Reviewed: Nvidia's new GeForce GTX 980 Ti

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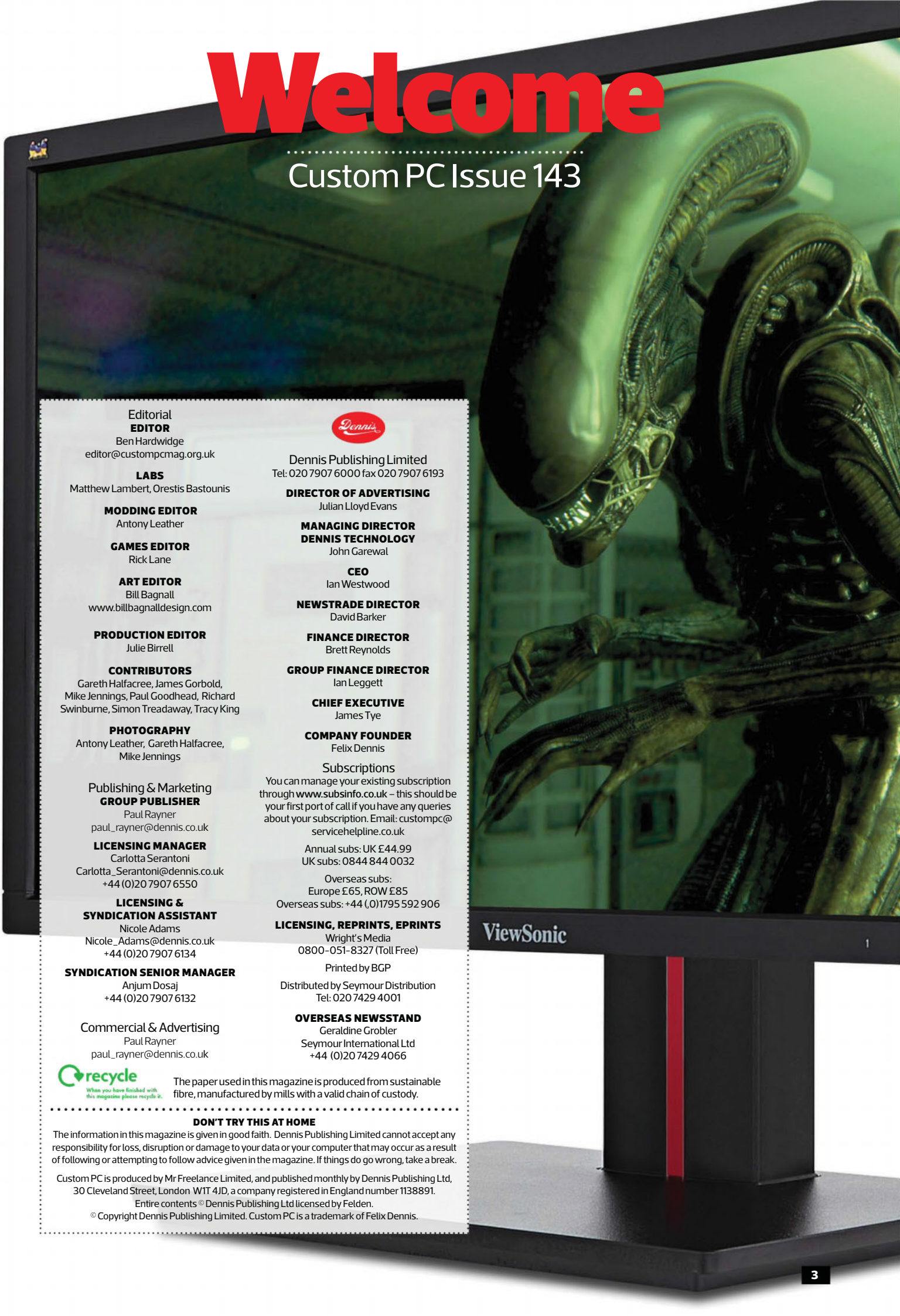

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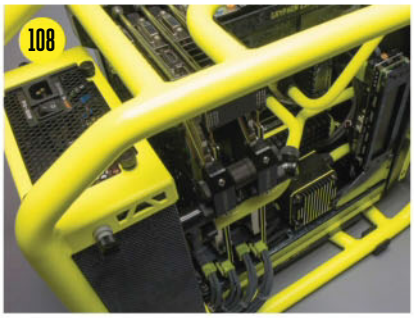

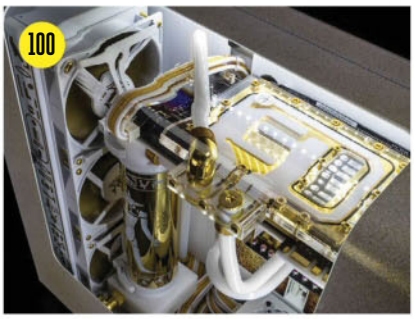

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Reviewed this month

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BEN HARDWIDGE / FROM THE EDITOR

THE PRICE OF EARLY ADOPTION

If Ben Hardwidge had bought a Titan X when it was launched, he'd now be fuming

If I'd bought a Titan X when it first launched, just two months ago, I'd currently be sitting in a corner, gradually boiling up, ready to explode into a Hulk-like Fury, but with less green, considerably less muscle and an English accent. It probably wouldn't be Hulk-like at all, in fact, but I would be seriously annoyed. Imagine you've just spent £850 on a graphics card, only for Nvidia to release one that's almost identical for £300 less cash in just a few weeks. It's like taking a seal away from a hungry polar bear, poking it with a stick and making lewd jokes about its parents. Why do it?

In this case, the answer is simply to make more money. You make a high-margin product that only people with lots of money can afford, and sell it as the equivalent of Formula 1 tech to PC enthusiasts. If you want the very best then you have to pay for it, knowing that you'll be able to get a much cheaper product that does the same job later down the line. It's understandable from a business perspective, but after two months? That's ridiculous.

We've been down this road before, of course. When the original Titan launched, the GeForce GTX 780 Ti came out soon afterwards and lots of people were annoyed. As such, most of us expected a new Nvidia card that sat between the GTX 980 and Titan X, but we thought it would come out later, and with performance much closer to the GTX 980 than the Titan X. After all, the latter's big advantage was that it could properly handle 4K gaming on a single GPU – you wouldn't want to mess with such a key selling point, would you?

> It's like taking a seal from a hungry polar bear, poking it with a stick and joking about its parents

Apparently Nvidia would. Not only is the GeForce GTX 980 Ti (see p20) much closer to the GTX 980 than the Titan X in terms of price, but it's also closer to the Titan X in terms of performance. In fact, in terms of playable minimum frame rates in our tests, it's basically the same – there's no advantage to buying a Titan X over a 980 Ti if you want to play 4K games on one GPU.

That's the price of early adoption, and it's a price the cynic in me can't really justify any more. We've seen a similar situation with the price of 4K kit. Less than two years ago, a 4K monitor cost just under three grand, and a 4K-capable PC cost a similar amount on top of that. But now, as our feature on p84 shows, you can get the whole caboodle for just £1,866 inc VAT. If I'd spent £6,000 on a 4K PC and monitor 18 months ago, I'd probably be pretty annoyed right now.

This situation isn't new, of course. The latest tech always comes with a high price before it filters down into cheaper products. But that high price can usually at least be justified by supply factors – 4K monitors were original expensive because of the lack of large-scale 4K panel production. Likewise, we've had to wait for NAND flash manufacturing techniques to advance before we could get hold of cheap, high-capacity solid state drives.

But selling a top-end GPU for £850 for just two months before releasing the same GPU with a few bits disabled for £300 less? I know the Titan X has twice as much memory, but that extra 6GB doesn't make a whole lot of difference to performance. The GTX 980 Ti is a fantastic card for a great price, but the situation takes advantage of early adopters to a very cynical degree. CPC

Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000. editor@custompcmag.org.uk @mandogfish

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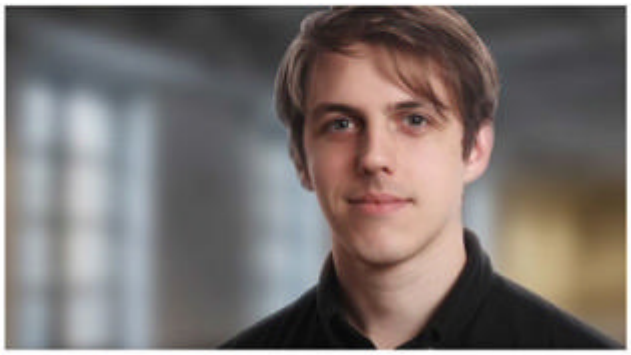


RICHARD SWINBURNE / VIEW FROM TAIWAN

COMPUTEX 2015 ROUNDUP

Richard Swinburne reports on all the exciting new tech that's been displayed and announced at the Computex trade show in Taiwan

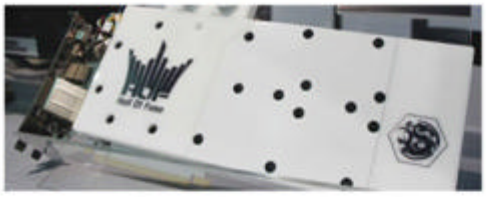
I've just got back from attending Computex 2015 – the large annual PC-tech-centric trade show that's held in Taipei, Taiwan, at the start of June. The show is generally a great guide to the tech treats that are coming out during the rest of the year, with niche and unique products from local Taiwanese brands, as well as names you'll regularly find in the UK. Anyway, here's a blow-by-blow account of the hot trends and new gear that I saw at the show.

Solid state drives

Just as I predicted in last month's column, SATA-Express is nowhere to be found, yet there were several premium 4x PCI-E drives with SF8639-connectors on display from Adata, Apacer and other SSD manufacturers. Of particular note is Adata's drive (pictured), which will be cheaper than Intel's 750 SSD (see p24), yet with a larger capacity of up to 2TB.

Graphics cards

Custom GeForce GTX 980 Ti (see p20) cards were everywhere, including these cards from Asus, Zotac and Galax, and most of them should be on sale in July. The most impressive card was the Galax HOF, with its three 8-pin PCI-E power connectors mounted on the very end, rather than the side, allowing for much neater cable routing. In addition, the Galax will have a massive number of VRMs and a Bitspower waterblock option. Meanwhile, Zotac is currently preparing fan-stop technology similar to the feature found on Asus' Strix cards, but there's no guarantee it will be implemented on its GeForce GTX 980 Ti cards.



Fancy SLI bridges

Also on display were Gigabyte and MSI's branded SLI bridges; Gigabyte's bridges were made from black plastic, with a blue eye motif, while MSI's aluminium bridges had a black and red colour combination.

ROG certified

Asus' Republic of Gamers (ROG) group has launched a 'certified products' program, showing off heatsinks, cases, memory and waterblocks. Asus also showed off its new Cherry MX Claymore keyboard with RGB lighting.

In Win's transforming case

The H-Tower is In Win's latest limited edition concept chassis, which transforms (really!), opening up like a flower to reveal its innards. With this chassis, the new super-sized 909 and more affordable 805, In Win is frankly ruling the high-end case arena, with its choices of premium materials and truly unique designs.

New G.Skill kit and PSUs

Like Asus, G.Skill has launched a new Cherry MX keyboard with RGB lighting, called the Ripjaws MX780 RGB, along with another mechanical keyboard with red-only lighting. Also on G.Skill's stand was a new gaming mouse with RGB lighting, two 7.1 headsets (one with ten speakers for true surround, and one with a cheaper, virtual surround two-speaker setup) and 80 Plus Gold/Platinum power supplies going up to 1,250W. Speaking of power supplies, PSUs sporting the 80 Plus Titanium badge (the top rank, above Platinum) only made a limited show, with Seasonic alone committing one to market.

Antec's new S10 chassis

After a few quiet years, Antec is now making an impact again with its new S10 chassis. Sticking to a compartmentalised design akin to the company's classic P180 case, the S10's front drive section is separated from the main case, which is in itself isolated from the drives and PSU area. This setup allows room for a 360mm radiator to be placed right next to the motherboard. There's a version with a brushed aluminium side, which looks a bit monolithic to me, but the version with a tinted, tempered glass side looks much more appealing.

An all-in-one PC with proper graphics

MSI showed off its AX24 all-in-one PC design, which eschews the standard fixed graphics system in favour of a chassis that can accept a full-sized graphics card, which can even be upgraded at a later date. A great idea!

MSI shows off 'Godlike' motherboard

MSI also showed off its new X99 motherboard. It has some neat touches, such as the RGB LEDs. However, we'll leave you to draw your own conclusions about the new 'Godlike' branding on the heatsink.

Skylake motherboards

As the launch of Intel's Skylake CPUs is still some way off, most of the Z170 Skylake motherboards shown off were only entry-level designs. However, ASRock broke rank with its Extreme 7, which showed a surprisingly tasteful black/gold theme, along with space for three PCI-E M.2 SSDs. ASRock has also already committed to a mini-ITX Z170 motherboard using the Fatal1ty brand.

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

Letters

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

Defending the 5.25in drive bay

I can barely express how much James Gorbold's 'Goodbye 5.25in drive bays' column concerns me. If this is your direction of travel, then **CPC** might well lose a subscriber and Scan a customer. He may not have used his 5.25in drive bays for three years (really, James, really?) but all of mine see use on a weekly, if not daily basis.

Firstly, buying and ripping CDs is often cheaper than downloading music and it gives you control over the bit-rate and format, as well as artwork and liner notes to peruse, while the audio quality of DVD-A is unsurpassed. Streaming individual low-res tracks may be okay for kids, but until you can download a full album in a single file with lossless audio, plus high resolution artwork, at a lower price than the physical version, I'm highly unlikely to make the switch.

Streaming movies also are a poor relation to DVD and Blu-ray, particularly when it comes to special features – commentaries, deleted scenes, alternative angles, seamless branching and so on.

Another drive bay on my system houses the I/O for my sound card, allowing me to plug in instruments, microphones and MIDI controllers to record music, while another bay contains a multi-card reader, which is almost always the quickest and most reliable way of transferring files, especially when your bloated phone/camera software goes wrong. There's all this, and I haven't even mentioned the benefits of fan controllers. If I had a case with no 5.25in bays, I'd have a tonne of stuff cluttering up my desk and no free USB ports, so consider this the start of a campaign to save the 5.25in bay!

BEN NUNN

All sorts of handy devices come in 5.25in drive bay format

Ben: Not all of us on the **Custom PC** team agree with James, Ben. In fact, if you read my column on p8 of that issue, I say that 'I still like to have an optical drive. I don't like optical media but, even today, the only way to get true lossless audio is often to do a lossless rip from a CD.' There are also other advantages to 5.25in bays, as you suggest in your examples, and there are plenty of 5.25in reservoirs too. But not everyone has the same needs as us, and I also see why people such as James (and Antony on the team, for that matter) have no need for 5.25in bays, and see them as needless clutter. We all have different priorities, and I like getting more choice in terms of drive bays in PC cases, so we can choose a case that suits our needs best.

PEDANTS' PARADISE

Acorns aren't fruit

I'm enjoying Issue 142, but in the Banana Pro review on p98, Gareth says 'but fruit themes aren't exactly rare in the computer industry: Just ask Apple, Acorn, Apricot.' The acorn is classed as a botanical, nut not a fruit. Also, in the AMD CPU and GPU news story on p17, you say 'the new CPUs are scheduled to be released in 2010'. Are they now ? Hmm. Happy editing!

JULIAN VICARI

What's a Core i7-5690X?

I subscribe to your magazine and while reading the Build a 4K dream PC feature, I noticed an error on p87. The Intel Core 'i7-5690X' should in fact read 'i7-5960X'. I just thought I would point this out in case it prompts any queries from your readers.

LIAM BETTS

Which memory?

I'm a great fan of **Custom PC** and a long-time subscriber. I consulted the Elite list, as I'm thinking of a new build and while I found most of what I wanted on the list, I would like to point out that, when it came to the RAM, I struggled to find the exact models you specified.

Firstly, the amount of RAM suggested (8GB) shows only under the 'All-purpose PC' list. Secondly, I ended up searching for '400MHz

> I'm 72, but I've just completed my latest build; it's nothing wild, but I like it

Vengeance Pro Series 2' thinking that 400MHz seemed a bit slow. That's a silly mistake on my part, but I'm sure others who aren't as well versed (like me!) would appreciate '2400MHz' (without the comma) to avoid confusion. Thirdly, could you include the latency timings or manufacturer code so there's no mistaking the product to which your excellent list refers.

VICTOR WONG

Ben: Sorry to hear you've had a hard time finding the right memory, Victor. You'll be pleased to know that I've added '8GB' to the appropriate entries on the Elite list – it should have been there in the first place, and I'm not quite sure why it wasn't! I'm afraid we're going to keep the comma in '2,400MHz' though – that's our style, and it's a standard one throughout the world when it comes to numbers.

With regard to the latency timings and manufacturer code, it's more a matter of space than anything else, and the fact that latency timings make so little difference to real-world performance for the most part. However, I've added the manufacturer code to all the parts where there's room, which should hopefully make it easy for you and our readers to find the memory we're recommending.

Coloured coolant in a closed-loop cooler

Firstly, may I say that you make a great magazine. You've guided me in my various experiments with PCs for a number of years. I'm 72 now, but I've just completed my latest build; it's nothing wild, but I like it. I have an NZXT Kraken X61 all-in-one cooler. Is it practical to replace those boring black rubber tubes with clear tubes and introduce some coloured coolant to jazz it up a bit?

MARTIN TURNER

Depending on the way the tubing connects to the parts, you can sometimes replace the tubing on an all-in-one liquid cooler and add coloured coolant

Ben: Great to hear from you, Martin! There are ways to change the cooling on some all-in-one liquid-coolers, but not all of them, and the job isn't entirely simple. Whether or not you can do it depends on how the tubing connects to the radiator and pump/block combo unit – I haven't used the Kraken X61 myself, but have a look at the tube connections on your unit – if the tubing simply slips over a standard barb, without using a custom sealed fitting, then you may be in luck. If not, then I'm afraid you're stuck with the black tubing. We did a guide to replacing the black tubing and adding coloured coolant to all-in-one liquid-coolers in Issue 128 (p110), using a Corsair unit as an example. If you have that issue, I recommend having a look through the guide to see what the job involves. If your Kraken X61 isn't compatible, then you'll definitely be able to do it with some of Corsair's coolers. CPC

Twitter highlights

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EckhardMahne I got a 2500K i5 CPU in my current PC. I use my PC just for gaming. Is a 4690K + new MB worth the upgrade just for gaming?
Ben: For gaming, not really. Sandy Bridge was a groundbreaking architecture when it came out, and while Devil's Canyon is faster, it's not that much faster in games, and your 2500K should be really overclockable too. The best upgrade you can get for gaming is a new GPU.

Ren_Gaming Not a bad way to spend an afternoon.

NeoThermic On p26 you say the BitFenix Aegis is available in black. True, but your photos show it in red, and there's blue, yellow and white too!
Ben: Indeed, the Aegis is available in a range of colours. Sorry for the omission of these colours in the specs list!

Lassar1982 Disappointed with the review of the Sennheiser G4me Zero. I have no issues with bass. They need a dedicated high impedance port!
Ben: The G4me Zero doesn't have a problem with bass, as such – we just said it doesn't handle bass as well as it handles other frequency ranges and that the MMX 300 is better in this respect. The Sennheiser is still a great headset

kajun_cheng No @Corsair Dominator Platinums in your dream PC?
Ben: That's a good question. We decided to go for Vengeance LPX memory, as the performance benefit of the Platinums in terms of performance is minimal, and they cost significantly more. But then again, the Platinums have a better heatsink and, perhaps more importantly, look fantastic, and that's all part of the dream PC ethos.

WHEN'S THE NEXT MAG COMING OUT?
Issue 144 of Custom PC will be on sale on Thursday, 16 July, with subscribers receiving it a few days beforehand.

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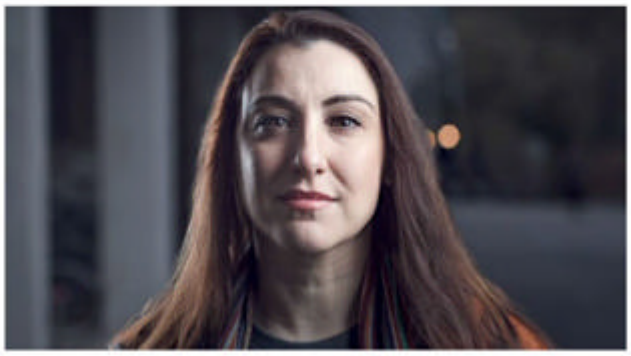


TRACY KING / SCEPTICAL ANALYSIS

REFUND RIGHTS

Steam finally has a scheme for giving customers refunds, but we've been legally entitled to such a system for years, says Tracy King

Your statutory rights are not affected, says the old disclaimer we've all seen on product packaging, usually under the 'if this is terrible, send it back to us' blurb. The invoking of statutory rights in that context is akin to claiming an aerosol can is 'CFC-free'. Manufacturers and retailers in those cases are boasting about something that's actually mandated by law. Score one for canny marketing. It's pretty difficult to imagine a scenario in which a manufacturer could affect your statutory rights. Rights are, well, rights. There's a clue in the name.

But when it comes to digital products, the waters are muddier, because digital products are comparatively new. Consumer protection regulations didn't spring up fully formed the first time someone made an axe and sold it to their neighbour for a chunk of gold. Legislation is honed and refined as time, and markets, go on. Lobbying is increasingly a factor, where manufacturers try to influence legislation in their favour rather than customers' favour, but the law for England and Wales is pretty heavily consumer-orientated, except when it comes to digital products.

Most people don't separate digital products from physical products, or from services. In our heads, any product we buy with money should be fair game for a refund if broken, or at the very least, to be made good via a replacement or getting the original product fixed. For the purposes of consumer protection, digital downloads aren't considered goods or services in English law, and have their own bit of legislation governing cancellations, but your rights remain the same when it comes to getting refunds for broken stuff. This situation appears to be news to the providers of digital content, though, who have long resisted fair refunds for buggy or unfinished games.

> If a download doesn't work, or match its description, you're entitled to a refund

The new Consumer Contract Regulations specify that downloaders of digital content have the same right to cancel the contract as anyone else (14 days), but by that time you'll have probably already downloaded the content. If so (which is likely, because that's how it works), you immediately lose your right to cancel. It's very clear to see why this happens. Digital products can't be given back once downloaded, and can be duplicated with no loss or degradation of the original. That isn't true of a sandwich, for example. However, if the download doesn't work, or doesn't match the description, you're absolutely entitled to a refund. However, digital retailers aren't at all keen on giving them.

This situation has long been the bugbear (pun intended) of Steam users, who seemingly have no recourse when downloading a game that turns out to be unplayable. Players in England and Wales could go down the small claims court route, but most people aren't prepared to go through that hassle for the sake of a few quid. Indeed, I'd wager that most gamers aren't even aware they have a legal right to a refund. As a result, the balance has been tilted away from gamers.

But now, after wrangling, Steam has announced its new refund policy, whereby a customer can get a refund on a game for any reason as long as they played it for under two hours. It's a slightly messy policy, inasmuch as smaller developers who make short games could easily fall foul of the two-hour rule, and games without DRM could easily just be copied to another directory and then refunded.

However, Steam and game developers are going to have to cross those bridges in these early days of digital consumer rights. If a product is broken then fix it, or at the very least give your customer a damn refund. CPC

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdoll

Incoming

We take a look at the latest newly announced products

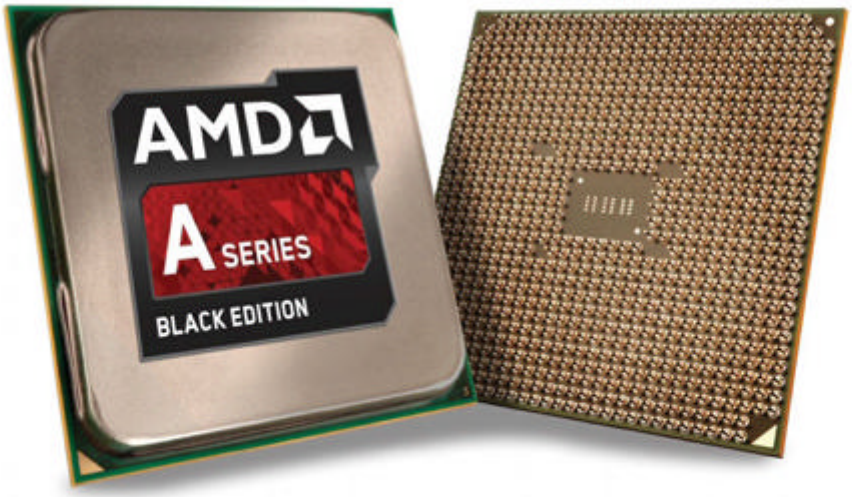
Steam hardware available for pre-order

Valve has finally launched its Steam hardware for pre-order, promising that gamers who take advantage of this offer will get their hardware on 16 October this year, while everyone else will have to wait for the general release on 10 November. In the UK, **www.game.co.uk** is offering a series of bundles containing the Steam controller on its own, and with the Steam Link device, which enables game streaming from your desktop PC to your TV at 1080p with a frame rate of 60fps. Prices start at £60 inc VAT for the controller with a £20 Steam Wallet Top Up, while £100 will get you the same bundle with the Steam Link device.

Valve says that full Steam machines will also soon get the pre-order treatment, naming CyberPower as the first manufacturer to offer one, with other PC builders following suit.

Windows 10 gets release date

Microsoft's next PC operating system, Windows 10, is going to arrive sooner than expected, with the company announcing an official launch date of 29 July this year. The new operating system will be available as a free upgrade for users of Windows 7 and 8.1 for a year, although only users of the Professional versions of the operating system will get a free upgrade to Windows 10 Pro. If you want to upgrade from an older system, or buy the new OS fresh, Windows 10 Home will cost $119 (around £78), while Windows 10 Pro will cost $199 (about £130).



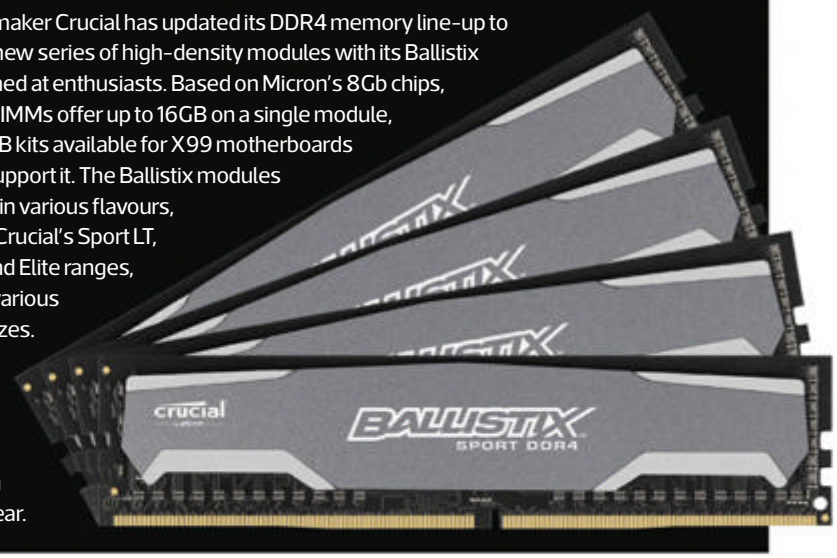
AMD launches top-end APU

AMD has added a new top-end APU to its A10-series line-up, codenamed Godavari. The A10-7870K Black Edition replaces the Kaveri-based A10-7850K as the flagship in AMD's APU range, and other Godavari parts are expected to follow soon. Like the 7850K, the 7870K features two Steamroller CPU modules, each containing two integer units for a total of four integer units.

Although the chip still has the same underlying architecture as its Kaveri brothers, it features a few tweaks in order to improve performance. The7870K's stock clock speed has been raised to 3.9GHz (4.1GHz boost) from the 7850K's 3.7GHz (4GHz boost), and the Radeon R7 GPU clock speed has also increased from 720MHz to 866MHz. The A10-7870K is available from **www.scan.co.uk** for £108 inc VAT now, and we hope to have a review soon.

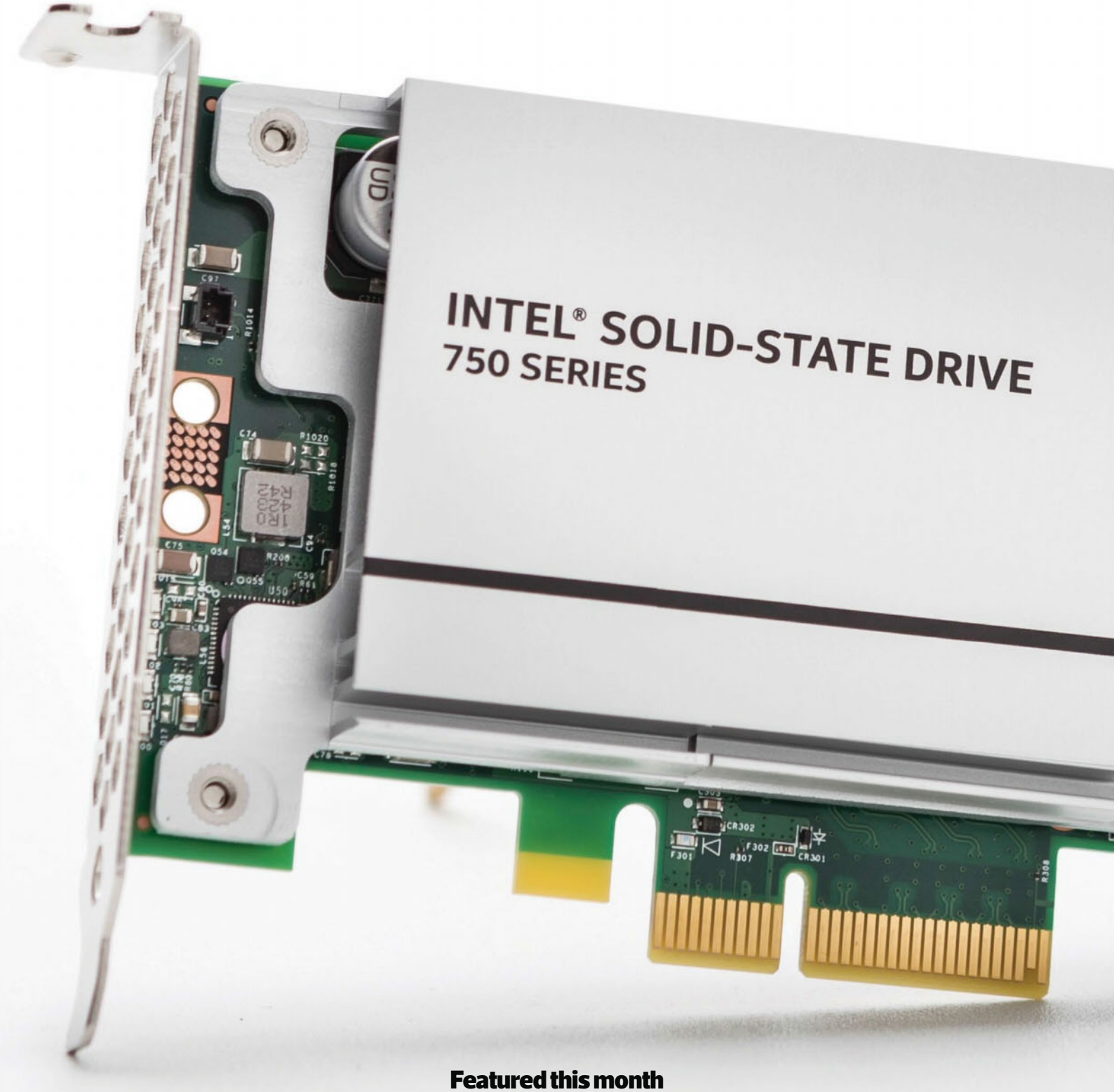
Crucial announces 128GB DDR4 Ballistix RAM kit

Memory maker Crucial has updated its DDR4 memory line-up to include a new series of high-density modules with its Ballistix brand, aimed at enthusiasts. Based on Micron's 8Gb chips, the new DIMMs offer up to 16GB on a single module, with 128GB kits available for X99 motherboards that will support it. The Ballistix modules will come in various flavours, including Crucial's Sport LT, Tactical and Elite ranges, covering various module sizes. Crucial says the new memory will ship in July this year.



Reviews

Our in-depth analysis of the latest PC hardware



Featured this month

HOW WE TEST
PAGE 32

CPU COOLER

Noctua NH-D9L / £39 inc VAT

SUPPLIER www.quietpc.com

Noctua's CPU coolers consistently offer great build quality, and while the company is perhaps better known for monstrous yet quiet coolers such as the NH-D15, it makes much smaller offerings such as the NH-D9L too.

The tiny NH-D9L measures just 110mm high, and costs £39 inc VAT, which might seem expensive for such a small CPU cooler, but it manages to justify its price tag. For starters, the packaging is superb. All the parts are neatly packed into their own small boxes, all of which fit precisely into the main box with no wasted space. You can quickly and easily pick out the parts you need for your particular setup, making installation easier.

There's a generous helping of thermal paste – enough for several mounts – and the cooler itself is positively gorgeous. It's extremely well made, compact and Noctua's fan clips are joyously simple to use compared with those used by many competitors. The NH-D9L itself sports two small aluminium heatsink stacks, fed by four 6mm heatpipes. These heatpipes, and the base of the cooler, are made from nickel-plated copper.

Our LGA1150 CPU was only 5°C warmer than with Corsair's H75

A single 92mm fan is sandwiched between the two heatsink stacks, which might seem inadequate for a small CPU cooler that Noctua claims can tame LGA2011-v3 CPUs. However, the reputation of Noctua's fans precedes them, and this particular PWM model can spin up to 2,000rpm while producing less than 23dB(A) of noise.

Noctua also includes a low-noise fan adaptor that drops the voltage for quieter noise levels and a slower spin speed. An additional set of fan clips is supplied too, enabling you to add another NF-A9 fan should you so wish.

Installing the NH-D9L is simple, just requiring you to secure two mounting plates to the motherboard, which are then secured to sprung screws on the heatsink. A long screwdriver is included, as you need to remove the fan to reach the screws, but it's very straightforward.

Cooling ability was remarkable for the cooler's size, although the fan was certainly audible at full speed outside of the case. Our LGA1150 CPU was only 5°C warmer than with Corsair's H75, although using the low-noise adaptor added another 5°C. It was perfectly able to deal with our overclocked LGA2011 CPU too, actually bettering the result from Corsair's H80i GT on its medium fan speed. It couldn't keep up with the DeepCool Assassin II on either test system, but the results are still remarkable for a small, sub-£40 cooler.

/SPECIFICATIONS

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

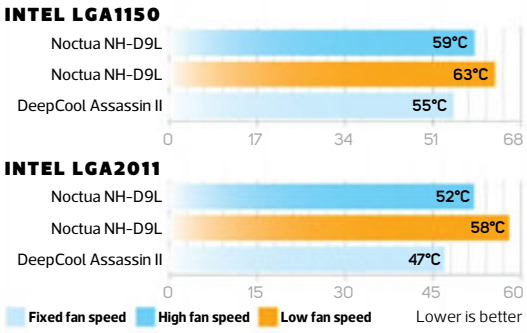
Heatsink size with fans (mm) 95 x 95 x 110 (W x D x H)

Fans 1 x 92mm

Stated noise Up to 22.8 dB(A)

The Noctua NH-D9L is a capable cooler, despite its small size, and it also offers great build quality and easy installation. If you need a small and relatively quiet cooler that can cope with reasonable overclocks, the NH-D9L has a great design that's more than up to the job.

ANTONY LEATHER



LGA115x

COOLING 31/40

DESIGN 29/30

VALUE 25/30

OVERALL SCORE 85%

LGA2011

COOLING 39/40

DESIGN 29/30

VALUE 24/30

OVERALL SCORE 83%

VERDICT

A compact, well-made CPU cooler that can cope with overclocked CPUs, even on Intel's top-end CPU sockets.

PREVIEW

Intel Broadwell for desktop

Broadwell has finally turned up in LGA1150 format, but are Intel's new unlocked CPUs worth the wait?

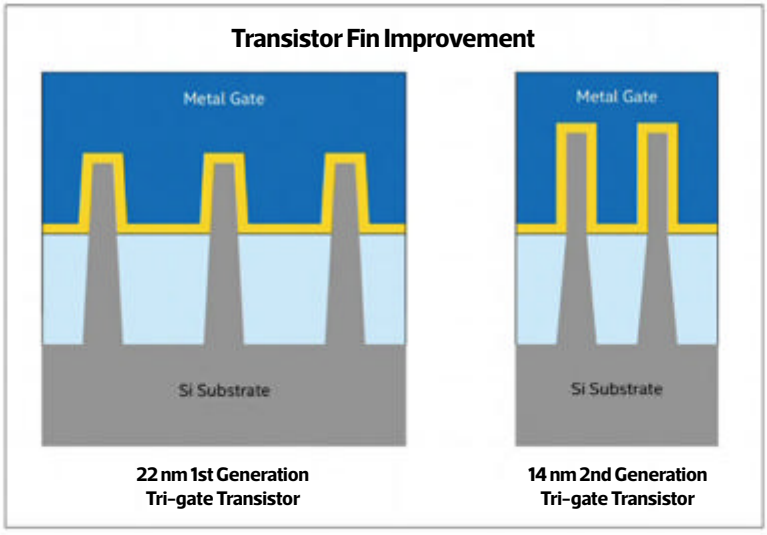
Not unlike a big-production sitcom, Intel's desktop CPU launches have followed a predictable formula for years. Intel calls it the tick-tock strategy, where a tock represents a new architecture (such as Sandy Bridge), and the tick is a later revision of that architecture, often with a die shrink (such as Ivy Bridge). It's a plan that was all going fine until Broadwell, the 14nm tick of Haswell's tock. We were originally expecting it to turn up last year, and we waited, then we waited some more, and then we instead got a tweaked version of Haswell, codenamed Devil's Canyon.

Now, after plenty of delays, Broadwell for the desktop is finally here, but again, it doesn't look like an Intel processor launch as we know it. For starters, there's only a handful of CPUs being launched, and only two of them are the LGA1150 CPUs we expected – the rest of them are BGA (ball grid array) chips for soldering directly to motherboards.

But before we delve into this miniscule range of new processors, let's first take a look at the Broadwell architecture. The main change from Haswell, in terms of the manufacturing process, is the move from 22nm transistors to a 14nm node. We first saw 22nm transistors in the Ivy Bridge architecture back in 2012, which introduced Intel's Tri-Gate 'three dimensional' structure.

Broadwell's 14nm transistors usher in the second generation of Tri-Gate, where the transistor fins are now thinner, taller and spaced more closely together, and Intel says it needs fewer fins too, reducing the area occupied by a transistor and thus also the die size. In fact, Intel claims that a 14nm SRAM cell size occupies almost half the area of the same cell with 22nm transistors. Smaller transistors also require less power to switch, and should output less heat too, reducing the power requirements and heat output of the Broadwell chips too.

Broadwell's 14nm transistor fins are thinner, taller and spaced more closely together



Farewell to K

With the manufacturing differences covered, let's take a look at the new chips themselves – the Core i7-5775C and Core i5-5765C. The 'C' at the end of the name basically has the same meaning as the 'K' at the end of current Intel CPUs' product names – these chips both have unlocked multipliers to enable overclocking.

As with other recent Intel desktop line-ups, the Core i5 chip has four physical cores, but doesn't support Hyper-Threading, while the quad-core Core i7 chip uses Hyper-Threading to effectively handle eight threads at once.

As expected after a die shrink, the quoted TDP of both chips is also significantly lower than that of their Devil's Canyon counterparts. Intel quotes a TDP of just 65W for both the new chips, compared with 88W for the Core i7-4790K and Core i5-4690K.

