh systems you can buy, in turn making the system far more tempting.

Each Google Wifi node consists of an impressively small, near-cylindrical white puck that's bisected by an RGB ring of light.



## Underneath you'll find a Type-C power socket and a couple of Gigabit Ethernet ports

Arguably, they're the most attractive-looking nodes of all the kits on test. They're featureless on the outside, aside from a subtle reset button on the back, and underneath you'll find a Type-C power socket and a couple of Gigabit Ethernet ports. Unlike the Lyra, these ports are pre-designated for use either as an internet input or for other wired devices. Wired backhaul is also supported, but only via a slightly convoluted setup procedure that Google doesn't explain.

On the downside, if you really don't want them visible on your desk, kitchen work surface or dresser top – no matter how smart they look – you'll be disappointed to learn they're not wall-mountable.

Setting up the Google Wifi was a little more clunky than expected too. It didn't help that our review kit arrived from another publication, so had to be hardware reset – you won't have to do the same with a new kit, but if you ever do have to perform a hardware reset, it's a process that proved rather unintuitive. The app is also a little too finicky, and you have to create an account to get the kit up and running.

That said, overall, it's a straightforward process; it's just that the likes of the Lyra and BT Whole Home are even quicker and easier to set up, and don't require a signup either. The app is also one of the more capable ones available, with options for parental control,

timed access and guest Wi-Fi. However, the Google Wifi does report back to Google on occasion about the status of your network. It doesn't send information about what you've been viewing, but anyone keen on absolute digital privacy may well want to avoid the Google Wifi for this reason.

As for performance, as mentioned, a single unit is nothing special. Up-close, it was the second fastest kit on test, but at a distance, it was consistently last. What's more, while speeds jumped up noticeably when the second node was added, the performance was still a long way behind all the other kits tested. You'll get a signal that's reliable and fast enough for most uses, but other kits offer considerably better performance at longer ranges. That's great surprise, as the internal hardware is indeed slower than the rest of the kits on test, with just a dual-band 2x2 setup for maximum speeds of AC1200 (800 + 400Mb/sec).

### Conclusion

The Google Wifi may be the most famous example of a mesh Wi-Fi router system, and thanks to a relatively low price, easy setup and adequate performance, it does enough to be worth considering. However, its raw performance is well behind the competition, which severely dents its appeal.

#### PERFORMANCE

35/50

#### FEATURES

20/25

#### VALUE

23/25

#### OVERALL SCORE

78%

#### VERDICT

Easy setup and a good price, but a lack of raw speed severely dents the appeal of the Google Wifi.



# Linksys Velop / £459 inc VAT

SUPPLIER: [www.currys.co.uk](http://www.currys.co.uk)

**T**he Linksys Velop is the most versatile Wi-Fi system on test. Each node can function as a router or an access point, and the system supports wired backhaul as well. So with this three-node system, you could, for instance, set up one node as the router, one node as a Wi-Fi extension in the house and one node as a wired extension out in the garage.

As well as being versatile, the Velop is also powerful, with each node packing a tri-band AC2533 Wi-Fi System into its chassis. This raw power puts it on a par with the Asus Lyra – in fact the two systems are all but identical in terms of features – and only behind the Netgear Orbi in terms of sheer Wi-Fi oomph.

What's more, unlike the Lyra, this power is reflected in our tests, with the Velop actually topping our short-range test and the single-node long-range test. It falls behind the Netgear Orbi in the two and three-node tests, but still comes out comfortably in second place overall. Each node also includes two Ethernet ports, which can be used either to attach the node to a router/modem or wired extension, or for adding wired client devices to the extended wireless network.

All told, this setup makes the Linksys Velop ideal for people seeking power and versatility, particularly for anyone with large sprawling homes with outhouses or other distant buildings. Unfortunately, it also makes the Velop expensive. This three-node kit can sometimes be found for under £400 inc VAT, but in most places, it's currently listed for over £450. Two-node kits cost £350 inc VAT and a single-node will set you back £230 inc VAT.

For that level of outlay, the Velop really should be blowing the competition away, and while it's definitely impressive, it's not perfect. For a start, there's the fact that the Netgear Orbi has a comfortable lead when it comes to sheer speed.

Then there's the units themselves. While they're attractive and well made, they miss out on a wall-mounting option – you can buy wall mounts separately, but that just adds further to the cost.



There are also no USB ports at all (not that the USB ports on the Orbi do much that's useful, but at least the potential is there), and you're only getting two Ethernet ports per node. Against most of the mesh systems on test, the Velop is on a par, but it does it for a high cost, and there are alternatives that offer more in some areas.

Another downside to the Velop system is that setup, while simple and intuitive thanks to a slick app, is slow and tedious and requires signing up to a Linksys account.

Setting up each node requires you to plod through far more steps than seems necessary, and when you're finally done with them all, the system starts an automatic update.

Many other systems offer automatic updates too, but don't set one off the moment you've finished setting up the system. In all, it takes 30–45 minutes to get the Linksys Velop kit up and running, compared to less than ten minutes for most of the other kits on test this month. Otherwise, though, the Linksys app is great, offering

a built-in speed test, parental controls, a guest network and device prioritisation.

Nonetheless, the Linksys Velop feels like it's aimed too high in terms of price premium, and not quite delivered on its promise. Aside from the wired backhaul feature, there's no specific feature you only get with the Velop that really feels like it justifies paying so much more than other systems.

## Conclusion

The Linksys Velop is a seriously powerful and versatile mesh network system, and it's made particularly tempting thanks to its wired backhaul feature and powerful tri-band Wi-Fi. However, its high price makes it hard to recommend in this increasingly competitive market segment. The Velop is good, but the Orbi is faster and other mesh systems offer most of the same features for less money.

PERFORMANCE

45/50

FEATURES

21/25

VALUE

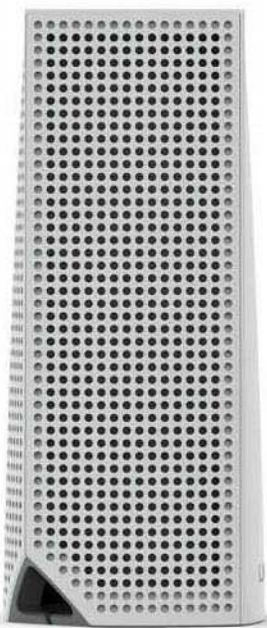
18/25

OVERALL SCORE

84%

## VERDICT

Great if you need wired backhaul, but other mesh systems offer most of the same features for less money.





# Netgear Orbi (RBK50) / £323 incVAT



SUPPLIER [www.currys.co.uk](http://www.currys.co.uk)

**T**he Netgear Orbi (RBK50) was the first big-name mesh-style router to hit the market, and it rightly made quite a splash. We'd simply never seen its sheer speed and range before and, even now, we haven't seen it since.

Available in a variety of kits, the original and best setup is the RBK50 kit that consists of a router and hub. You can add further hubs to this kit, but they're not all that readily available, so if you do think you might need more, you'll be better off taking the plunge and buying the RBK53 kit, which include two hubs. Alternatively, you could instead consider going with a system where it's easier to buy individual nodes one at a time.

The secret to the Orbi's speed is a dedicated 4x4 5GHz band, which is used for wireless backhaul. It provides a total throughput of 1.7Gb/sec between the router and its hub, where most other kits make do with connections half that speed. In fact, this month's test results really demonstrate the difference, showing the Orbi to be well in front of all its competitors. There are several other 4x4 routers available, of course, but no client devices are able to connect at such speeds. Using this technology as a backbone for the system as a whole appears to be a very sensible approach.

Just how fast are we talking? Well, with just the router and no hub, the Orbi surprisingly loses out to a single Linksys Velop, but it's still the second fastest single router option overall. However, add in the hub and the Orbi is streets ahead of the competition, being comfortably faster than the Velop and more than double the speed of all the other systems on test.

That's a lead that holds when the other systems use three nodes too. As such, if you live in any home smaller than a three-storey terraced/semi-detached house, then this two-node setup is the clear choice if speed is important to you. You only need to consider larger mesh systems if your house's area is particularly sprawling.

Incidentally, if you do add a second or third



node to the Orbi system, the advantage of its dedicated band diminishes, as it has to share the band across multiple hubs. In this regard, if you're specifically after a multi-node system with three or more units then you may be better off investing in one of the systems that has a cheaper cost per node, as the benefit of the Orbi diminishes as you add more nodes. Netgear does also offer cheaper Orbi systems with lower bandwidth, but we've yet to test them.

There's a couple of other reasons why the Orbi RBK50 is so appealing though. The first is that it's relatively feature-rich. Both the router

and hub each have four gigabit Ethernet ports, meaning power users don't have to faff around buying extra switches to accommodate all their wired devices.

What really would have been the icing on the cake is that each also includes a USB 2 port, and Netgear has suggested they could be used for sharing printers and files. However, Netgear still hasn't enabled these features

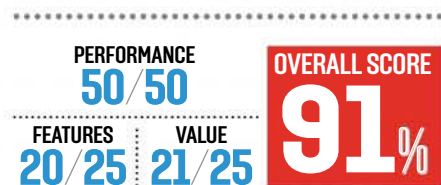
and shows no signs of doing so, which is a shame. You also miss out on wall mounting.

However, the Orbi does have one last hurrah, which is that it doesn't require an app or signup to set up. You can download an app if you want, but you can also just navigate to the router's web interface and set it up like a normal router.

## Conclusion

The Netgear Orbi blew us away when it first launched, and its sheer Wi-Fi speed continues to blitz every other mesh router system we've tested.

As such, for power users who want speed and function, as well as range, it's the one to get. For less demanding users, particularly if you have a very large house, or if you already have a quality router, other systems may offer better value for money, but for everyone else, the Orbi RBK50 is as good as it gets.

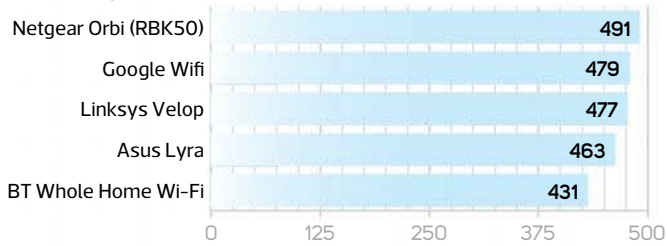


## VERDICT

For sheer performance, the Orbi remains the mesh router to beat.

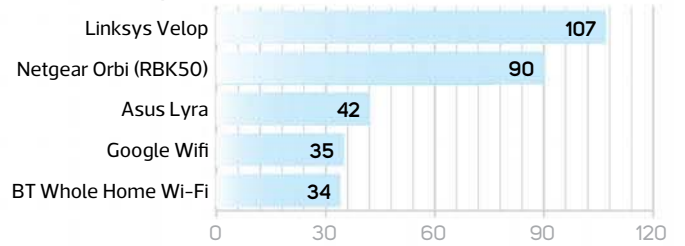
**WI-FI SPEED WITH ONE NODE (MBIT/SEC)**

2m line of sight



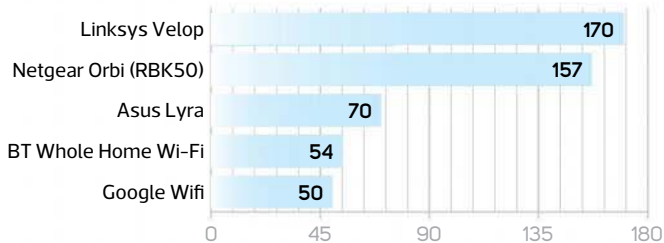
**WI-FI SPEED WITH ONE NODE (MBIT/SEC)**

Test 2 location (top floor)



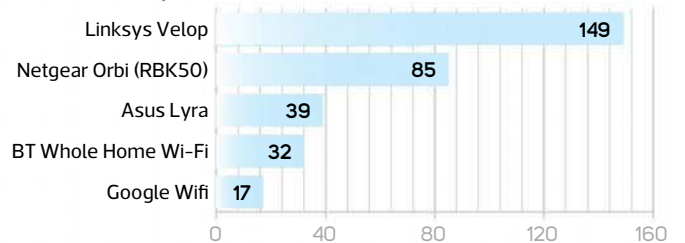
**WI-FI SPEED WITH ONE NODE (MBIT/SEC)**

Test 1 location (middle floor)



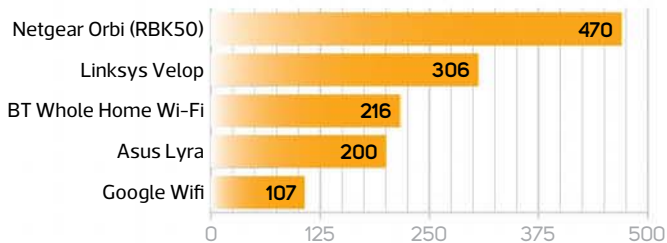
**WI-FI SPEED WITH ONE NODE (MBIT/SEC)**

Test 3 location (top floor)



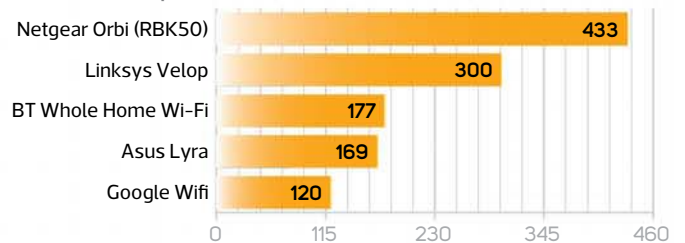
**WI-FI SPEED WITH TWO NODES (MBIT/SEC)**

Test 1 location (middle floor)



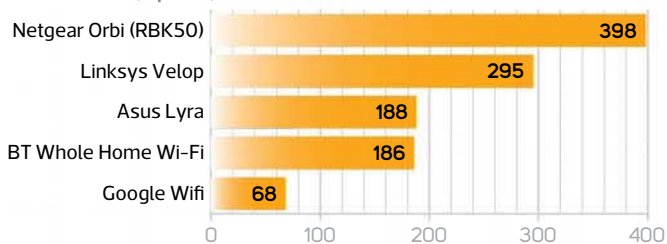
**WI-FI SPEED WITH TWO NODES (MBIT/SEC)**

Test 2 location (top floor)



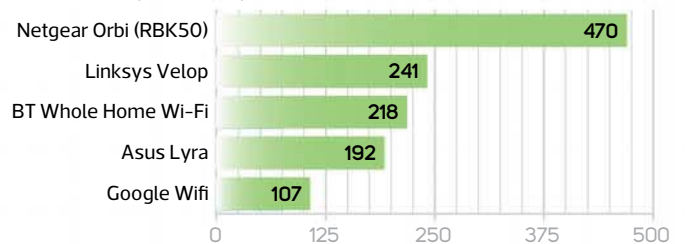
**WI-FI SPEED WITH TWO NODES (MBIT/SEC)**

Test 3 location (top floor)



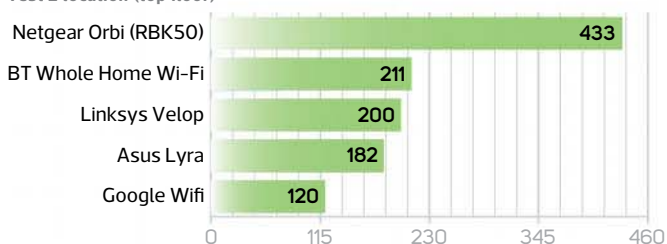
**WI-FI SPEED WITH THREE NODES (MBIT/SEC)**

Test 1 location (middle floor)



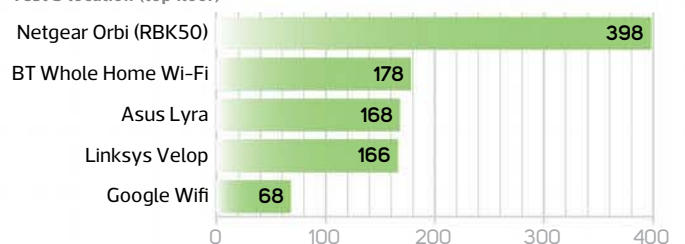
**WI-FI SPEED WITH THREE NODES (MBIT/SEC)**

Test 2 location (top floor)



**WI-FI SPEED WITH THREE NODES (MBIT/SEC)**

Test 3 location (top floor)



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Tatiana, 8 September

# PC system reviews

## GAMING PC

### PC Specialist Ultima X01 / £1,479 inc VAT

SUPPLIER [www.pcspecialist.co.uk](http://www.pcspecialist.co.uk)

Intel's Coffee Lake architecture promised more cores, more cache and higher Turbo frequencies, and the new 14nm parts have delivered in both single- and multi-threaded scenarios. PC Specialist is one of the first system builders to submit a Coffee Lake machine for review and, surprisingly, it costs just £1,479 inc VAT.

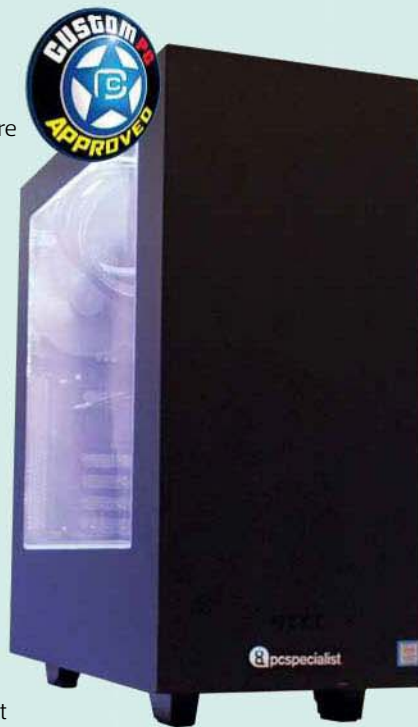
The Ultima X01 is powered by the Core i7-8700K – the beefiest new Coffee Lake component. It isn't overclocked, and the new chip's base clock of 3.7GHz is lower than that of the older Core i7-7700K chip, but in Turbo mode, the i7-8700K can hit 4.7GHz on one core and 4.3GHz across all six of its cores. Comparatively, the 7700K could only hit 4.5GHz on one core and 4.4GHz across four cores.

The 8700K's six cores can execute 12 threads simultaneously, thanks to Hyper-Threading, and it has 12MB of L3 cache too. The new chip requires more power than Kaby Lake, though, so it needs a revised version of the LGA1151 socket – and that means a new Z370 chipset and new motherboards.

PC Specialist has used an Asus Prime Z370-P. It's a solid ATX board with mainstream features, but you won't find any on-board displays or power, reset and OC buttons.

It does have two M.2 slots, two vacant DIMM slots and loads of free 1x PCI-E slots for expansion, but its second 16x PCI-E slot runs at a peak of just 4x speed, and there's no SLI support. The backplate has four USB 3.1 sockets, but no Type-C connector and only three audio jacks. This board isn't exactly swimming in features, but we don't expect a premium enthusiast board in a relatively affordable system. It will be fine for most people's needs.

There's also 16GB of Corsair Vengeance RGB memory clocked to 3000MHz, which is great, and the 256GB Western Digital Black SSD sits alongside a 1TB hard disk. The storage options aren't the fastest or the most capacious, but they're sensible choices at this price.



The PSU is solid, too – it's a semi-modular Corsair model with 80 Plus Gold certification.

You get a decent GPU in this sub-£1,500 rig too. The GTX 1080 has 8GB of GDDR5X memory and 2,048 stream processors, but the Palit-made card runs the GPU core at its stock speed of 1607MHz.

PC Specialist has screwed its components inside an NZXT S340 case. It's one of the most popular affordable enclosures around, thanks to its superb build quality and subtle design. The front panel is made from matt metal, and there's a blue ring around the front to provide a little colour. The front fan mounts are occupied by a Corsair Hydro cooler with 120mm fans and there's a single

120mm exhaust – a fine cooling setup for

stock-speed LGA1151 i7 hardware.

The PSU and hard disk are hidden beneath a metal shroud, which also houses a spare hard disk bay and two empty 2.5in SSD mounts, and the build is neat; the cables are coated with a discreet black finish, and they're routed neatly behind the raised blue shroud in the middle of the case. Meanwhile, white strip lights illuminate the interior from the front panel and the roof.

Finally, the Ultima is covered by a three-year labour warranty, although there's only a year of parts coverage, and just one month of collect and return service. It isn't a terrible deal at this price, but we'd prefer another year of parts cover.

### Performance

The Coffee Lake processor isn't overclocked, but Intel's revised 6-core chip returned a superb set of results – even when compared with an overclocked Core i7-7700K. The Box Cube Spartacus Nvidia Edition we reviewed overclocked the 7700K to 4.8GHz, but the i7-8700K's improved Turbo speeds helped it to equal the i7-7700K's result in our image editing test, which relies on single-core speed, and its video encoding score of 486,466 was more than 150,000 points ahead, thanks to these extra cores.

The stock-speed i7-8700K beat the overclocked i7-7700K in the multi-tasking test too, and its overall score of 198,969 was more than 40,000 points better. The i7-8700K's results were also quicker than AMD's Ryzen 7

### /SPECIFICATIONS

**CPU** 3.7GHz Intel Core i7-8700K

**Motherboard** Asus Prime Z370-P

**Memory** 16GB Corsair Vengeance RGB 3000MHz DDR4

**Graphics** Palit GeForce GTX 1080 8GB

**Storage** 256GB Western Digital Black M.2 SSD; 1TB Western Digital Black hard drive

**Case** NZXT S340

**Cooling** CPU: Corsair Hydro H100i V2 with 2x 120mm fans; GPU: 2x 80mm; rear: 1x 120mm

**PSU** Corsair TX650M 650W

**Ports** Front: 2x USB 3, 2x audio; rear: 4x USB 3.1, 2x USB 2, 1x Gigabit Ethernet, 1x PS/2, 3x audio

**Operating system** Microsoft Windows 10 Home 64-bit

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

- 1**  
**A dual-120mm Corsair Hydro unit easily tames the stock-speed CPU**
- 2**  
**You even get a Palit GeForce GTX 1080 graphics card in this sub-£1,500 rig**
- 3**  
**A 256GB PCI-E WD Black SSD sits in an M.2 slot at the bottom of the board**

chips, with large gains made in image editing and multi-tasking, and similar performance levels in video encoding. Even at stock speed, this Core i7-9700K machine outpaced the tweaked i7-7700K in every department and beat AMD's Ryzen 7 in most tests.

Meanwhile, the GTX 1080 handled 1080p and 2,560 x 1,440 gaming tests without breaking a sweat, and it ran games at 4K too – although its minimums of 26fps and 27fps in Fallout 4 and Deus Ex are a little close to the edge. Then there's the Western Digital Black SSD, which returned read and write scores of 1776MB/sec and 662MB/sec. Neither of those speeds match Samsung's best drives, but they're adequate and still a good step up from your average SATA SSD.

The PC Specialist's thermal performance was decent too. The CPU and GPU delta Ts of 58°C and 59°C are fine, and the system was near-silent when idling. At peak load, it was quieter than most other gaming systems too, no doubt helped by the stock-speed components and dual 120mm Corsair H100i V2 liquid cooler on the CPU.

### Conclusion

The Ultima X01 doesn't have flashy features or even overclocking, but it does have loads of power, a good build and a keen price. The debuting i7-8700K offers more power than its predecessor, and the graphics card, SSD and power supply are solid. The motherboard is basic, but you can't



expect a premium enthusiast motherboard in a 6-core machine at this price. With solid performance for the money in every area, particularly in heavily multi-threaded software, the Ultima X01 offers great value, even without an overclock.