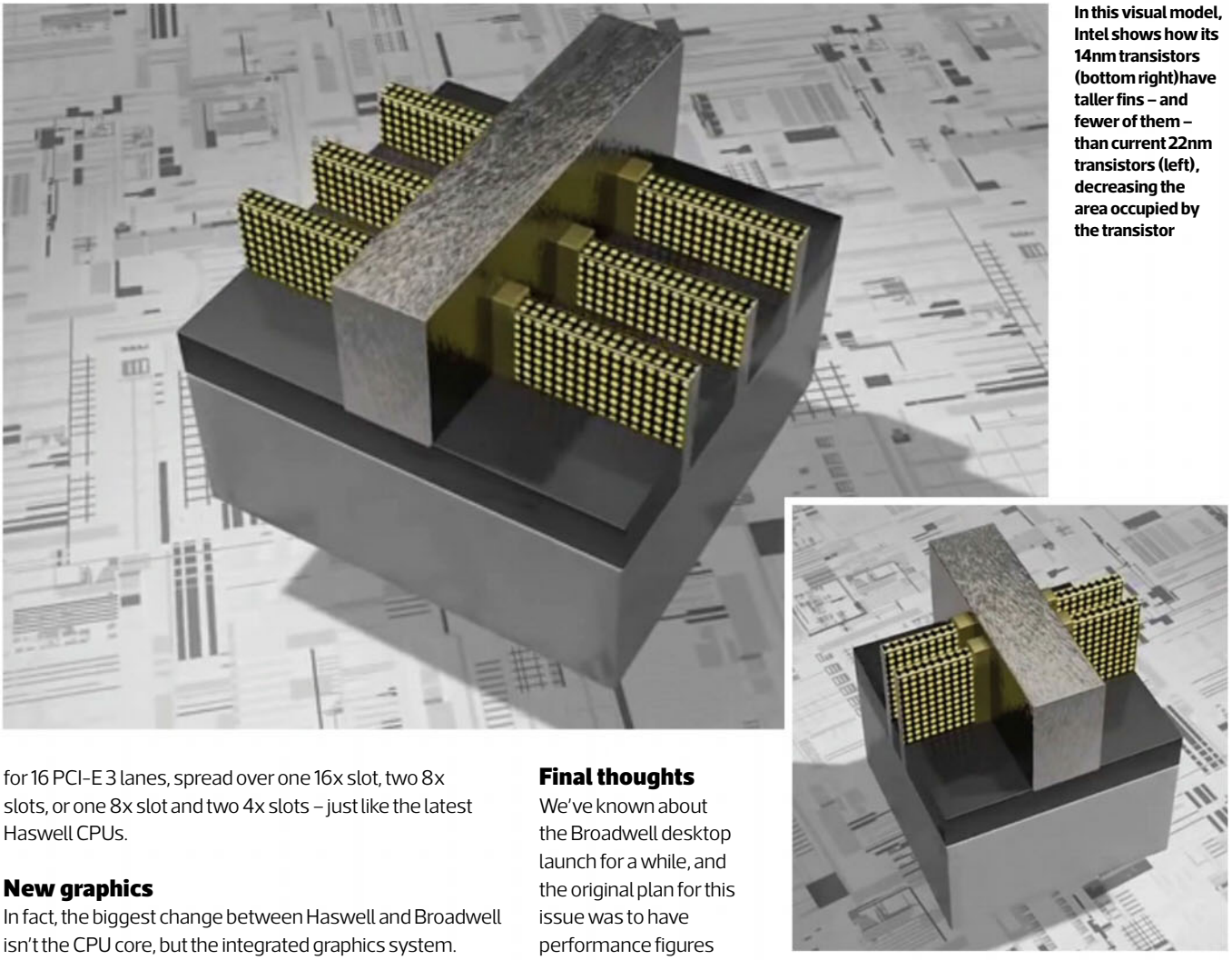
That's a significant reduction in power consumption for a die shrink, you might think, and you'd be right – because the die shrink isn't the only factor contributing to lower power consumption.

The other main factor is the clock speed; interestingly, this has been significantly reduced. The Devil's Canyon Core i7-4790K had a stock base clock of 4GHz, which uses Turbo Boost to hit up to 4.4GHz.

Comparatively, the Core i7-5775C has a base clock of just 3.3GHz, which can boost to 3.7GHz. That's a significant drop in clock speed of 700MHz.

Of course, we expect the number of instructions per clock (IPC) rate to also increase with a new CPU architecture, but that's a big reduction in stock clock speed, especially when new CPU architectures have seen gradual increases in clock speed since the Core architecture was first launched.

Otherwise, the CPU core specs are very similar to those of Haswell chips. There's 6MB of Level 3 cache, and support



In this visual model, Intel shows how its 14nm transistors (bottom right)have taller fins – and fewer of them – than current 22nm transistors (left), decreasing the area occupied by the transistor

for 16 PCI-E 3 lanes, spread over one 16x slot, two 8x slots, or one 8x slot and two 4x slots – just like the latest Haswell CPUs.

New graphics

In fact, the biggest change between Haswell and Broadwell isn't the CPU core, but the integrated graphics system. AMD's APUs have consistently outperformed Intel's CPUs in this respect, and not surprisingly so, given AMD's graphics expertise from the ATI buyout all those years ago. However, Intel's new integrated graphics system looks set to offer a serious challenge, with the GPU occupying a serious amount of die space.

Iris Pro graphics have previously been available in laptops, but this is the first time they've been available in socketed desktop CPUs. The new Iris Pro Graphics 6200 system offers 48 execution units – significantly more than the 20 in the Core i7-4790K's Intel HD Graphics 4600 system. The graphics base frequency sits at 300MHz, with a 1.1GHz maximum dynamic frequency, which is slower than the 350MHz (1.25GHz maximum dynamic) of the i7-4790K's frequency, but the extra execution units will counter that clock speed reduction - in graphics, parallelism is key.

The Iris Pro Graphics 6200 system also has access to 128MB of super-fast eDRAM, which acts a little like an L4 cache – like AMD's approach to integrated graphics, Intel is looking at the GPU as a part of the CPU, rather than an add-on. We've yet to test an Iris Pro Graphics 6200 system, but various reports in the industry point to it offering similar performance to the GPU in AMD's top-end GPUs – we look forward to finding out whether this is true. Intel itself claims it offers double the 3D graphics performance of Intel HD Graphics 4600 systems, with a 20 per cent increase in compute performance.

Final thoughts

We've known about the Broadwell desktop launch for a while, and the original plan for this issue was to have performance figures from not only the new CPUs, but also some fully built systems. However, we haven't received review samples of the chips from Intel. What's more, two system builders have now declined to send us Broadwell systems because of reduced performance, with one claiming they were struggling to get decent overclocks out of their engineering samples without experiencing thermal throttling.

We won't be able to verify desktop Broadwell's performance and overclocking headroom until we have the final chips in our hands, of course. However, with their significantly lower stock clock speeds, we'd be very surprised if the Core i7-5775C and Core i5-5765C offered a compelling upgrade for enthusiasts with current Devil's Canyon systems.

The power consumption might be lower, and the integrated graphics system might be more powerful than its predecessor, but that's only really useful for building very small form factor machines and low-budget PCs. Of course, that's a big market, but it isn't one we expected to be primarily targeted by Intel's new unlocked desktop CPUs.

Given that Intel's new Skylake CPUs, and 100-series motherboard chipsets, look scheduled to be released in less than a year, we think it's safe to say that it's best to wait and see what the future holds, rather than upgrading to a Broadwell CPU in preference to a Devil's Canyon chip now.

BEN HARDWIDGE

GRAPHICS CARD

Nvidia GeForce GTX 980 Ti / £540 inc VAT

SUPPLIER www.overclockers.co.uk

After GTX Titan left a massive gap between itself and the GTX 980 in terms of both price and speed, we all suspected a card such as the GTX 980 Ti was coming. Still, we weren't expecting the GTX 980 Ti to be so close to the GTX 980's price, while nearly matching the GTX Titan X's speed, making the latter almost redundant.

The GTX 980 Ti uses the same 28nm GM200 GPU as the Titan X, but with two of its 24 streaming multiprocessor (SMM) units disabled, leading to an 8 per cent reduction in stream processors and texture units, now 2,816 and 176 respectively. Otherwise, it's business as usual; the 1GHz clock speed (1,075MHz boost), 250W TDP and memory subsystem are unchanged.

Likewise, the six 64-bit memory controllers are retained for a full 384-bit bus with 16 ROPs per controller, there's a full 3MB of L2 cache and no partially disabled partitions. The GDDR5 again runs at 7GHz effective for a total memory bandwidth of 336GB/sec. The only other difference is the GTX 980 Ti's 6GB frame buffer, rather than 12GB. However, 6GB is still enough memory to run 4K games at maximum settings without bottlenecking the card before the GPU.

The GTX 980 Ti also fully supports DirectX 12 to feature level 12_1, which is where you find the most advanced rendering features, such as conservative raster (for accurate, ray-traced shadows) and volume tiled resources (for better rendering of 3D textures such as clouds, smoke and fire).

The card is equipped with future-proof display outputs, including HDMI 2 and three DisplayPort 1.2 connectors, any one of which can handle a G-Sync display. SLI is also supported all the way to 4-way setups. Meanwhile, power is received via the 8-pin and 6-pin PCI-E power connectors and delivered through the same 6+2 phase power system found on the Titan X.

Nvidia has wisely stuck to its lovely aluminium reference cooler too; the build quality is extremely solid and it looks the part too, although there's no backplate. A vapour chamber cools the GPU while a metal contact plate cares for the memory chips and VRMs. Heat is passed into two aluminium heatsinks, before the vast majority of it is blasted directly out the rear of your case by the radial fan.

Performance

You only need to glance at the performance figures to see the proximity in performance of the GTX 980 Ti and Titan X. Across 2,560 x 1,440 and 4K, the GTX Titan X is 4 per cent quicker than the GTX 980 Ti on average – a difference you're never likely to notice. Even in Alien: Isolation at 2,560 x 1440, where the Titan X's minimum frame rate is 11 per cent higher, both cards are running so fast here that you wouldn't notice the difference. In turn, the GTX 980 Ti is ahead of the GTX 980 by a healthy 29 per cent when taking the average of the game results, and ahead of the R9 290X by 42 per cent.

For 2,560 x 1,440 gaming, the GTX 980 Ti's minimum frame rates exceed 60fps in all but one of our games, Crysis 3, where the 53fps minimum is still smooth.

Even 4K is handled well, thanks to the 980 Ti's fast memory subsystem and large frame buffer. Again, in every game except Crysis 3, it stays well above 30fps – we're finally seeing cards that can handle 4K with maximum or close to maximum details by themselves. In Crysis 3, the 26fps minimum passes also our technically playable test, and is still a good result that matches that of the Titan X.

Power consumption is completely in line with the Titan X too. The fact that you can run games this fast in a PC that draws less than 400W from the mains is testament to Maxwell's outstanding efficiency. The cooler runs louder than on the GTX 980, and is clearly audible, but it will only be a distraction if you have your graphics card positioned very close to you and your gaming audio is set to a low volume.

/SPECIFICATIONS

Graphics processor Nvidia GeForce GTX 980 Ti, 1,000MHz (boost 1,075MHz)

Pipeline 2,816 stream processors, 96 ROPs

Memory 6GB GDDR5, 7GHz effective

Bandwidth 336GB/sec

Compatibility DirectX 12, OpenGL 4.5

Outputs/inputs 3 x DisplayPort, Dual-link DVI-I, HDMI

Power connections 1 x 8-pin, 1 x 6-pin, top-mounted

Size 267mm long, dual-slot

ELITE
NEW ENTRY
P62

The GTX 980 Ti is a great overclocker too. We added 250MHz (25 per cent) to the base clock, which saw it regularly boosting to over 1.4GHz in games. We could also increase the memory clock by 14 per cent to around 8GHz effective. As a result, performance leapt up significantly, with the new 33fps minimum in Crysis 3 being a real highlight. When the Titan X is also overclocked, both cards perform near enough identically – another win for the GTX 980 Ti.

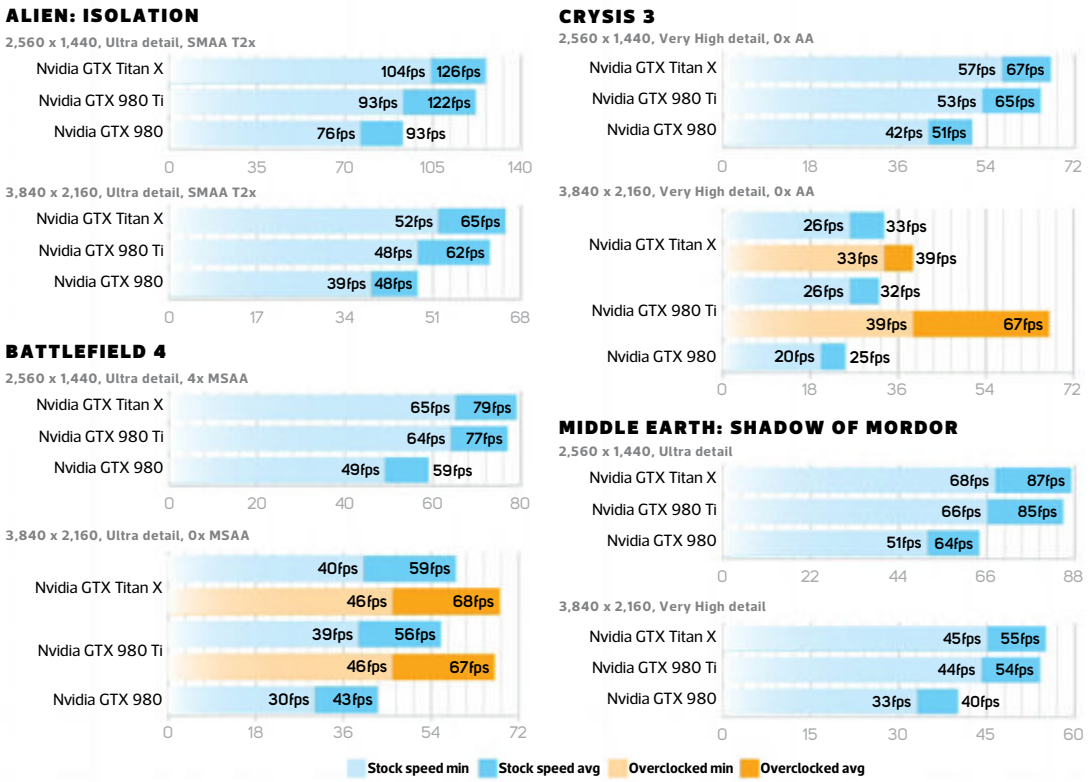
Conclusion

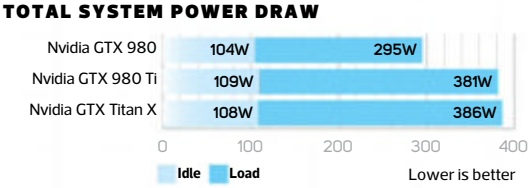
The GTX 980 Ti is a powerful pre-emptive strike against AMD, which at the time of publication still hasn't released its R9 300 series. The pricing is fair too; it's 30 per cent quicker than a GTX 980 and about 30 per cent more expensive. It's still costly, yes, but the performance benefit is equally massive. The card is also future-proof with DX12, HDMI 2 and G-Sync support as well as a 6GB frame buffer, and the overclocking potential is outstanding. However, Nvidia has

also dealt a blow to its own Titan X. Effectively, Titan X buyers are now paying £300 for 6GB of GDDR5, leaving a bitter taste in the mouths of early adopters.

It also means AMD has a tough challenge to fight back. Hopefully, cutting prices won't be the red team's only weapon against Nvidia, and performance alone will be enough to bring down prices generally. If you want great high-resolution gaming performance on a single-GPU for a respectable price, the GTX 980 Ti is currently the king of the castle. However, if possible, we recommend waiting to see the impact of AMD's R9 300 series before buying right now.

MATTHEW LAMBERT





SPEED **39/40**

FEATURES **18/20**

VALUE **27/40**

OVERALL SCORE **84%**

VERDICT

By offering 4K gaming on a single GPU for just £549, the GTX 980 Ti already makes the Titan X redundant. However, we recommend holding out to see the impact of AMD's R9 300 series before buying a premium GPU right now.

PC Specialist recommends Windows 8.1

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Intel SSD 750 1.2TB / £817 inc VAT

SUPPLIER www.scan.co.uk

SSDs have been pushing the bandwidth limits of SATA 6Gbps for some time, and even recent PCI-E based M.2 and expansion card SSDs are still held back by the Advanced Host Controller Interface (AHCI), the protocol that specifies how a storage device communicates with the system host controller. It was designed for older mechanical drives, but it's inefficient for SSDs and wastes CPU cycles. That's where the Non-Volatile Memory Host Controller Interface Specification (NVM Express or NVMe for short), used by Intel's new SSD 750 card, comes in.

Unlike AHCI, NVMe is designed specifically with PCI-E SSDs in mind, capitalising on their inherent parallelism and low latency. For starters, NVMe introduces significantly larger queue-depth support – AHCI supports a single command queue with 32 commands, while NVMe can support 64K queues, each with 64K commands. This setup helps to ensure that NVMe takes full advantage of the multiple CPU cores in today's systems, whereas AHCI was mostly limited by single-core performance.

The uncacheable register accesses per command have also been greatly reduced, cutting latency. Command parameters can now be received in one 64-byte memory fetch rather than two with AHCI as well. Essentially, NVMe allows CPU cores and SSDs to do more at once, with less latency between them.

Intel's SSD 750 is the first consumer NVMe drive. It communicates directly with the CPU via four PCI-E 3 lanes (up to 32Gb/sec). It's available in 400GB or 1.2TB capacities and as a 2.5in drive that uses the new SFF-8639 connector or, as with our sample, a 4x PCI-E card. It promises sequential read and write speeds of up to 2.4GB/sec and 1.2GB/sec respectively, and respective random read and write performance of 440,000 and 290,000 IOPS.

The drive targets enthusiasts and workstation users with demanding storage needs, rather than average home users or gamers. An important feature for the target audience is the full power loss protection afforded by the on-board capacitors, with all in-flight and cached data protected. The five-year warranty also covers a hefty 219TB written endurance rating, or 120GB per day – a serious workload.

Then we have the card's 18-channel Intel CH29AE41AB0 controller, which is already taking great advantage of parallelism; the vast majority of SATA controllers have just eight channels. To make up the 1.2TB capacity, there are 18 NAND packages on the front of the PCB, each with four IMFT 128Gb NAND dies inside them, and 14 single-die packages on the rear. The reason for this disparity in die count is that the front chips are cooled by the drive's heatsink, which is necessary as the drive can consume up to 25W when it's fully active. It also consumes 4W when idle, so we're unlikely to see this card in smaller, mobile-centric form factors.

Intel's Z97 and X99 chipsets support NVMe, although your motherboard may need a BIOS update first. The latter chipset is especially good for NVMe drives, thanks to its 40 PCI-E 3 lanes – enough for two SSDs and two graphics cards to run at full bandwidth. Z97, however, is limited to 16 lanes, so you'll lose some available graphics bandwidth if your motherboard doesn't have a PLX PCI-E lane switch, which you usually only find on high-end motherboards.

You'll also need Windows 7 or later, and Intel has released its own driver for the SSD 750, which is faster than the NVMe one that's built in to Windows 8.1. NVMe drivers are also available for Linux, ChromeOS and FreeBSD, and the drive is bootable if your motherboard is running UEFI 2.3.1 or later. RAID 0 configuration can be achieved too, but only through software, so it wouldn't be bootable. Support for true, hardware-level NVMe RAID will come in future chipsets.

/SPECIFICATIONS

Interface PCI-E 3.0 x4 (32Gbps), NVM Express
Nominal capacity 1.2TB
Formatted capacity 1,117.81GB
Controller Intel CH29AE41AB0
Cache 2GB Micron DDR3
Memory IMFT 20nm MLC NAND
Warranty Five years (219TBW)

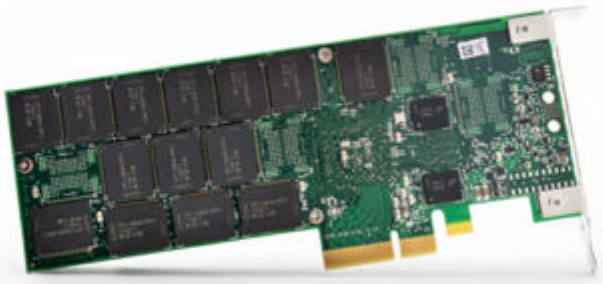
Performance

The SSD 750 dominates nearly all of our benchmarks, and is clearly capable of achieving the advertised speeds – in particular, the sequential read and write speeds are phenomenal. It's leagues ahead of SATA performance in every test except single-queue-depth reads, although it's still fast here too.

Even in PCMark 7 and 8, which use traces of software not optimised for NVMe, the SSD 750 has the best result in each test. That said, the differences are small and often inconsequential – in games and standard office apps, you're unlikely to notice any difference, although more demanding tasks such as heavy photo and video editing may be met with a small but appreciable speed bump.

Where it all comes together is in Iometer testing, which batters the drive with high-queue-depth, random read and write workloads typical of various professional and workstation environments. NVMe was designed to accelerate these workloads, and it works a treat; overall, the SSD 750 is almost five times faster than the Samsung SSD 850 Pro, which is the best SATA drive available for this work.

The Windows 7 boot times are the only letdown, and here we suspect the lack of native OS support is to blame – we had to point the OS installer to the Intel driver just to recognise the drive. If you want to boot from this drive, Windows 8.1 should be used.



Conclusion

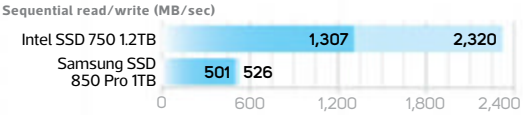
Clearly, NVMe is a turning point for flash-based storage, but at over £800, or around 73p per usable gigabyte, it comes with a high cost of entry. Still, many professional and workstation workloads will see a dramatic increase in throughput, which could well justify this price.

Average home users and gamers are unlikely to notice the difference, but if you're an enthusiast who wants the fastest storage system available, we recommend turning to the 400GB model – it's slightly slower, but the £300 price tag is much more palatable.

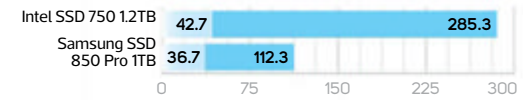
MATTHEW LAMBERT

AS SSD

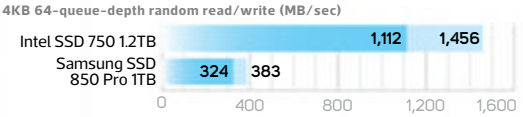
Sequential read/write (MB/sec)



4KB random read/write (MB/sec)

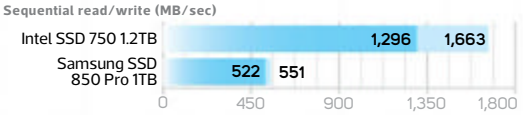


4KB 64-queue-depth random read/write (MB/sec)

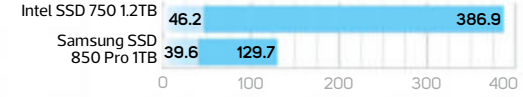


CRYSTALDISKMARK

Sequential read/write (MB/sec)



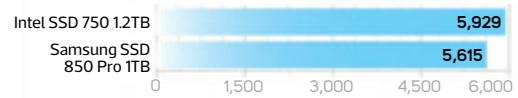
4KB random read/write (MB/sec)



4KB 64-queue-depth random read/write (MB/sec)

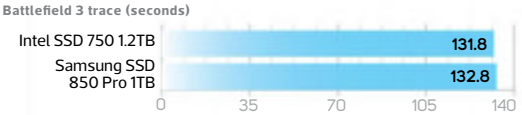
PCMARK 7

Secondary Storage score

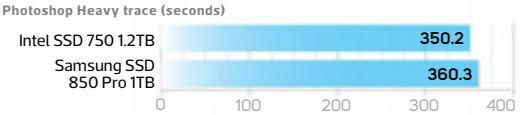


PCMARK 8

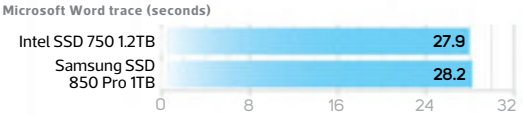
Battlefield 3 trace (seconds)



Photoshop Heavy trace (seconds)

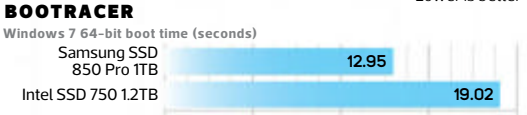


Microsoft Word trace (seconds)



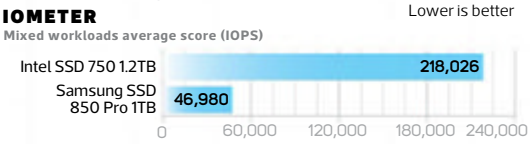
BOOTRACER

Windows 7 64-bit boot time (seconds)



IOMETER

Mixed workloads average score (IOPS)



SPEED 50/50

£/GB 10/20

BANG/BUCK 19/30

OVERALL SCORE 79%

VERDICT

NVMe has made a seriously impressive debut in the SSD 750, but at this price, only wealthy early adopters and workstation users need apply

GAMING LAPTOP

MSI GE72 2QD-037UK / £999 inc VAT

SUPPLIER www.scan.co.uk

MSI's GE72 costs just £999, which makes it the cheapest gaming laptop we've seen for some time. However, despite its price, it still has a beefy specs list, including a GPU from Nvidia's latest mobile range.

The GeForce GTX 960M sits right in the middle of the mobile 900-series, and it's well placed to deliver decent performance on the MSI's 1080p screen: it has 640 stream processors, 2GB of 5GHz (effective) GDDR5 memory and a core clock speed of 1,096MHz. It's based on the GM107 architecture, which first appeared in the desktop GTX 750 Ti GPU.

The rest of the specification is solid too. The Core i7-4720HQ processor has four cores that can boost from 2.6GHz to 3.6GHz, and there's 8GB of DDR3 memory – a fine amount, which is fine for gaming. Meanwhile, storage comes from a 128GB Kingston SSDNow drive and 1TB hard disk, and there's a DVD writer too.

The GE72 looks the part too. The brushed metal lid has subtle ridges bordering the slick MSI Gaming Series logo, and the interior is made from the same material. The touchpad is made from lighter metal, with a narrow chrome-effect border, and another logo signifies the high-quality SteelSeries keyboard.

The keyboard's base is solid, and the layout is reasonable – the single-height return key is the only negative on a typing unit that has a numeric keypad and plenty of large keys elsewhere. The typing action is consistent and fast, which are both key gaming attributes.

However, the keys don't have much travel, and they're a little soft; mechanical fans will feel the lack of physical feedback. It's also backlit, with a multi-coloured glowing pattern, which can be customised. Meanwhile, the large touchpad has a smooth, responsive surface, but the two buttons don't have the firm rapidity of proper desktop peripherals. Gamers will be better off with a proper USB mouse.

Most of the chassis feels solidly built too, although there's some give in the right-hand side of the wrist-rest, and the underside is a little spongy. Interior access isn't easy either – we had to remove almost 20 screws and the optical drive before we could heave off the base panel. Once inside, at least, the MSI is generous: one memory slot and two M.2 slots are free, and the major components are all accessible.

Three USB 3 ports, a USB 2 port, Gigabit Ethernet, HDMI and DisplayPort outputs and an SDXC card slot line the edges, and it's decently specified on the inside too: Ethernet is provided by Killer, and there's dual-band 802.11ac wireless and Bluetooth 4.0 too.

/SPECIFICATIONS

CPU 2.5GHz Intel Core i7-4720HQ

Memory 8GB DDR3

Graphics Nvidia GeForce GTX 960M 2GB

Screen size 17.3in 1,920 x 1,080

Storage 128GB Kingston SSDNow SSD, 1TB hard disk, DVD writer

Weight 2.4kg

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

Dimensions (mm) 383 x 260 x 27 (W x D x H)

Warranty Two years collect and return

Performance

The GE72 may sit at the affordable end of the gaming laptop scale, but its benchmark results aren't bad for the money, thanks to its quad-core CPU with Hyper-Threading support. The GE72's overall result of 81,712 isn't record-breaking, and we've seen better results from other gaming laptops, but it shows the MSI's performance is ample for gaming and other Windows tasks.

Meanwhile, gaming performance is a mixed bag. Let's start with the good, which is that the GE72 never dropped below 34fps when playing BioShock Infinite at top settings at the screen's native resolution. However, the rest of our game tests failed to hit our 25fps minimum target for playability, let alone 30fps.

To be fair, though, our games tests are very demanding, and the Battlefield 4 minimum of 24fps was very close – you'll only need to slightly tweak the graphics settings to make it playable. However, you'll need to do a fair bit of tweaking in Shadow of Mordor or Crysis 3 to make them playable on this machine at its native resolution. As a point of comparison, the Gigabyte P35X v3 (see Issue 138, p30) achieved 30fps minimums in all our 1080p games benchmarks with its GTX 980M GPU, but that range of laptops starts at £1,499.

On the plus side, the comparatively modest specifications means the GE72's noise output isn't bad. When running undemanding tasks, the GE72 is tricky to hear at all; it's louder when stress tested, but its modest fan is easier to ignore than the one in the aforementioned Gigabyte laptop. The temperatures weren't too toasty either; in stress testing, the CPU topped out at 87°C, and the GPU at 74°C – we've seen CPU temperatures go well above 90°C in other gaming laptops.

On the downside, the GE72's screen isn't great. The colour temperature of 7,549K is far too cool, and the delta E of 7.49 is way off the mark, meaning colours just won't be accurate.

Viewing angles aren't brilliant either, with big brightness deviations from even the slightest head movements, and the matt layer across the top of the PLS panel lends the screen a grainy finish. It's a shame, because the brightness measurement of 279cd/m² and measured contrast of 1,073:1 are both reasonable, and mean a good colour gamut with bright lighter shades and suitably inky black tones.

The Dynaudio speakers have mixed quality too. They provide some of the best bass we've heard from a laptop – it thumps and chugs without overwhelming the sound, but it's hindered by a weak top end that means lighter tones are underwhelming. The booming bass makes games sound explosive, but the audio kit could do with a better balance.

Battery life isn't much cop either, although that's to be expected from a gaming laptop. In a full-pelt gaming test with the screen at 100 per cent brightness, the GE72 lasted for 43 minutes – a few minutes less than some of its rivals. In short, you'll need to stay near the mains if you want to play games for any length of time.

Conclusion

The GE72's sub-£1,000 price might look attractive, but MSI has had to cut a couple of corners to achieve it, most notably on the screen and gaming performance.

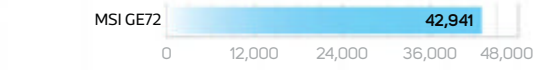
Of course, its gaming performance is much better than that of many laptops without a discrete GPU, but it's important to be aware of its limitations before forking out for a gaming laptop – you won't be able to run demanding current games at top settings at the screen's native resolution, but it will be fine if you're prepared to drop your graphics settings.

There's still plenty to like too. It looks great, the keyboard and touchpad are well built and you get solid state storage too. You can't get everything you want for this price, of course, but the GE72 makes sensible compromises rather than dramatic budget cuts, which makes it a genuinely viable alternative if you want a half-decent gaming laptop but can't afford the big bucks.

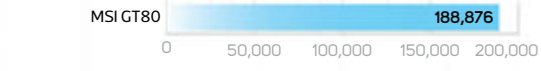
MIKE JENNINGS

CPC REALBENCH 2015

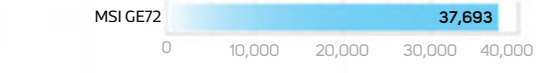
GIMP IMAGE EDITING



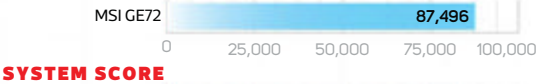
HANDBRAKE H.264 VIDEO ENCODING



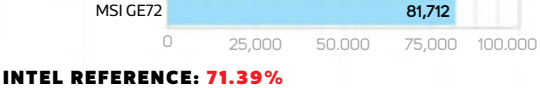
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



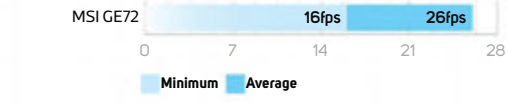
INTEL REFERENCE: 71.39%

BATTLEFIELD 4
1,920 x 1,080, Ultra Detail, 4x AA

BIOSHOCK INFINITE
1,920 x 1,080, Ultra Detail with Depth of Field

SHADOW OF MORDOR
1,920 x 1,080, Ultra Detail

CRYSIS 3
1,920 x 1,080, Very High Detail, 0x AA



SPEED	DESIGN	OVERALL SCORE
20/25	19/25	83%
HARDWARE	**VALUE**	
22/25	22/25	

VERDICT

You'll need to tone down your graphics settings to run demanding games at 1080p, but the GE72 is otherwise a solid gaming laptop for a very tempting price.

GAMING MOUSE

Natec Genesis GX88 / £52 inc VAT

SUPPLIER www.amazon.co.uk / MODEL NUMBER NMG-0502

Natec's Genesis GX88 looks like it's bristling with features compared with similarly priced mice, and the same goes for its specs list too. The 8,200dpi Avago 9800 laser sensor offers adjustment between 200 and 8,200dpi in 200dpi steps, so fine-tuning the sensitivity is certainly a strong point. What's more, the resolution for both the X and Y axes can be tweaked independently.

Perhaps more interesting is the fact that you can perform any of these tweaks without the software if need be; the F.S. button gives you access to the X or Y axis modes on the fly to make adjustments to one of the four dpi presets. Sadly, the way this information is displayed on the mouse using two lines of LEDs isn't particularly clear, and the dpi preset LEDs themselves are located on the side of the mouse, and are only just visible at a glance.

The F.S. button gives you access to the X or Y axis' dpi modes on the fly

A rocker switch beneath the thumb buttons enables you to flit between the dpi presets, which is roughly as easy as switching the usual buttons located behind the scroll wheel on most gaming mice, but not quite as quick to access as the switches on Logitech's G402 Hyperion Fury, which sit to the side of the left mouse button. The raised arch means the thumb buttons rest a fair way from your thumb too.

Meanwhile, the scroll wheel acts as a further three buttons, as it can be depressed, and tilted to the left and right, while two more buttons sit to the side of the right mouse button. All of this brings the total number of programmable buttons to nine, and 11 if you include scroll up and down; the dpi rocker is fixed to switch between dpi presets, so you can't reassign it. You can optimise the mouse's lift too, although you need to assign a button to this task, as it isn't set by default.

The software allows a fair degree of customisation, such as the dpi modes, USB polling rate and scroll acceleration, in addition to macros and custom button assignments. There are also five different modes for assignments too, which are colour-matched to LEDs on the GX88's mode button, giving you five separate gaming profiles.

In terms of grip styles, the GX88 is large and tall, so it's best suited to claw and palm-grip types. It's relatively weighty, but it glides smoothly across most surfaces and provides good support for all your fingers, except the end of your pinky. The mouse movement on-screen is equally responsive, and you quickly get used to the GX88's shape in your hand. That said, despite its large size, other mice such as the Logitech G402 Hyperion Fury are even more comfortable to use, and have slightly better button placement too.

CONCLUSION

The GX88 is a little complicated to set up, especially if you don't use the software, and the super-granular dpi adjustment can be tricky to tune on-the-fly. However, the software is good, it's generally comfortable to use and it has plenty of programmable buttons and modes. Its price isn't bad for the features on offer either. Its only problem is that the gaming mouse market is very crowded and it's up against some seriously stiff competition from the likes of Logitech and Mionix.

ANTONY LEATHER

/SPECIFICATIONS

Connection Wired, USB
Cable 2m, braided
Resolution 8,200dpi
Material Plastic
Extras Replacement Teflon feet

DESIGN	FEATURES	VALUE
31/40	30/35	22/25

OVERALL SCORE **83%**

VERDICT

A reasonably priced and well-made mouse with plenty of customisation options, but it's up against tough competition.

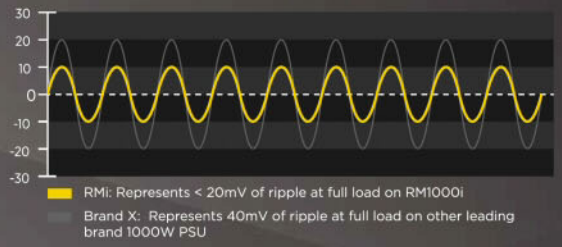
CORSAIR

PREMIUM COMPONENTS DELIVER
EXCEPTIONAL PERFORMANCE

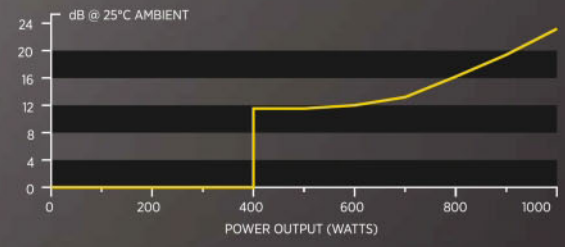
RM1000i

Corsair RMi Series power supplies are 80 PLUS Gold certified and give you extremely tight voltage regulation, virtually silent operation, and a fully modular cable set.

> **Engineered for extremely tight voltage regulation** and best-in-class ripple and noise suppression.



> **Zero RPM Fan Mode** delivers silent operation at low and medium loads.



> **Corsair Link Digital** makes it easy to monitor power supply performance, toggle between single and multiple +12V rail modes, and control fan speed directly from your desktop.

> **Fully modular cable set** allows for quick and easy installation and great looking builds.

> **100% Japanese 105° C capacitors** ensure reliability and long life, backed by a 7 year Guarantee.

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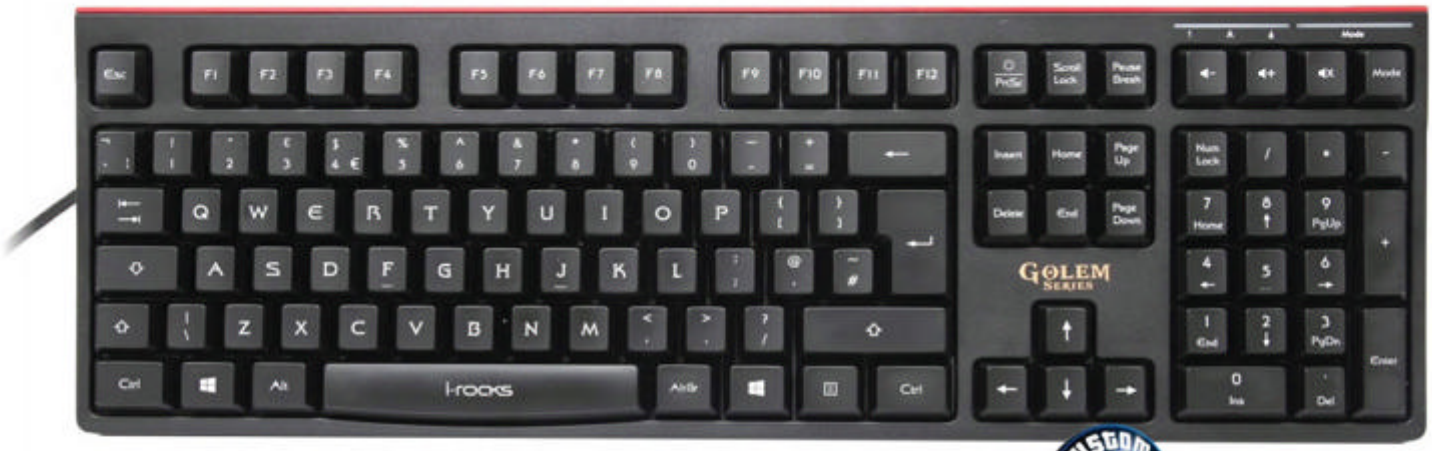
CASES

CPU COOLING

DRAM

SSDs

HOW WE TEST
PAGE 32



KEYBOARD

i-Rocks Golem Series K50 / £39 inc VAT

CUSTOM PC APPROVED

SUPPLIER www.amazon.co.uk / **MODEL NUMBER** B00UJASKOE

There are still plenty of PC users that use membrane keyboards, and for a variety of reasons. They're usually more affordable than keyboards with Cherry MX switches, plus they're much quieter as well. Several manufacturers have grappled with the latter point over the past couple of years, with some of them creating their own switch types. The Golem Series K50 is a case in point. It uses scissor switches, but i-Rocks has tweaked the switch design to make them more gaming-friendly.

Instead of offering feedback similar to that of your average laptop keyboard, many of which use a similar type of switch, the K50's scissor switches have a raised structure compared with the standard low-profile versions, offering a 3.8mm keystroke. Several manufacturers, including Razer, have experimented with scissor switches in their full-sized keyboards, but most of these designs have had low-profile keys.

The scissor switches have a raised structure, offering a 3.8mm keystroke

Of course, there's still a membrane base, so key presses result in the slight bounce that's characteristic of membrane keyboards, but you also get a more linear and responsive keystroke than you get from a standard membrane design. The keys are very pleasant to use for both typing and gaming, and an instant improvement over a membrane keyboard. The actuation force required is 55cN, which is less than Cherry MX Black switches but a fair bit more than Cherry MX Reds. However, anyone coming from a membrane keyboard will probably get used to it very quickly.

The best part, though, is the noise, or rather the lack of it – the K50 is easily as quiet as a membrane keyboard and massively less intrusive than any Cherry MX switch keyboard, especially on the upstroke, where some keyboards still produce a loud clack on the key return even if you type lightly.

/SPECIFICATIONS

Connection Wired, USB
Cable 2m, non-braided
Material Plastic
Switch type Scissor
Backlighting, 1 colour
Extras None

The K50 retails for £39, and it's devoid of quite a few features as a result. There are no macro keys, USB ports or customisation software included, and the only options for media keys are the volume control buttons.

Thankfully, the keys offer 24-key rollover with PS/2 or 13-key with USB, and they're backlit, albeit with a single lighting level and only in orange, but the brightness level is fine in both low light and completely dark lighting conditions.

There's no wrist rest either, and the support stands only offer a single, slightly overzealous height setting. That said, the K50's sloped key set made for comfortable typing without the stands engaged anyway.

There's no braided cable either, but there are cable channels that enable you to route the USB cable via either side or the centre.

Conclusion

While it lacks advanced features, the K50 is pleasant to use, very quiet and offers far more tactile feedback than membrane keyboards, although the membrane bounce means it isn't for Cherry MX fans.

With its sub-£40 price, though, it sits comfortably between membrane and mechanical price brackets, offering a solid step up if you're not quite prepared (or don't have the cash) to enter the realms of mechanical keyboards.

ANTONY LEATHER

DESIGN	FEATURES	VALUE
33/40	25/35	24/25

OVERALL SCORE 82%

VERDICT

A great upgrade for membrane keyboard owners, and it's quiet too, although it isn't going to challenge Cherry MX designs.

XFX
www.xfxforce.co.uk

AMD

(simulation)

No stuttering. No tearing. Just gaming.

Worlds: broken. Screen: intact.

AMD FreeSync™ puts an end to choppy gameplay and broken frames with fluid, artifact-freeperformance at virtually any framerate

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Gigabyte Z97P Motherboard
XFX Radeon 290X 4Gb
1TB Seagate Hard Drive
Kingston 120GB SSD Main Drive
XFX 850 Watt Power Supply
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AMD FREESYNC TECHNOLOGY

AMD RADEON GRAPHICS

How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

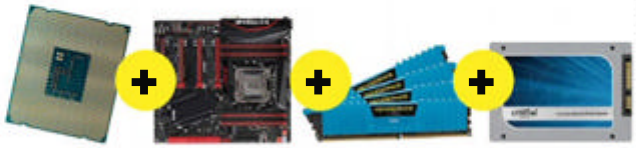
PROCESSORS

We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

INTEL LGA1150

Intel LGA1150 CPU | Asus Maximus VII Ranger | 16GB Corsair Vengeance Pro 1,600MHz DDR3 | 240GB OCZ Vector 150

INTEL LGA2011-V3



Intel LGA2011-v3 CPU | Asus Rampage V Extreme | 16GB Corsair Vengeance LPX 2,133MHz DDR4 | 512GB Crucial MX100

AMD FM2+

AMD FM2+ APU | Gigabyte G1 Sniper A88X | 16GB Corsair Dominator Platinum 2,133MHz DDR3 (GPU testing) | 8GB G.Skill RipjawsX 1,600MHz DDR3 (CPU testing) | 256GB Plextor M5 Pro

COMMON COMPONENTS

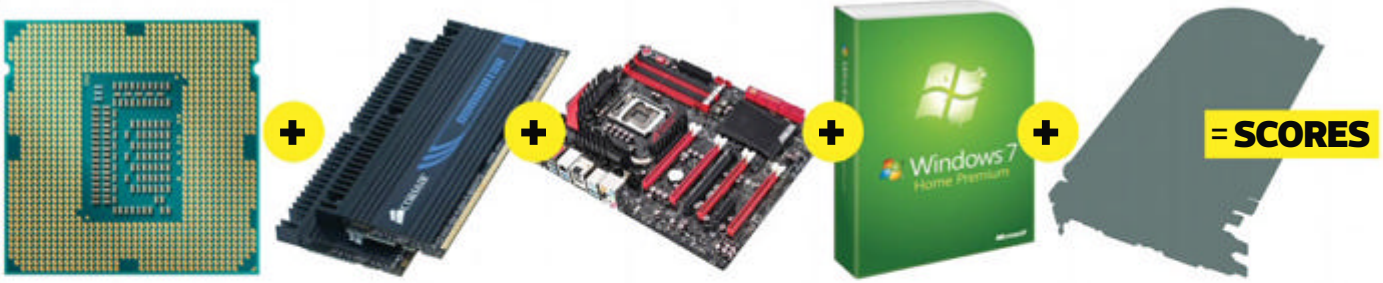
Nvidia GeForce GTX 780 3GB | Windows 7 64-bit

TESTS: We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

*Please note: We test AMD FM2+ APUs using the on-board graphics, not the Nvidia GeForce GTX 780 3GB

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.



4.2GHz Intel Core i5-3570K | 8GB Corsair Dominator 2,400MHz DDR3 | Asus Maximus V Extreme | Windows 7 64-bit | The graphics card we're reviewing

CUSTOM PC REALBENCH 2015

INTEL REFERENCE

Intel Core i7-4790K | 16GB of Corsair 2,400MHz DDR3 | 240GB OCZ 150 | Asus Maximus Gene VII | Nvidia GeForce GTX 780 3GB

AMD REFERENCE

AMD A10-7850K | 8GB of Corsair 2,133MHz DDR3 | 256GB Plextor M5 Pro | Asus A88X-Pro

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

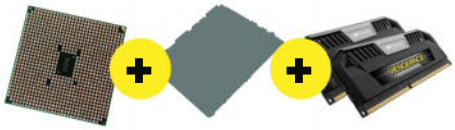
MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

INTEL LGA1150

Intel Core i7-4790K | Motherboard on test | 16GB Corsair Vengeance Pro 1,600MHz DDR3 | 240GB OCZ Vector 150

AMD FM2+



AMD A10-7850K | Motherboard on test | 16GB Corsair Vengeance Pro 2,133MHz DDR3

INTEL LGA2011-V3

Intel Core i7-5960X | Motherboard on test | Plextor M6 256GB | 32GB Crucial 2,133MHz DDR4

COMMON COMPONENTS

Nvidia GeForce GTX 780 3GB* | Windows 7 64-bit

TESTS: We use Custom PC RealBench 2015 and several games, and also test the speeds of the board's SATA ports. We try to overclock every motherboard we review by testing for a maximum QPI, base clock or HTT as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

*Please note: We test AMD FM2+ motherboards using the on-board graphics, not the Nvidia GeForce GTX 780 3GB

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 the four games (above) 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.

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.

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Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

USB DRIVE

PNY JetFlash 880 64GB / £25 inc VAT

On The Go (OTG) USB drives offer a flexible way to add extra storage to an Android tablet or phone, and the JetFlash 880 may be the best example we've seen yet. Firstly, it's tiny. Barely bigger than the USB 3 connection it's built around, the 880 is discreet and light. It's also water-resistant and stood up to a quick dunk under a running tap. Water-resistant doesn't mean waterproof, though, so it's unlikely to survive a trip through the washing machine.

It isn't the quickest USB 3 drive we've ever seen, with respective read/write speeds of 69.3MB/sec and 19.6MB/sec, but that's still plenty of bandwidth for watching 1080p video. It's reasonably priced too – £25 nets you the 64GB version, which is just £10 more than the 32GB USB2 SanDisk OTG drive we recently reviewed.

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SUPPLIER www.morecomputers.com

2.0 SPEAKERS

Microlab B58 / £17 inc VAT

Despite the budget price tag, first impressions of the Microlab B58 speakers are good; they're bigger and sturdier than other cheap 2.0 speakers we've seen and, while the styling on show isn't exactly scintillating, they are far from offensive. The budget leanings of the set become more apparent when they're tasked with belting out your favourite tunes, however. High frequencies such as like splashy hi-hats sounded crackly and distorted, mid-frequencies sounded wishy-washy and lacking punch, and the available volume from the speakers can best be described as measly.

The bass response – which was deep, booming and well behaved – was a rare highlight, but overall, the B58 is an unsatisfying set of desk speakers, despite its temptingly low price.

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SUPPLIER www.scan.co.uk

HDD CADDY

Icy Box IB-AC6034-U3 / £17 inc VAT

Finished in brushed aluminium and boasting a USB 3 connection, the AC6034-U3 initially looks pretty solid for its £17 asking price. Get your hands on it, though, and you can quickly see where costs have been cut. The aluminium casing is paper-thin, and there isn't any padding or protection in sight. The top doesn't screw down either – it just fastens in place with a flimsy friction clip.

What it lacks in luxury, it makes up in speed though. With an SSD inside it, and using a test folder containing videos and MP3s, we saw read/write speeds of 103.1MB/sec and 69.3MB/sec respectively. The AC6034-U3is a neat-looking device that offers decent storage speed. Just make sure you don't drop it if it contains a mechanical hard drive.

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SUPPLIER www.novatech.co.uk

SMART WATCH

Apple Watch Sport 38mm / £299 inc VAT

Let's start with the good news. The Apple Watch is impeccably manufactured, comfortable to wear and the 38mm version we tried isn't any more bulky than a traditional timepiece. Pairing is slick (point your iPhone camera at the Apple Watch and the two devices marry up instantly) and app support is already excellent. The Force Touch screen feels like a genuine innovation too, and getting alerts on your wrist quickly feels natural.

However, apps don't install on the Watch but on the paired phone, which causes lag as data is shunted between devices. You also can't enter text on the Watch (except via Siri), and it doesn't have a web browser, so you can do very little on the Watch itself. There's genuinely useful potential here, but for now it feels more like a tech demo.

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SUPPLIER www.apple.com

BLUETOOTH SPEAKER

QDOS Q-PUK / £40 inc VAT

As the name implies, the Q-PUK is around the size of an ice hockey puck. Consequently, we weren't surprised that its output lacked a little bit of oomph in the bass department. Mid and high frequencies were clear and bright, though, and the overall effect was acceptable for a small unit, and definitely preferable to a tinny smartphone speaker. Where the Q-PUK really shines, however, is in its ruggedised design and build quality. Compliant with the IP67 standard, it's dustproof and waterproof, so it's equally at home in the shower or at a dry and dusty festival. It floats too, so it's easy to find if you drop it in water. As such, it's more reliable and versatile than some of the more technically proficient, but fragile, portable Bluetooth speakers.

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SUPPLIER www.qdossound.com

CARD READER

PNY Wireless Media Reader / £28 inc VAT

Barely larger than a deck of cards, PNY's Wireless Media Reader shares the contents of an SD card or USB stick over its own private Wi-Fi network. Accessing the storage on a mobile device requires a dedicated app, and the iOS version we tried was simple to use, with smooth video streaming. It contains a 2,000mAh battery, but it runs dry in just five hours – barely enough time for two movies. You can also siphon off the battery to charge a phone, which could be useful in an emergency. However, given its limitations, the £28 price feels overpriced, especially when Android users can use USB OTG drives.

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SUPPLIER www.currys.co.uk

Seen something worthy of appearing in Custom Kit? Send your suggestions to paul_goodhead@dennis.co.uk

LABS TEST

Sync city

We put several FreeSync and G-Sync monitors through their paces to find the best displays for tear-free gaming

Tired of tolerating visual stuttering and tearing artefacts in games, in an age when technology should be better? Then join us in the frame-synced heaven of this month's monitor Labs. Nvidia's G-Sync and AMD's FreeSync are variable refresh rate technologies, synchronising a monitor's refresh rate in real time to the frame rate of the content being displayed. For games, where the frame rate varies constantly, these technologies theoretically lead to gameplay that's free from both stuttering and tearing.

G-Sync was unveiled by Nvidia in 2013, while FreeSync is AMD's equivalent technology, which the company says will do the same job, but for less money through the use of open industry standards. FreeSync has been demonstrated and discussed for a long time, but only received an official launch in March this year.

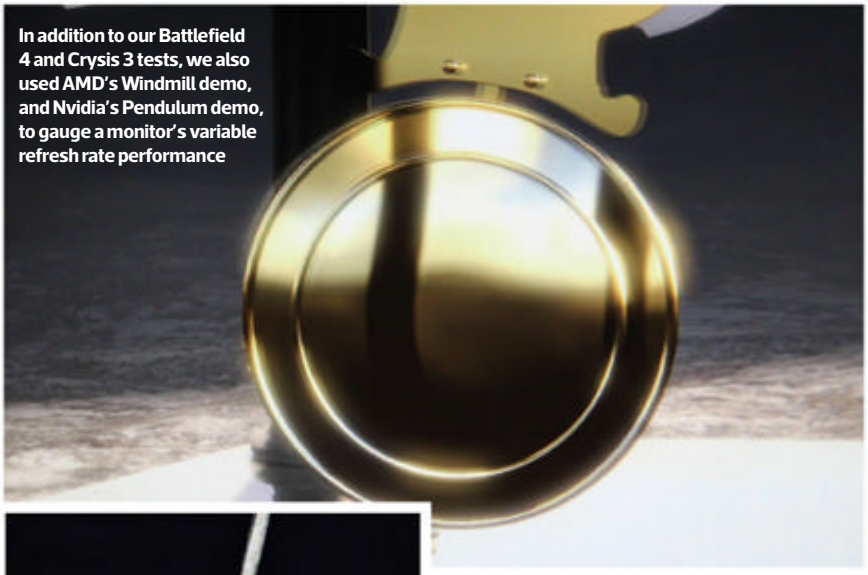
Since the launches, monitor manufacturers have quickly got on board with both technologies, and while panels that use either sync system tend to be more expensive than standard monitors, the promise of variable refresh rates in games for PCs is alluring. There's already a variety of screens available, with different maximum refresh rates, display inputs, resolutions and so on.

As such, we've gathered a selection of G-Sync and FreeSync screens, as well as a 144Hz panel with a fixed refresh rate, and will be putting them through their paces to see which ones are worthy gaming companions. We'll also explore how the technologies work, how to set them set up correctly and take a look at what the future holds for them as well.

MATTHEW LAMBERT AND ORESTIS BASTOUNIS

Contents

How we test



In addition to our Battlefield 4 and Crysis 3 tests, we also used AMD's Windmill demo, and Nvidia's Pendulum demo, to gauge a monitor's variable refresh rate performance

Adaptive-refresh technology was invented to provide better, smoother motion in games, by eliminating screen tearing and the reliance on vsync. The only way to judge how well each display managed this task was by loading a scene from a game and forming a subjective conclusion about its performance. We used sections of Battlefield 4 and Crysis 3 on each of them, adjusting the detail settings for a view of the screen's performance at a range of frame rates. We also used AMD and Nvidia's own demos to judge ghosting, testing the displays' overdrive settings where applicable.

In order to test panels beyond the subjective level, we also tested each monitor with a DataColor Spyder4Elite colorimeter, which accurately measures a monitor's colour accuracy, contrast ratio, brightness and gamma levels. The colorimeter is placed in the middle of the screen (which is reset to its factory settings), and the software then displays a number of different colours and shades of grey for the Spyder4 to measure.

The outcome is a detailed report of the measured values, which gives us an at-a-glance evaluation of the panel's performance. We're looking for a neutral colour temperature, also called the white point, that's as close to the sRGB colour space's 6500 Kelvin (K) measurement as possible; too high a value results in a cooler temperature and a blue tinge to the picture, while a low value signifies a warmer temperature and a red tinge. To ensure accurate and balanced detail in mid-tones, gamma levels at different shades of grey should be as close to 2.2 as possible, so as to match the Windows and sRGB standards.

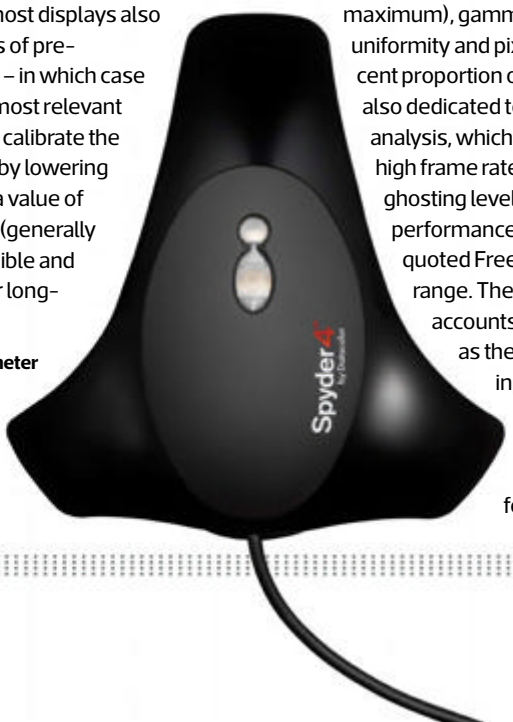
Meanwhile, the contrast ratio – the difference between the monitor's blackest black and whitest white – is measured by dividing the display's peak brightness in candela per square metre (cd/m^2) by the black point – the brightness of black on the screen. A higher value is considered better, although we've only tested using static contrast settings.

Dynamic contrast modes, available on some screens, can achieve greater contrast ratios, but at the cost of jarring and constant alteration of the panel's brightness based on what's currently displayed.

Then we have colour accuracy, which is measured by the colorimeter in dE2000 (delta-E 2000 equation), and reflects the difference between the colour measured and the colour the calibration software expects. Values below 1 are considered imperceptible, but any figure under 3 is still a very good result. The Spyder4 software tests 48 colours, alongside black, white and multiple shades of grey.

While each panel has its own factory default settings, most displays also come with a series of pre-calibrated profiles – in which case we've tested the most relevant one. We then fully calibrate the display. We begin by lowering the brightness to a value of around 120cd/m^2 (generally considered a sensible and realistic setting for long-term use), before adjusting the monitor's RGB values in the on-screen display (OSD) until its colour temperature is as close to 6,500K as possible. Calibration then begins and, in conjunction with the colorimeter, the software creates a custom Windows ICC colour profile to compensate as best as possible for the panel's natural colour and gamma levels, resulting in a best-case scenario for image quality.

Nevertheless, the scoring for image quality is heavily weighted towards factory and out-of-the-box settings, since only professionals are likely to fork out for a colorimeter. Also, many games ignore and override ICC profiles anyway. We scored each display based on its image quality, features and value for money. The image quality score was subdivided into ratings for its sRGB and NTSC coverage, contrast, delta E (uncalibrated, calibrated and maximum), gamma, brightness uniformity and pixel count. A 25 per cent proportion of this score was also dedicated to the subjective analysis, which looked at low and high frame rate performance, ghosting levels and performance within the quoted FreeSync or G Sync range. The features score accounts for features such as the range of display inputs, USB ports and flexibility of the stand's adjustment features.



We use a DataColor Spyder4Elite colorimeter to accurately measure a monitor's colour accuracy, contrast ratio, brightness and gamma levels

Acer XG270HU / £380 inc VAT

SUPPLIER www.ebuyer.com

Acer's 27in FreeSync display is sure to impress the moment it lands on your desk. Its striking bright black and red frame makes it stand out, and the almost impossibly slim bezel, measuring no more than a few millimetres across, goes some way towards shrinking the space between screens in multiple-display setups.

But while the slim bezel is undoubtedly a plus point for the XG270HU's aesthetics, other more fundamental aspects of its physical design are lacking. The stand can be tilted, but at a fixed height, with no portrait option. Also, there are no VESA mounting holes, so the stand can't be replaced with a monitor arm – a strange omission, when even cheap, low-end displays offer this feature, and one that rules out some multi-monitor gaming stands too.

It carries a standard array of video inputs: dual-link DVI, HDMI and DisplayPort, supporting the HDMI 2 specification, but there are no built-in USB ports. Meanwhile, the OSD is controlled by six physical buttons and presents a range of video presets, including Eco, Graphics, Movies and User so you can set your own preset. It covers the basics, but navigation of the menus is clunky when compared with BenQ's remote control system, or LG and Asus' joysticks.

It's a TN panel with a 2,560 x 1,440 native resolution and a 1ms response time. Desktop image quality is generally excellent. We measured a white point of 6700K in Graphics mode, while the factory default setting's white point of 6400K is even closer to the 6500K target. Colour reproduction is fine too, dropping to a delta E of 1.91 after calibration.

We also measured a very high brightness of 367cd/m^2, which is a good result for a TN panel, but the contrast ratio of 780:1 is even more impressive. Display uniformity is in a relatively narrow range, between 6 and 16 per cent, as expected with TN technology, although it drops off by 20 per cent at the bottom right, making it slightly weaker than average when compared with the other displays on test. You won't need a colorimeter to see slight tone drift at the sides of the screen, as with most TN displays – that's part of the price you pay for 1ms response times.

FreeSync performance was similar to other panels on test – within the supported 40Hz-144Hz frequencies, it performs spectacularly well, but at frame rates below this range it starts to tear and stutter, depending on whether vsync is enabled. As with the BenQ XL2730Z, enabling FreeSync disables the Overdrive function too. It's clear that, with FreeSync, it's important to use a high-end graphics card or in-game setting that can keep performance above 40fps to avoid tearing.

We spotted a little ghosting as well, which was present with or without FreeSync enabled. It showed up on the edges of objects in high-contrast, light-on-dark scenes, although it was only really noticeable when running the AMD FreeSync Windmill tech demo, rather than in games.

Conclusion

The Acer XG270HU has the highest contrast ratio on test, and great image quality on the desktop and in games, with the exception of slight ghosting. Of course, below the 40Hz range, you'll see the same screen tearing and stuttering with the XG270HU you get when playing games on any display, but that's currently true of all FreeSync monitors.

However, it's disappointing that Acer has skimped on extra features, such as VESA mounting holes, USB ports and a flexible stand, as well as the OSD controls. If these features aren't important to you then the XG270HU is a decent FreeSync monitor for the money, especially with its 2,560 x 1,440 resolution, but the BenQ XL2730Z is a better all-round package if you can stretch your budget a little further. **OB**

IMAGE	FEATURES	VALUE
50/55	7/15	24/30

VERDICT

Decent image quality, great looks and a high contrast ratio for a good price, but it lacks features.

OVERALL SCORE 81%

/SPECIFICATIONS

Native resolution 2,560 x 1,440
Screen size 27in
Panel type TN
Refresh rate FreeSync 40Hz-144Hz
Display inputs Dual-link DVI, HDMI and DisplayPort
Extras None

AOC G2460PG / £295 inc VAT

SUPPLIER www.box.co.uk

Costing just under £300, the AOC G2460PG is the cheapest variable refresh rate panel on test. It only has a 24in 1080p TN panel, but it does have a 144Hz maximum refresh rate, and this resolution is still a sensible choice for users of mid-range graphics cards or lower. It stands on a black, circular base and has a medium-sized bezel. It isn't particularly striking or attractive, but neither is it overly bulky or ugly, and importantly, it offers height, tilt and swivel adjustments as well as a portrait mode option.

The G2460PG sticks to G-Sync's single DisplayPort input with no speakers or audio, but there are plenty of USB connections – two USB 2 ports and two USB 3. The OSD navigation isn't a strong point, but there's no need to manually enable G-Sync at least. It doesn't have an overly complex menu structure, but the five physical buttons are less intuitive and more fiddly than other setups, such as a joystick control or context-sensitive buttons. The panel includes the option to display one of six reticule overlays too.

The TN panel means viewing angles are nothing special, but the adjustment options mean you can get its position right for you. The screen is set to its Warm profile by default, and it does have a slightly warm tinge, confirmed by a white point reading of 6,100K, which is still better than the BenQ and Philips G-Sync screens. Other, cooler settings go too far in the other direction though – even the Normal preset gave us a reading of 7,200K.

The contrast ratio of 520:1 isn't exceptional in terms of monitors as a whole, although only the Asus ROG panel offers a significantly better result as far as G-Sync screens go. On the plus side, the G2460PG offers full sRGB gamut coverage and the average delta E of 2.32 is a solid result for a TN panel.

Other screens offer a better average delta E, but the AOC's maximum was the lowest of the bunch, so there are no wild colour deviations. It also responds well to calibration, giving us a new average delta E reading of 1.11.

The gamma reading of 2 isn't ideal, but it does bring out a little detail from shadowy areas, which is potentially beneficial in games, and it isn't so far off as to be noticeably distracting when not playing a game. At around 85 per cent, the brightness uniformity is acceptable for a TN panel too, and the 34W power draw makes the AOC one of the least power-hungry monitors tested.

AOC also claim a 1ms response time and, by default, there was visible ghosting in the AMD windmill demo, but less than on the Acer and BenQ FreeSync panels. The overdrive options also work well to combat it, except for the Strong option, where the effect is overdone, causing clear colour artefacts.

G-Sync works completely without issue too, providing silky-smooth gameplay that's free from tearing and stutter, no matter what frame rate we provided. When you go above 144Hz, the panel defaults to vsync behaviour, but it's hard to detect stutter or input lag with a screen this fast – it's only really there if you look for it.

Conclusion

The price of Nvidia's G-Sync module clearly adds a fair amount to the cost of a screen, as you can see from the similar ViewSonic VG2401mh (p53), which comes without the technology and costs almost £100 less than the AOC. Still, relative to the rest of the pack, AOC's G2460PG offers good value for money and a flawless gaming experience. If you want a bigger or higher-quality panel, you'll need to spend more money, but for a standard, PC-only G-Sync gaming screen, the AOC G2460PG is a great option. **ML**

IMAGE	FEATURES	VALUE
44/55	10/15	28/30

VERDICT

G-Sync adds to the cost, but the AOC is one of the most affordable ways to enjoy G-Sync gaming.

OVERALL SCORE 82%

/SPECIFICATIONS

Native resolution 1,920 x 1,080
Screen size 24in
Panel type TN
Refresh rate G-Sync 30Hz-144Hz
Display inputs DisplayPort
Extras On-screen crosshair, 2 x USB 3 and 2 x USB 2 ports

FreeSync and G-Sync explained

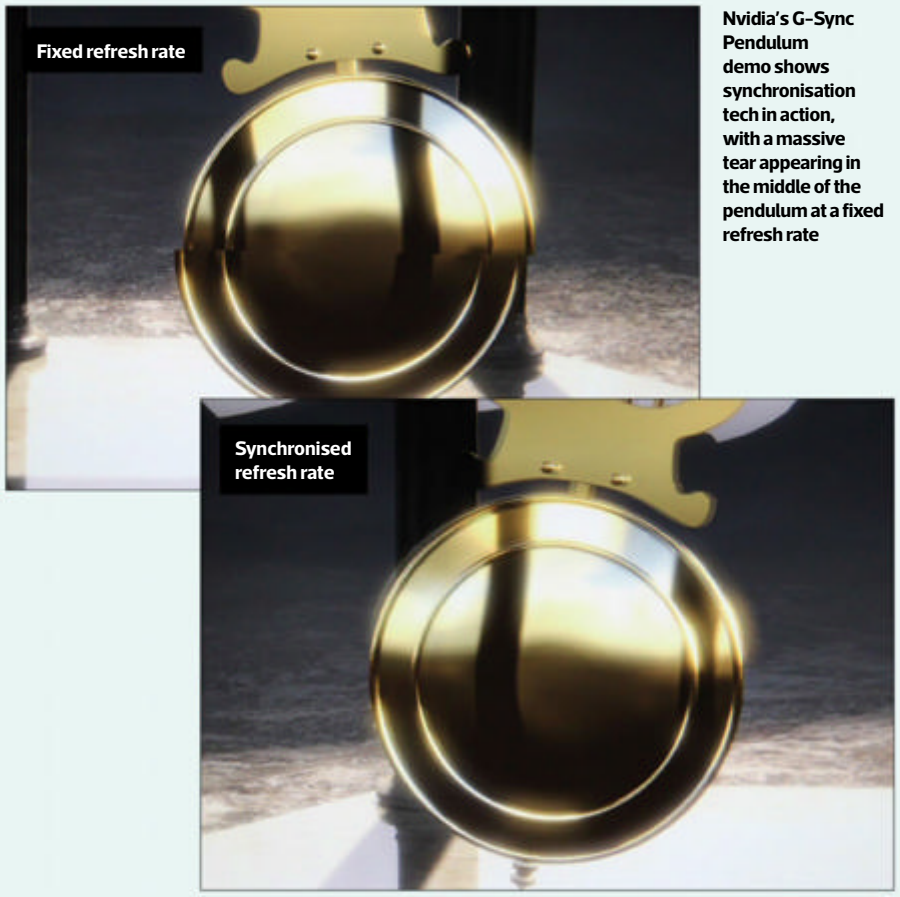
Why we need variable refresh rate technology, and how it works

Practically every display today runs at a fixed refresh rate, typically 60Hz. However, LCD panels don't require a fixed refresh rate to function; this standard is simply a legacy that dates back to vacuum tube-based televisions and CRT monitors. For gamers, fixed refresh rates are a problem – while the panel updates its image at fixed intervals, GPUs deliver frames at varying intervals, as the work required per frame changes constantly. If a frame is delivered mid-refresh, you get screen tearing, a phenomenon caused by the monitor displaying part of the old frame and part of the new one. It's particularly evident in scenes with lots of motion, and it can be very distracting.

Vertical sync, or vsync, solves this issue by synchronising the GPU to the monitor's refresh rate, forcing it to wait until the start of a screen refresh cycle, also known as the vertical blanking (VBLANK) interval, before delivering a frame. Vsync ensures that only full frames are ever displayed, eliminating tearing.

Vsync, however, introduces its own problems. If the GPU takes too long to render a frame, missing the refresh cycle, the screen simply repeats the previous frame, introducing visible stuttering and input lag. Even if the GPU renders a frame quickly enough, input lag can be an issue with vsync, as it will hold frames until the refresh period, meaning you're not being shown the latest information as soon as possible.

Higher refresh rate panels (such as 144Hz) help to combat these issues – the shorter wait between refreshes means tearing, input lag and stutter are harder to detect, but you need to be running at very high frame rates to get the most benefit, and the problems are lessened, not solved. However, variable refresh rate (VRR) technology, such as FreeSync and G-Sync, directly addresses and fixes these issues by making the GPU the master, synchronising and varying the refresh rate to match the render rate.



Nvidia's G-Sync Pendulum demo shows synchronisation tech in action, with a massive tear appearing in the middle of the pendulum at a fixed refresh rate

How G-Sync works

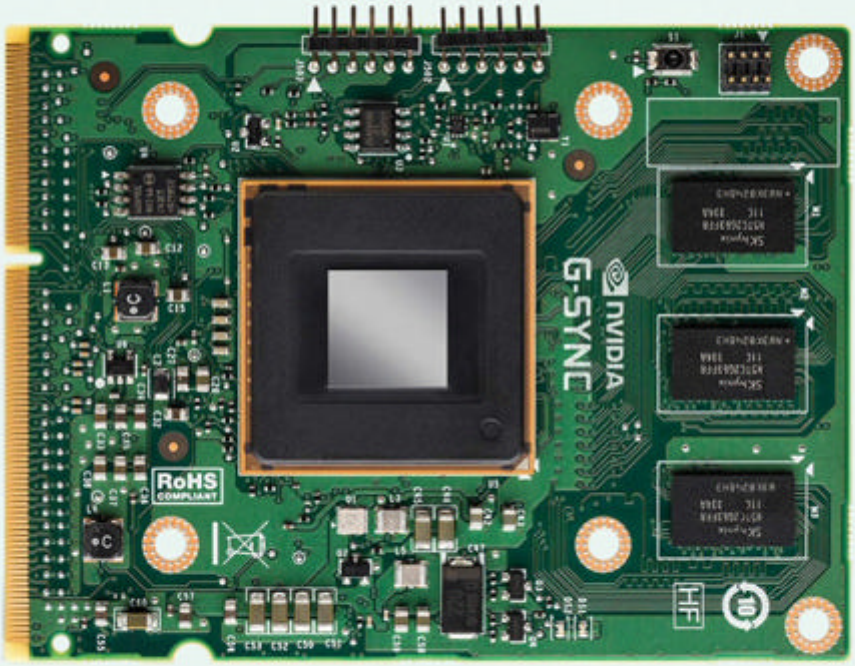
G-Sync uses a proprietary module developed by Nvidia that replaces a monitor's scaler, although it has no true scaling hardware of its own, passing scaling duties to the GPU. As a result, G-Sync monitors often feature just a single DisplayPort 1.2 input with no audio capabilities and reduced colour processing features. Extra inputs and features can be added by using a secondary, legacy scaler, although it adds to the cost.

G-Sync manipulates the panel's VBLANK period. If a frame takes longer than expected to render, the interval is extended and the screen refresh delayed until the new frame is ready. Alternatively, if it arrives quicker, G-Sync will shorten the VBLANK period and trigger the screen refresh immediately. The result is no torn frames, no repeated frames and user inputs translated into on-screen action as soon as possible.

Of course, G-Sync is still bound by panel limitations. All screens have a maximum refresh rate, and if you render faster than this rate, G-Sync resorts to standard vsync behaviour so you still avoid tearing.

More interesting is the lower limit. LCD panels must be refreshed a minimum number of times per second to prevent flicker, typically around 30Hz – VBLANK can't be extended indefinitely. However, if your frame rate does drop below 30fps, G-Sync still keeps the display running as smoothly as possible. A G-Sync module includes 768MB of DDR3 memory, which the logic uses to maintain a moving average of the past few frame times in order to estimate the next interval. If the interval is expected to exceed the panel's maximum permitted refresh time, G-Sync switches to a refresh rate that's a multiple of the incoming frame rate. For example, at 28fps, G-Sync can switch to 56Hz. This situation does lead to a repeated frame, but it's only shown for the shortest time possible before the next one is ready.

With G-Sync replacing a panel's scaler, it becomes responsible for ghosting too, where the on-board memory comes into play. Using



An Nvidia G-Sync module features 768MB of DDR3 memory

a feature called G-Sync Variable Overdrive, the module increases overdrive when a frame is predicted to arrive early, and does the opposite when it's likely to be late. The module can also be fine-tuned for each panel.

Nvidia hardware has wide support for G-Sync – every GPU from the GTX 650 Ti Boost upwards fully supports the technology, including in SLI configurations. Note that Kepler and first-generation Maxwell cards have slight latency when using G-Sync (1-3 per cent), as they have to poll the module after rendering a frame to see if the monitor is ready for it. This latency has been all but eliminated in second-generation Maxwell cards (GTX 900-series), which have updated display hardware.

How FreeSync works

FreeSync aims to do the same job as G-Sync but without using a proprietary module, and relying on open industry standards instead. AMD worked with VESA to add a new optional component to the DisplayPort 1.2 specification in 2014 called DisplayPort Adaptive-Sync. It works similarly to G-Sync, expanding the potential VBLANK timings of a display, and automatically ending VBLANK as soon as the GPU is ready with a frame.

While the new specification means FreeSync still requires a monitor upgrade, neither AMD nor VESA receive any money from manufacturers who opt to support DisplayPort Adaptive-Sync. As an extension of the DisplayPort specification, Adaptive-Sync is easy to integrate into existing designs, as it doesn't replace any other features, so multiple inputs, custom OSDs and image processing features can all be maintained. That said, it does put the onus of developing an overdrive system onto panel makers, since there's no custom logic involved to predict frame times.

While the specification can technically support 9-240Hz, FreeSync has similar limits to G-Sync, with panels capping out at 144Hz. This upper limit is handled slightly differently, though, as vsync can be switched on or off when using FreeSync, depending on user preference. The current lower limit of FreeSync is 40Hz. Annoyingly, it isn't fully clear how FreeSync handles the synchronisation when a card renders below the lowest supported refresh rate. AMD refused to explain it to us for 'patent application reasons', stating only that FreeSync 'can tune the low render rate behaviour for each display to accommodate the particulars of certain scaler/LCD combinations'.

Worryingly, the best available evidence suggests that, should the frame rate drop below the minimum refresh rate (such as 40Hz), not only does FreeSync behaviour and the accompanying smoothness stop, but the panel sticks at this lowest rate until it's exceeded again – basically, it waits until the maximum VBLANK interval has expired and is then forced to repeat a frame. This system results in screen tears at such frame rates (if vsync is disabled) or stutter/input lag (if it's enabled) being more apparent than on a fixed refresh rate screen, as the wait between frames is even longer than on a standard 60Hz panel.

Presently, only a limited selection of AMD GPUs support FreeSync: the R9 290-series, R9 285, R7 260 and R7 260X, as well as the 2014 A-Series Kaveri, Temash and Kabini APUs. Sadly, CrossFire isn't yet supported either.

MATTHEW LAMBERT

At its worst, a fixed refresh rate that's out of sync with your frame rate can cause considerable tearing

ELITE
NEW ENTRY
P62

Asus ROG Swift PG278Q / £587 inc VAT

SUPPLIER www.scan.co.uk

Asus' 27in ROG Swift is the priciest G-Sync monitor in this Labs by a wide margin. But good image quality, a wide range of additional features and superb gaming performance go a long way to justifying this cost.

A five-way joystick at the back is used to control the OSD, providing an easy means of navigating through the menus, and there are four separate physical buttons for additional controls. One of these buttons is labelled Turbo and adjusts the refresh rate, switching between 60Hz, 120Hz and 144Hz without needing to manually adjust the setting in the OSD. Like other manufacturers, Asus has added a button that enables an on-screen crosshair too, giving you a potential advantage in FPS games.

Meanwhile, the chunky wedge-shaped stand has a glowing red LED in the base that lights up when the monitor is powered on. The stand isn't just pretty either. It supports a full range of motion including height adjustment, rotate, 90-degree swivel and pivot from -5 to 20 degrees. There's a single pair of built-in USB 3 ports at the left-hand side of the screen too. Like other G-Sync displays, however, the range of video inputs is unfortunately limited to a single DisplayPort connector.

The TN panel itself is great too. At its native 2,560 x 1,440 resolution, the desktop shows up at a sharp pixel density of 109ppi, and a 590:1 contrast ratio, 6800K white point and delta E of just 1.69 are fine credentials for the screen's black levels and colour reproduction. Its brightness uniformity just about matches other displays as well, albeit with some slightly above-normal deviation in the lower right corner.

Although the desktop looks very good, however, the ROG Swift PG278Q doesn't offer the absolute best image quality on test, as its whites aren't the absolute brightest, and its blacks aren't the very deepest either. For accurate Photoshop use, an IPS display would probably provide better colour reproduction.

It's in the gaming tests where the PG278Q really shines, though, with little to no obvious tearing in either Crysis 3 or Battlefield 4, even at frame rates outside the 30Hz to 144Hz range it supports, beyond which vsync kicks in. Gaming remained absolutely smooth at all times, setting the ROG Swift PG278Q above other displays when it came to G-Sync performance. In fact, in gaming, the ROG Swift PG278Q is the best 144Hz screen we've tested. The promise of G-Sync gaming is the total elimination of screen tearing, which the FreeSync displays nearly achieve, but they fall down once you hit lower frame rates. No matter how we used the PG278Q, though, it produced a smooth gaming experience every time. Like other G-Sync screens, the PG278Q also supports Nvidia's ULMB blur-reduction mode.

There's slightly noticeable ghosting if you don't enable the Overdrive setting in the OSD, but this setting is enabled (and set to Normal) by default, which completely eliminates any ghosting. During testing, there was no need to push the Overdrive setting it to its Extreme mode either.

Conclusion

At £587 inc VAT, the Asus ROG Swift PG278Q isn't cheap, nor is it quite the best monitor in terms of image quality. However, its desktop image quality is still decent, and its gaming performance is phenomenal, and the latter is your main priority when investing in a G-Sync monitor. To top it all off, the PG278Q has a cracking feature set. With loads of features and simply superb gaming performance, the Asus ROG Swift PG278Q is the G-Sync monitor to buy if you can afford it. **OB**

IMAGE	FEATURES	VALUE
51/55	12/15	21/30

VERDICT

It's pricey, but the Asus' gaming performance is phenomenal, and it has a cracking feature set too.

OVERALL SCORE 84%

/SPECIFICATIONS

Native resolution 2,560 x 1,440
Screen size 27in
Panel type TN
Refresh rate G-Sync 30Hz-144Hz
Display inputs DisplayPort
Extras On-screen crosshair, Turbo Key, 5-way joystick-controlled OSD and 2 x USB 3 ports

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BenQ XL2730Z / £460 inc VAT

SUPPLIER www.box.co.uk

BenQ has clearly been thinking outside of the box with the design of the XL2730Z. As with its smaller 24in G-Sync relative (opposite), this 27in FreeSync display includes a wired remote that can be used to access all the OSD functions, complementing the more traditional physical buttons on the side.

Even with the best labelling and menu systems, buttons can be a real pain to use, and with some screens, it's all too easy to accidentally power off the screen by accidentally pressing the wrong one. The small joysticks used by Asus and LG are a big improvement, but BenQ's circular remote is equally useful, with large numbered buttons that can be assigned functions from the OSD, so you don't need to keep reaching forwards to flick through menus and adjust the setting you want. It connects to a mini-USB port at the rear and rests in a small holder built into the stand, so it won't become yet another small item left lying around your desk.

The stand is great as well. It can be rotated, swivelled, raised and tilted, with a range of clearly labeled inputs at the back, including a pair of HDMI ports, one of which supports HDMI 2, along with DisplayPort, DVI and VGA. Two USB 3 ports are also built into the side, with a small retractable red headphone rest above them, solving yet another minor cause of desktop clutter.

A further addition is a handle at the top of the stand, a non-essential but appreciated touch, showing the extra attention BenQ has paid to the needs of the average gamer.