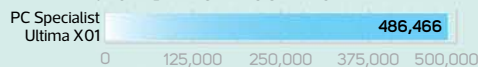
MIKE JENNINGS

#### CPC REALBENCH 2015

##### GIMP IMAGE EDITING



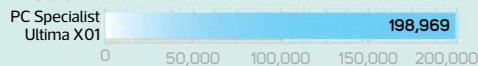
##### HANDBRAKE H.264 VIDEO ENCODING



##### HEAVY MULTITASKING



##### SYSTEM SCORE



INTEL REFERENCE: 173.84%

SPEED  
22/25

DESIGN  
22/25

HARDWARE  
21/25

VALUE  
23/25

OVERALL SCORE  
**88%**

#### VERDICT

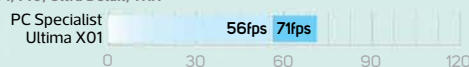
Impressive speed from Intel Coffee Lake arrives alongside solid components, a good-quality build and a surprisingly low price.

#### FALLOUT 4

1,920 x 1,080, Ultra Detail, TAA



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

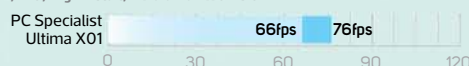


#### THE WITCHER 3: WILD HUNT

1,920 x 1,080, High Detail, Nvidia HairWorks off



2,560 x 1,440, High Detail, Nvidia HairWorks off

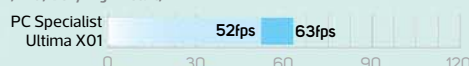


#### DEUS EX: MANKIND DIVIDED

1,920 x 1,080, Very High Detail, DX11



2,560 x 1,440, Very High Detail, DX11



Minimum Average

GAMING PC

CCL NebulaX / £1,599 inc VAT

SUPPLIER [www.cclonline.com](http://www.cclonline.com)

**C**CL's NebulaX is one of the most unusual small form factor rigs we've seen. It uses Phanteks' Enthoo Evolv Shift case, which takes the mini-ITX form factor to new heights. It's as tall as a typical ATX case, but it measures just 170mm wide and 274mm deep. The narrow tower positions its mini-ITX motherboard at the top of the chassis, with the ports facing upwards and accessible behind the spring-loaded roof.

At the front of the motherboard there's room for a low-profile Be Quiet! cooler, and at the back there's space for a full-length graphics card, which is connected to the motherboard with a bracket and PCI-E extension lead. Meanwhile, an SFX Corsair SF600 PSU sits at the bottom of the rig, and both side panels are made from tempered glass, and can be removed easily with thumbscrews; the interior is easy to access from any angle.

The Shift sits on small feet that allow air to reach the 120mm intake fan, and CCL's tidy build means that the cool air has a clear route through to the components. There's another intake fan on the side, and the top half of the machine has two free 2.5in drive mounts.

The Evolv Shift isn't the smallest mini-ITX case, but it's one of the best-looking ones. CCL has done its part too. The power cables are individually braided, and the top and bottom of the machine are ringed with RGB LEDs set to glow white, which illuminates the interior without proving distracting.

Meanwhile, the MSI-made GTX 1070 card mimics Nvidia's Founders Edition design with a single fan, and it has a small overclock. The GPU core's original speed of 1506MHz has been upped to 1,531MHz, which means the boost clock rises from 1683MHz to 1721MHz.

The mid-range price and small form factor precludes CCL from installing a high-end, overclocked processor, but it's the first small form factor machine we've reviewed with an AMD Ryzen CPU. The Ryzen 5 1600 is a fine chip. It has six cores, six more threads via SMT and its base speed of 3.2GHz can hit a turbo peak of 3.7GHz.

There's plenty of power to handle gaming and everyday computing tasks, and it has more multi-threaded grunt than your average quad-core CPU too.



The Gigabyte GA-AB350N-Gaming WIFI motherboard is another sensible choice. It's a mini-ITX board, so it has the usual dearth of expansion room, but it has programmable RGB LEDs, beefed-up audio gear and 802.11ac Wi-Fi. It uses the AMD B350 chipset, which supports overclocking and has support for plenty of USB and SATA ports. It isn't AMD's top Ryzen chipset, but the X370 chipset only really adds extra SATA ports and SLI support, and neither feature is necessary in a mini-ITX machine.

There's also 16GB of 3000MHz DDR4 memory and a fast 500GB Samsung 960 Evo SSD, which will give you loads of room for installing Windows, software and

plenty of games. The 4TB Seagate hard drive is a great inclusion too, being larger than the drives we see in most full-sized gaming systems.

CCL's machine has superb mini-ITX design, a solid mid-range specification and a fantastic three-year collect and return warranty, which covers both parts and labour for the duration. However, this small build has a relatively large price. This month's PC Specialist system (see p60) isn't a small form factor rig, but its £1,479 price includes an Intel Core i7-8700K and a GTX 1080. The CCL's higher price is down to its improved storage, miniature design and more expensive case, but it's still pricey for a Ryzen 5 1600 machine with a GTX 1070.

**Performance**

The overclocked GTX 1070 is a good mid-range card, although it can't quite handle gaming at 4K. Its results at 1080p and 2,560 x 1,440 were fine though. The Witcher 3 results were lower than expected, as this game doesn't always play happily with Ryzen systems, but the minimums of 34-35fps are playable. This month's PC Specialist rig was quicker, though, with 2,560 x 1,440 minimums of 52fps or better.

The stock-speed Ryzen chip returned solid results, however, with an impressive score of 352,039 in the video encoding test, clearly demonstrating that this 6-core chip excels in multi-threaded tasks, even when it isn't overclocked. Again, though, this month's Coffee Lake-based PC Specialist machine is quicker in most tests, with its system score of 198,969 outpacing the CCL's 141,773.

Where the CCL beats the PC Specialist, though, is with its storage system. We have no qualms with the SSD's read and write results of 3,364MB/sec and 1,648MB/sec. The

**/SPECIFICATIONS**

**CPU** 3.2GHz AMD Ryzen 5 1600

**Motherboard** Gigabyte GA-AB350N-Gaming WIFI

**Memory** 16GB Kingston HyperX Predator 3000MHz DDR4

**Graphics** MSI GeForce GTX 1070 8GB

**Storage** 500GB Samsung 960 Evo M.2 SSD, 4TB Seagate Barracuda hard drive

**Case** Phanteks Enthoo Evolv Shift

**Cooling** CPU: Be Quiet! Shadow Rock LP with 1200 fan; GPU: 1 x 70mm; front: 2 x 120mm fans

**PSU** Corsair SF600 600W

**Ports** Front: 2 x USB 3, 2 x audio; rear: 6 x USB 3.1, 2 x USB 2, 1 x Gigabit Ethernet, 1 x PS/2, 6 x audio

**Operating system** Microsoft Windows 10 Home 64-bit

**Warranty** Three years parts and labour collect and return

1

**CCL's tidy build means the cool air has a clear route to the components**

2

**A low-profile Be Quiet! cooler keeps the CPU cool and the system quiet**

3

**An SFX Corsair SF600 power supply sits at the bottom of the rig**

CCL machine impressed in thermal tests, too: the CPU and GPU delta Ts of 49°C and 59°C are great, and the machine remained quiet even during stress tests – quieter than most gaming PCs manage even when they're running idle.

### Conclusion

The CCL NebulaX is one of the best-built and best-looking mini-ITX systems we've seen. The tall Phanteks case makes a statement, and CCL has done a great job with keeping the rig tidy and well-lit. The build is cool, quiet and easily accessible too.

The processor and graphics card have ample power for single-screen gaming at 1080p and 2,560 x 1,440, as well as work tasks and general computing, the motherboard is a solid mini-ITX part, and the storage and memory are both fast and capacious. The only complaint is the price. This machine is much pricier than the core specs suggest, and it's even a little more expensive than this month's ATX Coffee Lake system from PC Specialist.

The extra budget gets you fast memory, a quicker SSD and loads of storage space inside a small, high-quality build, but faster performance can be found for less money if you forego the CCL's small stature and a few of the premium extras. If you do want a small rig, though, the CCL is a superb choice. It looks great, has a well-balanced spec, and it's cool and quiet. It's one of the best mini-ITX builds we've seen.

MIKE JENNINGS



#### CPC REALBENCH 2015

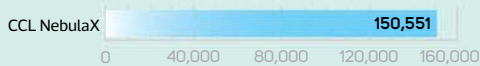
##### GIMP IMAGE EDITING



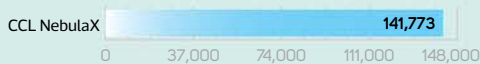
##### HANDBRAKE H.264 VIDEO ENCODING



##### HEAVY MULTITASKING



##### SYSTEM SCORE



SPEED  
20/25

DESIGN  
24/25

HARDWARE  
23/25

VALUE  
20/25

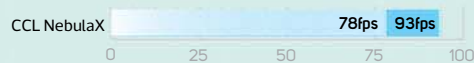
OVERALL SCORE  
**87%**

#### VERDICT

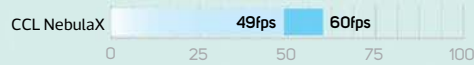
A high-quality mini-ITX rig in every department, although it's a little expensive for the core spec.

#### FALLOUT 4

1,920 x 1,080, Ultra Detail, TAA



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



#### THE WITCHER 3: WILD HUNT

1,920 x 1,080, High Detail, Nvidia HairWorks off



2,560 x 1,440, High Detail, Nvidia HairWorks off

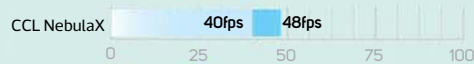


#### DEUS EX: MANKIND DIVIDED

1,920 x 1,080, Very High Detail, DX11



2,560 x 1,440, Very High Detail, DX11



Minimum Average

## GAMING PC

## Scan 3XS Vengeance Aura SLI / £3,799 inc VAT

SUPPLIER [www.scan.co.uk](http://www.scan.co.uk)

**S**can's 3XS Vengeance Aura SLI is a statement of intent. It uses Intel's new 6-core Coffee Lake Core i7-8700K (see p20), and Scan has overclocked this 3.7GHz chip to a mammoth 5GHz. That's one of the best overclocks we've seen on any Core i7 PC over the past couple of years, with older chips generally peaking with overclocks of 4.8GHz or lower.

The new silicon sits inside an Asus ROG Strix Z370-F Gaming motherboard. It's based on the new Z370 chipset because it's a requirement of Coffee Lake, but not much has changed in that department – it's a Z270 refresh that's designed to work with the increased power demands of Coffee Lake CPUs. It's all good though. The board sports RGB LEDs, good-looking heatsinks and plenty of features. It also has a spare M.2 slot, Asus SupremeFX audio, USB 3.1 Type-C on the backplate and two spare memory slots.

With six cores running at 5GHz, this machine can handle both games and heavily multithreaded software, and Scan has filled out the rest of the specification with both areas in mind. There's 32GB of DDR4 memory for productivity software, and storage includes a lightning-quick Samsung 960 Evo SSD and a 2TB hard disk.

The graphics hardware is significant too. Scan has included two GTX 1080 Ti cards, which means there's 22GB of combined graphics memory and 7,168 stream processors. The cards aren't running at their stock speed of 1480MHz either – the Asus-made cards arrive with overclocked speeds of 1569MHz and Scan has added 50MHz to that figure.

The two GPUs will handle any gaming task: today's toughest titles will run well on any screen, as well as on multi-monitor rigs and VR headsets. Two high-end graphics cards and a heavily overclocked, 6-core CPU will need a fair bit of power, of course, so it makes sense that Scan has deployed an 850W PSU. The unit here comes from Corsair, and it has a modular design and 80 Plus Gold certificate.

The case is similarly high-end. The Corsair Crystal 570X is a familiar sight on our test benches, and it looks stunning: its panels are made from tinted glass, the plastic beneath stands out in a honeycomb pattern and build quality is excellent. Scan has chosen the red variant of this case, which means the plastic edging, thumbscrews and PSU shroud are all finished in crimson. Scan has also chosen fans with red LEDs for the front of the machine and the Corsair Hydro H100i V2 CPU cooler. What's more, the High Bandwidth SLI bridge, graphics cards and power cables are finished in red and black. Even the memory is red.

The theme is classy and consistent, and Scan has kept the system tidy at the front and back,



with discreet cabling and neat building. The case looks fantastic, but it doesn't have much room to grow – the motherboard is packed with hardware, and the case has minimal features. That's our only complaint, but it's a minor quibble when this machine is already so powerful.

We have no issues with the warranty either. It's a three year parts and labour deal with a year of on site service.

### Performance

The overclocked i7-8700K performed exceptionally well in our single-threaded image editing benchmark. Its score of 70,426 outpaced every other PC we've tested recently, based on both Intel and AMD silicon. That's no surprise, because the 5GHz overclock is one of the most ambitious tweaks we've seen for months.

The only area where the Scan's i7-8700K didn't lead was in our Handbrake video encoding test, which tests a processor's ability to run heavily multi-threaded applications. It beat quad-core Intel chips and AMD Ryzen 7 parts, but its score of 516,590 couldn't outrun AMD Threadripper or Intel Core i9, which were both around 200,000 points faster.

That's hardly a black mark, as those chips are far more expensive than Intel's new mainstream Core i7 and have many more cores. The i7-8700K is great, though, offering table-topping results in most tests and a competitive pace throughout. The SSD is great too, with excellent read and write speeds of 3,068MB/sec and 1,730MB/sec.

The vast processing power is paired with the ample graphics speed, easily playing all our test games at 4K and churning out amazing frame rates at 2,560 x 1,440. The Scan managed a 4K minimum of 49fps in Deus Ex: Mankind

### /SPECIFICATIONS

**CPU** 3.7GHz Intel Core i7-8700K overclocked to 5GHz

**Motherboard** Asus ROG Strix Z370-F Gaming

**Memory** 32GB Corsair Vengeance LPX 3000MHz DDR4

**Graphics** 2 x Asus GeForce GTX 1080 Ti 11GB

**Storage** 500GB Samsung 960 Evo M.2 SSD, 2TB Seagate Barracuda hard drive

**Case** Corsair Crystal 570X

**Cooling** CPU: Corsair Hydro H100i V2 with 2 x 120mm fans; GPU: 4 x 90mm; front: 3 x 120mm; rear: 1 x 120mm

**PSU** Corsair RM850x 850W

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

**Operating system** Microsoft Windows 10 Home 64-bit

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



- 1** Two Asus GTX 1080 Ti cards in SLI make light work of gaming, even at 4K
- 2** A consistent red and black theme is applied throughout the system
- 3** The Core i7-8700K has a massive overclock, running at 5GHz

Divided, and it was quicker in our other two 4K tests. The two GPUs managed to play games at higher levels too. We tested The Witcher 3 and Deus Ex with Ultra graphics settings at 4K, where the Scan returned minimums of 80fps and 46fps.

Scan's machine was cool and quiet when its components weren't taxed, but a CPU stress test saw its delta T rise to 71°C, which is a little high, and the machine pumped out a low, persistent rumble. Adding a graphics stress test saw the CPU delta T rise by 2°C and the noise level increase slightly. Pleasingly, the GPU delta Ts never rose beyond 59°C. It's never dangerously hot or disarmingly loud, but the Scan definitely makes more noise when its components are pushed, so it will be better positioned under your desk rather than right next to you.

### Conclusion

Scan's Coffee Lake debut is a stunning system in every area, but at £3,799 inc VAT, it's also very expensive. That's no surprise, given that the graphics cards alone cost £800 each, but it's only worth considering if you really want that level of gaming and multithreaded power. PC Specialist's Ultima X01 (see p60) also shows you can get a decent system with the same CPU for much less money.

With this Scan system, you're paying for the whole lot – superb build quality and design, 32GB of memory, a super-fast overclock and incredible gaming power, but it all adds



up. If you have the money, though, it justifies its cost. If you're a streamer who regularly uses demanding applications, or if you simply use your PC for a wide variety of intensive tasks, from gaming to video encoding and rendering, this PC is a versatile and well-balanced triumph.

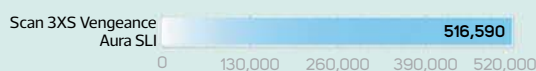
MIKE JENNINGS

#### CPC REALBENCH 2015

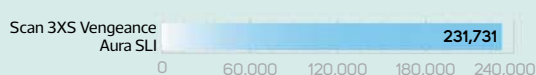
##### GIMP IMAGE EDITING



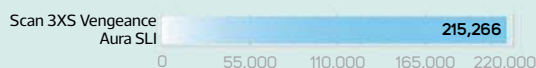
##### HANDBRAKE H.264 VIDEO ENCODING



##### HEAVY MULTITASKING



##### SYSTEM SCORE



INTEL REFERENCE: 188.08%

SPEED  
25/25

DESIGN  
24/25

HARDWARE  
24/25

VALUE  
17/25

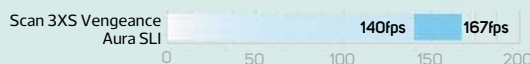
OVERALL SCORE  
**90%**

#### VERDICT

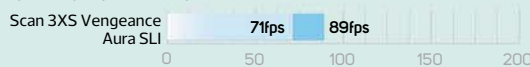
Stunning 6-core performance in a machine that impresses in every important area, although it isn't cheap.

#### FALLOUT 4

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

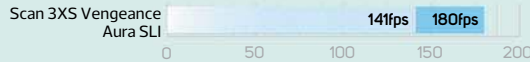


3,840 x 2,160, Ultra Detail, TAA

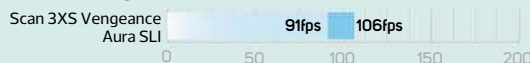


#### THE WITCHER 3: WILD HUNT

2,560 x 1,440, High Detail, Nvidia HairWorks off

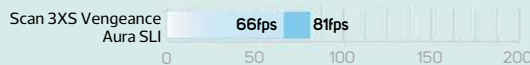


3,840 x 2,160, High Detail, Nvidia HairWorks off



#### DEUS EX: MANKIND DIVIDED

2,560 x 1,440, Very High Detail, DX11



3,840 x 2,560, Very High Detail, DX11











Minimum Average

# Elite

Our choice of the best hardware available

## Processors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	QUAD-CORE CPU	AMD Ryzen 3 1200 (AM4)	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 169, p20	£95
	BUDGET GAMING CPU	Intel Core i3-8350K (LGA1151-V2)	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 172, p22	£159
	6-CORE CPU	AMD Ryzen 5 1600 (AM4)	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 167, p44	£180
	8-CORE CPU	AMD Ryzen 7 1700 (AM4)	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 165, p23	£265
	6-CORE GAMING CPU	Intel Core i7-8700K (LGA1151-V2)	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 172, p20	£380
	10-CORE CPU	Intel Core i9-7900X (LGA2066)	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 168, p19	£860
	HEAVY MULTITHREADING CPU	AMD Ryzen Threadripper 1950X (TR4)	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 170, p20	£872
	EXTREME MULTITHREADING CPU	Intel Core i9-7980XE (LGA2066)	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 171, p20	£1,800




# CPU coolers

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>BUDGET AIR COOLER (LGA115X)</b>	Rajjintek Rhea	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 163, p86	£16
	<b>MID-RANGE AIR COOLER (LGA115X, LGA2011, AM4)</b>	ARCTIC Freezer 33	<a href="http://www.amazon.co.uk">www.amazon.co.uk</a>	Issue 165, p40	£30
	<b>SILENT COOLER (LGA115X)</b>	Nofan CR-95C IcePipe	<a href="http://www.quietpc.co.uk">www.quietpc.co.uk</a>	Issue 160, p84	£116
	<b>LOW-PROFILE AIR COOLER (LGA115X, LGA2011)</b>	Noctua NH-D9L	<a href="http://www.quietpc.co.uk">www.quietpc.co.uk</a>	Issue 143, p17	£45
	<b>120MM ALL-IN-ONE LIQUID COOLER (LGA115X, LGA2011, AM4)</b>	ARCTIC Liquid Freezer 120	<a href="http://www.aquatuning.co.uk">www.aquatuning.co.uk</a>	Issue 166, p88	£63
	<b>240MM ALL-IN-ONE LIQUID COOLER (LGA115X, LGA2011, AM4)</b>	Fractal Design Celsius S24	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 167, p25	£100
	<b>280MM ALL-IN-ONE LIQUID COOLER (LGA115X, LGA2011)</b>	NZXT Kraken X62	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 160, p52	£150



# Motherboards

## LGA1151-V2

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>ATX BUDGET Z370</b>	Gigabyte Z370 Aorus Ultra Gaming	<a href="http://www.novatech.co.uk">www.novatech.co.uk</a>	Issue 172, p46	£170
	<b>ATX MID-RANGE Z370</b>	Asus ROG Maximus X Hero	<a href="http://www.box.co.uk">www.box.co.uk</a>	Issue 172, p43	£240
	<b>ATX PREMIUM Z370</b>	MSI Z370 Godlike Gaming	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 172, p48	£530



## LGA1151

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>MINI-ITX Z270</b>	Gigabyte Z270N-Gaming 5	<a href="http://www.box.co.uk">www.box.co.uk</a>	Issue 166, p26	£150
	<b>MICRO-ATX Z270</b>	Asus ROG Strix Z270G Gaming	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 163, p22	£179

## LGA2066

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>ATX PREMIUM X299</b>	Asus Prime X299 Deluxe	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 168, p52	£389
	<b>ATX MID-RANGE X299</b>	Asus ROG Strix X299-E Gaming	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 168, p50	£296
	<b>ATX BUDGET X299</b>	ASRock X299 Killer SLI	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 171, p22	£229





# TR4

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>ATX MID-RANGE X399</b>	MSI X399 Gaming Pro Carbon AC	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 170, p50	£321
	<b>ATX PREMIUM X399</b>	Asus ROG Zenith Extreme	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 170, p48	£510

# AM4

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>ATX BUDGET B350</b>	Asus ROG Strix B350-F Gaming	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 167, p20	£118
	<b>MICRO-ATX BUDGET B350</b>	Gigabyte AB350M-Gaming 3	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 169, p28	£78
	<b>MINI-ITX B350</b>	Gigabyte AB350N-Gaming WiFi	<a href="http://www.cclonline.com">www.cclonline.com</a>	Issue 170, p36	£104
	<b>ATX BUDGET X370</b>	Asus Prime X370-Pro	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 165, p50	£137
	<b>ATX MID-RANGE X370</b>	Gigabyte Aorus AX370-Gaming 5	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 165, p52	£180
	<b>ATX PREMIUM X370</b>	MSI X370 XPower Gaming Titanium	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 166, p28	£247






# Memory

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>8GB DUAL-CHANNEL DDR4</b>	8GB Corsair Vengeance LPX 2666MHz DDR4 (CMK8GX4M2A2666C16)	www.scan.co.uk	Issue 163, p86	£100
	<b>16GB DUAL-CHANNEL DDR4</b>	16GB Corsair Vengeance LPX 3000MHz DDR4 (CMK16GX4M2B3000C15)	www.scan.co.uk	Issue 166, p90	£164
	<b>16GB DUAL-CHANNEL DDR4 RGB</b>	16GB G.Skill Trident Z RGB 3200MHz DDR4 (F4-3200C16D-16GTZR)	www.yoyotech.co.uk	Issue 169, p19	£160
	<b>32GB QUAD-CHANNEL DDR4</b>	32GB G.Skill Trident Z RGB 3200MHz DDR4 (F4-3200C16Q-32GTZR)	www.yoyotech.co.uk	Issue 169, p19	£310