Good marks for features, then, but the XL2730Z presents great image quality on the desktop as well. With the 'standard' OSD preset, a brightness level of 352cd/m^2 is second only to the Acer's figure of 367, while a 660:1 contrast ratio and uncalibrated average delta E below 3 (and below 2 when calibrated) indicates good colour reproduction. Its white point of around 6300K is very close to the 6500K target too. The 2,560 x 1,440 resolution is just right for the 27in screen size too.

Meanwhile, the OSD offers a range of gaming-focused presets and is set to 'FPS 1' by default, at which the colours and brightness were wildly off. There are more gaming presets in the OSD too, including another FPS setting, one specifically for RTS gaming, then three generic Gamer modes, as well as a Movie mode.

BenQ goes also includes a Blur Reduction option, which reduces the slight ghosting that's apparent in some game scenes – it works very well with fast-moving on-screen objects, or when there's a mix of bright and dark areas. The effect is subtle rather than overdone, so it doesn't create artefacts. This setting reduces brightness and unfortunately disables FreeSync though.

The FreeSync refresh rate range is the standard 40Hz-144Hz, and from our testing in games and demos, the XL2730Z worked superbly. Although tearing was still visible below this range, it was certainly no worse than on other screens. A potential downside, though, is the BenQ's power consumption. At 100 per cent brightness, the XL2730Z binged on 89W from the mains, considerably more than any other screen on test.

Conclusion

Although G-Sync displays have a slight edge over FreeSync monitors, with less tearing at lower frame rates, that's no good if you own an AMD GPU, and BenQ's XL2730Z offers a great display for AMD users.

If you're looking for a FreeSync monitor, the Ben Q XL2730Z's great image quality, genuinely useful features, good FreeSync performance and decent resolution make it a fantastic gaming monitor. **OB**

IMAGE	FEATURES	VALUE
49/55	14/15	24/30

VERDICT

With great image quality and features, plus a high resolution, this is our top-choice FreeSync monitor.

OVERALL SCORE 87%

/SPECIFICATIONS

Native resolution 2,560 x 1,440
Screen size 27in
Panel type TN
Refresh rate FreeSync 40Hz-144Hz
Display inputs Dual-Link DVI, 2 x HDMI, VGA and DisplayPort
Extras Remote for OSD, 2 x USB 3

ELITE
NEW ENTRY
P62

BenQ XL2420G / £400 inc VAT

SUPPLIER www.cclonline.com

BenQ's XL2420G has a few similarities to its 27in cousin, employing the same red and black design, but there are some important differences that come with this 24in 1080p model. It's the company's first G-Sync display, but the technology has been implemented in a slightly different way to the other hardware we've reviewed.

The G-Sync feature is entirely separate from the rest of the monitor's functions, so the XL2420G can work as either a normal, fixed refresh rate display at 60Hz in Classic mode, or as a 144Hz G-Sync monitor. This setup opens up a range of settings in the OSD, and has enabled BenQ to include two additional HDMI ports and a DVI input. This setup is great to see, considering every other G-Sync display we've tested has been limited to a single DisplayPort input only, which is a big limitation if you want to use your monitor with a second PC, a games console and so on. However, 144Hz gaming is only supported through the DisplayPort connector.

In addition, you get a pair of USB 2 ports and, as with the BenQ XL2730V, a mini-USB S-Switch remote control is included, which snaps onto the side of the stand for easy reach. It's without a doubt the best way to interact with the display's OSD, avoiding over reliance on the five touch-sensitive buttons at the side of the screen.

Plus, like the 27in XL2730Z, the stand is fully height-adjustable, with rotate, pivot and tilt options. There's a headphone rest at the back of the stand and a support for cable management too, surrounded by the trademark BenQ red trim.

Once again, the XL2420G is a TN panel with a 1ms response time. Desktop picture quality is respectable, but the contrast ratio of 460:1 isn't as good as some of the other monitors in this Labs, which in some cases go beyond 600:1. Likewise, the average delta E result of 3.2 is good enough to not be an issue, but it doesn't sound impressive when the delta E of other displays on test is under 2. Meanwhile, the white point hovers around 6000K, a good result but not quite as close to the ideal result as some of the other displays we tested.

In games, the XL2420G performs admirably, though, with G-Sync performing as smoothly as on the other screens, all the way up to 144Hz. Even below 30Hz, motion remains silky-smooth, avoiding a common problem with FreeSync screens at low frame rates. There was some ghosting in the Nvidia G-Sync demo with the Overdrive setting disabled in G-Sync mode. This effect was far less apparent in games, though, and less of an issue than with some of the FreeSync displays. Switching to the Fast Gaming mode unfortunately didn't alleviate the issue either.

Conclusion

There are certainly praiseworthy aspects of the BenQ XL2420G, not least its flexibility when it comes to connecting multiple devices, as well as its remote-controlled OSD system. However, the AOC G2460PG offers a very similar G-Sync gaming experience for £100 less money, while more expensive monitors give you superior image quality and higher resolutions. Unless you really need multiple inputs, we'd save £100 and buy the otherwise similarly specified AOC instead. **OB**

IMAGE	FEATURES	VALUE
42/55	13/15	23/30

VERDICT

Loads of great features, but you can get similar G-Sync performance for less money elsewhere.

OVERALL SCORE 78%

/SPECIFICATIONS

Native resolution 1,920 x 1,080
Screen size 24in
Panel type TN
Refresh rate G-Sync 30Hz-144Hz
Display inputs Dual-Link DVI, 2 x HDMI and DisplayPort
Extras Remote for OSD, 2 x USB 2 ports

LG 34UM67 / £400 inc VAT

SUPPLIER www.ebuyer.com

It isn't just the ultra-wide 21:9 screen aspect ratio that separates LG's 34in FreeSync monitor from the other displays in this Labs test. It's also the only IPS display on test, meaning more consistent viewing angles than TN panels, although at the expense of response time. The FreeSync frequency range it handles is restricted to between 48Hz and 75Hz, though, which is within the specification but still an unfortunate limitation when other displays can manage 40Hz-144Hz.

That said, such a wide aspect ratio provides a field of view the other monitors can't offer, which makes gaming on this screen a real pleasure. It feels a little like a multi-monitor setup, with the game extending just beyond your peripheral vision, but without the need for two physical screens, or a bezel running down the centre. LG has kitted out the rear panel with DVI, HDMI and DisplayPort inputs, but there's no USB hub. Meanwhile, the stand looks good, but it's rather limited – it can tilt between -5 and 15 degrees, but its height can't be adjusted, and it can't be rotated or swiveled into portrait mode either.

When it's first turned on, you'll immediately notice that this 34in screen's native resolution of 2,560 x 1,080 is like an extended version of 1080p, rather than a 2,560 x 1,440 screen – the latter is more common on 27in displays and gives you a higher pixel density. If you sit close to the 34UM67, the display seems comparatively chunky, from the desktop icons to on-screen text – an effect that's amplified by the generous display real estate.

Instead of using buttons, the OSD is controlled with a six-axis joystick right in the centre. Along with a specific menu option to enable or disable FreeSync, there's a setting to adjust the response time. It makes a difference too, with a noticeable reduction in ghosting as you turn it up, but without the colour inaccuracies such settings often introduce on other displays. Although this IPS panel has a quoted refresh time of 14ms, when TN screens manage 1ms, ghosting levels were pleasingly low on this screen, even with this setting on its lowest value.

> Instead of using buttons, the OSD is controlled with a joystick in the centre

The horizontal and vertical viewing angles of 178 degrees offer a noticeable improvement over TN screens too. With such a wide display, horizontal discolouration would likely be even more noticeable at different on a TN panel.

Meanwhile, colours look excellent on the desktop. The uncalibrated brightness of 328cd/m^2 and contrast ratio of 620:1 are good results, while the delta E result below 2 indicates excellent out-of-the-box colour reproduction. Power consumption of 48W at 100 per cent brightness isn't bad for a 34in display either, although the comparatively low number of pixels to illuminate is undoubtedly a contributing factor.

As long as you remain within the 40Hz-144fps frame rate range while gaming, the 34UM67 works just as well as any other FreeSync display. Below or above this range, however, it unfortunately introduces the same screen tearing you'll see on any standard monitor. Given that there's no way to really control the frame rate in many games, you'll likely see the 34UM67 drift in and out of FreeSync mode while playing.

Conclusion

A reasonable price, an ultra-wide aspect ratio and good image quality make the 34UM67 seem like a brilliant purchase at first, but its low pixel density and limited support for the extended FreeSync frequency range really damage it when compared with the competition, especially for a dedicated gaming monitor. All of this is a shame because, in all other respects, gaming on this screen is a blast. **OB**

IMAGE	FEATURES	VALUE
47/55	7/15	23/30

VERDICT

A great aspect ratio for gaming, but it's let down by a low pixel density and limited FreeSync range.

OVERALL SCORE 77%

/SPECIFICATIONS

Native resolution 2,560 x 1,080
Screen size 34in
Panel type IPS
Refresh rate FreeSync 48Hz-75Hz
Display inputs Dual-Link DVI, HDMI and DisplayPort
Extras Six-way joystick-controlled OSD

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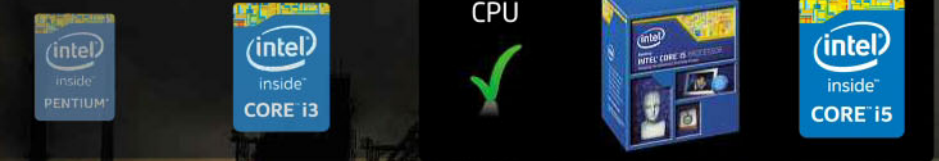

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HOW TO

Set up AMD FreeSync or Nvidia G-Sync

Follow these easy steps to enjoy variable refresh rate gaming in no time

1 Ensure you have the latest drivers

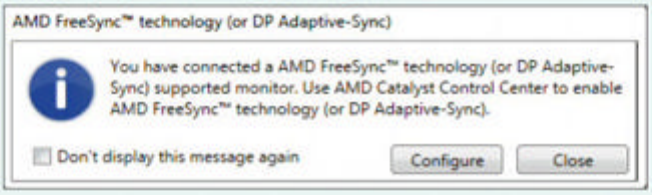
FreeSync: AMD's official driver releases aren't very frequent, so for maximum monitor compatibility, it's recommended to download the latest beta drivers from **http://support.amd.com**
G-Sync: Nvidia releases WHQL drivers regularly, so the latest official drivers from **www.nvidia.com** are fine.

2 Connect your graphic card to the right monitor input

Both FreeSync and G-Sync will only work using a DisplayPort connection. Also, FreeSync currently only works on single-GPU setups (AMD is working on CrossFire support at the moment); G-Sync is supported on SLI systems, however.

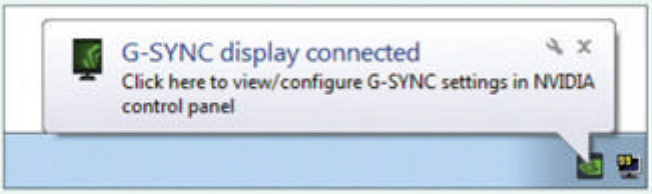
3 Auto-detection

FreeSync: You'll see the following pop-up dialogue:



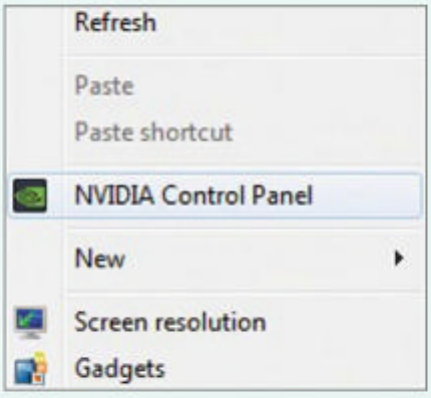
Click on Configure to access the Catalyst Control Center.

G-Sync: You'll see the following notification in the system tray:



Click on the notification to access the Nvidia Control Panel.

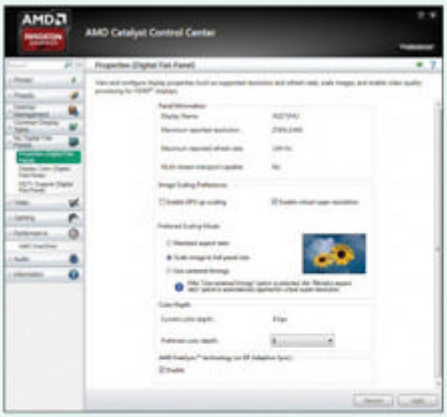
If you don't see a pop-up window or notification, the Catalyst Control Center and Nvidia Control Panel can both be accessed by right-clicking on your desktop.

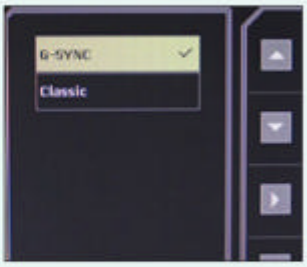


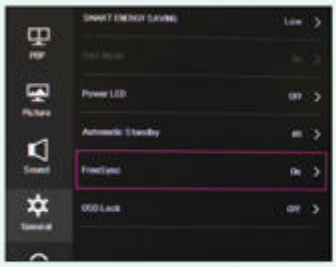
4 Enable FreeSync or G-Sync

FreeSync: In the Catalyst Control Center, expand the My Digital Flat-Panels tab and click on 'Properties (Digital Flat-Panel)'. At the bottom, tick the FreeSync checkbox and click Apply.
G-Sync: In the Nvidia Control Panel, expand the Display menu and click on 'Set up G-Sync'. Tick the checkbox and hit Apply.

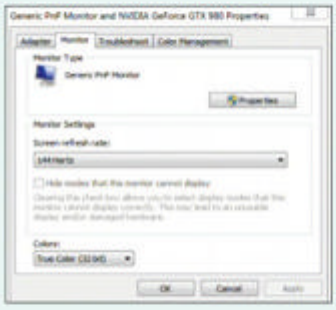
If you don't see the checkboxes, you may need to activate FreeSync or G-Sync in your monitor's on-screen display, as pictured. Toggle the setting, and then repeat steps 2 to 4.







5 Set your resolution and refresh rate



Right click on your desktop, select 'Screen resolution' and check that you're using your screen's native resolution. Hit 'Advanced settings' and select the Monitor tab. From the dropdown menu, select the highest 'Screen refresh rate' and hit Apply – this setting will give you the best possible gaming experience.

6 Reboot

Restart your system and check that the settings have been maintained. You can then run some games and enjoy high frame rates without any stuttering or tearing artefacts.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Philips 272G5DYEB / £395 inc VAT

SUPPLIER www.ballicom.co.uk

Like AOC's G-Sync panel, Philips' 272G5DYEB is a 144Hz 1080p TN model, but its diagonal measures 27in rather than 24in. It sits on a large circular base and has thick bezels, so it's comparatively chunky, but it does have the full suite of physical adjustment options, so you can easily minimise the impact of the average viewing angles you get from a TN panel.

The 272G5DYEB only comes with a single DisplayPort input, so you can't hook up multiple devices, or use a picture-in-picture mode, but the feature set is bolstered by a whopping count of four USB 3 ports.

Navigation is achieved via four touch-sensitive buttons and the OSD is easy to use, although it's still not as good as the remote control and joystick systems also on test this month. It's good to have 27 inches of screen real estate too , making for immersive gaming, but the screen size also magnifies the 1,920 x 1,080 resolution – you'll want to turn up your anti-aliasing to avoid seeing too many jagged edges.

In terms of image quality, the Philips screen has an overly warm image by default, more so than the AOC, with a reading of 5,900K – a 600K deviation is the ideal value. There are cooler image options but all of them were a little too blue. The contrast ratio of 530:1is very similar to AOC's reading too, and is roundly beaten by much of the competition.

With an average delta E of 2.23, the Philips' colour accuracy is better than the AOC, but the results are extremely close. Still, other displays managed even better out-of-the-box results. The Philips panel responds very well to being calibrated, though, achieving the second best delta E result in this regard.

Meanwhile, gamma comes out as a respectable 2.1, but the sRGB gamut cover is only 97 per cent, the second lowest result. Like the AOC panel, brightness uniformity comes out at around 85 per cent.

Philips says this screen can provide a 1ms pixel response time, with overdrive settings available in the OSD. The default setting is 'Faster' but you can turn it off altogether or select 'Fast' or 'Fastest' instead. We found the default setting was the best in scenes where ghosting is usually detected, however.

Once again, G-Sync proves that it's simply great for gaming – there's just no denying it. With this screen, regardless of your frame rate, you'll definitely have a smooth experience. As with the AOC, rendering above 144Hz triggers vsync, but with a panel this fast, it's hard to detect any visual artefacts, so this switch isn't really an issue. In fact, the gaming experience is very consistent across all G-Sync screens, and this one only has slight ghosting issues (easily overcome in the OSD).

Conclusion

The Philips 272G5DYEB is another good G-Sync screen that delivers a great gaming experience, although it doesn't have outstanding colour or image reproduction. However, while it's a better monitor than option than the BenQ XL2420G for roughly the same price, the 27in diagonal also reduces the pixel density – the image just isn't as sharp or detailed as with the Asus ROG Swift.

Also, £100 is a lot to pay for an extra three inches of screen real estate and some USB 3 ports, which is all the Philips really offers over the AOC panel. If you can't afford a 2,560 x 1,440 panel, we'd save some cash and buy the AOC instead. **ML**

IMAGE	FEATURES	VALUE
44/55	12/15	24/30

VERDICT

A good size, and 144Hz G-Sync is excellent, but it isn't quite worth the extra £100 over the AOC.

OVERALL SCORE 80%

/SPECIFICATIONS

Native resolution 1,920 x 1,080
Screen size 27in
Panel type TN
Refresh rate G-Sync 30Hz-144Hz
Display inputs Dual-link DVI, HDMI and DisplayPort
Extras On-screen crosshair, 4 x USB 3

144HZ FIXED REFRESH RATE MONITOR

ViewSonic VG2401mh / £199 inc VAT

SUPPLIER www.dabs.com

One of the major downsides of G-Sync and FreeSync technology is vendor lock-in, since AMD cards won't work at 144Hz with G-Sync screens, and vice versa. ViewSonic has taken a different approach with the VG2401mh, though, which supports a fixed 144Hz refresh rate, regardless of whether your graphics card has an Nvidia or AMD GPU.

With the notable exception of BenQ's 24in XL2420G, a further advantage of the ViewSonic over the G-Sync screens we've tested in this Labs is more video inputs than a single DisplayPort connector – an important consideration if you want to connect a games console, second PC or Blu-ray player in addition to your main PC.

The VG2401mh uses a 24in 1080p TN panel, with a quoted 1ms response time. Its frame and base are made from a standard dark grey plastic material, with a red stripe running up the stand, brightening what's otherwise a fairly common display design.

It presents excellent desktop image quality, with 348cd/m^2 brightness and a measured 640:1 contrast ratio. Screen uniformity deviates between 7 and 16 per cent, which is above average for a TN gaming panel too. Power consumption is notably reasonable as well, consuming just 35W at 100 per cent brightness.

There are dual HDMI 1.4 ports, plus DisplayPort and DVI connections. Two USB 3 ports are at the bottom too, and the fully adjustable stand gets full marks. It can be raised and lowered up to 120mm, with a tilt between -5 and 20 degrees, along with 90-degree rotation. There are two 3W speakers as well, and the option to display a crosshair on screen for assisted aiming in FPS games.

The OSD is controlled by five touch-sensitive buttons, with context-sensitive on-screen prompts to guide you through the menus. The response time is adjustable in the OSD too, although ghosting isn't a major issue on this screen anyway, regardless of this setting. The presets for this setting are labelled Standard, Advanced and Super Fast, with the latter introducing slight artefacts with movement – we found that the Advanced setting offered the best balance.

Compared with displays that adopt both G-Sync and FreeSync, the gaming performance of the VG2401mh measures up well enough to be considered a serious alternative, although there are some areas where you can see the difference between this 144Hz fixed refresh rate gaming monitor and Nvidia and AMD's official adaptive-refresh technologies.

At high frame rates beyond 90fps, there are small stutters, although they're hard to detect. At the other end of the scale, frame rates below 40fps introduce some stuttering, even with vsync enabled. Finally, once your frame rate goes above 144fps, you get some horizontal tearing, although the display introduces no perceptible input lag.

That said, gaming at 144Hz is still an impressive effect regardless of whether you opt for the VG2401mh or a screen that supports G-Sync or FreeSync. Both these technologies have a slight performance edge in terms of visual smoothness, but if you want an affordable all-round display that also supports gaming at 144Hz, the ViewSonic offers a great compromise for the sub-£200 price.

Conclusion

The VG2401mh works well at 144Hz regardless of your GPU, with good desktop image quality, little ghosting, a wide range of display inputs and an adjustable stand. If your budget can't quite stretch to a variable refresh rate panel, the ViewSonic is a good budget alternative. **OB**

IMAGE	FEATURES	VALUE
45/55	12/15	27/30

VERDICT

A great budget alternative to a sync display, with loads of inputs to boot.

OVERALL SCORE 84%

/SPECIFICATIONS

Native resolution 1,920 x 1,080
Screen size 24in
Panel type TN
Refresh rate Fixed 144Hz
Display inputs Dual-Link DVI, 2 x HDMI and DisplayPort
Extras On-screen crosshair, 2 x USB 3 and 2 x 3W speakers

The future of variable refresh rate tech

G-Sync laptops and 4K variable refresh rate displays are coming soon

As we were piecing together this Labs test, Nvidia shared some news concerning forthcoming G-Sync features and products with us. As such, we wanted to pass that information onto you, and discuss the potential future of variable refresh rate (VRR) technologies such as FreeSync and G-Sync too.

The first news is simply a new slew of Acer and Asus G-Sync screens, including 4K IPS panels and a curved 3K ultra-wide monitor. Nvidia isn't alone here, however; up to 20 FreeSync monitor SKUs are planned for 2015 as well.

Next, Nvidia announced that it will be enabling vsync as a user-configurable option when G-Sync is enabled, just like FreeSync. It also announced G-Sync windowed mode; previously, G-Sync was full-screen only.

We asked AMD whether windowed mode was possible with FreeSync, but were told that applications must be run in full-screen for the GPU to control the refresh rate – in windowed mode, this control falls to Windows, which isn't VRR- aware. It seems Nvidia has bypassed this limitation, probably thanks to the greater control afforded by the G-Sync module. Both these features should be available in Nvidia's latest drivers by the time you read this magazine.

The most exciting news, however, is the announcement of G-Sync gaming laptops.

Asus already has announced a 4K IPS panel that supports G-Sync, called the ROG Swift PG27AQ

The laptop market is ripe for variable refresh rates, as even the most powerful models struggle to consistently maintain 60fps, and are nearly always prone to tearing and stuttering. Interestingly, Nvidia has managed this feat without the need for a G-Sync module, perhaps paving the way for module-free desktop panels, at least when paired with the right GPU.

The company hasn't released technical details of this so-called G-Sync Direct technology, so it's unclear whether it will functionally be exactly the same as current desktop G-Sync tech, but it's promised that the refresh rate will be always synchronised, even when falling beneath the panel's minimum refresh rate. Both 17.3in and 15.6in models have been announced by Gigabyte, MSI, Asus and Clevo, all with a maximum refresh rate of 75Hz.

When quizzed, AMD admitted there were obvious opportunities for FreeSync to be brought to the laptop market (it was initially demonstrated on such a system, after all), but the company has nothing to announce at present. Sadly, AMD was also unable to give us an update about the expected time of arrival for FreeSync CrossFire compatibility, which missed the initial target of April 2015.

Whether FreeSync or G-Sync will win out against the other is impossible to call, but the experience they offer is so compelling that the PC gaming business, and PC gamers, would really benefit from having just one industry standard, rather than two competing technologies that effectively lock you into AMD or Nvidia graphics cards upgrades until you next replace your monitor.

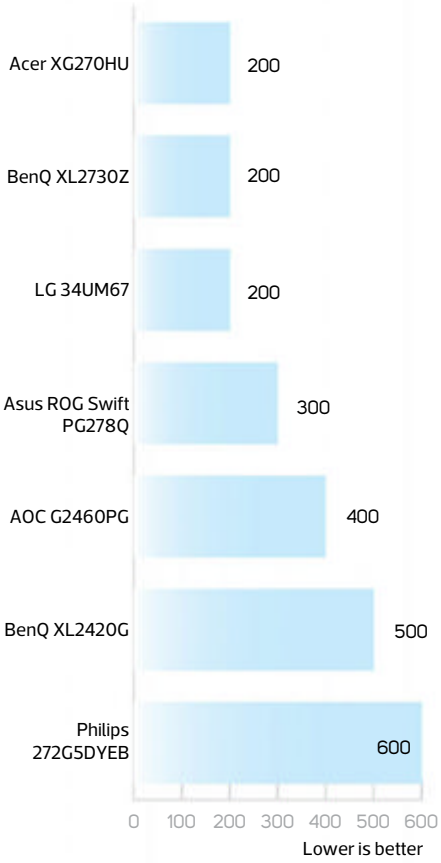
On the surface, the obvious candidate for this single standard is FreeSync, with its free approach and its lack of required monitor hardware. However, given Nvidia's investment in G-Sync, the benefits of closely controlling the hardware, as well as FreeSync's problems at low refresh rates, G-Sync also has clear benefits that Nvidia is very unlikely to abandon. **ML**

MSI is updating its GT72 gaming laptop to support Nvidia's G-Sync technology

Nvidia's G-Sync Direct technology for laptops doesn't require the hardware modules currently installed in G-Sync monitors

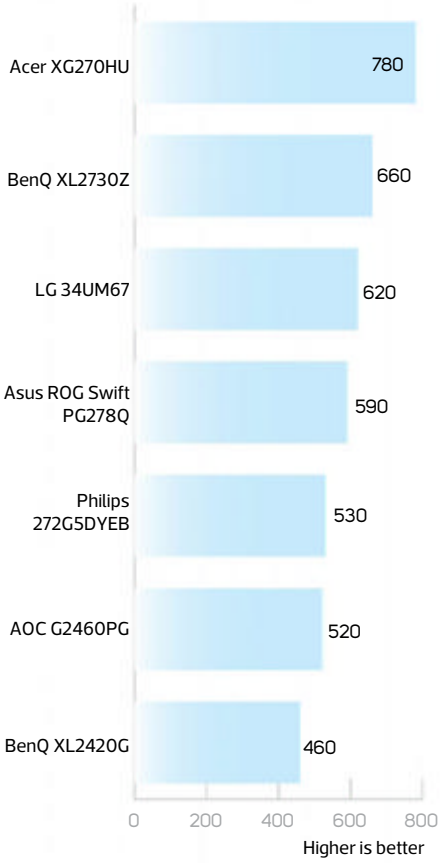
COLOUR TEMPERATURE (KELVIN)

Deviance from 6500K ideal



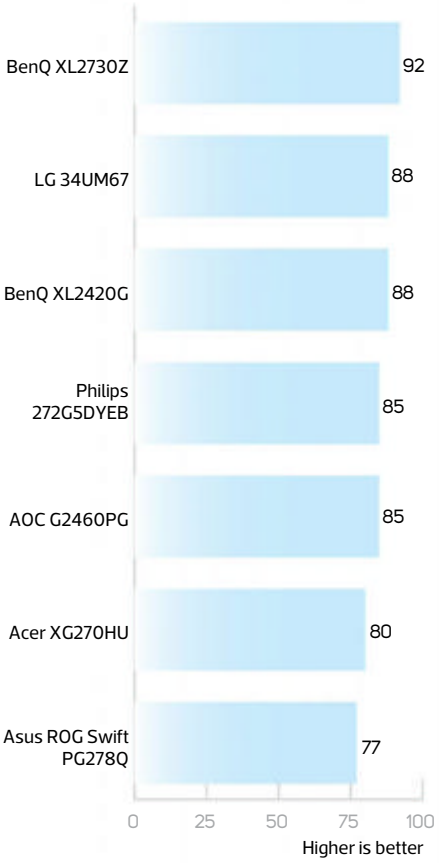
CONTRAST RATIO

Ratio of white to black luminance



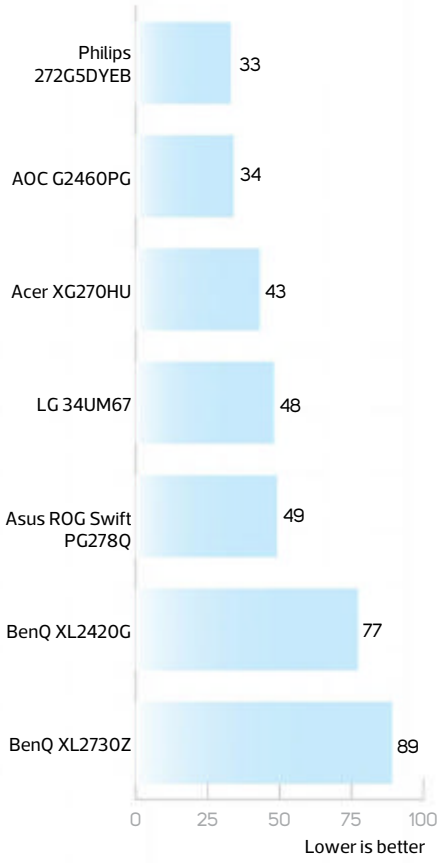
BRIGHTNESS UNIFORMITY (PER CENT)

Dimmest area divided by brightest area



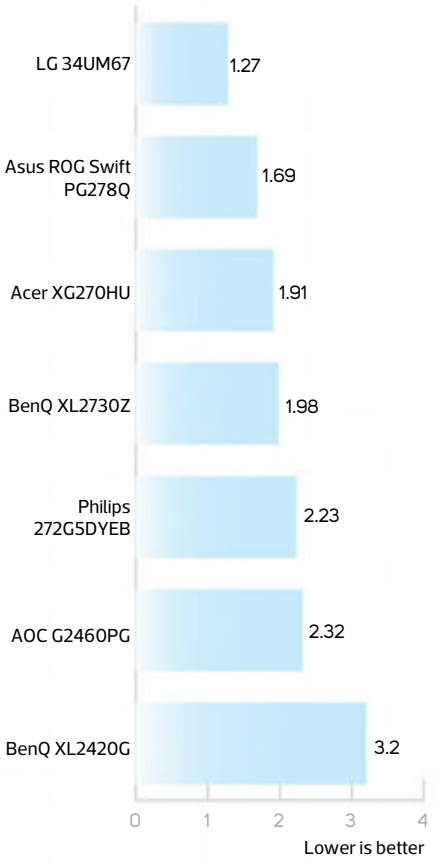
POWER CONSUMPTION (WATTS)

White screen at 100 per cent brightness



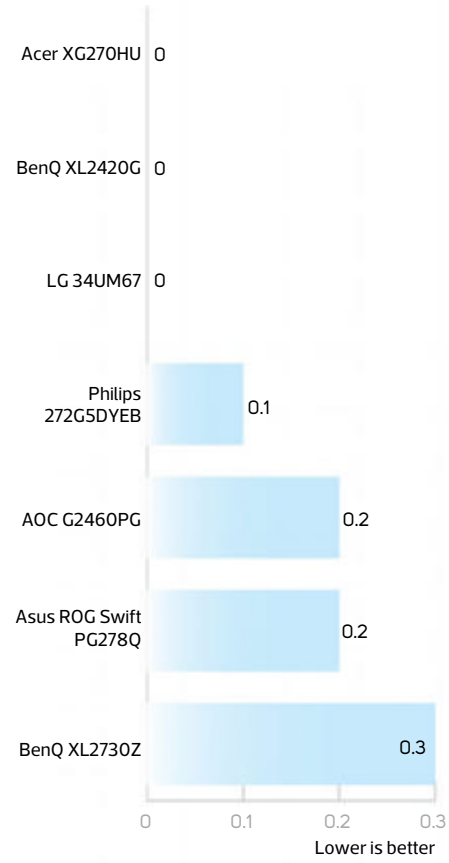
COLOUR ACCURACY

Average delta-E



AVERAGE GAMMA

Distance from ideal (2.2)



PC system reviews

GAMING PC

Box Cube Aero Series Watercooled Gaming / £999 inc VAT

SUPPLIER www.box.co.uk

The Cube Aero, from Birmingham-based builder Box, isn't the most extravagant system we've seen recently, but the firm hasn't set out to build a machine that turns heads. Instead, this PC is designed to scythe through games on a single 2,560 x 1,440 screen, and provide a solid base for future expansion.

The Aerocool GT-1000 chassis is a solid start, with impressive versatility throughout. The front half of the interior is dominated by storage bays, with five 3.5in bays and a pair of 2.5in bays divided into three cages, all of which can be moved or removed altogether. All those cages are filled with tool-free caddies with anti-vibration rubber washers, and two 5.25in bays lurk at the top of the chassis – again, they're tool-free, and they can be accessed from the front panel.

Meanwhile, the top panel and PSU both have removable dust filters, and there's another filter on the front panel that pops away with a push. The interior is littered with rubber-grommetted cable-routing holes too, and Box has done a great job with this machine's build – it's extremely tidy. The GT-1000 isn't the best-looking case, with its unfussy plastic front panel and plain side panels, and it isn't the strongest either – those panels are a little flimsy in particular – but it's a reasonable foundation for a sub-£1,000 PC.

The MSI Gaming Z97A 6 motherboard is similarly versatile, with plenty of expansion potential. Its two free memory slots allow for up to 32GB of overclocked DDR3 memory, and two graphics cards can be run at 8x speed together, so there's dual-GPU potential as well.

Several SATA connectors are vacant, there's a spare full-length M.2 connector and three 1x PCI-E slots are free for smaller expansion cards too. There are also spare USB headers and a two-figure LED POST display that can help to diagnose boot problems. The rear I/O isn't the most generous – it only has two USB 3 ports and two USB 2 ports, and no clear-CMOS button, but it has the basics covered.

Then there's the Nvidia GeForce GTX 970 graphics card, which has 4GB of 7,010MHz GDDR5 RAM. It's an overclocked version made by MSI, so its stock speed has been improved from 1,050MHz to 1,076MHz, with a revised boost peak of 1,216MHz. Meanwhile, processing power comes from a Core i5-4690K; like the GPU, has been overclocked – this time from 3.5GHz to 4.2GHz. It doesn't have the Hyper-Threading support of its Core i7 siblings, but it has power where it counts for gaming.

The overclocked processor is kept cool by a Thermaltake Water 3.0, which has a radiator attached to the exhaust, sandwiched between two 120mm fans. Cooling elsewhere is standard, with two more 120mm spinners in the front panel, and a 60mm fan on the graphics card.

The rest of the Cube's specification ticks the boxes for a mid-range gaming system. There's 8GB of Kingston HyperX Savage DDR3 memory, running at 2,400MHz, which is fine for gaming. Windows 8.1 is also installed on a 240GB Kingston HyperX SSD – a good inclusion when so many sub-£1,000 PCs still come with 120GB SSDs – and a 2TB hybrid hard disk handles data storage. Only a handful of fringe components are missing. There's no optical drive, for example, or a Wi-Fi adaptor, and the Aerocool PSU is only semi-modular.

/SPECIFICATIONS

CPU Intel Core i5-4690K overclocked to 4.2GHz

Motherboard MSI Z97A Gaming 6

Memory 8GB Kingston HyperX Savage 2,400MHz DDR3

Graphics MSI GeForce GTX 970 4GB

Storage 240GB Kingston HyperX Save SSD; 2TB Seagate hard disk

Case Aerocool GT1000

Cooling CPU Thermaltake Water 3.0 with 2 x 120mm fans; GPU 1 x 60mm fan; front 2 x 120mm fans

PSU Aerocool Integrator ModXT 650W

Ports front 2 x USB 3, 2 x audio; rear 4 x USB 3, 1 x Gigabit Ethernet, 1 x PS/2, 1 x optical S/PDIF, 6 x audio

Operating system Windows 8.164-bit

Warranty Two years parts and labour; first year collect and return and second year return to base

Performance

On paper, the Core i5-4690K is a step down from the stock-speed Core i7-4790K that forms the basis of our RealBench 2015 reference score, but Box's overclocking means it's only slightly behind, only really taking a hit in the multi-tasking test. Unless you're running highly multi-threaded

1 A Thermaltake Water 3.0 keeps the overclocked Core i5-4960K cool

2 Box has done a superb job on cable tidying, resulting in a very neat build

3 An MSI GeForce GTX 970 graphics card handles gaming duties

workloads, this machine's general purpose Windows performance will be fine.

The Box also has power where it counts when it comes to games. At 1080p, it never dropped below 65fps in Battlefield 4, and the Box returned great minimums of 58fps and 47fps in Shadow of Mordor and Crysis 3 respectively. It didn't have any problems at 2,560 x 1,440 either, never dropping below 30fps in any of our test games.

This system isn't designed for silence, though, and there's no denying the noise that emerges from the Aerocool chassis. Its quiet whirr when running low-intensity tasks isn't intrusive, but games and tough workloads cause the Thermaltake cooler and MSI graphics card to churn out plenty of noise. You're going to notice it unless you're wearing headphones, so this machine would be better positioned under your desk, rather than on top of it.

While the Box's isn't the coolest system we've tested, the Cube's CPU and GPU delta T results of 49°C and 58°C respectively are fine, and the peak power draw of 283W is perfectly respectable for the performance on offer too.

Conclusion

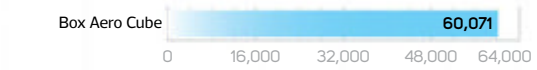
Box's machine isn't fussy or over the top, but it has power in every key department: there's enough gaming power to handle 2,560 x 1,440 gaming without breaking a sweat, and there's a fast processor, 240GB of solid state storage and a 2TB hard drive.

What's more, the versatile chassis and generous motherboard mean there's plenty of room for future upgrades too. It doesn't look as snazzy as other machines, and it's a little loud, but it's a solid and affordable mid-range gaming PC that can be upgraded for years to come.

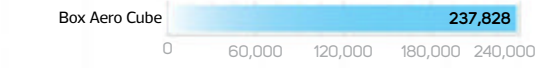
MIKE JENNINGS

CPC REALBENCH 2015

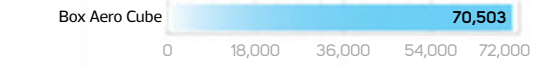
GIMP IMAGE EDITING



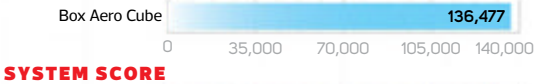
HANDBRAKE H.264 VIDEO ENCODING



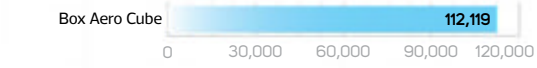
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 97.96%

BATTLEFIELD 4
2,560 x 1,440, Ultra Detail, 4x AA

BIOSHOCK INFINITE
2,560 x 1,440, Ultra Detail with Depth of Field

SHADOW OF MORDOR
2,560 x 1,440, Ultra Detail

CRYSIS 3
2,560 x 1,440, Very High Detail, 0x AA

SPEED	DESIGN	OVERALL SCORE
21/25	20/25	82%
HARDWARE	VALUE	
20/25	21/25	

VERDICT

Enough power to play games at 2,560 x 1,440 for under a grand, and there's plenty of room for future upgrades too.

GAMING PC

Scan 3XS X99 Carbon Ti / £1,999 inc VAT

SUPPLIER: www.scan.co.uk

Scan's 3XS X99 Carbon Ti has two components that attract more attention than most: Nvidia's brand-new GeForce GTX 980 Ti graphics card sits in the middle of this machine, and just below it sits Samsung's new SM951 – the first M.2 SSD we've seen to use PCI-E 3.

The new Nvidia card is designed for single-GPU 4K gaming, and has a specification that exudes power: its 2,816 stream processors bring its spec closer to the Titan X than the GTX 980, and it has 6GB of GDDR5 RAM, accessed using a 384-bit wide memory interface.

Scan has also deployed an overclocked version from EVGA, which increases the GPU core clock from 1,000MHz to 1,102MHz, and the Boost clock from 1,075MHz to 1,190MHz.

The M.2 512GB Samsung SSD is similarly impressive, with its use of the PCI-E 3 bus, rather than SATA, giving it loads of potential bandwidth. Unlike the Intel 750 (see p24), the SM951 doesn't support NVMe – which is an about-face on the initial plans for this drive – but that doesn't prevent Samsung from quoting theoretical read and write speeds of 2,150MB/sec and 1,500MB/sec respectively.

Meanwhile, the Scan's Core i7-5820K processor has been overclocked from 3.3GHz to 4.4GHz, and it's bolstered by 16GB of DDR4 memory that zips along at 2,666MHz. The capacious SSD is accompanied by a 2TB hard disk, and only an optical drive is really missing – a feature that's hard to include in a case with no 5.25in drive bays anyway.

All the parts connect to an Asus X99-A motherboard. It's a capable board with plenty of enthusiast features, including on-board power and reset buttons, a two-character POST display at the bottom, six USB 3 ports and a BIOS flashback button on the rear. What's more, its attractive black PCB and white heatsinks tie in with the slick visual design of the rest of the PC.