# Software

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>OPERATING SYSTEM</b>	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£100

# Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>JUST 1,920 X 1,080 GAMING</b>	Zotac GeForce GTX 1050 Ti 4GB Mini	www.ebuyer.com	Issue 163, p86	£142
	<b>1,920 X 1,080 AND SOME 2,560 x 1,440 GAMING</b>	Nvidia GeForce GTX 1060 3GB	www.scan.co.uk	Issue 159, p43	£199
	<b>2,560 X 1,440 GAMING</b>	Nvidia GeForce GTX 1060 6GB	www.scan.co.uk	Issue 159, p23	£257
	<b>SMOOTH 2,560 X 1,440 GAMING</b>	Asus Strix GeForce GTX 1070 OC	www.awd-it.co.uk	Issue 156, p51	£445
	<b>4K GAMING</b>	Asus ROG Strix GeForce GTX 1080 Ti OC	www.awd-it.co.uk	Issue 168, p28	£790






# Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>BUDGET ATX</b>	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£67
	<b>SUB-£100 ATX PERFORMANCE</b>	Phanteks Enthoo Pro M Glass	www.overclockers.co.uk	Issue 161, p24	£95
	<b>SUB-£100 ATX QUIET</b>	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£95
	<b>SUB-£150 FULL-SIZED ATX QUIET</b>	Nanoxia Deep Silence 5	www.quietpc.co.uk	Issue 144, p50	£143
	<b>SUB-£150 FULL-SIZED ATX</b>	Phanteks Enthoo Luxe	www.awd-it.co.uk	Issue 144, p53	£131
	<b>SUB-£150 MID-SIZED ATX</b>	Cooler Master Cosmos SE	www.scan.co.uk	Issue 144, p41	£70
	<b>PREMIUM ATX CASE</b>	Phanteks Enthoo Evolv ATX Glass	www.overclockers.co.uk	Issue 169, p43	£175
	<b>MINI-ITX TOWER</b>	Fractal Design Define Nano S	www.scan.co.uk	Issue 153, p22	£50
	<b>MINI-ITX CUBE</b>	Fractal Design Core 500	www.scan.co.uk	Issue 150, p20	£50
	<b>MICRO-ATX</b>	Fractal Design Define Mini C	www.scan.co.uk	Issue 161, p26	£75








# Case fans

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>120MM QUIET FAN (BEST RUN AT 5V)</b>	Corsair SP120 Quiet Edition	www.scan.co.uk	Issue 155, p56	£13
	<b>120MM PERFORMANCE FAN (BEST RUN AT 12V)</b>	Thermaltake Pure S12 LED	www.amazon.co.uk	Issue 155, p58	£9

# Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>BUDGET 400W</b>	XFX XT Series 400W 80 Plus Bronze	<a href="http://cpc.farnell.com">http://cpc.farnell.com</a>	Issue 163, p86	£38
	<b>MID-RANGE 450W</b>	Corsair CX450M	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 164, p84	£51
	<b>MID-RANGE 550W</b>	EVGA SuperNova GS 550W	<a href="http://www.alza.co.uk">www.alza.co.uk</a>	Issue 146, p50	£76
	<b>HIGH-END 550W</b>	Super Flower Leadex Platinum 550W	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 146, p52	£103
	<b>MID-RANGE 750W</b>	Corsair RM750i	<a href="http://www.aria.co.uk">www.aria.co.uk</a>	Issue 146, p55	£114
	<b>HIGH-END 1.2KW</b>	Corsair Professional Series AX1200i	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 111, p40	£340

# Storage






	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>MAINSTREAM HARD DISK</b>	Western Digital Blue 4TB	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 166, p54	£115
	<b>PERFORMANCE HARD DISK</b>	Seagate BarraCuda Pro 6TB	<a href="http://www.overclockers.co.uk">www.overclockers.co.uk</a>	Issue 166, p50	£225
	<b>500GB SATA SSD</b>	Samsung 850 Evo 500GB	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 158, p44	£153
	<b>1TB SATA SSD</b>	Samsung 850 Evo 1TB	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 141, p51	£302
	<b>HIGH-PERFORMANCE M.2 SSD</b>	Samsung SSD 960 Evo 500GB	<a href="http://www.scan.co.uk">www.scan.co.uk</a>	Issue 168, p59	£226
	<b>SINGLE-BAY NAS BOX</b>	QNAP TS-131P	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 171, p48	£168
	<b>DUAL-BAY NAS BOX</b>	Synology DS216j	<a href="http://www.ebuyer.com">www.ebuyer.com</a>	Issue 154, p28	£147







# Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	24IN MONITOR	Dell UltraSharp U2417H	www.laptopsdirect.co.uk	Issue 162, p58	£220
	24IN FREESYNC MONITOR	ViewSonic XG2401	www.box.co.uk	Issue 167, p52	£269
	24IN G-SYNC MONITOR	AOC AGON AG241QG	www.ebuyer.com	Issue 169, p55	£428
	27IN 2,560 X 1,440 FREESYNC MONITOR	Samsung C27HG70	www.overclockers.co.uk	Issue 171, p28	£590
	27IN 2,560 X 1,440 G-SYNC MONITOR	Asus ROG Swift PG279Q	www.scan.co.uk	Issue 155, p48	£695
	27IN 4K FREESYNC MONITOR	ViewSonic XG2700-4K	www.amazon.co.uk	Issue 157, p26	£552
	27IN 4K G-SYNC MONITOR	Asus ROG Swift PG27AQ	www.overclockers.co.uk	Issue 151, p42	£690
	34IN ULTRA-WIDE CURVED G-SYNC MONITOR	Asus ROG Swift PG348Q	www.ebuyer.com	Issue 157, p42	£985






# Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	ROUTER	Netgear Nighthawk X4S R7800	www.ebuyer.com	Issue 160, p44	£170
	BUDGET MESH ROUTER	BT Whole Home Wi-Fi	www.currys.co.uk	Issue 172, p54	£200
	PREMIUM MESH ROUTER	Netgear Orbi (RBK50)	www.currys.co.uk	Issue 172, p57	£323
	WI-FI ADAPTOR	Asus PCE-AC68	www.scan.co.uk	Issue 128, p88	£66
	PREMIUM ROUTER	Asus ROG Rapture GT-AC5300	www.overclockers.co.uk	Issue 170, p35	£390

# Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>MECHANICAL GAMING KEYBOARD</b>	Cooler Master MasterKeys Pro L White	www.scan.co.uk	Issue 165, p55	£80
	<b>PREMIUM MECHANICAL GAMING KEYBOARD</b>	Corsair Gaming K70 RGB Rapidfire	www.ebuyer.com	Issue 154, p21	£140
	<b>MMO KEYBOARD</b>	Corsair Gaming K95 RGB Platinum	www.ebuyer.com	Issue 164, p26	£182
	<b>BUDGET GAMING MOUSE</b>	Cooler Master Xornet II	www.box.co.uk	Issue 149, 28	£25
	<b>GAMING MOUSE</b>	Corsair Glaive RGB	www.overclockers.co.uk	Issue 167, p19	£55
	<b>AMBIDEXTROUS GAMING MOUSE</b>	Roccat Kova	www.box.co.uk	Issue 150, 28	£39
	<b>MMO GAMING MOUSE</b>	Corsair Scimitar Pro RGB	www.box.co.uk	Issue 164, p24	£75
	<b>WIRELESS GAMING MOUSE</b>	Logitech G403 Prodigy Wireless	www.overclockers.co.uk	Issue 171, p40	£100
	<b>STEERING WHEEL AND PEDALS</b>	Logitech G920 Driving Force	www.currys.co.uk	Issue 159, p55	£220

# Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	<b>PCI-E SOUND CARD</b>	Asus Strix Raid DLX	www.scan.co.uk	Issue 148, p28	£173
	<b>2.1 SPEAKERS</b>	Acoustic Energy Aego <sup>3</sup>	www.amazon.co.uk	Issue 164, p49	£250
	<b>SOUNDBAR</b>	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£200
	<b>HEADSET</b>	HyperX Cloud II	www.box.co.uk	Issue 142, p46	£80
	<b>SURROUND-SOUND HEADSET</b>	Asus ROG Centurion	www.cclonline.com	Issue 163, p49	£215

# Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	SKYLAKE-X PC	Scan 3XS Carbon Aura	www.scan.co.uk	Issue 168, p66	c.£2,750
 <b>NEW ENTRY</b>	BUDGET COFFEE LAKE PC	PC Specialist Ultima X01	www.pcspecialist.co.uk	Issue 172, p60	£1,479
 <b>NEW ENTRY</b>	PREMIUM COFFEE LAKE PC	Scan 3XS Vengeance Aura SLI	www.scan.co.uk	Issue 172, p64	£3,799
	DREAM PC	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	AMD RYZEN 7 PC	CCL Shadow Hawk	www.cclonline.com	Issue 171, p58	£1,950
	THREADRIPPER PC	CyberPower Ultra Threadripper Xtreme	www.cyberpowersystem.co.uk	Issue 171, p62	£3,469
	SUB-£2,000 GAMING PC	Palicomp Infantry Brigadier	www.palicomp.co.uk	Issue 165, p64	c.£1,999
	MINI-ITX GAMING PC	Corsair One Pro	www.scan.co.uk	Issue 167, p62	c.£2,200
	PREMIUM MINI-ITX PC	Overclockers 8Pack Asteroid	www.overclockers.co.uk	Issue 154, p56	c.£3,990
	PREMIUM PC	Scan 3XS Carbon Fluid Extreme SLI	www.scan.co.uk	Issue 170, p58	c.£4,950
	WATER-COOLED PC	Overclockers Infin8 Toxicity	www.overclockers.co.uk	Issue 150, p58	c.£3,414
	HIGH-PERFORMANCE GAMING LAPTOP	Scan 3XSLG17 Carbon Extreme	www.scan.co.uk	Issue 159, p30	c.£2,550
	THIN AND LIGHT GAMING LAPTOP	Alienware 13	www.alienware.co.uk	Issue 168, p32	c.£1,849
	BUDGET GAMING LAPTOP	MSI GE72 7RE Apache Pro	www.saveonlaptops.co.uk	Issue 167, p28	c.£1,137
	ULTRABOOK LAPTOP	Razer Blade Stealth	www.razerzone.com	Issue 167, p36	c.£1,350

# Games

A dramatic fantasy battle scene. In the center, a large dragon breathes fire. To the left, a knight on a dragon is visible. In the foreground, a horde of orcs is engaged in combat. The sky is filled with lightning and dark clouds.

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RICK LANE / INVERSE LOOK

# TAKING IT EASY

Despite what elitist gamers say, there's no shame in playing games in easy mode, argues Rick Lane

Playing games in easy mode has long been viewed with derision by gaming culture. What began as a joke in games such as *Wolfenstein 3D*, with its tongue-in-cheek difficulty settings such as 'Can I play, daddy?' and 'Don't hurt me', has now become an embedded social hierarchy within the hobby. People who play games in easy mode are viewed as babies and pretenders, while only the truest, most elite gamers play games on hard.

Such thinking has always been lingering in the shadows, like rats in a restaurant that doesn't clean up properly, but the issue has become more pertinent in recent years due to the growing trend of games that are difficult by default. This fad was initially perpetuated by *Dark Souls* and continued by games such as *XCOM*, and most recently *Cuphead*. These games incorporate challenge and failure as integral parts of their design, and if you don't like it then tough luck; you either need to get good or accept that you're not a proper gamer.

I've no problem with a developer making a game difficult, although difficulty isn't the foundation of any of the aforementioned games. If *Dark Souls* were easier, it would still be set in a masterfully constructed 3D world with a wonderfully cryptic and subversive fantasy story. But difficulty elitism is both foolish and childish. It's like saying someone isn't a true bookworm because they got bored reading *War and Peace*.

In fact, I'd argue that playing games on easy is by and large the sensible option. There are a ridiculous number of fantastic games all clamouring for players' attention these days, many of which are huge time sinks, regardless of which difficulty

If you don't like it, tough luck; you either need to get good or accept that you're not a proper gamer

you use. With only one lifetime in which to play them, it seems silly to deliberately make a game more obstructionist for yourself, bouncing off an arbitrary wall of challenge while the sand slips irrevocably through the hourglass of your life.

Moreover, life is challenging enough without worrying that the game you're playing to *relax* is going to trigger further worries. I have a one-year-old daughter, and looking after her is the hardest game of all, an 18-year-long escort mission with an AI that seems determined to walk straight into all the traps and monsters from which I'm supposed to protect it. Add the

constant worrying about money, politics, climate change, the possibility of dying in nuclear hellfire and whether or not I need to put the recycling bin out, and the last thing I want is my backside kicked into touch by a bloody toy.

More importantly however, modern games can challenge us in far more interesting ways than a simple reflex test. From the mind-bending majesty of *Portal*'s puzzles to the agonising moral choices of *The Witcher*, the spectrum of challenge is far wider than in the days of *Doom*. *Papers Please* can let us experience an ethical dilemma first hand, while *What Remains of Edith Finch* can confront us with the topic of grief in a way that's far more palpable than any novel or film.

Focusing on raw game difficulty as a measure of both game and player quality is backwards and narrow-minded, ignoring the far more important ways that games can be challenging, by provoking new thoughts and questioning established beliefs. Nowadays, when we think about games in terms of challenge, we should be considering not whether it will be easy or hard, but whether it will be interesting. **CPC**

Rick Lane is Custom PC's games editor. [@Rick\\_Lane](#)



# Total War: Warhammer II / £39.99 inc VAT



DEVELOPER The Creative Assembly / PUBLISHER The Creative Assembly / WEBSITE [www.totalwar.com/total\\_war\\_warhammer](http://www.totalwar.com/total_war_warhammer)



**N**ot even 18 months have passed since Total War: Warhammer spilled onto hard drives like a seething horde of Vampire Counts, yet the Creative Assembly has already released a fully fledged sequel to its dream strategy mashup. It's such a speedy follow-up, you'd be forgiven for being a mite concerned that it might be rushed or feature-light. Forgiven, but still wrong. Not only is Warhammer II a worthy successor, it might just be better than the original.

Warhammer II introduces a very different campaign, which can be played using four newly introduced Warhammer races – High Elves, Dark Elves, Scaly Elves (also known as Lizardmen) and Rat Elves (Skaven).

All the armies from the previous game make an appearance too, but only as AI fodder to be crushed beneath the might of your elvish, reptilian or verminous forces.

It's a bold move by The Creative Assembly, given that these races are the Warhammer equivalent of a B team. Elves, let's face it, are a bit dull, while the Lizardmen and Skaven are undoubtedly the more eclectic of the Warhammer armies. In Total War, however, they're brought brilliantly to life by The Creative Assembly, featuring some of the weirdest and most wonderful units of the entire series.

The Lizardmen are the surprise headliners, mainly because their monster units are full-blown dinosaurs,



such as the Feral Carnosaur that can charge into enemy armies and scatter them like bowling pins.

The Skaven are a close second, taking to the field in huge numbers that splash like waves into the opposing forces. The cowardly rats rout easily, but they're just as quick to rally, making them deceptive in a fight. They also have some neat monster units, including the Hell Pit Abomination, a giant undead horror that spills hundreds of rats from its corpse when it dies.

Even the Elves get cool units, such as flying dragons and phoenixes that can swoop down on enemy armies and reduce them to cinders. With the other Warhammer armies featuring in the Campaign as well, the result is the most

OVERALL SCORE

88%

**/ VERDICT**

It may be the most cumbersome Total War to date, but Warhammer II is also the most dazzling and strategically satisfying entry in the series.

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spectacular and diverse battle scenes Total War has ever seen. Watching a Sun Dragon burn a line through the seething masses of a Skaven army is one of PC gaming's most dastardly delights.

But there's more to Warhammer II than simple fantasy carnage. The campaign has also undergone significant alterations. These changes include a new, story-based objective, which centres around a magical Vortex that swirls at the centre of the Elven Homeland. The Vortex keeps the forces of Chaos at bay, but it's weakening, so the High Elves want to restore it while the other three races want to control it. To complete their objectives, all four factions must complete a series of rituals, which they can only perform once they've gathered enough of their requisite resources (such as Way Fragments for the High Elves).

This mechanic makes your campaign more directed than in the previous game, meaning you can target certain structures to build, and provinces to conquer, rather than simply attacking any object and every creature (although you can still do that if you want). At the same time, it gives you more strategic problems to consider. The other races are trying to complete their rituals at the same time as you, so you want to try to hinder them as best you can. However, each time you start a ritual, you give Chaos an opportunity to invade your realm, so you'll also need to build

sufficient defences to keep the Chaos armies at bay.

Alongside the Vortex is a whole range of new, faction-based mechanics. The High-Elves, for example, are masters of diplomacy. Their trade routes double as spy networks, letting them see other factions' movements from afar, and they can even gain territory from diplomacy by assimilating smaller factions into confederations. The Skaven, meanwhile, live and die on their stomachs. Food is the engine of the Skaven, and they need to be constantly on the move in order to collect enough of it, conquering new provinces and exploiting their resources. A low food surplus can lead to rioting, but a high food surplus can be spent on various perks, including raising extra units into armies just before a battle.



These additional abilities make the various factions almost as diverse on the campaign map as on the battlefield. However, there's a downside to these extra elements; Warhammer

II is enormously complex. It can be hard to keep track of all the action going in any given campaign. Moreover, this complexity also slows down the game. Mechanics such as climate, which affects your faction's suitability to a given environment, can make it tough to expand your faction's borders, especially when you need to keep one eye on a potential Chaos invasion.

Warhammer II isn't the slickest Total War game, lacking the simpler immediacy of Shogun 2. However, that's a small price to pay for a game with such a broad strategic scope, so many different ways to play and such dazzling fantasy battles.

RICK LANE



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## Divinity: Original Sin 2 / £29.99 inc VAT

DEVELOPER Larian Studios / PUBLISHER Larian Studios / WEBSITE [www.divinity.game](http://www.divinity.game)



It's better to think of Divinity: Original Sin 2 less as a typical fantasy RPG, and more like an AI gamemaster in Dungeons & Dragons. It genuinely strives to let you play it however you please, to pose a problem and let you come up with the solution. It's one of the smartest, most creative and entertaining RPGs we've ever played, even if, like the rules of D&D, it can be a little obscure at times.

From the character screen onwards, Original Sin 2 is dedicated to enabling the player's creativity. You can create your own avatar or play as one of six premade characters, each of whom has their own back story. The remaining premade characters fill the remaining slots of your party, and you can change all of their classes and abilities to better suit your needs.

Either way, the options on offer to you are wonderful. You could play as an elf who can retrieve memories of the dead by eating their body parts, or as an undead character who is healed by poison magic and can pick a lock with their bony fingers, but must conceal their face and body when in a town or village. The classes are equally diverse. Polymorphs can sprout wings and turn people into chickens, while Witches can reanimate corpses on the battlefield and make it rain blood.

The main story of Original Sin is thoroughly entertaining, as a half-dozen factions, from Paladins to Necromancers, all seek to obtain the same power that your party seeks out. All the factions have logical motives for their goals, and all of them strive to achieve them in morally questionable ways. You can choose to side with any of them at different points in the game, or

you could choose to kill anyone in your path. Your party members all have individual stories too, and their personal goals may not always coincide with your own. Going along with them may result in them killing an important non-player character, but stopping them may upset them or make them decide to leave the party.

Original Sin does all of the above well, but where it shines best is in the witty and imaginative smaller stories you encounter. These quests range from solving murders to finding out what happened to a disembodied arm you found in the stomach of a dying shark, and from helping a chicken find her missing eggs to locating an ancient lost library amid the gore-splattered rocks of Bloodmoon Island. Depending on your position in the game, Original Sin 2's tone can range from lighthearted comedy to verging on horror, and its ability to accommodate these tonal shifts through its clear and evocative writing is remarkable.

Arguably more impressive than the inventiveness of the game's quests is the myriad ways you can solve them. To give a general example, let's say you need to release a party



OVERALL SCORE

92%

### / VERDICT

Bursting with detail, diversity and some of the best dynamic design around, Divinity: Original Sin 2 is a fantasy RPG to savour.

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member from a prison cell. You could pick the lock, or you could talk to your neighbouring prisoner to ask if they know a way out. If one of your party has a teleport spell, you could teleport your incarcerated friend out of there. If you have the Pet Pal perk, you could talk to a rat in the corner who might know a secret passage. If you have the Spirit Vision spell, you could talk to a ghost who might know another secret passage. If for some reason you can't perform any of these activities, you could just get your party to kill all the guards, steal the key and bust you out that way.

There's a downside to such breadth, though, which is that Original Sin 2 sometimes struggles to communicate these options to you. The quest journal is cryptic at best, and the game tends to be sparing with quest markers. Divinity wants you to investigate solutions for yourself, to rummage through desks for keys or revealing notes, to talk to people, animals and ghosts for clues. But sometimes its solutions are too well hidden for its own good, and this situation can lead to frustration.

That's not the only way Original Sin 2 can be disproportionately challenging either. The game's combat is just as creative and surprising as the rest of the game, letting you combine various elemental effects to damage and discombobulate your enemies. Water and blood can be electrified with a lightning bolt, or frozen with a magical hailstorm, while any surface from fire to poison can be 'cursed' or 'blessed' to create additional effects. But the combat is also highly strategic, and can be extremely difficult if you're not at the right level, or if you fail to maximise your party's abilities.

It wouldn't hurt Original Sin 2 to be a touch more helpful and forgiving towards the player, but that doesn't prevent it from being a phenomenal RPG. There's so much in this game to discover and with which to play, and you can play it either on your own or with three friends in cooperative. It's the most accomplished RPG we've played since The Witcher 3, and one of the best games released this year.

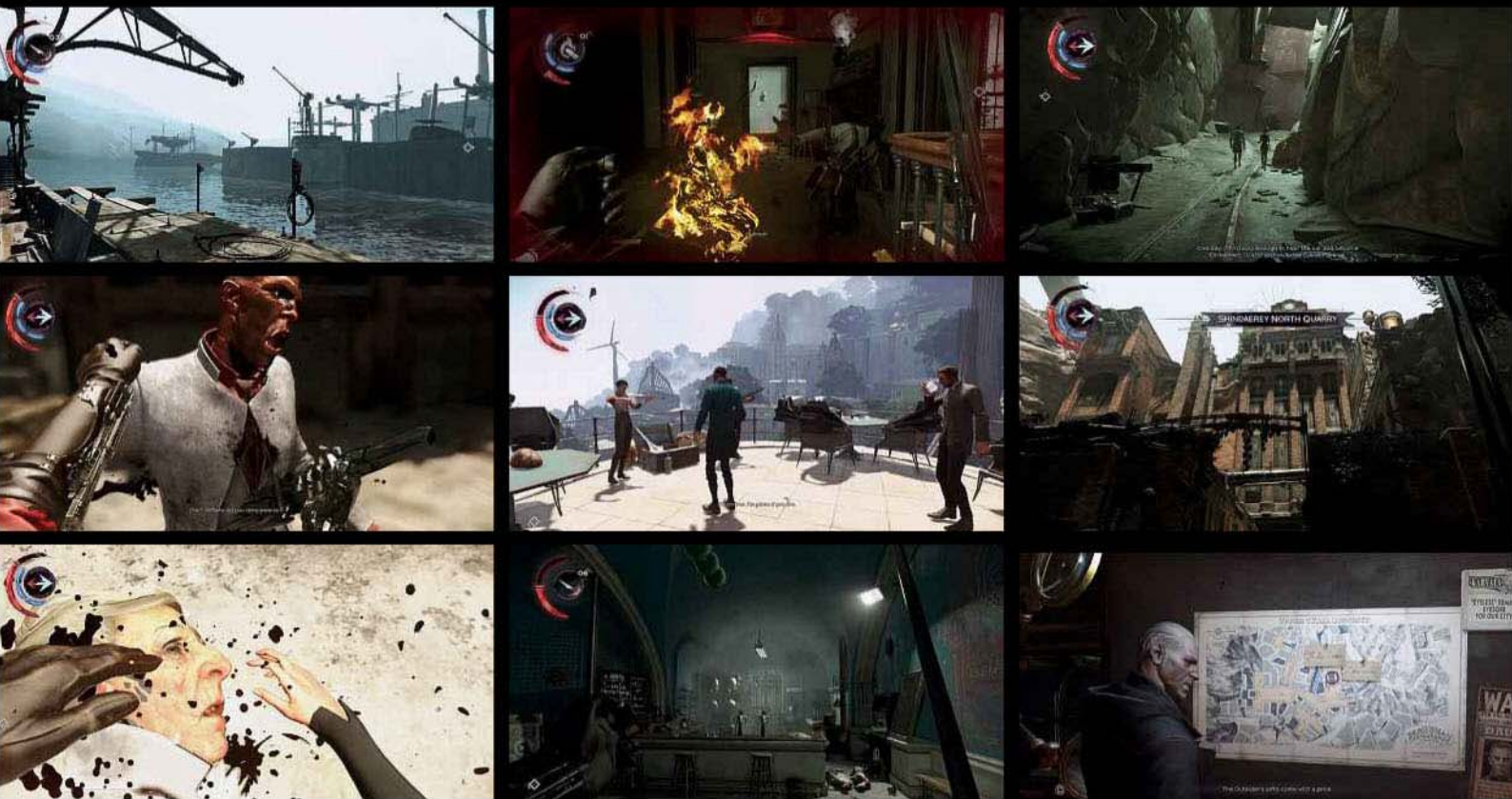
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## Dishonored: Death of the Outsider / £19.99 inc VAT

DEVELOPER Arkane Studios / PUBLISHER Bethesda Softworks / WEBSITE <https://store.bethsoft.com/dishonored-the-death-of-the-outsider>



**F**ew game developers are as ambitious in their expansions as Arkane Studios. In this standalone story, former Assassin Billie Lurk is on a personal quest to kill the Outsider, the series' enigmatic god who treats reality like a single-player chess game. It introduces new missions and a new roster of abilities with which to explore them. Sadly, though, it doesn't gel together as well as previous games.

### OVERALL SCORE

# 60%

### / VERDICT

One brilliant highlight aside, Death of the Outsider lacks the consistency and creative problem solving of the rest of the Dishonored series.

The expansion comprises three new missions and one reworked level from Dishonored 2. The first half is a masterclass in level design from Arkane. The standout mission is the Bank Job, a sprawling and many-layered heist that sees Billie robbing the high-tech elevator vault inside Karnaca's largest bank. It's a superb level, with stunningly detailed architecture and at least half a dozen ways to complete your objective.

Sadly, the second half is less impressive. The third mission is a daytime rerun of Dishonored II's Royal Conservatory, while the final mission is a disappointingly linear affair featuring thick knots of guards who are difficult to bypass other than through combat. It's haphazardly designed compared with the first half of the game, as if the developer had to rush the expansion to launch.

Meanwhile, Billie Lurk has new gadgets and powers. The former is one of the expansion's highlights, including a gas grenade that knocks out groups of enemies, and the devilish Hook Mine, which can grab an unsuspecting guard and fling them across a room. Often removing a limb in the process.

Then there are the new powers. Displace is a short-range teleport, like Blink in previous Dishonored games, but the teleport marker can be placed in advance of committing to the move. Foresight lets Billie scout out areas in a spirit form and mark guard patrols for meticulously planned movements. Finally, there's Semblance, which lets Billie steal people's faces and wear them like masks.

The powers are great in theory, but they have limited uses. Foresight is only practical out of combat, while Semblance drains mana too quickly to be used for more than a few seconds. They don't facilitate creative thinking in the same way as the previous powers, and as that's a founding pillar of Dishonored's design, it's a significant flaw.

Death of the Outsider isn't a bad expansion, but it's nevertheless a step backwards from Arkane's previous work. That said, The Bank Job is one of the best missions Arkane has designed, and if you're a fan of the series, you won't want to miss it.

RICK LANE

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RICK LANE / THE ENGINE ROOM

# RimWorld

Rick Lane explores the space colony simulator and its AI-driven, emergent storytelling

**A** good colony sim is essentially a story engine, a complex algorithmic mechanism that churns out characters and situations that smash together to form thousands of little plots, intrigues and dramas. 'There's a high-level result that occurs in many games, including Dwarf Fortress, which is emergent, character-driven stories where players become invested in a generated character,' says Tynan Sylvester, designer of space colony sim RimWorld. 'I used to have this experience as far back as the original X-Com, where I'd get really attached to some randomly generated character and be devastated when they ended up mind-controlled and killing their buddies.'

RimWorld is one of a spate of colony sims that emerged in the wake of Dwarf Fortress, which also includes the likes of Prison Architect. The game tasks players with building a colony on an alien planet, providing the means for the colonists' survival, and protecting them from hazards such as diseases and alien wildlife. Like other colony sims, RimWorld uses this structure to generate interesting stories for the



**Colonists can succumb to various uncontrollable 'mental states' including pyromania**

**Various hazards can affect the physical and mental health of your colonists, from disease to alien wildlife**

player, but it also goes one step further. A game of RimWorld is overseen by what Sylvester refers to as an 'AI storyteller'.

RimWorld uses the Unity engine, but the AI storyteller is a unique system coded specifically for the game. 'The storyteller observes what's going on in the game and generates semi-randomised story "incidents" to create change and challenge in the colony,' he says. 'She might send a raid from slaver pirates, a pack of manhunting wild boars or a wave of disease. She can also send helpful incidents, such as crashed cargo or refugee pods, wandering cats or chickens and so on.'

Sylvester says the AI storyteller is assembled from two sets of subsidiary systems, named 'story watchers' and 'incident generators'. The story watchers process what's happening in the game into a set of simple statistics, such as wealth, colony combat power or danger-pressure experienced, he says. 'The incident generators then use those stats to create various incidents according to a target-pacing pattern.'

RimWorld features three different AI storytellers, which cater to different types of play. Cassandra Classic is the standard experience, while Phoebe Chillax is more lenient towards the player and Randy Random generates more unpredictable events. Each one runs on a different set of algorithms, but they're all formed from the same essential components of story watchers and incident generators.

However, although the AI storytellers monitor the player's colony and respond to its status in different ways, they can't influence the behaviour of the colonists themselves. Indeed, the colonists possess an AI system of their own, operating largely independently of both the storyteller and the player, according to a different set of behaviours.

This AI system is a fundamental component of most colony sims, and also the greatest challenge in developing them. A colony sim must balance AI autonomy with player control, so colonists can act independently of the player to





The AI storyteller monitors data about your colony, such as wealth, and creates scenarios in response to that information



RimWorld's colonies are vast, sprawling constructions that perform many different functions

the game appears to make sense and is fun to play. Nevertheless, in a game that's intended to generate dramatic and unpredictable scenarios, bugs and mistakes do occasionally slip through the net. 'I've had my share of amusing bugs, such as wild animals entering the colony, taking a tray of nutrient paste from a dispenser and sitting at a table to eat with the colonists,' Sylvester says.

Fortunately, because of the way RimWorld is designed, unexpected bugs usually stand out from the unexpected events that are intended features of the game. 'When something happens that's not designed, it's generally clear there's something wrong. We work really hard to keep RimWorld code working within parameters; the game simulation is complex enough that if we let bugs creep in, they could quickly have destructive and unpredictable effects.'

RimWorld demonstrates both the power of AI-driven games, and the key to making such games fun to play. Good video game AI isn't just about complexity or its ability to produce creative game scenarios, it's also about communicating to the player what the AI is doing and why it's doing it. Indeed, the clarity of RimWorld's AI structure helps the process of development when introducing added complexity. 'There are always lots of ways to improve the game without adding a burden for players,' Sylvester concludes. 'There are lots of ways we can enrich the AI behaviour and feedback without adding more decisions for players.' **CPC**

generate those unique stories, but are not so independent that the player is reduced to the role of watching a virtual ant farm. In addition, there's a further problem, as Sylvester explains. 'There has to be space for the AI to do right and wrong and play out a story, but the player also has to feel the AI is following commands responsively.'

Sylvester's solution to this problem is multi-layered, but it begins with defining the limits of both the player's interaction and the colonist AI. 'In some areas, the player is deliberately not given specific control over what the AI can do.

For example, when the AI is choosing food to eat, or choosing how to spend their free time, the player can't directly control their choice. Taking away this control actually reduces the player's burden of micromanagement, and players are okay with it, since it feels legitimate that the AI would choose how to make itself happy.'

In addition, RimWorld's colonists are susceptible to what Sylvester calls 'mental states', behaviours wherein the colonists go completely beyond the player's control. 'A pyromaniac may go on a fire-

starting spree, or any colonist may go berserk or hide in their room if their mood is too low.' These states are clearly communicated to the player, so they know the reason why that colonist won't respond to orders or job assignments.

Lastly, RimWorld includes a 'mood' mechanic, which shows players the current emotions of each colonist, and subtly encourages them to improve those emotions to retain a semblance of control. 'The AI wants various things, and will have a low mood (and mental breaks) if it doesn't get them, so the player tries to fulfil those needs,' Sylvester says. 'In this way, I give the player control while the game character's desires are also a major guide to what they're doing. It's a way of aligning the player's and the AI's choices.'

With such a complex system involving multiple AI agents, good communication is critical to ensure

You're not alone on RimWorld. There are other settlements that can interact with yours



While conceptually RimWorld is similar to Dwarf Fortress, the art has more in common with Introversion's Prison Architect

JOE MARTIN'S

# Virtual world

Joe Martin discusses modding games for VR, and explains why he'll take any port in a VR storm

One of the most common criticisms of virtual reality is that, as a platform, it lacks a real killer app from a major developer. Sure, there are some great games available, such as *Arizona Sunshine* and *Vanishing Realms*, but they're from small, relatively unknown studios. Even indie darling *Superhot* doesn't have the same sort of clout as a triple-A title, and Valve's *The Lab* is little more than an adorable half effort.

It's a complaint with which I have some sympathy. Before the current generation of VR headsets landed, I was a staunch VR sceptic, and it wasn't until I saw a video of a *Half-Life 2* VR mod using the Razer Hydra controllers that I really changed my mind. I'd seen other VR games and tech demos before then, but it took a *Half-Life 2* mod to get my attention.

Why? Because it was *Half-Life 2*. Timeless, polished and sublime – a real killer app in every sense of the word, albeit from last decade. It wasn't just that, however. The *Half-Life 2* VR mod also seemed to throw open the doors to a much larger library of games than had been announced or demoed elsewhere. After all, if someone had ported *Half-Life 2* to VR, there could be plenty of



**Alien: Isolation in VR is not for the fainthearted**

other mods available in due course too. My mind started to swim with ideas for other games that may make the jump. *Deus Ex*? *Thief*? *System Shock 2*?

## VR mods

Fast-forward to now and fan-made mods are still the closest titles VR has to real killer apps, and there's a handful of truly excellent ones available. *MotherVR* is a pant-crappingly good VR port of *Alien: Isolation*, for example, but there are also mods for *Grand Theft Auto V*, *Doom 3* and more. There's even a

VR mod for the original *Quake*, if you can stomach the motion sickness.

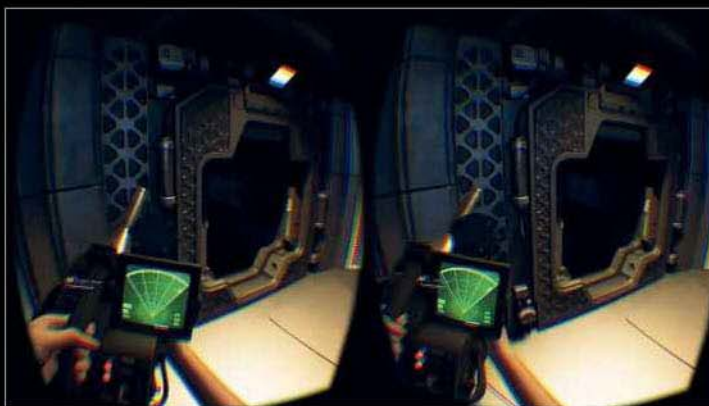
The *Doom 3* VR mod, which we've covered previously, is worth highlighting again, as it's had several updates. It's now an incredibly robust VR experience, with multiple locomotion options, support for

HD-texture mods and a bevy of tweaks to eliminate motion sickness and improve performance. It even supports voice commands through the HTC Vive's built-in microphone, so you can switch weapons like a millionaire with an invisible, gun-laden butler on hand. Just say which weapon you want and it will automatically swap into your hands.

However, therein lies the problem of porting existing games to VR platforms; because non-VR games obviously weren't created with VR in mind, some of the most exciting potential mods just don't work in practice.

Pretty much any game with an inventory screen, or that needs more than ten buttons to control, is a complete write-off, because those types of user interface are hard to translate to VR. They can be *made* to work, and *Doom 3* VR's voice commands and options menu are a good illustration of how to do it, but it's never ideal. As such, the lack of menus means we'll probably never see VR ports of *Deus Ex* or *System Shock* either.

**MotherVR makes Alien: Isolation VR compatible**



Menus aren't the only barrier either – there are issues surrounding movement, graphics and balancing too. The first and last of these aspects are closely tied, as the ideal way to move in VR is often by using a teleport mechanic (especially if you aren't playing with a room-scale setup). Imagine how easy most games would be if you suddenly added Dishonored-style Blinking in order to make the game playable. Doom 3, with its claustrophobic corridors and repetitive monster closets, is one of the few games that actually survives the addition, but only because there's so little space in which to teleport around the game levels. Other games don't transition so smoothly.

The yet-to-be-released Budget Cuts has shown that stealth games and VR can go together like cheese and wine, but only because that game was designed with VR in mind. Porting Thief or Metal Gear Solid to VR would doubtlessly be a less successful experiment.

## VorpX

Of course, mods and ports come in all different flavours. So far I've focused on the crème de la crème of total conversions, but there are other ways to get old games working in VR too. One method involves using VorpX, an unofficial driver that enables you to play almost any DirectX 9, 10, 11 or OpenGL game in VR. It actively supports 150 of the most popular PC titles, including BioShock: Infinite, No Man's Sky, Fallout 4 and Battlefield 4, but the developer also claims that dozens of other games will 'just work out of the box'. I can't vouch for that figure, but experience certainly suggests it works with games as diverse as Mirror's Edge and Skyrim.

VorpX isn't a mod, so it doesn't address in-game issues such as balancing or movement mechanics, but bundled software does aim to eliminate the more stomach-churning issues of VR gaming. Customisable hotkeys enable you to switch between a variety of 3D



Doom 3 VR makes full use of the Vive hardware

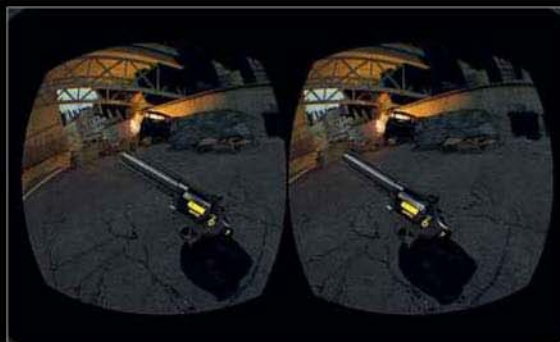


Half-Life 2 VR mods will suffice until Valve pulls its finger out

modes, for example, while features such as EdgePeek help to keep UI elements visible. You can even move the view in fixed-camera cutscenes, so you aren't left disorientated by in-game camera cuts.

VorpX isn't perfect though. Aside from the fact that it can take a fair bit of tweaking to get some games working, the biggest issue is that it still requires you to play at an actual PC. As such, you can't stand and move around – there's no dodging bullets or ducking and covering.

VR modders have to use crafty UI solutions



Instead, you have to wear a headset at your PC and blindly grope at the keyboard, mouse or gamepad while you ogle the environment in 3D.

An overlay of customisable shortcuts is included to help offset the hassle, but it's still little more than a halfway house compared with other VR experiences. VorpX isn't quite killer app material, but it does offer an easy, zero-frills entry point to a world of near-compatibility. It may not seamlessly port every game into VR in the same way as a lovingly made mod, but it makes up for a lack of quality with quantity. Until Bethesda releases official versions of Fallout 4 VR and Doom VFR, it seems that's the best that VR gamers can expect.

Now, if you'll excuse me, I'm going to try to get VorpX working with System Shock 2., but I'd love to hear your thoughts too. Let me know what games you'd love to see ported to VR at [letters@custompcmag.org.uk](mailto:letters@custompcmag.org.uk) **CPC**

Follow Joe on Twitter at [@JoeThreepwood](https://twitter.com/JoeThreepwood) for real-time updates of objects he knocks over while exploring virtual worlds.



# THE MAKING OF TOTAL WAR: WARHAMMER

RICK LANE SPEAKS TO THE CREATIVE ASSEMBLY TO EXPLORE HOW IT ADAPTED ITS HISTORICAL STRATEGY GAMES INTO THE REALM OF FANTASY

**T**he Total War series made its name with its representation of historical conflict. It explored warfare in arenas ranging from the Roman Empire to Feudal Japan, from Medieval Europe to the Napoleonic Wars. Wherever the series has roamed, however, one factor has remained consistent – the nations, factions and armies it depicts all really existed.

Then, recently, the series took a dramatic shift into the realms of the fantastical. Total War: Warhammer merged the colourful armies and races of Games Workshop's Warhammer world with the vast and detailed real-time battles of Total War. It seems like a marriage made in heaven, bringing Warhammer miniatures to life on the battlefield, and letting Total War swap out its samurai and legionnaires for orcs and dragons. But how exactly did this marriage come together? And how did The Creative Assembly combine two long-running strategy games in very different mediums with very different rules?





Flying units such as dragons add huge tactical variety, but required technical changes to implement into battles

As it turns out, the idea of developing a fantasy version of Total War isn't a recent one. 'For at least 15 years, when the first few Total War games were being made, a lot of people wanted to do a fantasy version,' says Ian Roxburgh, game director of the Total War: Warhammer series. 'But things never worked out that way. We even had a few chats with various people, many, many years ago. But then, you know, time goes on, you make the history games and you build up a brand there.'

The notion of doing a Warhammer game specifically, however, is a more recent phenomenon. The Creative Assembly is a subsidiary company of Sega, which has its own links to Games Workshop through another subsidiary, Relic Entertainment, developer of Warhammer 40,000: Dawn of War. 'Four or five years ago, another conversation happened that just got a bit more traction. We forged a good relationship with Games Workshop,' Roxburgh says. 'When the opportunity to do Warhammer came along, and you know just how rich and vast this whole IP is, you could just see straightaway how it would be the perfect fit for Total War.'

## LAYING DOWN THE LORE

The decision to create a fantasy Total War would result in many new challenges. The initial phase of design, however, mainly involved researching the background and lore of Warhammer, a process that proved very similar to working on Total War's historical games. 'It's not just a bunch of rules for moving figures around on a tabletop. There's a whole, massive history there that goes back thousands of years,' says Jim Whitson, lead designer on both Total War:



The Mortal Empires campaign combines the first two games' campaigns into one huge strategy game

Warhammer and the sequel. 'We've got ideas as designers of things we'd like to do, features that we'd touched on in past Total War games ... you'll read something and think: 'Hey, that would be really good, if we just do a bit of tweaking here or add a new feature there!'

In addition to researching the lore of Warhammer, The Creative Assembly spent

much of the early design period playing the tabletop game. 'Very early on, Games Workshop very kindly sent us two of every model it's ever made,' Roxburgh says. 'It was great, because although there are already a lot of Warhammer fans in the office and on the team, other people who weren't necessarily familiar with it could grab a box of figures, take it home, paint them, come in and fight a battle.'

This process of background research and playing the physical game helped the team to learn how each individual unit worked, and how they could adapt it into Total War. One example is the Greenskins' Doomdiver catapult, an artillery weapon that fires a projectile with a living goblin attached, who steers the projectile toward the enemy. 'The way it worked mechanically is you'd fire the missile, but then you'd roll a dice and you'd get to choose which direction it scattered in order to home in on the enemy,' Roxburgh explains. 'We have a system in our game that can replicate that. So that's why now, if you have the Doomdiver catapult and you go into



Magic units such as the Goblin Shaman wield devastating spells, and balancing these spells required some wizardry on the part of the developers



## FEATURE / ANALYSIS

The first Warhammer let you play as the Empire, Dwarves, Greenskins and Vampire Counts

first-person mode, you can actually fly the guy around and direct him yourself.'

Warhammer's battles are turn-based, while Total War's battles happen in real time, which results in fundamental changes to the rules, such as the removal of dice rolls and a greater emphasis on a player's movements and their ability to react quickly to shifting battle lines. Roxburgh points out that the key to making that transition successful was to retain the flavour of each race. 'The Dwarves are about artillery. They're slow, strong and they have armour. So you get that in Total War, and you also get some of the little nuances about them; about the way individual units might work.'

Whitson, meanwhile, observes that Total War's depiction of Warhammer battles is really just a visualisation of a tabletop player's own imagination. 'You'll fire your Doomdiver and make several dice rolls, but in your mind you're seeing a little goblin in a pointy hat with wings strapped to his arms guiding himself into the target. It's not too much of a step to go from that to the Total War real-time battles.'

## BALANCE OF POWER

A more substantial challenge was replicating the sheer diversity of Warhammer's different armies. In the historical Total War games, the armies in each game operated on

broadly similar lines. In Rome: Total War, for example, nearly every army uses a mixture of infantry, archers and cavalry, while Napoleonic armies all rely on artillery and organised ranks of riflemen. You might have one faction that's better at artillery than the others, or can field a few unique units such as the War Elephants of Carthage, but otherwise, the weapons and tactics used by each game's factions tended to be similar.

Warhammer couldn't be more different. The Dwarves, for example, don't use cavalry, while the Vampire Counts have no ranged units whatsoever. This situation made balancing each faction, so it had no significant advantage or disadvantage in a real-time battle, extremely difficult. Indeed, there was serious discussion within The Creative Assembly about whether the team should scour the lore for units that could potentially operate as archers or cavalry units where the relevant faction lacked them. In the end, however, they opted to stick to the spirit of Warhammer.

'We decided we wanted to embrace that asymmetry, because that was very much the flavour of the Warhammer tabletop game,' Roxburgh says. 'And it became quite apparent that it actually created diversity and interest, and made you think about things in different ways depending on what faction or race you're playing ... it added massively to



Armies in the first game were limited in terms of which provinces they could capture

the tactical elements of our battles rather than detracting from them.'

Alongside the general problem of balance, the diversity of Warhammer meant each army posed a unique design challenge. 'Sometimes the art and animation side might be more challenging. At other times, the design of the gameplay may be more challenging,' Roxburgh says. That said, some races were more difficult to design than others, such as the Vampire counts. Alongside having no ranged units, the Vampires are fearless and don't rout in battle. Instead, they keep on fighting until their units take so much damage that they crumble to dust all at once, which was an especially tricky trait to balance. 'We wanted to really get that idea of the crumbling element of the Vampires; where they start to crumble and fade away. Using that in the battles was quite a big challenge,' Roxburgh adds.