Likewise, the NZXT H440 is an impressive-looking monochrome chassis: the power supply and its cables are hidden at the bottom by a white shroud with a black panel and smart-looking NZXT logo, and the storage bays sit behind a slab of white metal. The motherboard tray and fan blades are white, but the expansion-slot blanking plates, rubber grommets and cables are all black. It's impeccably tidy inside too: cables in the front half of the case are barely visible, and they're all tied down in straight lines around the back.

It's similarly striking on the outside. The panels are white with black trim, and a large window allows the high-end components to be viewed. The NZXT balances good looks with decent practicality as well. Four 3.5in bays are vacant and made with sturdy metal rubber pads, although they're not tool-free – and need to be accessed by removing the rear case panel. There are two 2.5in bays free around the front too, so at least adding SSDs is simple.

Meanwhile, the motherboard has three 16x-sized PCI-E slots and a single 1x PCI-E slot free, providing loads of room for future upgrades. Upgrading could be a little trickier in the top half of the board though. While four memory slots are free, they're awkward to access because of the sheer size of the Be Quiet! Dark Rock Pro 3 cooler, which has two large fans. That said, it will be a while before you need more than 16GB of memory anyway. There's plenty of cooling gear elsewhere too, with three 120mm fans at the front, and a 140mm unit at the back.

Scan's system comes with a great three-year parts and labour warranty too, with the first year of coverage provided on-site and return-to-base for the last two years. That's a good deal, but that's not all you get with this machine – for the first time, Scan has included a USB stick with a host of troubleshooting tools, which comes attached to the inside of the case with a spot of Velcro.

/SPECIFICATIONS

CPU Intel Core i7-5820K overclocked to 4.4GHz

Motherboard Asus X99-A

Memory 16GB Corsair Vengeance LPX 2,666MHz DDR4

Graphics EVGA GeForce GTX 980 Ti 6GB

Storage 512GB Samsung SM951 SSD, 2TB Seagate Barracuda 7200.14 hard disk

Case NZXT H440

Cooling CPU Be Quiet! Dark Rock Pro 3 with 1 x 120mm and 1 x 135mm fan; GPU 2 x 90mm fans; front 3 x 120mm fans; rear 1 x 140mm

PSU Corsair CS750 750W

Ports Front 2 x USB 3, 2 x USB 2, 2 x audio; Rear 6 x USB 3, 4 x USB 2, 1 x PS/2, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating System Windows 8.1 64-bit

Warranty Three years parts and labour, first year on-site, and second and third years return to base

Performance

Nvidia says that the GTX 980 Ti is designed for 4K gaming, and we've no reason to quibble. In Battlefield 4 at 3,840 x 2,160 and Ultra settings, the Scan hit a minimum of 33fps, and it managed a better minimum of 48fps in Shadow of Mordor – both scores that will ensure smooth gameplay. Crysis 3 was a little more challenging, with a minimum of 25fps at the game's toughest settings, but the average of 35fps is better and that's a remarkable achievement for a single-GPU system at this price.

The Core i7-5820K is no slouch either, helping the Scan to an overall application benchmark score of 160,430 points. That's 40 per cent better than our reference system, and the 6-core CPU, not surprisingly, excelled in the heavily multi-threaded parts of our test suite.

There's no denying the sheer speed on offer from Samsung's PCI-based SSD either. Its sequential read and

ELITE
NEW ENTRY
P62

1 The star of the show is a GeForce GTX 980 Ti, enabling 4K gaming on one GPU

2 The M.2 Samsung SSD uses the PCI-E 3 bus, and is blisteringly fast

3 An overclocked Core i7-5820K sits under this massive Be Quiet! cooler

write results of 1,847MB/sec and 1,502MB/sec respectively are blistering, being around three times the pace we're used to seeing from SATA drives.

However, it gets toasty inside this rig. The CPU core hit 94°C under stress testing (a 72°C delta T), while the GPU delta T sat at 60°C. These results are within the chips' thermal limits, and the Scan has a good warranty, though, so there's no cause for concern. The noise isn't bad either – the Scan is near-silent at idle and only produced a low, consistent rumble when running tough games, helped by the noise-absorbing foam on both side panels and the roof.

Conclusion

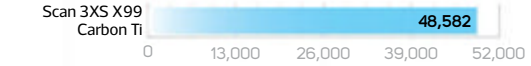
Scan's choice of components is clever and powerful: the GTX 980 Ti has the power needed to play games at 4K, the SSD offers blistering pace and the Core i7-5820K is very fast in multi-threaded apps.

Whether you want to run multi-threaded software or demanding games, this machine will do it all, and for under two grand. It impresses elsewhere too, with a great case and surprisingly low noise levels. It isn't cheap, of course, especially for an entirely air-cooled machine, but it's a good deal for the kit on offer, making the Scan 3XS X99 Carbon Ti a good-value investment for high-resolution gaming.

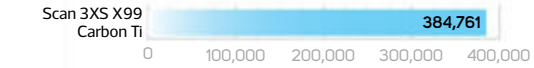
MIKE JENNINGS

CPC REALBENCH 2015

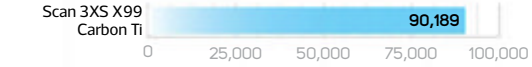
GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING

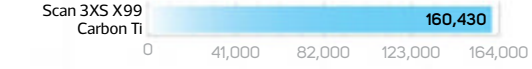


LUXMARK OPENCL



HEAVY MULTITASKING

SYSTEM SCORE



INTEL REFERENCE: 140.17%

BATTLEFIELD 4

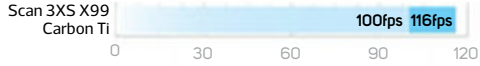
2,560 x 1,440, Ultra Detail, 4x AA

3,840 x 2,160, Ultra Detail, 4x AA

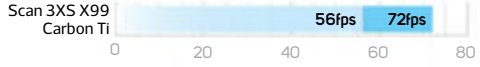
Minimum Average

BIOSHOCK INFINITE

2,560 x 1,440, Ultra Detail with Depth of Field

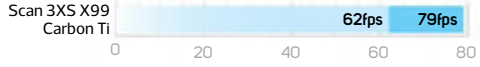


3,840 x 2,160, Ultra Detail with Depth of Field

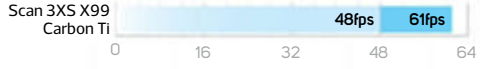


SHADOW OF MORDOR

2,560 x 1,440, Ultra Detail



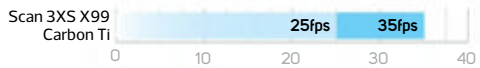
3,840 x 2,160, Ultra Detail



CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA

3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

SPEED 24/25

DESIGN 22/25

HARDWARE 22/25

VALUE 22/25

OVERALL SCORE 90%

VERDICT

Rapid speed from every component, and a slick design, make the 3XS X99 Carbon Ti a superb gaming machine.

GAMING PC

CyberPower Fang Trinity 300 / £1,999 inc VAT

SUPPLIER www.cyberpowersystem.co.uk

CyberPower's latest machine is, technically, a desktop PC, but it doesn't look like any gaming system we've seen recently. It uses the DeepCool Gamer Storm Tristellar case – a chassis that divides the system's components into three discrete sections, described as 'blades'. The trio of blades are coated with thick surrounds of sandblasted metal and make this machine look like a spaceship. The cables that flow between the components and their separate sections are stored in a strut in the middle of the case, and the large power button is illuminated with red LEDs.

There's no denying its striking appearance, but manufacturer Deepcool says there are practical benefits too: the separation of major components keeps down temperatures, and the modular design means it's easy to access particular parts if they need to be replaced. It isn't difficult to get inside; the metal shrouds all slide away after removing a couple of thumbscrews.

The top blade houses the overclocked MSI Nvidia GeForce GTX 980 graphics card and the 250GB Samsung 850 Evo SSD, with the rest of the components divided between the two lower sections. One section houses the full-sized Cooler Master PSU and the hard drive, while the other contains the mini-ITX motherboard and cooler.

The Tristellar's looks will divide opinion, and its width and shape means it's not as easy to accommodate as a traditional tower case, but its build quality is rock-solid, with a metal skeleton beneath thick, sturdy panels. It has a surprising amount of upgrade room too; the top blade has two tool-free SSD bays vacant, and there's room for a second hard disk towards the bottom. It's no match for the versatility of ATX towers, but it isn't bad when compared to other mini-ITX machines.

Plus, while the CyberPower be a mini-ITX system, it has a specification we'd expect from a full-sized desktop. The Core i5-5820K processor has had its six cores overclocked from 3.3GHz to 4GHz, and there's 16GB of DDR4 RAM too. That's a good selection of components, but the CyberPower still can't compete with traditional towers such as Scan's 3XS X99 Carbon Ti – another machine that also costs £1,999.

The Scan machine shares the Core i7-5820K and 16GB of memory, but both are clocked a little faster: the CPU at 4.2GHz and the memory at 2,666MHz. The 3XS system also has the GTX 980 Ti rather than just the standard GTX 980 too, enabling the Scan machine to play 4K games. And, while we're pleased by the CyberPower's Samsung Evo SSD, Scan goes one step further, with a 512GB SM951 model that uses PCI-E 3 to deploy stupendous read and write speeds. Like the Scan, the CyberPower doesn't have an optical drive either, although there's room for a slimline model in a 5.25in bay between the two hard disk bays.

The CyberPower's ASRock X99E-ITX/ac motherboard is obviously also missing expansion features when compared with full-sized ATX boards, although it does have an M.2 slot that supports PCI-E 3.

Meanwhile, the rear I/O panel sports four USB 3 ports, a pair of USB 3.1 connectors, a PS/2 port and five audio jacks alongside dual-band 802.11ac wireless. Amazingly, CyberPower has also managed to cram a liquid-cooling system inside the Trinity – a 120mm Cooler Master Seidon with one fan.

The Fang also comes with a three-year labour warranty with two years of parts coverage, and it's a return-to-base deal for the whole three years. That's a decent deal, even if Scan's is a little better thanks to three years of parts coverage and a year of on-site repairs.

Performance

The CyberPower machine might be a mini-ITX build, but it still has strong application power. Its encoding benchmark score of 358,997 is fantastic thanks to the i7-5820K's six cores, and it also excelled in the multi-tasking test with a result of 183,879. The CyberPower's overall result of 152,964 is superb – not far behind the Scan's 160,430 score, and enough to ensure that high-end games and work tasks are completed swiftly.

There was more of a gulf between the CyberPower's GTX 980 and the Scan's GTX 980 Ti, although that's no surprise: the CyberPower's card has a far weaker specification that's not really designed for 4K. Its minimum frame rate in Crysis 3 at 2,560 x 1,440 was a comfortable 34fps, but that figure dropped to just 7fps with an average of 22fps when we raised the resolution to 3,840 x 2,160.

/SPECIFICATIONS

CPU Intel Core i7-5820K overclocked to 4GHz

Motherboard ASRock X99E-ITX/ac

Memory 16GB Kingston HyperX Fury 2,400MHz DDR4

Graphics MSI GeForce GTX 980 4GB

Storage 250GB Samsung 850 Evo SSD; 2TB Seagate hard disk

Case DeepCool Gamer Storm Tristellar

Cooling CPU: Cooler Master Seidon with 1 x 120mm fan; GPU: 1 x 60mm fan; rear 1 x 90mm fan

PSU Cooler Master RS-600 600W

Ports Front 2 x USB 3, 2 x audio; Rear 4 x USB 3, 2 x USB 3.1, 2 x USB 2, 1 x PS/2, 2 x Gigabit Ethernet, 1 x eSATA, 1 x optical S/PDIF, 5 x audio

Operating system Windows 8.164-bit

Warranty Two years parts and labour return to base, with a third year labour only

It was a similar story in other games. A playable 2,560 x 1,440 minimum of 46fps in Battlefield 4 dropped to 22fps at 4K, although Shadow of Mordor didn't drop below 31fps at 3,840 x 2,160.

The CyberPower's SSD can't compete with that of the Scan either. Its sequential read and write speeds of 469MB/sec and 412MB/sec are good, but they're less than a third as quick as the Scan's Samsung M.2 drive. In fairness, though, the average home user or gamer is unlikely to see much advantage from the Scan's high storage speeds anyway.

There's little to choose between the two machines when it comes to temperatures, with the CyberPower's CPU and GPU topping out with delta Ts of 70°C and 61°C – that's hot, but still within the CPU's thermal limits. However, the cramped CyberPower makes a little more noise than the Scan. It isn't too bad, though, and will be easily countered with some decent speakers or a set of headphones.

Conclusion

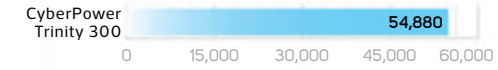
CyberPower's system is striking thanks to its triple-pronged case design, and there's plenty to like about the Tristellar chassis: its looks will draw admiring glances, and it's well built too. There are reminders throughout, though, that the Fang makes compromises in order to look so outrageous. Its processor and memory are a little slower than the similar hardware in the Scan, and the GTX 980 and SSD are outpaced by Scan's machine too.

There's no denying the Trinity's outstanding design though – if you're not bothered by 4K gaming, and your priority is a system that looks great, and you're prepared to pay for it, the Fang Trinity 300 is still a cracking PC – just be aware that you can get more performance for the same money in a standard PC case elsewhere.

MIKE JENNINGS

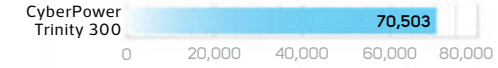
CPC REALBENCH 2015

GIMP IMAGE EDITING

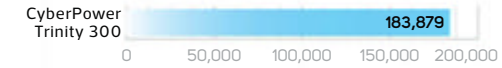


HANDBRAKE H.264 VIDEO ENCODING

LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE

INTEL REFERENCE: 133.65%

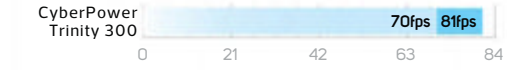
BATTLEFIELD 4

2,560 x 1,440, Ultra Detail, 4x AA

3,840 x 2,160, Ultra Detail, 4x AA

BIOSHOCK INFINITE

2,560 x 1,440, Ultra Detail with Depth of Field



3,840 x 2,160, Ultra Detail with Depth of Field

SHADOW OF MORDOR

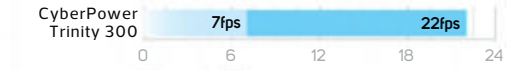
2,560 x 1,440, Ultra Detail

3,840 x 2,160, Ultra Detail

CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA

3,840 x 2,160, Very High Detail, 0x AA



SPEED	DESIGN	OVERALL SCORE
21/25	23/25	85%
HARDWARE	**VALUE**	
21/25	20/25	

VERDICT

A striking, sturdy design and great performance in most tests, but more traditional PCs can offer 4K gaming performance for the same money.

Elite

Our choice of the best hardware available

Build a budget PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, a decent-quality case and the OEM version of Windows 7 Home Premium.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
1	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
2	Corsair CS550M	www.scan.co.uk	Issue 135, p46	£64
3	500GB Seagate Barracuda ST500DM002	www.scan.co.uk	Issue 104, p72	£36
4	Microsoft Windows 7 Home Premium 64-bit OEM	www.ebuyer.com	Issue 75, p46	£68

All-purpose PC

The parts you'll need to add to the core components to build a general-purpose PC. This machine will handle general computing tasks with no trouble, and will also cope with basic gaming, although you'll have to lower the detail settings. It features high-speed memory to boost the performance of the AMD APU's graphics system.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Gigabyte GA-F2A88XM-D3H	www.cclonline.com	Issue 126, p22	£58
	AMD A10-7850K	www.scan.co.uk	Issue 127, p17	£116
	8GB Corsair Vengeance Pro Series 2,400MHz DDR3 CMY8GX3M2A2400C11R	www.scan.co.uk	Issue 132, p22	£50
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
			TOTAL	£478

Gaming PC

The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor. The machine has a discrete graphics card, a highly overclockable dual-core CPU and high-speed memory. Meanwhile, the Z97 motherboard gives you headroom to upgrade to a faster CPU later.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	ASRock Z97 Pro3	www.scan.co.uk	Issue 130, p50	£79
	Intel Pentium G3258	www.scan.co.uk	Issue 132, p17	£52
	AMD Radeon R9 280 3GB	www.ebuyer.com	Issue 140, p42	£150
	8GB Corsair Vengeance Pro Series 2,400MHz DDR3 CMY8GX3M2A2400C11R	www.scan.co.uk	Issue 132, p22	£50
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
			TOTAL	£585

Recommended extra

A solid state drive will make a huge difference to the responsiveness of Windows, as well as boot-up times. We strongly recommend adding one to any build.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Crucial BX100 250GB	www.ebuyer.com	Issue 141, p43	£69

Build a mid-range PC

Work PC

The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-4690K Haswell CPU up to 4.8GHz, so it has some serious performance potential. Also included is a solid Corsair PSU, a 500GB SSD and 8GB of high-speed memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Gigabyte Z97X-SLI	www.overclockers.co.uk	Issue 130, p54	£90
	Intel Core i5-4690K	www.scan.co.uk	Issue 132, p18	£179
	8GB Corsair Vengeance Pro Series 2,400MHz DDR3 CMY8GX3M2A2400C11R	www.scan.co.uk	Issue 132, p22	£50
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£70
	Corsair CS550M	www.scan.co.uk	Issue 135, p46	£64
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£58
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£10
	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£137
	Microsoft Windows 7 Home Premium 64-bit OEM	www.ebuyer.com	Issue 75, p46	£68
			TOTAL	£824

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 x 1,080** AMD Radeon R9 280 3GB	www.ebuyer.com	Issue 140, p42	£150
	**2,560 x 1,440** AMD Radeon R9 290 4GB	www.scan.co.uk	Issue 140, p48	£227

Build a performance PC

Work PC

The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, beautifully built case, and has a Core i7-4790K CPU. This processor's support for Hyper-Threading effectively splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid 850W PSU, giving you plenty of headroom for overclocking and adding multiple graphics cards, and an all-in-one liquid cooler.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT H440 Special Edition	www.overclockers.co.uk	Issue 140, p24	£125
	Asus Maximus VII Ranger	www.scan.co.uk	Issue 131, p20	£131
	Intel Core i7-4790K	www.scan.co.uk	Issue 132, p19	£252
	8GB Corsair Vengeance Pro Series 2,400MHz DDR3	www.scan.co.uk	Issue 132, p22	£50
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£70
	SilverStone Strider Gold 850W	www.overclockers.co.uk	Issue 135, p56	£110
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£58
	Samsung 850 Evo 500GB	www.scan.co.uk	Issue 141, p51	£156
	Microsoft Windows 7 Home Premium 64-bit OEM	www.ebuyer.com	Issue 75, p46	£68
			TOTAL	£1,020

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**2,560 x 1,440** AMD Radeon R9 290 4GB	www.scan.co.uk	Issue 140, p48	£227
	**4K** 2 x Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p50	£504

Recommended extra

A discrete sound card gives you higher-quality sound when playing back or recording music.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Creative Sound Blaster Z	www.scan.co.uk	Issue 116, p42	£62

Build a 6-core workstation

Multi-threaded workstation

The parts you'll need to build a PC with serious power in multi-threaded workstation software, such as 3D rendering apps and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and cooler listed. Also supplied is 16GB of RAM, 1TB of solid state storage and a 1.2kW PSU, providing loads of headroom for adding multiple GPUs.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Corsair Obsidian 750D	www.scan.co.uk	Issue 123, p30	£137
	Asus X99 Deluxe	www.overclockers.co.uk	Issue 136, p20	£310
	Intel Core i7-5820K	www.scan.co.uk	Issue 134, p43	£305
	AMD Radeon R9 280 3GB	www.ebuyer.com	Issue 140, p42	£150
	16GB Corsair Vengeance LPX 2,666MHz DDR4 CMK16GX4M4A2666C16	www.scan.co.uk	Issue 136, p14	£150
	Corsair Hydro Series H110i GT	www.scan.co.uk	Issue 140, p17	£101
	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£254
	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£308
	Seagate Barracuda 2TB ST2000DM0001	www.scan.co.uk	Issue 104, p75	£58
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£10
	Microsoft Windows 7 Professional OEM (or Windows 8.1 if you're using a 4K monitor)	www.ebuyer.com	Issue 75, p46	£110
			TOTAL	£1,893

4K gaming PC

This LGA2011-v3 system can support multiple graphics cards over 28 PCI-E 3 lanes, making it an ideal foundation for high-resolution PC gaming, replacing the graphics card listed above with two high-spec cards. We recommend using Windows 8.1, rather than Windows 7, if you're using a 4K monitor.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**4K** 2 x Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p50	£504
			TOTAL	£2,247

Build a mini PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, 8GB of RAM, an overclockable Haswell CPU, an all-in-one liquid cooler and Windows 7 Home Premium. Also included is a short-PCB graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a 512GB SSD.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Intel Core i5-4690K	www.scan.co.uk	Issue 132, p18	£179
	8GB Corsair Vengeance Pro Series 2,400MHz DDR3	www.scan.co.uk	Issue 132, p22	£50
	Corsair H75	www.scan.co.uk	Issue 138, p46	£64
	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£300
	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£137
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£58
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£10
	Corsair CS550M	www.scan.co.uk	Issue 135, p46	£64
	Microsoft Windows 7 Home Premium 64-bit OEM	www.ebuyer.com	Issue 75, p46	£68

Mini-ITX PC

The parts you'll need to build a pint-sized powerhouse.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Corsair Obsidian 250D	www.dabs.com	Issue 136, p41	£70
	Asus Maximus VII Impact	www.overclockers.co.uk	Issue 136, p52	£180
			TOTAL	£1,180

Micro-ATX PC

The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£66
	Asus Maximus VII Gene	www.overclockers.co.uk	Issue 133, p18	£165
			TOTAL	£1,161

Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Budget ATX**	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	**Sub-£100 ATX quiet**	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£87
	**Sub-£100 ATX performance**	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	**Air-cooling Sub-£150 ATX**	SilverStone Fortress FT05	www.scan.co.uk	Issue 139, p24	£131
	**Water-cooling sub-£150 ATX**	NZXT H440 Special Edition	www.overclockers.co.uk	Issue 140, p24	£125
	**Water-cooling ATX**	SilverStone Temjin TJ07B-W	www.overclockers.co.uk	Issue 63, p87	£225
	**Mini-ITX tower**	Corsair Obsidian 250D	www.dabs.com	Issue 136, p41	£70
	**Mini-ITX cube**	Antec ISK600	www.overclockers.co.uk	Issue 126, p28	£50
	**Micro-ATX**	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£66
	**Water-cooling micro-ATX**	Parvum Systems S2.0	www.overclockers.co.uk	Issue 129, p22	£140

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 x 1,080 gaming**	AMD Radeon R9 280 3GB	www.ebuyer.com	Issue 140, p42	£150
	**2,560 x 1,440 gaming**	AMD Radeon R9 290 4GB	www.ebuyer.com	Issue 140, p48	£227
	**High-end single-GPU gaming**	Nvidia GeForce GTX 980 Ti UPDATED	www.overclockers.co.uk	Issue 143, p20	£540
	**4K gaming**	2 x Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p49	£504
	**Mini-ITX**	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£300

Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Mid-range 550W**	Corsair CS550M	www.scan.co.uk	Issue 135, p46	£64
	**High-end 750W**	Corsair HX750i	www.dabs.com	Issue 135, p52	£115
	**Mid-range 850W**	SilverStone Strider Gold 850W	www.overclockers.co.uk	Issue 135, p56	£110
	**High-end 1.2kW**	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£254

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Router**	Asus RT-AC68U	www.dabs.com	Issue 128, p88	£145
	**Wi-Fi adaptor**	Asus PCE-AC68	www.dabs.com	Issue 128, p88	£70

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Hard disk**	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£58
	**250GB SSD**	Crucial BX100 250GB	www.ebuyer.com	Issue 141, p43	£69
	**500GB SSD**	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£137
	**1TB SSD**	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£308
	**High-performance SSD**	Intel SSD 750 1.2TB UPDATED	www.scan.co.uk	Issue 143, p24	£817
	**NAS box**	Synology DS215J	www.cclonline.com	Issue 138, p17	£140

Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**24in monitor**	Dell U2414H	www.overclockers.co.uk	Issue 129, p43	£200
	**29in monitor**	Asus PB298Q	www.scan.co.uk	Issue 129, p52	£294
	**28in 4K monitor**	Asus PB287Q	www.dabs.com	Issue 133, p44	£420
	**G-Sync monitor**	Asus ROG Swift PG278Q UPDATED	www.scan.co.uk	Issue 143, p44	£587
	**FreeSync monitor**	BenQ XL2730Z UPDATED	www.box.co.uk	Issue 143, p46	£460

Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Budget mechanical keyboard**	Gigabyte Aivia Osmium	www.awd-it.co.uk	Issue 139, p40	£72
	**Mechanical gaming keyboard**	CM Storm Trigger-Z	www.ebuyer.com	Issue 139, p44	£100
	**Mechanical MMO keyboard**	Corsair Vengeance K95	www.ebuyer.com	Issue 123, p64	£95
	**Gaming mouse**	Logitech G402 Hyperion Fury	www.currys.co.uk	Issue 139, p53	£40
	**Wireless gaming mouse**	SteelSeries Sensei Wireless	www.box.co.uk	Issue 139, p61	£90
	**Flight stick**	Saitek X-55 Rhino H.O.T.A.S.	www.overclockers.co.uk	Issue 131, p29	£170
	**Steering wheel and pedals**	Thrustmaster TX Ferrari 458 Italia Edition	www.overclockers.co.uk	Issue 137, p32	£260

Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**PCI-E sound card**	Creative Sound Blaster Z	www.scan.co.uk	Issue 116, p42	£62
	**USB DAC**	Asus Xonar Essence One	www.overclockers.co.uk	Issue 118, p44	£363
	**2.1 speakers**	Acoustic Energy Aego M	www.amazon.co.uk	Issue 142, p52	£165
	**Soundbar**	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£165
	**Headset**	HyperX Cloud II	www.ebuyer.com	Issue 142, p46	£75
	**Surround-sound headset**	Asus Strix 7.1	www.cclonline.com	Issue 142, p43	£146

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Sub-1,000 gaming PC**	Box Cube Aero Series Watercooled Gaming UPDATED	www.box.co.uk	Issue 143, p56	£999
	**Quiet gaming PC**	Chillblast Fusion Serenity	www.chillblast.co.uk	Issue 138, p66	c. £1,499
	**Dream PC**	Scan 3XS Bear	www.scan.co.uk	Issue 125, p58	c. £6,999
	**Sub-£2,000 gaming PC**	Scan 3XS X99 Carbon Ti UPDATED	www.scan.co.uk	Issue 143, p58	£1,999
	**4K gaming PC**	Overclockers Infin8 Nebula	www.overclockers.co.uk	Issue 141, p58	c. £3,116
	**Micro-ATX gaming PC**	AWD-IT Chimera i5 Dead Silence Gaming PC	www.awd-it.co.uk	Issue 135, p64	c. £949
	**Gaming laptop**	MSI GT70 2PC Dominator	www.overclockers.co.uk	Issue 129, p26	c. £1,320
	**Haswell-E PC**	Scan 3XS X99 Cyclone SLI	www.scan.co.uk	Issue 134, p60	c. £3,349

Games

Featured this month

RICK LANE / INVERSE LOOK

DIFFICULTY SPIKED

Tough games are back in fashion, but these new challenges don't signal a return to a golden age, argues Rick Lane

Since the release of Dark Souls in 2011, there's been a minor renaissance of challenging games. Titles such as XCOM and Spelunky have demonstrated how losing can be as fun as winning, while Kickstarter's kindling of nostalgia has resurrected notoriously tough game genres – isometric RPGs such as Pillars of Eternity and Wasteland 2, and adventure games such as Broken Age (see p76).

All of the above are fantastic games (except the second half of Broken Age), but this resurgence of difficult games doesn't hark back to a golden age. Modern difficult games are an entirely different breed from those original games of the 1980s and 1990s, and it's the differences between modern games such as Dark Souls, and nostalgic games such as Broken Age, that demonstrate why.

The notion of challenge being a core part of a game's existence has its roots in the arcades, where creating games that were difficult to complete had a clear financial gain. The tougher a game, and the more limited the player's lives, the more money its players would need to pump into the machine to get to the end. To complete a game, you either needed a fat wallet or a lot of skill.

When home consoles arrived, challenge became less of a concern, but by this point players were used to it, and so expected it. Moreover, a harder game takes longer to complete, and a longer game can justify a higher price tag. It reached the point where simplicity and brevity were viewed with outright scorn. In his 25th anniversary lecture on the wonderful adventure game Loom, designed to be brief and accessible, its creator Brian Moriarty revealed that the game was routinely mocked for these qualities upon its release in 1990.

> Lives and passwords were replaced by saves, then quicksaves and autosaves. We became comfortable, complacent

As games diversified and the audience broadened, the need for challenge took a back seat. Teenagers in the arcades became adults with jobs and families. Meanwhile, games could justify their price tags by being enormous rather than difficult. So games' lives and passwords were replaced by saves, which were replaced by quicksaves and autosaves. We became comfortable, even complacent.

Then Dark Souls came along and pushed gamers out of their comfort zone, and many players found it immensely satisfying. But to judge Dark Souls by its difficulty is to misunderstand it. Dark Souls is about learning and interpretation, piecing together snippets of information, and correcting your mistakes to emerge victorious. It isn't a return to an idea that gaming lost – it's an entirely new idea.

But being pummelled by a dragon in Dark Souls because you lack the necessary skills is different from being pummelled by a dragon in Pillars of Eternity because your level is too low. The same goes for learning how to manage a complex extraterrestrial response unit in XCOM, and being stymied by a badly thought-out, illogical puzzle in Broken Age. The former examples are instructive, the latter is obstructive.

That's the fundamental difference between the old and new style of challenging games, and an important one to recognise. There's a huge difference between making a game that's difficult through the nature of its systems, and making a game that's difficult for difficulty's sake.

There must be a reason behind challenge in a game, otherwise it's simple elitism, buying into an outmoded concept because it's incorrectly deemed to be integral part of gaming. CPC

Rick Lane is Custom PC's games editor. @Rick_Lane

Grand Theft Auto V / £40 inc VAT

DEVELOPER Rockstar North/ **PUBLISHER** Rockstar Games
WEBSITE www.rockstargames.com/v

OVERALL SCORE
80%

/ VERDICT
A flawed yet fascinating creation, GTA V is astonishingly ambitious, yet lacks coherence and doesn't best utilise its astounding world.

Rockstar North's latest crime saga is an astonishing technical achievement, with lofty narrative ambitions and a remarkable simulation of civilisation. But Rockstar's love of scripted events and cinematic drama prevents its virtual world from fully realising its dynamic delights.

The PC version is split into two components, a single-player story and GTA Online. Both are highly ambitious yet flawed. The single-player tells the story of three bank robbers. Michael is a retired former thief who spends his days drinking, watching TV and arguing with his family. Franklin is a repo man and small-time gangster who aspires to better himself. Upon encountering each other, after Franklin repossesses Michael's car, they decide to pull off a small heist together.

Their work attracts the attention of Trevor, a severely unhinged accomplice of Michael in a grimy trailer in the sticks, who has spent the past 20 years believing his partner in crime was dead. Even though this situation generates friction, together they arrange increasingly dangerous heists, with their lust for money just about outweighing their mutual resentment of one another.

Despite having three protagonists, the most interesting character in GTA V remains the world itself: the city of Los Santos and the surrounding Blaine County. Rockstar's latest open world is a microcosm of America as a whole. Its vast expanse includes towering commercial utopias, dilapidated backstreet ghettos, glitzy Vinewood mansions and trailer-strewn deserts. There's even a Twin Peaks-inspired small town.

What impresses most about GTA V's world isn't the scope or variety, but the detail. Walk into one of the character's homes, and you can sit and watch entire TV programmes created just for the game, then pop into the kitchen and drink a beer.

Walk past someone on the phone and you can hear half of a conversation recorded purely for that purpose. Cut up a driver on the highway, and they'll parp their horn and gesture rudely out their window, uttering a string of insults prepared entirely for responding to the player's actions. It's a world designed with tremendous care, and a terrifying number of work hours.

The PC is also the best place to experience it. Not only does the PC version cater for a wide range of machines, from laptops to GTX Titan Black behemoths, it also lets you play the game entirely in first person. This perspective brings you closer to the simulation, making it easier to spot details and lending a much stronger sense of scale. Towering skyscrapers and passing freight-trains seem *enormous* when viewed from behind your car windscreen. It's a world so painstakingly created that it warrants exploration in and of itself.

It's just as well, though, because mechanically, the game is less ambitious. In terms of missions, GTA V is fairly traditional. You drive to a location, watch a cutscene, shoot some enemies, drive back and watch another cutscene. It's extremely rigorous and dictatorial. Go here, watch this, do that. Even in the game's signature heist missions, where it

lets you choose between multiple approaches, and requests you to source equipment yourself, it never lets go of the reins completely.

As with all Rockstar's games since GTA IV, the designers want to tell a story. And boy, is there a lot of story, told through hours of supremely acted cutscenes in which characters relentlessly posture, insult or just yell at one another. GTA V pitches itself as a satire, and certainly it casts a sidelong glance at almost every aspect of society. Modern cinema, social media, the news, celebrity culture and even the stock exchange are all lampooned.

The problem is that none of it's particularly funny, because GTA also aspires to be a serious drama, influenced by TV shows, such as the Wire. Consequently, GTA ends up being misanthropic rather than satirical. It's an angry game that shows disdain for pretty much everything, and it ends up feeling miserable as a result.

If you want to ignore the plot and just have fun, you'll find GTA an abundant but vacuous experience. Side-activities range from robbing convenience stores to playing entire games of simulated tennis. You can go hunting, fly planes, go whale watching, or simply buy a sandwich and listen to your car radio. But it's all arbitrary. There's nothing tying all these systems together apart from a few basic ability meters (playing tennis will slightly increase your stamina, for example). Meanwhile, the most fun activity in GTA is to go on a rampage, and play cat and mouse with the cops, but even then the fun element is increasingly hidden beneath the series' obsession with mocking and mimicking real life.

GTA Online fares better in this regard, although not quite as well as we hoped. It lets you create your own miscreant, and then work your way through a series of criminal ranks, increasing your prestige and monetary worth as time goes on.

The potential for amusing shenanigans in GTA Online is greater, as players explore the game's amazing world together, playing around with its vehicles or simply trying to kill each other. Meanwhile, activities such as playing tennis or robbing shops make more sense, as you might need to make a quick buck to buy a better weapon, or increase your stamina to compete better against other players.

Sadly, GTA Online isn't quite the dynamic amusement park it promises though. Many of its activities are sectioned off into separate instances, and use traditional frameworks such as deathmatch, team-deathmatch and racing.

There are more involved 'jobs' you can pull off together, and the recently added multiplayer heists are fantastic cooperative experiences. Again though, it's all highly organised and directed; there's no possibility to create your own heist where you mark the target and make the plan. GTA Online isn't short of toys, but it only lets you play with them under certain conditions.

It's these contradictions that stop GTA V from achieving its full potential. It wants to be an open-world game, but also a directed, cinematic experience. It wants to be a crude satire, but also taken seriously. It wants to be a crime epic, but you have to play by the rules. It's a midlife crisis in game form – rich, indulgent and successful, yet unsatisfied and confused.

RICK LANE

Project CARS / £40 inc VAT

DEVELOPER Slightly Mad Studios / **PUBLISHER** Slightly Mad Studios / **WEBSITE** www.projectcarsgame.com

Slightly Mad Studios' new racing sim was built in collaboration with its community, which has been funding, testing and even creating parts of the game throughout its four-year development. The result is a beautiful, varied and incredibly flexible racer with something for everyone to enjoy.

Focusing mainly on track races, with a small side dish of road action, you work your way up an extensive career ladder, or create your own races using a wide array of tracks, cars and race conditions. Project CARS never gates off any of its content with levels or experience points. It can all be explored from the start, while the career mode lets you work your way up from the very bottom as a kart or touring car driver, or jump straight into the glamorous world of Formula A.

Project CARS wants you to concentrate on racing, and the racing experience is wonderful. The difference between each car's handling is cavernous. The Formula A and B vehicles stick to the corners like glue, but spin like a dreidel if you accelerate too quickly. By comparison, the GT cars feel like a cruise liner going into a corner; solid, heavy and smoother than a baby wrapped in silk.

As well as your choice of car, the tyre temperature and amount of fuel you're carrying also influence balance and

OVERALL SCORE 85%

/ VERDICT
With a powerful engine, elegant bodywork and an abundance of customisation options, Project CARS is a stellar drive.

Broken Age / £19 inc VAT

DEVELOPER Double Fine / **PUBLISHER** Double Fine / **WEBSITE** www.brokenagegame.com

After three years of development and three million dollars in community funding, Double Fine's much anticipated adventure game is finally complete. Broken Age's story is divided into two acts, each of which switches between two characters.

Vella is a smart, affable young woman destined to be sacrificed to a terrifying monster in her town's so-called Maiden's Feast festival, a prospect about which everyone except her appears to be extremely enthusiastic.

Elsewhere, Shay lives on a spaceship that acts as both playpen and prison. Having outgrown the nursery-like surroundings, Shay's life is one of numbing routine and stifling safety, and he bristles under the overprotective love of his AI mother.

Both are teenagers struggling to accept the paths life has laid out for them, and initially Broken Age explores this theme well. Act One is a simplistic adventure game buoyed by excellent writing and a general sense of warmth and fun. Double Fine's trademark wit elegantly juxtaposes the often sinister subject matter, and the tremendous voice acting elevates the script. However, the idea of playing two characters simultaneously is never really explored in a systemic sense, and Vella's story loses urgency in the middle. Even so, it's consistently entertaining and occasionally hilarious (the sequence involving a talking tree is a highlight).

OVERALL SCORE 50%

/ VERDICT
Act I provides a decent foundation, but the catastrophic Act II torpedoes the entire experience.

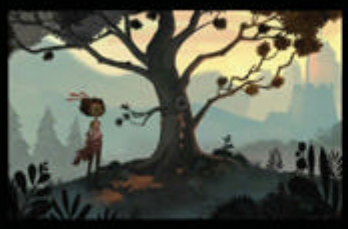
grip, while the driving experience can be customised extensively. Vehicles can be tuned to the finest detail, and an abundance of driving-assists alter the experience to be as easy or difficult as you like.

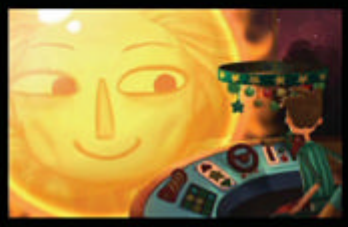
But CARS' most impressive feature is its time and weather simulation. Races can take place at any time and in almost any condition, from clear, sunny days to stormy nights where you can barely see the car in front of you. The weather can even change during a race. Time is another factor. Brands Hatch might look glorious at sunset, but the sun's glare can also obscure the track at certain corners.

On the downside, some race types are better than others. The lower tier of karting is almost unplayable due to the tiny tracks and poor handling. More broadly, the game is very rigorous about staying on the track during practice and qualifying. Even brushing the grass will often invalidate your lap time, and there's no option to switch off this punishment. Lastly, the career mode attempts a human side with a fake social media feed that shows you the thoughts of your fans. Frankly, it's a bit garish, and imaginary fans moaning at you for poor performance is just annoying.

By and large though, Project CARS is an engrossing and exhilarating racer. It isn't radically different from other examples of its genre, but it does its job better than most, and lets you approach it however you choose.

RICK LANE



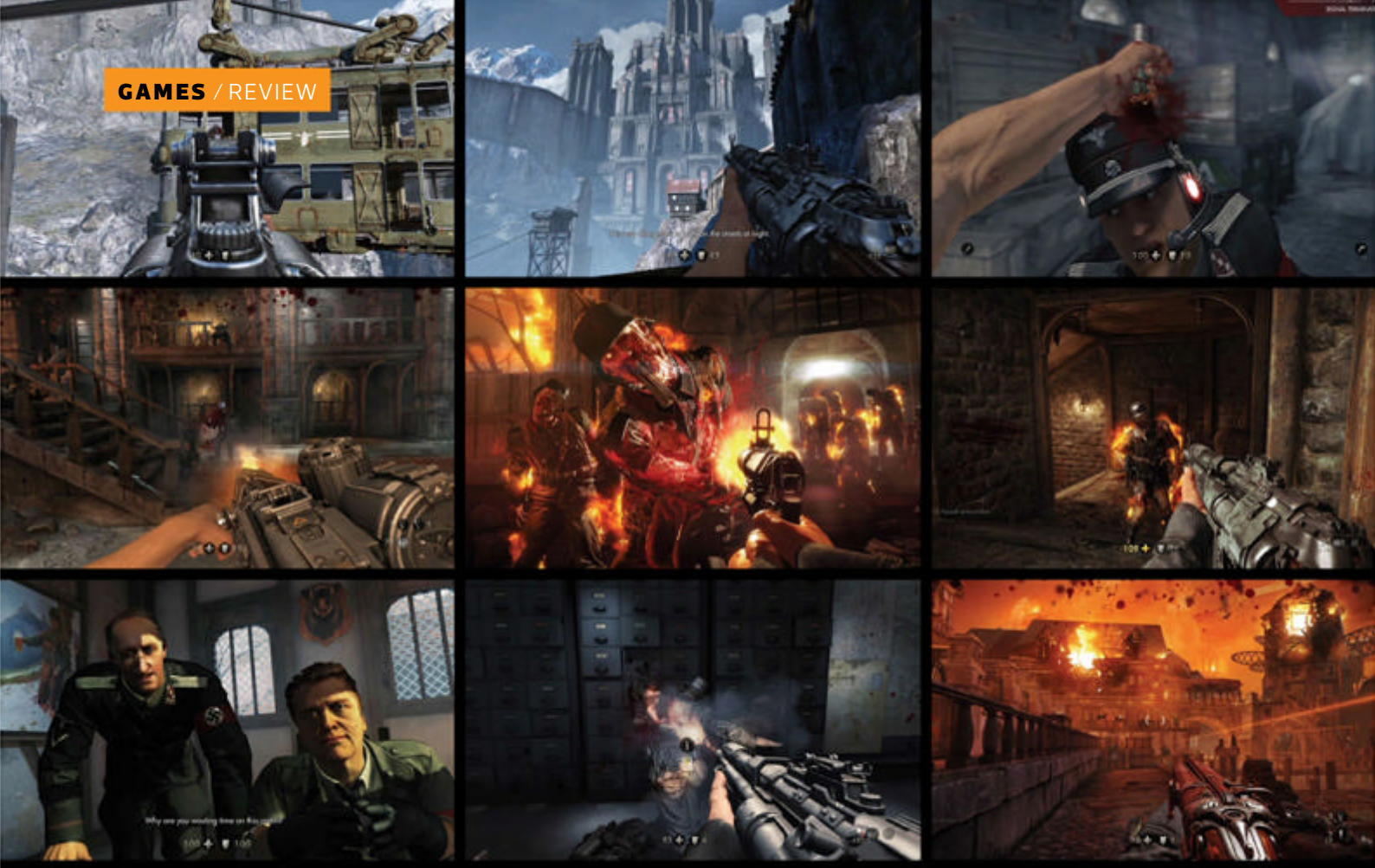


However, Act Two is an unmitigated disaster. It fails to build on the story of Act One in almost every way. The determination to keep the characters' stories separate means they never get much of a chance to interact, and the lack of any new locations to explore is deeply disappointing. The exploration of adolescence is pretty much abandoned, and the sense of adventure is reduced to performing endless repair jobs and menial tasks.

All of which leads us to the worst aspect of Act II – the puzzles. They're convoluted, illogical and often downright obtuse. There's a puzzle about untying knots that changes every time you make a mistake, and involves descriptions and diagrams that bear only passing relation to the knots. Then there's a sequence of circuit-rewiring puzzles, where the solutions require information from both characters' perspectives, even though they can't communicate with each other. If you complete these puzzles without a walkthrough, you can probably see the future. Congratulations! What are next week's lottery numbers?

Act II is shockingly dreadful when you consider that Double Fine has worked on it for 15 months. It's still funny, of course, but the laughter is tainted with frequent bouts of frustration and bewilderment. If you like a giggle and have a brain that can do backflips, you might find Broken Age enjoyable. Otherwise, seek out a different adventure.

RICK LANE



Wolfenstein: The Old Blood / £16 inc VAT

DEVELOPER MachineGames / **PUBLISHER** Bethesda Softworks / **WEBSITE** www.wolfenstein.com

Wolfenstein: The New Order was one of last year's pleasant surprises, giving the great-granddaddy of first-person shooters a refreshing new spin. Set in an alternate future where Hitler won the war, it featured giant robot dogs, dual-wielded shotguns and a Nazi moon base. The Old Blood is a standalone expansion to MachineGames' slick and entertaining reboot, set in 1946, before the events of The New Order but after the war starts to turn in Hitler's favour. It sees the granite-chinned BJ Blazkowicz infiltrating the mighty Castle Wolfenstein to steal a secret document that may provide the Allies' last chance of victory.

Returning to the grey stone corridors of Castle Wolfenstein seems like an odd decision, given that The New Order moved away from the classic locations and increasingly hackneyed themes. Indeed, during the Old Blood's initial hour, The New Order seems a distant memory. With your plans foiled by the Nazis, you're forced into a tedious stealth section, whacking cyborg dogs and heavily armed super-soldiers over the head with a broken pipe.

Fortunately, the action picks up as you proceed deeper into the castle. Blazkowicz's weapon slots are quickly filled, and the game starts throwing enemies at you in droves. In a welcome change, there's less focus on bullet-sponge opponents than in The New Order. Aside from the Kampfpistol grenade launcher, there isn't much new in terms of weaponry, but the intelligent level design, and the way your enemies take advantage of it, makes the concentrated bursts of gunplay just as satisfying.

The high point comes during a daring escape sequence involving a cable car, a big drop and a longer climb to salvation. Unfortunately, while the second act starts promisingly – set in a stunning baroque German town – it soon resorts to the exhausted trope of zombies. To be fair, Wolfenstein was tinkering with occult silliness before the virtual zombie epidemic reached critical mass, but the shambling corpses in The Old Blood simply aren't much fun to fight. They shuffle forwards in groups, and then one will burst forward to take a swipe at you, tearing a big chunk off your health bar if it connects. Compared with the human opponents, they're a noticeable step backwards.

Issues from The New Order also linger. The guns remain oddly quiet compared with the rest of the game, and the writing still struggles to balance fun schlock with grim drama, with Blazkowicz entering into lengthy, sad monologues just after obliterating an entire platoon of Nazis with his twin shotguns.

The Old Blood isn't terrible, but it's a little disappointing. It's understandable that MachineGames would want to try out the eponymous original location, but in turning back the clock, it's also undone much of its previous excellent work.

RICK LANE

OVERALL SCORE
60%

/ VERDICT
The Old Blood retains the fun gunplay of The New Order, but loses much of its unique charm.

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RICK LANE / THE ENGINE ROOM

GameMaker

Rick Lane investigates the indie darling of creation tools that's behind Hotline Miami, Gunpoint and Super Crate Box

There's a curious irony at the heart of GameMaker, YoYoGames' 2D game design tool and the program we've been using to create our own game over the last couple of issues. GameMaker's focus on 2D games and simplifying the design process makes it the indie darling of creation tools, used by developers to make Hotline Miami and Super Crate Box, and by one-man bands such as Tom Francis, who made Gunpoint.

Yet in recent years, GameMaker's own design has been influenced far more by its mainstream industry peers. Created by Dutch computer scientist Mark Overmars in 1999, GameMaker was purchased by YoYoGames in 2007. In 2009, the Dundee-based studio hired current CTO Russell Kay and head of engineering Mike Dailly, with a focus on turning GameMaker into a more professional design suite.

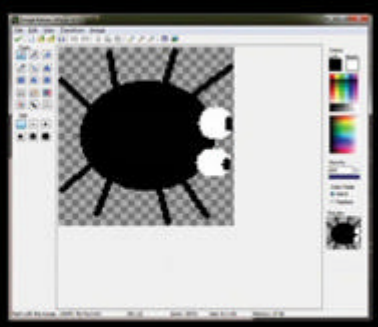
'Until 2007, GameMaker was really just a one-man band, with Mark doing everything,' Kay explains. 'Since Mike and I started, we've brought a lot of triple-A knowledge in terms of how games are put together. We applied that to GameMaker, which fundamentally changed the internals. It's completely different now.'

GameMaker's story over the past five years is one of gradual, hard-earned transformation. Overmars originally coded GameMaker in a programming language called Delphi. 'It's a Pascal-based object-oriented language that comes from around about the turn of the century,' Kay jokes.

Not many programmers are familiar with Delphi, and the code Overmars had written for GameMaker's compiler was incompatible for porting onto any system other than Windows, so much of YoYoGames' time has been spent slowly reprogramming GameMaker in its entirety. Thus far, GameMaker's compiler and runner have been rewritten in C++ and C# respectively, and the team is currently working on adapting the final parts into C#.

Currently in development, Orphan demonstrates the power of GameMaker's shading capability

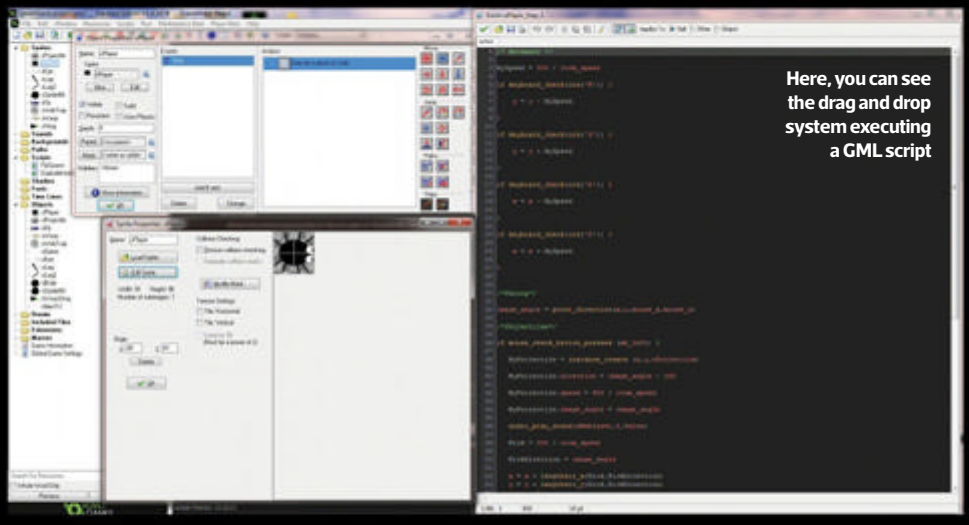
As a creation tool, GameMaker is based around two fundamental components. The first is its drag and drop system, allowing you to create a game without coding knowledge – it lets you assign simple commands such as 'Jump' onto objects through dragging and dropping icons. The second is its scripting language – GML. Designed to be highly flexible, GML is easy to learn due to its colour-coded functions and dynamic error checking. It also allows greater control and customisation options for developers who have reached the limits of drag and drop.



GameMaker's image editor is one of the last vestiges of the Delphi codebase

A big part of YoYoGames' work involved unifying these two features. 'GML code and drag and drop code used two different execution engines, and each code fragment was separate,' says Kay. 'So it would compile each code fragment separately and execute them in different ways. We took that whole pipeline and made it into one.'

GameMaker's compiler now turns drag and drop code into GML code, which greatly speeds up the compiling of a game prior to running it, decreasing iteration times. It also helps to combat piracy of GameMaker games, as previously all game code was executed as ASCII text. 'You could just take the ASCII out of the final executable and regenerate the project, so there were lots of games getting ripped off that way,' Kay adds. This unified system could also potentially make it easier



Here, you can see the drag and drop system executing a GML script

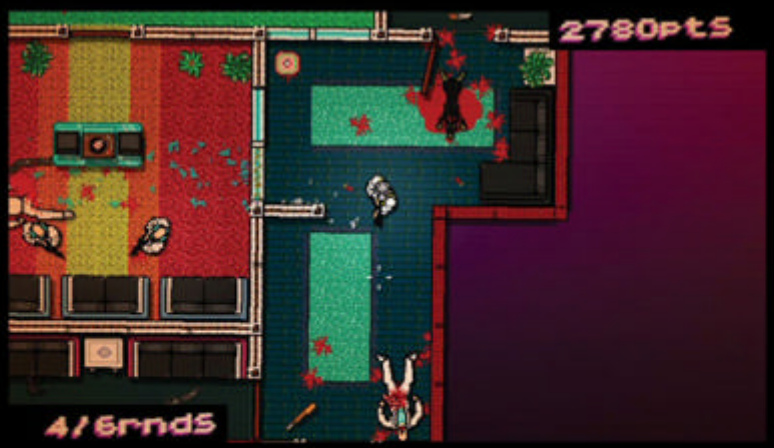
for developers to learn GML. Mike Dailly says there's a plan to allow developers to see the scripts behind the drag and drop functions 'as a kind of introduction to real scripting.'

This feature would form a useful addition to GameMaker's already developer-supportive scripting language. GML exhibits GameMaker's design ethos of making game development simple at almost every turn. Aside from the colour coding and error checking, clicking the middle-mouse button on any GameMaker function automatically brings up a page explaining what that command does, with examples of how to use it.

But what kinds of games can you actually *make* in GameMaker? It's designed to cater for 2D games, but Dailly says, 'The actual pipeline is a full 3D pipeline. It's got a full 3D matrix; triangles with full X, Y, Zs [the coordinates of a triangle] on them, but the Z is always the same kind of value. [Developers] can take their 2D game and split it apart and stick it on a cube if they want. It's all there.'

Gunpoint was Tom Francis' first game, and it was made with GameMaker

The main difference between a 2D and 3D engine is how objects are drawn. In a 3D graphics engine, the visual information is stored in a static buffer, from which the rendering pipeline calls to draw the graphics onto the screen. However, in 2D graphics, the image is so much simpler, so you just draw as much as possible in one go. 'In 2D, you're dynamically building these buffers all the time,' says Dailly, 'so your trick is to get as much into the single batch as you can. GameMaker's become very good at that.'



Hotline Miami is one of the most famous examples of a GameMaker game

Otherwise, GameMaker's engine can do much the same as any 3D engine. In 2013, for example, YoYoGames added programmable shaders to it, which opened up far greater possibilities for visual effects, as seen in the screenshots of the forthcoming game Orphan. 'You can put normal mapping onto your sprites, and do really nice lighting in 2D, plus reflections and water,' Dailly says. Most recently, YoYoGames added a 2D particle physics system called liquid fun, which allows for dynamic 2D water simulation.

GameMaker is a great introduction to game design, but there are flaws. The sprite painting tool particularly shows its age, for example, being devoid of important artistic components such as layers. The developers have their own personal gripes. Dailly describes GML's collision functions as 'terrible', and the sheer amount of work needed to bring the codebase up to date has also limited it. 'GameMaker had really good roots. It did some things really nicely, but fell down with limits that were placed on it because of some of the tech that had been used to actually create it,' Kay says.

Reprogramming remains YoYoGames' primary focus, and Dailly reckons it will be some time before the last vestiges of Delphi are completely removed. But other changes are on the horizon. There's a new sprite painting tool in the works, although Kay won't go into specifics. 'Let's just say that the version we're working on just now is very different,' he says. The team is also working on expanding GameMaker's toolset.

YoYoGames also wants broader compatibility. GameMaker games are already supported on 14 platforms and recently announced that, with Windows 10, GameMaker games will function across many Microsoft systems, including Windows desktops and tablets, and even the Xbox. 'Over the last few years we've been trying to raise the limits, so you could use GameMaker not just for doing your prototype but for actually releasing your full game,' Kay says. Judging by the immense growth in GameMaker's popularity, YoYoGames has succeeded. GPC

INDIECORNER

Fire! Horror! Betrayal! Annihilation! No, it isn't the 2015 election result, it's Rick Lane's roundup of the best indie games coming soon to a PC near you!

Firewatch

DEVELOPER Campo Santo / **RELEASE** 2015
WEBSITE www.firewatchgame.com

Firewatch is a first-person adventure that casts you as a tower lookout in Yellowstone park, charged with looking out for fires and other hazards. This lonely job is perfect for protagonist Henry, who seeks solitude after a tragic event in his past. His only contact is Delilah, his superior, who routinely sends him into the park on jobs. Yet a string of mysterious occurrences pull Henry out of his peaceful existence, forcing him to explore deeper into the park, and further into danger. Henry can interact with Delilah in various ways, affecting their relationship as the game progresses, and the story is responsive to your actions. In one of Henry's early forays, he encounters skinny-dippers swimming in a lake, and the game registers whether you're friendly, hostile or ignore them entirely, and adapts accordingly. It's also highly interactive in a broader sense, as Henry needs to navigate Yellowstone through a combination of hiking, climbing and spelunking.

The visual design is gorgeous, and the 20-minute demo at GDC suggests the game is well written and acted to boot. The script is penned by former lead writer's of Telltale's Walking Dead series, Sean Vanaman, so Firewatch has experience on its side. Let's hope Campo Santo sustains that level of quality over the game.

Adr1ft

DEVELOPER Three One Zero / **RELEASE** 2015
WEBSITE http://adr1ft.com

Adr1ft is a horror game without monsters, menace or supernatural elements. Strongly evoking Gravity (the film, not the force), Adr1ft sees you stranded in space after a space-station orbiting Earth was destroyed. Awaking with no memory of the accident, you must attempt to repair the station's emergency escape pod and travel safely back to Earth.

It's designed to be non-confrontational, so there are no aliens turning up to lay eggs in your chest, but it won't be an entirely sedate experience either. The player's oxygen tether only reaches so far, and exploring more distant parts of the station requires you to uncouple yourself from this oxygen supply and rely on canisters you encounter as you investigate. At the same time, oxygen provides your only method of propelling yourself through space, so there's an interesting balancing act between short and long-term survival.

The idea of setting an adventure game in an entirely 3D environment is an intriguing one, and developer Adam Orth is emphasising this setting by making the game Oculus Rift compatible. Orth claims to have conceived the game before Gravity was released, but either way, setting Adr1ft in a more realistic space environment will set it apart from the majority of sci-fi games.

Outer Wilds

DEVELOPER Alex Beachum / **RELEASE** Out now (Alpha)
WEBSITE http://outerwilds.com

You have 20 minutes to explore the solar system before the sun explodes. That's the oddly grim premise of cheerful space camping trip Outer Wilds, which emphasises learning, discovery and choice. The game begins on your home planet, where you must acquire the launch codes for your spaceship and then figure out how best to control it. It's then a case of choosing a point of interest in the sky and flying towards it with all haste.

What makes Outer Wilds interesting isn't so much how it functions as how it conceives its alien environment. There's no procedural generation; every part has been designed specifically for the player to discover. The solar system is seamlessly rendered. Each planet is a little ball of rock surrounded by a hazy atmosphere, and each hides a different secret. Some of them are home to alien ruins with esoteric murals that hint at the planet's dangers, while others sport entire continents that bob and splash in its vast, deep oceans.

The brief playtime makes it easy to dip into Outer Wilds, and with each play-through you learn a little more about the game or discover something new. An Alpha version is free to download on the website, while the developer is currently working on a larger, commercial version.

Sub Rosa

DEVELOPER Cryptic Sea / **RELEASE** 2015
WEBSITE www.crypticsea.com/subrosa

Sub Rosa might look blockier than a conveyor obstruction at a Lego factory, but the lo-fi visuals hide a fascinating concept. It's an open-world multiplayer game where players are employed by one of four companies, which then assign procedurally generated missions to their employees. The missions range from holding up buildings to acquiring rival companies' 'disks'. Acquisitions either involve exchanging cash for goods, or exchanging bullets for corpses before escaping with the loot.

Sub Rosa creates an environment of tense exchanges, double-crosses, standoffs and car chases. Both sides have an interest in remaining civil for mutual benefit, but it's also tempting to stitch the competition and take everything for yourself. Players must also arrange the time and location of the deals themselves, so there's always a possibility of walking into an ambush. The sides aren't always clearly defined either. A rival company might inspire your teammates to stab you in the back, or they might simply try to take all the profits for themselves.

Sub Rosa particularly was created as part of a 7-Day FPS game jam back in 2012, and has been gradually expanding its feature set ever since.

Hunger

DEVELOPER Tarsier Studios / **RELEASE** TBA
WEBSITE http://tarsier.se/ourwork/hunger

Hunger isn't the most Google-friendly title for a game set in a post-Hunger Games world, but Scroll through enough Jennifer Lawrence photos, and you'll eventually find this remarkable-looking platform-horror game by Swedish developer Tarsier Studios. Hunger's incredible visual style immediately grabs you. Combining dollhouse-style art with puppet-esque animations, Hunger sees a cute rainmac-wearing girl traversing a land of creepy giants.

It's a jumping platform game, which immediately sets off alarm bells, but it also appears to combine 2D and 3D exploration, which could be interesting. Tarsier has worked on LittleBigPlanet, and prior to that, it designed a game called City of Metronome – an eerie 3D action adventure set in a warped Victorian cityscape that sadly failed to find a publisher. Hunger is pitched as a spiritual successor to Metronome, and appears to blend Tarsier's experiences in developing both games.

There's little other information available about Hunger at this stage. Typical elements of the platform genre appear to be implemented in the game, including lots of climbing and physics-based puzzles. However, the trailer alone is a little work of art (**http://tinyurl.com/HungerTeaser**), so we're looking forward to seeing the game in its entirety. CPC

BUILD A COMPLETE 4K PC

Now that the kit required to build a complete 4K system has plummeted in price, Antony Leather takes you through building a complete 4K gaming rig, complete with monitor, for well under two grand

Unbelievably, in under two years, the price of 4K-capable kit has dropped like a brick from the top of the Eiffel Tower. Not only has the price of a 4K monitor nosedived from £2,999 (see Issue 12, p27) to well under £500, but even the required graphics equipment no longer costs the earth. In fact, thanks to Nvidia's Maxwell architecture, £562 will buy you the whole graphics subsystem, and it won't eat your power supply for lunch either.

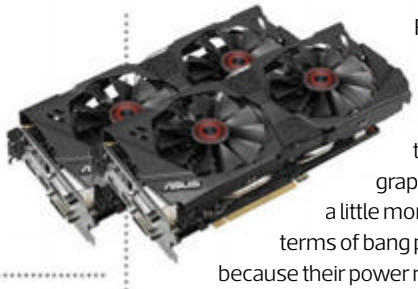
The result of all these plunging prices is that, with the right component choices, you can now build an all-singing, all-dancing, 4K gaming PC for well under £2,000, and the price even includes the monitor, SLI graphics and Windows 8.1. Over the next few pages, we'll show you exactly what you need, how to put it together, and how to fine-tune and overclock your new PC.

Hardware

GRAPHICS CARD

2 x Asus STRIX GTX 970 Direct CU II / **£281 (£562)**

SUPPLIER www.scan.co.uk



There are several graphical routes towards playable frame rates at 3,840 x 2,160, all with their pros and cons. The Nvidia route involves either doubling up graphics cards in SLI with GTX 970s or GTX 980s, or opting for a GTX 980 Ti (see p20) or Titan X. On the red team, you can achieve the same effect with two AMD Radeon R9 290 cards in CrossFire configuration, or use its R9 295X2. The latter is extremely power-hungry and hot-running, though, as are AMD's single-GPU models.

For this reason, we've leaned towards Nvidia, even though its graphics cards are a little more expensive terms of bang per buck, simply because their power requirements are significantly lower, which becomes a bigger deal when you're using multiple cards. A pair of GeForce GTX 970 cards offer enough performance to topple a GTX 980 Ti and even a Titan X in some games, while third-party coolers such as the Asus ones on these Strix GTX 970 Direct CU II cards, are incredibly quiet, even when gaming.

More importantly, they can handle even tough games such as Crysis 3 at maximum settings with room to spare.

PSU

SilverStone Strider Gold 850W / £110 inc VAT

SUPPLIER www.overclockers.couk

As Nvidia's latest Maxwell GPU architecture is so efficient, you can easily get away with using a sub-1,000W PSU, saving you money in addition to extra heat and noise. In fact, our 4K PC will consume less than 500W under full load, but you want a little more headroom above this level to achieve optimum efficiency. As such, we've chosen our Elite-listed SilverStone Strider Gold 850W as our power supply of choice. It's a fully modular PSU with than enough power to deal with our system, even with the CPU and graphics cards under full load.

MONITOR

Asus PB287Q / £420 inc VAT

SUPPLIER www.dabs.com

To display all those high-resolution visuals, we've chosen Asus' PB287Q – a 28in monitor that actually uses a TN panel, rather than IPS. However, as Asus has opted for a 10-bit panel, it's vastly superior to a run-of-the-mill TN screen, with much more vibrant colours. It will serve you well in games too, thanks to a grey-to-grey response time of 1ms. There are, of course, more desirable screens available, and Asus itself currently offers a slightly smaller monitor – the PB279Q, which uses an IPS panel – for around £180 more. However, the PB287Q is fine for our gaming needs, and it can dish out a 4K image at 60Hz too.

CPU

Intel Core i5-4690K / £180 inc VAT

SUPPLIER www.ebuyer.com

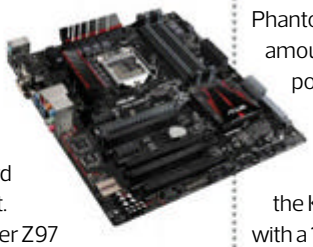
For a pure gaming system, there's little point in opting for a CPU that features more than four cores, or Hyper-Threading, as gaming performance is more dependent on clock frequency anyway. As such, Intel's overclocking-friendly Core i5-4690K is the ideal CPU for the job, costing less than £200, while still providing plenty of grunt for other tasks such as photo and video editing.

MOTHERBOARD

Asus Z97 Pro Gamer / £108 inc VAT

SUPPLIER www.overclockers.co.uk

Handling a solid Intel CPU overclock and providing enough bandwidth for two graphics cards in SLI requires a motherboard with Intel's Z97 chipset. However, some cheaper Z97 motherboards don't support SLI. More importantly, some boards also lack the ability to offer an 8x/8x PCI-E lane configuration with two graphics cards installed. For example, many boards drop the second 16x PCI-E slot to 4x speed, which could have an impact on the performance for high-end GPUs. As such, we opted for Asus' Z97 Pro Gamer, which costs just £108 inc VAT, supports SLI and provides two-way setups with eight PCI-E lanes apiece.



MEMORY

16GB Corsair Vengeance Pro 2,400MHz Red / £94 inc VAT

SUPPLIER www.scan.co.uk

If you're keen to save money then you could opt for an 8GB memory kit – games won't require any more than 8GB at the moment anyway. However, as you can now buy a decent 2,400MHz memory kit for under £100, we decided to go for a bit of future-proofing by installing 16GB (2 x 8GB for dual-channel bandwidth) of Corsair's 2,400MHz Vengeance Pro Red memory.

CPU COOLER

NZXT Kraken X41 / £70 inc VAT

SUPPLIER www.overclockers.co.uk

CASE

NZXT Phantom 530 / £85 inc VAT

SUPPLIER www.overclockers.co.uk

We've selected our current Elite-listed case and CPU cooler to house and cool our 4K system – NZXT's fabulous Phantom 530 case and its Kraken X41 all-in-one liquid cooler. The Phantom offers a huge amount of expansion potential, plus its large 200mm front intake fan provides a generous flow of cool air to our duo of GTX 970s. Meanwhile, the Kraken X41 is a powerful CPU cooler with a 140mm fan and, combined with NZXT's excellent CAM software and the Phantom 530's built-in fan control, you'll be able to fine-tune your system to keep it cool and quiet at the same time.

SSD

500GB Crucial BX100 / £142 inc VAT

SUPPLIER www.ebuyer.com

For a pure gaming system, a 500GB SSD offers enough space to run Windows and store dozens of games and programs too. Our SSD choice comes down to Crucial's BX10,0 and the half-terabyte version weighs in at £142. The NZXT Phantom has plenty of space for additional SSDs and hard disks if you need more storage space though.

OPERATING SYSTEM

Windows 8.1 Pro 64-bit / £115 inc VAT

SUPPLIER www.scan.co.uk

The final piece of the puzzle is your operating system. Windows 8's interface divides opinion, but the latest 8.1 version is by far the best current PC operating system for handling 4k resolutions, not least because it has the ability to scale up Windows features, such as desktop text and icons, well beyond Windows 7's 150 per cent limit. Unlike Windows 7 Home Premium, Windows 8.1 Pro can also address more than a total 16GB of memory.

Building the PC

Before you install the hardware in the case, make sure the foundation of your system works. Lay the motherboard on its box, insert the CPU, connect the cooler, one of the graphics cards, the memory and PSU connectors, and use a screwdriver to short the power button pins on the motherboard to switch on the PC. Connect the PC to your monitor and you should be presented with the POST screen. Run the test with the second graphics card to make sure it works too, then you can install the hardware. Refer to our PC building masterclass (see Issue 139, p90) if you need more information about the basics and theory of PC building. 01

It's easiest to install the Kraken X41 by mounting the pump to the motherboard first, securing the motherboard to the case, then installing the radiator. It has thermal paste pre-applied, so you don't have to apply your own. We've mounted the radiator to the rear of the case where the stock exhaust fan was located. You'll need to remove the latter, but don't be tempted to use it with the Kraken – it only has a 3-pin fan header, while the Kraken's fan is 4-pin, allowing it to be controlled by the cooler's software. However, we can use that fan elsewhere. 02

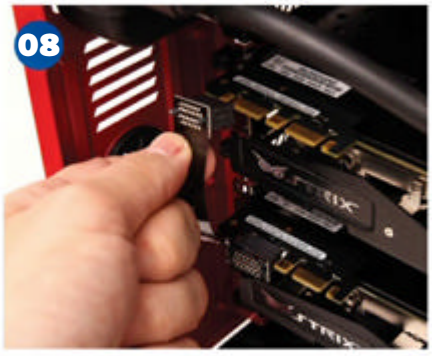
Once the radiator is installed, secure the 140mm fan that came with it to the radiator using the included screws. The fan mounts on the Phantom 530 have runners, enabling you to slide the radiator up and down if necessary to fit. 03

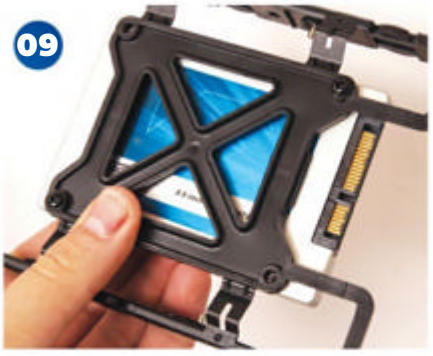
As our PSU is fully modular, you can start routing cables through the case early in the build process. One trick with the EPS 12V connector cable is to pass it from the PSU bay, around the back of the motherboard tray and over the top to where the connector on the motherboard is waiting. SilverStone includes an extra-long EPS 12V connector with the Strider Gold 850W for this purpose, so use that cable, rather than the short one.

You can also pass the Kraken's radiator fan cable through this hole to meet the power cable from the pump, and hide them all from sight. 04

You can now install your graphics cards. If you're using a different motherboard from ours, check its manual to find the correct slots for a two-way setup. The Asus Z97 Pro Gamer has a 1x PCI-E slot and a PCI slot in between its two primary PCI-E graphics slots, allowing plenty of airflow room for two dual-slot graphics cards. 05

Our PSU is fully modular, so it doesn't need to be installed until all the other hardware is in place. Route all the power cables through the





case's cable-routing holes and connect them to the PSU, omitting any unused cables.

As we only require single SATA and Molex connectors for the SSD and fan controller, the ATX and EPS12V motherboard power cables, and the graphics card PCI-E cables, you can leave the rest of the wires in your PSU's box. 06 07

With your graphics cards installed, you can go ahead and install the SLI ribbon connector. This part will come with the motherboard and is required to link the graphics cards for SLI to be enabled. 08

Our lone SSD has several mounting options. We wanted it to be on view in the motherboard compartment, but there's also a 2.5in mount behind the motherboard tray. You can fix the SSD or a hard disk to one of the drive mounts. Mount the SSD with the ports facing the rear so you can easily tidy away its cables. 09 10

The Phantom 530 includes a fan hub that's linked to the case's fan controller. Make sure the front fan and all the other fans are attached to this hub, except the radiator fan, which needs to be wired up to the pump. We've set the fan controller to its lowest setting. 11

As you removed the rear exhaust fan to fit the Kraken cooler, you can now relocate it. The best place is in the roof, acting as a further exhaust fan. You just need a small, flat-blade screwdriver to pop off the roof section. which reveals the top fan mounts where you can install the fan. Route its cable over the motherboard tray and around the back to the fan hub. 12 13

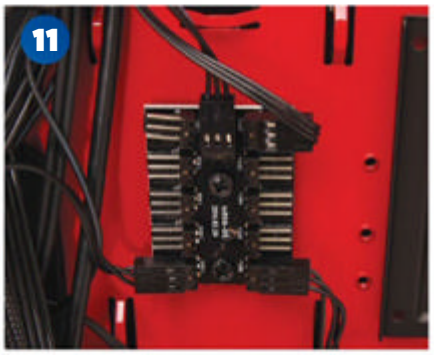
You can now finish routing cables around the case. We found that placing the two 8-pin connector cables from the graphics cards between the cards neatly channelled them out of sight. Just make sure the lower card's cable doesn't interfere with the upper card's fans. 14 Use small cable ties to anchor loose cables to the case, or take up their slack at the rear of the case.

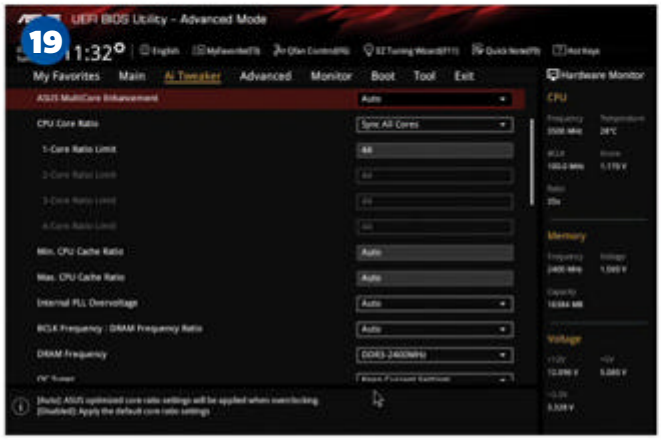
With all the cables tucked out of sight and anchored down, you can connect the remaining ones to the PSU. Avoid tucking any cables in the base of the case, as there are lots of vents – there's plenty of space behind the motherboard tray for this job. 15

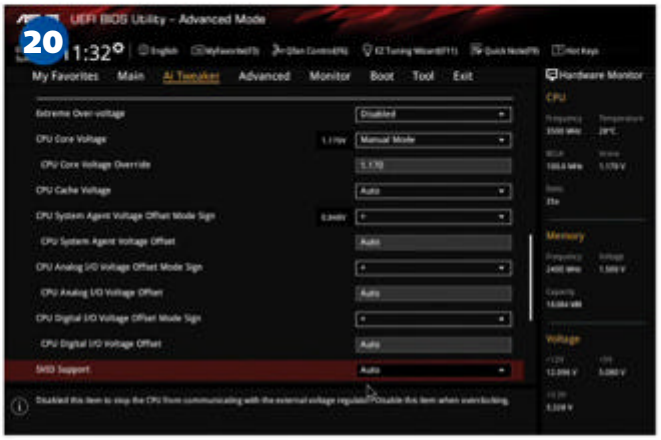
The Phantom 530 has several removable drive mounts at the front, most of which are redundant if you're only using a single SSD or hard disk. Remove these mounts to improve airflow, as they block the front 200mm fan. We've kept one to house our SSD, but you can get rid of all of them if you decide to mount the SSD at the rear of the case. 16

The last job is to tie down the remaining cables at the rear of the case. The Phantom 530 includes a wealth of anchor points behind the motherboard tray. Cable tidying isn't fun, but it's pretty easy with this equipment, and we tied this neat bundle in less than ten minutes. 17 18

You're now free to power on your PC and, hopefully, it will fire up first time. We haven't







included an optical drive with our system, as it's easy to install Windows from a USB stick by creating an install using Wintoflash (**https://wintoflash.com**). You can use a another PC equipped with an optical drive to create your USB Windows installation stick, which will install Windows much faster than an optical drive too. However, the Phantom 530 does have room for an optical drive if you want one – it will add an extra £10 to the total system cost.

Overclocking and tuning

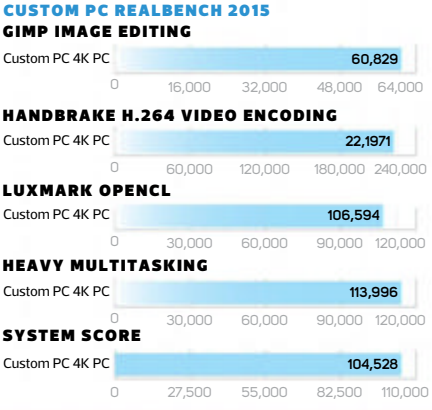
We overclocked our Core i5-4690K to 4.4GHz, which can be achieved by heading into the EFI and, on Asus motherboards, finding the AI Tweaker section 19. In this section, you'll get access to the CPU core ratio (multiplier), plus the memory speed and CPU voltage. We manually set the CPU ratio to 44x, to give us a clock speed of 4.4GHz, and set the memory to the correct speed of 2,400MHz too. All CPUs are different, so you'll need to fine-tune the voltage. Start with a voltage of 1.2V and work your way back 20. 1.17V should work with most Core i5-4690Ks at 4.4GHz, but you may find that more or less voltage results in a stable overclock, depending on your chip.

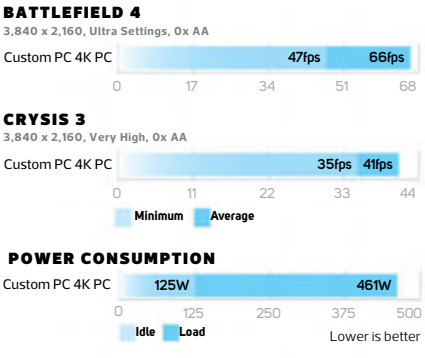
With Windows installed, download and install Prime95 (**www.mersenne.org/download**), Unigine Valley (**https://unigine.com**), GPU-Z (**www.techpowerup.com/gpuz**), CPU-Z (**www.cpuid.com**) and Core Temp (**www.alcpu.com**) 21. Test that your overclock is stable using Prime95's smallfft test and using Core Temp to check the temperatures – all of the cores' temperatures should be lower than 90°C.

Next, run Valley and load GPU-Z to check your graphics cards' temperatures. If your CPU is running quite hot, increase the fan profile using NZXT's CAM software 22. We found that the whisper-quiet Silent mode was still cool enough keep our CPU below 90°C under full load in Prime95. **CPC**

Performance

Our 4K PC's 461w power consumption barely taxed our 850W PSU – with Prime95 and Unigine Valley running concurrently. Meanwhile, our GPUs hit 71°C under load (a delta T of 50°C), while the CPU sat at 88°C, (a delta T of 67°C). These temperatures are quite warm, but still within the chips' thermal limits. The game results also speak for themselves. Our highly demanding Crysis 3 test, with Very High settings, never dropped below 35fps at 4K. Even better, Battlefield on Ultra settings never dropped below 47fps.





VENOM

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MOD SCENE MAYHEM

Earlier this year, Valve introduced paid mods to its Steam Workshop pages, but it was removed a few days later after a massive online backlash. Rick Lane investigates the fallout

On 23 April, a new feature was launched on Steam that allowed modders – amateur creators of modifications for various games – to charge real money for their work. Starting with Bethesda's Nordic RPG Skyrim, the plan was to gradually roll out this scheme across a range of games with extensive modding communities, in cooperation with the developers of those games.

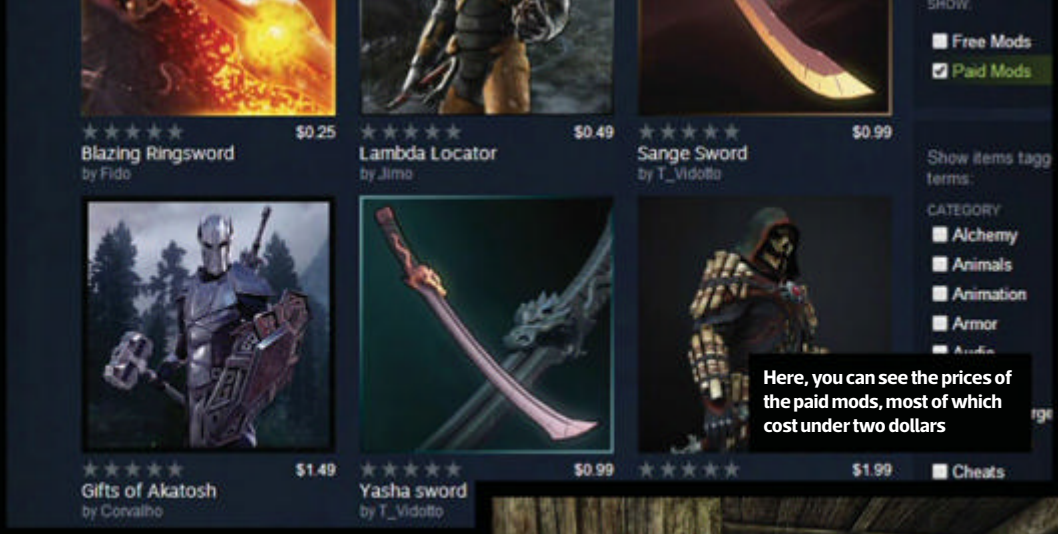
Only four days after paid mods were implemented, however, the program was abandoned, after an incendiary backlash from Steam users, Skyrim players and the online community in general.