## ADDING MAGIC

Alongside the breadth of Warhammer armies were entirely new features and abilities that The Creative Assembly wanted to include, but risked breaking the game to do so. One of them was magic. The developers loved the idea of lone wizards on the battlefield ripping into enemy ranks with devastating spells, such as fireballs and lightning storms. Yet while having a single goblin shaman devastate an entire army looks cool, from a strategic perspective, it destroys your game.

'You'll notice that if you cast a big spell, it will do X amount of damage in a balanced context with the rest of the battle, but the amount of units or entities within a unit that fly about as a result of this spell smashing into them is greater than the amount that actually die. Men will fly about and get up again, and some of them will die. We can create that spectacle without unbalancing the game,' Roxburgh explains.

Other new features required fundamental changes to Total War's technology. Flying units such as Eagles and Dragons are a core part of Warhammer's universe, and add a lot



The races of Warhammer II are arguably more colourful than the first. The Lizardmen, for example, can field dinosaurs into battle



The Vortex is the centre of the second game's new narrative-based objectives

of tactical flexibility to Total War, as they can interrupt cavalry charges and counter artillery. But figuring out how to implement them involved answering a lot of questions. 'How high should they fly? How do they negotiate around impassable objects? How are you going to see them when you're controlling this massive battle? Are you going to be able to keep pitching the camera up to be able to see them?' Roxburgh says. 'We had to make a lot of calls and do a lot of prototyping very early on to make sure these creatures could fly and contribute, but still be seen and form part of the battle.'

In the end, most of the decisions to which The Creative Assembly committed in Total War: Warhammer proved to be the right ones. The game was one of the most popular in the series, with the diversity of the game's armies and battles proving a hit with players, and far less controversial than the developers had feared.

'That was a massive piece of positive feedback, which we used as vindication to go on and take it a step further. If there had been a massive outcry, saying "Oh no, you've got to have archers as Vampire Counts, the game is shit", we would have considered that strongly. I'm not saying we'd just do what our fans suggest, but if people aren't enjoying what you're doing then you have to re-evaluate it.'

Indeed, not every aspect of the game was so wildly received. One element that provoked a mixed reaction was the limited terrain capture, which decreed that different races could only occupy specific territories. For example, the Empire couldn't occupy Dwarfven strongholds. 'It was very much a Marmite feature,' Roxburgh says. 'Around 50 per cent of people loved the fact that you could only capture certain territories, because they could appreciate how that changed your strategy on the campaign map. But then other people would say: "I just want to paint the map red, no matter what." So you kind of get that 50-50 split.'

The Creative Assembly considered that feedback when designing the sequel. Hence



Concept art for the Empire's Captains, the equivalent of spies in historical Total War games

one of the new features in Total War: Warhammer II is that any race can capture any province, albeit sometimes at a cost. Each province has a specific climate, and if your chosen race isn't suited to that climate, then it will be harder to thrive in that province than in your home territories. 'You've still got the opportunity in that sandbox to go and own a region that's right in the middle of that sandbox and not suitable for you, but you'll get penalties,' Roxburgh says.

## CREATING A NARRATIVE

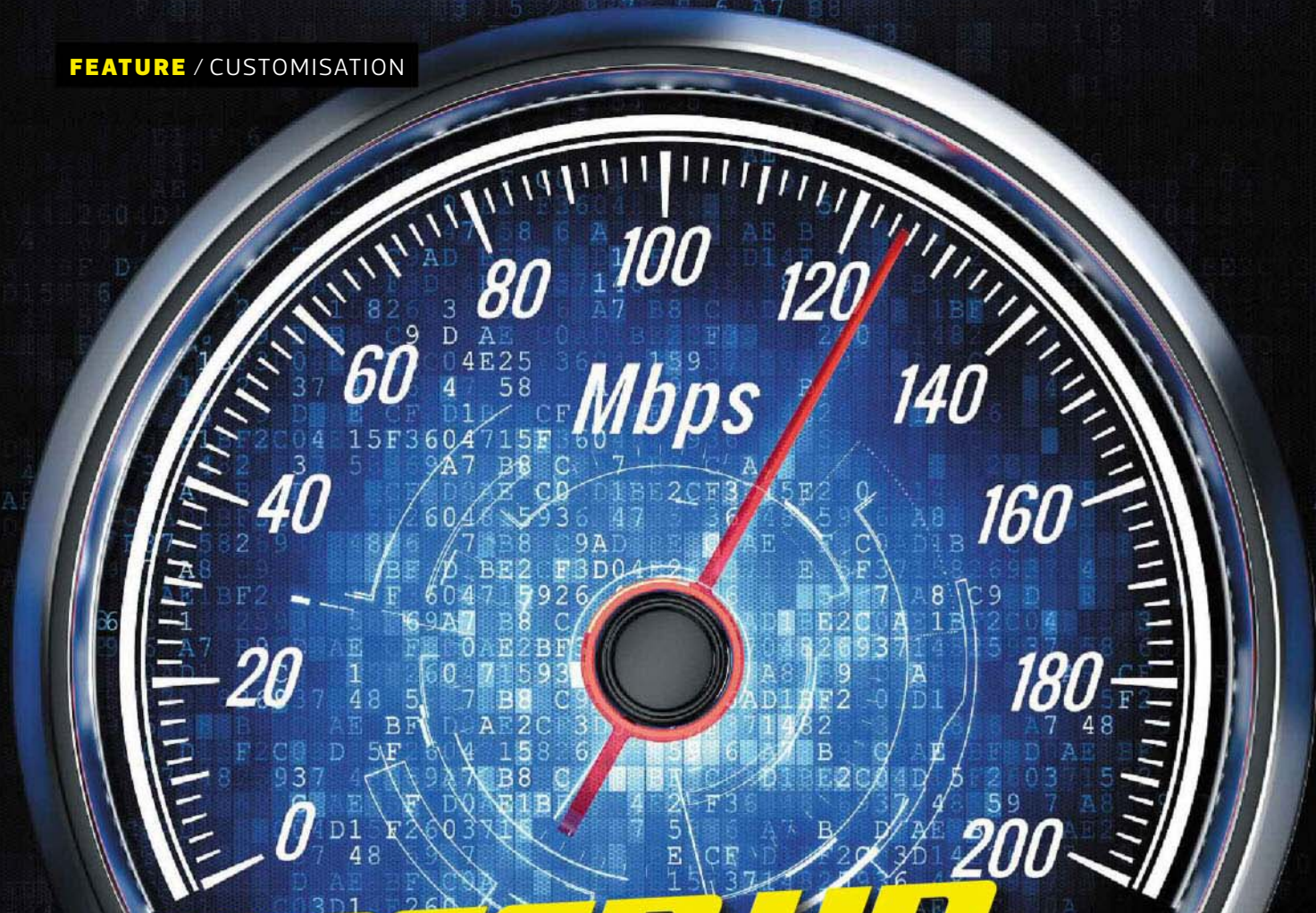
The biggest new feature for Warhammer II, however, was the introduction of story-driven campaign objectives. Again, like the fantasy setting, a central narrative was a feature the developers had wanted to introduce to the series for years. 'People do like games with a narrative; it helps them feel immersed in the game world. It helps them to become familiar with the race they're playing. It just adds so much more flavour to that sandbox environment,' Roxburgh says, 'but it's very difficult to do while maintaining a complete sandbox.'

The solution came in the form of the Great Vortex, a huge storm that swirls at the centre of the newly introduced High-Elf faction's homeland. The Vortex keeps the forces of Chaos at bay, but its power is weakening. Consequently, the game's four playable races – High Elves, Dark Elves, Lizardmen and Skaven – want to use this weakening as an opportunity to take control of it.

'It's the perfect example of the symbioses between those two game systems,' Whitson explains. 'As designers, we had ideas we wanted to tackle within the Total War game, but you open up those Army books and there it is – the great Vortex. The Lizardmen have obviously had a great deal to do with it. The High Elves created it. Malekith from the Dark Elves attacked it and tried to destroy it. So it's there staring you in the face.'

Although there have been bumps along the road, by and large, Total War and Warhammer have complemented each other superbly, and it's a relationship that's set to continue for the foreseeable future. The Creative Assembly had always planned Total War: Warhammer to be a trilogy, meaning there's a third game still to come. Not only that, but the developers recently released the Mortal Empires campaign, which combines the maps of Total War: Warhammer 1 and 2 into one huge campaign, and will add the third game to it once it's released. This campaign is freely available to anyone who owns both games.

'We'll look to continue the principles we've applied so far right to the end of the trilogy. We'll just keep bringing out new and interesting content, and as much free content as we can,' Roxburgh concludes. 'We're dedicated to continuing to improve and make the game better. We'll use our own internal and external feedback from everyone, and we'll continue to try to perfect the game as much as possible.' **CPC**

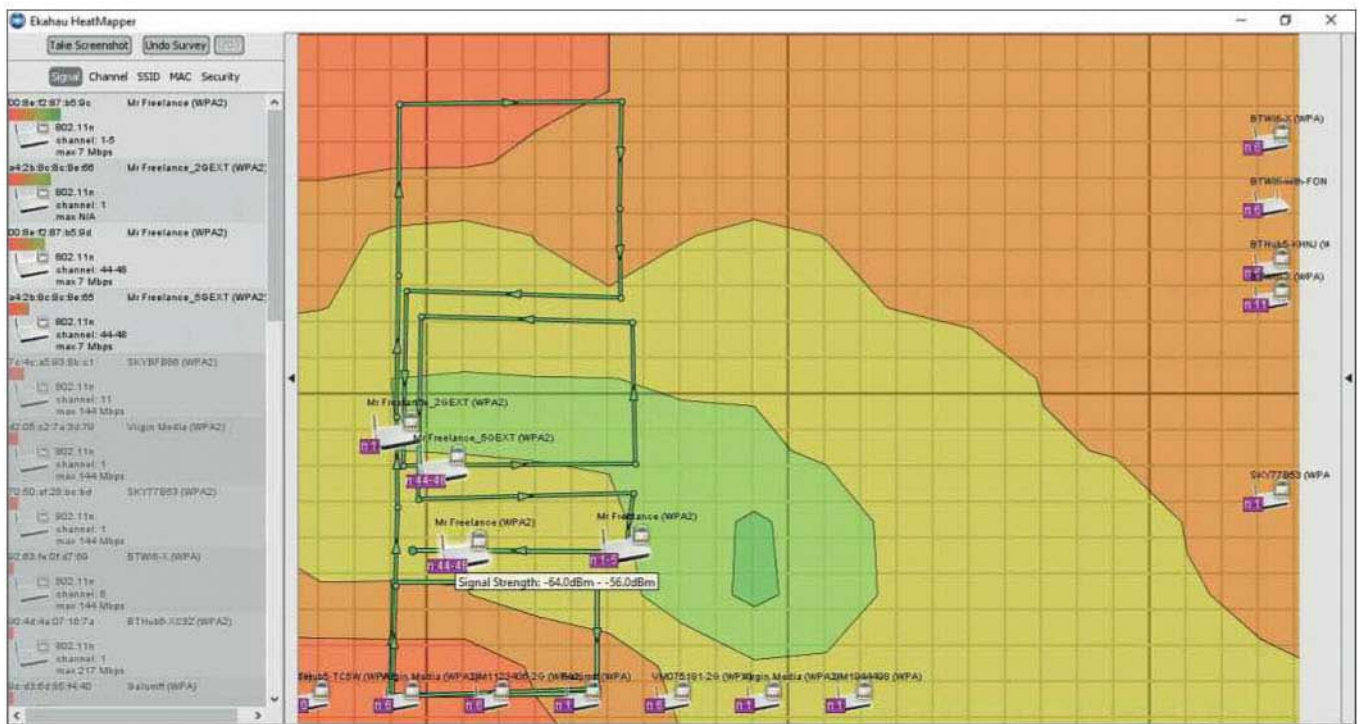


# SPEED UP YOUR WI-FI CONNECTION

*A PATCHY WI-FI CONNECTION CAN BE A CONSTANT SOURCE OF FRUSTRATION, BUT NIK RAWLINSON IS HERE TO SHOW YOU HOW TO MAKE YOUR WIRELESS NETWORK BEHAVE*

**S**low downloads; blank web pages; endless staring at the spinning loading circle in the middle of your screen. In an era when we expect information immediately, having a dodgy Wi-Fi connection can be one of the most irritating experiences of the modern world. One solution, of course, is to buy a new mesh router system (see p52), but that may not solve all your problems, depending on your setup, and there are lots of other ways to tweak your Wi-Fi network that may well give you a speed boost.

Your first job, however, is to make sure that the bottleneck is definitely your Wi-Fi connection, and not your broadband provider. Point your browser at [www.speedtest.net](http://www.speedtest.net) from a regular, Wi-Fi-connected laptop, and run the test to see what sort of connection speed you're getting. Then, repeat the test from a PC or laptop that's directly connected to your router via an Ethernet cable. If the second test generates a much higher result than the first, the problem lies with your Wi-Fi. But don't panic, as there are plenty of simple tweaks you can perform to improve matters.



### Router position and basic configuration

The first step is the easiest one: make sure your router or Wi-Fi access point isn't sitting on the floor. Even placing it on a low table can make a big difference to signal propagation. If that move doesn't immediately solve the problem, it's time to dig a little deeper to see where your network is really struggling.

A computer-generated heatmap of signal strength can be very useful here, giving you a graphical representation of the hot spots (and dead spots) on your network. There are plenty of heatmapping tools; Ekahau's HeatMapper for Windows ([www.ekahau.com/heatmapper](http://www.ekahau.com/heatmapper)) is a powerful, free tool that measures the fluctuating strength of the network detected by your laptop as you carry it around your home. This software lets you see the effect of moving your router to various locations – or, if you need to extend your network, you can easily see the best place to situate a Wi-Fi extender or second access point.

This latter option may be simpler than it sounds. If you have an old router knocking around that's been replaced by a newer model, you can easily set it up as a secondary access point. This setup allows you to divide up your traffic to streamline it and reduce interference: the older router can serve older smartphones and tablets using 802.11n, while your current router runs a dedicated 802.11ac network for the devices you use most often.

If you're setting up multiple wireless networks in your house, pay attention to the channels on which they're transmitting. Manually set them to broadcast on channels at least five spaces apart to avoid overlap and minimise interference. Look out for channel width too. A narrow channel (encompassing fewer frequencies) will be less prone to interference, as it's less likely to conflict with neighbouring networks. If your hardware allows it, set a channel width of 20MHz.

### Check your neighbours' Wi-Fi

On that note, one common cause of slow Wi-Fi is interference from neighbours' wireless routers. Check which channel they're using for broadcasting, and pick a different one for your own network. The easiest way to check the channels used by neighbouring networks is by using a phone app such as Wifi Analyzer for Android (<http://tinyurl.com/WifiAnalyze>) or Airport Utility for iOS (<http://tinyurl.com/AirPortUtility>).

Although AirPort Utility only scans for Apple base stations by default, there's an option to scan all Wi-Fi networks available at your location.

Each network's channel is displayed below its name in the results. As you can see from the image (right),

**Ekahau's HeatMapper gives you a graphical representation of the hot spots and dead spots on your network**

**Check which wireless channels are being used by nearby networks, then choose a different one for your own home**

two of the networks available at our location use channel 6 and two use channel 1, so there's lots of potential for interference and impeded performance.

It's worth rechecking which channel is the least congested every few months or so. Whenever one of your neighbours upgrades or switches providers, there's a good chance they'll end up with a new router that defaults to a different channel, potentially impacting your own online experience.

### Secure your network

If your neighbours' networks are leaking into your house, your network is most likely doing the same to theirs. If your network isn't protected with a WPA2 password then anyone within range could be connecting and bogging down your connection. You may have also read recently that researchers have discovered some security

vulnerabilities in the WPA2 protocol, so look at your router manufacturer's website to see if there's a new firmware update patch for it that addresses these issues too. Set a long, unguessable password for access – after all, you shouldn't need to enter it too often. For extra security, consider hiding your SSID, so that your network can't even be seen by people who don't know its name.



In the past, we would also have recommended enabling MAC address filtering, which only grants access to devices whose physical hardware ID appears on the router's whitelist. However, some devices now randomise their MAC addresses as a security feature – Apple devices running iOS 8 or later use random MAC addresses when scanning for available networks, for example – and it's not difficult to spoof these addresses, making this function less useful than previously.

**Enable Quality of Service of Service**

Not all traffic is equal. Emails and web pages are lightweight compared to VoIP and media streaming, so if your Wi-Fi tends to suffer most when you're watching Netflix or Skyping family members, check whether your router allows you to prioritise these uses over other traffic.

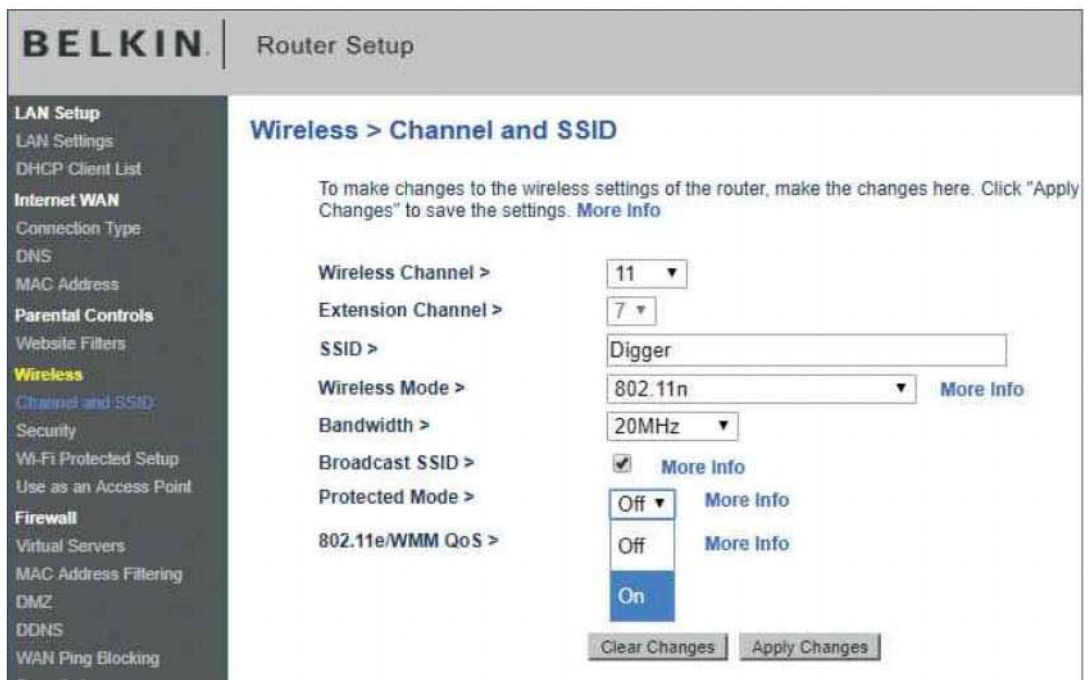
You'll need to dig into your router's configuration interface to switch it on, and the exact process will vary from device to device, but look for WMM (or WME) QoS, which examines traffic passing through the router and ranks it according to its detected type.

VoIP gets top priority, to minimise latency, with streamed media placed second, so you can reliably watch a handful of simultaneous standard-definition streams or one high-definition broadcast.

So-called 'best effort' packets, classed as any data packets from devices that don't explicitly support QoS are ranked third; the final classification is background tasks, such as print jobs and file downloads. The latter get the lowest priority, since latency issues and the odd stumble won't normally be noticeable for this type of traffic.

**Share a wired connection**

If you have a PC that's connected to your router over Ethernet, it may have a built-in wireless interface



**Quality of Service lets your router prioritise more demanding traffic over background tasks, such as downloads and print jobs**

that's sitting idle. You can configure this Wi-Fi connection as an access point, to share your network connection with nearby devices. These devices can then latch onto a stronger signal.

What's more, it will mean your router has to deal with less wireless congestion and interference, since fewer devices are communicating directly via its antennae.

Start by opening a new Command Prompt in Windows – type 'cmd' into the Start menu Search bar, or navigate to Windows System in the Start menu and click on Command Prompt. When the Command Prompt appears, type 'netsh wlan show drivers' (omit the quotation marks in all these commands) and hit Return. Wait for it to return a result (which may take several seconds), and look for the line 'Hosted network supported'. If the variable beside it says 'Yes', you can set up your PC as an access point.

To set up your new access point, type 'netsh wlan set hostednetwork

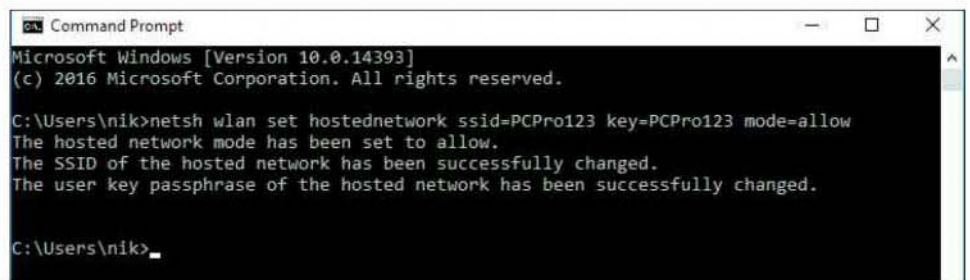
ssid=CPC123 key=CPC123 mode=allow' – changing the first CPC123 to the name you want to identify the network, and the second one to the password clients will need to use to connect. Hit Return, wait for the process to complete, then activate the network with 'netsh wlan start hostednetwork'. The SSID you set should now show up in the list of available networks on other devices within range.

Reversing the process is as simple as changing some of the variables we've already entered at the Command Prompt. To stop sharing your network, enter 'netsh wlan stop hostednetwork', and to disable it, use 'netsh wlan set hostednetwork mode=disallow'.

**Upgrade your firmware**

If you're happy to get your hands dirty with open-source software, you may be able to replace your router's firmware with a powerful free system called DD-WRT. Be warned that doing so will almost certainly

**Sharing your PC's network connection is a quick way to extend Wi-Fi coverage in your home**



void the warranty on your router, and, if you're renting it from your ISP, possibly be in breach of your terms and conditions. However, if you're happy to give it a try, you can check whether your router is supported, and find out how to install the firmware, using the DD-WRT router database (<http://tinyurl.com/RouterDatabase>).

Once installed, DD-WRT gives you access to a lot of functions that are frequently not supported by the default firmware. Not all of them address Wi-Fi speed issues, but you may be interested in tools such as Afterburner, which improves speed performance on compatible client devices, and provides more granular QoS support.

Indeed, DD-WRT's QoS features alone could make it worth the installation: in addition to looking at data types, you can directly specify which ports or interfaces should be given the greatest bandwidth, and target different machines through MAC address interrogation.

### Upgrade your router

If none of these steps does the trick, it may be time to upgrade your router. If you're using a router that came bundled with a budget broadband connection, or if you haven't

## POWER UP YOUR NETWORK

If you have an older house with thick stone walls – or a new house with eco-friendly insulation – you may still find your Wi-Fi signal has trouble reaching the furthest points, which will impact performance. In that case, the simplest solution is often to invest in an inexpensive powerline networking kit, which routes network traffic over your domestic mains circuit.

These kits cost less than £50 inc VAT for a basic pair of plugs; one connects to an Ethernet port on your router, and the other can be located wherever it's needed, to connect a computer that's too far away for a reliable Wi-Fi signal. In our tests, they're nowhere near as fast as Gigabit Ethernet, or even solid 802.11ac Wi-Fi, but they're a great alternative if your options are limited.

More expensive Powerline kits have their own built-in Wi-Fi access points at the remote end, which reduces the associated cabling and makes it easy to connect several devices at once. Look for plugs with pass-through power sockets so you don't lose a wall socket, and don't plug powerline gear into an extension lead, or you risk degrading performance.



Powerline networking kits conveniently extend your wired network through your ring main

upgraded for a few years, it could be the case that your current router simply can't handle the pace.

Look for a device with MU-MIMO (Multi-User Multiple Input Multiple Output), which connects to each of the clients on your network at the same time, rather than dealing with them in turn, round-robin style. Also check that the router supports beamforming, a clever radio

**It might be time to upgrade your router. Look for one with MU-MIMO, such as the Elite-listed Netgear Nighthawk X4S R7800**

technique that focuses the Wi-Fi transmission on the client, rather than allowing the signal to fan out in all directions, as with older routers. A more focused signal will likely be stronger and faster than one that's sent in all directions at once.

If you have money to spend and struggle to get a decent Wi-Fi connection across your whole house, it's also worth investing in a mesh router (see p52), which will string together at least two boxes, and sometimes more, which you can spread round your home, but they will be seen as a single Wi-Fi network.

Not only will you then get better coverage around your home, but you also won't have to fuff around with range extenders and having to connect your devices to multiple networks.

It's clear that there's no magic bullet to guarantee to turn a slow Wi-Fi connection into a fast one though. The best approach is to work through the above tweaks and fixes in turn, and when you find one that works, try rolling back the others to see what difference it makes. The fewer adjustments you need to make, the better, as the next time you experience degraded performance, it will be easy to keep track of what's changed and what might need further refinement. **GPC**





GARETH HALFACREE'S

# Hobby tech

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

## REVIEW

## DFRobot LattePanda

It's fair to say I see a lot of single-board computers (SBC) pass through the office for testing, and they're almost always based around the ARM instruction set architecture (ISA). That's no surprise. ARM, now owned by Japanese technology giant SoftBank, provides the intellectual property that goes into the overwhelming majority of chip designs for mobile, embedded and other low-power markets – it's exactly what you want for an SBC.

The LattePanda, though, ditches convention and hitches its wagon to the x86 ISA with a key focus on a very particular market: Windows developers who fancy a go at low-power embedded work, but who don't want to have to learn an entirely new platform on which to do so.

Based around the 64-bit Intel Atom x5-Z8300 quad-core processor running at 1.44GHz (core) and 1.84GHz (single-core burst), the

LattePanda has power to spare and includes 2GB of DDR3L RAM and 32GB of eMMC storage, while a higher-end model includes 4GB of RAM and 64GB of storage.

In either case, the LattePanda includes a copy of Windows 10 pre-installed. It's not the cut-down Windows 10 IoT Core of the Raspberry Pi either – it's Windows 10 Home 64-bit. Connect a keyboard and mouse, and

you're free to do any task you could on a similarly-specified desktop, but on a bare PCB marginally larger than a Raspberry Pi.

The Pi is, naturally, the go-to comparative for these reviews, and the LattePanda can certainly hold its own. The 2GB RAM/32GB storage version on test completed a SysBench CPU run in 20.83 seconds single-threaded and 5.96 seconds multi-threaded, compared to a Raspberry Pi 3's considerably slower 182.23 seconds and 49.03 seconds respectively.

The same proved true throughout our benchmarks, with the

LattePanda's 4,917 Dhrystone MIPS and 1,727 Whetstone

MWIPS outstripping the Pi's 2,458 MIPS and 711

MWIPS. Likewise, the

LattePanda's 1,557 Linpack

single-precision MFLOPS was

way ahead of the Pi's 193.36

MFLOPS unaccelerated and

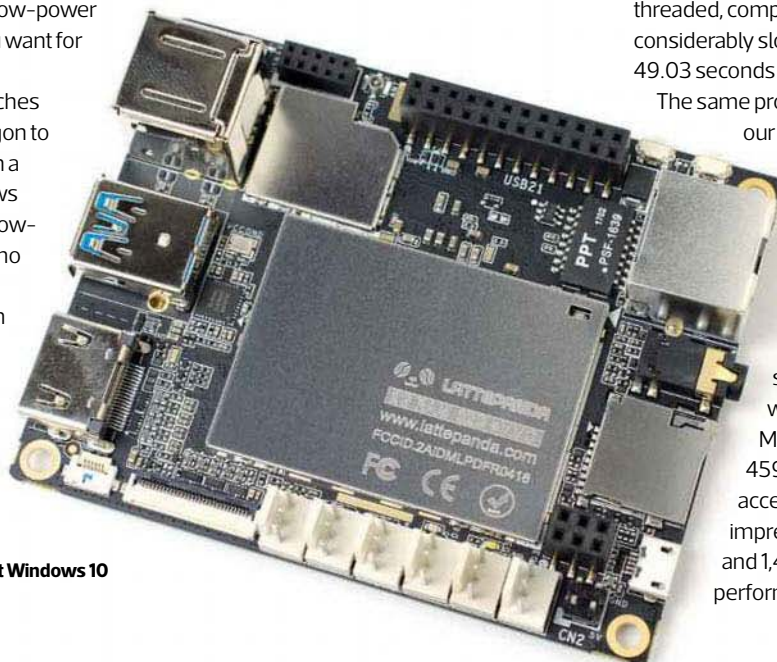
459.18 MFLOPS with NEON

acceleration. Finally, the

impressive 1,012MB/sec write

and 1,446MB/sec read memory

performance, compared to the Pi's



**The LattePanda boasts a full 64-bit Windows 10 install and integrated Arduino**



**The top RF shielding hides barely anything of interest, bar a surprisingly hot-running Wi-Fi module**

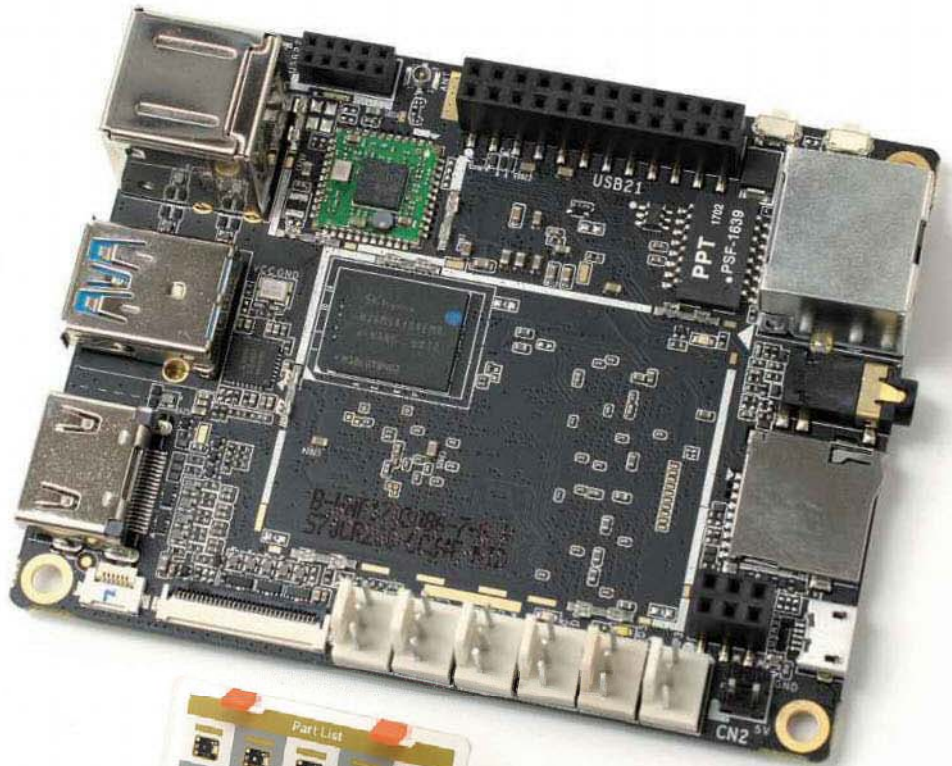
305MB/sec and 354MB/sec respectively, show the LattePanda to be one of the fastest devices ever featured in Hobby tech.

Performance, naturally, comes at a price. The LattePanda draws around 0.31W while idle and 0.91W under peak CPU load, a significantly higher figure than the Raspberry Pi 3's 0.58W peak for the same workload. This disparity is exacerbated by Windows 10 itself; switching away from an Ubuntu Linux boot for benchmarking purposes, another handy feature of a standards-compliant x86 system, back to Windows 10 causes the power draw to jump to 0.55W when idle and 1.33W at peak load.

Where there's power, there's heat. A look under the thermal camera reveals a number of hotspots beneath the metal shielding on both sides of the board. Removing these shields reveals the sources: an upper hotspot is caused, surprisingly, by a Wi-Fi and Bluetooth piggyback module, while the three rear hotspots are the DDR3 modules, the Atom system-on-chip (SoC) itself, and a power management chip (PMIC).

A closer look shows that the Atom is entirely reliant on the thin, shiny shielding for its thermal management, using the metal as a heatsink. Sadly, an ineffective one: under sustained load, the Atom begins to hit its thermal throttle point very quickly, especially if you're running the LattePanda on a desk where the shield is unable to bleed off the heat. Removing the shield and applying a proper heatsink with thermal tape or epoxy improves matters, and doesn't void your warranty, but potentially exposes potentially exposes the system to radio interference.

Interestingly, the LattePanda doesn't rely on the Atom for its general-purpose input/output (GPIO) capabilities. Instead, the Atom is



**An optional sensor kit connects to the Grove-style pins and communicates with the Atmel microcontroller**

connected to an on-board Atmel microcontroller – equivalent to the one you'd find on an Arduino Leonardo.

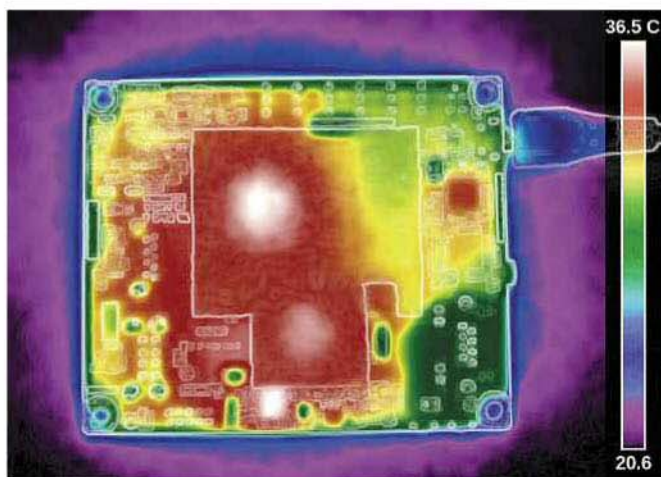
The official instructions for its use are geared towards Windows users coding in Visual Studio, but there's a copy of the Arduino IDE pre-installed – albeit the ancient

1.0.6 version, which you should upgrade at the earliest opportunity – if you prefer.

A 2.5mm female header at the top of the board provides access to the microcontroller's GPIO pins, and they're also broken out at the bottom in Grove-style connectors, which are compatible with the optional sensor box's range of add-on hardware.

Another welcome extra for the LattePanda is a 7in 1,024 x 600 LCD panel, which connects to the board's DSI connector and can be used as a primary or secondary display.

You'll pay dearly for all this gear though: the 2GB/32GB LattePanda we tested is available now from <http://uk.rs-online.com> priced at £83.99 (or £113.99 with a Windows 10 Home licence), while the sensor starter kit costs £53.99 and the LCD is priced at £31.19 (all inc VAT). At the time of writing, RS didn't stock the 4GB/64GB version, or the touch-screen overlay for the LCD.



**The decision to use the RF shielding as a heatsink sees the Atom hitting its thermal throttle point quickly under load**



**Full-fat Windows 10 Home makes a distinct change from the cut-down Windows 10 IoT Core of its rivals**

INTERVIEW

Joel Hughes, Indiegogo

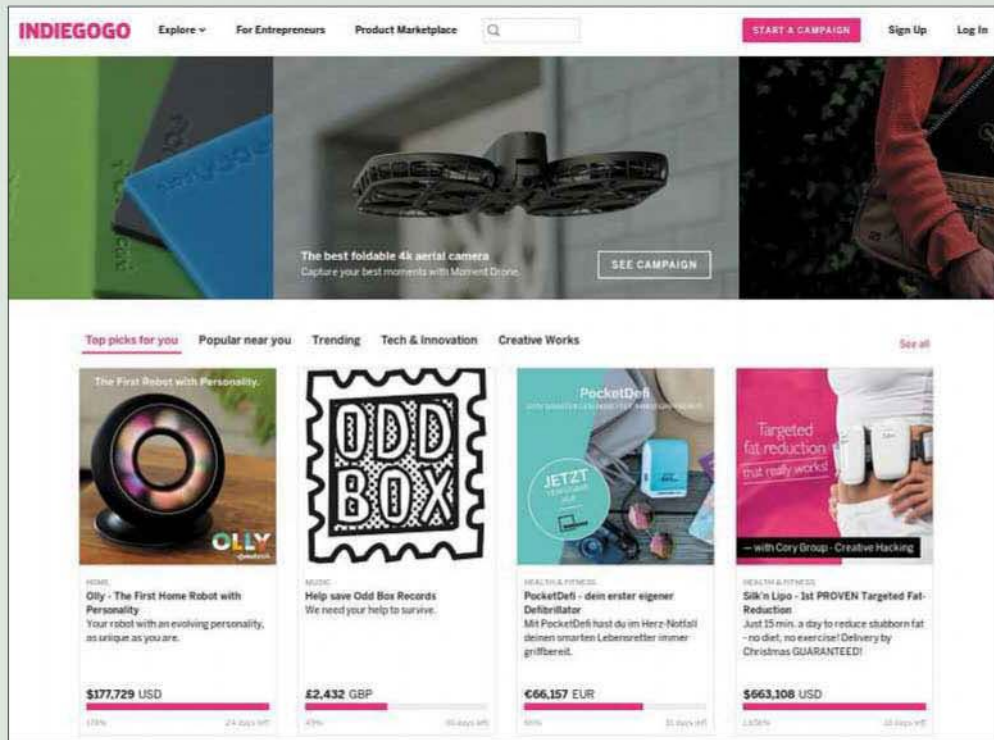
It's a platform for entrepreneurs, startup businesses, existing businesses and corporates as well,' a clearly enthused Joel Hughes explains by way of introducing his employer, crowdfunding site Indiegogo. We're sitting in the press tent at TechBBQ 2017, a two-day event primarily designed to showcase the best and brightest technology talent in Denmark and the Nordics, but which has attracted attendees from around the world.

'Essentially, we want to democratise funding as much as possible and level the playing field for people with great ideas,' Hughes continues, as the sound of gunfire rings out through the hall – it's simulated, thankfully, during a product demonstration on the main stage from a startup seeking to produce realistic imitation firearms for the entertainment industry. 'We're an enabler. We support people who are taking great new products and innovative ideas to market, and help them with that process.'

Nobody should be surprised at the concept of crowdfunding in 2017. The idea of selling ideas directly to prospective customers, cutting out the middleman and the need to seek bank loans or venture capital to fund a production run, is well established – and extremely lucrative. 'There's a campaign called the Mate e-Bike. It raised in excess of \$5.5 million US after the campaign launched last year,' Hughes tells me, reeling off a list of other campaigns he feels also exemplify the potential of the crowdfunding platform.

Mate is an example of success, but not every campaign always goes so smoothly. 'Unfortunately, there are sometimes campaigns that don't have the necessary means to fulfil on time, or issues crop up,' says a suddenly hesitant Hughes, as the topic of the ZX Spectrum Vega+, a retro gaming console funded to the tune of over £500,000 on Indiegogo and

**Indiegogo's Joel Hughes sees his company's role as being at the heart of 'democratising funding'**



Indiegogo lets you raise funds for almost any project, from pre-prototype concepts to ready-to-ship stock

currently running more than a year over schedule with only silence from its creators, comes up.

Speaking only generally, Hughes explains one possible reason for crowdfunding companies to go dark: 'If you think about a

company that's maybe attracted thousands of customers, and they've scaled up perhaps too quickly, they don't have the resources internally to respond to all of these comments, and also at the same time to continue to develop the product and get it as close to fulfilment as possible.

'We listen to feedback from backers about that, and three weeks ago implemented an update to our system that now requires campaign owners to post at least one update every month,' Hughes adds. 'That's the biggest pain point, I feel, that our backers have: they feel they're getting a real lack of information. I don't feel, the majority of the time, that it's malicious from the campaign owners' perspective at all. I think they're busy doing their own thing and almost forget about the comment section a little.'

The requirement to post monthly updates is one of a range of recent tweaks designed to encourage confidence in the platform, Hughes tells me. On the topic of creating campaigns based around nothing but ideas and shiny rendered images, Hughes explains Indiegogo's reasoning:

'[Campaign creators] have to



Reviewed in Issue 171, the Gamebuino is a great example of an Indiegogo project that delivered on its promise



‘Really, it’s up to the market to do the necessary checks, and be happy supporting a campaign that’s in Concept stage’

select a category, you have to categorise yourself. They have the option of it being a Concept, which is the rendered images or the not-quite prototype stage, or you can choose Prototype Production or Shipping.

‘We want to make it as wide-ranging and as wide-reaching as possible for people, and then of course, the self-regulation is very important. Really, it’s up to the market to do the necessary checks, and be happy that it’s supporting a campaign that’s in concept stage and understand that there are risks associated with that.’

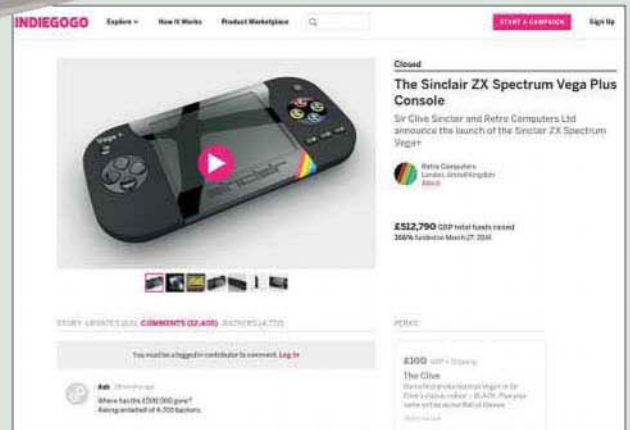
For campaign creators, Hughes is clear about what makes the difference between a successful campaign and a failure. ‘Don’t try to do it alone,’ he offers, tapping a finger against his palm to emphasise each point in turn. ‘Build a team around you, or find the skills somewhere else. Grow your community. Spend time and, if possible, resources on a good video. And reach out ... Actually, reach out to us, reach out to

Indiegogo. If the campaign looks like it has legs, and it has potential, there’s probably something we’ll be able to help you with.

‘The reason the crowdfunding success rate is so low is because there isn’t enough understanding about what you need to run a successful campaign,’

Hughes laments in closing, getting ready to head back to the airport.

‘So that’s what I’m doing all the time, trying to hammer it home to people that they can talk to us, that there are resources



A year past its target date and with silence from its creators, the Vega+ project highlights the risks of crowdfunding

available online that they can look at and learn from and, you know, don’t put a great idea online unless you’ve done the necessary preparation.’

## NEWS IN BRIEF

### New Arduino wireless microcontrollers

The Arduino Team has announced two new microcontroller boards, focusing on wide-area networking: the Arduino MKR WAN 1300 and the MKR GSM 1400. Both boards are based on the MKR Zero gumstick-style footprint, and include the same Microchip SAM-D21 Arm Cortex-M0+ microcontroller. However, the WAN 1300 uses a Murata radio module for connection to networks based on the popular LoRa standard, while the GSM 1400 uses a u-blox modem for a GSM mobile network connection. Pre-orders have opened at €35 for the WAN 1300 and €59.90 for the GSM 1400 (around £31 and £53 respectively, exc tax).



OPINION

# Cambridge Computers Z88

**W**hen you have a hammer, the saying goes, every problem looks like a nail. When you have a collection of vintage computing hardware, I'd add, you can't help wonder how to make better use of devices that would have been cutting-edge when they originally launched years ago.

Regular readers may recall my writing about the Amstrad Notebook Computer 100 in Issue 119, but my NC100 had to find a new home, as I cleared out the office after the birth of my second child, and since then, I've felt diminished in my nostalgic techno-hipsterism every time I pull out a modern laptop to make notes.

Enter the Z88. Created by Cambridge Computers in 1987, the Z88 is immediately recognisable as a product of Sir Clive Sinclair – the 'innovative' rubber keyboard is a dead giveaway. Similar in layout to the NC100, the Z88 is a black slab of roughly A4 size, powered by AA batteries that are good for 20 hours of active use and a year on standby.

Its display, at 64 vertical by 640 horizontal pixels, is hardly high-resolution and entirely unusable in the dark, but it's clear and crisp in good lighting. There's even room for solid-state storage, although not in the way you might recognise it today; expansion cards slot beneath a cover at the front base, offering RAM expansion, utilities loaded onto ROMs and non-volatile EPROM storage for any data you'd hate to lose.



Look like a standard nine-pin serial port? Sir Clive would like a word with your wallet



Written in Python, Z88 transfer makes getting files on and off the Z88 a breeze

Like the NC100, the Z88 is a prime candidate for on-the-go vintage computing. Unlike the NC100, though, the Z88 has a few little intricacies that make its integration with modern systems a little tricky. The first is what appears to be a nine-pin serial port at the side,

which uses a custom pin layout, meaning off-the-shelf serial cables simply won't work. If you wire up your own cable, you can begin to transfer files to and from the device using the built-in Import/Export utility, but it's a laborious process: file names must be entered by hand and the transfer uses a custom protocol, rather than the common Xmodem protocol available on the NC100.

A quick scour on the auction sites bought me a Cambridge Computers PC Link kit. Inside the packaging is a pair of floppy disks – 5.25in and 3.5in – with the PC Link software, a ROM cartridge with the server to run on the Z88, and a custom 9W to 25W serial cable.

Problem number one: all my USB RS232 dongles have 9W connectors. A hunt through various boxes still not catalogued following the office move found a surprisingly new Belkin-branded cable with both 9W and 25W connectors at both ends. A 25W gender changer sorted out the physical connection, and I should have been away.

However, after a couple of hours with nothing going in either direction, I pulled out a multimeter and confirmed my suspicion: the Belkin cable is a crossover, or null-modem, cable – a cable-type I'd half-forgotten in these days of ubiquitous USB connectivity.

With the connections shifted, I was able to talk to the Z88, and a copy of Z88transfer from <http://rastersoft.com> gave me an interactive file browser that's a million miles away from the original DOS-based PC Link II software. How well does it work? Well enough to write this column entirely on the Z88, which is good enough for me. **GPC**

NEWS IN BRIEF

## Mini Commodore 64 announced

Fresh from the hype surrounding Nintendo's vintage console remakes comes an announcement from Retro Games that it's bringing back the Commodore 64 – sort of.