The abrupt succession of announcement, backlash and withdrawal of the paid mods scheme has left the modding community reeling. The debate over whether mods are free by their nature, or whether modders deserve compensation for their work, has revealed striking divides in the community that weren't visible previously. Meanwhile, the explosive and, in many instances, toxic nature of the backlash has left many modders, especially Skyrim modders, embittered toward the communities of which they have been a part for so long. Some have even decided to abandon modding entirely.

Elder Scrolls real estate

For Valve, the paid modding fiasco has proved a rare error in its business judgment, but for the modding community it's been disastrous. 'Things have changed,' says modder Sherri-Lyn. 'Things that should never have been said have been said, and there's no going back.'

Better known by her online alias Shezrie, Sherri-Lyn is one of the most



Here, you can see the prices of the paid mods, most of which cost under two dollars

experienced modders in the Skyrim community. She began modding shortly after the release of The Elder Scrolls III: Morrowind, back in 2002, after searching online for a 'house' mod to add into the game.

'I went through quite a few house mods that I downloaded but couldn't find anything that suited,' she explains. 'So I finally opened that daunting Construction Set that came with Morrowind, and started to disassemble a house mod so that I could figure out how it was put together.'

This curiosity gradually became an obsession with modding that's lasted over a decade. In that time, Sherri-Lyn has created over 50 mods, all for the last three Elder Scrolls games – Morrowind, Oblivion and Skyrim. Most of her work focuses on adding houses, housing extensions and towns to the game. Her largest mod, which expands the sleepy Oblivion hamlet Pells Gate into a bustling town, was the result of three years of work, and added extensive dialogue and entire quest lines.

When Oblivion was at its most popular, Sherri-Lyn even ran her own modding community – the Oblivion Real Estate website – dedicated to showcasing the best user-created houses, villages and towns for the game. 'We had a forum where the house modders could all hang out together and share our love for making house and town mods. We were a very close-knit community and had a lot of fun over the seven years we were going. We also had some serious modding talent among our members and turned out some brilliant new modding talent over the years.'

In all that time, through all that work, Sherri-Lyn hasn't charged a single penny for any of her mods.

Shezrie's underground Bleakden town for Skyrim contains no loading screens between buildings

When asked if she's thought about becoming a professional developer, she immediately says no. 'In the game development profession, you create what you're told to create,' she explains. 'Sure, you have a certain amount of creative freedom, but I need total creative freedom to really let my imagination loose and enjoy what I'm doing.'

Making money from mods is difficult for several reasons. Unlike games, mods are always related in some way to another developer's work, which comes with obvious copyright issues. Furthermore, mods can range enormously in their quantity and quality. Some mods are a simple tweak of a game's code to make the graphics better or alter the game's behaviour, while others are huge, total conversions. Essentially games in their own right, these massive projects often only share the toolsets and code in common with their parent game.

Sherri-Lyn's mods land somewhere in the middle of this scale, being substantial creations that involve considerable work, but they exist and function within Bethesda's fantasy worlds. A few mods, such as Counter-Strike and the hardcore WW II shooter Red Orchestra, have been upgraded into full-priced games. But until recently, it was difficult to see how mods, such as Sherri-Lyn's Bleakden Town or Old Hroldan, could be anything but freely distributed.

Then one day, Sherri-Lyn logged into her Bethesda forum account to find a message from Bethesda inviting her to join a private Steam group. 'It all sounded intriguing and exciting, so I agreed. Then things were explained more fully via email; that it was about allowing content creators to create content and set it for sale.' The announcement took Sherri-Lyn completely by surprise. 'I was in a bit of shock for at least a few days.'

The specifics of the arrangement are important to note. Sherri emphasises that Valve clearly stated modders could only sell updated versions of mods, while existing mods would remain freely available. 'The concern from the public about free mods disappearing and then reappearing as items for sale was completely unnecessary. It was never going to happen,' she says.

Furthermore, the modders would receive a 25 per cent revenue share of every mod sale, while the rest of the money was divided between Valve and Bethesda. Sherri-Lyn admits that initially she wasn't happy with the percentage, but accepted it after considering Valve's role in providing the distribution platform, and Bethesda's providence of both the base game and the Creation Kit, which Elder Scrolls modders use to create their work. 'But I really think that if Bethesda did increase the percentage given to modders, it would make a larger profit in the long run, as more modders would have a greater incentive, and users would feel they're getting value for money and feel better about buying,' she adds.

When the time came for the grand unveiling, Valve decided to announce the scheme at the same time as implementing it, rather than leaving a gap between announcement and launch. There's a question over whether the surprise nature of the launch increased the severity of the backlash, but Sherri-Lyn doesn't believe so. 'People weren't as

Above left: Tripwire Interactive's Red Orchestra is one of a small number of mods that have been turned into fully-fledged games

Above right: Counter Strike is the original mod-turned-pro

blindsided as is often claimed. The owner of Nexus [the premiere Skyrim mod community outside of Steam] had written a blog post on his site about paid mods and the likelihood of them coming, weeks before we went public.'

Before we delve into the consequences of the launch, it's worth noting that Skyrim modders didn't leap on the opportunity like wolves on a fresh kill, exploiting the system for every penny possible. Shortly after the announcement, one of the biggest mods on the scene made a statement explaining how it would remain free.

A free total conversion

Enderal is an upcoming total conversion for Skyrim, and 'total' is most definitely the operative word. A completely separate fantasy RPG, Enderal features a huge new world with its own lore and storyline, full voice acting, overhauled gameplay, a new class system and homebrewed survival mechanics. The German development team behind it, SureAI, is even including complete English localisation.

'It's hard to list everything we've improved and changed, because it's a lot,' says Nicolas Lietzau, creative director on Enderal. This isn't the first massive Elder Scrolls conversion SureAI has created either. The developer's last project, Nehrim: At Fate's Edge, was a total conversion for Oblivion, the product of 25,000 working hours. Enderal currently stands at approximately 22,500 working hours, with some way yet to go. 'I think the nuts and bolts of pulling through a grand-scale project such as Enderal is a certain mindset. It's important to feel a certain responsibility and not just see the project as being a pure fun task, simply because it's non-commercial,' says Lietzau.

Enderal is the product of several dedicated team members and a large body of volunteer designers, artists, voice actors and so on. SureAI is more organised than most modding teams of this scale. Lietzau explains that the team uses management practices and schedules similar to those of commercial game developers. But Sure AI's mindset is shared by all dedicated modders, as are its obstacles, the main one being a lack of funding. 'There's no budget available, which often leads to unavoidable, personal outfalls and deadlines not being met. It's important to keep everyone intrinsically motivated,' he says.

All of this makes SureAI's decision to keep Enderal free more intriguing. Lietzau offers two reasons behind this choice. Firstly, charging for Enderal would make it a commercial project, and consequently, SureAI would have to pay all its volunteers for their work, and purchase commercial licences for their software. 'All of it would have summed up to a six-digit number,' claims Lietzau. 'Even if Enderal would have sold well, it would have been unlikely that we could cover the incidental expenses.'

Lietzau's second reason is much simpler: 'We promised that Enderal would be released for free, and we wanted to stick to that promise.' That said, SureAI isn't against the notion of modders being paid for their work. 'People often underestimate how much time modders put into their projects,' says Lietzau. 'It might be worthwhile thinking about some kind of "quality assurance", which ensures that only projects of a certain quality can be put up for sale.'

Such measures could work. Valve's extremely hands-off approach when it comes to managing its own storefront is arguably one of its failings. Vetting such a vast number of games and mods might be a substantial task, but Valve almost certainly has the resources to do it. Even so, it's unlikely that such a quality assurance system would have helped to soothe the Internet's fury at the time of the scheme's launch.

SureAI doesn't do mods by halves

The reactor explodes

The reaction to the paid mods scheme was explosive; within a couple of days, 133,000 people had signed a petition protesting it. A controversy involving Chesko's fishing mod, which was pulled from sale, as it was using animations by another modder who was against the idea of paid mods, further fuelled

The desert locales demonstrate how much SureAI has changed in Enderal

the flames. The Skyrim Steam Workshop page was flooded with 'protest' mods – hastily constructed rubbish with absurdly high prices. And those modders who were part of the launch program, such as Sherri-Lyn, were subjected to a tsunami of online abuse.

'There were literally hundreds of absolutely foul comments,' Sherri says. 'Some as simple as "Go kill yourself, you sell out" to "I will track you down, make you watch while I kill your family, and then kill you and rape your corpse bitch".' In addition, Sherri-Lyn was sent images of rude gestures and male genitalia, and her mods were torn apart in dozens of vindictive reviews. Worst of all, she says, were the online campaigns to steal and pirate the updated versions of the mods she had put up for sale.

'The community advocating the piracy of our work is the hardest thing for me to forgive or forget,' she says. 'We have always rallied against piracy and fought on behalf of our modders, as a community. To see this endorsement of the theft of our mods, and to see the majority of the community encourage and support others stealing our work, was devastating.'

Four days after the launch of the paid mods scheme, Valve pulled paid mods from Steam Workshop. Sherri-Lyn explains that there wasn't much discussion between the modders, Valve and Bethesda. '[Valve] said it had its reasons, and after all, it's a business, and must make decisions as a business.' At her lowest ebb, Sherri-Lyn pulled all her mods from Steam Workshop and Nexus, and cut off all possible communication between herself and the modding community. 'I felt sick to my stomach at the thought of giving more of my work to people that wished me dead, among other things, and decided that the only option was to leave.'

Sherri-Lyn was far from the only person affected by the fallout. Other modders, including Chesko, have also departed the community as a consequence of harassment, while many more felt betrayed by Valve and Bethesda for caving in so quickly to an angry Internet mob. Although not directly involved, SureAI was equally shocked by the severity of the response. 'Honestly, we found some of the reactions seriously alarming and, even though they weren't directed at us, insulting.'

Not everyone reacted to Valve's U-turn with despair, though. One of the more ambitious ideas to emerge from the debacle is Project Ascension, intended as an open source game launcher 'to promote diversity in the gaming market'.

'Currently, there isn't a non-associated launcher and distribution service,' says project lead TheDarocker, who gives his first name as Dave. 'Steam obviously only works with the Steam Storefront, uPlay with its own and so on. [Ascension] is really trying to get the best deal for consumers with minimal effort on their part.'

This mod, called Give Me Money For No Reason, is a typical example of the protest mods uploaded after the launch of the paid mods scheme

Ascension isn't setting itself up as a competitor or alternative to Steam. Rather, it intends to integrate harmoniously with existing storefronts, acting as a shell to incorporate them all so users can see all the options available to them in a single glance. This setup, the developers hope, will include modding websites and communities. 'We'll be attempting to integrate with popular modding sites, some of which do have this feature, to handle modding,' Dave says.

Ultimately, Ascension plans to help to provide an opportunity for modders to charge for their work if they wish, but such a system involves navigating a host of legal issues first. 'Paid mods do have some legal ramifications,' says Dave, 'especially when you charge for them without the consent of the original game developer.'

Ascension currently has a 17-person team, and work is apparently underway, but it's still very early days. Right now, however, the viability of Ascension is less important than how it demonstrates the effect of the paid mods debacle. The genie might be back in the bottle for the moment, but Valve has shown that charging for mods is a possibility, and the subject will almost certainly rear its head again in the future.

Despite her recent traumatic experience, Sherri-Lyn proclaims that she will never give up on modding. Indeed, after withdrawing her work from availability, she started receiving messages of support rather than abuse.

'To be honest, I realise now that I was more than happy to be convinced and given a reason to stay, as quite frankly, I didn't want to leave – I just felt that I had no other option,' she says. 'Since then, I've been re-uploading my mods so that users aren't inconvenienced anymore. I will not stop modding.' CPC

GARETH HALFACREE'S

Hobby tech

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

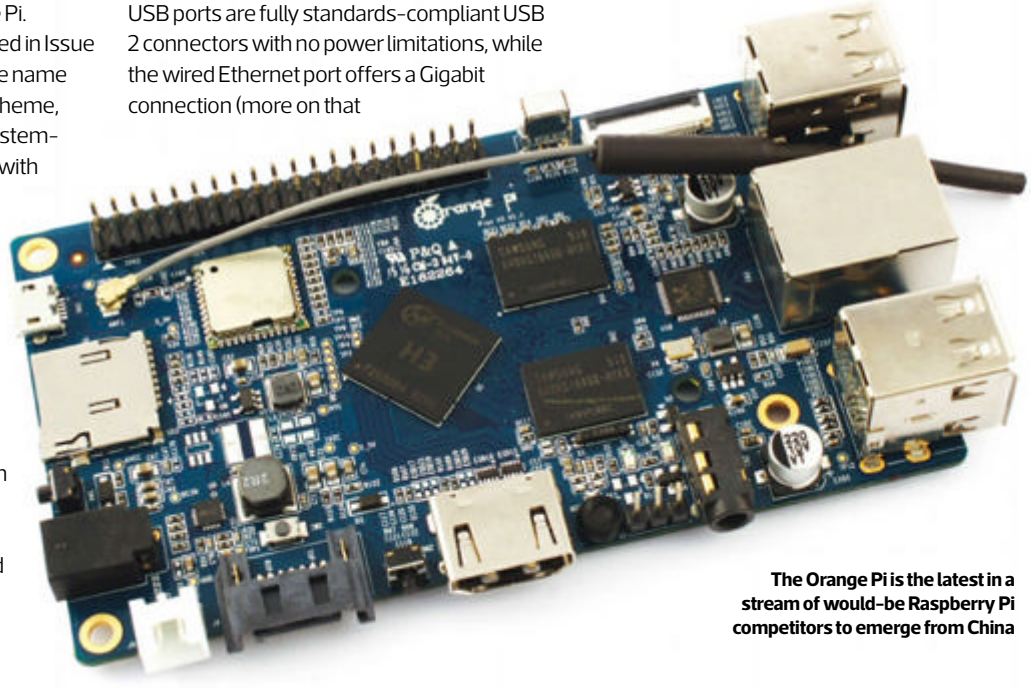
REVIEW
Orange Pi

The unparalleled success of the Raspberry Pi has created a sea of competitors, many of which have appeared on the market from the industrious technologists of China. The latest of these companies is Shenzhen Xunlong Software, which has created what it claims is an 'open source' Raspberry Pi-like single-board computer (SBC) dubbed the Orange Pi.

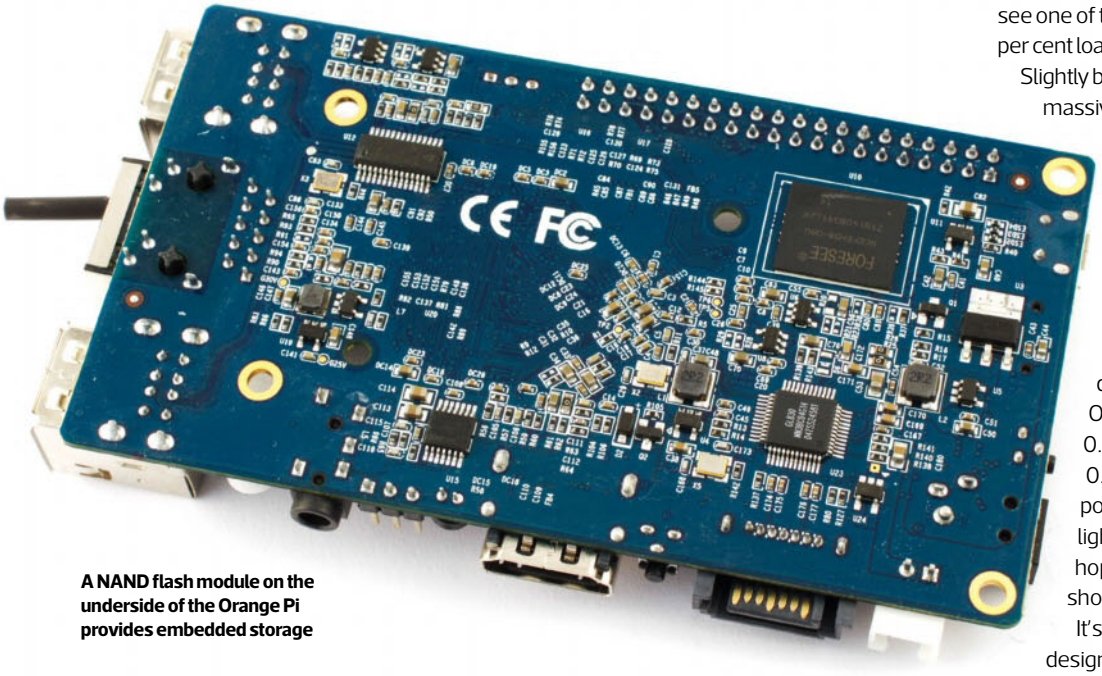
Like Lemaker's Banana Pi, reviewed in Issue 134, the Orange Pi is exactly what the name suggests: a riff on the Raspberry Pi theme, but using a more readily available system-on-chip (SoC) processor compared with the restricted-supply Broadcom BCM2835/2836. That SoC, in this instance, is the H3, a quad-core 1.6GHz Cortex-A7 part featuring an integrated Mali-400MP2 graphics processor and a shared 1GB of DDR3 memory.

Like most low-cost Chinese SBCs, the Orange Pi attempts to differentiate itself from its inspiration through the inclusion of additional features: 8GB of on-board eMMC flash storage is included as standard on the model reviewed, as is a SATA 2.0 port – complete with 5V power supply pins – for storage beyond the micro-SD card slot. Meanwhile, a Realtek RTL8189ETV offers integrated 802.11b/g/n Wi-Fi support through a bundled dipole antenna, and there's even an on-board microphone and an infrared receiver.

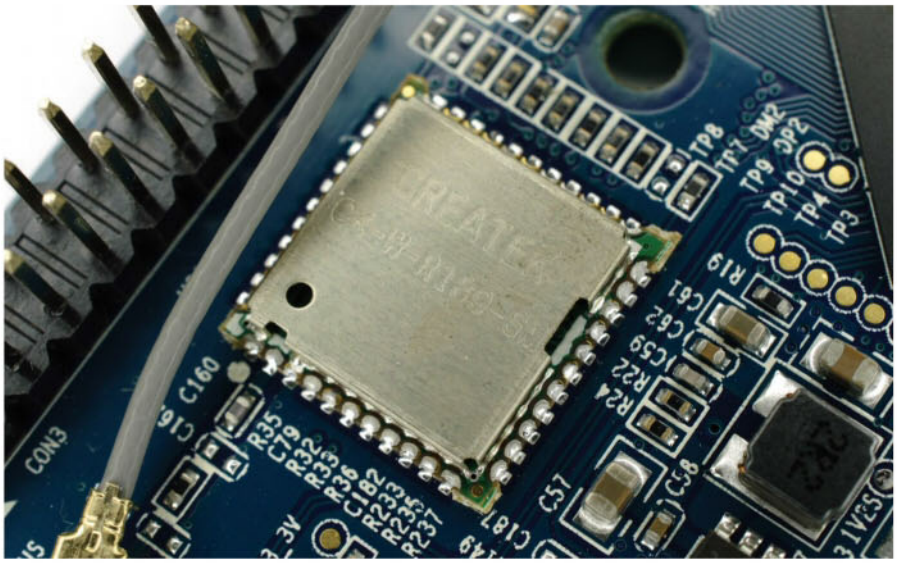
The features it does share with the Raspberry Pi are typically tweaked: the four USB ports are fully standards-compliant USB 2 connectors with no power limitations, while the wired Ethernet port offers a Gigabit connection (more on that later), and a power switch too. A 40-pin header replicates the pin-out of the Raspberry Pi's GPIO, and using Raspbian – one of the available operating systems, along with Lubuntu, Debian and Android – it's possible to use Raspberry Pi and Pi+ accessories, albeit with some mounting difficulties thanks to the board's different shape.



The Orange Pi is the latest in a stream of would-be Raspberry Pi competitors to emerge from China



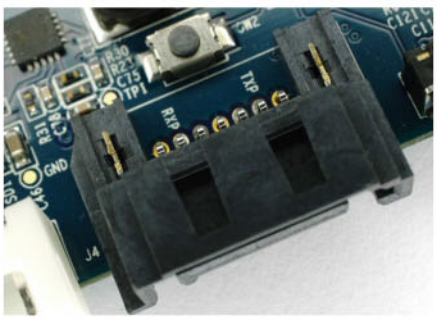
A NAND flash module on the underside of the Orange Pi provides embedded storage



An embedded 802.11b/g/n Wi-Fi radio with bundled whip antenna helps the Orange Pi to stand out

Initially, the Orange Pi looked promising; booting from Raspbian installed to a 64GB micro-SD card (not supplied), I ran a SysBench CPU test that showed the AllWinner H3 outperforming the already impressive Broadcom BCM2836 of the Raspberry Pi 2 – a total execution time of 72.76 seconds beat the Pi 2's 74.48 seconds, as did its single-threaded 95th percentile time of 22.27ms compared to 29.65ms. For CPU-laden tasks, the Orange PI is ahead.

Network performance too, was a great improvement over that of the Raspberry Pi 2. Connected to a Gigabit network through the on-board RJ45 port and transferring an uncompressible file via netcat, the Orange Pi managed a throughput of 677.2Mb/sec – below what you would expect from a true Gigabit connection, but far in excess of the 89.72Mb/sec the Pi 2's 10/100 port can manage. The bandwidth limit appears, as in many cheap SBC designs, to be a hard limit; the network port is heavily CPU-limited, and during data transfer, you can expect to see one of the four cores sitting at around 70 per cent load.



A SATA port is a welcome addition

Slightly boosted CPU performance and a massive improvement in network throughput look good for using the Orange Pi as a network server, but there's one area in which the design doesn't improve over its inspiration: power draw. Where the Raspberry Pi 2 draws around 0.37A under CPU-only load, dropping to 0.19A at idle, the Orange Pi recorded a far higher 0.65A under CPU-only load and 0.44A at idle. Sure, for mains-powered applications it's a lightweight device – but anyone hoping to run it on battery power should take note.

It's clear that the Orange Pi is designed for home theatre use, where it works well. HDMI CEC is supported, while the infrared receiver can – with a little fiddling and hacking – be used for remote controls if your HDMI display doesn't pass CEC data back down the line. Running Android, video is accelerated and smooth while the wireless connection makes it easy to install in areas where wired networking isn't available. Unlike the Raspberry Pi, though, there's no Kodi (XBMC) image available.

One major selling point of the Orange Pi over the Raspberry Pi is its claim to be open source and, sure enough, free membership of the official website at **www.orangepi.org** allows you to download schematics and mechanical drawings that would, in theory, allow you to produce your own ones. Source code is also provided for certain AllWinner-themed portions of the firmware.

As with many Chinese Pi-alikes, getting your hands on an Orange Pi is – at present – a question of importing. The Orange Pi Plus, as reviewed, is available from **www.aliexpress.com** for £33.84, while the Orange Pi Mini 2 – lacking SATA – costs just £19.56. Both prices exclude VAT, but in both cases you may be charged VAT and a handling fee upon receipt.

The quad-core AllWinner H3 is surprisingly capable, bettering the Raspberry Pi 2 for performance

TUTORIAL

Building the Kim Uno

The MOS Technologies KIM-1 launched in 1976 as an engineer-friendly, build-your-own-microcomputer kit designed by Chuck Peddle to showcase the MOS 6502 microprocessor. It cost $245 at launch, plus the cost of a power supply and optional accessories. Its name, short for Keyboard Input Monitor, reveals that it was never designed to be a serious computer, but its popularity grew when the beginner-unfriendly machine code language was replaced with Tiny BASIC, enabling higher-level programming when connected to a cheap terminal system or teletype.

The KIM-1 made enough of a splash that MOS Technologies ended up being bought out by Commodore International, directly leading to the Commodore PET and the Commodore 64 – the latter being one of the biggest-selling computers the world had ever seen.

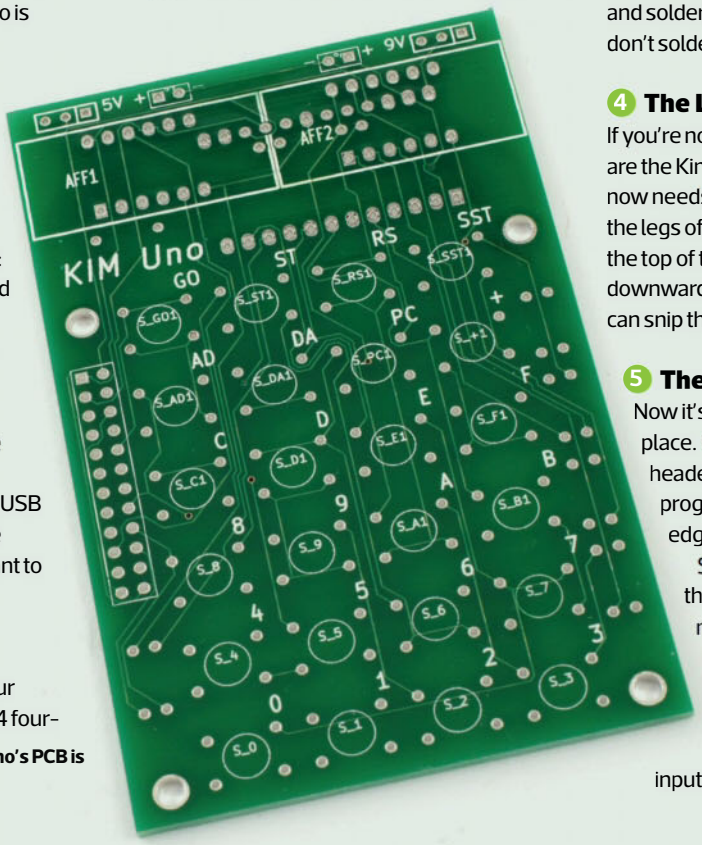
Why the history lesson? Because this month I've been playing with a modern equivalent: the Kim Uno. Designed by Oscar Vermeulen, the Kim Uno is an open-hardware recreation of the KIM-1 using an Arduino Pro Mini microcontroller, cunningly hidden around the back. Taking up less space than the keypad of the original, the Kim Uno is nevertheless capable of running software written for the 6502 – including Peter Jennings' Microchess, written in 1976 and offering a full game of chess in just 924 bytes of code.

The Kim Uno isn't just smaller than the original, it's also cheaper: $245 has become $26.50 (around £17) including shipping to the UK. However, just as with the original, you'll have to provide your own power supply. There's also no need for a dedicated terminal: the Arduino's serial port can be connected to a PC through a TTL-USB adaptor, although you can use the front-facing buttons if you just want to play around in machine-code.

The original MOS KIM-1's price was affordable at the time, but the price of its Arduino-based recreation's leaves it in the dust

1 The buttons

Check you have all the parts in your package, and then inserting the 24 four-legged tactile switches into the front part of the calculator-like PCB. These switches have a tendency to go in skewiff, so care is needed, along with a fine-nosed set of pliers to correct any errant legs. When they're all inserted, flip over the board and take care of the 96 solder joints on the back with your soldering iron.



With its very simple layout, the Kim Uno's PCB is a great soldering kit for beginners

2 The resistors

The circuit design of the Kim Uno is very simple and, in dramatic contrast to the Sinclair ZX81 kit I built back in Issue 109, there are only 11 resistors in total, of two values. The eight 1K Ohm resistors protect the LED segments that constitute the Kim Uno's display; the three 2K Ohm resistors provide current limiting for the keypad scanning process. Bend each leg over your thumbnail, stick them through the rear of the board and solder them into place.

3 The pin headers

This is probably the second trickiest part of the build, and it's still pretty easy. These headers provide the connection for the Arduino Pro Mini board at the rear. Measure them against the marked outline and snap them to length, then add an additional two pins at the top and a potential second pair to the side of these. If you're unsure, compare the holes with your Arduino; not all models need the second set (mine didn't). Use the Arduino to hold the pins steady, flip the board and solder the pin headers into place, but don't solder the Arduino to the headers yet.

4 The LEDs

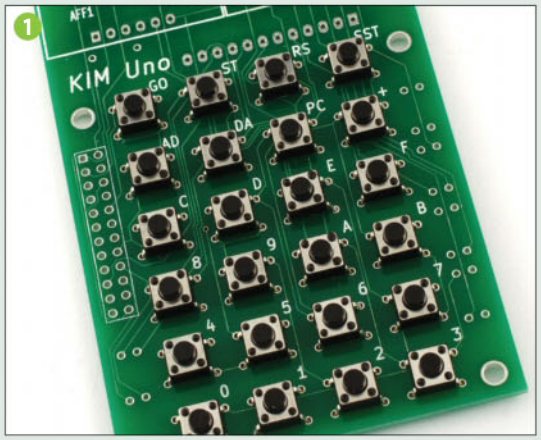
If you're not using the serial console, the LEDs are the Kim Uno's only output. The Arduino now needs to be removed so you can get to the legs of the LED segments. Stick them in the top of the board, with the dots pointing downwards and solder them into place. You can snip the legs short when you're done.

5 The Arduino

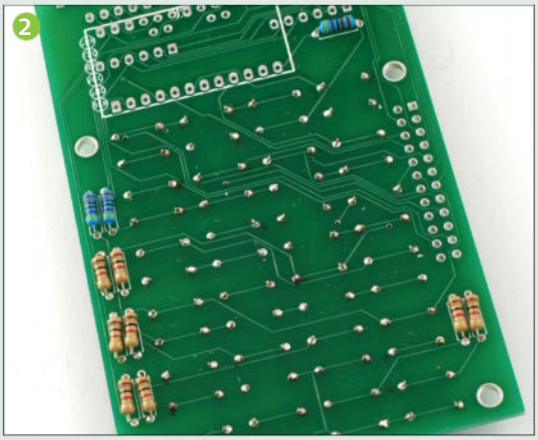
Now it's time to solder the Arduino in place. Put the Arduino Pro Mini onto the headers with the chip upwards and the programming pins pointing over the edge of the board.

Solder, paying careful attention to the two (or four) internal pins; you may need a finer than normal iron to solder these pins.

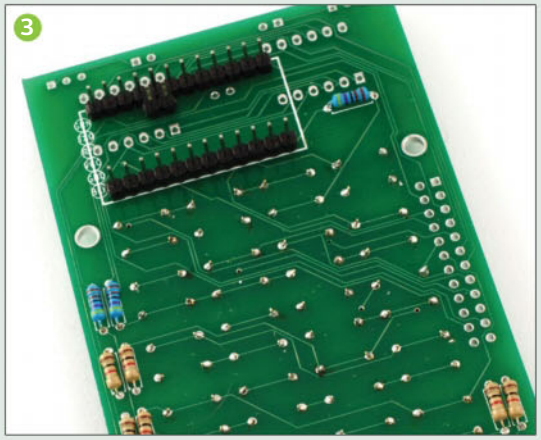
You're now done. The Kim Uno can be powered through 5V to the Arduino, or via its own power inputs (5V or 9V) at the top of the board.



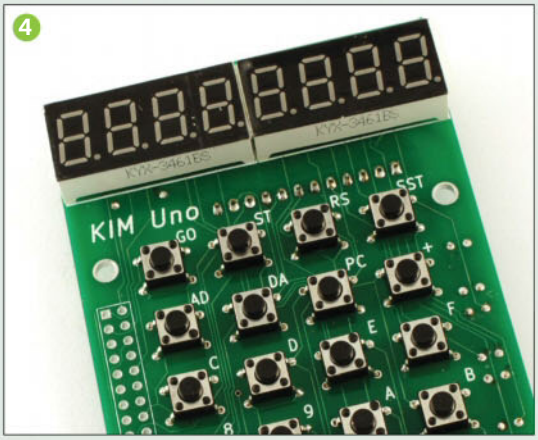
Getting the buttons into place can be a pain, but pliers can help with leg alignment



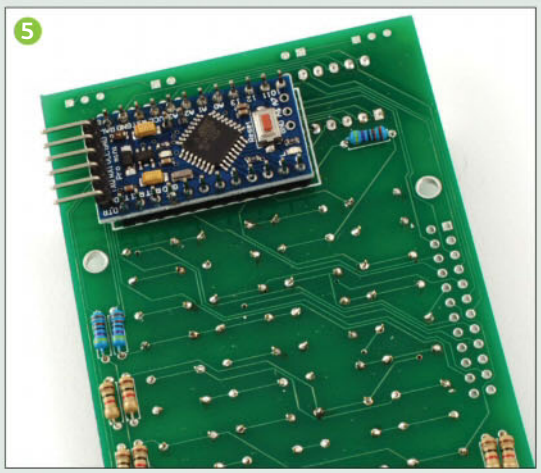
There's only a handful of resistors to solder, with just two values – helpfully with different-coloured bodies



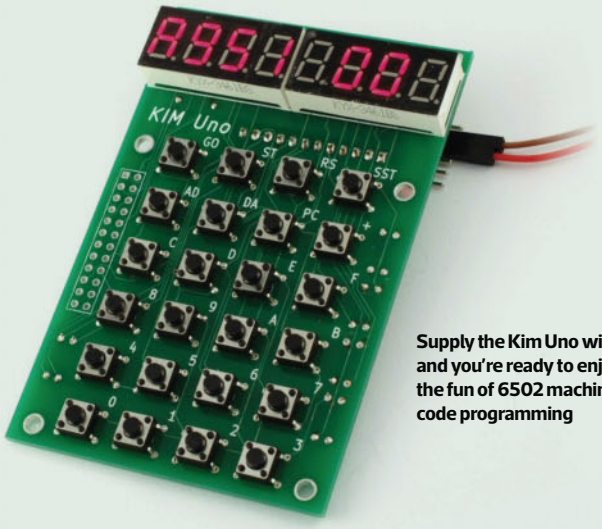
If you haven't read the instructions properly, soldering the headers is where you're likely to go wrong



A pair of four-digit, eight-segment LED panels make up the Kim Uno's display



The brains of the Kim Uno is an Arduino Pro Mini, although the emulator also runs happily on almost any other Arduino or compatible device



Supply the Kim Uno with 5V and you're ready to enjoy the fun of 6502 machine-code programming

You're ready to experience programming as it was done in the good old days, or just use the system as the world's least user-friendly programmable calculator. The downloadable user manual is a must, unless you're a KIM-fan already, as is at least a nodding knowledge of hexadecimal.

The Kim Uno is available from **http://obsolescence.wix.com/obsolescence** for $15 (£10) plus shipping, or $40 (£26) pre-soldered. Circuit files are available to print, as are instructions on loading the code into any compatible Arduino device for a try-before-you-build experience.

NEWS IN BRIEF

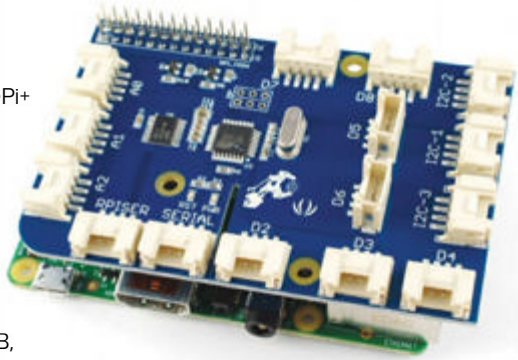
Windows 10 gets Arduino certification

Microsoft's upcoming Windows 10, which will include an Internet of Things (IoT) variant designed for devices, including the Intel Galileo and Raspberry Pi, has become the first operating system to gain official Arduino Certification. Assigned by Arduino LLC, the certification promises full compatibility with the Arduino development platform. At its Build conference, Microsoft demonstrated the Windows Remote Arduino application running on a Windows Phone 10 device, controlling hardware connected to an Arduino Uno equipped with Bluetooth radio module.

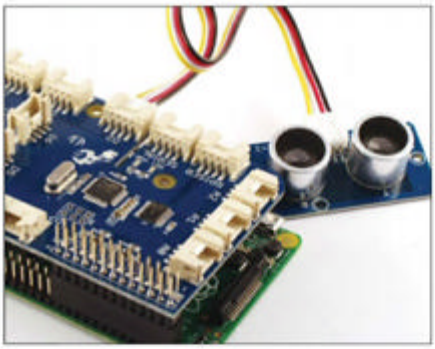
REVIEW

GrovePi+ Starter Kit

Created as a partnership between US-based Dexter Industries and China's Seeed Studios, the GrovePi+ is a Raspberry Pi add-on that promises compatibility with Seeed's Grove platform. For those not familiar, the Grove platform is a clever means of making it simple for newcomers to the world of electronics to build relatively complex devices. Each input or output – from ultrasonic distance sensors to LEDs – has its own 'module' PCB, which connects to the master Grove controller via a keyed cable to guarantee that all the parts are wired up the right way around.



The GrovePi+ board mounts on top of any Pi, and you can still use the GPIO port for other hardware



The bundled sensors offer enough to get you started, including this ultrasonic distance sensor

While the original Grove controllers were Arduino-based, the GrovePi+ is designed by Dexter Industries to bring the same features to the Raspberry Pi. Designed as a piggyback board – but not a Hardware Added on Top (HAT) – the GrovePi+ uses the older 28-pin general-purpose input-output (GPIO) connector standard, although it's fully compatible with the new 40-pin Pis. Better still, it can be used alongside other GPIO-based devices, as all the 28 pins are broken out and only the I^2C bus (plus power) is in use.

Installation is fairly simple: insert the board, load the Dexter Industries' customised Raspbian image or run the installation script from the company's website and you're ready to play. Opting for the latter option, I did encounter one small problem: the clever script, which takes care of everything from downloading the software to enabling I^2C support and disabling the Linux serial console to free up the UART, failed to register the GrovePi Python library correction. A quick manual install of that particular package – a one-line command – and I was ready to rock and roll.

The kit includes 12 Grove modules to get you started. There are sensors for sound, light, angle, distance, and one offering combined temperature and humidity. There are also modules with red, green, and blue LEDs, plus modules with a piezoelectric buzzer, a button, a small relay and a neat character-based LCD display with user-adjustable RGB LED backlighting. Each module connects to a port on the GrovePi+ board, which – as mentioned – guarantees that it's wired up correctly and nothing will go bang. The only exception is the LEDs, which require a keen eye to spot the anode and cathode before insertion in the Grove module; if it doesn't light up first time, try swapping it around.

The GrovePi+ is a full kit, with all the parts you need to get started, bar a Raspberry Pi

The bundled software includes a wide selection of examples written in Python, supported by a handy pocket-sized manual, which details projects ranging from making an LED blink to getting the most from the LCD. Unfortunately, although the manual promises support for C, no libraries have been developed, owing to what the project maintainers describe as a lack of demand from users.

That's a minor point, however: the GrovePi+ is aimed primarily at beginners, and most Raspberry Pi beginners will be using the Raspberry Pi Foundation's recommended Python programming language to get started.

For more advanced users, the GrovePi+ board itself offers a few advantages over just sticking things in the GPIO header too. It adds support for pulse-width modulation (PWM) control, for adjusting the brightness of LEDs or controlling a servo, and it adds analogue inputs too. It also features an on-board ATmega328 microcontroller, the same found on many Arduino boards, which takes the pressure off the Pi's CPU and allows for true real-time sensing and control.

The GrovePi+ Starter Kit is available from **www.unmannedtechshop.co.uk** for £48 inc VAT, while the GrovePi+ board itself is available separately for £20 inc VAT. CPC

NEWS IN BRIEF

Samsung launches Artik IoT boards

Samsung has thrown its lot in with the Internet of Things (IoT) in a major way, announcing a new product family dubbed Artik, which has formal Arduino certification. The ultra-compact Artik 1 measures a mere $12mm^2$ and packs a dual-core 250MHz/80MHz application processor and 1MB of RAM, while the larger 29 x 25mm Artik 5 offers a 1GHz dual-core ARM chip and 512MB of RAM. Finally, the 29 x 39mm Artik 10 has an 8-core chip and 2GB of memory. Each board includes various radio features, but pricing has yet to be disclosed.

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree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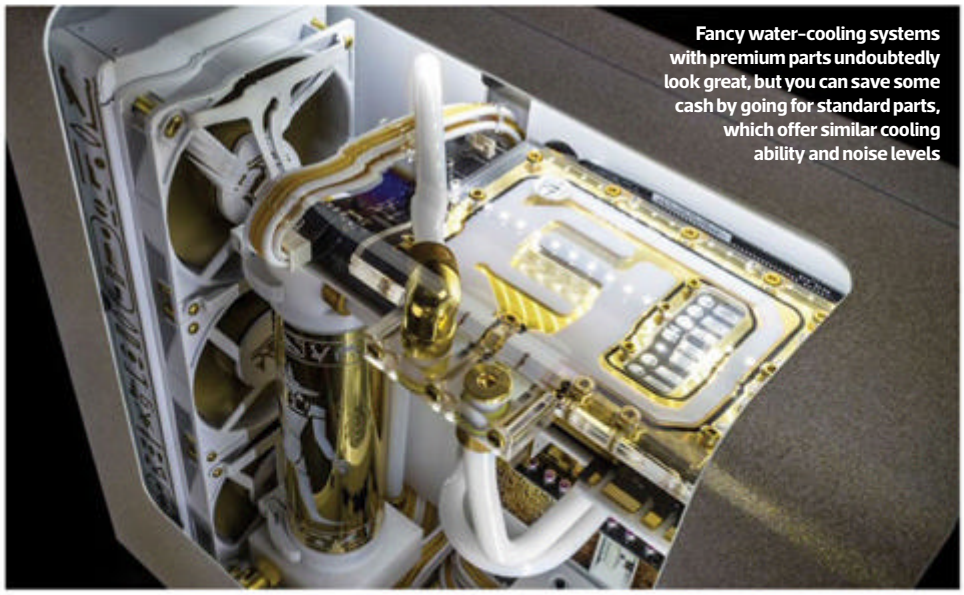
Water-cooled PCs don't have to cost the earth

It's easy to think of water cooling as a super-expensive way of cooling your PC that's overkill. It's certainly expensive compared with all-in-one liquid coolers. For example, some of the more expensive fittings or barbs can cost upwards of £5 apiece – even £10 in some cases – so that's £50 in fittings alone if you're talking about cooling your CPU and graphics card. When you add a premium pump, radiator and reservoir into the mix, you can quite easily spend over £300 on just cooling a couple of components, but it doesn't have to be this way.

There's a lot of premium gear out there that costs a small fortune, and it certainly looks good. Many of the PCs we feature in Readers' Drives use this gear too, but it's important not to become obsessed with PC mods and lavish water-cooling equipment as if they're the norm. Water cooling offers benefits such as better cooling and lower noise levels, and it's these aspects that got me interested in it in the first place, rather than aesthetics.

I was speaking to the UK's public relations guy from Aquatuning the other day and he made quite an interesting point. Aquatuning's best sellers in terms of the water-cooling gear it sells are actually the cheaper components. It sells a huge amount of standard fittings and radiators, even though a glance at any online modding forums might suggest otherwise. It seems that enthusiasts water-cooling their PCs don't always opt for super-premium components; they just want to water-cool their PC.



Fancy water-cooling systems with premium parts undoubtedly look great, but you can save some cash by going for standard parts, which offer similar cooling ability and noise levels

Personally, while I could quite easily bend some acrylic tubing and splash out on the shiniest gear for my own, personal water-cooled PC, I've always used basic tubing and cheap fittings, while trying to recycle gear whenever possible. I want my water-cooling system to be practical above all else – it already takes an entire afternoon to remove and refit a water-cooled graphics card – I don't want to make my personal PC even more complicated by throwing acrylic tubing or complicated fittings into the mix too. If you have the money, of course, and you want a great-looking PC, then go for the premium components – my guide to hard tubing on p102 shows some great effects that can be achieved.

But don't worry if you don't have the mega bucks. While there are plenty of shiny projects out there, far more that aren't shown on forums use basic water-cooling gear for the simple

reason that their owners love water cooling, but don't want to, or can't, spend a fortune doing it. If you're pricing up a new water-cooling system, ask what your priorities are before splashing out needlessly large sums of cash.

Hands on with Bitspower's GTX 960 block

First it seemed that no one was going to make a full-cover waterblock for Nvidia's GTX 960, then Bitspower announced it would make a single model compatible with Asus' STRIX OC card. It was kind enough to send me a one of the first samples to be made, and I have to say I'm rather impressed. It's a hefty waterblock, considering the small size of the graphic card it's cooling, but Bitspower has really gone to town on making it both attractive and well-functioning. It's engraved the clear acrylic top with a STRIX logo, and put a mirrored metal plate above the VRM section.

The initial images of the waterblock hinted at the coolant channel only passing over the GPU core, but the finished waterblock cools the VRM section too. Bitspower has also thrown in a custom backplate, which is again engraved with the Asus Strix logo.

One downside to this otherwise great bit of kit, however, is its depth. A large extension for the ports sits on the outside, meaning the waterblock measures nearly 140mm across. As such, your card ends up being nearly 35mm wider than your average graphics card, such as a reference-cooled GTX 780. Another issue is availability – getting hold of Bitspower waterblocks is tricky in the UK so if you're dead set on water-cooling a GTX 960 Strix graphics card with a full-cover waterblock, then check out **www.frozencpu.com** and **www.performance-pcs.com**, although you'll have to pay international shipping costs and import duty.

Case makers should take advantage of SSDs

When it comes to modding and water cooling, enthusiasts often remove a case's hard disk mounts, freeing up a huge amount of space for water-cooling hardware such as pumps or radiators. Even if the mounts are riveted in place, it's a simple job to drill them out.

Bitspower has engraved the clear acrylic top with a STRIX logo, and put a mirrored metal plate above the VRM section

Local hard disks are becoming less necessary as NAS boxes become more popular and SDDs drop in price. With 500GB SSDs now retailing for under £150, there's definitely scope for building SSD-only systems, which opens up many cases to extensive water cooling; sling an SSD or two in your system and you can strip out all the other hard disk mounts to create space for pumps and radiators.

I'm currently playing with Phanteks' Enthoo Evolv ITX, which we reviewed in Issue 142, and in my mission to mod it and cram some water-cooling gear inside, I've completely stripped out the interior to make way for two large radiators plus a combined pump and reservoir. However, removing the hard disk mount means I'm left with just one SSD mount behind the motherboard tray. There's room for a number of other SSD mounts, but even Phanteks, a company I consider to be at the forefront of case design, especially when it comes to SSD mounts and water cooling, hasn't really taken advantage of the flexibility of SSDs, such as the fact you can stuff them anywhere, and that many people don't need stacks of hard disks any more.

Thankfully, Phanteks does offer an optional dual SSD mount that replaces the single mount behind the motherboard tray, which is available for around £10. This mount solved my problem, as I have two SSDs in my PC, albeit at extra expense, but it wouldn't be very difficult at all for case makers to just drill a few mounting holes in the case to allow people the freedom of ditching their hard disks. SSDs are small, don't need any airflow and can be shoved anywhere – I'd like to see more companies taking advantage of these benefits. CPC

SSDs are small, don't need any airflow and can be shoved anywhere

Antony Leather is Custom PC's modding editor @antonyleather

How to

Become a pro with rigid acrylic and metal tubing

There's a number of advanced ways to use rigid tubing in your water-cooled PC. Antony Leather takes a look at them

TOTAL PROJECT TIME / 3-6 HOURS

Last month we built a water-cooled dream PC, which used rigid acrylic tubing rather than standard flexible PVC tubing. Hard tubing gives you clean, sharp bends and straight lines, while offering resilience against clouding that can spoil your view of the coolant. It comes in a variety of colours, and you can also use metal tubing and even copper piping.

Following on neatly from our Dream PC feature last month, in this month's modding guide, we look looking at how to use metal tubing and create advanced shapes using acrylic tubing too.

TOOLS YOU'LL NEED

Alphacool hard tube fittings and adaptors / www.aquatuning.co.uk

Alphacool HardTube / www.aquatuning.co.uk

Primochill hard tube fittings and acrylic tubing / www.overclockers.co.uk

Monsoon hard tube fittings, glue and acrylic tubing / www.overclockers.co.uk

Monsoon tube bending kit / www.overclockers.co.uk

Copper pipe cutter / Most hardware stores

Soft copper pipe / www.ebay.co.uk

Copper pipe bender / www.ebay.co.uk

Vice or Kwix UK tube straightener / www.amazon.co.uk

PICK MATERIAL AND FITTINGS

1 / ACRYLIC OR METAL?

First you need to decide whether you'll be using acrylic or metal-based tubing for your project. Acrylic is popular, easy to bend, cheaper and comes in a variety of colours. Metal tubing looks fantastic, but most of it doesn't bend and soft copper piping requires tools to bend it to shape.

2 / CHOOSE YOUR FITTINGS

There's an increasing variety of fittings from which to choose but the choice mainly comes down to aesthetics. It's easy to work with Alphacool and Primochill's fittings, and they're cheap too, while Monsoon and EK offer more attractive, premium fittings.

3 / MONSOON FITTINGS

Monsoon's fittings work with 13mm or 16mm outside-diameter tubing, and include locking caps to prevent the tubing from slipping out of the fitting. The downside is that they require more work, as you need to glue the caps onto the tube using adhesive. Once set, the caps can't be removed either.

4 / GLUE MONSOON TUBE CAPS

Apply a generous amount of adhesive to the inside of the cap, then twist the cap around so the adhesive fills the gap between the cap and tube with no air bubbles. Allow it to dry for four hours, and then you can connect the tube to the fitting.

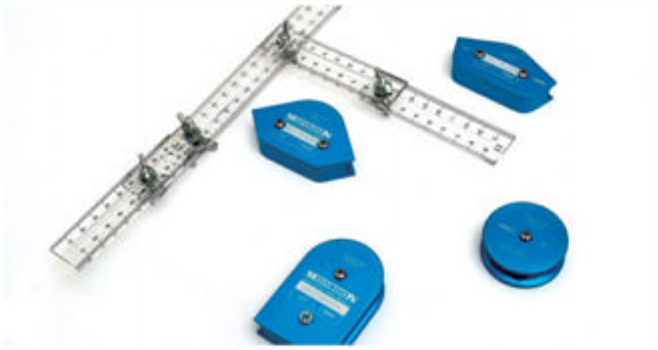
5 / PRIMOCHILL FITTINGS

Primochill fittings are the simplest to fit and just use a single large O-ring, which you secure to the tubing – the locking ring compresses this O-ring, creating a tight seal.

6 / ALPHACOOL FITTINGS

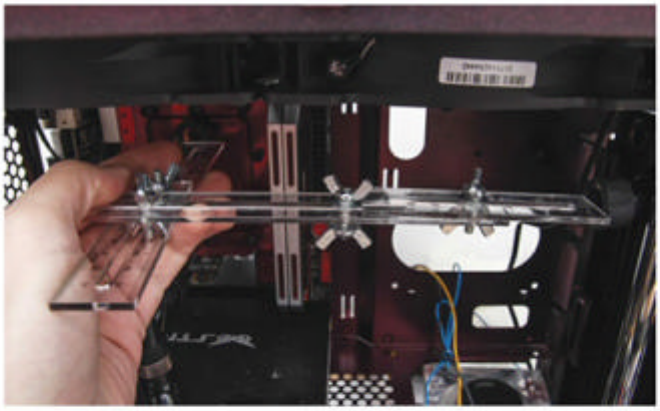
Alphacool's fittings work using a similar method, except there's an O-ring in the base and another that's pre-attached to the tubing, with a separate compressing plate over the top for good measure.

ACRYLIC TUBING



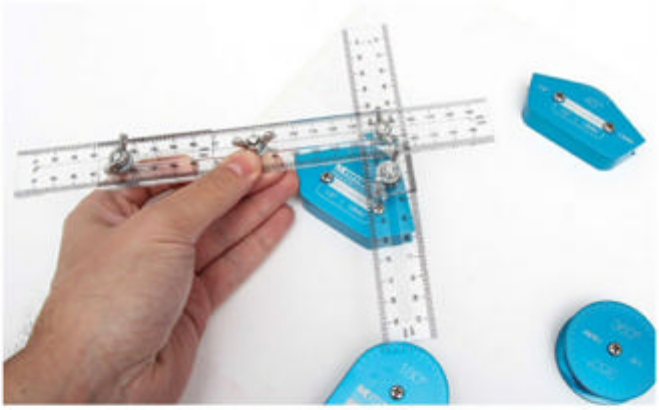
1 / MONSOON'S BENDING KIT

If you're dealing with acrylic tubing then Monsoon's bending kit is invaluable. It includes guides for a variety of angles that can be attached to a hard wood board, and the complete set has all the parts and tools you need, including a heater for the acrylic.



2 / USING THE RULES

The kit features several different rules that can be attached together to allow you create an entire length of tubing with a bend, or bends, in the middle. Create a section that stretches from one fitting to the other.



3 / MEASURE TO SHAPE

Use the cut-out in the centre of the rule as a guide for where the tubing will sit, and then overlay this cut-out onto the appropriate guide before marking the lengths of tubing you'll need on the board.

4 / CUT THE TUBING

The kit also comes with a hacksaw and cutting support. Use these tools to cut the tubing to the required length required to reach from fitting to fitting, and also to apply your desired bend.

5 / BEND TO SHAPE

With the tube at the right length, warm it gently with the heat gun until it becomes pliable in the area you need to bend it. You can then place it onto the guide and gently move it around, pressing it firmly into the groove in the guide.

6 / USE DEBURRING TOOL

The kit's deburring tool uses metal blades to smooth both the inner and outer edges of the tubing, removing any shards and rough edges. This process is important to prevent damage to O-rings inside the fittings.

ADVANCED ACRYLIC TUBE BENDING

1 / LOCATE SUITABLE TEMPLATE

Once you've got to grips with acrylic tube bending, you can start to consider more advanced bends, such as this spiral. Start by locating a suitable template such as a glass or strong cardboard roll.

2 / INSERT TWO TUBE SUPPORTS

By using two tube supports that meet in the middle of your spiral, instead of one, you can halve the distance they need to travel in order to be removed. Additionally, coating them in a generous amount of washing-up liquid lubricates them, but doesn't stain the tube when heated.

3 / HEAT UP AND BEND AROUND TEMPLATE

Heat the tube slowly and, as it becomes pliable, gently bend it into a spiral form. Anchor the end of the tubing while you heat the tubing, and watch the place where the tube supports join, as it can be prone to kinking.

4 / REMOVE TUBE SUPPORTS

Once your spiral is complete, and you've waited for it to cool down, you should be able to slide out the tube supports easily. If you used washing-up liquid as a lubricant, you'll also need to rinse the tubing thoroughly before you connect it to your water-cooling system.

STRAIGHT METAL PIPES

1 / STRAIGHT METAL PIPES

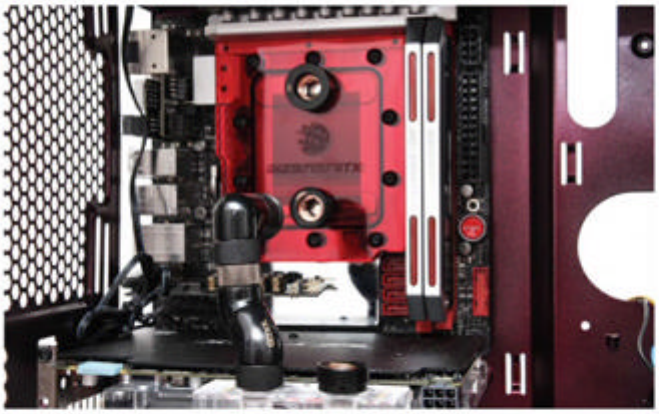
Alphacool offers an alternative to acrylic tubing – metal pipes made of thick brass and coated in nickel with a chrome or dark nickel finish. Unfortunately, they can't be bent without splitting them, so you have to create multiple joins to use them, although this job can be easier than tube bending.

2 / ELBOW AND ANGLED ADAPTORS

Joining metal pipes requires a combination of different fittings and joints. Right-angled fittings attach directly to components, with a fitting on a female thread at the end. Elbow joins have female threads on either end, and can make a bend in the middle of your case via two hard tubing fittings.

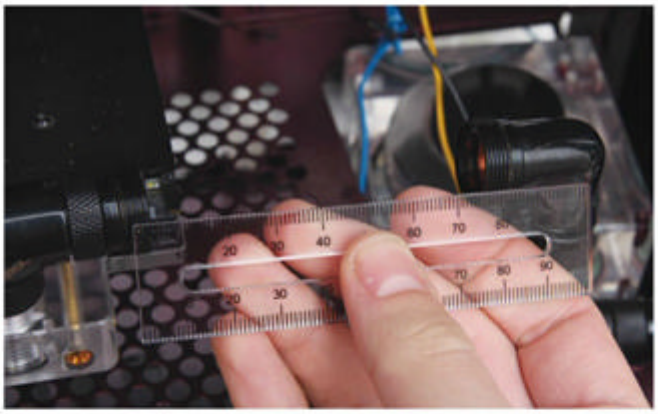
3 / FLEXIBLE ADAPTORS

Flexible fittings are essential for lining up metal tubes. They can rotate at the base and middle, and have a revolving tip, so you can fine-tune a fitting's direction to line up with the next fitting, and achieve straight lines. You can also use extenders to raise the fittings or adaptors above components.



4 / INSERT FITTINGS

Before you start measuring up and cutting the tubing, you first need to install all your water-cooling components and their fittings, including any adaptors or extenders.



5 / MEASURE FOR TUBING

Use a ruler to measure the distance between fittings. You need to allow for the distance that the tubing protrudes into the fittings as well. For the Alphacool fittings we used, this distance was around 5mm, but it differs between fittings.

6 / CUT TO SIZE

A cutting tool can be used with soft copper tubing but, as brass is much harder, we decided to use a Dremel and cutting disc, which cut through the metal tubing in a matter of seconds.

7 / FILE TUBE ENDS

The downside to using a Dremel is that the cut isn't as clean as a hand-tool cut, but using a metal file and deburring tool gets the tube ends shipshape in a few minutes. You also need to file the edges of the end of the metal pipe, in order to make it easier to insert into Alphacool fittings' O-rings.

COPPER TUBING

1 / CHOOSE TUBING WIDTH

You can use 1/2in outside-diameter copper tube and readily available 13mm fittings, but the appropriate bending tools are expensive. Cheaper tools can deal with 10mm or 12mm tubing, but you'll need specific 12mm fittings from the likes of EK or Bitspower.

2 / STRAIGHTEN TUBING

You can use a workbench vice to straighten the copper tubing, as it will arrive off a reel. This job can take an hour or more for an entire PC's worth of tubing. However, **www.kwixuk.com** offers a hand tube straightener, which costs around £40 and is perfect for the job, saving you time.

3 / CUT AND DEBURR

Use a tube cutter to cut the copper. This tool works by using a metal disc to slowly cut into the tube, which is forced against it using a thumbscrew. It can be hard work for your hands, but the process doesn't take long and gives you a very clean cut. You then need to deburr the edges.

4 / USE COPPER PIPE BENDER

Finally, use a copper pipe bender, which uses force to bend the tubing around groves, preventing it from kinking. The right size of tool is essential – even 12.7mm (1/2in) tubing is too big for a 12mm tool. The tool has angles marked on it so you can accurately bend the tube. CPC

DOWNLOAD FROM WWW.ASUS.COM/CAMPAIGN/REALBENCH

CUSTOM PC REALBENCH 2015

in association with ASUS

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench, then disable any power-saving tech in your BIOS that changes your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You then need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

Gimp

We use Gimp as the basis for our image editing test, opening and editing several large images. Unlike the Media Benchmarks 2007 Gimp benchmark, this test uses more than one CPU core, although it's still much more sensitive to clock speed increases than more CPU cores.

Handbrake H.264 video encoding

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

CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the LuxMark renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

Heavy multi-tasking

Our overhauled multi-tasking test plays back a full screen 1080p video, while running a Handbrake H.264 video encode at the same time.

Scores

RealBench 2015 breaks down the individual scores for each test, and then gives you a total system score, as well as a percentage reference score.

Intel 100 per cent reference specs: stock speed Core i7-4790K, 16GB of Corsair 2,400MHz DDR3 RAM, 240GB OCZ 150 SSD, Asus Maximus Gene VII motherboard, Nvidia GeForce GTX 780 3GB graphics card.

AMD 100 per cent reference specs: stock speed A10-7850K APU (using the integrated graphics), 8GB of Corsair 2,133MHz DDR3 RAM, 256GB Plextor M5 Pro SSD, Asus A88X-Pro motherboard. CPC

WINNERS!

Congratulations to **JourneymanMike**, **carl.symons** and **Lordsoth**, who are the lucky winners of a shiny new Asus Z97-Pro Gamer motherboard, following our competition in Issue 142. Please email the RBR file that corresponds with your leaderboard result to editor@custompcmag.org.uk so that we can verify it, and we'll get your board sent to you.

CUSTOM PC REALBENCH 2015 LEADERBOARD

	SYSTEM SCORE	REFERENCE	USERNAME	MOTHERBOARD	CPU	CPU CLOCK	MEMORY	PRIMARY GPU
1	201,446	176%	CustomPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.3GHz	16GB Corsair 2,666MHz	Nvidia GeForce GTX Titan X
2	197,964	173%	Carbonleg	Asus X99-E WS	Intel Core i7-5960X	Not reported	32GB Corsair 2,400MHz	AMD Radeon R9 200 Series
3	189,230	165.3%	shadowsrayne	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Corsair 2,133MHz	Nvidia GeForce GTX 980
4	165,512	144.6%	Penfold	Asus X99-Deluxe	Intel Core i7-5820K	4.5GHz	32GB Corsair 2,333MHz	AMD Radeon R9 200 Series
5	163,650	143%	shaunhanson	MSI X99S SLI Plus	Intel Core i7-5820K	Not reported	16GB Corsair 2,133MHz	Nvidia GeForce GTX 980
6	161,503	141.1%	Chris_Waddle	Asus Rampage IV Black Edition	Intel Core i7-4930K	4.72GHz	16GB Corsair 2,400MHz	Nvidia GeForce GTX 780 Ti
7	155,685	136%	MAQ	Asus Rampage V Extreme	Intel Core i7-5930K	Not reported	32GB Corsair 2,133MHz	Nvidia GeForce GTX 970
8	148,641	129.9%	claire.york83	Asus X99-S	Intel Core i7-5820K	4GHz	16GB G.Skill 2,666MHz	AMD Radeon HD 7900 Series
9	146,635	128.1%	hutch	Asus Rampage IV Extreme	Intel Core i7-4930K	4.5GHz	32GB Kingston 1,333MHz	AMD Radeon R9 200 Series
10	146,123	127.7%	Samual	Asus Maximus VI Extreme	Intel Core i7-4790K	4.95GHz	16GB Team Group 2,666MHz	Nvidia GeForce GTX 780
11	145,751	127.4%	sparrowhawks	Asus Rampage V Extreme	Intel Core i7-5820K	Not reported	16GB Kingston 2,400MHz	Nvidia GeForce GTX 980
12	143,892	125.7%	robert_a_inglis	Asus Rampage V Extreme	Intel Core i7-5930K	Not reported	16GB Corsair 3,000MHz	AMD Radeon HD 5800 Series
13	139,757	122.1%	dainye	Asus P9X79 Pro	Intel Core i7-3930K	4.6GHz	8GB Kingston 1,600MHz	AMD Radeon HD 7900 Series
14	136,031	118.9%	Karol	Asus Z97-A	Intel Core i7-4790K	4.8GHz	16GB Corsair 2,400MHz	Nvidia GeForce GTX 970
15	133,050	116.3%	adrian_symonds	Asus Maximus VI Gene	Intel Core i7-4790K	4GHz	16GB Patriot 2,400MHz	Nvidia GeForce GTX 980
16	132,143	115.5%	andy.gwynnette	MSI Z97M Gaming	Intel Core i7-4790K	4.6GHz	16GB Avexir 2,666MHz	Nvidia GeForce GTX 970
17	128,862	112.6%	chrisray84	Asus Maximus VI Formula	Intel Core i7-4790K	4.5GHz	16GB Corsair 1,866MHz	Nvidia GeForce GTX Titan X
18	124,784	109%	semmyconcious	Gigabyte GA-X99-UD4-CF	Intel Core i7-5820K	Not reported	16GB Corsair 2,133MHz	Nvidia GeForce GTX 970
19	124,431	108.7%	decks	Asus Z87-PRO	Intel Core i7-4770K	4.5GHz	8GB Team Group 2,133MHz	AMD Radeon R9 200 Series
20	124,246	108.6%	andrew.mcleod	Asus Maximus VI Hero	Intel Core i7-4770K	4.5GHz	16GB Kingston 1,600MHz	AMD Radeon R9 200 Series

Readers' Drives

Lumo

After spotting In Win's D-Frame Mini, Daniel Harper saw the potential for a great mod with a striking coat of fluorescent yellow paint, plus custom CNC and laser-cut parts

/MEET THY MAKER

Name Daniel Harper (B NEGATIVE)

Age You love this, don't you? Yes, I'm 40

Location Dirty South London

Occupation Medical equipment technician

Main uses for PC CAD and Arma III

Likes In Win, CNC, the redhead at the bus stop I drive past in the morning, Jim Knees' shoe collection and Arma III

Dislikes Shellfish, ironing instructions, childproof caps and League of Legends

CPC: What originally inspired you to build this project?
Daniel: The In Win D-Frame Mini case. I saw it in some of the Computex reviews, spotted the potential immediately and started bothering In Win about it immediately. I very much like the quirky nature of In Win's products – the company makes lovely cases that require a little planning and care to achieve spectacular results. Such a striking case needed a striking theme, so I then rummaged through **www.specialistpaints.com** to find what I wanted – a PC mod always starts with the colour palette for me.

CPC: Where does the name come from?
Daniel: It comes from the name of the paint. My rig-naming skills are poor – I can't come up with catchy names!

CPC: What specs did you choose, and why?
Daniel: In its stock form, the case is a mini-ITX design, but it has more than enough room for a canny builder to fit larger kit inside it. I went to Asus to see if I could get hold of its micro-ATX Gryphon Z97 board as the base, as it's such a good board for modders. The PC also features a pair of GeForce GTX 680 cards, which needed a good home.

Finally, Be Quiet! is my go-to manufacturer for fans and PSUs, as the fans are so quiet!

Lumo was built to replace my S3 LAN box, but while I start with a application in mind, I tend to build much more overhead into my machines than required, so they end up being multipurpose PCs. Even the most basic enthusiast kit is more than powerful enough for pretty much any task you throw at it now, outside of professional workloads – I think the days of focused machines are long gone. Nowadays, I'm more concerned with portability and noise levels than processing power.

CPC: What difficulties did you come across when building Lumo?
Daniel: Space for water cooling in the case was originally a big concern for me. I got around this issue by designing a 25mm-thick acrylic tray, clad with 1mm stainless steel, to house the reservoir and drives, and hide all the wiring. Designing the tray took a few hours in SolidWorks, and the final result came out well.

I had to take a good look at radiators first, as their depth couldn't be more than 40mm – EK stepped up and provided the radiators I needed, even though my waterblocks weren't EK-branded – the company understood my need to recycle perfectly good hardware. Other than that, the build process was quite smooth.

CPC: Tell us about all the mods in this PC.
Daniel: I've already mentioned the acrylic tray, but there are modded parts everywhere you look on this built. The paint job is obvious, as is the hard acrylic tubing, but the modding goes down to individual component levels too – even the fittings have inlays in them.

My favourite mod has to be the pin-stripe around the graphics cards' PCBs – it looks really good, and it's so easy to do. I'll be using the tray idea again too – it gives you so

SEE THE FULL PROJECT LOG:
http://tinyurl.com/LumoModCPC

much more scope for tidying up a PC's interior.

CPC: What tools and machinery did you use?
Daniel: I used a spray gun, fretsaw and files, and I also took advantage of the excellent services offered by Justin and Shaun at Parvum for the tray milling, while Nate at e22 laser-cut the stainless steel for me. Every aspect of my original drawings was followed to the letter, and done in good time – I couldn't ask for more, though I think I really need a CNC mill now! I also applied paint techniques that were new to me.

SYSTEM SPECS

CPU Intel Core i7-4670K

Graphics card 2 x Nvidia GeForce GTX 680

Case In Win D-Frame Mini

Memory 16GB Crucial DDR3

Motherboard Asus Gryphon Z97

Storage 120GB and 240GB Corsair GT SSDs, and a 2TB Western Digital Black hard drive

PSU Be Quiet! Dark Power 850

Cooling EK PE radiators, pump and pump-top, custom reservoir, MIPS IceForce CPU block, Watercool GPU blocks and plates

CPC: What media interest has Lumo attracted?
Daniel: It's a very popular build. It's been promoted by most of the modding forums, it's on various mod of the month pages, and OC3D had it on the front page, while OCN used it to promote the WC Club. More importantly, the designer of the case at In Win has commented in the build logs! It will be on the In Win stand at the summer I-Series event too, for anyone who wants to take a real-life look at it. I think it's my best modding work to date.

CPC: How long did the build process take?
Daniel: Overall, around four or five months, which is quite quick for me, but it was all planned out before the case was even available in the UK. Getting the whole project planned first was a new process for me, but I think the results speak for themselves!

CPC: What did you learn from this build?
Daniel: Firstly, that yellow fluorescent paint dust gets everywhere! I've also started to look at mods differently now – I think I could get into the integration ethos in a big way.

CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?
Daniel: Finally, for once I'm happy with the end result. I'll actually be building it again too, but with even more capacity – I have a really good idea for it, but I have to clear the decks with my current workload first. A future project will probably involve two of these beasts and full-sized ATX gear. Stay tuned! 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** 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.

THANKS FROM DANIEL

Justin and Katherine at In Win, Derick and Niko at EK, Gareth at Asus, Katharina at Be Quiet! UK, Justin and Shaun at Parvum, and Nate at E22. I would also like everyone to take two minutes to think about the guys at Specialtech, who helped, but the company is sadly no longer with us. These guys gave me my first leg-up, and it's a real shame to see them go, so I'd like to give a really massive thank you to Ayd, Rootz and Steve for all you've done for me and the UK water-cooling community. We miss you.

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 graphite Series 230T case and RM 550w Modular power supply

TOTAL VALUE £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great case. The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand outs from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.

Mayhems coolant and dyes

VALUE £50 inc VAT / **MANUFACTURER** 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.

Phobya Modding Kit

VALUE £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-braided extension cable gives you extra routeing options in your case, and it also enables you to run up to four fans from one compatible motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors. As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.

Folding@Home

Join our folding team and help medical research

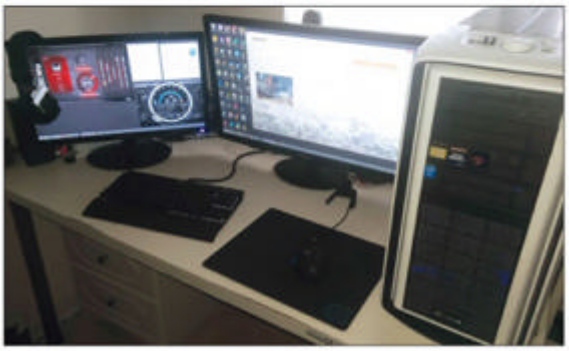
Folder of the month / We catch up with: killtothis

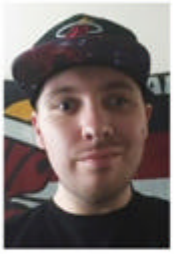
CPC: So who is killtothis?
Killtothis: My name is Jay, and I currently work for my father as an assistant at his business, but I'm now having time off after having my pancreas and spleen removed. Other than that, I'm a keen gamer and Miami Heat fan!

CPC: Why did you start folding?
Killtothis: Medical problems have hit quite close to home; cancer has run in my family and I'd been suffering from chronic idiopathic (unknown cause) pancreatitis from the age of 16.

CPC: What excites you most about folding?
Killtothis: The fact that one day, as a community, we can make a difference.

CPC: How many machines do you have folding?
Killtothis: Just the one currently. It's a Core i5-4690K overclocked to 4.5GHz (1.2V), with 8GB of 1,600MHz Corsair RAM, a Gigabyte Z97 Game 3 motherboard, a Palit SuperJetstream GTX 980 graphics card and a Corsair AX760 PSU – it runs Windows 8.1. It's in my games room, but I like to call it an office so I sound important.





CPC: What's your best piece of folding kit?
Killtothis: My GTX 980, without a doubt.

CPC: Do you intend to keep up your current production level?
Killtothis: Yes, absolutely. If I had the funds, I'd build another system and use that too!

CPC: Any tips for fellow team members?
Killtothis: Obtain a Passkey! Also, keep an eye on temperatures and make sure any overclocks are stable.

CPC: What do your friends and family think about your folding?
Killtothis: My wife thinks it's a good idea, and I've mentioned it to my parents but they don't really understand it.

CPC: What's your worst folding experience?
Killtothis: I haven't had one yet – touch wood – if anything, I'd say maybe the cost of running my system, but it's quite efficient as Nvidia did a great job with the Maxwell architecture.

CPC: What's your best folding experience?
Killtothis: Getting to the top 1,000 leaderboard, and seeing my rank go up, along with knowing that I'm contributing to a great cause.

CPC: Is there anything else you would like to add?
Killtothis: I'd like to thank my family – my wife, who I love more than the earth, and I want to give a special mention to my son, who changed my life and gave me a purpose.

'Persistence always overcomes resistance' – Mr Magic.

STATS

Team rank 271
World rank 12,902
Score 5,130,507
Work units 281
Daily points average 167,491

TOP FOLDERS: This month's shout-outs go to Maglor, daxchaos and Portchylad. If you fold under any of these names, email **folding@custompcmag.org.uk**

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 on the **www.bit-tech.net** forums.

MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE
Philhasnoidea whathe\\'sdoing	20000
tallandgentle33uk	20000
TimmyH	30000
whiskeyecho	30000
bradbooth	40000
Alee4177	50000
JamieRStone	60000
upthesaddlers +mrslippery	60000
Jaffo	80000
rob_woolcott	80000
Davith	90000
Parmesan	90000
Albie1971	100000
Cryptofrog	100000
Seamus3900	100000
talpigi	100000
TheTomBoy	100000
TroyS2	100000
Baxtee	200000
Bleakknave	200000
Bobthetoolnut	200000
davm64	200000
Kentara	200000
Rateye	200000
reidmarc	200000
MetallicGloss	300000
pete	300000
RaistlinRTCW	300000
RougeNikov	300000
wew	300000
Atanamir	400000
bastardo_bill	500000
Blexis	600000
Bob_D	600000

USERNAME	POINTS MILESTONE
MikePreston	600000
mrorange	600000
Quozzbat	600000
GJBriggs	700000
RadeonRaider	700000
daza17	800000
Lethaertes	800000
NoizDaemon666	800000
Chrisseboooboo	900000
Lunnbow	900000
Pickles	900000
carbontwelve	1000000
Damien_Tanner	1000000
Gingerbunny44++	1000000
Hateboy	1000000
HHomputers	1000000
Sparrowhawk	1000000
Trunkey	1000000
varnis	1000000
Zeffer83	1000000
billssteam	2000000
BondyBoy	2000000
Hagrids-Desktop-18	2000000
matgsi	2000000
techknowledgey	2000000
adbygrave	3000000
andboo1	3000000
Scammelio	3000000
ZeDestructor	3000000
daxchaos	4000000
killtothis	4000000
MarkVarley	4000000
robgsxrk4	4000000
Uncle_Fungus	4000000
Bluce_Ree	5000000
Ken_Swain	5000000

USERNAME	POINTS MILESTONE
Liam266	5000000
RabidMongoose	5000000
Skidder	5000000
Tommye123	5000000
Brentwood-Computers.com	6000000
davmonk	6000000
madmatt1980	6000000
SP1	6000000
Bedders	7000000
gupsterg	7000000
Mem	7000000
Simlec	7000000
Votick	7000000
Humwawa	8000000
MattEngr	8000000
Andy_J	9000000
rvalkass	9000000
Dave_Laffin	10000000
gtDunk	10000000
ITHelpDirect	10000000

USERNAME	POINTS MILESTONE
Maglor	10000000
ChunkyBrother	20000000
Little_Willie	20000000
SicoAnimal	20000000
BeezaBob	30000000
Vaio	30000000
sonic_vortex	40000000
Wilding2004	40000000
Angy	50000000
Assassin8or	50000000
Roveel	60000000
mmorr	70000000
apeman556	100000000
HHComputers	100000000
PC_Rich	300000000
piers_newbold	400000000
coolamasta	700000000
johnim	300000000
StreetSam	500000000
DocJonz	1000000000

THE NEXT OVERTAKE

WORLD RANK	TEAM NAME	POINTS	DAILY POINTS AVERAGE	TIME UNTIL OVERTAKE
2	[H]ardOCP	49,886,628,654	9,948,368	11.1 years
7	TSC! Russia	17,109,043,510	17,720,642	4.3 years
8	Custom PC & bit-tech	16,092,576,593	18,315,644	0
23	LinusTechTips_Team	4,559,969,429	30,813,017	2.5 years

TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	Nelio	2,346,278,033	111,150
2	DocJonz	1,082,740,220	172,293
3	coolamasta	713,130,383	163,743
4	Scorpuk	561,411,577	14,906
5	StreetSam	554,610,316	89,852
6	Dave_Goodchild	457,895,338	117,692
7	piers_newbold	442,767,978	38,615
8	johnim	347,196,540	79,749
9	PC_Rich	315,369,267	73,216
10	Slavcho	269,197,151	32,441
11	phoenicis	250,044,587	95,660
12	Lordsoth	242,759,901	91,599
13	The_M2B	234,049,671	55,038
14	Wallace	212,477,027	6,204
15	zz9pzza	211,014,628	15,794
16	HHComputers	191,649,882	12,999
17	TheFlipside	172,381,857	20,323
18	Ben_Lamb	166,053,146	2,891
19	Christopher_N._Lewis	152,388,004	35,885
20	Laguna2012	144,174,857	16,140

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	HHComputers	2,564,069	191,310,241
2	DocJonz	1,666,335	1,082,446,466
3	piers_newbold	1,414,687	442,617,166
4	PC_Rich	1,130,653	315,334,724
5	StreetSam	751,544	554,545,092
6	johnim	679,815	347,044,471
7	Slavcho	633,994	269,089,554
8	Lordsoth	571,912	242,663,261
9	The_M2B	567,535	233,984,497
10	Desertbaker	535,464	139,115,477
11	Scorpuk	530,981	561,289,634
12	coolamasta	464,497	713,079,897
13	apeman556	394,036	101,791,687
14	Nelio	367,905	2,346,255,823
15	Laguna2012	339,567	144,126,321
16	Dickie	306,823	17,256,434
17	Maglor	293,850	12,625,796
18	KevinWright	254,876	144,071,499
19	TheFlipside	238,823	172,379,833
20	Wilding2004	222,840	43,744,095

JAMES GORBOLD / HARDWARE ACCELERATED

DESKTOP BROADWELL ARRIVES

But it's too late and too expensive, argues James Gorbold

E3 might have playable demos of the latest games and CES might have the shiniest gadgets, but to my mind, the Computex show, held in Taiwan every June, with its barrage of product unveilings is the true highlight of the PC enthusiast's year. This year has been no exception, with hundreds of new products clamouring for attention. Last year, Intel used Computex to unveil its Devil's Canyon processors based on the Haswell architecture, ushering in the company's first mass-produced 4GHz CPU. This year Intel unveiled two new desktop CPUs based on the Broadwell architecture.

As you might imagine for a CPU architecture designed first and foremost for mobile devices, Broadwell is a lot more power-efficient than Haswell, so the new Core i5-5675C and Core i7-5775C have an attractively low TDP of 65W. However, as both chips are clocked significantly lower and have less cache than the Haswell equivalents, the Core i5-4690K and Core i7-4790K, the latter remain top dogs, delivering much higher performance in applications and games.

Broadwell on the desktop may have made sense in the sub-£400 gaming PC market. Such cheap PCs may sit below the radar of most PC enthusiasts, but it's a buoyant market, thanks to a growing youth market that plays online games such as Minecraft and League of Legends. What's more, it's a market in which AMD can seriously threaten Intel.

Broadwell could have made a good stab at this market – rather than sticking with the woefully underpowered HD Graphics 4600 GPU, the two new chips feature the Iris Pro Graphics 6200 GPU. The latter is far more capable, having more than double the number of execution units – 48 compared to 20 – and access to 128MB of Level 4 cache. The end result is the first Intel desktop CPU that can play games at a smooth frame rate without dialling all the quality settings so low you may as well play a game from ten years ago. Of course, you still need to make considerable sacrifices compared with playing on a half-decent discrete graphics card, but this GPU is still a big milestone for Intel.

However, because Intel has saddled the capable Iris Pro Graphics 6200 GPU with Core i5 and Core i7-level CPU performance, the new chips are woefully overpriced. Even the cheapest chip, the Core i5-5675C, retails for £226 inc VAT, meaning it's impossible to build a sub-£400 gaming PC with it, as there isn't enough money left for the motherboard, RAM, case, storage and Windows.

> Even the cheapest Core i5-5675C retails for £226, so you can't build a sub-£400 gaming PC with it

As such, the introduction of two costly Broadwell CPUs hasn't changed the market dynamic at all. That's because, while AMD's latest APU, the A10 7870K, is slower than Broadwell, it's still more than fast enough to play games such as Minecraft and League of Legends smoothly. It also costs just £107 inc VAT, leaving sufficient money for the other components needed to spec up a gaming PC for under £400. Alternatively, if you had a little more to spend, then an Intel Pentium CPU plus a discrete graphics card such as a GeForce GTX 750 Ti delivers far more bang for your buck than a Broadwell CPU.

Still, even if these two high-end Broadwell desktop CPUs don't make much sense, there are many more exciting new products from Computex coming out, such as the GeForce GTX 980 Ti (see p20), which delivers Titan X-like performance at a fraction of the cost. I certainly know which one I'm ogling for my next upgrade. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

Silencio Series Chassis

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