Roughly half the size of the original, TheC64 Mini includes 64 pre-loaded games, HDMI video and audio output, and a USB joystick. What it lacks, however, is authenticity: the device is reportedly based around an ARM processor running software emulation, and the keyboard is entirely non-functional, which the company says it will address with a larger model later in 2018. TheC64 Mini will launch in early 2018 at £69.99 (inc VAT), with more information available from <https://thec64.com>



Gareth Halfacree is the news reporter at [www.bit-tech.net](http://www.bit-tech.net), and a keen computer hobbyist who likes to tinker with technology. [@ghalfacree](https://twitter.com/ghalfacree)

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ANTONY LEATHER'S

# Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

## Water-cooling AMD's Radeon RX Vega

While AMD's Vega GPUs are a tad disappointing given the wait, we were interested to see if there was much scope for improvement. After all, the Vega 56 might not have blown us away, but it's at least competitive with Nvidia's GeForce GTX 1070. There's nothing you can do about stock levels, of course, or the fact that prices are a little higher than the initial RRP too. What you can fix, though, is the awful stock cooler that seems to be fitted to nearly all the Vega cards.

When I was writing this column, some shots of Asus and Gigabyte Vega cards sporting triple fan coolers had appeared in the press, but two months on from the launch, we're still waiting for separate third-party coolers that can tame these toasty GPUs. It's no wonder that AMD has resorted to cooling top-end Vega cards with all-in-one liquid coolers. There's scope for water-cooling Vega though. EK Water Blocks recently sent me its Vega waterblock and, to cut a long story short, you'll see a lot more performance, even at stock speed, if you water-cool a Vega GPU.

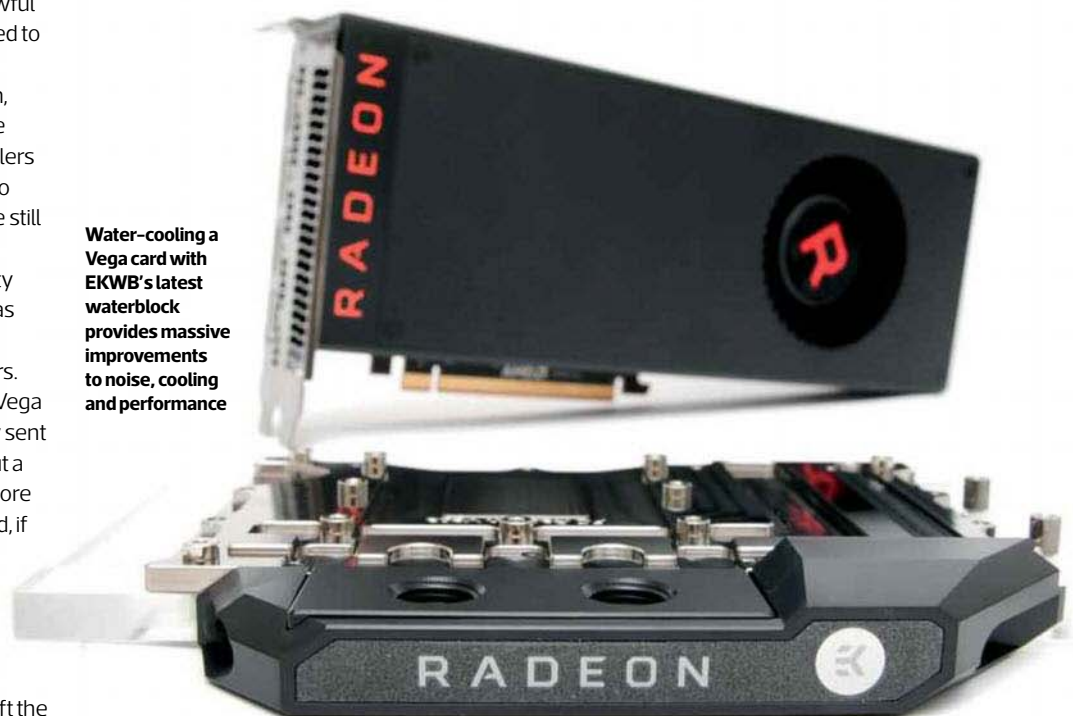
I carried out some testing with a Vega 64 to see just how much it was limited by the stock cooler and the results were quite surprising. To start, I left the

card at stock speed and didn't touch any power or fan settings. The temperature peaked at 80°C, the core frequency at around 1400MHz and it scored 5,797 in the 4K Unigine Superposition benchmark. Using water cooling, the score rose to 6,026, the temperature fell to just 35°C and the core speed would regularly rise to 1500MHz throughout the benchmark.

I then increased the temperature and power targets to their maximums,

and this saw the stock speed score rise a few points to 5,819, thanks to a small increase in the reported peak frequency, but the temperature sat at the limit of 85°C, so the card was still clearly throttling. Amazingly, the water-cooled card leaped ahead here, with the extra power allowing the score to rise to a massive 6,455 – that's 11 per cent faster than the air-cooled card and the temperature only reached 40°C.

**Water-cooling a Vega card with EKWB's latest waterblock provides massive improvements to noise, cooling and performance**



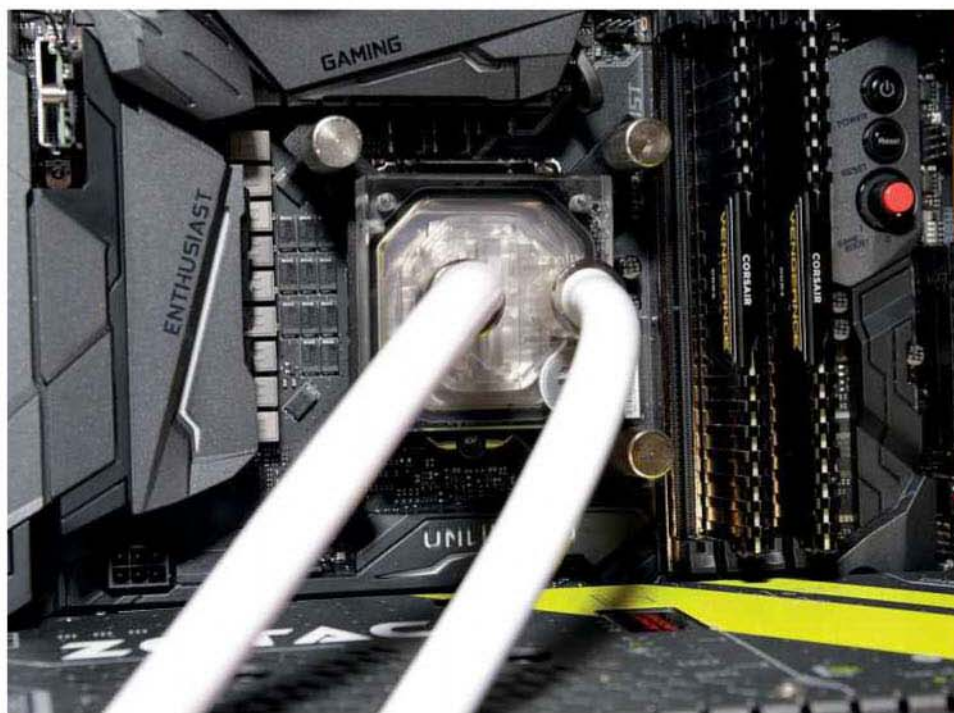
Next, I increased the fan speed on the stock cooler to an ear-splitting 4,000rpm and also applied a 4 per cent overclock. This tweak saw a big boost to the Unigine Superposition 4K score, returning 6,149 before the temperature again hit 85°C, with the peak GPU frequency hitting 1570MHz thanks to the better cooling. The water-cooled card again battered these results, though, with a score of 6,555, which is 7 per cent faster, while the core frequency topped 1650MHz and the core temperature never rose above 43°C – a massive 42°C cooler than with the stock cooler.

If you're thinking of buying a Vega card, perhaps to get the benefits of FreeSync, I can highly recommend water-cooling it, even at stock speed. Even if you push the stock cooler to a deafening 4,000rpm, the results and cooling still pale against a water-cooled card, which was barely audible by comparison. In addition, if you can't afford or don't want to water-cool your Vega card, then it's definitely worth waiting for a third-party card with a big cooler. It will be quieter and will likely offer much better performance, even if it's running at stock speed. You can see a full guide on how to water-cool a Vega GPU on p104.

### Is it worth water-cooling Coffee Lake?

I was a little disappointed with Skylake-X CPUs. They're fast in heavily multithreaded software, but Intel's use of thermal paste between the CPU die and heatspreader seems to be hampering thermals significantly. So much so, in fact, that even water-cooling the CPUs doesn't really add much benefit in terms of cooling, with a clear bottleneck being this thermal paste. Meanwhile, delidding the CPUs – removing the heatspreader and applying a high-performance thermal paste – offers a huge reduction in temperatures and greater overclocking headroom, according to leading overclockers.

That's a shame, because when I water-cooled an AMD Threadripper CPU last month, it showed some decent gains compared with an all-in-



one liquid cooler and even managed to increase the overclock. You don't need to worry about replacing the thermal paste in Threadripper and Ryzen CPUs either, as they all feature solder between the die and heatspreader. Delidding isn't for everyone, of course, as it carries a risk with it, but if I were buying a Skylake-X CPU, I would definitely consider delidding it, even with an expensive model.

So what about Coffee Lake? Again, we're not dealing with a soldered die here, and the CPU architecture isn't massively different from that of its predecessors. However, the CPUs have more cores than their Kaby Lake counterparts, and they also have a tweaked power delivery system (which is why the new CPUs aren't compatible with Z270 motherboards), so I still wanted to see if any gains could be made from water cooling.

To start, I used an NZXT Kraken X42 to push our Core i7-8700K to its limits, and with a 1.26V vcore, I reached 5GHz across all cores, with the CPU temperature topping 85°C. Increasing the voltage to 1.35V did see stability at 5.1GHz, but the temperature was then just too toasty for the all-in-one liquid cooler, even with the fan and pump at maximum speed.

**Water-cooling Coffee Lake enabled us to get the CPU frequency all the way up to 5.1GHz**

Switching to custom water cooling, I used an EKWB Supremacy Evo, along with the company's X-Res D5 pump and reservoir, and a 60mm-thick double 120mm-fan radiator, all just hooked up to the overclocked Core i7-8700K. With the fans at their full speed of 2,300rpm, the new cooling system knocked 5°C more off the load temperature, which sat at 80°C when the CPU was running at 5GHz with a 1.26V vcore. Suspecting this might be enough cooling power to get to 5.1GHz while remaining stable, I plumbed in 1.35V and a multiplier of 51x, and managed to get the load temperature stabilised at 92°C. Clearly, this temperature is very warm, but it wasn't possible with our CPU using even a fairly potent all-in-one liquid cooler.

Is it worth it for performance? Well, at 5.1GHz, the CPU scored 1,670 in Cinebench, while at 5GHz, the score dropped to 1,646. It's a welcome gain but not worth spending an extra £100-150 on your cooling system. Again, though, the Alphacool fans I used were much quieter than those on the NZXT cooler at full speed, so you'll gain some noise reduction, as well as lower temperatures and slightly more overclocking headroom, if you water-cool your Coffee Lake CPU. **GPC**

# How to Water-cool a Radeon Vega graphics card

Antony Leather shows you how to get the most out of Vega by banishing the stock cooler and adding a waterblock

**TOTAL PROJECT TIME / 1 HOUR**

**A**s we found in Customised PC this month (see p102), water-cooling a Vega GPU is very beneficial. You can knock over 40°C off the load temperature, drastically reduce noise and also increase performance by up to 11 per cent, even at stock speed. If you're considering buying a Vega GPU, perhaps to reap the benefits of FreeSync, but don't want the stock cooler, your new card will respond extremely well to water cooling.

This month, EK Water Blocks has sent us its EF-FC Radeon Vega full-cover waterblock, and here, we'll show you how to remove the stock cooler and fit the waterblock. Bear in mind, however, that proceeding will likely void your graphics card's warranty.

## TOOLS YOU'LL NEED



GPU waterblock / [www.overclockers.co.uk](http://www.overclockers.co.uk)



Small screwdriver / Most hardware stores



Isopropyl or thermal paste cleaner / [www.overclockers.co.uk](http://www.overclockers.co.uk)



### 1 / IDENTIFY YOUR CARD

Most current Radeon Vega cards are based on the same reference PCB, so waterblock compatibility is very good. However, it's best to check the waterblock manufacturer's website just in case. You can check compatibility for our EK block at [www.ekwb.com/configurator](http://www.ekwb.com/configurator)



### 2 / UNSCREW BACKPLATE

The backplate on the reference card is easy to remove, as there are just half a dozen or so cross-head screws holding it in place, although you'll need a fairly small screwdriver for the job.



### 3 / REMOVE HEATSINK SCREWS

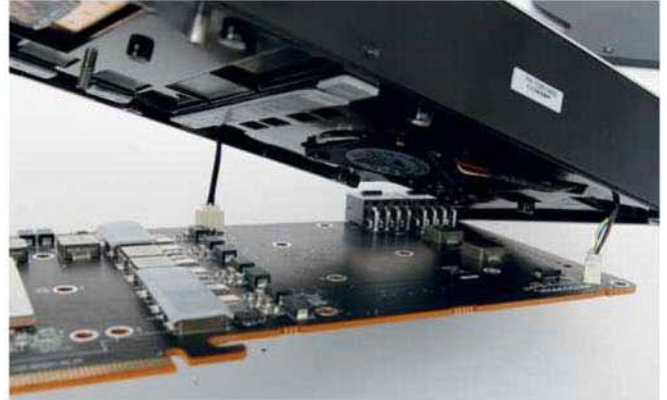
Identify the core screws and their cross-shaped support and leave these parts until later – focus on the rest of the screws under the backplate for now. There are quite a few, so make sure you unscrew all of them before moving on to the core screws.





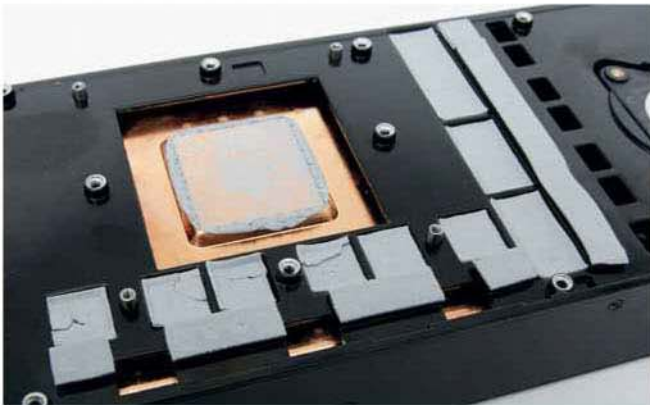
#### 4 / REMOVE CORE SCREWS

Lay the cooler face down on a flat surface while you unscrew the core screws, in order to support it. Put all the fittings and screws into a bag, and keep them safe, either in the waterblock box or graphics card box.



#### 5 / DETACH CABLES

Vega GPUs have two cables towards the rear of the PCB, which you'll need to detach before you can remove the cooler. If they're tough to remove, use a pair of needle nose pliers, so you don't risk damaging the cables or connectors.



#### 6 / REPLACE THERMAL PADS

The waterblock will come with all the thermal pads and paste you need, so remove any pads from the memory modules or VRMs and place them back onto the stock cooler. That way if you sell it in the future, you can do so with it in a working condition.



#### 7 / APPLY NEW THERMAL PADS

The instructions will tell you where to position the thermal pads. Our EK Water Blocks model requires you to deal with two thicknesses of pads, catering for the HBM2 modules and VRMs.



#### 8 / CLEAN CORE AND APPLY TIM

Wipe the core clean, ideally with thermal paste cleaner or isopropyl alcohol and a lint-free cloth. Then apply small portions of thermal paste to the core components in blobs a couple of millimetres wide, as shown.



#### 9 / INSTALL WATERBLOCK

Align the card with the block before making contact, to avoid spreading thermal paste everywhere. Lay the block face down, place the PCB on top and lightly tighten the screws, starting with the four core screws. Then tighten the screws with a moderate amount of force. **EPC**

# How to Use a vinyl cutter

Antony Leather shows you how to use a vinyl cutter to make custom stickers and paint masks

 **TOTAL PROJECT TIME / 2 HOURS**

**E**ver wondered how those logo stickers and amazing other designs appear on professional modders' PCs? It's likely they used a vinyl cutter – a compact, printer-like machine that uses a fine cutting blade to carve out designs you can create or import in software. You won't be able to cut thick acrylic or metal with it, but it's perfect for creating custom vinyl stickers.

As well as creating logos, you can add self-adhesive labels or create design patterns in metallic or coloured vinyl. We'll be looking at this process using a Silhouette Portrait cutter and also how to save yourself hours masking up fine details before your spraying session by creating your own masking material in a custom design. We're recreating an Asus Republic of Gamers logo, with kind permission from Asus, but bear in mind that this reproduction of Asus' logo only applies to this modding guide – it can't be used on products for sale.

## TOOLS YOU'LL NEED



Silhouette Portrait cutter / [www.yolo.co.uk](http://www.yolo.co.uk)



Adhesive vinyl sheet / [www.yolo.co.uk](http://www.yolo.co.uk)



Clear transfer/ application tape / [www.yolo.co.uk](http://www.yolo.co.uk)



Adhesive masking vinyl sheet / [www.amazon.co.uk](http://www.amazon.co.uk)



### 1 / MEET THE VINYL CUTTER

Vinyl cutters work much like inkjet printers, with a rail system that moves back and forth, along with a cutting blade. The material can also be moved in and out, and a variety of sizes are supported, the smallest of which is A4, which is ideal for PC use.



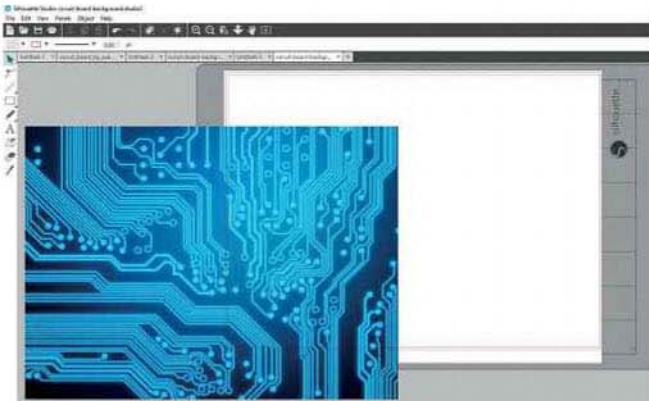
### 2 / SET CUTTING BLADE DEPTH

Depending on the material you're using, you'll need to set the cutting blade depth using the socket inside the cutter. Most materials need the lowest setting, which we'll also be using to cut our adhesive vinyl.



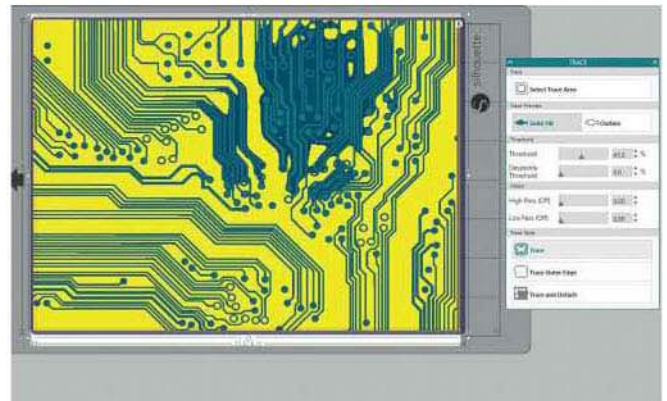
### 3 / INSERT MATERIALS

Sheet materials need to be manually inserted into the cutter. First, stick the material with its backing to the included cutting sheet, which acts like a cutting mat and prevents the material from moving. You can then press the Feed button, so the rollers can grip it.



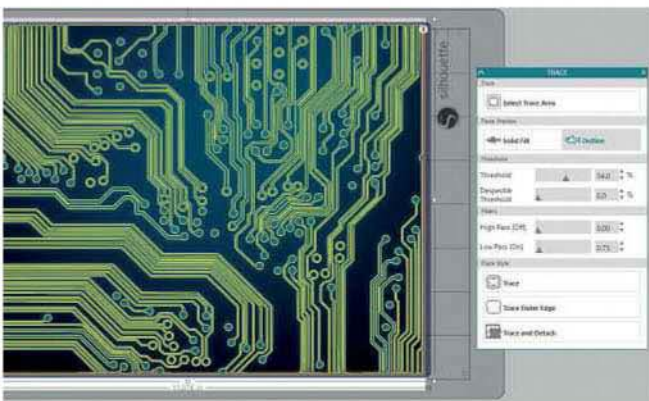
#### 4 / IMPORT PHOTOS

You can create your own designs in the software using Paint-like tools, or you can import an image. They can be very detailed but must have good contrast between colours, with no feathering or soft edges.



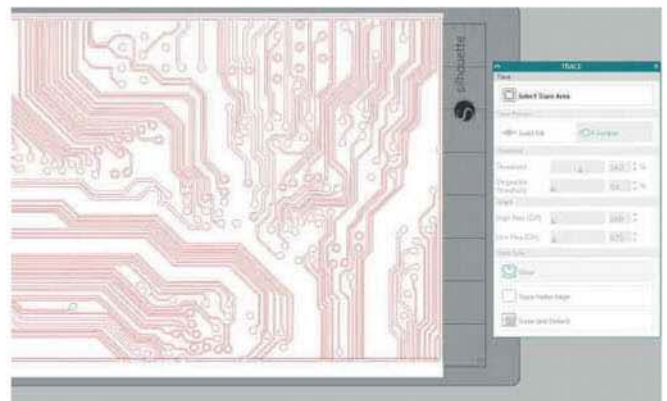
#### 5 / SET TRACE AREA

Align the imported image onto the cutting area and then click the Trace button. This action will plot out the image, but you'll need to make further adjustments to make the trace lines clear.



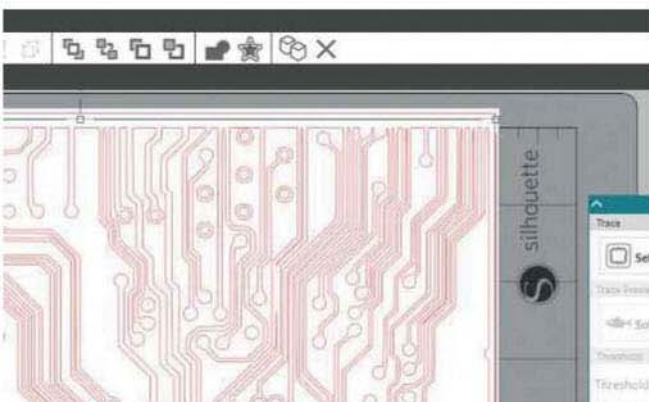
#### 6 / FILTER DOWN TO LINES

Use the Threshold and Filter tools to remove the background so the only required lines are shown. The lines need to be perfectly sharp and precise, or you'll affect the cut's accuracy.



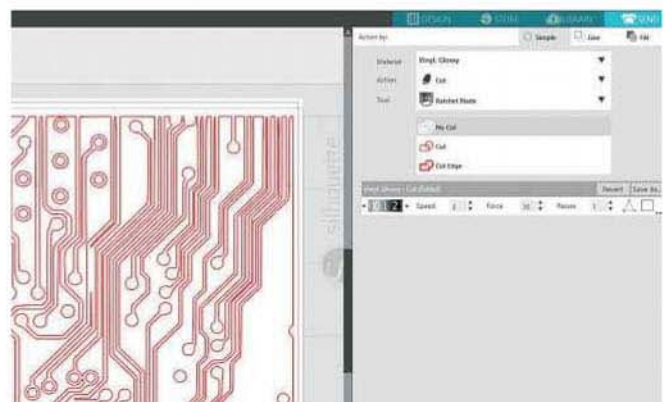
#### 7 / CREATE OUTLINE

Once you've extracted the outline of the image you want to cut, click Trace, and you'll be able to drag the original image to the side and delete it. You'll be left with red lines marking out the cutting lines.



#### 8 / CHECK FOR BORDERS

Align the image so it sits properly on the page when it's cut. It's easy for an edge to drift over the cutting border, so zoom in and check that the edges are well within the limits.



#### 9 / PERFORM CUTTING ACTION

Select the material from the cutting menu, and the software will suggest the correct cutting depth if you haven't set it already. You can also increase or decrease the speed and force, but it's usually best to leave the default settings. You're now ready to cut.



**10 / REMOVE CUT-OUTS**

Once the machine has finished, you'll be left with a large sheet that you can pull off to reveal the details, or you can remove the details to leave a large pattern to cover a larger area. A scalpel is ideal for picking off the details.



**11 / USE TRANSFER TAPE**

Transfer tape lifts your cuttings off their backing material and allows you to set them in place on another surface – essential for any vinyl cut, especially a detailed one.



**12 / USE MASKING SHEET**

As well as creating custom stickers, you can also use a vinyl cutter to create patterns to mask while spray-painting. You'll need masking vinyl for this job, and the cutting process is identical to the one used to cut regular vinyl.



**13 / SPRAY AND CUT OUT MASKING SHEET**

Before applying the masking, prime the surface and spray it with the base colour you want to show through the final layer. Allow the base colour to dry for 24 hours before you mask it, then cut out your design in the masking sheet using the usual method.



**14 / APPLY MASKING AND SPRAY**

Apply your masking to the paint using transfer tape, and gently press down the pattern, so it adheres to the paint. You can then remove the transfer tape, leaving your vinyl behind, and spray the top layer.



**15 / REMOVE MASKING**

Remove the masking after the paint has dried for a few minutes, or the paint layer can tear. Adding a clear coat will create an even-looking surface, but again remove the masking first to avoid tearing the finish. **GPG**

# Folding@Home

Join our folding team and help medical research

## MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE
IanPocock	70000	waffo118	800000	SIcCracing	6000000	Ken_Swain	80000000
Peanut.Rec.	80000	Woomera	800000	Dutchchemist	7000000	SP1	100000000
Granby	100000	chris_eccles	1000000	Jazajay	9000000	Sparkymatt	100000000
Peanut.Rec.	100000	DaveBrooks	1000000	dumbdodo	10000000	ZardoSpeaks	100000000
Unreal2will	200000	Jaffo	1000000	fatchef	40000000	clanseven	200000000
EVRE	400000	teens:)unite	2000000	Origami_Tsuki	40000000	daxchaos	700000000
blotty	600000	teago2	3000000	Hopper	50000000	apeman556	800000000
green.pig	800000	pig_farmer_uk	5000000	MazdafanGaming	50000000	Slavcho	1000000000
SirNigel16	800000	Count_Stex	6000000	adbygrave	70000000		

### WHAT IS FOLDING?

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research. You can download the client from <http://folding.stanford.edu> and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding with us and other readers online at the [www.bit-tech.net](http://www.bit-tech.net) forums.



### TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	Doclonz	5,308,529,434	245,856
2	Nelio	3,900,524,249	406,217
3	HHComputers	3,536,323,724	84,422
4	PC_Rich	2,284,177,243	113,400
5	piers_newbold	1,936,941,191	87,856
6	Lordsoth	1,650,628,488	128,814
7	Scorpuk	1,424,566,889	42,946
8	Unicorn	1,077,787,508	44,273
9	Slavcho	1,038,794,276	47,066
10	coolamasta	1,008,368,694	190,492
11	Laguna2012	890,706,728	38,050
12	apeman556	825,825,718	40,693
13	Desertbaker	725,287,206	34,634
14	daxchaos	718,975,254	20,663
15	KevinWright	664,956,838	41,398
16	Roveel	653,319,645	11,452
17	StreetSam	571,113,589	90,251
18	The_M2B	569,530,021	73,074
19	BeezaBob	559,774,176	25,740
20	johnim	534,006,305	83,262

### TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	Doclonz	6,016,552	5,308,529,434
2	PC_Rich	3,352,761	2,284,177,243
3	Nelio	3,088,570	3,900,524,249
4	clanseven	2,652,063	200,795,136
5	piers_newbold	2,194,894	1,936,941,191
6	daxchaos	2,106,011	718,975,254
7	Slavcho	2,097,672	1,038,794,276
8	Lordsoth	1,936,991	1,650,628,488
9	Unicorn	1,442,571	1,077,787,508
10	apeman556	1,010,984	825,825,718
11	Laguna2012	966,776	890,706,728
12	BeezaBob	955,993	559,774,176
13	Desertbaker	808,081	725,287,206
14	kcanti	754,229	148,004,859
15	KevinWright	683,306	664,956,838
16	Hopper	646,486	50,809,274
17	Jobjohn	602,011	176,245,605
18	Allan_Smith	511,017	126,063,824
19	madmatt1980	486,446	490,494,636
20	Ken_Swain	425,738	85,857,939

# Readers' Drives

## Black Ice

Eager to create a Ryzen gaming PC he could display with pride, Jonathan Mephram snapped up a Thermaltake Core P3 open chassis and built his first custom water-cooling loop

### **GPE:** What originally inspired you to build this project?

**Jonathan:** I'd been running my old dog system with an AMD FX-8320 and a Radeon HD 7770 for a few years and it was really starting to show its age. I'd been watching a lot of great YouTubers with their builds and mods, as well as reading

Custom PC for ideas, and decided that I wanted to build something that I'd be happy to show people with pride. The timing also coincided with the launch of Ryzen and, having always been a little bit of an AMD fanboy, I jumped on that bandwagon as soon as it launched.

### **GPE:** Why did you use the open Thermaltake Core P3 case?

**Jonathan:** I really wanted a case that showcased everything that goes into the build, and it also forced me into making my build a lot neater than my previous efforts. Building with this case is also really easy, and it has so much room

for future expansion too, especially if I get a 3D printer.

### **GPE:** What specs did you choose, and why?

**Jonathan:** The primary purpose of the PC was gaming. I've always played games on my PC, although the age of my old system meant I was compromising too much, so I began playing on consoles more, and using that PC less. I really wanted a system that could play games maxed out without breaking a sweat. VR was also a consideration for me; I'm lucky enough to own an HTC Vive and absolutely wanted to get the best out of it. When I get spare time I'm also trying to get back into 3D modelling recreationally, so having the multi-core CPU makes easy work of any task I'm likely to throw at it.

### **GPE:** What other mods have you built?

**Jonathan:** I've never really gone beyond standard builds previously, although I've built plenty of them. I've been a system builder since my first job at a high street electronics retailer, and I've put together plenty of systems over the years, both recreationally and built to order. I've just put together a really nice gaming system for one of my younger employees. It's his first gaming PC, and there's no custom loop or anything like that, but it has a GTX 1080 and Ryzen 5 1600, so there's plenty of horsepower for a first PC. I'm very eager to build a desk PC at some point soon, though, and would definitely like to do far more customisation on that type of project.

### **GPE:** What difficulties did you come across?

**Jonathan:** Any difficulties I hit during the build tended to result

from not properly doing my research, or an eagerness to get the build done. I dived straight in when I was buying RAM originally, and Ryzen had real issues with many modules when it first came out. However, I was able to swap out that memory and put in some replacement modules. They're still not running at their rated speed, but at least they're not running at 2133MHz like my previous modules. Given time, I'm hoping that BIOS updates should improve this situation further.

I also didn't check which M.2 slots on this board would work with each type of drive, so I ended up with one of my SATA drives in a slot that didn't support it, which was a slight pain to remedy with the loop and GPU setup, but I swapped them over with a bit of patience. Lesson learned – read the manual! The only other real concern was with the loop itself; using so many fittings in places made some sections particularly weighty, and they sagged as a result, which didn't look great. I ended up spending a bit of time securing those sections in place using discreetly placed cable ties – it's far from perfect, but it doesn't show and now the loop is holding up straight.

### **GPE:** How did you find working with rigid tubing?

**Jonathan:** I took what many people are telling me is the easy route with rigid tubing in all honesty, but it suited the look that I wanted to achieve. I didn't want the look you get by bending the tubes for this build; I wanted a more industrial look, using fittings to create angles instead of tube bends, although it certainly would have been a lot cheaper to use bends. I took my time with this part of the build. As they say: measure twice,



### /MEET THY MAKER

**Name** Jonathan Mephram

**Age** 31

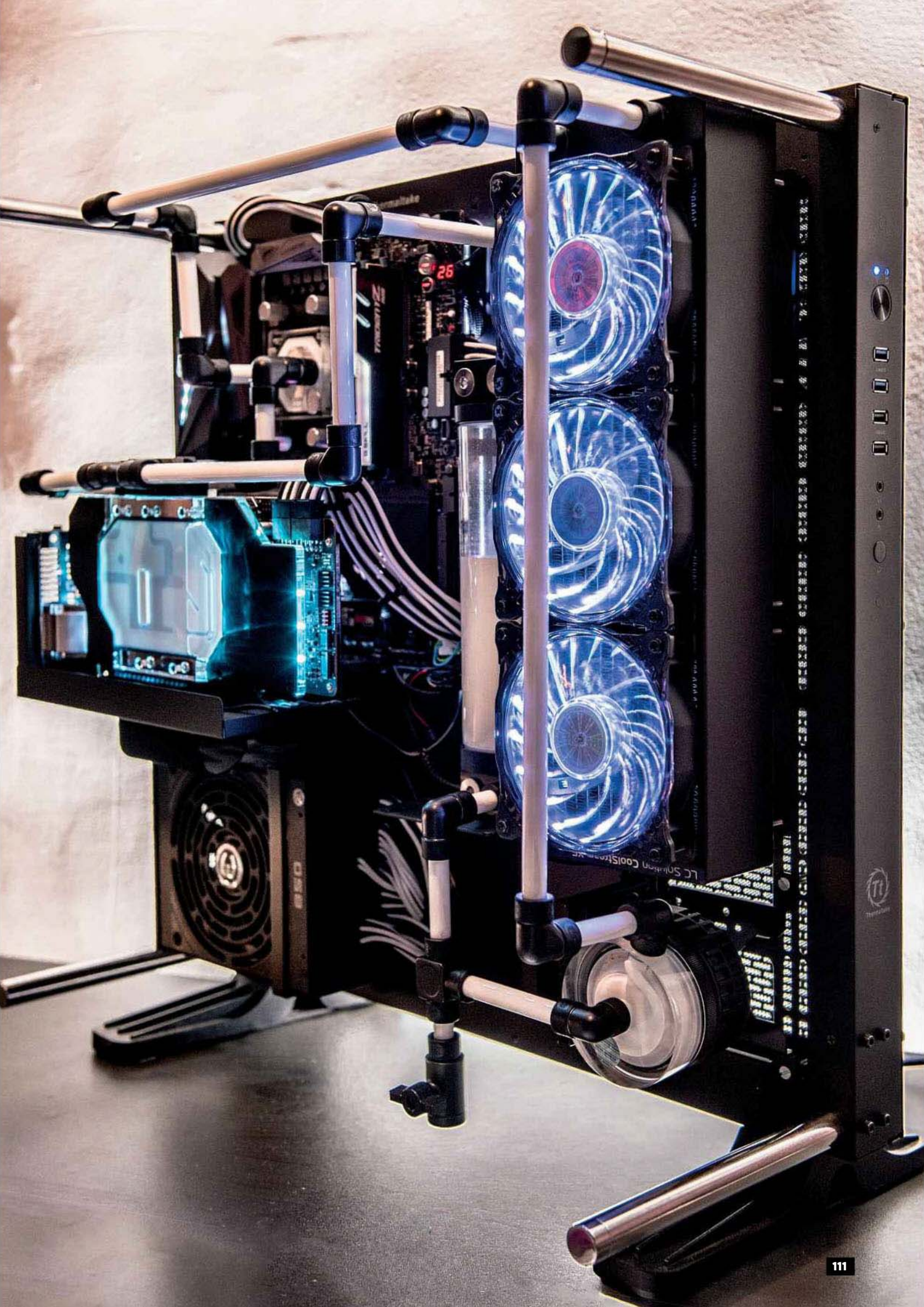
**Location** Christchurch, Dorset

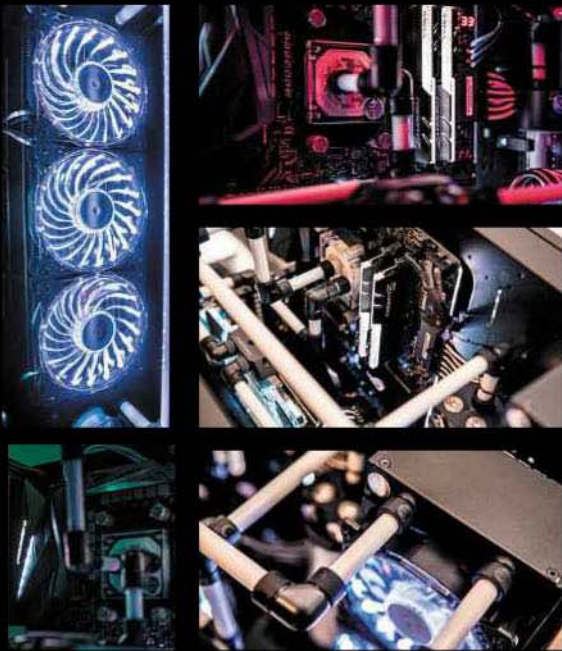
**Occupation** Newsagent owner

**Main uses for PC** 35 per cent gaming, 15 per cent 3D work and the other 50 per cent watching nursery rhyme YouTube videos with my daughter

**Likes** The Miami Dolphins, first-person shooters, cartoons, travel

**Dislikes** The New England Patriots, people who use their phone when they're at a shop counter





cut once. I'd advise anyone doing the same job to order more tubing than you think you'll need.

**CPC: What tools did you use?**

**Jonathan:** My toolbox is fairly basic, and as I wasn't bending the tubing, I didn't need many extras for this job. I used a plumber's tube cutter, which was really cheap and did a really good job cutting neat and straight – it's also far less effort than using a saw. I used a deburring tool to prep the ends of the tubing, so I didn't need to use a file and sandpaper.

**CPC: Has your project attracted any online media interest?**

**Jonathan:** I've shared it on a few of my Facebook groups, and it's received mostly positive feedback, but you'll always get critics in this

game. Most of criticism concerned the fact that I've not done any bends, or that I chose the Ryzen 7 over a Core i7-7700K.

**CPC: How long did the build process take?**

**Jonathan:** It's pretty much been an ongoing process since the day Ryzen launched. I started out with a water-cooling kit just to cool the CPU, using soft tubing and a small reservoir, so I upgraded those parts when I changed motherboard. I went from an MSI Titanium to the Asus Strix board, mainly for aesthetics. I also had a Radeon RX 480 at the start, as I was waiting for Vega, but I got bored with waiting and bought an Asus Strix GTX 1080 Ti, just before the mining trend send GPU prices through the roof. I still don't feel it's finished though; I really enjoy tinkering, and will find any excuse to remove the front panel and upgrade it.

**CPC: What did you learn from the build process?**

**Jonathan:** I've learned that I absolutely love building custom water-cooled systems. It's almost an art, and there are stacks of builders who do take it to an artistic level. I've also definitely learned that I don't spend enough time researching; I should have spent more time looking at qualified vendor lists when Ryzen came out.

**CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?**

**Jonathan:** I'm pretty content with the build. It definitely looks how I'd envisaged it, but I'm also really keen to do something with the front panel, maybe getting it etched to give it a finishing touch. I'd also like to build a system with a separate loop for the GPU and CPU. Maybe a Volta/Threadripper system will be on the cards next year! **CPC**

**BE A WINNER**

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to [www.bit-tech.net](http://www.bit-tech.net) and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

**SYSTEM SPECS**

**CPU** AMD Ryzen 7 1800X overclocked to 4GHz

**Case** Thermaltake Core P3

**Graphics** Asus ROG Strix GTX 1080 Ti OC

**Memory** 32GB 2800MHz G.Skill TridentZ RGB

**Motherboard** Asus ROG Crosshair VI Extreme

**Storage** 1x 500GB Samsung 960 Evo M.2 NVMe SSD, 2 x 525GB Crucial M.2 SATA SSDs

**PSU** EVGA Supernova 850 Gold G2 Modular

**Cooling** Custom loop using mostly EKWB parts. EK Supremacy Evo CPU waterblock, Phanteks Glacier Full GPU waterblock, EK Coolstream XE-360 radiator



# Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

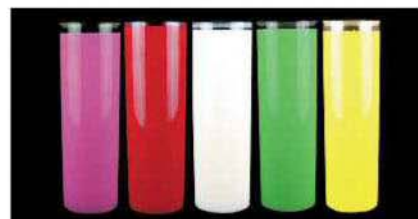


## Corsair K70 LUX RGB keyboard with your choice of switches

**TOTAL VALUE** £160 inc VAT / **MANUFACTURER** [www.corsair.com](http://www.corsair.com)

The K70 LUX RGB is a part of Corsair's LUX flagship line of gaming keyboards, featuring Cherry MX key switches backed by a lightweight, durable aluminium frame and dynamic, multi-colour lighting. The USB pass-through port is positioned for uninterrupted gameplay and ready for your mouse or wireless headset adaptor. You can also harness the power of CUE for sophisticated macro programming and dramatic lighting effects and animations.

Meanwhile, 100 per cent anti-ghosting with full key rollover on USB helps to ensure accuracy, so every keystroke translates directly into accurate gameplay. The contoured, textured FPS and MOBA keycap sets keep you in control, while the Cherry MX key switches give you a linear response and fast actuation. Corsair will provide a keyboard with your own choice of Cherry MX switches – both Brown and Red RGB models are available.



## Mayhems coolant and dyes



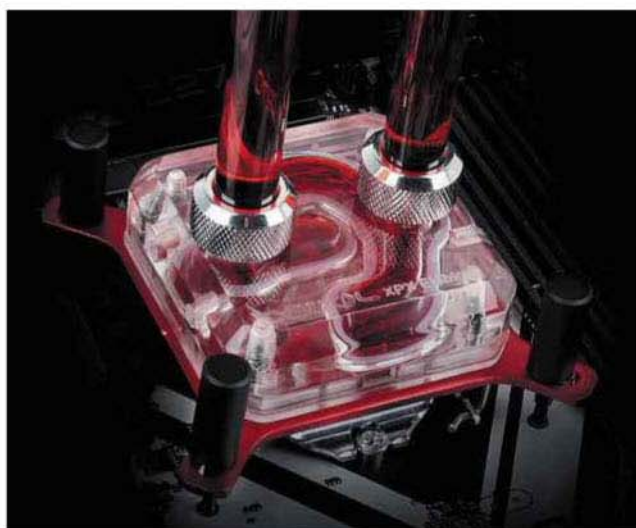
**VALUE** £50 inc VAT / **MANUFACTURER** [www.mayhems.co.uk](http://www.mayhems.co.uk)

Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives – they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

## Alphacool water-cooling gear

**VALUE** £150 inc VAT / **MANUFACTURER** [www.alphacool.com](http://www.alphacool.com), [www.aqua-tuning.co.uk](http://www.aqua-tuning.co.uk)

Water-cooling hardware manufacturer Alphacool is offering a choice of £150-worth of its water-cooling components to every featured Readers' Drives modder. The company is behind some great products we've seen recently, including all-in-one liquid coolers and external radiators. For your prize, you can select from DIY water-cooling kits, the Eiswolf and Eisbaer all-in-one CPU and GPU liquid coolers, as well as a vast range of individual components, including waterblocks (pictured), fittings, reservoirs, pumps and radiators. Alphacool also makes coolant, tubing and fans, as well as modding and water cooling-related tools.





JAMES GORBOLD / HARDWARE ACCELERATED

# BAFFLINGLY BIG BOXES

The ATX mid-tower still dominates the PC market, despite being a poor fit for most people's needs, argues James Gorbold

**D**espite the increasing miniaturisation of electronics and integration of more functions into motherboards, the mid-tower case is still the number one choice for most PC buyers. It's evolved considerably since its humble beginnings in the 1990s. Long gone are the beige steel boxes of yesteryear – we now have a massive variety of shapes and styles, plus lighting effects and multiple materials, including tempered glass.

The internal design has changed a fair bit too, casting out the 1980s era AT form factor in favour of ATX. However, as somebody who has designed and reviewed thousands of PCs in my career, it fascinates me that ATX mid-tower PCs are still the most popular choice in the market. Like most other purchases, such as vehicles, housing, cutlery or crockery, your decision should be driven by need. For example, very few single people buy people carriers or four-bedroom houses.

Very few PC users need the space of a ATX mid-tower PC. The once popular sound card and network card have almost disappeared in gaming PCs, as these functions are now built into the motherboard and, unless you're a musician or running a server, it simply isn't necessary to buy a discrete card anymore. As such, despite catering for up to seven expansion slots, the vast majority of gaming PCs are only fitted with a single discrete graphics card. While nearly all these cards take up two physical slots, thanks to having a large heatsink and fan, that still leaves most of the motherboard and case real estate left empty, never to be used.

It's not as if leaving all this space free brings many advantages either. Sure, it's quicker and easier to build an ATX mid-tower PC

than a mini-ITX PC. Traditionally, larger cases also had better cooling too, but that's no longer always the case, with popular mini-ITX cases such as the NZXT Manta being able to support a 280mm radiator. On the other hand, smaller PC cases are easier to cool, as the fans are closer to the hot-running components. What's more, they use fewer materials, which should make them cheaper to produce. Finally, while it's obvious, it also still needs saying that smaller PCs take up less space, an important consideration in many domestic and commercial environments.

Yet, despite the logic of smaller PCs being a better fit for people's needs today, ATX mid-towers continue to dominate the PC market. For instance, if we look at the market as a whole, ATX mid-towers account for roughly 72 per cent of sales, micro-ATX 18 per cent and mini-ITX just 9 per cent, with the rest being taken up by exotic form factors. The difference is even more stark when it comes to professionally manufactured PCs, with the breakdown as follows: ATX 90 per cent, micro-ATX 6 per cent and mini-ITX 4 per cent. What's even more telling is how many ATX PCs are sold with micro-ATX motherboards installed – a pet hate of mine as it makes the interior look even more ridiculously empty.

What's the reason for this collective irrationality? I think it's firstly inertia; we've become accustomed to buying oversized PCs. Secondly, many buyers still associate large cases with higher performance. Next time you're thinking of upgrading your existing PC or buying a new one, I'd suggest pausing and thinking for a moment about what size you need – the answer might surprise you. **GPG**

The once popular sound card and network card have almost disappeared in gaming PCs

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

BLACK HAWK™

RED EAGLE™

# GAMING ON THE EDGE



24.5" **G-MASTER™ G2530HSU**  
27" **G-MASTER™ G2730HSU**

**@75Hz** WITH FreeSync SUPPORT,  
1920x1080 (FULL HD),  
LOW ENERGY CONSUMPTION,  
A+ ENERGY EFFICIENCY CLASS PANEL

27" **G-MASTER™ GB2760QSU**

**@144Hz** WITH FreeSync SUPPORT,  
2560x1440 (WQHD) RESOLUTION  
FOR 77% MORE ON-SCREEN SPACE  
THAN WITH FULL HD

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